Servomotor Configuration

Expanded Offering Provides the Best Servomotor Solution for Your Application

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White Paper

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It's no longer necessary to pour over endless catalogs from multiple manufacturers looking for just the right servomotor to fit your needs. At least one manufacturer of motion system components can now offer you more motor choices than a menu in a Chinese restaurant.

Brush-type motors, stepper motors, and brushless AC servomotors are widely used in semiconductor manufacturing, aerospace controls, electronics assembly machines, packaging equipment, medical devices, robotics, and many other industries. Each application potentially requires a different motor, and the selection process can be daunting when the possibilities in motor catalogs look virtually endless.

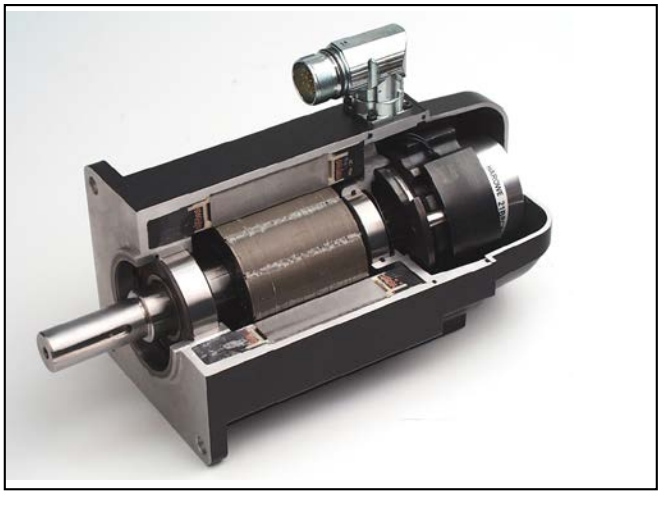
The best manufacturers ensure that their products meet advertised performance specifications starting with torque, speed and voltage ratings. These parameters are chosen based on the machine load and motion profile requirements taking into account load acceleration including the motor inertia. Motor sizing software, such as Kollmorgen's MOTIONEERING® Application Engine, is available to conveniently accomplish this. Performance requirements are followed closely by decisions for feedback devices, mounting configurations, and the operating environment.

Torque Density and Voltage

At the same time, factory equipment and machinery are continually shrinking, and the motors are keeping up the pace. For example, Kollmorgen has increased torque density to make their motors deliver more power in smaller packages while keeping the temperature rise below 100 C. A shorter motor can reduce the size of a protective machine cover, as well as lower weight and inertia benefiting the dynamic response of the system. Torque density refers to the amount of torque a motor can develop for its size. Generally speaking, higher voltage motors produce less torque for the same package size resulting in less torque density. This is because higher voltage systems require thicker insulation necessitating smaller, higher resistance wire. Since lower power motors require less voltage and current to develop speed and torque, their voltage ratings are generally lower. This however can complicate machine design when motors of various power requirements are needed on a machine resulting in multiple supply voltages required.

Kollmorgen has designed a 230 Vac size motor to operate on 480 Vac. Moreover, any new 58 mm and larger frame size AKM™ servomotor specified to run on 75, 120, or 230 VAC, contain the same uniform 480-VAC Class F insulation. As a result, when a machine or motion control system calls for a 120 or 230 Vac motor in one axis, and a 480 Vac motor in another, the 230 Vac motor can be supplied as an AKM 480 Vac motor with the same specifications, retaining the same mounting and physical size as the lower voltage motor. So, only a 480-Vac source is needed to run the motors in both axes.

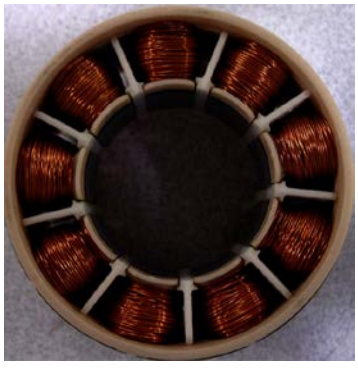
This is possible by abandoning the typical shuttle winding system as used in most factories in favor of a unique servo-controlled laminar scheme where the turns lie much closer to one another. This packs dramatically more copper into the lamination slots and substantially increases torque density. The technique produces either a smaller motor for a given power rating, or a higher power motor in a given package size.



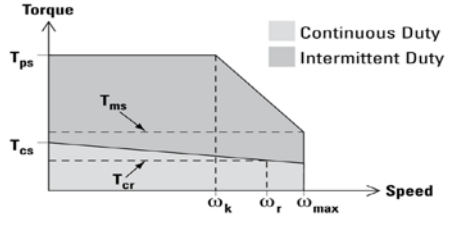
The cutaway view of Kollmorgen's AKM™ servomotor clearly illustrates the overall compact size, high-density torque/volume stator and rotor, bearings, brake, and encoder. All versions of the AKM series are almost identical, which keeps manufacturing costs low and quality high.

