Mounting and installation of frameless brushless motors

Brushless Motor System Configuration

A brushless motor, drive amplifier, feedback device(s), and power supply are the components in a standard brushless system. Motion results as the brushless motor converts electrical amplifier signals into torque. Torque and velocity can then be monitored through the feedback devices and compared with command input values. The servo amplifier adjusts the electrical output to the motor to meet the command input requirement. Precision motion control is achieved through velocity, current, and frequency locked control loops (see Figure 1).

Hall devices, encoders, and resolvers are feedback devices usually mounted on the brushless motor axis. One or more of these, in addition to current sensors, can be used to provide the position and velocity feedback to the amplifier (Current sensors are built into the amplifier). Hall sensors and resolvers may serve several functions including giving velocity feedback for the control loop and giving position information to commutate the motor. Position loops, which can use an encoder or resolver, require special amplifier and system configurations.

Careful selection of system components optimizes brushless system performance. Kollmorgen Motion Technologies Group offers components for two types of brushless systems: trapezoidal (six-step) and sinusoidal. These two types differ in their methods of commutation and the selection of each should be made based on the application and performance requirements of the system. For most applications six-step is the appropriate choice. When very smooth operation, under load, at slow speed is required, then sinusoidal commutation can provide exceptionally smooth, low torque ripple operation.

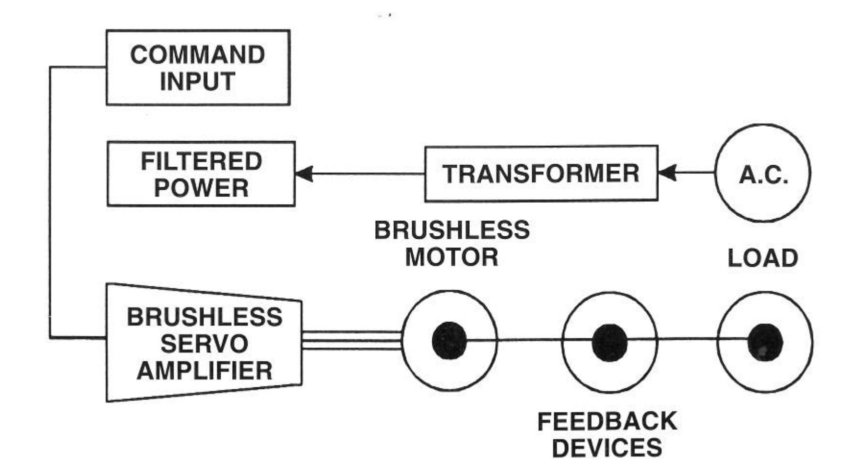

Figure 1. Brushless system diagram

Brushless motors are not commutated mechanically, such as with a commutator and brushes, but electronically. Kollmorgen Motion Technologies Group's six-step amplifiers are designed to utilize Hall effect devices for commutation position signals. Hall effect sensors mounted onto the stator send the rotor magnet position information to the amplifier. This position information is necessary for commutation, that is, for changing the direction of current flow in the motor windings in the proper sequence relative to the rotor position. The Hall devices must be accurately aligned with the stator windings for the correct position information to be transferred. This alignment is performed at the factory for all motors supplied with Hall effect sensors.

Kollmorgen sinusoidal amplifiers are designed to utilize resolver or encoder position information for commutation. The feedback device may be customer supplied or factory supplied for housed motors. Sensor selection will vary depending on the motor chosen and the application. Motor selection for a sinusoidal system may require factory consultation to assure performance requirements will be met. While six-step systems can provide torque with ripple as low as five or six percent, sinusoidal systems can provide values as low as one percent. Amplifiers for both systems are primarily pulse width modulated.

Brushless Motor Construction

Generally, a frameless brushless motor consists of three components: the armature assembly, the field assembly, and a position sensing device.

The stator or armature assembly is the outer, wound member and is stationary. It consists of lamination material formed into a core with slots that are either straight or skewed. After the core is bonded the slots are electrically insulated and the windings are inserted. The windings consist of a series of copper coils for each motor phase. Phase interconnections are made inside the winding, and leads are brought out for connection to an amplifier (see Figure 2).

