AEROSPACE & AVIATION

HARSH ENVIRONMENTS

DESIGNED FOR EXTREME SMOOTHNESS, STEADINESS, SPEED & STRENGTH

SPECIAL SOLUTIONS
FROM THE STEPPING MOTOR SPECIALISTS
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## Designed for Extreme Smoothness, Steadiness, Speed & Strength

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## ABOUT LIN ENGINEERING

16245 Vineyard Blvd.,
Morgan Hill, CA 95037
Phone: (408) 919-0200
Fax: (408) 919-0201
www.linengineering.com

### Customization
We can customize windings to ensure maximum torque and performance at a desired speed as well as customize the wiring, shaft, housing, and add an encoder. Our motors are designed to fit your application, not the other way around.

### Certification
- **ISO9001:2015** - Medical, Automation
- **AS9100D** - Space, Aviation

### Rapid Prototyping
We can provide working prototypes quickly, which allows you to begin critical testing of the application right away so that getting the product to market happens as fast as possible.

### Offshore Quality Team
Should problems arise in high volume production, our overseas quality assurance team guarantees that the issue will be dealt with at the source.

### Extensive Sales Network
In addition to our inside sales team, Lin Engineering employs a worldwide network of over 40 sales representative firms located throughout the United States, Canada, Europe, the Middle East and Asia. Our sales reps can provide the service and personal attention required to serve your company.

### Domestic & Overseas Operations
In addition to minimizing lead-time, our U.S. facility also functions to support our overseas production. This allows us to meet the initial demands for high volume orders, thus helping you avoid the delays associated with high volume production ramp-ups.

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**Rapid Prototyping Offshore Quality Team**

**Extensive Sales Network**

**Domestic & Overseas Operations**

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The harsh environment of vacuum and microgravity pose many issues which we don’t commonly have to deal with here on earth. That is especially true when it comes to motion control in space. There are many inherent problems with creating motion in that environment mainly due to the fact that motors require, considerable amount of power, they can generate excessive heat, they can introduce unwanted vibrations, and they can also become a source of contaminants.

Dealing with these issues can come at a substantial cost. Higher power requirements necessitate larger power generation systems, more heat generated requires bigger cooling systems, dealing with unwanted vibrations requires more robust damping systems, and contaminations can cause havoc on instruments and other on-board components. This complexity can translate in to potential component or system failures—yet, there is no room for that in space applications, which is why it’s important to work with a company that has expertise in space flight requirements. Lin Engineering has designed their space hybrid stepper motors to work in harsh environments and accurately deal with the inherent problems of motion control in space. Plus, the motors are assembled in accordance with Aerospace AS9100D standards in a fully compliant facility in California, where each component origin is traceable to maintain strict control over the manufacturing process as well as the final product specifications. How do we address these challenges?

**Optimized Power Consumption**

In space applications, power comes at a premium. Every watt that is wasted by a system that has not been fully optimized for space costs precious resources. Optimizing for power consumption includes customizing motor windings so that they are able to deliver a peak amount of dynamic torque at the desired operating speed—which takes the proper integration of high-precision components, such as low inertia rotors operating at their highest efficiency. Depending on the specific application, each motor is tailored to deliver the ideal performance necessary while accounting for the power constraints of the overall system. Using proprietary, and proven, algorithms based on 30+ years of tailoring the performance of electric motors to meet the specifications needed for particular applications, Lin Engineering is able to optimize torque and speed, noise reduction, heat generation or loss, and/or power optimization.

**Temperature Management**

Two critical concerns related to temperature affecting the performance of hybrid stepper motors in space include the temperature range in which the motor operates and the amount of heat the motor generates. Satellites and other spacecraft operate in extreme temperature ranges. Externally mounted systems expected to function in these extreme temperature variations can cause operational issues if not designed properly.

For example, heat affects the magnetic strength of permanent magnets embedded in the rotor. As heat increases, motor performance decreases. The solution to this challenge is to incorporate permanent magnets that are constructed from an alloy that provides greater magnetic power at higher and lower temperatures. For example, either rare-earth samarium-cobalt or neodymium are both used for this purpose.
Heat also drastically effects the life of the bearings used in the motor and therefore shortens the lifespan of the whole system. To alleviate this problem, it is necessary to use bearings with grease that can withstand high dynamic temperature ranges—from 80°C to +200°C. Any type of oil or grease imaginable can be specified for a particular application, including dry-lube, no-lube. Plus, high-temperature, non-outgassing bearings can be designed in as well.

Excessive heat generated by the motor itself can also be an issue. Although all motors generate some heat, in a vacuum environment, this can become a major problem because there is no atmospheric medium through which heat can dissipate—from the motor or the vehicle. On Earth, air acts as a conductor, which dissipates the generated heat, while in space, heat needs to be dissipated by other means. Those other means often include unwanted weight additions and increased mass, which adds unnecessary build complexity into the craft or satellite. Further, any heat generated by a stepper motor can affect nearby instruments and components, especially in insulated areas of the craft. By optimizing the winding of the stepper motor, the amount of heat generated can be reduced considerably. In addition, the incorporation of conductive pathways in the motor design also assist in temperature management. These pathways include thermally conductive materials that allow for heat dissipation between the insulator (glue) and motor end bells.