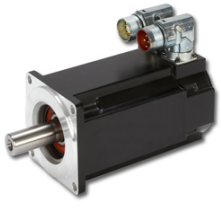
Insulation breakdown (due to excessive voltage and temperature) is one of the most common causes of motor failure. Now, superior wire insulation is used, and the entire higher density stator is enclosed in potting material. This lowers the thermal resistance and the heat conducts out into the atmosphere much more quickly and efficiently. The higher thermal transfer helps smaller motors deliver more power to the load.

AKM servomotors stators are wound around a single tooth, each phase is insulated for 480 V, and none of the coils overlap which prevents coil-to-coil shorts. Rare earth magnets provide maximums torque in a low cogging design with redundant magnet retention.



AKM Systems Overview



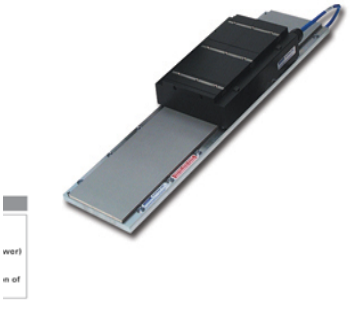


A torque vs. speed operating envelope describes the performance characteristics of a brushless motor and drive servo system. The two shaded areas under the curve indicate the continuous duty and intermittent duty areas of the system.

Direct Drive Motors

Direct Drive Rotary (DDR) servomotors pioneered by Kollmorgen offer an alternative to conventional shafted servomotors when speed reduction, and torque multiplication are required. These motors provide a zero maintenance solution, improved accuracy, better reliability and smoother, quieter operation compared to systems incorporating a mechanical reducer. Kollmorgen also offers direct drive linear servomotors for linear motion applications having the same advantages as the DDR models eliminating the need for a rotary to linear transmission like a linear actuator or a rack and pinion.

Kollmorgen's Direct Drive (DDR) servomotors provide high torque directly to the load without the need for a gear reducer. Different models are offered including the Cartridge C(H) series, the D(H) housed series and the KBM™ frameless models. In addition to direct drive rotary solutions, Kollmorgen offers ironless and iron core direct drive linear solutions in the IL and IC series.



Direct Drive Linear (DDL) motor is basically a rotary motor that is laid out flat and directly coupled to the driven load. By eliminating mechanical transmission components, this design delivers exceptional performance, extremely high stiffness, very high dynamic speeds and accelerations.

Motor Sealing

Seals protect a servomotor against solids or liquids that can enter the motor and affect its performance or life. Seals protect the motor body and electrical connections as well as the output shaft. Brushless motors have an advantage here because they are inherently clean, compared to brushed servomotors that produce carbon dust. When a motor is exposed to a liquid, determine if the liquid is corrosive and specify a seal material that does not deteriorate. In the food industry washdown motors are required to meet FDA and USDA standards. In clean-room environments such as semiconductor manufacturing, motor seals reverse in function; they protect the environment from any possible contaminants emitted from the motor. When motor sealing is not a critical requirement due to the environment a lower cost motor alternative like Kollmorgen's VLM series is the best economic choice.

Kollmorgen offers a wide range of motors for washdown applications and other options to meet special environmental considerations. For example, in the area of washdown, Kollmorgen has the AKM Washdown, AKM Food Grade and Stainless Steel W series of motors.

Kollmorgen AKM Washdown and Washdown Food Series motors are available in frame sizes 2 through 6. These innovative motors incorporate our industry-leading AKM electromagnetics within a housing protected by a 2-K coating and IP67-rated seal configuration.

The W Series offers motor technology in a stainless steel housing with sealing technology that provides IP67 ingress protection for use in washdown environments.

Mounting

Motor mountings are available to satisfy almost every requirement, including the Japanese metric, European metric, and North American NEMA standards. Currently, more than 75 different motor mounting standards are used worldwide. Kollmorgen can kit a wide variety of standard motors with one common set of castings that meet both UL and CE requirements.

The large variety of mountings adapt easily to different mechanical components or machine configurations. For example, a flange type mount is the most common connection for a gearbox. Regardless of the mount chosen, motors are provided with a pilot, a raised circular surface on the motor face concentric with the output shaft. A recess for this is machined in the surface of the mounting surface of the machine or mechanism and ensures alignment. When the motor shaft couples to a mechanism containing a bearing such as a gearbox, it guarantees that the motor and gearbox shafts align accurately. This is critical because misalignment can cause bearings to fail prematurely. Various industry standards for motor mounts include the National Electric Manufacturers Association (NEMA) and the International Electrotechnical Commission (IEC).