The rotor or field assembly, is the second component of a brushless motor and is the rotating member. It typically consists of permanent magnets bonded to a flux carrying yoke ring. The magnet material selected will depend on the application requirements. Magnet materials available include Samarium Cobalt and high energy Neodymium-Iron-Boron compounds. Magnets are mounted circumferentially around the outside of the rotor (see Figure 3). A band can be placed around the rotor to ensure mechanical integrity at high speeds.

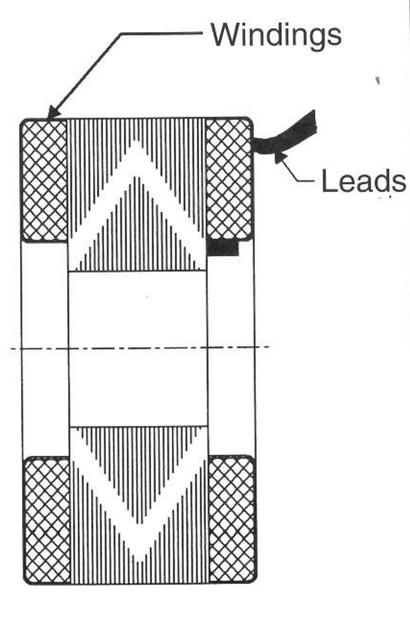

Figure 2. Frameless armature assembly

A device for sensing rotor position is necessary for providing feedback to the amplifier. This is often achieved through the use of Hall effect devices. The magnetically sensitive Hall effect sensors can be formed into an epoxy ring or segment or can be mounted directly onto the windings of the stator. A resolver or other position sensing device can replace the Hall effect sensors in certain applications.

Housing Design

Here are some design considerations for the stator housing as well as the rotor and shaft adapter. Although very few of Kollmorgen Motion Technologies Group's frameless motors require very tight mechanical tolerances, you should still keep in mind the tolerances your machine shop can maintain.

Selection of the housing material should be considered first. The housing structure must be strong enough to support the stator so that no distortion occurs after the stator is clamped in place and the rotor is in operation. The housing material for a rare-earth magnet motor should be nonmagnetic. Aluminum, brass, and non magnetic stainless steel are suitable materials.

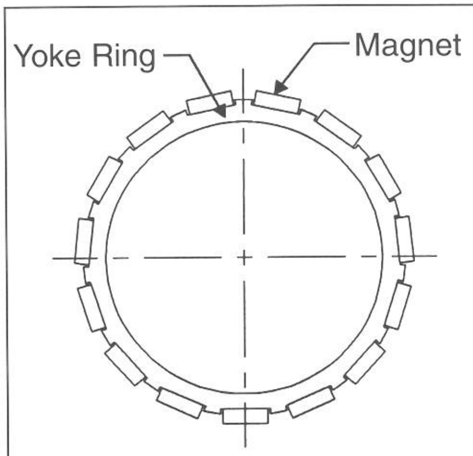

Figure 3. Basic configuration for a field assembly.

Next, consider tolerances. As a general rule, for many of Kollmorgen's motors, the inside diameter should be .001 to .002 [.03-.05] greater than the outside diameter of the stator.[1] The housing should include a shoulder for banking the stator. The inner diameter of this shoulder should be somewhat larger than the maximum outside diameter of the windings, while still allowing for an adequate banking surface.

Three methods are commonly utilized for securing the stator into the housing. It can be clamped in place using a clamp ring, an end bell, or the stator may be bonded into place. Whichever method is used, a key and keyway can be added in the motor design stage for additional security.