**VIBRATION MANAGEMENT**

Getting a spacecraft into orbit is a violent ordeal. Components are exposed to high amplitude vibration, low amplitude vibration, and shock from several different directions during the launch. Then there are the vibrations generated by the stepper motor during its normal operations.

The optimization of the motor windings is a practical way to minimize the resonance frequency that develops at specific operating speeds. By using high quality components, which are specifically machined to high concentricity and dimensional accuracy, it is possible to ensure that components such as rotors or shafts do not introduce unwanted vibrations into the system.

In space, however, vibrations need to be avoided at every turn. Unwanted vibration can affect on-board sensors and instruments. Low-level oscillations can affect measurement sensors as well as the quality of imaging devices. Dampening vibrations in a microgravity environment is challenging since the craft or satellite is suspended in space where there is nothing to transfer the energy to. Every component has to withstand these challenges, which is why every stepper motor designed for space must use the proper materials to create the structural integrity to handle any and all expected forces it may encounter—without altering dimensional accuracy or mechanical integrity. In fact, Lin Engineering has incorporated such materials in their standard motors, which makes them sufficiently robust for space applications where launch stress and wide temperature variations are typical.

**OUTGASSING AND CONTAMINATIONS**

On the microscopic level, there are plenty of gases and liquids trapped inside of paints, coatings, greases, and materials. In the vacuum of space, these trapped gases from inside the motor can expand or condensate, and liquids can evaporate, introducing unwanted contaminates into the environment. If these contaminates settle on imaging sensors, measurement instruments, or other critical systems, they will reduce overall performance or render them useless.

Motors can be designed to minimize outgassing. This happens when all of the stepper motor components—including the end caps, stator, rotor, and screws—are made from low outgassing materials. Most components on the motors are metal alloys, which, without paint, are rated for vacuum use. Plastic materials used in the design are non-outgassing polymide or nylon. Special sealed bearings filled with low outgassing lubricants are also available. Additionally, all components are thoroughly cleaned and vacuum baked. After the bake-out process each stepper motor is assembled in a cleanroom environment and vacuum sealed to ensure no contaminates enter the package during transportation and storage. Finally, corrosion protection is achieved by the use of specially made vacuum- and space-compatible coatings, whether for ferrous components or aluminum.

Overall, the longevity of components that go into space is a factor of the time and effort put into the proper design of the components and their final assembly using the latest materials while manufactured in a clean room facility. Maintaining the value of a product is always evident by the time put into understanding the environment in which it will be placed. Space flight and satellite applications require a keen sense of the problems associated with their operating environment. Lin Engineering has provided custom motors for a wide variety of applications, and has the expertise to design a stepper motor for use in any harsh environment, including deep space.

**PROPRIETARY MOTOR ASSEMBLY PROCESS**

In order to create the cleanest motor on the market, we’ve created our own motor assembly process and put the results to the test—against a known competitor’s motor. To do so, we placed our motor into a positive flow chamber (N2 Gas flow 5mm/1min) and measured its outgassing levels over a 72 hour period at a temperature of 125°C. Then we took the following measurements:

- **Total Mass Loss Percentage (%TML)**—The larger the percentage, the more contaminated the specimen.
- **Total Mass Loss (ug/motor)**—This is the weight of the mass that was evaporated into the chamber from the specimen. The larger the number, the more contaminated the specimen.

**OUR RESULTS**

<table>
<thead>
<tr>
<th>SAMPLE</th>
<th>% TOTAL MASS LOSS (TML)</th>
<th>MASS LOSS (ug/motor)</th>
</tr>
</thead>
<tbody>
<tr>
<td>COMPETITOR</td>
<td>0.030</td>
<td>105,000</td>
</tr>
<tr>
<td>LIN ENGINEERING</td>
<td>0.008</td>
<td>20,000</td>
</tr>
</tbody>
</table>

The Lin Engineering vacuum rated motor lost far less mass than the competitor’s motor, proving the cleanliness of the system. Our cleaning process in 375% cleaner than the competition.

**ADDITIONAL APPLICATIONS**

**Cleanrooms**

Since vacuum rated motors do not introduce contaminates into the environment, they are perfect for sensitive environments where outgassing needs to be avoided, particularly during the semiconductor manufacturing process where even the smallest contamination can ruin the production yield.

**Vacuum chambers**

Vacuum rated motors are often used in vacuum chambers for testing and manufacturing purposes.
### VACUUM MOTOR OPTIONS

#### 211 Series
- **NEMA 11 (28 mm)**
- **Up to 16 oz-in (0.12 N·m)**
- **Holding Torque**

#### Specifications

<table>
<thead>
<tr>
<th>Dimension A (MAX)</th>
<th>Model Number</th>
<th>Connection</th>
<th>Rated Current (Amps/Phase)</th>
<th>Holding Torque (oz-in)</th>
<th>Resistance (Ohms/Phase)</th>
<th>Inertia (oz-in²)</th>
<th>Weight (Lbs.)</th>
<th>Number of Leads</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.26&quot; (32.0 mm)</td>
<td>211-13-01</td>
<td>Bipolar</td>
<td>0.67</td>
<td>9.2</td>
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<td>0.24</td>
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<tr>
<td>1.77&quot; (45.0 mm)</td>
<td>211-18-01</td>
<td>Bipolar</td>
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<td>7.00</td>
<td>0.31</td>
<td>0.35</td>
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<tr>
<td>2.05&quot; (51.3 mm)</td>
<td>211-20-01</td>
<td>Bipolar</td>
<td>0.67</td>
<td>16.6</td>
<td>0.32</td>
<td>8.60</td>
<td>0.32</td>
<td>0.44</td>
</tr>
</tbody>
</table>

