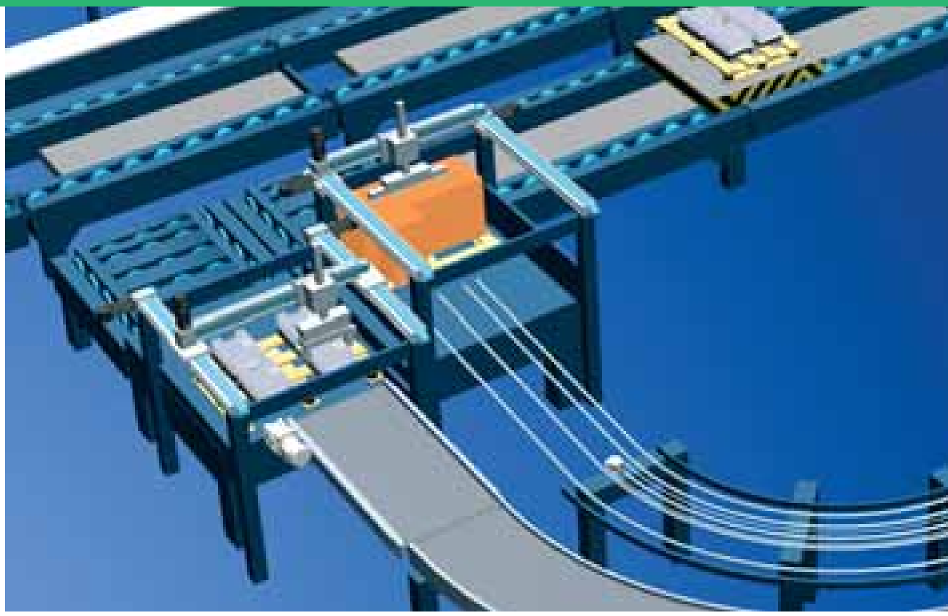
Drive solutions

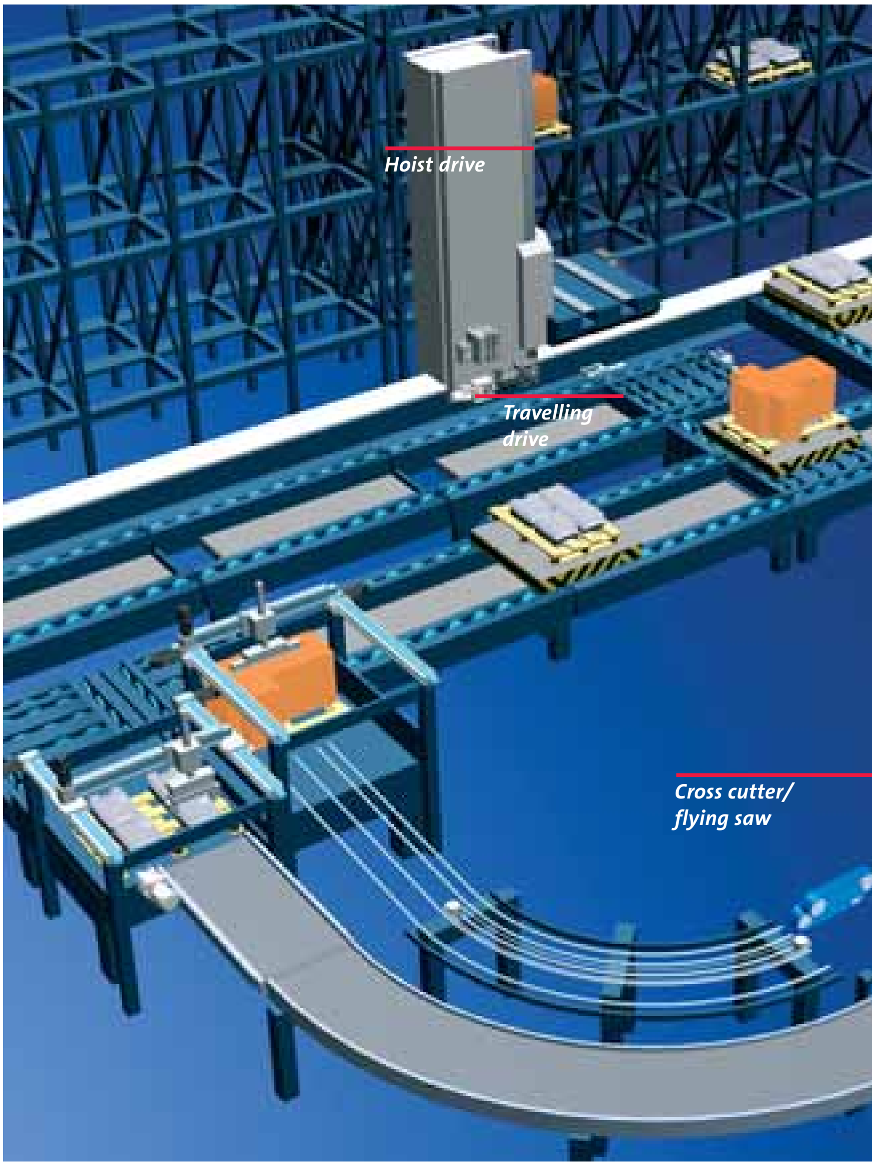
Mechatronics for mechanical and system engineering



Lenze

Your partner | for drive and automation tasks

If you need to implement modern machine and system concepts simply and effectively, or to optimise and modernise existing concepts, you need look no further than Lenze's comprehensive range of products and services, which offers everything you need.



Rather than dealing primarily with individual components, Lenze prefers to focus on drive solutions which have been specifically designed for handling and materials handling technology, for all types of automotive engineering processes, for robotics, for a wide range of packaging machines and for many other applications. These solutions are the key to implementing innovative machine and system concepts quickly and successfully in the interests of increased productivity.

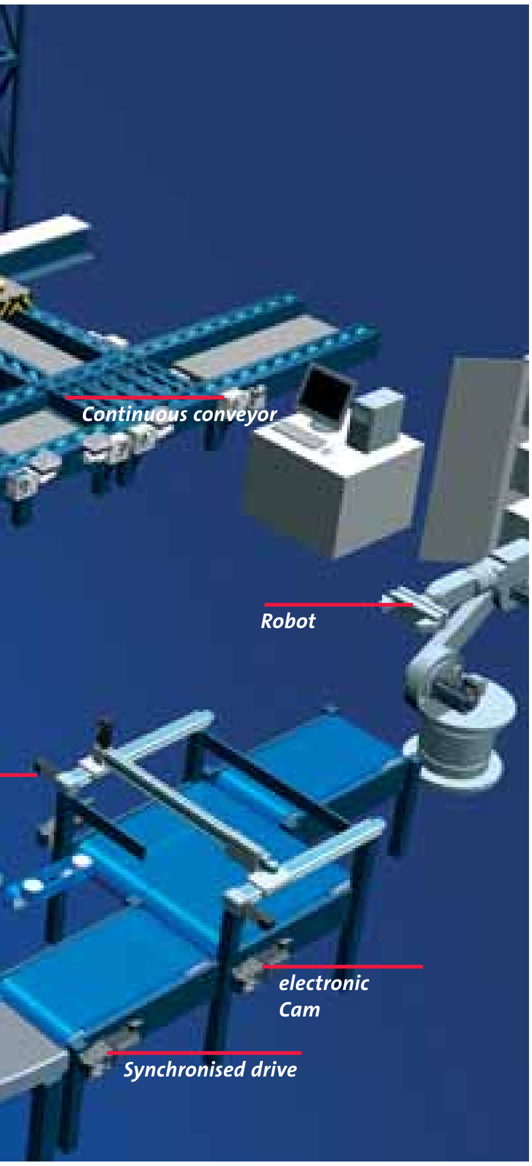
Lenze's powerful and highly reliable products are based on established standards and are user-friendly. They enable us to create the ideal conditions to enable you to adapt your machines and systems in line with market requirements flexibly and easily.

Our made-to-measure solutions and services will provide you with the winning formula as you race towards your goals. You will also benefit from our extensive technology and application expertise.

Mechanical engineering calls for a variety of drive functions

- Machines and systems are now required to perform considerably more tasks than in the past, with the result that drive tasks have to be implemented flexibly and must be tailored to requirements.
- Generally speaking, our customers, who come from all sectors of industry, expect to be provided with standardised solutions that are easy to use, but which can also be adapted to their individual needs.

Contents



Drive solutions

Product information

Product range

→ **The following pages illustrate how Lenze technology can solve the drive tasks associated with a variety of machines.**

Drive solutions | Conveyor drives

Automatic conveyors are used to transport and sort materials. They are sometimes installed as part of a storage or logistics system or may be used between the machining stations of a production facility. In the case of unit loads, the speeds of individual conveyor sections must be adapted to the flow of material. By contrast, bulk materials are conveyed continuously.

Typical applications include
- roller conveyors
- belt conveyors
- screw conveyors
- ejectors
- circular conveyors

As their name suggests, continuous conveyors support constant movement. Their speed depends on the materials being transported and the process conditions. Defined acceleration and deceleration ramps prevent materials from tipping over or slipping during stopping and starting. Frequency-controlled operation has become the standard whenever variable speeds are required.

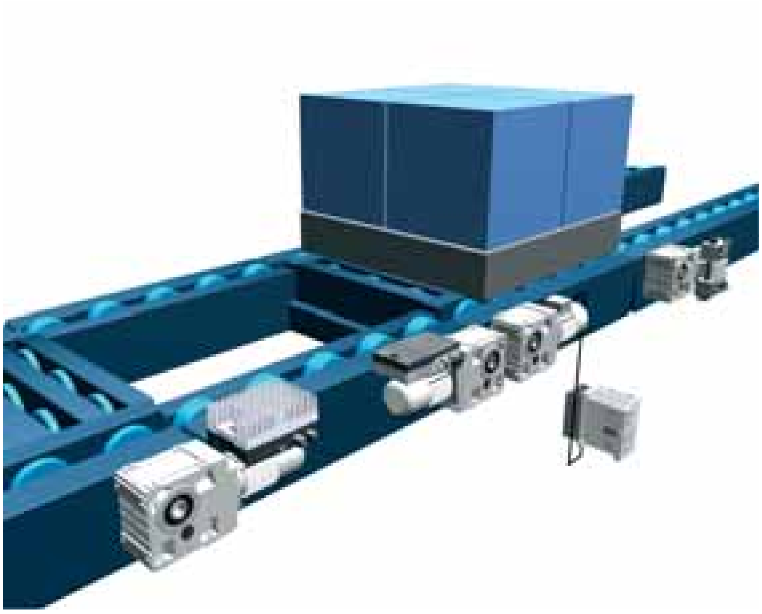
When conveyor drives run continuously the torque is calculated using the friction and the work for deformation and flexure of the belts. When differences in height have to be overcome, the potential energy component is also included. Acceleration is not important because the drives change their speed slowly. In sections where individual units are discharged and therefore sorted, the speed of the goods needs to be changed in a specific way. Additionally the dynamic torque has to be taken into account here. This explains why servo drives are often used for dynamic sorting processes.

Drive solutions for conveyor drives
The most important drive components in conveyors are geared motors, mostly with standard three-phase AC motors. If they are working at a fixed speed, the motors are either controlled via a contactor or motor starter which can power up the motor voltage for a smooth start via a ramp. Integrated backstops or holding brakes prevent unwanted movements from occurring in the conveyor equipment.

A frequency inverter provides features like variable speeds, precise acceleration, braking and stopping in precise positions. The decentralised 8200 motec frequency inverter is fitted outside the control cabinet on the mechanical construction itself or on the motor in place of the terminal box. This allows conveyor sections to be tested before delivery with little effort, cutting down on the installation and commissioning times.

This results in cost savings, all the more so since this structure allows the energy and control cables to be looped through.

Lenze servo drives are designed for dynamic performance applications. The servo motors can be combined with the complete Lenze range of gearboxes and this means that they can be adapted perfectly to the requirements of any conveyor section.