If a clamp ring or end bell is used, the depth of the housing bore should be approximately .100 [2.54] less than the stack length of the stator. The clamp ring is usually a thin ring machined from the same type of material used on the stator housing while the end bell is an integral part of the housing. The inside diameter of the clamp ring

[1] All dimensions are expressed in inches [millimeters].

or end bell should be the same as the inside diameter of the stator housing banking diameter. A counterbore with the same diameter as the bore in the stator housing and a depth of only .031 -.063 [.79-1.59] should be made to position the clamp on the stator (see Figure 4). The outside diameter of the clamp ring needs to be large enough to accommodate through holes for clamping screws. These screws will pass through the clamp ring into tapped holes in the stator housing, axially positioning the stator. A minimum of three screws should be used.

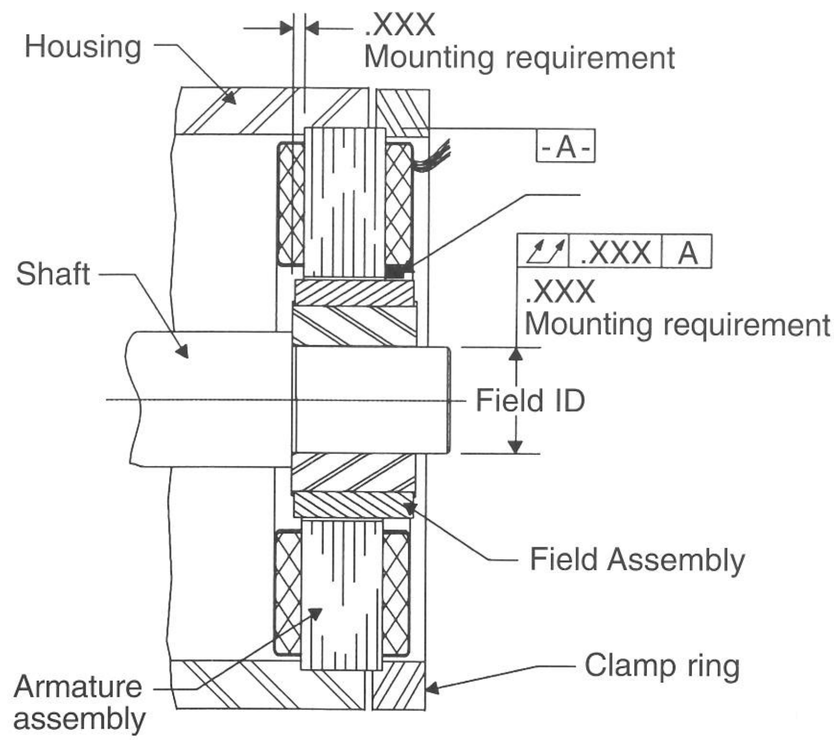

Figure 4. Mounted frameless motor

Shaft Design

The next step is to determine the way the rotor is to be secured to the shaft. Although many users of a frameless motor mount the field onto a rotor adapter or hub, rather than a shaft, the same design considerations apply in either case. The rotor may be secured by bonding it to a shaft, clamping it in place, or holding it with a shrink ring.

Bonding the rotor to the shaft is the most common method of rotor mounting. As with the stator, a key and keyway can be applied for added strength.

When bonding the rotor, the shaft diameter tolerance should be held to .001-.002 [.03-.05] below the minimum rotor diameter (see Figure 5). With a shrink ring, which is frequently used on larger diameter motors, the tolerance must be within the same range.

After determining the way the rotor is to be secured to the shaft, the rotor must be positioned axially. The best way to do this is to machine a shoulder on the mounting shaft. The rotor should then bank against this shoulder when mounted to the shaft. The outside diameter of the axial locating shoulder should be kept below the bottom of the magnets if possible.

