

# Direct Drive DC Torque Motors



The Direct Drive DC torque motor is a servo actuator which can be directly attached to the load it drives. It has a permanent magnet (PM) field and a wound armature which act together to convert electrical power to torque. This torque can then be utilized in positioning or speed control systems. In general, torque motors are designed for three different types of operation:

- High stall torque (“stand-still” operation) for positioning systems
- High torque at low speeds for speed control systems, and
- Optimum torque at high speed for positioning, rate, or tensioning systems.

Direct drive torque motors are particularly suited for servo system applications where it is desirable to minimize size, weight, power and response time, and to maximize rate and position accuracies.

Frameless motors range from 28.7mm (1.13in) OD weighing 1.4 ounces (.0875 lbs) to a 4067 N-m (3000 lb-ft) unit with a 1067mm (42in) OD and a 660.4mm (26in) open bore ID. Housed motors range from a one inch cube design with 0.049 N-m (7 oz-in) peak torque to any of the frameless motors housed to customer specifications with integral DC tachometers, resolvers, encoders and shaft configurations.

# Direct Drive DC Torque Motors

## INTRODUCTION

### Advantages of Direct Drive DC Torque Motors

#### High Torque-to-Inertia Ratio at the Load

A direct drive motor provides the highest practical torque-to-inertia ratio where it counts—at the load. In a geared system, reflected output torque is proportional to the gear reduction while reflected output inertia is proportional to the square of the gear reduction. Thus, the torque-to-inertia ratio in a geared system is less than that of a direct drive system by a factor equal to the gear-train ratio. The higher torque-to-inertia ratio of direct drive motors makes them ideally suited for high acceleration applications with rapid starts and stops.

#### High Torque-to-Power Ratio

Most torque motors are designed with a large number of poles and a high volume of copper to achieve a high torque-to-power ratio. Thus, input power requirements are usually low.

#### Low Electrical Time Constant

Typical torque motor design features — such as high-level magnetic saturation of the armature core and the use of a large number of poles — keep armature inductance at a very low value. Consequently, the electrical time constant (the ratio of armature inductance to armature resistance) is very low, providing excellent command response at all operating speeds.

#### High Linearity

In a DC torque motor, torque increases directly with input current at all speeds and angular positions. The theoretical speed-torque characteristic is a set of parallel straight lines (Figure 1). This torque linearity is maintained even at low excitation, assuring no dead-band created by torque non-linearities for all input currents up to the peak rating of the motor.

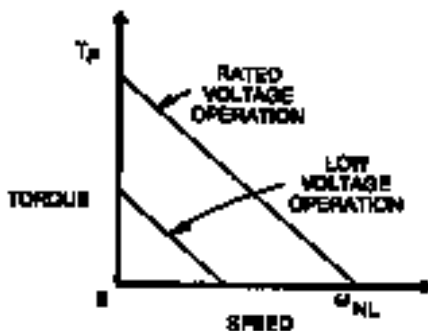


Figure 1

#### Reliability and Long Life

Basic simplicity and an absolute minimum of moving parts make a torque motor inherently reliable. Extensive design and production experience have placed Kollmorgen's motors in critical applications where high performance motion control is required for the last three decades. These include applications in all conditions and environments, ranging from thousands of feet underwater to years of unattended operation in outer space. Brushes are capable of operating in a hard vacuum with "high altitude" additives.

#### High Resolution

The direct drive use of torque motors allows them to position a shaft more precisely than a geared system. With typical gearing, the backlash contributes to a "dead zone" which falls in the region of the system null point and reduces positional accuracy. In a direct drive system, however, the positional accuracy is, in practice, limited only by the error-detecting transducer system.

#### Compact, Adaptable Design

Frameless torque motors are built to be "designed-in" as an integral part of a system, thus saving the weight and space associated with conventional motor frames or housings. This frameless design allows the motors to be mounted anywhere along the driven shaft. The "pancake" configuration (thin, compared to diameter) minimizes the volume required for mounting and offers a convenient packaging arrangement for combinations of torque motors and tachometer generators.