#### Dimensions

![Dimensions Diagram](image)

#### Torque Curves

- **211-13-01**
  - DC, 0.47 Amps/Phase, Bipolar, 1/2 Stepping

- **211-18-02**
  - DC, 0.67 Amps/Phase, Bipolar, 1/2 Stepping

- **211-20-01**
  - DC, 0.67 Amps/Phase, Bipolar, 1/2 Stepping

#### 4118 Series
- **NEMA 17 (42 mm)**
- **Up to 115 oz-in (0.81 N·m)**
- **Holding Torque**

#### Specifications

<table>
<thead>
<tr>
<th>Dimension A (MAX)</th>
<th>Model Number</th>
<th>Connection</th>
<th>Rated Current (Amps/Phase)</th>
<th>Holding Torque (oz-in)</th>
<th>Resistance (Ohms/Phase)</th>
<th>Inertia (oz-in²)</th>
<th>Weight (Lbs.)</th>
<th>Number of Leads</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.34&quot; (34.0 mm)</td>
<td>4118S-04P</td>
<td>Parallel</td>
<td>1.34</td>
<td>42.0</td>
<td>0.30</td>
<td>2.50</td>
<td>0.18</td>
<td>0.40</td>
</tr>
<tr>
<td>1.58&quot; (40.3 mm)</td>
<td>4118M-06P</td>
<td>Parallel</td>
<td>1.40</td>
<td>53.0</td>
<td>0.44</td>
<td>2.70</td>
<td>0.28</td>
<td>0.60</td>
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<tr>
<td>1.89&quot; (48.0 mm)</td>
<td>4118L-07S</td>
<td>Series</td>
<td>1.05</td>
<td>83.0</td>
<td>0.59</td>
<td>5.20</td>
<td>0.37</td>
<td>0.70</td>
</tr>
<tr>
<td>2.34&quot; (59.4 mm)</td>
<td>4118C-01</td>
<td>Bipolar</td>
<td>2.00</td>
<td>115.0</td>
<td>0.88</td>
<td>2.00</td>
<td>0.56</td>
<td>0.90</td>
</tr>
</tbody>
</table>

#### Dimensions

![Dimensions Diagram](image)

#### Torque Curves

- **4118S-04P**
  - DC, 1.44 Amps/Phase, Bipolar Parallel, 1/2 Stepping

- **4118M-06P**
  - DC, 1.8 Amps/Phase, Bipolar Parallel, 1/2 Stepping

- **4118L-07S**
  - DC, 2.0 Amps/Phase, Bipolar Series, 1/2 Stepping

- **4118C-01**
  - DC, 2.3 Amps/Phase, Bipolar Series, 1/2 Stepping

More Torque Curves available online at www.linengineering.com
**5718 Series**

- NEMA 23 (57 mm)
- Up to 305 oz-in (2.16 N-m)
- Holding Torque

## Specifications

<table>
<thead>
<tr>
<th>Dimension A (MAX)</th>
<th>Model Number</th>
<th>Connection</th>
<th>Rated Current (Amps/Phase)</th>
<th>Holding Torque (in-lb)</th>
<th>Resistance (Ohms/Phase)</th>
<th>Inertia (oz-in²)</th>
<th>Weight (Lbs.)</th>
<th>Number of Leads</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.74” (94.4mm)</td>
<td>5718X-01P</td>
<td>Parallel</td>
<td>2.80</td>
<td>100.0</td>
<td>0.70</td>
<td>1.0</td>
<td>1.05</td>
<td>4</td>
</tr>
<tr>
<td>2.32” (58.4 mm)</td>
<td>5718M-02P</td>
<td>Parallel</td>
<td>4.20</td>
<td>173.0</td>
<td>0.50</td>
<td>1.5</td>
<td>1.50</td>
<td>4</td>
</tr>
<tr>
<td>3.10” (78.7 mm)</td>
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<td>2.80</td>
<td>204.0</td>
<td>1.00</td>
<td>2.0</td>
<td>2.00</td>
<td>4</td>
</tr>
</tbody>
</table>

**Dimensions**

**Torque Curves**

**Ask us about more vacuum options:**
- Bigger and Smaller motors
- 0.9° and 0.45° step angle

More Torque Curves available online at www.linengineering.com

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**Sealed Motors**

**FOR AVIATION INDUSTRY**

- Manufactured in accordance to AS9100D standards
- IP65 and IPX7 rated
- Sealed and protected against weather
- Wide temperature operation range

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**AEROSPACE INDUSTRY APPLICATIONS FOR IP RATED MOTORS**

The aerospace industry—and especially general aviation applications—where exposure to the elements can cause problems with your equipment, it is essential to use IP Rated motors manufactured in accordance to AS9100D Aerospace Standards. Aerospace engineers constantly face the challenge of designing products that will be exposed to a variety of environments including:

- Rain & snow
- Sleet & ice
- Dust & dirt
- Mud & Slush
- Airborne Particulates
- Miscellaneous debris

Taking environmental conditions under consideration during the design process, will allow for product features that can eliminate even microscopic levels of dust. Although, IP ratings assure that levels of dust and moisture are within the range of the protection code they are given, additional elements must also be controlled—like the ability to operate under the wide temperature ranges.

