Mounting design and installation of frameless motors

After the motor and winding designation have been selected, the motor design should be incorporated in the layout phase of the mechanical design. A frameless brush-type motor may be either totally frameless, frameless with an armature adapter machined to fit the customer's existing shaft, or partially housed with a mounting flange or tabs for mounting the stator.

For totally frameless units or units with armature adapters, a housing for the stator must be included in the system design. Partially housed motors do not need a special stator housing. Since they can be bolted onto a flat plate, they are well suited for mounting on the exposed end of a shaft. Mounting features for this arrangement include round or square flanges or tabs on the stator housing.

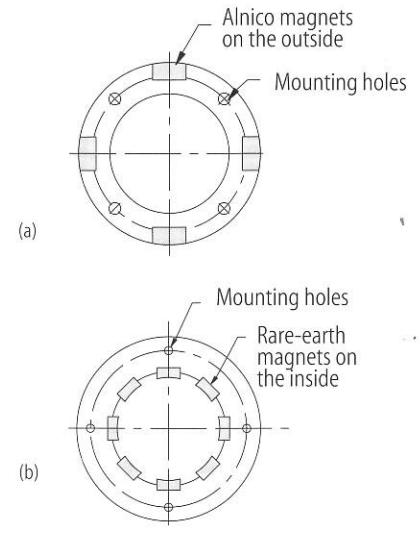


Figure 1. Basic configuration for a permanent-magnet stator.

Here are some design considerations for the stator housing as well as the motor shaft or adapter. Although very few of Kollmorgen's frameless motors require very tight mechanical tolerances, you should still keep in mind the tolerances your machine shop is capable of holding. Let's first review the parts of a frameless dc brush-type motor with permanent magnets.

The stator or field assembly is the stationary outer member which contains the permanent magnets mounted into a steel yoke ring. Alnico magnets are mounted circumferentially around the outside of the stator (Figure 1a). Rare-earth magnets are mounted radially on the stator's inside perimeter (Figure 1b).

The rotor or armature is the rotating inner member. It contains the wound copper coils and commutator. (Figure 2.)

The brush-ring assembly, which mounts on the stator, contains the brushes and leads that transmit current to the commutator. The brushes are either cantilever or cartridge type. Cartridge brushes are typically used in servo motors for running applications, because they not only have a longer life but are also easier to replace. (Figure 3.)

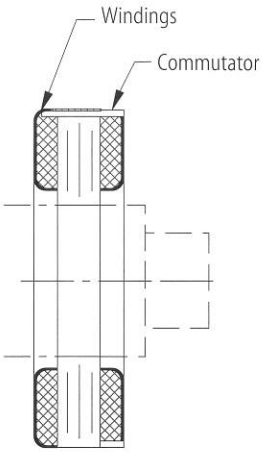


Figure 2. Frameless armature for a permanent-magnet motor

Designing the Stator Housing

Housing material should first be considered. The housing structure must be strong enough to support the stator so that there is no distortion after the stator has been bolted in place