Shaft Modifications

Occasionally, an output shaft modification is needed to mate with another manufacturer's mechanism or specific load. The shaft may require a special keyway, different diameter or length, a spline or taper. These modifications should be made at the factory to ensure that it receives the proper machining accuracy. Also, when the shaft diameter is reduced it must undergo an engineering evaluation. A smaller diameter shaft can fail prematurely when subjected to peak torques, and will reduce the shaft's torsional resonant frequency (TRF). And, reducing the TRF, in turn, can have a detrimental effect on the overall system responsiveness because the drive gains may have to be reduced to prevent exciting resonances.

Brakes

A brake should be specified when an axis of motion needs to be held or stopped without servo control. The most common application is a vertical axis driven with a ball screw or another mechanism that can fall or move when the servo is not energized. Brakes in servomotors provide static parking in any axis. They are considered fail-safe and are mechanically engaged to an ON condition when they are electrically OFF. Unlike an automotive disc brake for example, fail-safe brakes are not intended for repetitive operation in a dynamic mode. They do not have the surface area to endure, or the heat sinking ability to dissipate a lot of energy continuously. When an application requires a brake that must be used dynamically, add an external brake designed for that purpose. Occasionally, it is necessary to have a manually released brake or a power-on, brake-on type included in the motor.

Feedback Devices

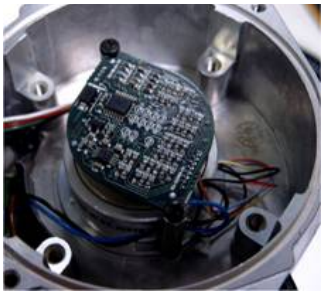
The most common types of feedback devices used for servomotors are resolvers, incremental encoders, and sine encoders. They come in a wide range of choices for accuracy, resolution, and repeatability. Accuracy is defined as the maximum error or the difference between the expected value and the actual value. It can be measured in linear or rotary units depending on the mechanical design. Rotary position units are typically measured in arc-minutes or arc-seconds, while linear devices are measured in decimal values of inches or microns (millionths of a meter).

The resolution of a position feedback device is the smallest increment of displacement that can be obtained. Rotary devices typically measure in counts or lines per revolution, and linear devices typically measure the smallest incremental distance in microns. An added benefit of high resolution is the ability to increase the servo drive gains without causing instability. This allows for faster response and shorter settling times.

Repeatability refers to the ability of the device to position accurately to the same location repetitively. The repeatable accuracy of a device may be much greater than its fundamental accuracy.

Servomotor feedback devices generally measure velocity or position, and often in a combination. The choice largely depends on the type of servomotor and amplifier selected. A brushless servomotor requires a position feedback device to report the rotor's position to the drive so it can electronically switch the current in the windings (electronic commutation). This type of position feedback device may also be used to determine velocity as a function of position vs. time and provide feedback to the position controller.

With Kollmorgen's AKM servomotors, several different feedback devices may be installed including optical absolute encoders, sine encoders, resolvers, and optical commutation encoders. Plug-and-Play feedback provides motor recognition drive commissioning with Kollmorgen's AKD® servo drives to reduce setup time. In all cases, only one type of end bell is used, which simplifies assembly and substantially increases the motor's quality.



Lastly, feedback devices vary with respect to the output waveform and voltage. Select a feedback device that is compatible with the drive amplifier, or select a drive amplifier that can support the feedback device required for the application. Most amplifiers can support a variety of feedback devices. As a general rule, purchase the motor and drive from the same manufacturer to assure optimal interoperability.

Summary of Four Commonly Used Position Feedback

Parameter	Resolver	Incremental Encoder	Sine Encoder	Smart Feedback Device (SFD)
Mechanical Shock and Vibration Resistance	Excellent	Fair to good	Excellent	Excellent
Temperature Rating	Typically same as motor windings: up to 170 ° C	80 to 115 ° C	Typically same as motor windings: up to 170 ° C	-20 to 115 ° C
Resolution	Dependent on resolver to digital (RtoD) converter, typically 12 to 16 bits (4096 - 65,536 counts for single speed type)	500 to 20,000 lines (2000 - 80,000 counts) or more per revolution (4000 lines is typical minimum for velocity control)	500k to 2 million counts depending on amount of interpolation of the fundamental number of lines of resolution	> 16 million based on 2^{24} built-in interpolation of integral single speed resolver
Accuracy	10 to 20 arc-minutes	3 to 5 arc-minutes; can be much less…Stegmann Endat encoders are 45 arc seconds	20 to 60 arc-seconds	9 to 16 arc-minutes
Speed	12,000 RPM or more	Typically 7,000 RPM max.	12,000 RPM or more however can be limited by an input frequency limitation of the amplifier	12,000 RPM or more
Output	Analog requiring R to D converter or drive interpolation software	Digital output	Analog - requires converter or drive interpolation software	RS-485
Dynamic Response	Good, signal conversion results in some phase delay	Good to excellent, related to resolution of device	Excellent due to high resolution	Excellent – update every 51.2 µs
Commutation Method	Direct based on absolute feedback of resolver (motor poles must be evenly divisible by resolver poles)	Requires additional Hall effect devices or commutation tracks to initialize motion until absolute position can be determined	Direct based on absolute feedback nature of sine encoder	Direct based on the absolute feedback nature of the device
Distance from Controller	up to 75 meters (typical)	up to 30 meters (typical)	up to 40 meters (typical)	up to 75 meters or more (typical)
Cable Conductors	3 pair	7 pair	5 pair	2 pair – 2 for power, 2 for RS-485
Cost	Low	Low to moderate	Moderate to high	Low to moderate