Material selection is a critical design concern when working with aerospace industry applications. Not only must the devices be properly sealed, they must provide component longevity to maintain operation when located in areas that may be exposed to the environment.

For motor design, the proper IP Ratings might require permanent joints that are continuous. Motor surfaces that are smooth, impervious, and free of sharp corners. Materials must provide a minimum of outgassing, and be quiet in operation. Because we’ve worked in this industry for years, our IP65 and IPX7 motors are ideal for aerospace applications. Contact us for specific information.

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**Sealed Motors**

**FOR AVIATION INDUSTRY**

- Manufactured in accordance to AS9100D standards
- IP65 and IPX7 rated
- Sealed and protected against weather
- Wide temperature operation range
**MOTORS AVAILABLE WITH THE IP65 & IPX7 RATING**

<table>
<thead>
<tr>
<th>Series</th>
<th>Version</th>
<th>Stepper Angle</th>
<th>Rating</th>
<th>Torque</th>
</tr>
</thead>
<tbody>
<tr>
<td>4118</td>
<td>NEMA 17</td>
<td>1.8 Deg</td>
<td>IP65 and IPX7 Rated</td>
<td>Up to 125 oz-in (0.88 N-m)</td>
</tr>
<tr>
<td>5718</td>
<td>NEMA 23</td>
<td>1.8 Deg</td>
<td>IP65 and IPX7 Rated</td>
<td>Up to 294 oz-in (2.08 N-m)</td>
</tr>
<tr>
<td>8718</td>
<td>NEMA 34</td>
<td>1.8 Deg</td>
<td>IP65 and IPX7 Rated</td>
<td>Up to 1,288 oz-in (9.09 N-m)</td>
</tr>
</tbody>
</table>

**ADDITIONAL APPLICATIONS**

- **Avionics**
  IP rated motors can be used in avionic devices which may be exposed to outside environment, such as communication and navigation equipment.

- **Control surfaces**
  Sealed motors are ideal for implementation in aircraft control surfaces that are exposed to harsh environment.

- **Externally mounted application**
  Any application that can come in contact with the outside environment.
Sealed Motors

**IP65/IPX7**

**Features and Benefits**

- Dust proof
- Water resistant
- Multiple stack lengths

Every new application creates its own restrictions and challenges, so when you discover that your motion system will have to operate in extreme environmental conditions, such as rain, dust, or even under water, what do you do?

Luckily, Lin Engineering continues to research, develop, and unveil cutting-edge technologies to facilitate wider and wider ranges of applications. While the company’s standard lines of stepper motors are well-known for their durability, their IP65 and IPX7 lines can also withstand harsh environments where typical motors will fail.

**IP65 Sealed Steppers**

The IP65 Rated Series provides dust proof operation, and can withstand low-pressure jets of water sprayed from all directions from a distance as close as three meters for extended periods of time. The water jets can be delivered at pressures of up to 30kPa, at a rate of 12.5 l/min, and for durations of up to three minutes. In addition to extended protection from challenging environmental factors, the IP65 rated motors have a food grade coating, making them ideal for the wash down cycles of food processing applications.

**Motors Available with the IP65 & IPX7 Rating**

- **4118 Series**
  - NEMA 17
  - 1.8 Deg Step Angle
  - IP65 and IPX7 Rated Motor
  - Up to 125 oz-in (0.88 Nm) Holding Torque

- **5718 Series**
  - NEMA 23
  - 1.8 Deg Step Angle
  - IP65 and IPX7 Rated Motor
  - Up to 294 oz-in (2.08 Nm) Holding Torque

- **8718 Series**
  - NEMA 34
  - 1.8 Deg Step Angle
  - IP65 and IPX7 Rated Motor
  - Up to 1,288 oz-in (9.09 Nm) Holding Torque

**IPX7 Sealed Steppers**

The IPX7 Rated Series of motors are completely protected against dust and withstand immersion into liquids at depths of 15cm to 1m for up to 30 minutes or longer. Lin Engineering stepper motors are now available with an IPX7 Rating in three sizes—NEMA 17, 23, and 34. The motors are capable of producing holding torque up to 1,288 oz-in. Plus, unipolar and bipolar windings are available to allow for the torque and speed required to accommodate your specific application.
**IP Motors Applications**

**Food**
Commonly used in food production and packaging applications. IP65 and IPX7 use FDA approved coatings and are suitable for wash-down procedures.

**Aerospace**
IP65 and IPX7 stepper motors are routinely used in Aerospace applications where motors are exposed to extreme environments. For instance: wing control surfaces, landing gears, and other externally mounted applications. Our IP65 and IPX7 motors are assembled in accordance to AS9100D Aerospace standards.

