SM3002

High Speed Servo Motor

Manual

PUSHCORP, INC.

Dallas, Texas

May, 2006

Do NOT start or stop the servo motor instantaneously. Doing so will damage the motor and power amplifier.

Do NOT overheat the servo motor. Supply the motor cooling water to maintain a temperature below 176 °F (80 °C).

Us the proper warm-up procedure before operating the motor at full speed.

All *PushCorp, Inc.* electrical cables are rated for high twist and flex robotic applications with a minimum cable bending radius specification of 125mm (5 in). Cable damage resulting from failure to abide by this specification will not be covered under warranty.

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1.0 Limited Warranty

Duration:

One year from date of delivery to the original purchaser.

Who gives this warranty (warrantor):

PushCorp, Inc.
Telephone: (972) 840-0208

Corporate Address:
P. O. Box 181915
Dallas, Texas 75218

Shipping Address:
3001 W. Kingsley Rd.
Garland, Texas 75041

Who receives this warranty (purchaser):

The original purchaser (other than for purposes of resale) of the *PushCorp, Inc.* product

What products are covered by this warranty:

Any *PushCorp, Inc.* industrial equipment or accessory supplied or manufactured by the Warrantor.

What is covered under this warranty:

Defects in material and/or workmanship which occur within the duration of the warranty period.

What is NOT covered in this warranty:

A. IMPLIED WARRANTIES, INCLUDING THOSE OF MERCHANT-ABILITY AND FITNESS FOR A PARTICULAR PURPOSE ARE LIMITED TO ONE YEAR FROM THE DATE OF ORIGINAL PURCHASE. Some states do not allow limitations on how long an implied warranty lasts, so the above limitations may not apply to you.

B. ANY INCIDENTAL, INDIRECT, OR CONSEQUENTIAL LOSS, DAMAGE or EXPENSE THAT MAY RESULT FROM ANY DEFECT, FAILURE, MALFUNCTION OF THE *PUSHCORP, INC.* PRODUCT. Some states do not allow the exclusion or limitation of incidental or consequential damages so the above limitation or exclusion may not apply to you.

C. Any failure that results from an accident, purchaser's abuse, neglect, unauthorized repair or failure to operate the products in accordance with the instructions provided in the owner's manual(s) supplied with the product.

Responsibilities of the Warrantor under this warranty:

Repair or replace, at Warrantor's option, products or components which have failed within the duration of the warranty period.

Responsibilities of the purchaser under this warranty:

A. Deliver or ship the *PushCorp, Inc.* product or component to PushCorp, Inc. Service Center, Dallas, TX. Freight and insurance costs, if any, must be borne by the purchaser.

B. Use reasonable care in the operation and maintenance of the product as described in the owner's manual(s).

When warrantor will perform repair or replacement under this warranty:

Repair or replacement will be scheduled and serviced according to the normal work flow at the service center, and depending on the availability of replacement parts. Purchasers requiring quicker repair may receive such with payment of a *PushCorp, Inc.* predetermined expediting fee.

This Limited Warranty gives you specific legal rights and you may also have other rights which vary from state to state.

2.0 General Overview

The SM3002 is PushCorp's smallest, lightest and fastest motor. Weighing in at 6 pounds (3 Kg), with 2 hp (1.5 kW), and a 30,000 RPM top speed, the motor excels in applications such as high-speed routing and de-burring. Servomotor technology keeps the rotational speed within +/-5% of the commanded speed providing efficiencies of over 90%. The manually clamped collet requires the user to change media.

The SM3002 High Speed Servo Motor has been developed as an alternative to inefficient and high maintenance air motors. The unit uses a high torque, water cooled, servo motor, with over 90% operational efficiency, to produce exceptional performance in a compact and light weight package. A manual ER-11 series collet is used, which provides the ability to clamp a very wide range of tool shaft diameters. The user may choose from a range of collets in the ER-11 series, 1/16 to 1/4 inch (0.5mm - 7 mm). The SM3002 uses sealed duplex spindle bearings to insure a long life with low run-out. The bearings have additional contamination protection from a PushCorp proprietary high speed motor shaft seal. This special seal eliminates the need for constant purge air, as required by other high speed motors.

During operation the SM3002 generates heat due to the compact size, speed, and high torque capability. Excessive operating temperatures will significantly reduce the life of the motor. The motor should never be allowed to exceed an internal temperature of 176 °F (80 °C). Operating the unit above 176 °F (80 °C) will cause the rotor to de-magnetize and the bearings to fail. High temperatures will also cause the O-rings that seal the cooling water channels to fail. PushCorp has provided for water cooling of the motor to allow high duty cycles without overheating.

Simple reliable construction combined with high speed and precision control make the *PushCorp* SM3002 a rugged, state-of-the-art Servo Motor.