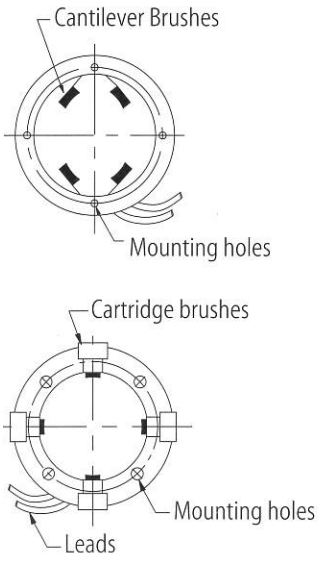


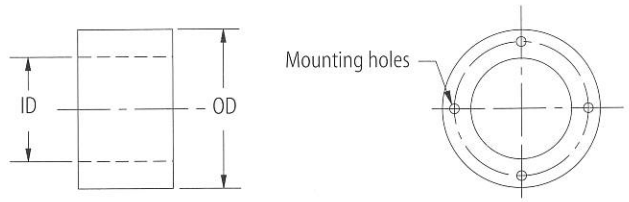
Figure 3. Brush-ring assembly

and the motor is in operation. The housing material for a rare-earth magnet motor may be either magnetic or nonmagnetic; however, an Alnico magnet motor must be mounted in a nonmagnetic housing in order to preserve the motor's specified performance characteristics. Aluminum, brass, and nonmagnetic stainless steel are suitable materials. If a magnetic housing is lined with non-magnetic material, the liner must be at least one-fourth inch thick to separate the stator from the magnetic material of the housing.

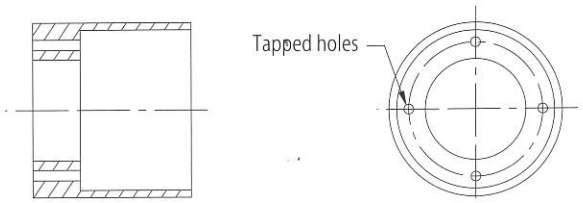
Next, consider tolerances. As a general rule, the inside diameter of the housing should be 0.001 to 0.002 greater than the outside diameter of the stator.[1]
The housing should include a shoulder for the stator to bank against, with tapped holes for mounting the stator. (Figure 4.) The inner diameter of this shoulder should be somewhat greater than the rotor diameter, but should allow enough material for the required tapped mounting holes.

To determine the size of the screws that secure the stator in its housing, refer to the dimensions of the stator mounting holes. The stator mounting holes are designed to provide clearance for the recommended mounting screw size. This hole diameter is clearly shown on the outline drawing of each Kollmorgan model. Screw selection is based on generally accepted design practice.

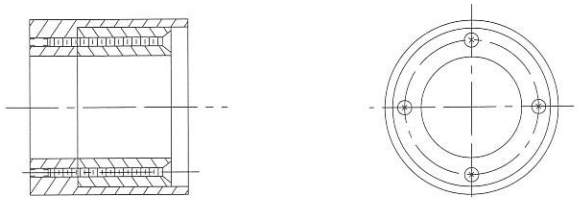
The brush-ring assembly, which mounts to the stator, will usually have an outer diameter slightly smaller than that of the stator. Also, the brush-ring assembly will have holes for direct mounting on the stator. Screws for mounting the brush ring to the stator are provided with frameless motors.



(a) Frameless stator



(b) Typical stator housing



(c) Stator mounted in the housing

Figure 4. Stator housing

Designing the Shaft

Next, determine the way the rotor is to be secured to the shaft. Although many users of a frameless motor mount the rotor onto an armature 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 or using a clamp ring to fasten it to the shaft.

With bonding, the shaft diameter tolerance should be held to ±0.001. With a clamp ring, which allows easy disassembly, the tolerance must also be within ±0.001. Each method is described below. (Two other methods, a shrink fit and a press fit, are sometimes used, but Kollmorgen does not recommend them.)

After determining the way the rotor is to be secured to the shaft, the rotor must be located axially so that the rotor stack is not only under the magnets, but the brushes are also tracking the commutator. The best way to locate the rotor axially is to machine a shoulder on the mounting shaft. The rotor should then bank against this shoulder when mounted to the shaft. The maximum outside diameter of the axial locating shoulder should be less than the minimum inside diameter of the rotor's encapsulated end turns. Leave sufficient diametrical clearance — a minimum of 0.020 for most models, and 0.010 for motors with an air gap diameter less than two inches.

The mounting requirement from the back of the stator to the stack of the rotor is shown on each outline

[1] All dimensions are expressed in inches.