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Environmental Specs

In addition to sealing requirements, servomotors are specified for environmental considerations, which include temperature, shock, and vibration. The primary concern is the operating temperature at which the motor torque is specified. Typically, vendors specify torque ratings at 25 or 40 deg. C ambient. Continuous torque ratings are based on the maximum temperature rise from ambient temperature to the maximum allowable limit. Since temperature rise is related to the power dissipated in the motor, a motor operated in a higher ambient than specified must be derated. Conversely, if a motor is operated in a lower ambient, the torque rating is increased (see below, *Calculation Method*, for the calculation method for modifying a motor's continuous rating in other ambient temperatures). In addition, know the heat sink size the motor is mounted against to meet the advertised ratings. If the machine interface offers less surface area, contact an applications engineer to review the motor sizing. Other environmental factors include whether the motor is operated in a vacuum or exposed to nuclear radiation.

For a motor operating in a vacuum, it can only dissipate heat through conduction or radiation so must be derated significantly and require some material changes. For motors operating in a nuclear-radiation environment they will need special insulation, bearing lubrication, and possibly other material changes. Contact the motor manufacturer about any of these specific environmental considerations.

Calculation Methods

Operation of a motor in ambient conditions other than that for which the motor is specified will affect the motors.

$$\text{Torque rating (new)} = \text{Torque rating (continuous)}\sqrt{\frac{\text{Actual temp rise (deg C)}}{\text{Rated temp rise (deg C)}}}$$

Example: Consider operation of Kollmorgen AKM65K servomotor in a 65°C ambient

Motor continuous torque in 40°C ambient = 24.8 Nm
Motor rated temperature rise = 100 °C

$$\text{Torque (new)} = 24.8 \text{ Nm}\sqrt{\frac{100+40-65}{100}} = 21.5 \text{ Nm}$$

This represents a torque reduction of 16%, which will reduce the current rating by the same percentage.

Connectivity

Servomotors often come with various options for lead termination from flying leads to motor mounted connectors that can be rotated allowing more convenient and neater cable dressing. In addition, they vary widely from a sealing standpoint from relatively unprotected flying leads to highly sealed motor mounted connectors that are resistant to water jets. In order to make a decision about what type to purchase, understand the environment in which the motor will be placed and the degree of protection required. Kollmorgen uses the International Protection (IP) rating standard which defines the resistance of enclosures to solids and liquids by a two digit code.

Bearings

The trend in servomotors has been to go to larger bearings and larger shaft diameters to increase axial and radial load capacity and to obtain longer life. Sometimes special bearings (such as precision, duplex, or cross roller types) are used to provide greater run-out accuracy or load capacity based on specific requirements. Servomotor bearings are generally permanently lubricated and sealed. Standard bearing lubrication accommodates operation in a wide range of temperatures, and special lubricants are available if temperatures are at an extreme, either hot or cold.

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Conclusion

Some standardization exists in the servomotor manufacturing industry, and a few manufacturers are working hard to overcome this by being more flexible in their product offerings. Kollmorgen is one such company with aggressive engineering goals to minimize the difficulty of building a system. Regardless of your application complexity, it is always good to talk to a manufacturing representative to confirm the optimum product selection for your design specification.

Often times with highly specialized machines a co-engineering collaboration is required to meet technical challenges and market requirements. Beyond optimizing technical performance, co-engineering teams help manage machine lifecycles and upgrades, operator training and safety, and customer service and support. Kollmorgen brings this capability to the engineering design cycle including enhancing business processes through kanban supply chain management and just-in-time delivery.

ABOUT KOLLMORGEN

Kollmorgen is a leading provider of motion systems and components for machine builders around the globe, with over 70 years of motion control design and application expertise.

Through world-class knowledge in motion, industry-leading quality and deep expertise in linking and integrating standard and custom products, Kollmorgen delivers breakthrough solutions unmatched in performance, reliability and ease-of-use, giving machine builders an irrefutable marketplace advantage.

For more information visit www.kollmorgen.com, email support@kollmorgen.com or call 1-540-633-3545.

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