Suitable Lenze products for

- ▶ applications with basic requirements
  - — MDXMA or MHXMA standard three-phase AC motors with G-motion gearboxes with or without backstop and brake
  - — smd frequency inverters
- ▶ applications with medium requirements
  - — MDXMA or MHXMA standard three-phase AC motors with G-motion gearboxes with or without backstop and brake
  - — tmd/tml, 8200 vector, 8400 or 9300 vector frequency inverters
  - — SMV frequency inverters with a high degree of protection or 8200 motec decentralised motor inverters
- ▶ applications with higher requirements
  - — SDSGS, MCS or MDXKS synchronous servo motors with G-motion gearboxes with or without brake
  - — ECS servo system for multi-axis applications or Servo Drives 940, 9300 or 9400

Application examples with typical parameters

Machine type	Application area	Typ. speed [m/s]	Conveyed mass / capacity	Required power [kW]
Belt conveyors	Bulk material	≤ 4	≤ 1600 t/h	≤ 200
Screw conveyors	Bulk material	0.1 ... 0.5	≤ 400 m³/h	≤ 25
Belt conveyors	Individual units	0.5 ... 2	≤ 1000 units/h	≤ 3
Roller conveyors	Individual units	0.1 ... 1.5	≤ 1600 units/h	≤ 0.75
Pop-up ejecters	Individual units	0.5 ... 1.2	≤ 3500 units/h	≤ 0.25
Power & free conveyors	Individual units	0.1 ... 0.5	≤ 1500 kg	≤ 5

Drive solutions | Travelling drives

Travelling drives are used to move vehicles that transport payloads horizontally or along slopes. The vehicles are guided by wheels, which may be attached to rails or may be free to move across a surface.

Typical applications include

- ▶ rail vehicles or rail carriages
- ▶ overhead cranes and gantry cranes
- ▶ monorail overhead conveyors
- ▶ storage and retrieval units
- ▶ driverless transport systems

The drive in travelling drives moves with the vehicle. Therefore a flexible transfer of energy and data is necessary. Force is transferred by wheels, chains, toothed belts or rack and pinions. Rail-based vehicles may have two motors which are either switched in parallel to one inverter or controlled by two inverters via an electronic differential gear.

The torque required is first calculated from the acceleration needed and the vehicle mass. It takes effect during acceleration and braking. When travelling at a constant speed, it is just the friction that has to be overcome – and a correspondingly low level of energy is needed for this. Slopes increase the amount of stationary torque to be applied.

Drive solutions for travelling drives

Standard geared motors and geared servo motors with right angle or axial gearboxes are used. A brake is integrated for holding at a standstill. Lenze can supply the special GKK range of gearboxes with integrated disconnect clutch for monorail overhead conveyors and other rail-guided vehicles.

Travelling drives are typically driven by a frequency inverter with standard three-phase AC motor. The target position is approached using the deceleration ramp of the frequency inverter. By this, sufficient levels of positioning accuracy are usually achieved. S-shaped acceleration ramps preserve the mechanical components and the goods being transported.

Servo drives with asynchronous servo motors are used for applications with high requirements to dynamic performance and positioning accuracy, e.g. in storage and retrieval units and carriages for machines with a high number of cycles.

Positioning and logic functions and autonomous travel programs can be integrated in the Lenze servo inverters. If high levels of motor power are used, e.g. with gantry cranes, several motors with an electronic differential gear are used with the control function implemented in the servo inverter.

Travelling drives often have to offer safety functions so that they do not put people at any risk. Many Lenze frequency and servo inverters contain the corresponding safety functions as "Drive-based Safety" which cuts down on additional safety components. This saves space, wiring work and money.

Special decentralised motor controls for travelling drives contain the specific functions for controlling carriages and for safety engineering. They are designed and optimised for mobile applications, e.g. for inductive energy transfer or for controlling monorail overhead conveyors.

Suitable Lenze products for

- applications with medium requirements
  - MDXMA or MHXMA standard asynchronous motors with G-motion gearboxes and integrated brake
  - GKK range of gearboxes with integrated disconnect clutch
  - smd, tml/tmd or 8200 vector, 8400 and 9300 vector frequency inverters, with integrated safety functionality as an option
  - SMV frequency inverters with a high degree of protection or 8200 motec decentralised motor inverters
- applications with higher requirements
  - SDSGA, MCA or MQA asynchronous geared servo motors with G-motion gearboxes and brake
  - GKK range of gearboxes with integrated disconnect clutch
  - Servo Drives 9300 or 9400 with integrated positioning control and optional safety functionality
  - LCU, OCU or ICU motor controls

Application examples with typical parameters

Machine type	Application area	Typ. speed [m/min]	Typ. masses [t]	Required power [kW]
Storage and retrieval units	Logistics	240	5 ... 15	55
Monorail overhead conveyors	Materials handling technology, logistics, transport, automotive industry	130	5	5
Overhead cranes and gantry cranes	Materials handling technology	200	≤ 200	≤ 500 *
Rail vehicles	Logistics, materials handling technology	100	100	≤ 150
Industrial trucks	Materials handling technology, mounting, automotive industry	40	4	10

* Several parallel drives

Drive solutions | Hoist drives

Hoist drives are used for lifting and lowering loads and for holding these loads securely at defined positions.

Typical applications include

- freight lifts, crane systems and winches
- hoists in storage and retrieval units
- hoisting stations and scissor-type elevating platforms, e.g. in the automotive industry
- lifts, escalators, theatre equipment
- high-speed doors

Unlike applications with horizontal movements, hoist drives have to continuously apply a high level of torque when lifting or lowering. The power required of the hoist drive is basically calculated from the mass to be lifted, the travelling speed and acceleration. Counterweights, which are standard, for example, in passenger lifts and certain freight lifts, reduce the stationary torque required, but increase the amount of dynamic torque. When lowering, energy is regenerated. Ropes, toothed belts, chains, spindles or rack and pinions are used to transfer force from the hoist to the drive.

Drive solutions for hoist drives

Standard geared motors and servo geared motors are used in lifting applications. Direct drives are also used in some cases. A brake is integrated in the motor to hold the load, which satisfies specific safety requirements.

When using frequency or servo inverters, smooth acceleration and deceleration ramps can be set. S-shaped acceleration ramps smoothly raise the payload, produce good travelling performance and preserve mechanical components. Some Lenze inverters have integrated brake logic to ensure a jerk-free transition when applying and releasing the brake.

The drive behaviour of a frequency inverter is sufficient for many lifting applications. It is only in applications with high dynamic performance and positioning accuracy or with high levels of drive power, for example in storage and retrieval units, that servo drives are used. Integrated positioning control handles the entire lifting process without a superimposed control. In such cases, the PLC simply outputs commands relating to the position to be approached.

The energy regenerated by the drive when lowering the load is usually converted thermally in brake resistors. The brake transistor is already integrated in some series of inverters. If not, external braking units are provided. In applications with higher rates of regenerated power or which are particularly energy efficient and where there should be no heat loss, the braking energy can be returned to the mains via regenerative units.

Hoist drive systems are usually subject to strict safety engineering requirements. Therefore safety functions are integrated in the inverter which offers high cost-cutting potential.

Suitable Lenze products for

- applications with medium requirements
  - MDXMA or MHXMA standard asynchronous motors with G-motion gearboxes with brake
  - 8200 vector or 8400 frequency inverters with integrated brake transistor and optional safety engineering
  - 8200 motec decentralised motor inverters with integrated brake unit
  - 9300 vector frequency inverters with integrated brake logic and optional safety functions
  - 9340 regenerative unit
- applications with higher requirements
  - SDSGA, MCA or MQA asynchronous geared servo motors with brake
  - Servo Drives 940, 9300 or 9400 with integrated positioning control
  - 9340 regenerative unit

Application examples with typical parameters

Machine type	Application area	Typ. speed [m/min]	Typ. masses [t]	Required power [kW]
Storage and retrieval units	Logistics	120	10	5 ... 150
Crane systems, winches	Materials handling technology	200	150	100
Theatre equipment	Materials handling technology	120	1.5	22
Elevating platforms	Materials handling technology, logistics, transport	10	10	7.5
Lifts	Materials handling technology, logistics, building equipment	120	5	45

Drive solutions | Positioning drives

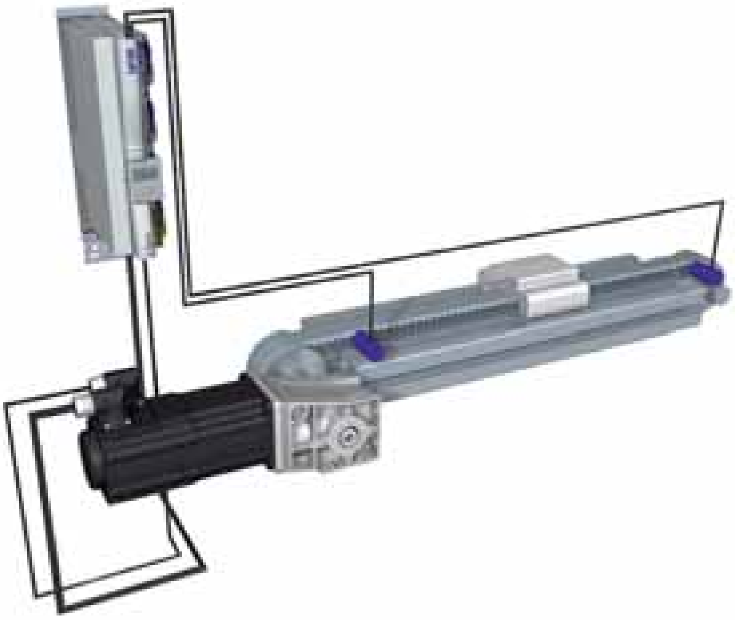
Positioning drives move transported materials, workpieces or tools in a rotary or linear way to precisely defined target positions. Positioning is understood to mean the movement of mobile machine parts to a defined destination. With point-to-point positioning, only the final position matters, not the entire route required to reach it.

Typical applications include
- assembly machines
- rotary indexing tables
- adjustment of limit stops in production machines
- travelling and hoist drives, e.g. in storage and retrieval units
- tool changers

Linear movements can be achieved with rotary drives using belts, spindles, rack and pinions, ropes or rolling mechanical components. The different drive mechanisms have different features.

- Toothed belt: low cost, high degree of efficiency, low inertia, high speeds and accelerations, medium accuracy
- Spindle: high degree of precision, high drive speeds (may be possible to dispense with gearbox), relatively small traversing range and low efficiency
- Rack and pinion: any traversing range, simple mechanism, medium accuracy, higher backlash
- Direct drive with linear motor or torque motor: high acceleration, speed and accuracy

The drive system is sized on the basis of the masses to be accelerated, moments of inertia and motion profiles used. It can be optimised by selecting the appropriate physical parameters of leadscrew pitch, diameter, belt pulley/gear characteristics.



Drive solutions for positioning drives

Standard, servo geared motors and, for special requirements, spindle or linear motors, are used depending on the dynamic performance required. In some applications, a brake is integrated in the motor to hold the load in the target position. If the drive system needs to offer high levels of positioning and repeat accuracy, low backlash gearboxes such as the Lenze servo planetary gearbox or direct drives are used.

Selecting the right angle sensor system for position detection is crucial for accuracy. Homing procedures are not necessary when using multi-turn absolute encoders.

Positioning control integrated in the inverter handles the entire motion sequence without a superimposed control. Therefore the software of intelligent servo inverters includes sequential positioning controls and table positioning controls. The PLC only has to output the position that the drive is to approach.

The energy regenerated when braking into the target position can be converted into heat using brake units or returned to the supply system in dynamic applications with high masses using a regenerative unit.

Suitable Lenze products for

- applications with simple or medium requirements
  - MDXMA or MHXMA standard three-phase motors with G-motion gearboxes
  - 8400 frequency inverters with integrated positioning control
  - 8200 vector frequency inverters with Lenze control Drive PLC
  - 930 fluxxtorque motor integrated servo inverters for decentralised applications
- applications with higher requirements
  - all synchronous and asynchronous geared servo motors with or without a brake, possibly combined with GPA planetary gearboxes
  - MDSLS servo spindle motor
  - Servo Drives 940, ECS, 9300 or 9400 with integrated positioning control
  - 9340 regenerative unit

Application examples with typical parameters

Application	Typ. accuracy [mm]	Typ. masses [kg]	Typ. speed [m/s]	Typ. acceleration [m/s²]	Required power [kW]
Pick and place	0.5 ... 1	5 ... 100	10 ... 20	20 ... 30	0.55 ... 10
Adjustment of limit stops (spindle)	0.01	5 ... 50	0.05	0.5	0.25 ... 3
Positioning with linear axis (toothed belt)	0.1	1 ... 50	10	10 ... 50	0.55 ... 15

Drive solutions | Coordinated drives for robots

Handling systems and robots are used to move goods, workpieces or tools along defined paths within their 3D work envelope. They are important components for factory automation and enable motion sequences that would otherwise require a great deal of manual labour.

Typical applications include
- six-axis articulated robots
- SCARA robots
- gantry systems and linear X-Y-Z-axis systems
- parallel kinematics, e.g. hexapods
- assembly machines

The typical areas in which robots and handling systems are used are
- body construction in the automotive industry, in the processes of welding, gluing, painting and sealing
- automatic equipment assembly,
- loading and unloading of machines, e.g. machine tools
- picking and palletising

With coordinated drives, the control (central control, robot control) generates position values for the drive movements of the individual axes. Unlike point-to-point positioning, this trajectory control allows mathematically defined 3D motion sequences to be executed.