Kollmorgen also supplies housed motors, complete with housing, shaft and bearings for use in similar applications.

### System Performance Characteristics

The same features which give torque motors an advantage over other types of servo actuators also allow the designer to obtain the following system performance characteristics.

#### High Servo Stiffness

The direct-drive torque motor is coupled directly to the load, thus eliminating gears and backlash errors. The resulting high coupling stiffness and associated high mechanical resonance frequency yield high servo stiffness.

#### Fast Response

The low electrical time constant of torque motors allows torque to develop very rapidly when voltage is applied. This fast response is an important aid to servo stiffness.

#### High Resolution

The direct-drive use of torque motors allows them to position a shaft more precisely than a geared system. With typical gearing, the backlash contributes to a “dead zone” which falls in the region of the system null point and reduces positional accuracy. In a direct-drive system, however, the positional accuracy is, in practice, limited only by the error-detecting transducer system.

#### Low Speeds with High Accuracy

Because of the high coupling stiffness and high resolution of direct-drive torque motors, it is possible to achieve high accuracy at low speeds. An example is a table for testing rate and integrating gyros. This table has a speed range of 0.017 to 100 rpm with absolute instantaneous accuracy over this speed range of 0.1 percent.

#### Smooth, Quiet Operation

Torque motors exhibit smooth, quiet operation when they are run at low speeds. They typically have a large number of slots per pole to reduce cogging and allow for smooth operation.

### Motor Selection

#### Frameless or Housed?

Both the torque motor section and the servo motor section of this catalog are divided into subsections of frameless motors and housed motors.

Housed motors have a traditional configuration including frame, bearings, and shaft. In use, the housed motor shaft is coupled to the system element being driven. Housed motors are ideal for use in harsh environments or other applications requiring totally closed units.

The frameless motor concept was developed to meet the need for motors with a large hole through the center. This need is still one of the main reasons that the large diameter, narrow width frameless configuration is often selected over the traditional housed configuration. The large rotor bore can be used as a route for lead wires, as a mounting area for other hardware such as tachometer generators or resolvers, or as an optical path.

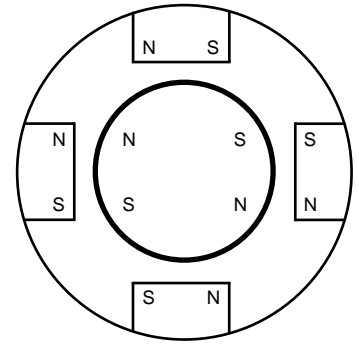
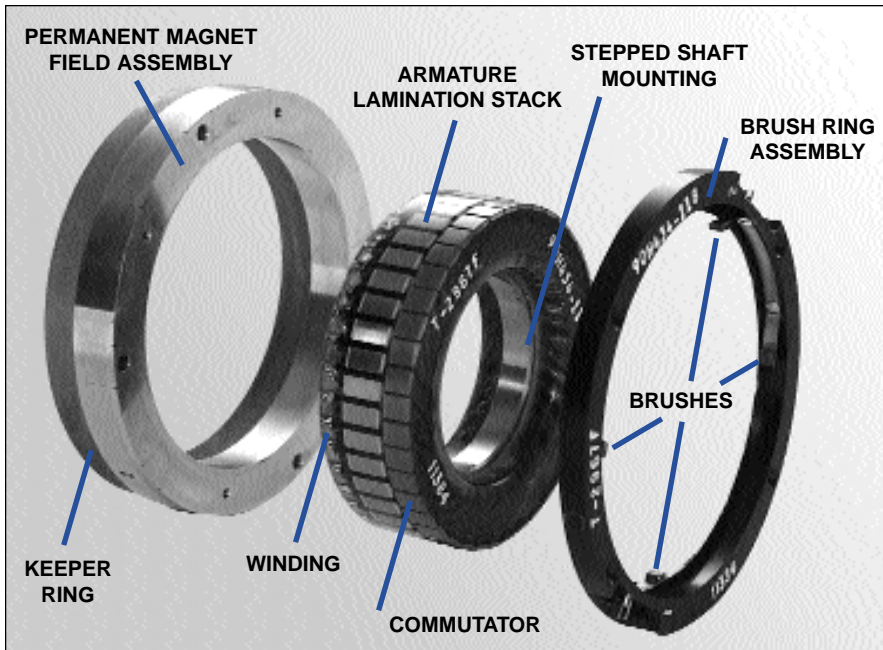
Frameless motors are built to be “designed in” as an integral part of the system hardware. They are generally supplied as three separate components: stator (field) assembly, rotor (armature) assembly and brush ring or brush segment assembly (See Figures 2, 3). The frameless motor can be integrated into the customer hardware rather than coupling a motor shaft to the element being driven. This allows significant savings in space and weight over housed motors by eliminating the motor housings, bearings and shaft. Also, since the frameless motor can be mounted on the driven shaft, the coupling stiffness is improved. The backlash normally associated with couplings or gear trains is eliminated from the drive system.