**Medical**
Medical and Laboratory equipment such as liquid handlers or devices exposed to moisture or particles.

**Harsh Environment**
Any application where dust, liquids, or corrosion is of concern.

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**Specifications**

<table>
<thead>
<tr>
<th>Model Number</th>
<th>Connection</th>
<th>Rated Current (Amps/Phase)</th>
<th>Holding Torque (oz-in)</th>
<th>Resistance (Oms/Phase)</th>
<th>Inertia (oz-in sec)</th>
<th>Weight (Lbs)</th>
<th>Number of Leads</th>
</tr>
</thead>
<tbody>
<tr>
<td>4118S-04P</td>
<td>Bipolar</td>
<td>1.34</td>
<td>42.0</td>
<td>0.30</td>
<td>2.50</td>
<td>0.18</td>
<td>0.40</td>
</tr>
<tr>
<td>4118M-06P</td>
<td>Parallel</td>
<td>1.40</td>
<td>43.0</td>
<td>0.46</td>
<td>2.70</td>
<td>0.29</td>
<td>0.50</td>
</tr>
<tr>
<td>4118L-07S</td>
<td>Series</td>
<td>1.05</td>
<td>83.0</td>
<td>0.59</td>
<td>5.20</td>
<td>0.37</td>
<td>0.70</td>
</tr>
<tr>
<td>4118C-01</td>
<td>Bipolar</td>
<td>2.00</td>
<td>115.0</td>
<td>0.88</td>
<td>2.00</td>
<td>0.56</td>
<td>0.90</td>
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**Dimensions**

<table>
<thead>
<tr>
<th>Dimension A (Max)</th>
<th>Model Number</th>
<th>Connection</th>
<th>Rated Current (Amps/Phase)</th>
<th>Holding Torque (oz-in)</th>
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<td>0.40</td>
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<tr>
<td>1.60” (40.1mm)</td>
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<td>2.70</td>
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<td>1.85” (48.0mm)</td>
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<td>0.59</td>
<td>5.20</td>
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<td>2.34” (59.4mm)</td>
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<td>0.90</td>
</tr>
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</table>

**Torque Curves**

**4118 Series**
- NEMA 17 (42 mm)
- Up to 115 oz-in (0.81 N-m)

**Holding Torque**

<table>
<thead>
<tr>
<th>Model Number</th>
<th>Connection</th>
<th>Rated Current (Amps/Phase)</th>
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<td>83.0</td>
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<td>115.0</td>
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<td>0.56</td>
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</table>

More Torque Curves available online at www.linengineering.com
# Specification Data

## 5718 Series

- **NEMA 23 (57 mm)**
- **Up to 305 oz-in (2.16 N-m)**

### Dimensions

<table>
<thead>
<tr>
<th>Dimension A (MAX)</th>
<th>Model Number</th>
<th>Connection</th>
<th>Rated Current (Amps/Phase)</th>
<th>Holding Torque (oz-in)</th>
<th>Resistance (Ohms/Phase)</th>
<th>Inertia (oz-in²)</th>
<th>Weight (Lbs.)</th>
<th>Number of Leads</th>
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<td>5718L-01P</td>
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<td>1.00</td>
<td>2.60</td>
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</tr>
</tbody>
</table>

### Torque Curves

![5718M-02P Torque Curve](image)

![5718L-01P Torque Curve](image)

More Torque Curves available online at www.linengineering.com

## 8718 Series

- **NEMA 34 (80 mm)**
- **Up to 1288 oz-in (9.09 Nm)**

### Dimensions

<table>
<thead>
<tr>
<th>Dimension A (MAX)</th>
<th>Model Number</th>
<th>Connection</th>
<th>Rated Current (Amps/Phase)</th>
<th>Holding Torque (oz-in)</th>
<th>Resistance (Ohms/Phase)</th>
<th>Inertia (oz-in²)</th>
<th>Weight (Lbs.)</th>
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<tbody>
<tr>
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<tr>
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<td>Series</td>
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<td>1288.0</td>
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<td>1.20</td>
<td>6.44</td>
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</table>

### Torque Curves

![8718M-03S Torque Curve](image)

![8718N-03S Torque Curve](image)

![8718M-05S Torque Curve](image)

More Torque Curves available online at www.linengineering.com

Ask us about more vacuum options:
- Bigger and Smaller motors
- 0.9° and 0.45° step angle
Lin Engineering standard motors are rated to operate in ambient temperatures between 50 degrees C and -20 degrees C. While this satisfies the majority of uses, there are certain applications that require the motor to operate at higher or lower temperature ranges than what standard motors allow for. Unfortunately, operating standard motors anywhere outside these temperature ranges will result in poor performance.

Like any specific application concerns, motors that must work under extreme conditions of hot and cold require critical design features to accommodate their use. Whether your application is situated in the heat of a desert or the freezing temperatures of the arctic, Lin Engineering has the expertise to provide the right motor for you. The company has designed two types of specialty hot/cold motors meant to operate specifically in extreme temperature ranges—Type I and Type II.

Magnet performance degrades at high temperatures unless a special alloy with high-temperature tolerance and high curie point is used—similar to what might be used in a space or vacuum motor depending on the application. For these applications, the wire has to have special insulation that can tolerate high heat as well. Upgraded insulation also helps to reduce stress fractures due to heat-up and cool-down cycles. Type II motors require additional insulation material to prevent burnout.