The sizing of the drives depends on the mass to be moved and the dynamic performance required. Drive elements used for the connection of the drives and mechanical components include shafts, spindles and toothed belts. Gearboxes are sometimes connected directly with the mechanical joints.

Drive solutions for coordinated drives
Synchronous and asynchronous servo motors with integrated brakes and resolvers as the angle sensor are used. They can be combined with low backlash planetary gearboxes or special robot gearboxes.

Since in every mechanism several motors are used, inverters with a common power supply unit are highly suitable. These then only need one common power supply with one mains filter and one brake unit integrated in the supply unit.

A motion control unit or a special industrial PC handles motion control. This control uses the multi-dimensional motion sequence to calculate the speed and/or torque setpoints for the individual axes. The servo inverters for the axes are linked to the control via a real-time capable communication system, e.g. via CAN or EtherCat.

Suitable Lenze products for

- applications with medium requirements
  - all synchronous and asynchronous servo motors with brake, possibly combined with low backlash GPA planetary gearboxes
  - ECS servo system and Servo Drives 9400 as a multi-axis system with central mains supply
- applications with higher requirements
  - synchronous and asynchronous MCS, MDXKS and MCA servo motors with high-resolution resolvers as an angle sensor and with integrated brake
  - ECS servo system and Servo Drives 9400 as a multi-axis system with central mains supply

Application examples with typical parameters

Machine type	Typ. accuracy [mm]	Typ. cycles [rpm]	Required power [kW]
Body construction in automotive production	≤ 0.1	20 ... 60	1.0 ... 15
Order picking systems	0.1 ... 0.5	< 30	1.0 ... 15
Sorting systems	≤ 0.01	< 120	< 5
Assembly of small parts	0.1	< 120	< 5
Handling machines for workpieces	0.1 ... 0.2	20 ... 60	< 10

Drive solutions | Synchronised drives

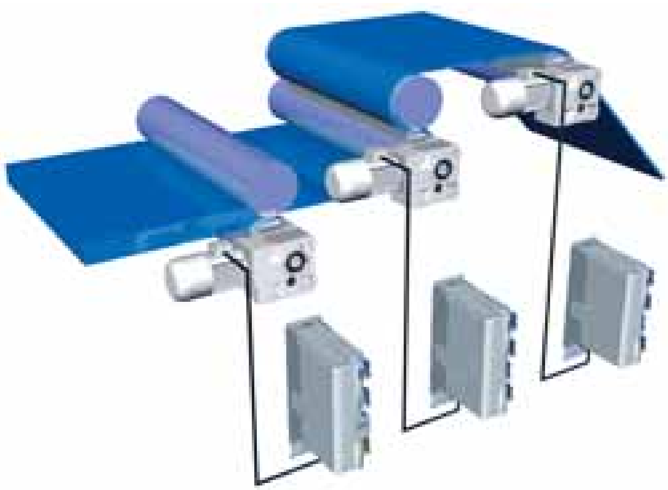
Synchronised drives are used for manufacturing, transporting, processing or refining continuous materials. The types of material include, for example, paper, films, textile yarns and webs, sheet metal and wire.

Typical applications include

- plants for rolling, tensioning, stretching , transporting and straightening continuous materials
- calendars
- printing units with single drives

Synchronised drives are quasi-stationary drives where precision in respect of speed, torque or angular guidance is crucial. The speed changes during machine starting and stopping as well as during material changes. A high smooth running performance ensures precise production processes and is therefore important for the quality of the product being processed.

Printing units with single drives are a special type of synchronised drive. These function as adjustable electronic gears where precision in respect of angular synchronism is crucial to ensure perfect register precision for the different colours of the printing units.



In the case of synchronised drives, the ratio between the speed or angle of several drives is fixed (electronic gearbox). If individual processes within a plant need to be decoupled, dancer controls or tension controls are used for this purpose.

The physical sizing of the drives depends on the process parameters for tensile force, speed, moment of inertia and on the acceleration required in the event of an emergency stop.

Drive solutions for synchronised drives

Geared motors with standard three-phase AC motors are used, sometimes with downstream belt ratios and sometimes also direct drives.

In a few simple applications, a frequency inverter with vector control without angle and/or speed measurement is sufficient. However a servo inverter is usually used and this evaluates the angle sensor integrated in the motor, allowing for precise speed control. Intelligent Lenze servo inverters equipped with special technology functions can autonomously execute the tasks typical of many synchronised drives:

- speed and torque setting with adjustable speed and tensile force
- electronic gearbox
- relative synchronism with mark synchronisation
- register control

A DC-bus connection can be used to exchange energy between the drives on the process line. The benefits of the DC-bus connection are a lower rating of the power supply, reduced energy consumption and fewer components in the control cabinet. Regenerated braking energy from the drive system is returned to the mains via a brake unit or regenerative unit.

Safety functions used for personal protection can be implemented inside the drive. The benefits are reduced costs due to fewer components along with faster installation.

Suitable Lenze products for

- applications with basic requirements
  - MDXMA or MHXMA standard three-phase AC motors without angle sensors, possibly combined with G-motion gearboxes
  - tml/tmd, 8200 vector or 8400 frequency inverters
  - SMV frequency inverters with a high degree of protection or 8200 motec decentralised motor inverters
- applications with medium requirements
  - MDXMA or MHXMA standard three-phase AC motors with angle sensors, possibly combined with G-motion gearboxes
  - 8400 or 9300 vector frequency inverters
- applications with higher requirements
  - MDXMA or MHXMA standard three-phase AC motors with high-resolution angle sensors
  - SDSGA, MCA or MQA asynchronous servo motors with high-resolution angle sensor, possibly combined with G-motion gearboxes or as direct drives
  - 9300 or 9400 Servo Drives with integrated drive functions for 'electronic gearboxes'

Application examples with typical parameters

Application	Application area	Typ. speed [m/min]	Required power [kW]
Manufacturing, processing and refining paper or plastic films	Paper, plastics	1 ... 2000	0.37 ... 100
Manufacturing and refining textile webs	Textiles	5 ... 150	0.37 ... 55
Rolling, annealing and refining sheet metal	Metal	5 ... 300	0.37 ... 200
Wire drawing machines	Wire industry	5 ... 2000	0.75 ... 250
Printing on paper and plastic films as well as textiles	Printing	5 ... 1000	0.75 ... 110

Drive solutions | Winding drives

In general, continuous material is stored on a reel, unwound for processing and then wound back onto a reel at the end of the process. The synchronised drives are located between the unwinder and rewinder.

Typical applications include

- winding devices for textiles, films, paper and sheet metal
- printing machines
- packaging machines
- continuous processing and refinement processes

The wound material is rolled up or unrolled at a constant circumferential speed, which is set in accordance with the material speed of the upstream or downstream process. The tensile force acting on the material is subjected is kept constant or varied in accordance with diameter. Dancer or tension controls are used to ensure this. As the radius is constantly changing during winding and unwinding, the drive needs a high speed and torque setting range. During unwinding, the drive always operates as a generator. It decelerates the material and recovers energy during this process.

Most winders with defined tensile material forces are designed for stationary operation. The drive's dynamic reserves are then used to decelerate the reel in an emergency. In central winders, field weakening is often used because speed increases with a smaller diameter, yet the torque required is lower. The drives can therefore be considerably smaller.

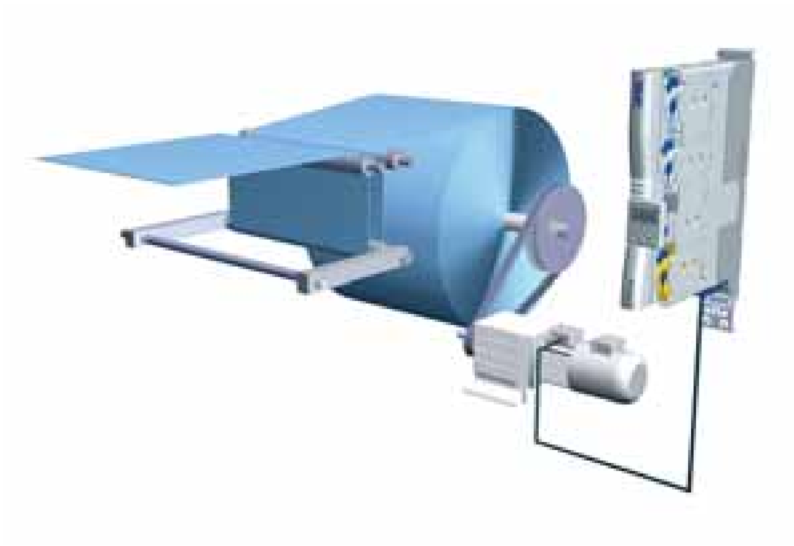
Drive solutions for winding drives

Geared motors with standard three-phase AC motors are installed as the dynamic requirements of winding drives are not complex. Low friction and low backlash gearboxes are preferably used because corresponding disturbances may impact on the winding result.

Frequency inverters are sufficient for applications with basic requirements. A dancer control monitors the winding process. In applications with higher requirements, servo inverters with geared motors are used with integrated angle sensors.

Intelligent Lenze servo inverters, equipped with winder technology functions, can be used for complete reel control, including the reel calculator with precise feedforward control of torque and speed depending on the extent to which the reel is filled.

The power regenerated when unwinding can be used through a DC-bus connection with synchronised drives or rewinders. Alternatively, brake units or regenerative units can be used.



Suitable Lenze products for

- ▶ applications with basic requirements
  - — MDXMA or MHXMA standard three-phase motors with angle sensors, possibly combined with G-motion gearboxes
  - — 8400 or 9300 vector frequency inverters
- ▶ applications with higher requirements
  - — MDXMA and MHXMA standard three-phase AC motors or asynchronous servo motors with high-resolution angle sensors, possibly combined with G-motion gearboxes or as a direct drive
  - — Servo Drives 9400 or 9300 servo PLC with 'Winder' technology package

Application examples with typical parameters

Material	Application areas	Typ. speed [m/min]	Required power [kW]
Paper and plastic sheeting	Printing and paper industry, plastics industry	30 ... 2000	0.37 ... 400
Textile webs	Textile machine construction	5 ... 150	0.37 ... 55
Sheet metal or metal foils	Forming technology	5 ... 300	0.37 ... 200
Cables	Cable industry	5 ... 250	0.37 ... 75
Wires	Construction of wire machining centres	5 ... 2000	0.75 ... 200

Drive solutions | Intermittent drives for cross cutters and flying saws

Cross cutters and flying saws are machine functions with which continuous material is processed in cycles or separated during the movement in continuous processes.

Typical applications include
- cutting
- sawing
- punching
- welding
- embossing
- perforating

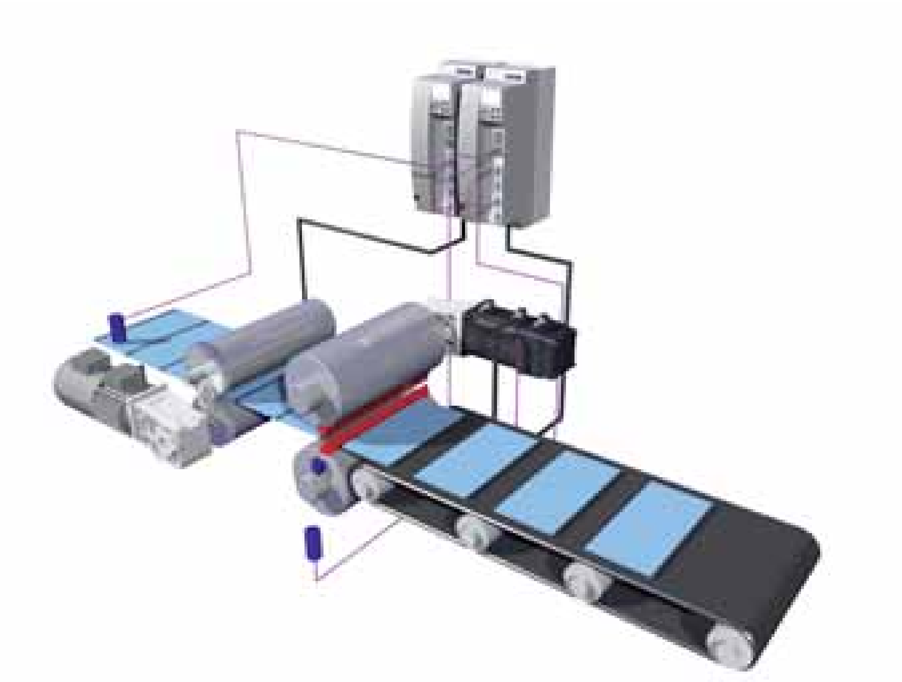
paper webs, metal webs, plastic films, wood or plastics

In all these tasks the movement during processing is synchronised with the material speed. The position of the next step is approached in the time between the processing steps and this sometimes has to be synchronised to a registration mark. This movement therefore depends on the format length to be produced. Cross cutters and similar machine functions such as welding bars or embossing stamps function in a rotary way. The drive at the output end rotates by one cycle for each machining process. Highly dynamic acceleration and braking is needed for this. Cross cutters therefore place great requirements on the dynamic performance and precision of the drive.