#### Torque Motor or Servo Motor?

A torque motor is typically described as having a “pancake” configuration, i.e., a large diameter and a narrow width. This configuration generally has a large number of poles to increase the torque available in a given volume. This large number of poles, however, also causes more commutation arcing as speed increases than for a motor with few poles. Torque motors are most commonly used in positioning and slow-speed rate applications where commutation is not a limitation. A servo motor is characterized by a long, small diameter configuration. Lengthening a motor while maintaining a small diameter allows a significant increase in torque while minimizing the increase in rotor inertia. The end result is an improved mechanical time constant and, therefore, improved motor response. Servo motors are most commonly used in running applications where good high-speed commutation is demanded and operation at or near stall is not required.

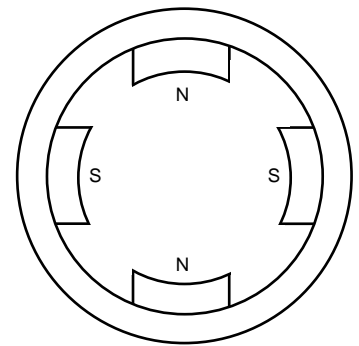
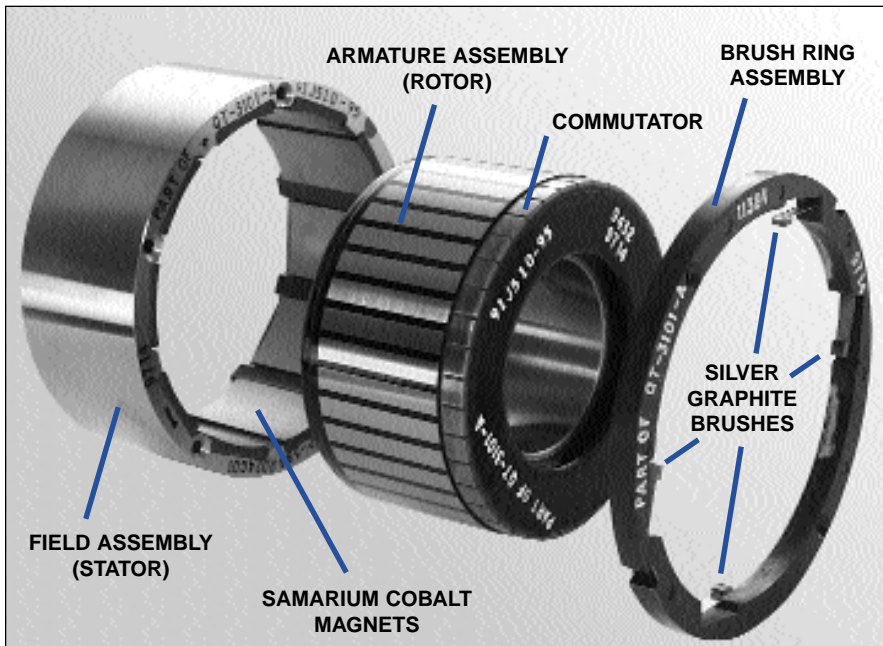
# Direct Drive DC Torque Motors