The bearings for hot/cold motors require special grease dependent on whether they are used in high or low temperature and can be selected at the time of purchase for the specific application they will be used for.

Through the use of higher grade, specially formulated materials, motors can be designed for extreme temperatures well beyond what a standard motor can withstand. Other factors that can affect motor use in extreme temperature situations includes how often the load is applied. Most standard motor ratings are for continuous duty operation, but if your load cycling specifications are anything less than continuous, it will affect your motor selection process.

Although most Lin Engineering motors are available as Type I components, we currently have two standard Type II motors available:

### APPLICATION EXAMPLES

**Refrigerated Environments**
Medical and Laboratory equipment such as liquid handlers or devices exposed to moisture or particles.

**Heated Environment**
Perfect for use in devices operating in heated environments or exposed to heat for extended periods of time.

### MOTOR OPTIONS

<table>
<thead>
<tr>
<th>MOTOR FRAME</th>
<th>TORQUE RANGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>NEMA 8 (20mm)</td>
<td>up to 4 oz-in (0.03Nm)</td>
</tr>
<tr>
<td>NEMA 11 (28mm)</td>
<td>up to 16 oz-in (0.12Nm)</td>
</tr>
<tr>
<td>NEMA 17 (42mm)</td>
<td>up to 115 oz-in (0.81Nm)</td>
</tr>
<tr>
<td>NEMA 23 (57mm)</td>
<td>up to 305 oz-in (2.16Nm)</td>
</tr>
<tr>
<td>NEMA 34 (80mm)</td>
<td>up to 1,288 oz-in (9.09Nm)</td>
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### OPERATING CONDITIONS

<table>
<thead>
<tr>
<th>TYPE I</th>
<th>OPERATING CONDITIONS:</th>
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<tbody>
<tr>
<td>Range</td>
<td>Ambient: -40°C to 80°C</td>
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<table>
<thead>
<tr>
<th>TYPE II</th>
<th>OPERATING CONDITIONS:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Range</td>
<td>Ambient: -40°C to 110°C</td>
</tr>
</tbody>
</table>
A conventional hybrid stepper motor utilizes a permanent magnet in the rotor. Our patented design uses a ring magnet in the stator instead. This drastically reduces the detent torque (unenergized drag torque) because the magnetic flux path is able to reach over the stator windings and only go through the outer edge of the rotor. Reducing detent torque improves accuracy, smooth operation and reduces noise. Best of all, modifying the magnet location does not change the dynamic torque.

**Extreme Step Accuracy**
Z-Series motor maintains ±1.5 arc minutes error under 64x microstepping. Industry average can range from ±4.5 to ±18 arc minutes in 0.9° step motors.

**Quiet Operation**
By eliminating detent torque, the motor operates substantially quieter than regular hybrid stepper motors.

**Application**
Z-Series motors are perfect for any application which requires extreme precision, smoothness, and quiet operation.
Conventional stepper motors cannot accommodate large diameter shafts without sacrificing torque and performance. Torque is dependent on the size of the magnet placed in the rotor. A large diameter shaft reduces space available for the magnet, thus sacrificing torque.

Since we’ve moved the magnet from the rotor into the stator stack, we can accommodate a large shaft without sacrificing torque or performance.

**Performance**
ZH-Series motors benefit from the same performance enhancements as the Z-Series motors. Eliminating the detent torque drastically improves the accuracy, smoothness and noise emissions.

**Application**
ZH-Series motors are perfect for any application which requires a hollow shaft. Hollow shaft lets you pass instrumentation through the motor and are ideal for:
- Hollow Shaft up to 11mm in diameter
- No Torque Loss Due to Large Hollow Bore
- Up to 33.5 oz-in (0.24 N-m) Holding Torque
- Smooth and Quiet Operation

Zen technology significantly reduces vibration without the use of external dampers: this results in extremely smooth and accurate motion.

**Application**
Vibration can cause serious problems when smooth and precise motion is critical. This is especially the case in the semiconductor industry where assemblies are getting exponentially smaller or medical applications where precision and accuracy could literally be a life or death matter.
**Z417 Series**

### SPECIFICATIONS

<table>
<thead>
<tr>
<th>Dimension A (MAX)</th>
<th>Model Number</th>
<th>Rated Current (Amps. /Phase)</th>
<th>Holding Torque (oz-in)</th>
<th>Resistance (Ohms/Phase)</th>
<th>Inertia (oz-in²)</th>
<th>Weight (Lbs.)</th>
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**ZN417 Series**

### SPECIFICATIONS

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<th>Dimension A (MAX)</th>
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<th>Rated Current (Amps. /Phase)</th>
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**Z SERIES MOTOR OPTIONS**

- More Torque Curves available online at www.linengineering.com
## Z417 Series

### Specifications

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<tr>
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</table>

### Dimensions

![Dimensions Diagram](image)

### Torque Curves

- ZH417-11-03 (0.9° Step Motor) 24VDC, 1.2 Amp/Phase, Bipolar, 1/2 Stepping
- ZH417-11-06 (0.9° Step Motor) 24VDC, 1.2 Amp/Phase, Bipolar, 1/2 Stepping
- ZH417-11-09 (0.9° Step Motor) 24VDC, 0.8 Amp/Phase, Bipolar, 1/2 Stepping
- ZH417-11-02 (0.9° Step Motor) 24VDC, 0.8 Amp/Phase, Bipolar, 1/2 Stepping

More Torque Curves available online at www.linengineering.com

### Ask us about more vacuum options:
- Bigger and Smaller motors
- 0.9° and 0.45° step angle
**ENHANCED MOTORS**

**Hercules STEPPER MOTORS**

**EXTREME TORQUE IN A SMALL PACKAGE**

- Up to 40% More Holding Torque
- Less Resonance
- More Efficient

**HOW DO THE HERCULES STEPPER WORKS?**

Inherently, every stepper has flux leakage which equates to torque loss. By inserting magnetic pins within the rotor, Lin Engineering was able to mitigate flux leakage, resulting in improved torque by up to 40%.