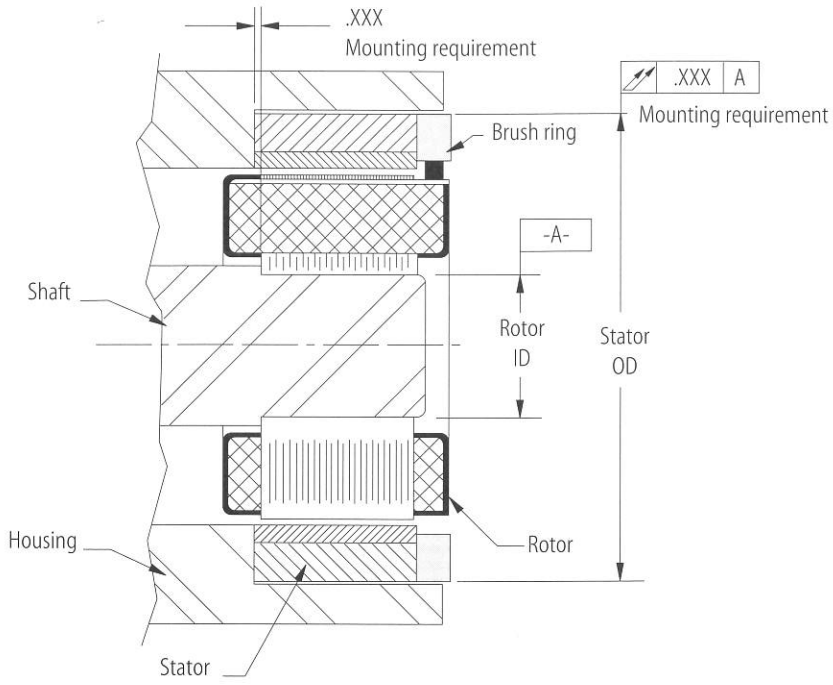


Figure 5. Mounted frameless motor

drawing. (See Figure 5.) If this axial tolerance is exceeded, the brushes may fall off the commutator or ride into the rotor stack. If axial deflections or tolerance buildups do not allow for this mounting dimension, call the factory for advice.

Many frameless motors made by Kollmorgen call for a concentricity of 0.002 (0.004 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 call the factory before applying power to the motor.

Bonding the rotor to the shaft is probably the most common method of rotor mounting, especially when the shaft has a hole through it. (However, the rotor will be difficult to remove from the shaft if the unit needs to be disassembled later.) With this method, the shaft diameter should be 0.001 to 0.002 less than the minimum rotor diameter. (See Figure 6.) To secure the rotor to the shaft, use Loctite RC-640 or a comparable bonding material, and follow the manufacturer's instructions. An axial dowel pin should be installed at the rotor shaft interface to prevent any radial motion between the shaft and rotor.

Using a mechanical clamp ring is possible if the shaft is solid. Machine the shaft diameter to 0.001 to 0.002 under the rotor inside diameter. Unlike the other cases, however, the shaft must be machined so that the length from the axial locating shoulder to the end of the shaft is less than the stack length. (Refer to Designing the Shaft.)

A hole should then be drilled and tapped axially in the end of the shaft. Finally, make a clamp ring, which is essentially a specially machined flat washer. It requires a clearance hole for a bolt through the middle and an outer diameter identical to that of the axial locating shoulder. (See Figure 7.)

To secure the rotor axially in place, slide it on the shaft and bolt the clamp ring to the shaft. One advantage of this method is that the motor can be easily disassembled. If the motor is to be used in a high-speed or reversing-load application, use a lock washer, Loctite on the bolt, or even two bolts to hold the clamp ring in place.