Flying saws and related functions on the other hand are translatory. During the machining process, they move synchronously with the material speed. At the end, they have to move back to the next processing position. High dynamic performance is again often needed here for the return travel. Drives for cross cutters and flying saws are sized on the basis of the dynamic requirements of the motion sequence.

Drive solutions for cross cutters and flying saws

The demand for exact position control and high dynamic performance require the use of geared servo motors. Synchronous motors are used for smaller ratings and achieve a high dynamic performance thanks to their low mass inertia and high overload capacity.



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The motion sequence is either defined by the servo inverter or an external control. To prevent the mechanical components from being excited by the intermittent drive, jerk-free acceleration profiles are used. The angle position of the master drive needed for synchronisation is transferred via a real-time communication system, such as CAN or ETHERNET Powerlink. Marks also sometimes have to be detected to allow the processing position to be recorded with accuracy. The Lenze servo inverters therefore have quick touch probe inputs.

Appropriate measures have to be taken for the energy regenerated when braking, e.g. the use of brake units. If the DC bus capacity of the inverter is of a sufficient size, the energy recovered when braking can be absorbed by the DC bus and therefore it does not have to be converted into heat. Therefore it is suitable to use the DC bus connection with other inverter drives or specifically extend the DC bus by adding capacitor modules.

Suitable Lenze products for

- applications with medium requirements
  - all synchronous and asynchronous servo motors with angle sensors, possibly combined with G-motion gearboxes
  - ECS servo system, if necessary with capacitor module or Servo Drives 9400 as a multi-axis system with central mains supply
  - 9300 servo inverters
- applications with higher requirements
  - all synchronous and asynchronous servo motors with high-resolution angle sensors, possibly combined with G-motion gearboxes or as direct drives
  - ECS servo system, if necessary with capacitor module or Servo Drives 9400 as a multi-axis system with central mains supply
  - 9300 servo PLC servo inverters

Application examples with typical parameters

Application	Material	Typ. speed [m/min]	Typ. accuracy [mm]	Cycles [rpm]
Cross cutters	Packaging material	100 ... 200	0.1	300 ... 600
	Corrugated cardboards	100 ... 400	0.1 ... 0.5	60 ... 300
	Steel wires	40 ... 80	0.2 ... 0.3	60 ... 300
Flying saws	Wood materials	5 ... 40	0.1 ... 0.5	5 ... 10
	Metal webs	5 ... 50	0.1 ... 0.5	4 ... 10
	Plastic profiles	4 ... 60	0.1 ... 0.5	5 ... 20

Drive solutions | Drives for electronic cams

Drives for electronic cams transform linear position information relating to a master axis into curved motion profiles via a path-controlled profile generator. These profiles result in gentle, low-jerk sequences that protect both the materials and the machine's mechanical components. They are the key to achieving high speeds and therefore result in higher cycle rates. Examples for this are cutting, punching, bonding, coating, welding, bending and forming processes.

Typical applications include

- packaging machines
- form, fill, and seal machines
- automatic assembly robots
- book binding machines
- wood working machines
- textile machines

Cam drives are used when the position of one or more axes depends on the position of a master axis. These are non-linear, position-coordinated motion sequences. In the past, cams were mainly mechanical components. A line shaft used mechanical means to ensure synchronous operations.

Electronic cam drives imitate cam mechanisms. As many cam characteristics as necessary can be implemented. These provide optimised motion profiles and can be changed in next to no time. The advantages of this are increased flexibility and productivity with modern production and processing machines. The electronic solution reduces the masses to be moved. The advantages of this are increased dynamic performance due to smaller moments of inertia, less wear, smaller drives.

Drive components are sized on the basis of the dynamic requirements of the motion sequence.

Drive solutions for electronic cams

As a result of their demanding dynamic performance and accuracy requirements, cam applications are operated using servo inverters, geared motors – preferably with synchronous servo motors – and angle sensors. In terms of gearboxes, the motors are often combined with low backlash planetary gearboxes.

Since there are high data volumes involved in calculating cam processes, it is reasonable to implement this task in a servo inverter that contains the corresponding technology functions. If the communication system used – e.g. CAN or ETHERNET Powerlink – offers the corresponding performance, the curve profiles can also be calculated by an industrial PC or Motion Control. In such cases, the inverters receive the motion sequence as a speed setpoint via the bus. If working with motion sequences with several servo drives, we would recommend inverters with a shared power supply unit.

Suitable Lenze products for

- applications with medium requirements and involving a single axis
  - all synchronous and asynchronous servo motors, possibly combined with G-motion gearboxes
  - 9300 Cam servo inverters, 9300 servo PLC or Servo Drives 9400
- applications with higher requirements in multi-axis systems
  - all synchronous and asynchronous servo motors, possibly combined with G-motion gearboxes
  - ECS servo system or Servo Drives 9400 in a multi-axis system with central mains supply
  - ETC motion control system

Application examples with typical parameters

Application	Application area	Typ. accuracy [mm]	Cycles [rpm]	Required power [kW]
Book binding machines	Paper	0.1 ... 0.4	<100	1 ... 55
Bag form, fill, and seal machines	Packaging	0.1 ... 0.5	< 600	1 ... 55
Assembly of packaging material	Packaging	> 0.1	30 ... 500	0.75 ... 5.5
Labelling	Paper, plastics	0.1	< 200	0.75 ... 5.5
Sealing machines	Packaging	0.1 ... 0.5	75	0.75 ... 3
Wood working machines	Wood working	1 ... 2	< 85	0.75 ... 5.5
Textile machines	Textiles	0.1	800	1 ... 15

Drive solutions | Drives for forming processes

Forming processes create work pieces from raw materials or later on provide these with its final shape. There is a wide range of raw materials and consequently there are various forming processes and different drive solutions which work continuously or in cycles.

Typical applications include

- ▶ extruders
- ▶ presses
- ▶ deep drawing machines
- ▶ edge bending of metal workpieces

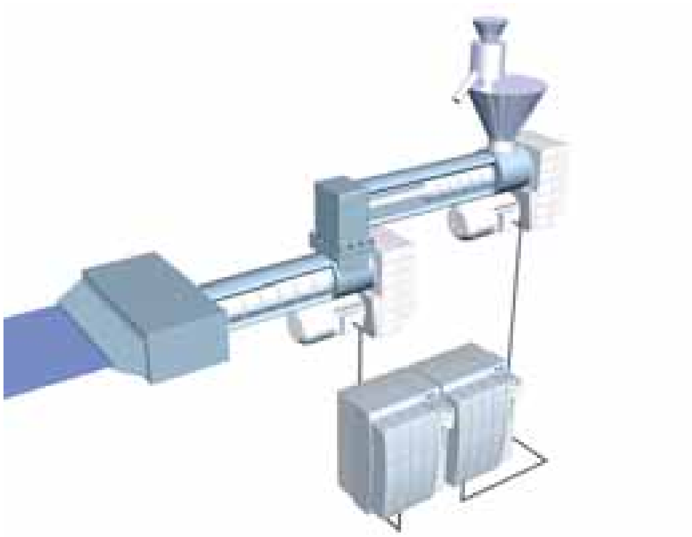
Bulk materials assume the required shape in a continuous forming process, e.g. when extruding plastic profiles. During these processes, load changes cannot be allowed to result in speed variation, otherwise the strength of the material will be affected. Great forces are required when a plant is starting up or is being operated at lower speeds.

Cyclic forming drives are used when a work piece already exists in a rough shape but still requires refinement. Since this kind of material shaping is linked to an external process cycle, the requirements for accuracy and dynamic performance are much higher than with continuous shaping processes.

Drive solutions for forming processes
Continuous processes mainly use standard three-phase AC motors which, depending on the mounting position, are combined with axial or angled gearboxes. When working with extruders, high axial forces occur at the extruder worm which have to be absorbed by the gearboxes. Asynchronous geared servo motors with angle sensors are usually used in drives operating in cycles.

Continuous production usually works with frequency inverters. To ensure uniform production quality even during slow

forming processes or at the start and end of the production stage through the use of good speed consistency, the devices have a vector control system with or without a speed sensor on the motor. Cyclic processes place strict requirements on dynamic performance, overload capacity and accuracy of the drives which explains why servo inverters are used.



Suitable Lenze products for

- continuous applications with simpler and medium requirements
  - MDXMA or MHXMA standard three-phase AC motors with or without angle sensors, possibly combined with G-motion gearboxes
  - tml/tmd, 8200 vector or 8400 frequency inverters
  - 8400 or 9300 vector frequency inverters with angle sensor evaluation
  - SMV frequency inverters with a high degree of protection or 8200 motec decentralised motor inverters
- cyclic applications with higher requirements
  - SDSGA, MCA and MQA asynchronous servo motors, combined with G-motion geared motors
  - Servo Drives 940, 9300 or 9400

Application examples with typical parameters

Application	Application area	Typ. accuracy [mm]	Cycles [rpm]	Required power [kW]
Extrusion	Plastic processing		continuous	1 ... 400
Deep drawing of plastic parts	Plastic processing	0.1	< 60	1 ... 75
Deep drawing of sheet metal parts	Automotive industry	0.1	< 20	5 ... 75
Pressing	Automotive industry	0.1	< 20	30 ... 400
Vibration	Cast stone industry		continuous	5 ... 30

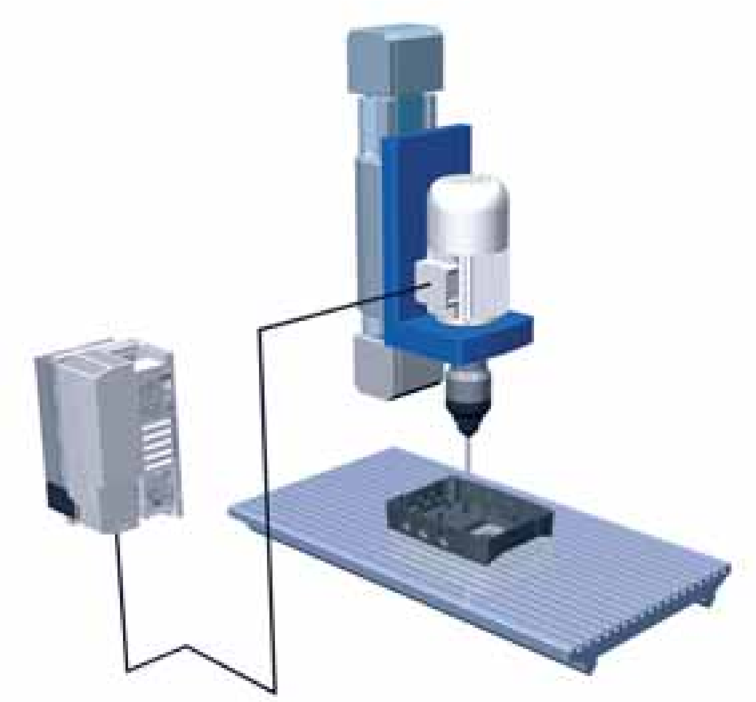
Drive solutions | Main drives and tool drives

A main drive is the central drive in a machine or system. The speed of the main drive specifies the process speed. It moves the masses to be processed and therefore provides the process with the required power.

A tool drive determines the speed of a tool and therefore provides the processing power. During machining, there are processes for separating and for removing material.

Typical machines with main drives are
- presses
- test benches
- machine tools
- stirring machines

Typical machines with tool drives are
- machining centres
- milling, drilling, turning and sawing machines
- polishing and grinding machines



When designing main drives, the focus is on the machine's continuous required power. In tool drives on the other hand, a high accelerating power determines the size that can usually be provided by the drives' overload capacity.

The drive's speed depends on the tool and the material of the work piece and should be kept constant over the entire machining process. The torque required, however, changes – especially at the start and end of a process. A lot of tools operate at very high speeds in combination with motors designed for these special requirements. Inverters provide the high frequency required for these motors. Such medium frequency drives sometimes also supply several tools, e.g. in wood working machines. Individual tools are activated and deactivated separately in such applications.