**Available Hercules Motors**

**NEMA 23 | 1.8° Step Angle**

- **E5618**
  - HOLDING TORQUE
  - Up to 150 oz-in (1.06 N·m)
  - 2.01" Max body length

**NEMA 34 | 1.8° Step Angle**

- **E8718**
  - HOLDING TORQUE
  - Up to 600 oz-in (4.20 N·m)
  - 3.54" Max body length

Hercules steppers provide up to 40% more torque throughout the entire speed range than standard motor of the same size.

**Less Resonance**

Hercules steppers generate less resonant frequency due to the oscillation. Making the motor smoother, quieter, and precise.

**Available Hercules Motors**

**NEMA 23 | 1.8° Step Angle**

- **E5618**
  - HOLDING TORQUE
  - Up to 150 oz-in (1.06 N·m)
  - 2.01" Max body length

**NEMA 34 | 1.8° Step Angle**

- **E8718**
  - HOLDING TORQUE
  - Up to 600 oz-in (4.20 N·m)
  - 3.54" Max body length
The 106 measures just 16mm in width, making it one of the smallest Hybrid Stepper Motors on the market today. The NEMA 6 frame size means that the 106 Hybrid Stepper Motor can be designed into challenging spots with minimal allotted space. Spots where conventional hybrid stepper motors could not previously fit. This opens up a far broader Engineering flexibility and the ability to design much smaller equipment.

By increasing the step angle from a typical 1.8 degree to 3.46 degree, we are able to achieve nearly twice as much holding torque as the closest competing design, and nearly four times more holding torque than a conventional permanent magnet (PM) stepper motor of similar size (which usually top-out at only 0.5 oz-in of holding torque).

A typical PM motor may only deliver 20 steps per revolution, or a step angle of 18 degrees. In comparison, our 3.46 degree motor delivers 5.7 times higher resolution than a typical PM motor. High resolution translates to higher precision. The 106 offers all of the benefits of a hybrid stepper, and none of the drawbacks of a PM motor.

The 106 can deliver similar speed performance of a BLDC motor. By combining the 3.46 degree step angle with our low inertia rotor design, we are able to achieve over 1 oz-in of dynamic torque at 8,000 RPM.

One of the biggest problems Engineers face while designing ever-smaller devices is making things move. As the size of equipment decreases, the demand for smaller motors increases. However, oftentimes small enough motors simply don’t exist, and if they do, they do not provide enough torque or speed to be useful in the application. Often, the only option is to use a large framed motor and shrink everything else around it. Motion control is the real bottleneck which forces Engineers to compromise on the footprint of their device.

Our new 106 Hybrid Stepper Motor is what many Engineers have been waiting for. It solves many of the problems in motion control which prevented equipment from getting smaller.

By applying our experience and our Engineering know-how in the field of Hybrid Stepper Motor technology, we were able to succeed where many have failed. We’ve successfully created a NEMA 6 sized stepper motor that delivers plenty of performance. The 106 outperforms all other motors of similar size on nearly all metrics: it delivers more torque at higher speeds with greater accuracy.

### Application Examples

The 106 is a perfect candidate for many applications that require tiny motors, especially in the field of medical devices and laboratory automation. Applications that require high degree of precision like miniature pumps, fluid metering and control, and optical sensor controls can take advantage of the 106 motor. The 106 can even be incorporated into motorized hand tools like electronic pipettes, and other handheld devices where Hybrid Stepper Motors were previously impossible to integrate.
**STEPPER MOTORS**

**3709**

- NEMA 14, 0.9° Step Angle
- Signature Series Technology for ultimate smooth motion and high accuracy
- 8 different mounting options
- Up to 16 oz-in (0.12 N·m) holding torque.

**THIN & COMPACT**

3709 Series motors feature a flat/puck-shaped design and range from 14 to 22 mm in thickness. Making the motor a perfect fit for compact and portable devices, where size or weight is essential.

**HOW DID WE DO IT?**

The motors feature a unique end-cap design that incorporates the bearings, and the entire unit is sealed and laser welded for strength and longevity of the product. Being resourceful allows us to create a very compact motor.

**SLIM & COMPACT**

**PART OF OUR SIGNATURE SERIES**

0.9 Degree step angle ensures smooth motion, while Signature Series further reduces resonance for higher accuracy. The Signature Series was developed to help reduce system resonance and provide overall smooth motion.

Depending on Application, using motors with the Signature Series technology may result in up to 40% less resonance being produced.

**REDUCE RESONANCE**

Depending on application, Signature Series Stepper Motor user can expect anywhere from 10-40% less resonance being produced.