## INTRODUCTION



ALNICO DESIGN

Figure 2 - Frameless Alnico torque motor, showing hole for axial-shaft mounting.



RARE EARTH DESIGN

Figure 4  
 Alnico and rare earth magnet designs

Figure 3 - Frameless rare earth torque motor.

### Magnet Material

The motors are manufactured with one of two magnet materials: Alnico or rare earth (Samarium Cobalt and Neodymium-Iron-Boron). Model numbers preceded by “T”, “NT”, or “OT” have Alnico magnets and models preceded by “QT” have rare earth magnets. These magnet materials have different characteristics which determine their suitability for various applications.

*Performance:* A major advantage of rare earth magnet motors is stability of magnetic characteristics in overcurrent conditions. In Alnico magnet motors, exceeding the rated current  $I_p$  to develop more torque may demagnetize the permanent magnet field and cause a permanent reduction in torque per unit current. The degree of demagnetization is determined by the magnitude of the overload current.

In rare earth magnet units, currents in excess of  $I_p$  can be applied for short duration to develop higher torque without demagnetization of the PM field. The limits now become primarily the thermal capacity of the motor and the current density rating of the brushes.

Rare earth magnet motors that are designed to have comparable resistance to similar Alnico designs will generally have a lower inductance value than the Alnico design. Thus, the electrical time constant of rare earth units is normally lower than Alnico units, allowing more rapid system response.

*Installation:* Alnico magnet motors require a keeper ring or keeper segments to provide a return flux path for the field when the rotor is not in place. Removing or shifting the keeper before inserting the armature into the field will cause significant degradation of performance. In rare earth magnet motors the magnet material has much higher intrinsic coercive force. This feature makes the field assembly immune to the effects of an open magnetic circuit and therefore a keeper is not required. Eliminating the keeper can simplify installation considerably.

The mounting surfaces for frameless Alnico magnet motors must be made of non-magnetic material such as aluminum, brass or non-magnetic stainless steel. The minimum thickness of non-magnetic material required to separate the field structure from magnetic material is one quarter inch. Rare earth motors may be mounted in magnetic or non-magnetic housings.

Rare earth magnet material is more brittle than Alnico, and care must be exercised to avoid chipping or cracking. Because rare earth motors are designed with the magnets on the inner diameter of the stator assembly facing the armature, extra care must be taken when inserting the armature into the field assembly. Most rare earth units have larger radial air gaps than similar size Alnico units. The larger air gap of rare earth units makes rotor-to-stator concentricity less critical (See Figure 4).