Drive solutions for main drives and tool drives

Standard three-phase AC motors, synchronous and asynchronous servo motors or medium frequency motors are used when very high rated speeds are needed. The drives often operate as direct drives without gearbox ratios.

Frequency inverters with vector control provide a good speed stability. The inverters generate output frequencies of more than 500 Hz so that the tool drives' high speeds can be reached.

If the speed stability or acceleration capacity requirements are high, servo inverters with precise speed control can be used.

Suitable Lenze products for

- applications with medium requirements
  - MDXMA or MHXMA standard three-phase AC motors without angle sensors as direct drives or combined with G-motion gearboxes
  - 8200 vector or 8400 frequency inverters
  - SMV frequency inverters with a high degree of protection or 8200 motec decentralised motor inverters
- applications with higher requirements
  - MDXMA and MHXMA three-phase asynchronous motors or servo asynchronous geared motors with angle sensors
  - 9300 vector or 8400 frequency inverters with angle sensor evaluation
  - Servo Drives 9300 or 9400

Application examples with typical parameters

Application	Materials	Typ. speed [rpm]	Required power [kW]
Drilling, milling, grinding, polishing	metal, wood, stone, glass and plastics	12,000 ... 18,000	0.5 ... 5.5
Sawing, breaking	metal, wood, stone, glass and plastics	1000 ... 5000	0.5 ... 400

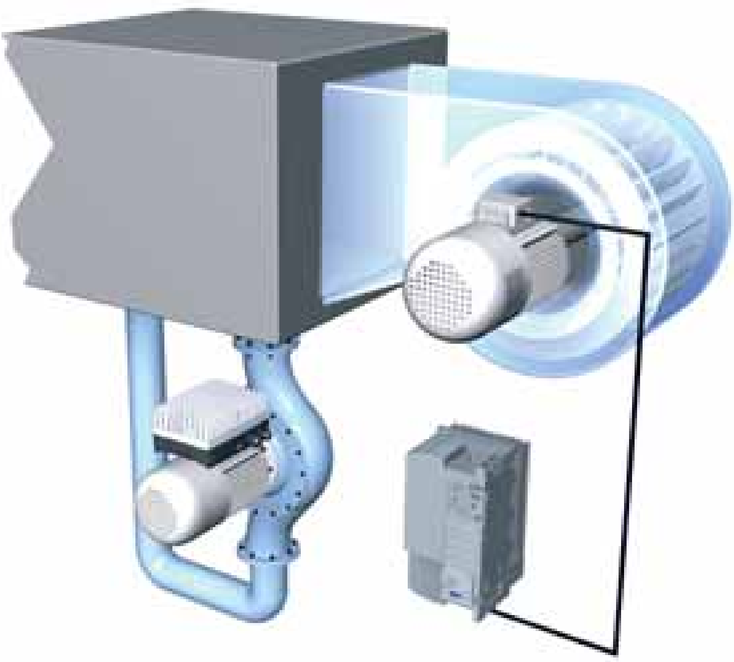
Drive solutions | Drives for pumps and fans

Pumps and fans convey and/or compress gases and liquids. A distinction is made between two working principles: piston and gear pumps as well as axial fans use displacement, whereas radial fans and centrifugal pumps use centrifugal force.

Typical applications include

- building equipment (HVAC)
- chemicals and food industry (conveying, dosing, filling)
- water supply
- production of compressed air
- fans for industrial processing (dryers, air cushion kilns)
- extraction plants within the wood, paper and printing industries
- waste water technology
- refrigerators
- environmental technology
- vacuum pumps

Many of these applications work at a constant speed and therefore require no speed adjustment. Here, the flow or pressure is controlled using choke or bypass controllers. The higher level of process automation – pressure monitoring, sequence control and remote control – and the energy saving requirements – sequential deactivation, partial load operation – however, mean that more and more frequency inverters are used for motor control. The benefit of this is that pumps and fans are designed for the maximum power rating required, e.g. summer and winter operation of air conditioning systems. This operating point is however only reached on a few days in the year. Instead of continuing to operate the motors at full load and wasting the excess power through bypasses or throttle valves, controlling speed to match requirements means that a large amount of energy is saved. Drives for pumps and fans are sized on the basis of continuous power.



Drive solutions for pumps and fans

Since the speed requirements of pumps and fans often compare to the motor speed, standard three-phase AC motors without gearbox ratios or with belt ratios are often used.

By using a variable output frequency, frequency inverters allow an energy efficient operation in the partial-load range. Square-law V/f characteristics allow the motor control to be adapted to the load characteristics of pumps and fans. Use of an integrated PID controller means that frequency inverters are able to handle all pressure control in conjunction with a pressure sensor.

Since pumps, fans and compressors are often standalone devices, motor inverters or starters installed in decentralised locations are increasingly used. They can be fitted on the motor outside the control cabinet in place of the terminal box.

Suitable Lenze products for

- applications with basic requirements
  - MDXMA or MHXMA standard three-phase AC motors
  - smd or tmd/tml frequency inverters
- applications with higher requirements
  - MDXMA or MHXMA standard three-phase AC motors
  - 8200 vector or 8400 frequency inverters
  - SMV frequency inverters with a high degree of protection or 8200 motec decentralised motor inverters

Application examples with typical parameters

Application	Application area	Typ. pressure [bar]	Required power [kW]
Feed pumps and waste water pumps	Municipal water supply	1 ... 10	400
Fans	Air conditioning technology, building equipment	0.5 ... 1	2 ... 350
Process technology	Chemical and pharmaceutical and medical technology	1 ... 10	400
Air compressors and compressors for technical gases	Various industries	0.8 ... 10	55 ... 400
Water supply	Air conditioning technology, building equipment	2 ... 10	90

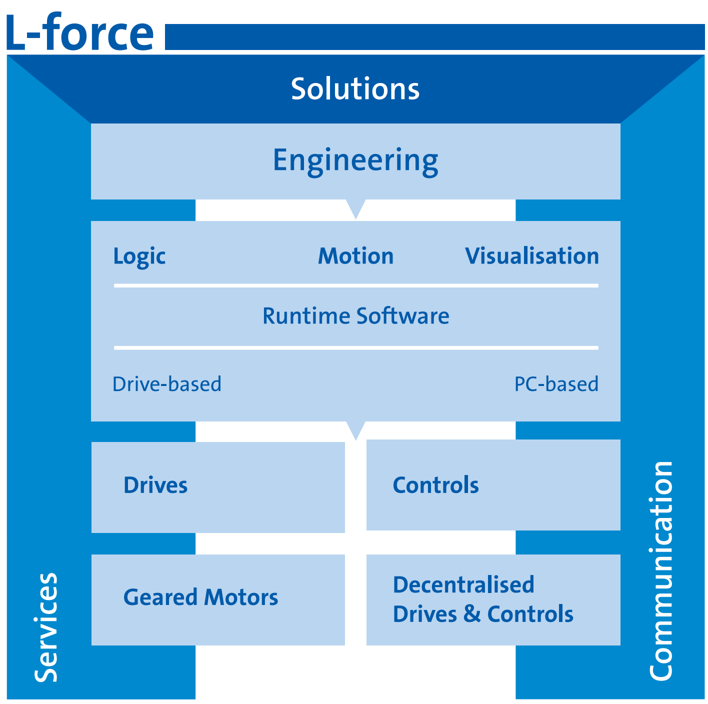
Product information | L-force – the solution

Demands are growing all the time. The main challenges of the future lie in cost efficiency, saving time and improving quality. Furthermore, the importance of energy-saving solutions will grow in the future. Faster project planning and commissioning, more power and greater flexibility in production are expected. New ideas are needed for the machines of the future.

L-force is a comprehensive and uniform architecture that provides machine and system manufacturers with consistent solutions for their current and future needs.

L-force is our response to ever more complex applications and processes. It involves an innovative and scalable range of products that covers all areas of drive and automation technology. Users can benefit from its flexibility, usability and cost-effectiveness.

- Driven by innovation – new ideas that open up new opportunities
- Driven by flexibility – a high degree of scalability for individual solutions
- Driven by usability – simple solutions, even for complex requirements
- Driven by modularity – with uniform products and solutions



Overview | Our products for drive solutions

Frequency inverters

Servo inverters

Decentralised drive technology

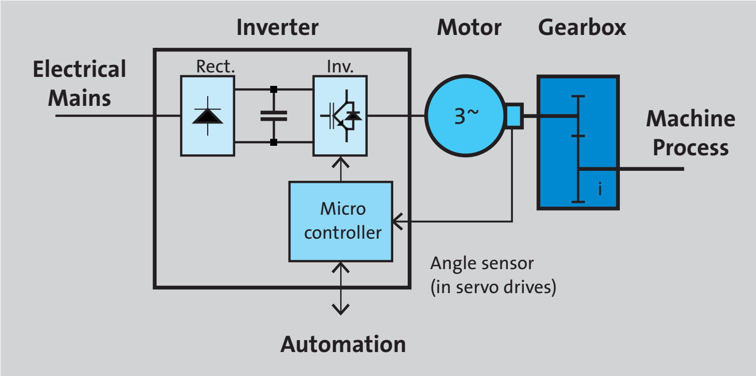
Standard three-phase AC motors, synchronous and asynchronous servo motors

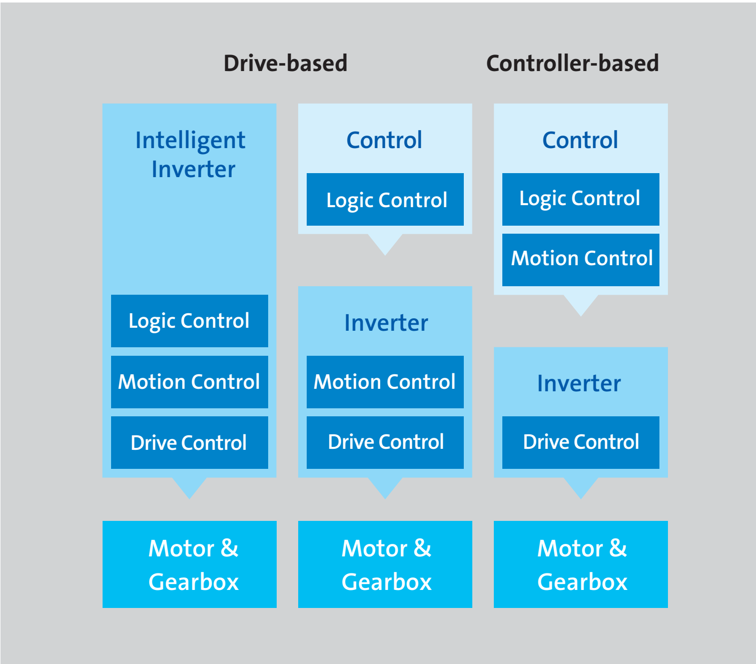
Gearboxes and geared motors

Product information | Drive systems and inverters

Structure of drive systems
Drive systems consist of the following components:
- the inverter, which transfers the electrical power from the mains in a controlled manner
- the electric motor, which converts electrical power into mechanical power
- the gearbox, which adapts the mechanical power of the motor in line with the operating point of the machine (by reducing the speed and increasing the torque)

Fixed speed applications do not require the use of an inverter. In such cases, electronic motor starters or conventional motor contactors are used.





If the motor's high output speed can be used directly, there is no need for a gearbox, for example with pumps.

Open and closed-loop drive control
The inverter is responsible for drive control. There are two basic configurations:
- open-loop speed control without an encoder (frequency inverter)
- closed-loop speed control with an encoder (servo inverter)

Open and closed-loop control
In an automation system, open and closed-loop drive control consists of the following three function levels:
- Logic Control – PLC functions
- Motion Control – e.g. for positioning
- Drive Control – speed, torque, angle of rotation

Controller-based and drive-based
Motions can be managed by a control (PLC, CNC, industrial PC) or directly by the drive. The former is referred to as a controller-based approach and the latter as a drive-based approach.

Whereas a controller-based concept is required for performing three-dimensional movements (for example, in the case of robots), a drive-based concept is implemented in the case of the following drive tasks, in particular:
- positioning
- continuous process
- winding
- cross cutters/flying saws
- electronic cams

For the purpose of motion control, intelligent drives also process drive-based logic functions.

Frequency inverters
Frequency inverters are used in conjunction with standard three-phase AC motors for the purpose of varying their speed. The electrical power is converted as follows:

- Rectifiers
- DC bus with capacitor for storing energy
- IGBT pulse width modulation inverter, switching frequency of e.g. 8 kHz

The pulse width modulation inverter is controlled by a microprocessor. The processor's software is responsible for controlling the electric drive. There are two motor control methods available for frequency inverters:

- V/f characteristic control
- Vector control

Vector control makes better use of the torque, features faster torque build-up and provides higher speed accuracy. Some frequency inverters will also evaluate signals from an angle sensor for the purpose of speed control. In this respect they resemble servo drives.