3.0 Installation

3.1 Mounting the SM3002

3.1.1 Mounting to an AFD1000/70

The SM3002 Servo Motor is designed to be easily installed, removed, and accuately re-installed. The rear housing of the motor has a locating counterbore for accurated mounting. The counterbore is 1.000 inches (25.40 mm) in diameter, and .100 inches (2.54 mm) deep. The customer must provide a 1 inch boss on their mounting plate/bracket to use this feature. There is also a 5mm clocking hole provided on the housing. Figure 1 shows the overall mounting dimensions, and the location of these features.

The Parallel-Axis configuration, shown in Figure 2, illustrates the attachment of the SM3002 to the AFD Carriage with a customer supplied angle bracket. The Mounting Bracket is first attached to the AFD Carriage using the customer's fasteners. Then the SM3002 is positioned on the Mounting Plate, and securely attached using four (4) M5x.8x40mm Socket Head Cap Screws. Tighten the four (4) M5x.8 Socket Head Cap Screws to the torque specified in Section 4.0.

By rotating the mounting bracket and the SM3002 90 degrees to the Carriage, a Cross-Axis configuration can be achieved as shown in Figure 3. The unit is attached using the same fasteners and methodology as the Parallel-Axis configuration.

To attach the SM3002 to an AFD in a Perpendicular-Axis configuration (See Figure 4), the customer supplied mounting plate is first attached to the AFD Carriage. Then position and secure the SM3002 using the four (4), M5x.8x40mm, Socket Head Cap Screws. Tighten the fasteners to the torque specified in Section 4.0.