**INCREASE ACCURACY**

The design creates double the detent positions (un-energized caging) in the standard stepper. When doubled, the amount of torque or drag that each detent position has is decreased by half, thus creating a smoother motor during operation.

**AVAILABLE OPTIONS**

- **Custom Winding**: Custom windings can insure maximum torque at a desired speed. This service is offered free of charge.
- **Customized Leads**: Custom connections can range from EMI or IP protection, to custom color coding.
- **Various Shaft Options**: With in-house machining capabilities, we’re able to provide a variety of shaft options at a cost effective price with minimal lead times.

3709 Series motors are capable of producing up to 16 oz-in of holding torque. This is quite astounding for such a small motor.

**HIGH TORQUE**

3709 Series motors are capable of producing up to 16 oz-in of holding torque. This is quite astounding for such a small motor.

**MULTIPLE MOUNTING OPTIONS**

Motors are offered in variety of standard mounting options in NEMA 17 offsets. Available hole patterns include Thru hole D0 0.13, #4-40 UNC and M3 x 0.5.

Additionally, Lin Engineering can place the motor in almost any customer supplied/designed housing imaginable. Multiple Shaft options are also available.

**Laser welded**

14 to 22 mm
Compact & Powerful
STEP MOTOR
G3718V

- Improved passive cooling by design
- Up to 50% more torque than similar size motors
- Smooth Motion, high accuracy similar to a 0.9° motor
- Holding Torque: Up to 25 oz-in (0.18N-m)

The G3718V whisper torque motor incorporates a heat-sink design within the stator laminations to allow for passive cooling. When your motor operates cooler, you can increase power to gain more torque without overheating, or you can save energy and still perform at an optimal performance. This is what makes all G-series steppers from Lin so unique: the motors are green and energy efficient.

It’s Slimmer
The G3718V is slim by design. End caps are laser welded to the stator, eliminating much wasted space in traditional stepper motor designs. This laser welding assembly eliminates the need for assembly screws to hold the motor together. This unique construction offers great length to torque ratio. At only 22.8mm long, the motor produces 25 oz-in of torque. Applications can mount this motor by utilizing the 4 through holes that are designed into the stator lamination.

It’s Customizable
If encoder feedback is needed, the sleek and slim CUI encoder is a great addition to the G3718V. The CUI incremental encoder uses a patented capacitive ASIC Technology with low power consumption. Choose from various quadrature resolutions up to 2048.

Application Examples
- PE Eletronic Assembly
- SMT Placement
- PTZ Camera
- Laboratory automation system

Available Options
- Custom Winding
  Custom windings can insure maximum torque at a desired speed. This service is offered free of charge.
- Customized Loads
  Custom connections can range from EMI or IP protection, to custom color coding.
- Various Shaft Options
  With in-house machining capabilities, we’re able to provide a variety of shaft options at a cost effective price with minimal lead times.

It’s Smooth, Quiet, Accurate, and Delivers Ample Amount of Torque
This stepper motor is a 1.8 degree per step motor, but it is as smooth as Lin’s smoothest 0.9 degree stepper. With all the know-how and technology that Lin Engineering brings, implementing key design aspects from the 0.9 line into the G3718V has created a motor that wins in both smoothness, accuracy and torque. In traditional designs, one must compromise torque for smoothness or vice versa. With the G3718V, you can still get both.
G3718V MOTOR OPTIONS

<table>
<thead>
<tr>
<th>Specifications</th>
<th>Dimensions</th>
<th>Torque Curves</th>
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### Dimensions

<table>
<thead>
<tr>
<th>Model Number</th>
<th>Rated Current (Amps/Phase)</th>
<th>Holding Torque (oz-in)</th>
<th>Inertia (oz-in•sec²)</th>
<th>Resistance (Ohms/Phase)</th>
<th>Weight (Lbs.)</th>
<th>Number of Leads</th>
</tr>
</thead>
<tbody>
<tr>
<td>G3718V-01</td>
<td>0.44</td>
<td>25</td>
<td>0.18</td>
<td>18.00</td>
<td>0.08</td>
<td>0.29</td>
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<tr>
<td>G3718V-02</td>
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<td>25</td>
<td>0.18</td>
<td>8.42</td>
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<td>1.20</td>
<td>25</td>
<td>0.18</td>
<td>2.33</td>
<td>0.08</td>
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<tr>
<td>G3718V-04</td>
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<td>25</td>
<td>0.18</td>
<td>1.39</td>
<td>0.08</td>
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<tr>
<td>G3718V-05</td>
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<td>0.18</td>
<td>33.13</td>
<td>0.08</td>
<td>0.29</td>
</tr>
</tbody>
</table>

### Torque Curves

- G3718V-01 24VDC, 0.44 Amps/Phase, Bipolar, 1/2 Stepping
- G3718V-02 24VDC, 0.65 Amps/Phase, Bipolar, 1/2 Stepping
- G3718V-03 24VDC, 1.20 Amps/Phase, Bipolar, 1/2 Stepping
- G3718V-04 24VDC, 1.60 Amps/Phase, Bipolar, 1/2 Stepping
- G3718V-05 24VDC, 0.30 Amps/Phase, Bipolar, 1/2 Stepping