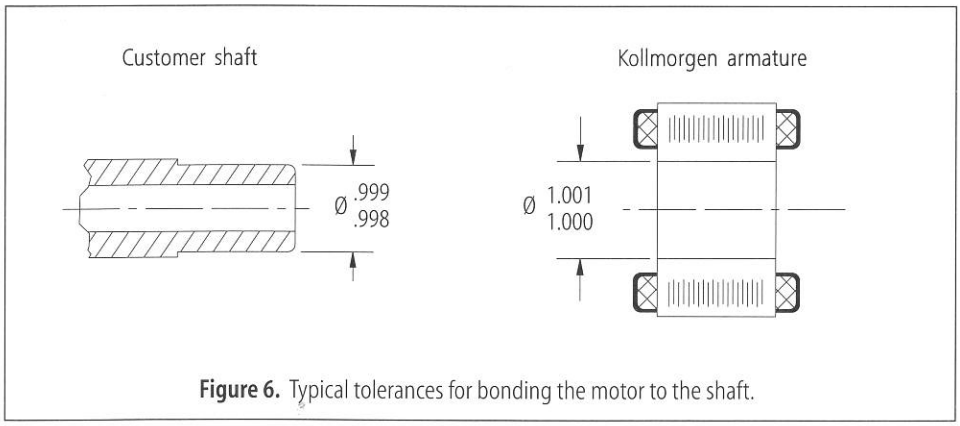


Figure 6. Typical tolerances for bonding the motor to the shaft.

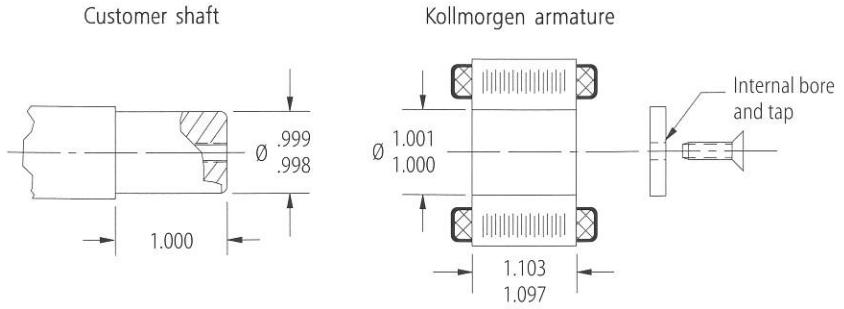


Figure 7. Typical tolerances for using a mechanical clamp ring to fasten the motor to the shaft.

Installation

The method for installing frameless torque motors varies with the motor design. With most frameless motors – whether rare earth or Alnico – the field, armature, and brush-ring assembly are shipped as separate components. For Alnico units, the permanent-magnet field assembly is shipped with a keeper to be removed only after the field and the armature are mounted in the housing.

Some frameless designs with larger diameters or longer axial lengths require the motor to be partially assembled at the factory. That is, the field and armature are assembled at the factory and fastened together with either a clamp plate, clamp bolts, or pole-piece clamps. The clamp is removed after the field and armature are mounted in the customer's housing. With some partially housed designs, the field, armature, and brush-ring assembly are assembled and clamped together before shipping.