Braking energy
Initially, a frequency inverter can only transfer motor power from the mains to the motor. By contrast, regenerative power occurs in the following applications:

- generally when braking a motor
- lowering with a hoist drive
- unwinding drives

This braking energy can be converted as follows:

- via a brake unit (brake transistor and brake resistor) into heat
- to the motor by means of DC-injection braking
- into motor energy for other drives by connecting the DC buses of several inverters in the case of multi-axis applications
- to the electrical mains via a regenerative feedback inverter

Inverter	Frequency inverter	Servo inverter
Motor	Standard three-phase AC motor	Servo motor
Angle sensor	No	Yes
Speed setting range	1:50 ... 100	>1:10 000
Speed accuracy	3 ... 5% (V/f) 0.5% (vector)	<0.01%
Dynamic (minimum acceleration time to rated speed	100 ms ... 1 s	10 ... 100 ms

Servo drives
Servo drives consist of a servo inverter and a servo motor. The servo motor features an angle sensor which is evaluated by the inverter. This results in precise and dynamic control of the drive's speed and position:

- Servo control

This solution offers far more, in terms of the speed setting range and the level of dynamic performance that can be achieved, than is possible with a frequency inverter in combination with a standard three-phase AC motor.

Motor starters
The purpose of a motor starter is to switch a fixed speed drive on and off and to ensure that the drive starts up smoothly. Motor starters are particularly found within the context of distributed conveyor applications where the power and control signal wiring (e.g. fieldbus systems) is installed in a linear fashion for several drives.

Product range | Frequency inverters

smd frequency inverters

- compact frequency inverters for simple applications
- power range 0.25 to 22 kW
- integrated operating unit
- V/f control operating mode
- pluggable memory chip for the parameter set (EPM)

tml/tmd frequency inverters

- compact frequency inverters for simple applications
- power range 0.25 to 18.5 kW
- integrated operating unit
- sensorless vector control operating mode for exact motor control
- pluggable memory chip for the parameter set (EPM)

SMVector frequency inverters

- frequency inverter with high degree of protection (Nema 1, Nema 12, Nema 4x)
- power range 0.25 to 18.5 kW
- mains supply voltages of up to 600 V
- V/f control or sensorless vector control
- integrated operating unit
- pluggable memory chip for the parameter set (EPM)
- fieldbus communication

8200 vector frequency inverters

- modular frequency inverters
- power range 0.25 to 90 kW
- sensorless vector control for exact motor control
- overload capacity of up to 180 %
- available with optional integrated safety engineering
- fieldbus communication

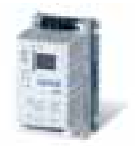
8400 frequency inverters

- the new, scalable family of frequency inverters
- power range 0.25 to 15 kW, extensions in preparation
- vector control with and without speed feedback
- overload capacity of up to 180 %
- available with optional integrated safety engineering
- fieldbus communication
- freely configurable function block structure
- pluggable memory chip for the parameter set

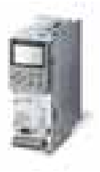
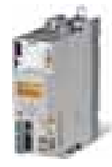
9300 vector frequency inverters

- for demanding applications
- power range 0.37 to 90 kW
- freely configurable function block structure
- vector control with and without encoder feedback
- can be combined with regenerative unit 9340

Product range | Frequency inverters

	smd	tmd/tml	SMVector
● = Standard ○ = Option □ = Variant			
Voltage and power range	1-ph. 180 ... 264 V: 0.25 ... 2.2 kW 3-ph. 320 ... 528 V: 0.37 ... 22 kW	1-ph. 180 ... 264 V: 0.25 ... 2.2 kW 3-ph. 320 ... 528 V: 0.37 ... 7.5 kW	1-ph. 90 ... 132 V: 0.25 ... 0.75 kW 1-ph. 170 ... 264 V: 0.25 ... 2.2 kW 3-ph. 170 ... 264 V: 1.1 ... 7.5 kW 3-ph. 340 ... 528 V: 0.37 ... 18.5 kW 3-ph. 425 ... 660 V: 0.75 ... 18.5 kW
Approvals	CE, UL508C, cUL	CE, UL508C, cUL	CE, UL508C, cUL, GOST, C-Tick RoHS-compliant
Permissible mains supply types	TN, TT	TN, TT	TN, TT
Switching frequencies	1 kHz to 16 kHz	1 kHz to 16 kHz	4, 6, 8, 10 kHz
Mechanical design			
Built-in unit	●	●	●
Push-through technique			
Cold plate			
Installation backplane			
Degree of protection	IP20	IP20	IP31, IP54, IP65 up to 2.2 kW
Operation in generator mode			
Integrated brake transistor			
External brake transistor			○
Capable of recovery			
Motor control method			
V/f control	●	●	●
Vector control (sensor-less)		●	●
Vector control (with encoder)			
Drive functionality			
Frequency control	●	●	●
Torque control		●	●
Speed control		●	
PID controller	●	●	●
Motion control			
Programmability			
Parameter setting	●	●	●
Function block programming			
IEC 61131-3			
I/O			
Analog input/output	1/1	2/1	1/1
Digital input/output	4/1	4/2	4/1
Relay output	1	1	1
Speed feedback			
Emulated encoder output			
PTC or/and KTY			
Fieldbuses			
CAN bus	□		□
PROFIBUS			
INTERBUS			□
Modbus	□	●	
LECOM	□	●	
AS interface			□
DeviceNet	□		
Ethernet TCP / IP			□
EtherCAT			
ETHERNET Powerlink			
Safety functions			
Safe torque off			
Diagnostic support			
LEDs			
Keypad	●	●	●
Remote keypad (for mounting in control cabinet door)	○	○	
PC interface		□	□
Memory module	●	●	●
PC tools	Tech-Link	Tech-Link	Tech-Link

Frequency inverters

8200 vector	8400	9300 vector
		
1-ph. 180 ... 264 V: 0.25 ... 2.2 kW 3-ph. 100 ... 264 V: 0.55 ... 7.5 kW 3-ph. 320 ... 550 V: 0.55 ... 90 kW	1-ph. 180 ... 264 V: 0.25 ... 2.2 kW 3-ph. 320 ... 550 V: 0.55 ... 15 kW **)	3-ph. 320 ... 528 V: 0.37 ... 90 kW
CE, UL508C, cUL	CE, UL *) RoHS-compliant	CE, UL508C, cUL
TT, TN, (IT variant from 15 kW)	TT, TN, IT *) RoHS-compliant	TT, TN, IT
2, 4, 8, 16 kHz	2, 4, 8, 16 kHz	1, 2, 4, 8, 16 kHz
● ● ● (up to 22 kW)	● □ □	● ● ● (up to 22 kW)
IP20	IP20	IP20
● (up to 11 kW) ○ (as of 15 kW)	● (StateLine, HighLine) ○ (BaseLine)	 ○ ○
● ●	● ● ● (HighLine)	● ● ●
● ● ● ●	● ● ● ● (StateLine, HighLine) ● (HighLine)	● ● ● ●
●	● ● (StateLine)	● ●
1/1 or 2/2 *) 5/1 or 7/3 *) 1 (2 from 11 kW and above) ●	1/1 4/1 1 ● (StateLine, HighLine) ● (StateLine, HighLine)	2/2 7/4 2 1
○ ○ ○ ○ ○ ○ ○	● (StateLine, HighLine) ○ (StateLine, HighLine) ○	● ○ ○ ○ ○ ○ ○
□ (from 3 kW)	○ *)	□
● ○ ○ ○	● ● (BaseLine) ○ (StateLine, HighLine) ○ (StateLine, HighLine) ● ●	● ○ ○ ●
Global Drive Control	L-force Engineer	Global Drive Control
*) Standard I/O or Appl. I/O	*) In preparation **) Extension of power range in preparation	

Product range | Decentralised drive technology

8200 motec frequency inverters

- power range 0.25 to 7.5 kW
- V/f control or sensorless vector control
- wall or motor mounting
- high degree of operational reliability thanks to thermally independent system
- gateway functionality for process signals

LCU, OCU, ICU motor controls

- LCU – motor starter as a reversing starter or for two-motor operations
- LCU – frequency inverter with good functionality and modularity
- ICU – motor control for inductive energy transfer
- OCU – motor control for monorail overhead conveyors, sliding/skid applications

Servo Drives 930 fluxxtorque

- power range 0.14 to 0.5 kW
- naturally ventilated
- integrated positioning control
- control via digital inputs/outputs and/or fieldbus
- can be installed without a control cabinet

Product range | Servo inverters

PostionServo 940

- easy to use
- power range 0.25 to 2.2 kW
- overload capacity of up to 300 %
- pluggable memory chip for the parameter set (EPM)
- integrated operating unit
- positioning control

ECS servo system

- compact multi-axis system with central supply
- power range 1.1 to 13.8 kW
- overload capacity of up to 300 %
- safe torque off
- two integrated CAN interfaces

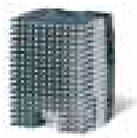
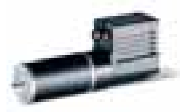
9300 servo inverters

- intelligent servo inverter
- power range 0.37 to 75 kW
- control via digital inputs/outputs and/or fieldbus
- freely configurable function block structure or programmability in accordance with IEC 61131-3
- CAN interface as standard
- comprehensive encoder interfaces

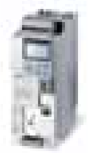
9400 Servo Drives

- new generation of intelligent servo inverters
- power range 0.37 to 370 kW
- single axis and multi-axis applications
- freely configurable function block structure
- optional safety functions including Profisafe and safe encoder evaluation
- control via digital inputs/outputs and/or fieldbus
- modular safety engineering
- innovative backplane system
- pluggable memory chip for the parameter set
- power recovery modules

Product range | Distributed drive technology and servo inverters

	Decentralised drive technology	
	8200 motec	**930 fluxxtorque**
● = Standard ○ = Option ☐ = Variant		
Voltage and power range	1-ph. 180 ... 264 V: 0.25 ... 0.37 kW 3-ph. 320 ... 550 V: 0.55 ... 7.5 kW	1-ph. 230 V: 0.25 ... 0.5 kW 24 or 48 V DC: 0.14 ... 0.17 kW
Approvals	CE, UL508C, cUL	CE
Permissible types of mains supply	TN, TT	TN, TT or DC mains
Switching frequencies	2, 4, 8, 16 kHz	10 kHz
Mechanical design		
Built-in unit		
Push-through technique		
Cold plate		
Installation backplane		
Motor mounting	●	●
Wall mounting	●	
Degree of protection	IP65	IP54
Operation in generator mode		
Integrated brake transistor	●	●
External brake transistor		
Capable of recovery		
Motor control method		
V/f control	●	
Vector control (sensor-less)	●	
Servo control		●
Drive functionality		
Frequency control	●	
Torque control	●	●
Speed control	●	●
PID controller	●	●
Motion Control		●
Programmability		
Parameter setting	●	●
Function block programming		
IEC 61131-3		
I/O		
Analog input/output	1/1 or 2/2 *)	
Digital input/output	5/1 or 7/3 *)	1/1
Relay output	1	
Speed feedback		
Emulated encoder output		
PTC or/and KTY	●	●
Fieldbuses		
CAN bus	○	☐
PROFIBUS	○	☐
INTERBUS	○	
Modbus		
LECOM	○	●
AS interface	○	
DeviceNet	○	
Ethernet TCP /IP		
PROFINET		
EtherCAT		
ETHERNET Powerlink		
Safety functions		
Safe torque off		
Other safety functions		
Diagnostic support		
LEDs	●	
Keypad		
Remote keypad (for mounting in control cabinet door)	○ (hand-held)	
PC interface	○	●
Memory module		
PC tools	Global Drive Control	fluxx