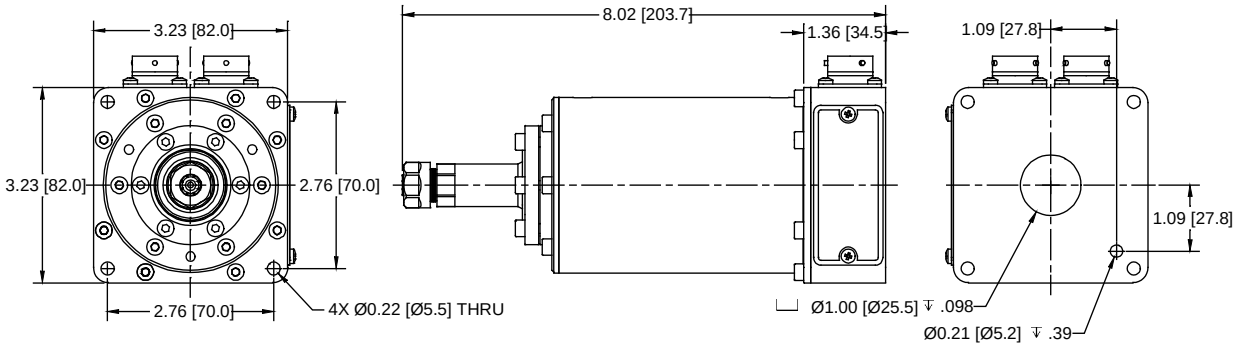


Figure 1. SM3002 Mounting Dimensions

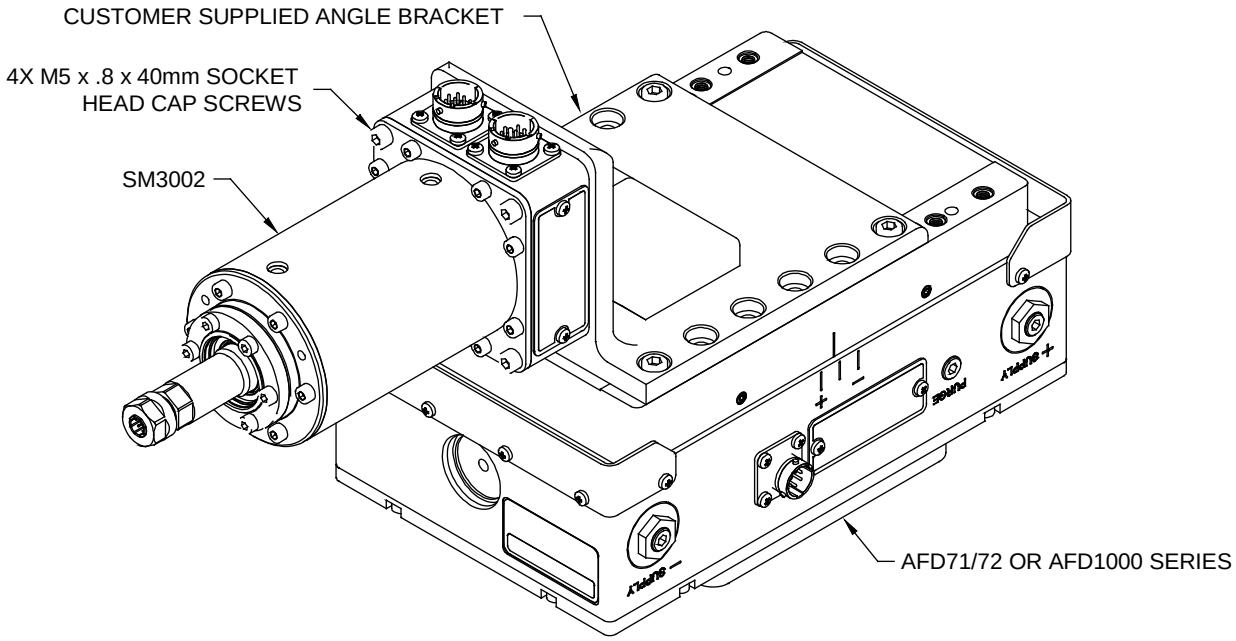


Figure 2. SM3002 Parallel-Axis Configuration

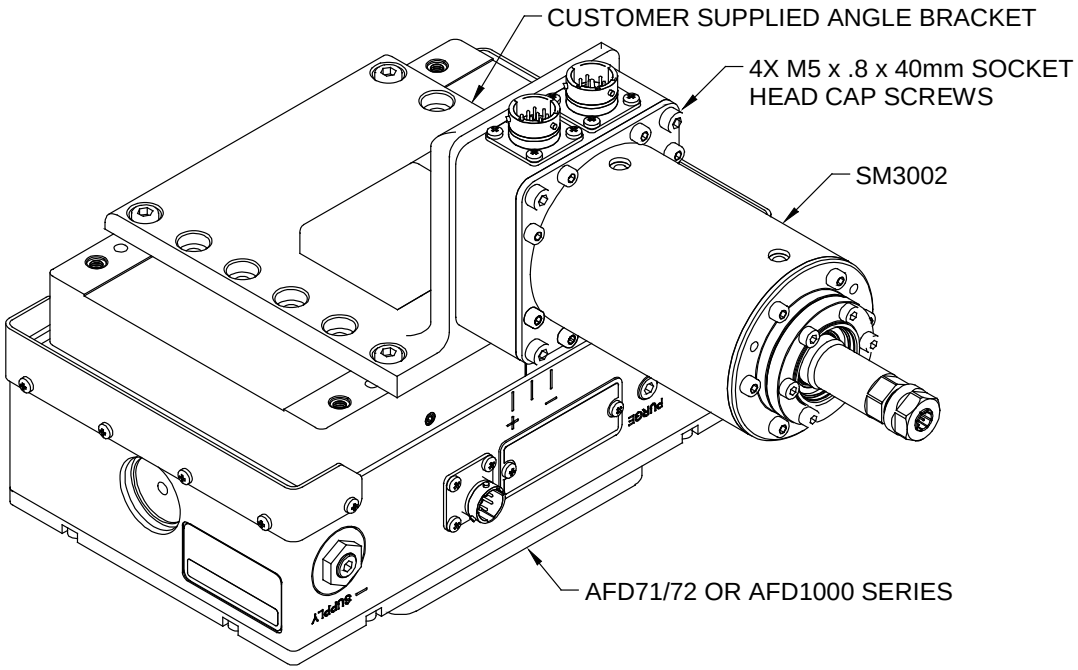


Figure 3. SM3002 Cross-Axis Configuration

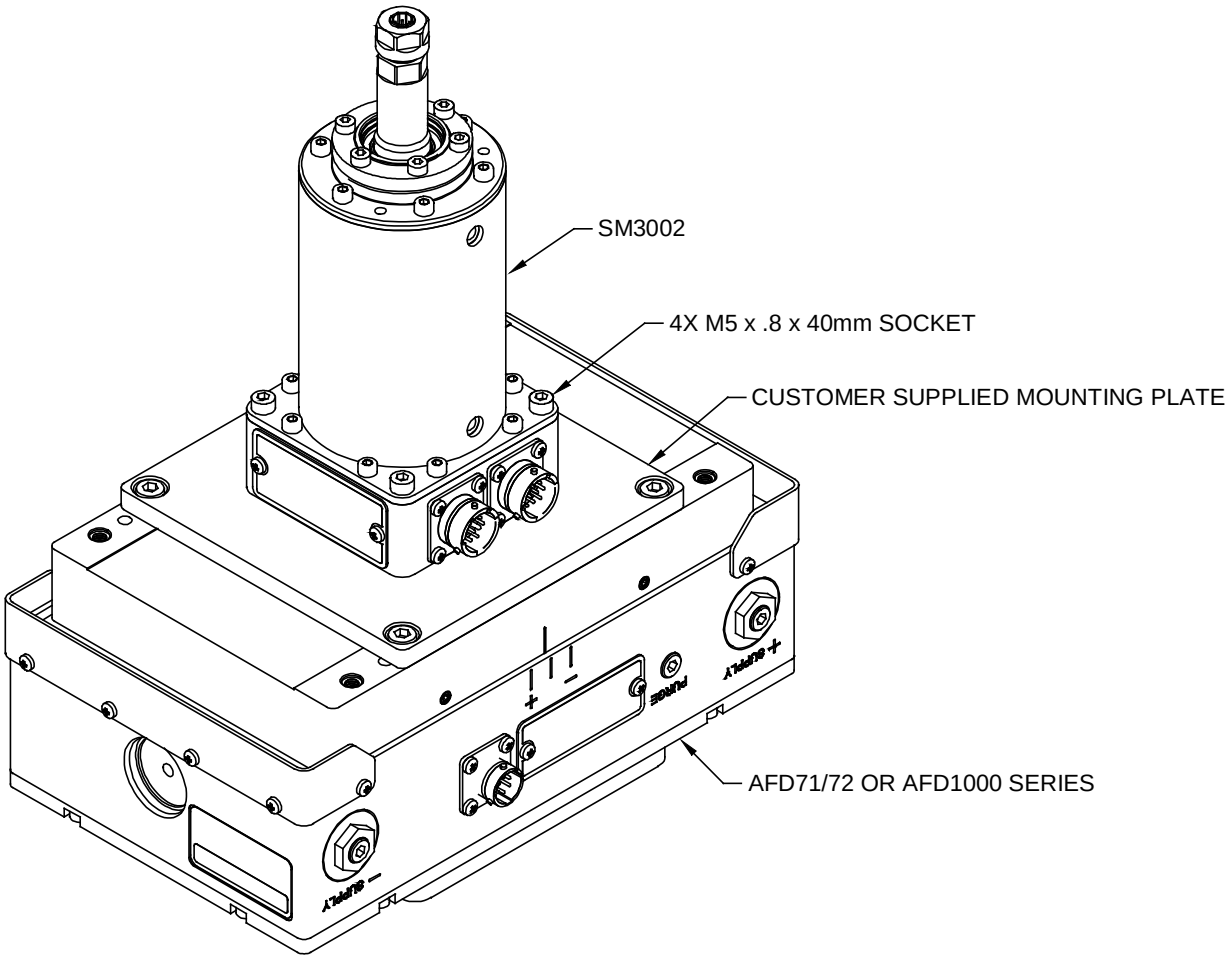


Figure 4. SM3002 Perpendicular-Axis Configuration

3.1.2 Mounting Directly to a Robot

For some processes compliance and force control are not required. The SM3002 can be mounted directly to the robot, in these cases, and the system can be operated in position mode. This robotic system is equivalent to a 5-axis machining center with a very large work volume and lower positional accuracy. Certain product types and processes are well suited for a Robotic Machining Center (RMC).