Frameless Brush-Type Motor Installation

Rare-earth magnet motors

1. Insert the permanent magnet field assembly into the housing cavity. If the housing material is magnetic,

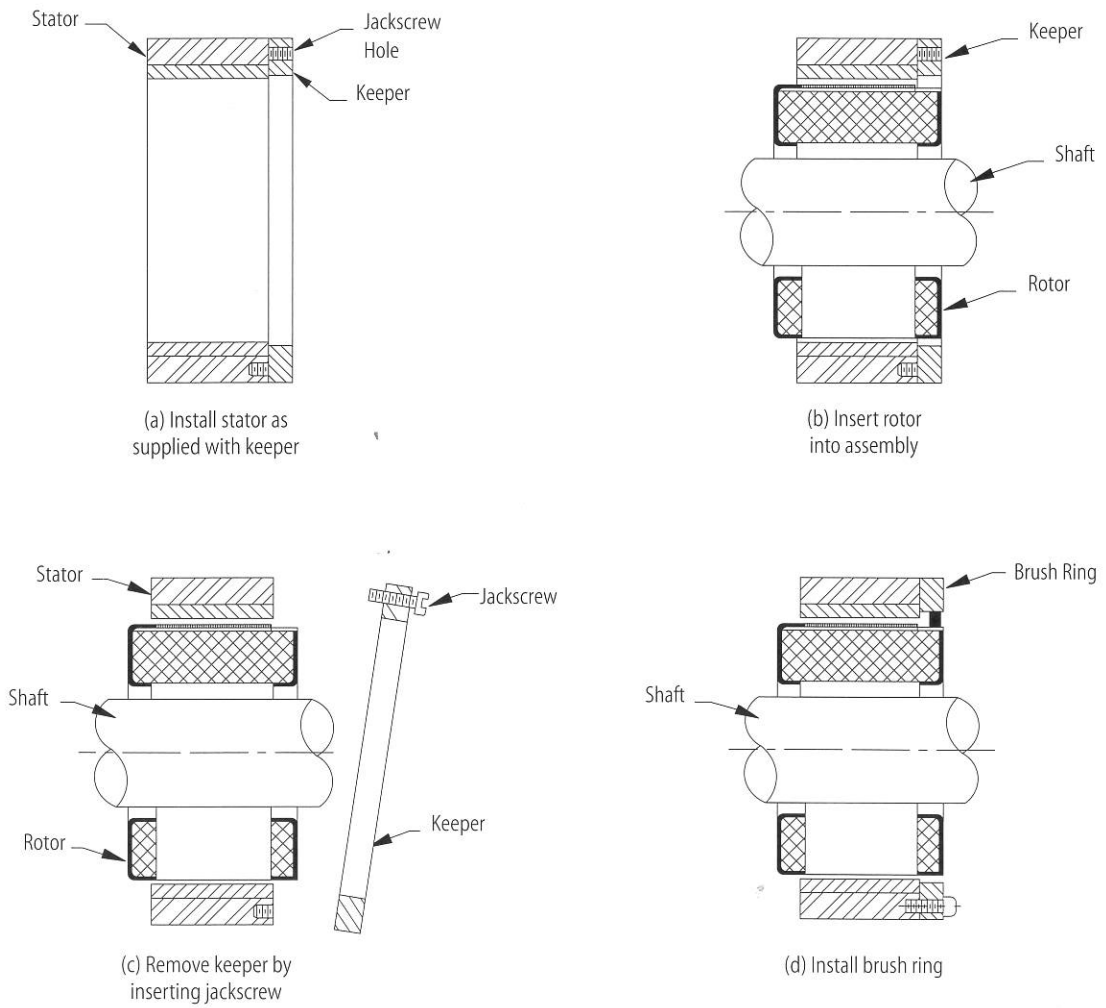


Figure 8. Installing an Alnico magnet motor

take care to avoid sudden impact of the field against the housing.

2. Secure the field assembly to the housing with mounting screws.

3. Wrap the armature with a piece of polyester film, such as Mylar, that is thinner than the air gap of the motor. This protective film should extend above the armature for later grasping and removal. Guide the armature into its final position within the field assembly being careful to position the commutator surface for proper brush alignment.

Be careful not to scratch the commutator surface or chip the magnets. Make sure the armature is firmly seated against the mounting surface and clamp in place. Once the armature is in place, remove the polyester film.

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

4. Install the brush ring. Take care in guiding the brushes over the commutator. Avoid bending the brush springs or scratching the commutator surface. For proper brush assembly positioning, align the numbers marked on the field and brush ring assembly. Then secure the brush ring assembly in place with the brush ring mounting screws provided.

Alnico magnet motors

This installation procedure is identical to that of the rare-earth magnet motors, with three exceptions. The field assembly can not be installed in a housing made of a magnetic material. A Mylar wrap around the armature is normally not required. Also, Alnico fields are shipped with keeper rings which are removed after the field and armature are in place. Refer to Figure 8.