*) Standard I/O or Appl. I/O

	servo inverters			
	940	ECS	9300	9400
				
	1-ph. 200 ... 240 V: 0.25 ... 2.2 kW 3-ph. 400 ... 480 V: 0.50 ... 2.2 kW	3-ph. 180 ... 528 V: 1.1 ... 13.8 kW	3-ph. 320 ... 528 V: 0.37 ... 75 kW 460 ... 740 V DC: 0.37 ... 75 kW	Single Drives: 3-ph. 180 ... 550 V: 0.37 ... 370 kW 260 ... 775 V DC: 0.37 ... 370 kW Multi Drives 260 ... 775 V DC: 0.37 ... 11 kW
	CE, UL508C, cUL	CE, UL508C, cUL	CE, UL508C, cUL	CE, UL508C, cUL
	TT, TN	TT, TN, IT	TT, TN, IT	TT, TN, IT
	8, 16 kHz	4, 8 kHz	8, 16 kHz	1, 2, 4, 8, 16 kHz
	●	● ● ●	● ● ● (up to 22 kW)	● ●
	IP20	IP20	IP20	IP20
	●	●	 ● ○	● ○
	  ●	 ●	 ●	● ● ●
	 ● ● ●	 ● ● ● ●	 ● ● ● ●	● ● ● ● ●
	●	● □	● ● □	● ●
	1/1 2/2 or 14/5 1 (2 ○) ●	1/- 4/1 1 2 1 ●	2/2 6/4 3 1 ●	1/0 (StateLine); 2/2 (HighLine) 5/1 (StateLine); 9/4 (HighLine) 2 (3 ○) ○ ●
	○ ○ ○ ○ ○ ○	● (2) ○ ○ ○ ○ ○	● ○ ○ ○ ○ ○	○ (StateLine) ● (HighLine) ○ ○ ○ ○ ○ ○
		●	□	○ ○
	 ● ● ●	● ○ ○ ○	● ○ ○ ○	● ○ ○ ● ●
	Motionview	Global Drive Control, Drive PLC Developer Studio	Global Drive Control, Drive PLC Developer Studio	L-force Engineer

Product information | Motors and gearboxes

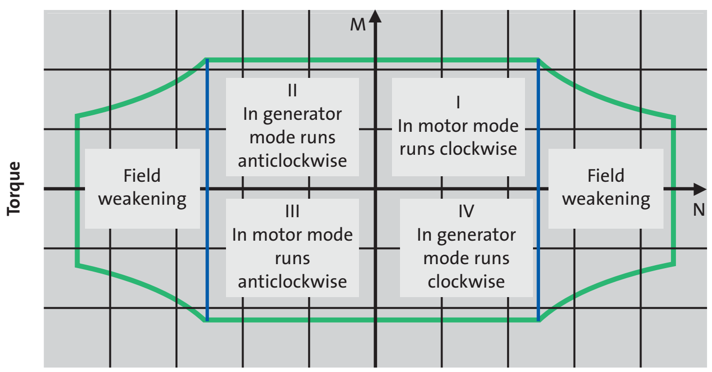
Standard three-phase AC motors
The standard three-phase AC motor converts electrical energy into mechanical power and can also function as a generator at the same time. The rated speed of the motor is determined by the number of pole pairs. 4-pole motors are the most frequently used type (1500 rpm at 50 Hz), but 2 and 6-pole motors are also sometimes used.

A magnetising current is always necessary so that a magnetic field can be generated even if the motor is in the idle state. With asynchronous motors the motor speed drops under load. A frequency inverter can be used to compensate for this so called 'slip', via its control function, e.g. vector control. Above the rated speed, operation is possible with reduced torque (field weakening range).

Standard three-phase AC motors are available in different efficiency classes. From 2011 onwards, only motors of efficiency class IE2 or higher may be used in the EU. The today most widely used motors of class IE1 will then be forbidden in new installations.

The main dimensions of the motor, e.g. shaft diameter, flange diameter, shaft height, are standardised.

Operating ranges for variable speed drives



The motor is adapted to the application using different built-on accessories, e.g. brake, angle sensor or fan unit.

Servo motors
Servo motors differ from standard three-phase AC motors in that they offer optimised drive behaviour with high dynamic performance and accuracy. They are ideal for use in conjunction with servo inverters.

Two motor types are used:
- synchronous servo motors with high-energy permanent magnets
- asynchronous servo motors

Compared with asynchronous servo motors, synchronous servo motors achieve lower mass inertia, have smaller designs and need no magnetising current with the same rated torque. This results in higher dynamic performance.

Asynchronous servo motors, on the other hand, can operate above the rated speed with reduced torque in the field weakening range.

Servo motors are characterised by their narrow design with high power density, low inertia and high efficiency. The shafts and flange diameters are based on standard three-phase AC motors. Servo motors are usually equipped with an angle sensor – and often also with a brake, e.g. for lifting applications.

Gearboxes and geared motors

Gearboxes function as speed and torque converters. The gearbox ratio enables the motor speed and torque to be adapted in line with the machine's operating point. When it comes to combining motors and gearboxes (geared motors), there are two basic designs:

- If fitting is based on the use of a coupling, then IEC standard motors can be used. The coupling provides additional elasticity, which affects the drive characteristics.
- In the case of direct mounting, the motor and gearbox form an integrated unit. The motor is simultaneously an integral part of the first gearbox stage. This mounting option optimises the operating characteristics and construction volume.

The various gearbox ranges differ in terms of their design and the shaft. This means that the right design will always be available for any application, regardless of whether you need an axial shaft section, an angular section or even an offset hollow shaft in the case of a shaft-mounted helical gearbox. Planetary gearboxes offer the highest torque density.

Angle sensors

Angle sensors ensure that the servo inverter control receives the current actual values. The sensors are installed inside the motors. The following types are used:

- resolvers
- encoders
- absolute encoders

The type used will depend on the required level of accuracy and positioning range:

	Absolute positioning		
	No	**1 rev. (single-turn)**	**4096 revs. (multi-turn)**
Accuracy	**Asynchronous motor only**		
Medium **10 arcmin**		**Resolver**	
High 2 arcmin	IK2048-5V-T IGxxxx-5V-T TTL signals	AS1024-8V-H sin/cos signals HIPERFACE	AM1024-8V-H sin/cos signals HIPERFACE
Very high 1 arcmin		AS2048-5V-E **sin/cos signals** EnDAT	AM2048-5V-E **sin/cos signals** EnDAT

Brakes

The brakes, which are integrated inside the motors, hold the motor shaft at standstill. If inverters are used, the inverter controls the decelaration in a wear-free manner. In this case, the brake will only be used for an additional braking in emergency stop situations, e.g. when there is a mains failure. Two different designs are used:

- spring-applied brakes generate braking torque by applying spring force to the armature plate and brake rotor.
- with backlash-free permanent magnetic brakes, braking torque is generated by the force of the permanent magnets on the armature plate.

Product range | Motors

MDXMA, MHXMA and 13.750 standard three-phase AC motors

- optimised for use with inverters
- flange or foot mounting
- Reinforced insulation for inverter operation
- select from options for shaft versions, fans, brake attachment and angle sensor
- MHXMA with energy efficiency class IE2

SDSGS synchronous servo motors

- excellent smooth running characteristics
- smooth surface – easy to clean
- options, e.g. angle sensors
- different variants for low voltage 24 V and 42 V DC supply

MCS synchronous servo motors

- superb dynamic performance and power density
- minimal detent torques
- high energy magnets
- innovative winding technology
- electronic nameplate
- generously dimensioned bearings for long service life
- fully encapsulated stator

MDXKS synchronous servo motors

- high dynamic performance
- high overload capacity
- excellent smooth running characteristics

SDSGA asynchronous servo motors

- smooth surfaces – easy to clean
- naturally ventilated
- excellent smooth running characteristics
- pluggable connections for rapid mounting
- compact design

MCA asynchronous servo motors

- surface-ventilated
- slimline design
- high power
- high power density
- extensive field weakening range
- low mass inertia for high dynamic performance
- electronic nameplate

MQA and MDFQA asynchronous servo motors

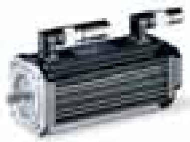
- high power density and dynamic performance
- generously sized bearing
- extensive field weakening range
- internally ventilated
- IP23 degree of protection
- insulated non-drive end bearing to reduce bearing currents
- MQA with electronic nameplate

MDSLS servo spindle motor

- integrated ball screw drive
- linear feed of up to 170 mm
- high feed force and compact dimensions
- high energy magnets

Product range | Motors

				
	Standard asynchronous motor MDXMA, MHXMA 13.750	**Synchronous servo motor SDSGS**	**Synchronous servo motor MCS**	**Synchronous servo motor MDXKS**
	Asynchronous three-phase AC motor with options for inverter drives	Synchronous servo motor, optional with attached Servo Drive 930 fluxxtorque	Highly dynamic servo motor with high power density	Synchronous servo motor
Degree of protection	IP54/IP55	IP54/IP55	IP54/IP65	IP54/IP65
Dynamic performance	average	high	very high	very high
Mass inertia	average	low	very low	very low
Overload capacity	average	very high	very high	very high
Power density	average	high	very high	very high
Field weakening	average	low	low	low
Detent torque (in relation to M_0)	none		< 1%	
Torque ripple total at M_r (approx. guide values)	3.5% ... 4.5%		≤ 2.5%	
No. of frame sizes	13	4	5	3
Power	30 W ... 45 kW	140 W ... 750 W	250 W ... 15.8 kW	250 W ... 5.9 kW
Speed	1400, 2500, 2800 rpm	2000 ... 3000 rpm	1050 ... 6000 rpm	500 ... 3500 rpm
Constant torque	0.2 ... 292 Nm	0.45 ... 2.2 Nm	0.5 ... 72 Nm	0.6 ... 16.2 Nm
Square dimension/diameter		Ø 65, 75, 85, 95 mm	□ 6, 9, 12, 14, 19 cm	
Axis height	50, 56, 63, 71, 80, 90, 100, 112, 132, 160, 180, 200, 225 mm	33, 38, 43, 47 mm	31, 45, 58, 71, 96 mm	35, 51, 65 mm
Fan/brake	with axial external fan (MDXMA, MHXMA) or integral fan	no fan, spring-applied brake, permanent magnet brake	no fan, axial external fan, permanent magnet brake	no fan, axial external fan, permanent magnet brake
Encoder	MDXMA, MHXMA: resolver, incremental encoder, sin/cos encoder	resolver, sin/cos encoder	resolver, sin/cos encoder, sin/cos absolute encoder	resolver, sin/cos encoder, sin/cos absolute encoder
Electronic nameplate			●	
Gearbox for direct mounting	GST, GFL, GKS, GSS, GKR, SSN (depending on frame size)	GST, GKR, SSN	GST, GFL, GKS, GSS, GKR	GST, GFL, GKS, GSS, GKR
Gearbox for standard mounting	GST, GFL, GKS, GSS, GKR, SPL (depending on frame size)	GST, GKR, SPL	GST, GFL, GKS, GSS, GKR, GPA	GST, GFL, GKS, GSS, GKR, GPA
Motor-device combination	smd, tml/tmd, SMV, 8200 vector, 8400, 8200 motec, ECS, 9300, 9400	930 fluxxtorque, 9300, 9400	940, ECS, 9300, 9400	940, ECS, 9300, 9400

			
Asynchronous servo motor SDSGA	**Asynchronous servo motor MCA**	**Asynchronous servo motor MQA and MDFQA**	**Servo spindle motor MDSLS**
Asynchronous three-phase AC motor with options for inverter drives	Totally enclosed fan-cooled asynchronous servo motor	Enclosed-ventilated asynchronous servo motor with high power and power density	Totally enclosed fan-cooled synchronous servo motor with integrated linear spindle
IP54/IP55	IP23/IP54/IP65	IP23	IP54
average	high	very high	very high
high	low	very low	very low
high	very high	very high	very high
average	high	very high	high
high	high	high	low
none	none	none	< 2%
	3.5% ... 4.5%		3.5% ... 4.5%
3	9	4	2
75 W ... 600 W	0.8 kW ... 53.8 kW	9.6 kW ... 95 kW	160/170 mm lift
2700 rpm	530 ... 4100 rpm	500 ... 3000 rpm	250 mm/s speed
0.27 ... 1.9 Nm	2 ... 75 Nm	75 ... 480 Nm	1.9 ... 15 kN force
Ø 75, 85, 95 mm	☐ 100, 130, 140, 170, 190, 210, 220, 260 mm	☐ 200, 220, 260, 320 mm	☐ 100, 130 mm
38, 43, 47 mm	56, 71, 80, 90, 100, 112, 132 mm	100, 112, 132, 160 mm	56, 71 mm
no fan, spring-applied brake, permanent magnet brake	no fan, with axial external fan, permanent magnet brake	radial external fan, spring-applied brake	no fan, spring-applied brake
resolver, incremental encoder	resolver, incremental encoder, sin/cos encoder, sin/cos absolute encoder	resolver, incremental encoder, sin/cos encoder, sin/cos absolute encoder	resolver sin/cos absolute encoder
	●	● (MQA)	
GST, GKR, SSN	GST, GFL, GKS, GSS, GKR		
GST, GKR, SPL	GST, GFL, GKS, GSS, GKR, GPA	GST, GFL, GKS, GSS,	
smd, tml/tmd, SMV, 8200 vector, 8400, 8200 motec, ECS, 9300, 9400	9300, 9400	ECS, 9300, 9400	ECS, 9300, 9400