The SM3002 can be attached to the robot mounting flange using a customer supplied, Mounting Plate. For direct mounting it is recommended that a breakaway clutch is installed. The breakaway clutch will help protect the motor in the event of a robot crash. Loads on the motor shaft of over 300 lb (136 kg) radially and 150 (68 kg) axially will damage the bearings.

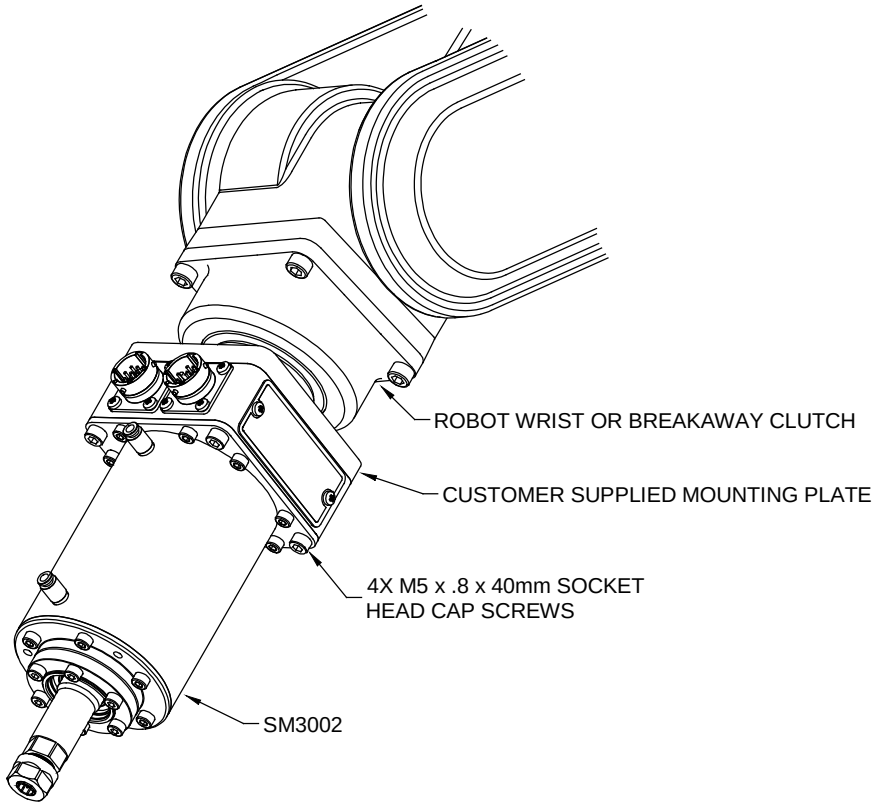


Figure 5. SM3002 Direct Mounting

To mount the SM3002, first attach the Mounting Plate to the Robot Wrist or to the Breakaway Clutch, per the manufacturer's specifications. Once the Mounting Plate is secured, place the SM3002 against the Mounting Plate and install the (4) four, M5x.8x40mm, Socket Head Cap Screws. (See Figure 5.) Tighten the fasteners to the torque specified in Section 4.0.