# Direct Drive DC Torque Motors

## FRAMELESS TORQUER SELECTION GUIDE

Model Number	Peak Torque @ Stall		Pp Watts	Motor Constant		Theoretical No Load Speed v NL rad/sec	Electrical Time Constant Te msec
	Tp oz-in	N-m		oz-in / <input type="text"/>	Km N-m / <input type="text"/>		
NT-0786	2.80	0.020	40	0.440	3.1 x 10 <sup>-3</sup>	2000	0.16
QT-0717	3.84	0.027	53	0.530	3.7 x 10 <sup>-3</sup>	1950	0.12
T-0709	6.60	0.047	60	0.850	6.0 x 10 <sup>-3</sup>	1300	0.26
QT-0707	7.70	0.054	50	1.09	7.7 x 10 <sup>-3</sup>	920	0.25
T-2003	9.50	0.067	41	1.48	1.0 x 10 <sup>-2</sup>	610	0.10
NT-0796	10.6	0.075	73	1.24	8.8 x 10 <sup>-3</sup>	990	0.35
QT-1106	11.0	0.078	49	1.57	1.1 x 10 <sup>-2</sup>	636	0.14
QT-1204	11.0	0.078	57	1.46	1.0 x 10 <sup>-2</sup>	732	0.11
QT-0706	12.3	0.087	63	1.55	1.1 x 10 <sup>-2</sup>	725	0.32
T-1218	15.0	0.106	63	1.90	1.3 x 10 <sup>-2</sup>	580	0.31
T-1259	15.0	0.106	40	2.40	1.7 x 10 <sup>-2</sup>	374	0.50
QT-1207	20.0	0.141	82	2.21	1.6 x 10 <sup>-2</sup>	580	0.20
T-1292	20.0	0.141	64	2.51	1.8 x 10 <sup>-2</sup>	450	0.37
T-1352	20.0	0.141	60	3.00	1.8 x 10 <sup>-2</sup>	400	0.34
T-1410	21.0	0.148	49	3.00	2.1 x 10 <sup>-2</sup>	360	0.31
NT-1319	24.0	0.170	64	4.00	2.1 x 10 <sup>-2</sup>	375	0.29
T-1915	24.0	0.170	36	3.40	2.8 x 10 <sup>-2</sup>	209	0.22
T-1242	25.0	0.177	55	3.40	2.4 x 10 <sup>-2</sup>	307	0.68
T-3001	26.5	0.187	9.6	8.55	6.0 x 10 <sup>-2</sup>	51	0.23
NT-1372	30.0	0.212	52	4.15	2.9 x 10 <sup>-2</sup>	245	0.30
QT-2406	30.0	0.212	54	4.10	2.9 x 10 <sup>-2</sup>	250	0.13
T-2413	30.0	0.212	51	4.22	3.0 x 10 <sup>-2</sup>	238	0.20
T-2509	30.0	0.212	48	4.33	3.1 x 10 <sup>-2</sup>	220	0.25
T-2804	30.0	0.212	67	3.66	2.6 x 10 <sup>-2</sup>	320	0.30
NT-1383	32.0	0.226	83	3.50	2.5 x 10 <sup>-2</sup>	368	0.50
T-2157	35.0	0.247	41	5.45	3.8 x 10 <sup>-2</sup>	160	0.60
T-1342	40.0	0.283	97	4.05	2.9 x 10 <sup>-2</sup>	340	0.30
QT-2104	48.0	0.339	39	7.70	5.4 x 10 <sup>-2</sup>	114	0.50
QT-1217	50.0	0.353	165	3.90	2.8 x 10 <sup>-2</sup>	467	0.38
QT-1906	50.0	0.353	115	4.66	3.3 x 10 <sup>-2</sup>	326	0.17
T-2314	54.0	0.381	58	7.13	5.0 x 10 <sup>-2</sup>	150	0.66
QT-1401	55.0	0.388	217	3.74	2.6 x 10 <sup>-2</sup>	557	0.21
T-1911	60.0	0.424	60	7.75	5.5 x 10 <sup>-2</sup>	143	0.40
T-2170	60.0	0.424	34	10.5	7.4 x 10 <sup>-2</sup>	79	0.91
QT-2504	60.0	0.424	55	8.10	5.7 x 10 <sup>-2</sup>	128	0.29
T-2516	60.0	0.424	55	8.10	5.7 x 10 <sup>-2</sup>	127	0.43
QT-1404	65.0	0.459	98	6.55	4.6 x 10 <sup>-2</sup>	214	0.24
QT-2502	68.2	0.482	54	9.25	6.5 x 10 <sup>-2</sup>	113	0.18
QT-2105	75.0	0.529	35	12.8	9.0 x 10 <sup>-2</sup>	65	0.77
T-1421	77.4	0.547	112	7.31	5.2 x 10 <sup>-2</sup>	205	0.55
QT-2202	81.8	0.578	58	8.28	5.8 x 10 <sup>-2</sup>	168	0.84
T-2809	85.0	0.600	103	8.40	5.9 x 10 <sup>-2</sup>	170	0.30
NT-1308	90.0	0.636	255	5.65	4.0 x 10 <sup>-2</sup>	407	0.40
QT-1903	90.0	0.636	107	8.70	6.1 x 10 <sup>-2</sup>	167	0.22
T-2719	97.0	0.685	38	15.8	1.1 x 10 <sup>-1</sup>	54	0.77