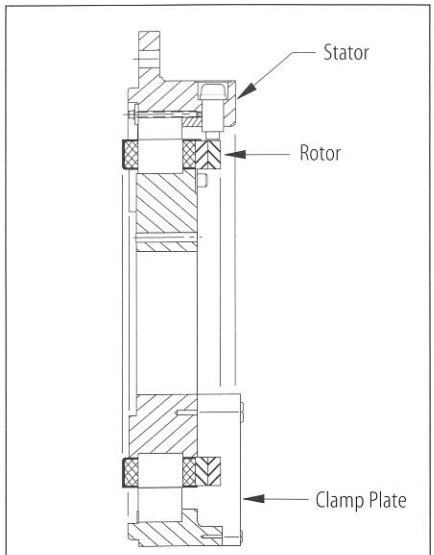


Figure 9

1. Insert the field into its housing cavity. WARNING: Do not loosen or remove the flux keeper until the armature is in place, or motor performance will be [significantly] degraded.

2. Guide the armature into its final position within the field assembly. Be careful not to damage the commutator surface.

3. Remove the keeper ring using the jackscrew as shown in Figure 1c.

4. Secure the field assembly to the housing with mounting screws.

5. Install the brush ring. Take care in guiding the brushes over the commutator. Avoid bending the brush springs or scratching the commutator surface. For proper brush assembly positioning, align the numbers marked on the field and brush ring assembly. Then secure the brush ring assembly in place with the brush ring mounting screws provided.

Partially Housed Motor Installation

For partially housed Alnico units with shipping clamp-plates, such as used on the T-10036 motor, the armature must not be removed from the field or partial demagnetization and change of motor torque characteristics will occur (see Figure 9). The field and armature assemblies are installed onto the shaft and the field support as a single unit. The clamp plate is then removed to permit rotation of the armature. After removing the clamp plate, be sure to tighten the mounting bolts.

Partially housed Alnico units with clamp-bolts or pole-piece clamps are similar to each other in that the accessory clamp elements are simple screws. In the case of the clamp-bolt types, typified by the T-10035 motor, securing the clamping bolts moves the armature axially a sufficient amount to lock the armature and field together at an existing interface (see Figure 10).

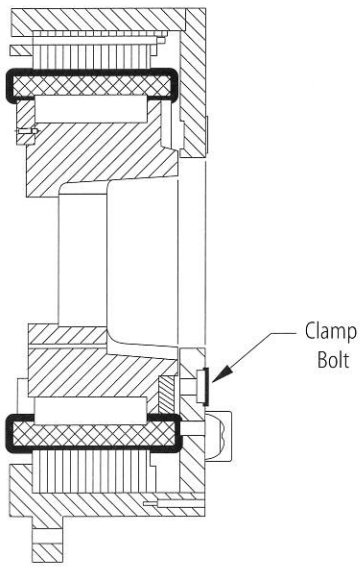


Figure 10

The pole-piece clamp type, as seen on the T-18002 motor, locks the armature to the field at the air gap by forcing a number of movable field pole-pieces radially inward until clamping action takes place (see Figure 11). After installation of this type motor, the clamping set screws are loosened, and the pole-piece stud nuts are retightened to secure the pole-pieces in their proper position.

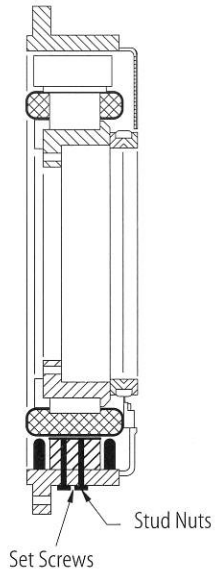


Figure 11

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 bend any of the brush springs or score the mounting surfaces. Keep the commutator surface free of scratches, fingerprints, and oils.

WARNING: For an Alnico magnet motor, do not loosen or remove the flux keeper until the armature is installed, or the magnets will demagnetize, substantially degrading motor performance.

Transport

If a motor must be transported, it should be repacked in the original shipping container for protection against shock and vibration. If it is an Alnico magnet motor, the flux keeper must be reinstalled before the armature is removed from the field.

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 any 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.

Kollmorgen Motion Technologies Group
501 First Street/Radford, VA 24141
(540) 639-9045 ph/(540) 731-4193 fax