3.2 Collet Operation

The Collet for the SM3002 is tightened and loosened manually. The Motor Shaft must be held using the Motor Shaft Flats, while the Collet Nut is turned, see Figure 9. Turning the Collet Nut forces the Collet into the Motor Shaft causing it to clamp around the Tool Shaft. Rotating the Collet Nut clockwise will tighten the Collet. To loosen the Collet, rotate the Collet Nut counter-clockwise. If the Collet is to be removed, continue rotating the Collet Nut counter-clockwise and the Collet Nut and Collet will come off together. The Collet is an ER Series (DIN 6499 Form B) Size 11. The recommended tightening torque for the Collet Nut depends on the bore diameter of the Collet. For Collet bore diameters 0.118 – 0.276 in. (3.0 – 7.0 mm) the recommended tightening torque is 16 lb.-ft. (21.6 N·m), and not to exceed 20 lb.-ft. (27 N·m). For Collet bore diameters 0.020 – 0.098 in. (0.5 – 2.5 mm) the recommended tightening torque is 10.4 lb.-ft. (14 N·m), and not to exceed 13 lb.-ft. (17.6 N·m). The maximum depth a tool can be inserted into the collet is shown in Figure 6.

CAUTION: Higher tightening toques may permanently deform the collet cavity of the toolholder.

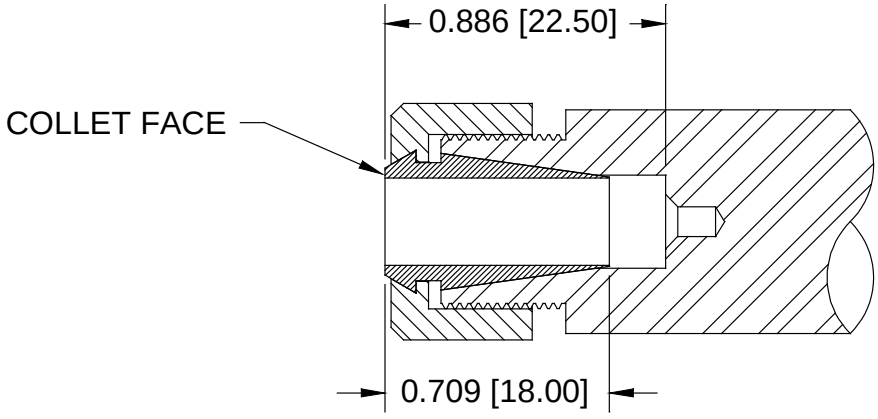


Figure 6. Collet Drawing

3.2.1 Collet Assembly and Removal

To assemble the Collet insert the Collet Groove into the Eccentric Ring of the Collet Nut at the mark on the bottom of the Collet Nut. Push the Collet in while rotating the Collet up, until it clicks in. See Figure 7.

To remove the Collet, first unscrew the Collet Nut from the Motor Shaft. After the Collet Nut is unscrewed, press on the face of the Collet while simultaneously pushing sideways on the back of the Collet until it disengages from the Collet Nut. See Figure 7.

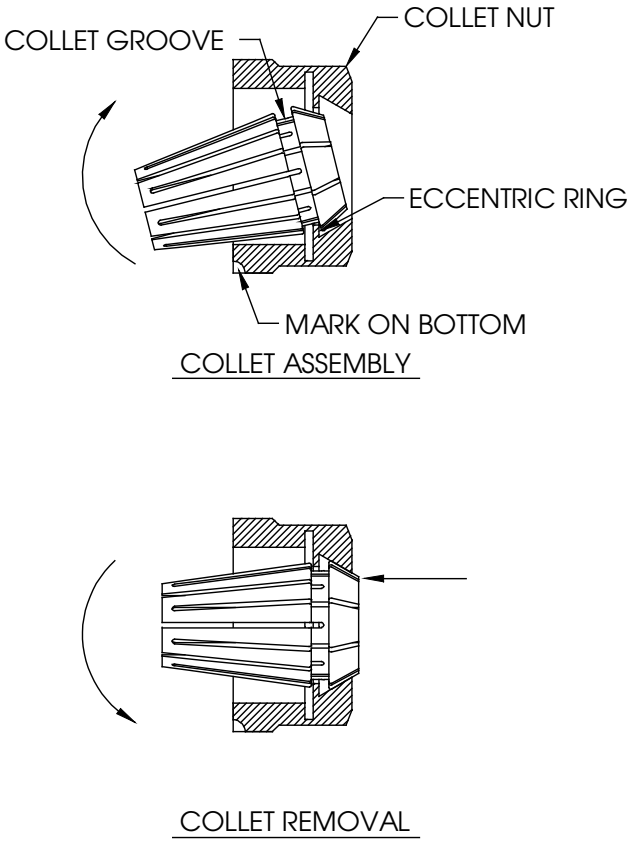


Figure 7. SM Collet Assembly and Removal

Improper assembly or removal of the Collet can permanently destroy the concentricity of the Collet and may result in a damage Collet Nut.