The mounting diameter from the back of the field to the stack of the armature is shown on each

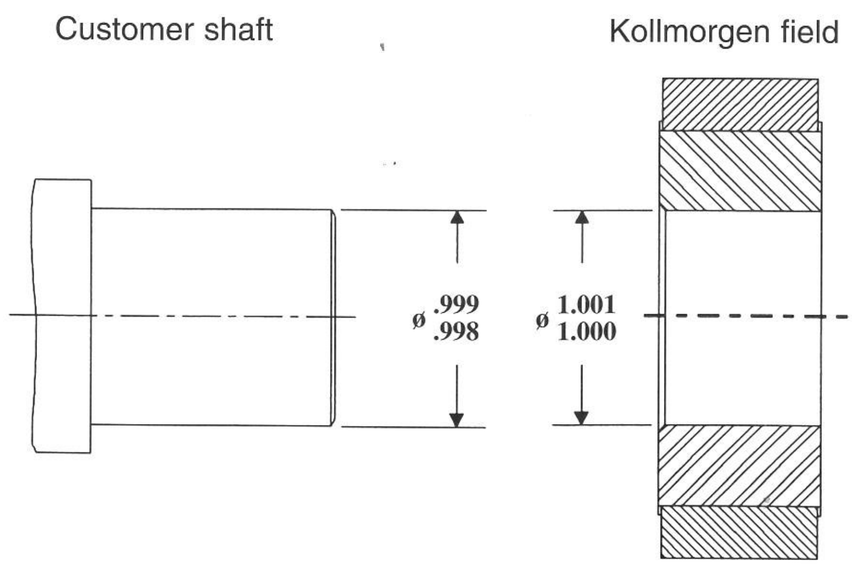

Figure 5. Typical tolerances for bonding the field to the shaft

outline drawing (see Figure 4). This toleranced dimension must be held to maintain optimum motor performance. If axial deflections or tolerance buildups do not allow for this mounting dimension to be held, call the factory for advice.

Many frameless motors made by Kollmorgen Motion Technologies Group call for a concentricity of .002-.004 [.05 .10] total indicator reading or full indicator movement between the inner diameter of the rotor and the outside diameter of the stator. In dimensioning the various mounting hardware drawings the worst-case tolerance buildup may exceed the concentricity limit. If it is possible, measure the actual motor components before the final machining of critical mounting diameters. If a motor's mounting requirements cannot be met, please contact the factory before applying power to the motor.

Installation

1. Insert the armature into the housing cavity. Use care to avoid contact of the windings with the banking surface when inserting. Care must also be taken to protect the leadwires while handling and installing. Temporarily taping the leadwires to the armature housing will protect them from damage by the rotating member.

2. Secure the armature to the housing by either clamping or bonding in place. If a key and keyway are being used, align the keyways and insert the key at this time.

3. Wrap a piece of protective film, such as Mylar, that is thinner than the airgap of the motor, around the inside diameter of the armature. This protective film should extend above the armature for later grasping and removal. Guide the permanent magnet field assembly into its final position within the armature assembly, being careful not to chip the magnets during installation.

Caution: The attractive forces of rare earth magnet motors can be very great as the field enters the armature. Therefore, a means of restraining the field should be provided. Also, sudden impact of the field into its position could damage the assembly's bearings from the shock impact if allowed to freely enter the armature.

Make sure the field is firmly seated against the mounting surface and bond or clamp in place. Once the field is in place, remove the Mylar film.

Motor Handling

Because frameless dc motors are designed to be an integral part of system equipment, they require some special handling procedures. Improper handling or storage can substantially degrade motor performance.

Unpacking

A frameless motor should be unpacked carefully to avoid damaging the motor components in order for the motor to perform properly. Be careful not to damage or score any of the mounting surfaces. Avoid any significant impact on the windings or stress on the leadwire.

Transport

If a motor must be transported, it should be repacked in the original shipping container for protection against shock and vibration.

Storage

In storage, containers and racks should be of nonmagnetic materials. Field assemblies should be spaced a minimum of one-half inch apart. Motor parts should be protected against exposure to, or contact with, small magnetic particles such as iron filings, chips, or dust because they are very difficult to remove from the magnetic areas of the motor. Furthermore, motor performance could be seriously degraded should sufficient material lodge in or across the motor air gap.

Motor components may be stored in normal ambient temperatures. However, for extended storage or storage in humid environments, the motor parts should be protected against corrosion. Seal the parts in plastic bags that contain a desiccant. The original packaging by the factory is adequate if it is kept intact.

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