Product range | Gearboxes and geared motors

G-motion GST helical geared motors

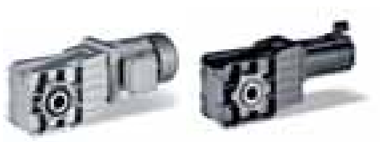
- 1-, 2- and 3-stage geared motor with closely stepped ratio
- high radial force permissible
- robust design
- solid shaft with keyway
- foot or flange mounting

G-motion GFL shaft-mounted helical geared motors

- 2- and 3-stage parallel-axis gearbox for space-saving mounting
- hollow shaft with keyway or shrink disc
- solid shaft with keyway
- foot or flange mounting
- integrated torque plate incl. rubber buffer

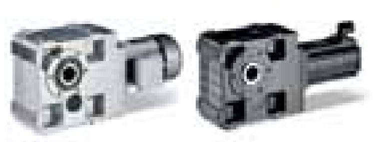
G-motion GKR bevel geared motors

- 2-stage geared motor, the alternative to the worm gearbox
- wear free tooth system
- high energy efficiency thanks to good efficiency factor
- solid shaft or hollow shaft design
- foot or flange mounting
- integrated torque plate incl. rubber buffer



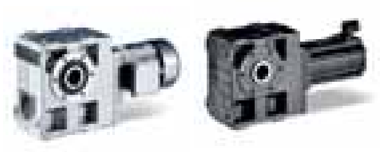
G-motion GKS helical-bevel geared motors

- 3- and 4-stage geared motor with closely stepped ratio
- robust cast iron housing
- solid shaft or hollow shaft design
- foot or flange mounting
- integrated torque plate incl. rubber buffer



G-motion GSS helical-worm geared motors

- 2- and 3-stage geared motor
- solid shaft or hollow shaft design
- foot or flange mounting
- integrated torque plate incl. rubber buffer
- good efficiency with high ratios thanks to helical pre-stage



GPA planetary geared motors

- ideal for applications where a high degree of accuracy and dynamic performance is required
- compact design
- minimal backlash
- high rigidity

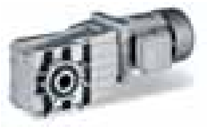
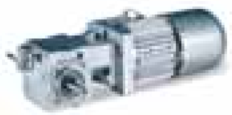
GKK bevel geared motors

- for applications where a manual motion is required as an alternative to motor operation
- with disconnect clutch
- typical application case in monorail overhead conveyors

Product range | Gearboxes and geared motors




	Helical gearbox GST	Shaft-mounted helical gearbox GFL	Helical-bevel gearbox GKS	Helical-worm gearbox GSS
	Single-stage or two-stage, coaxial gearbox (three-stage with pre-stage)	Two-stage shaft-mounted helical gearbox (three-stage with pre-stage), flat design	Three-stage right-angle gearbox with helical and bevel stage (four-stage, with pre-stage)	Two-stage right-angle gearbox with helical and worm stage (three-stage, with pre-stage)
Torque density	medium	medium	medium	medium
Efficiency	high	high	high	medium
Backlash	low	low	low	medium
No. of sizes	8	7	7	4
Power	0.06 ... 45 kW	0.12 ... 45 kW	0.12 ... 45 kW	0.12 ... 9.2 kW
Rated torque	45 ... 5920 Nm	190 ... 11 600 Nm	190 ... 11 790 Nm	180 ... 1250 Nm
Ratio	1.6 ... 435	3.5 ... 856	5 ... 1510	5.6 ... 1847
Shaft	solid shaft	solid/hollow shaft	solid/hollow shaft	solid/hollow shaft
Design	foot/flange	foot/flange	foot/flange	foot/flange
Motor for direct mounting	MDXMA, MHXMA, 13.750, SDSGS, MCS; MDXKS, SDSGA, MCA	MDXMA, MHXMA, MCS MDXKS, MCA	MDXMA, MHXMA,MCS, MDXKS, MCA	MDXMA, MHXMA,MCS, MDXKS, MCA
Motor for standard mounting	MDXMA, MHXMA, MCS, MDXKS, MCA, MQA, MDFQA	MDXMA, MHXMA, MCS, MDXKS, MCA, MQA, MDFQA	MDXMA, MHXMA, MCS, MDXKS, MCA, MQA, MDFQA	MDXMA, MHXMA, MCS, MDXKS, MCA, MQA, MDFQA

				
Bevel gearbox GKR	**Bevel gearbox GKK**	**Planetary gearbox GPA**	**Planetary gearbox SPL**	**Worm gearbox SSN**
Two-stage right-angle gearbox with helical and bevel stage	Bevel gearbox with integrated disconnect clutch	Planetary gearbox with coaxial input and output shaft	Planetary gearbox with coaxial input and output shaft	Right-angle gearbox with worm stage
medium	medium	very high	high	high
high	high	high	medium	low
low	low	very low	low	medium
4	4	6	5	3
0.06 ... 7.5 kW	0.12 ... 5.5 kW	0.25 ... 9.5 kW	0.025 ... 0.750 kW	0.025 ... 0.240 kW
45 ... 450 Nm	70 ... 900 Nm	19 ... 1000 Nm	3 ... 120 Nm	7 ... 36 Nm
3.4 ... 76	7.7 ... 86.8	3 ... 100	3.7 ... 168	5 ... 80
solid/hollow shaft	solid shaft	solid shaft	solid shaft	solid/hollow shaft
foot/flange	foot/flange	flange	flange	foot/flange
MDXMA, MHXMA, SDSGS, MCS, MDXKS, SDSGA, MCA	MDXMA			SDSGS, SDSGA
MDXMA, MHXMA, MCS, MDXKS, MCA		MCS, MDXKS, MCA	SDSGS, SDSGA	

Selection guide | overall technical/commercial evaluation

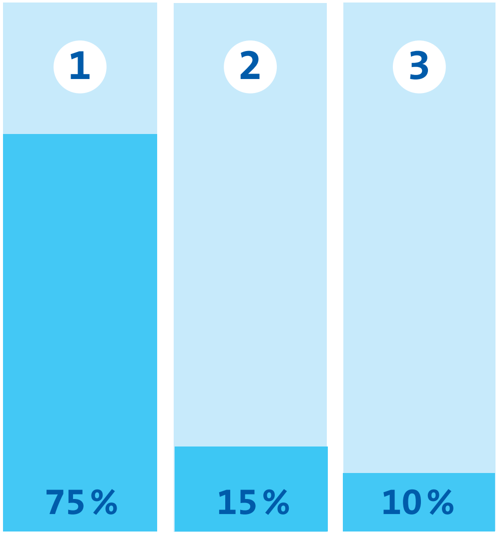
			Conveyor drives	Travelling drives	Hoist drives	Positioning drives	Co-ordinated drives for robots	Synchronised drives	Winding drives	Intermittent drives for cross cutters and flying saws	Drives for electronic cams	Drives for forming processes	Main drives and tool drives	Drives for pumps and fans
Frequency and servo inverters														
	Servo inverters	**9400**	●●	●●	●●	●●	●●	●●	●●	●●	●●	●●	●●	○
		9300	●●	●●	●●	●●	○	●●	●●	●●	●●	●●	●●	○
		ECS	○			●●	●●			●●	●●			
		940	●●	○	●	●●	○					○	●	
		930 fluxxtorque	○			●●								
	Frequency inverters	**9300 vector**	●●	●	●●	●		●	●			●	●●	●●
		8400	●●	●●	●	●		●	●			●	●	●●
		8200 vector/motec	●●	●●	○			○	○			●	●	●●
		tml, tmd	●●	●●				○				●	●	●●
		smd	●●	●									○	●●
		LCU, OCU, ICU		●●										
Motors														
	Asynchronous motors	**MQA/MDFQA**	●●	●●	●●	●●	●	●●	●●	○		●●	●●	●●
		MCA	○	●●	●●	●●	●●	●●	●●	●●	●●	●●	●●	
		SDSGA	○	○	●●	●●	●	●●	●●	●●	●●	●●	●●	
		MDXMA, MHXMA, 13.750	●●	●●	●●	●		●●	●●			●●	●●	●●
	Synchronous motors	**MDSLS**					○							
		MCS	○		●	●●	●●			●●	●●			
		SDSGS	●●		●	●●	●			●●	●●			
		Direct drives	●	●	●●	●●	●●	●		●●	●●		●	●
Gearboxes														
	Axial gearboxes/ ratios													
	Planetary	**GPA**	●	●	●	●●	●●	●●	●●	●●	●●	●	●	
	Planetary	**SPL**	●	●	●	●	●	●	●	●	●	●	●	
	Shaft-mounted	**GFL**	●●	●●	●●	●	●	●●	●●	●	●	●●	●●	○
	Helical	**GST**	●●	●●	●●	●	●	●●	●●	●●	●	●●	●●	○
	Traction drives	**Positive fit [1]**	●●	●●	●●	●●	●●	●●	●●	●●	●●	●●	●	●●
		Friction locking [2]	●●	●●	○				○			●●	●●	●●
		Chain	●●	○	●								○	
	Right-angle gearboxes													
	Bevel and clutch	**GKK**	●	●●										
	Bevel	**GKR**	●●	●●	●●	●	●	●●	●●	●●	●	●●	●●	○
	Helical bevel	**GKS**	●●	●●	●●	●	●	●●	●	●●	●	●●	●●	○
	Helical worm	**GSS**	●●	●	●●	○	○	○	○		○	●	●●	
	Worm	**SSN**	●●	●	●								●	○

[1] e.g. toothed belt
[2] e.g. V-belt, flat belt

●● very well suited
● well suited
○ limited suitability

Energy-saving drive solutions

When evaluating energy use, the entire drive system, comprising inverter, motor and gearbox, should always be considered as the total efficiency determines how much electric energy is required for a defined process. Work often focuses on increasing the efficiency of the electric motor although greater energy savings can in many cases be obtained by optimally adapting the drive to the operating process.

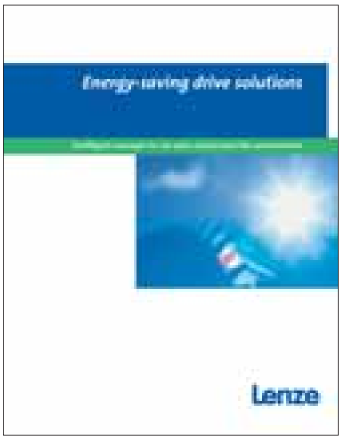


Proportion of potential savings

The overall cost effectiveness of the drive system can only be assessed as part of a life cycle costs analysis (LCC analysis). Due to the energy savings achieved energy-efficient drive systems are usually paid off in a couple of years.

Saving energy is one of the biggest challenges we face today and in the future. Lenze is facing up to this responsibility. And we will show you how you can use drives to save energy.

The brochure “Energy-saving drive solutions” contains a detailed description of the possibilities to save energy by using drives .



1. Using electrical energy intelligently: as little as possible	2. Converting energy with a high degree of efficiency	3. Using regenerated braking energy
Concepts with high energy efficiency (should be used)		
▶ Requirements-based dimensioning ▶ Controlled drive (frequency inverter) ▶ Energy-efficient open-loop and closed-loop motion control	▶ Components with a high degree of efficiency	▶ Energy exchange between the drives ▶ Intermediate storage of the braking energy ▶ Feeding back of the braking energy
Concepts with low energy efficiency (should be avoided)		
▶ Oversizing ▶ Uncontrolled operation	▶ Components with a low degree of efficiency	▶ Using a brake resistor

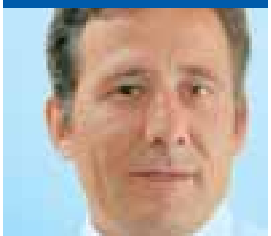
It's good to know | why we are there for you

"Our customers come first. Customer satisfaction is what motivates us. By thinking in terms of how we can add value for our customers we can increase productivity through reliability."

Vitamin L:

Ideas and added value for your drive and automation solutions.

"We will provide you with exactly what you need – perfectly co-ordinated products and solutions with the right functions for your machines and installations. That is what we mean by 'quality'."



"Take advantage of our wealth of expertise. For more than 60 years now we have been gathering experience in various fields and implementing it consistently and rigorously in our products, motion functions and pre-configured solutions for industry."

"We identify with your targets and strive towards a long-term partnership which benefits both sides. Our competent support and consultation process means that we can provide you with tailor-made solutions. We are there for you and can offer assistance in all of the key processes."

You can rely on our service. Expert advice is available 24 hours a day, 365 days a year, in more than 30 countries via our international helpline: 008000 24 Hours (008000 2446877).

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