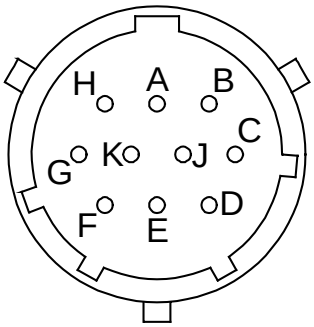
NOTE: Only attach Collet Nuts with correctly assembled Collets, to the Motor Shaft! Never place the Collet into the Motor Shaft without first assembling the Collet into the Collet Nut.

NOTE: Never clamp oversized, or undersized, Tool Shafts! (i.e., Never use a ∅5-6mm Collet to clamp a ∅6.35mm Tool Shaft.) Always use the corresponding Collet for the Tool Shaft being used.

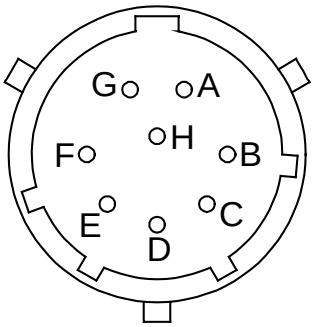
NOTE: Insert the Tool Shaft the full length of the Collet for best results, if possible. However, never insert the Tool Shaft less than 2/3 of the Collet bore length. Improper tool insertion can permanently deform the Collet and will result in excessive run-out.

3.3 Electrical Connections

The SM3002 has two electrical connections, the Motor Power and Motor Feedback (See Figure 8). PushCorp supplied cables and amplifiers allow the motor to be easily connected. If the customer wishes to use their own cables and/or amplifier the pin-outs for the Motor Power and Motor Feedback connectors are shown below in Figure 8. The Collet release of the SM3002 is manual and requires no electrical connections.



FEEDBACK CONNECTOR



POWER CONNECTOR

FEEDBACK PIN-OUTS

PIN	SIGNAL
A	HALL + SUPPLY
B	HALL - SUPPLY
C	HALL C
D	HALL B
E	HALL A
F	THERMISTOR
G	THERMISTOR

POWER PIN-OUTS

PIN	SIGNAL
A	MOTOR A
B	MOTOR B
C	MOTOR C
D	GROUND

Figure 8. Electrical Connector Pin-outs

CAUTION: Do not run the Motor Power Cable together with any feedback or control cables because of possible noise problems.

3.4 Motor Cooling

The SM3002 is a compact 2.0 Hp (1.5 kW) Servo Motor which will require liquid cooling. The high-speed Servo Motor is designed to operate below a temperature of 176 °F (80 °C). The optimal motor temperature range is 122 – 140 °F (50 – 60 °C). Therefore it is necessary to carefully monitor the internal motor temperature during normal production operation (see Section 3.6). The SM3002 contains cooling channels in the Motor Housing surrounding the motor stator. These channels allow efficient removal of the heat. The coolant enters and exits the Motor Housing through two Motor Coolant Ports as shown in Figure 9. The front Motor Coolant Port should be used as the Inlet.

Water has a high capacity to transfer energy. This means that liquid cooling efficiently removes heat from high duty cycle and high power applications. **The SM3002 requires a closed-loop liquid cooling system.** A closed-loop system requires a separate cooling unit to circulate liquid through the Motor Housing and remove the heat. All of the coolant is recirculated in the system, and no continuous supply or discharge is required. A mixture of pure distilled water and a corrosion inhibitor is required such as DowTherm SR-1, or equivalent. Typical cooling units are comprised of a pump, water to air heat exchanger, and fan. These units are commercially available from several manufacturers (eg Miller Coolmate 3, www.millerwelds.com). The cooling unit should be sized based on the motor power output of 2.0 Hp (1.5 kW) with an overall motor efficiency of 90% and the motor load conditions. Again it is recommended to closely monitor the motor temperature during actual production operation to ensure that it does not overheat.

NOTE: The life of the SM3002 motor is directly related to the operational temperature, so proper cooling is critical.

The SM3002 is supplied with two 4 mm (5/32 inch) diameter tube push-lock fittings for installation in the Motor Cooling Ports. Remove the shipping plugs and install the desired size push-lock fittings. If another type of fitting is desired, replace the existing fitting with a fitting having an M5 x .8 thread. Be sure to not over tighten the fitting.

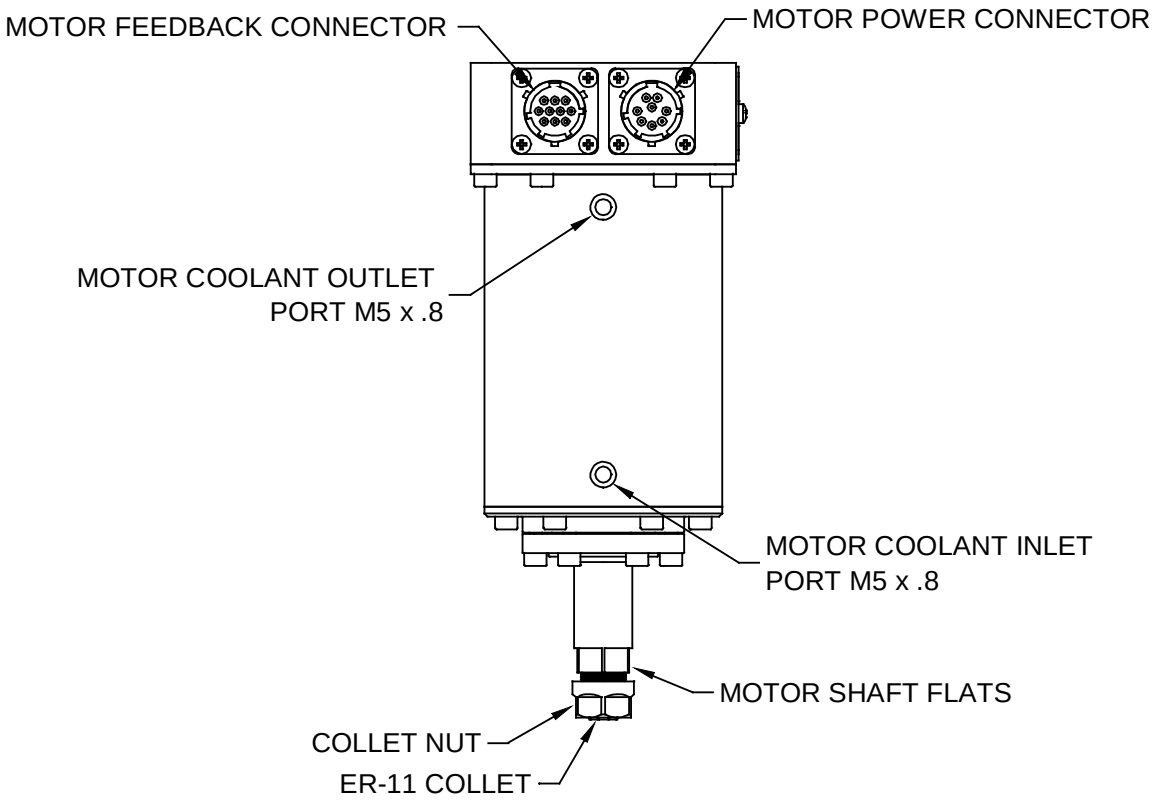


Figure 9. SM3002 External Connections

3.5 Monitoring Motor Temperature

As previously stated, the SM3002 is designed to operate below a temperature of 176 °F (80 °C) and within an optimal range of 122-140 °F (50-60 °C). In many situations it is desirable to monitor the internal motor temperature to ensure that the maximum temperature rating is not exceeded, and that the optimal temperature range is maintained. To facilitate this, the SM3002 has a thermistor that is imbedded in the motor windings. The thermistor connection is provided on the Motor Feedback Connector as shown in Figure 8. The thermistor temperature signal is a logarithmic function of the output resistance. The graph shown in Figure 10 illustrates the internal motor temperature verses the thermistor output resistance. In the graph, a temperature of 176 °F (80 °C) corresponds to a resistance of 2000 ohms. If the thermistor indicates a resistance of less than 2000 ohms then the motor should be immediately shut down before thermal damage occurs.

The motor also contains a thermal cutoff. If the temperature exceeds 212 °F (100 °C) the motor will stop running until it has cooled off. This feature should not be used to control the motor temperature. The thermal cutoff is designed to operate only when all other precautions have failed.

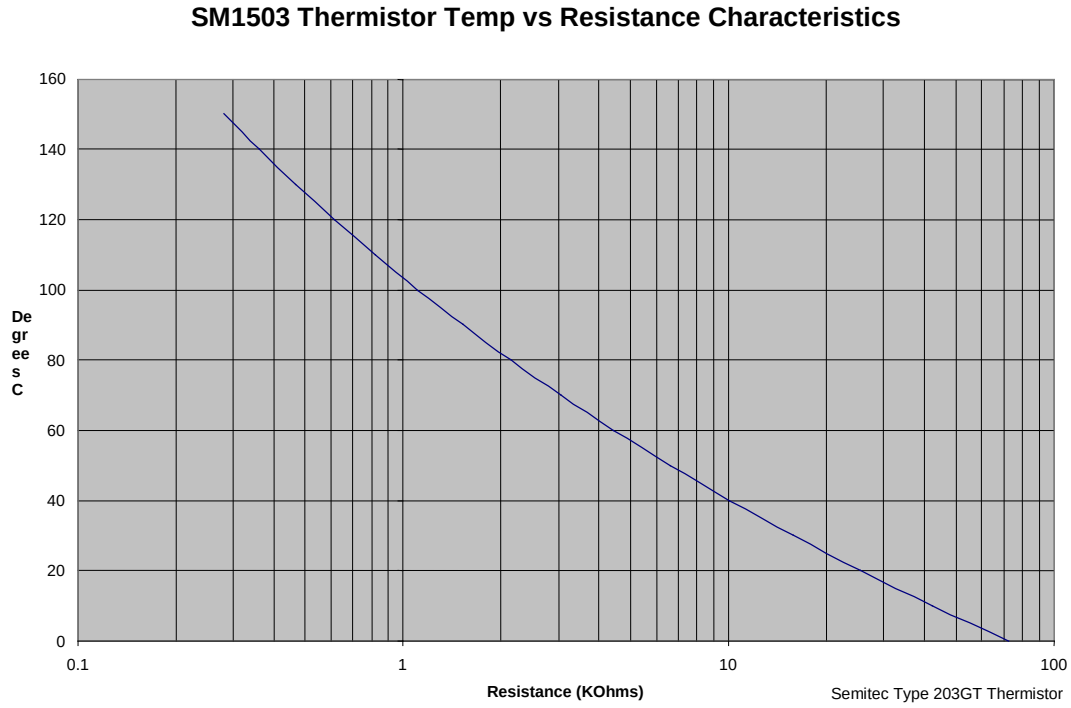


Figure 10. Thermistor Chart

The following equation can be used to calculate the motor temperature based on the measured thermistor resistance:

$$T = \frac{1}{2.656\times10^{-3} + 2.317\times10^{-4}\ln(R) + 1.752\times10^{-7}\ln(R)^3} - 273.15$$

R is resistance in Kohms

$\ln()$ is the natural logarithm function (Base *e)*

T is temperature in °C

3.6 Motor Acceleration/Deceleration

Servo Motors have the ability to start and stop very quickly. As long as the motor does not overheat or the amplifier exceed the allowable current input, the motor will continue to operate. The problem is that the motor and amplifier can experience excessive current spikes with rapid acceleration and declaration. Media or tooling with a large mass or large diameter (i.e., high moment of inertia) only increases the current surge. The amount of time allowed to reach the desired speed or stop will directly effect the life of the motor. PushCorp recommends a smooth, linear velocity ramp with a *minimum* period of one second be used to accelerate to full speed or to decelerate to zero speed. The minimum one-second-acceleration period must be increased if larger, higher inertia tools are used to prevent servo amplifier faults and avoid long-term damage.

3.7 Motor Warm-Up Procedure

The high-precision duplex spindle bearings used in the SM3002 require a warm-up period, if the motor is starting from room temperature. This is because of the close tolerances involve with the bearings. When starting at room temperature use the following sequence when initially starting the mortor:

Run Time	% Maximum Speed
3 Minutes	25%
3 Minutes	50%
3 Minutes	75%
2 Minutes	100%

Once the motor is warmed up (i.e. 50-60 °C), you can run it as desired. Please follow normal Acceleration/Deceleration guidelines given in Section 3.6 during the warm-up procedure.

4.0 Technical Specifications

MOTOR SPECIFICATIONS:

Power: Water Cooled – 2.0 hp (1.5 kW)
Continuous Stall Torque: Water Cooled – 1.22 lb.-ft. (1.7 N·m)
Minimum Speed: 60 RPM
Maximum Speed: 30000 RPM
Speed Regulation: 5% (Reversible)
Weight: 6 lb. (3 kg)
Operating Temperature: Optimal: 122 – 140 °F (50 – 60 °C)
Maximum: 176 °F (80 °C)
Thermal Cutoff: 212 °F (100 °C)
Max. Coolant Pressure: 60 psi (4.1 Bar)

COLLET SPECIFICATIONS:

Collet: ER Series (DIN 6499 Form B) Size 11
Collets available from:
Rego-Fix
7752 Moller Rd.
Indianapolis, IN 46268
www.rego-fix.com
Tool Shaft Range: 0.020-0.275 inch (0.5-7.0 mm) diameter
Requires power amplifier and cables.
For specific dimensions see www.pushcorp.com for detail drawings.

Specifications subject to change without notice.

Fastener Tightening Torque Specs

Fastener Size	Torque			Minimum Depth	
	in.-lbs.	ft.-lbs.	N·m	in.	mm
M4 x .7	50	4.2	5.6	0.17	4.3
M5 x .8	85	7.1	9.6	0.21	5.3
M6 x 1	140	11.7	15.8	0.25	6.3
M8 x 1.25	348	29.0	39.3	0.33	8.4
M10 x 1.5	600	50.0	67.8	0.41	10.5