*Continued on adjacent page.*

Note: Metric conversions provided for reference only.

# Direct Drive DC Torque Motors

## FRAMELESS TORQUER SELECTION GUIDE

Friction		Rotor Inertia		Physical Dimensions						Weight	
Tf		Jm		OD		ID		Length			
oz-in	N-m	oz-in-sec <sup>2</sup>	Kg-m <sup>2</sup>	in	mm	in	mm	in	mm	oz	g
0.20	0.0014	4.5 x 10 <sup>-5</sup>	3.2 x 10 <sup>-7</sup>	1.13	28.7	0.19	4.83	0.38	9.65	1.4	39.7
0.25	0.0018	4.5 x 10 <sup>-5</sup>	3.2 x 10 <sup>-7</sup>	1.13	28.7	0.19	4.83	0.38	9.65	1.4	39.7
0.25	0.0018	1.1 x 10 <sup>-4</sup>	7.8 x 10 <sup>-7</sup>	1.13	28.7	0.19	4.83	0.56	14.2	1.6	45.4
0.30	0.0021	1.1 x 10 <sup>-4</sup>	7.8 x 10 <sup>-7</sup>	1.13	28.7	0.19	4.83	0.56	14.2	1.6	45.4
0.40	0.0028	1.6 x 10 <sup>-3</sup>	1.1 x 10 <sup>-5</sup>	2.46	62.5	1.50	38.1	0.31	9.65	2.5	70.9
0.40	0.0028	1.6 x 10 <sup>-4</sup>	1.1 x 10 <sup>-6</sup>	1.13	28.7	0.19	4.83	0.75	19.1	2.3	65.2
0.60	0.0042	3.2 x 10 <sup>-4</sup>	2.3 x 10 <sup>-6</sup>	1.38	35.1	0.50	12.7	0.39	9.91	1.5	42.5
0.60	0.0042	4.2 x 10 <sup>-4</sup>	3.0 x 10 <sup>-6</sup>	1.50	38.1	0.63	16.0	0.39	9.91	1.7	48.2
0.40	0.0028	1.6 x 10 <sup>-4</sup>	1.1 x 10 <sup>-6</sup>	1.13	28.7	0.19	4.83	0.76	19.3	2.5	70.9
0.50	0.0035	6.0 x 10 <sup>-4</sup>	4.2 x 10 <sup>-6</sup>	1.50	38.1	0.63	16.0	0.51	13.0	2.3	65.2
0.50	0.0035	5.7 x 10 <sup>-4</sup>	4.0 x 10 <sup>-6</sup>	1.50	38.1	0.46	11.7	0.51	13.0	2.4	68.1
0.70	0.0049	6.0 x 10 <sup>-4</sup>	4.2 x 10 <sup>-6</sup>	1.50	38.1	0.63	16.0	0.51	13.0	2.3	65.2
0.55	0.0039	9.0 x 10 <sup>-4</sup>	6.4 x 10 <sup>-6</sup>	1.75	44.5	0.63	16.0	0.53	13.5	2.8	79.4
0.70	0.0049	8.8 x 10 <sup>-4</sup>	6.2 x 10 <sup>-6</sup>	1.94	49.3	0.63	16.0	0.50	12.7	4.3	122
0.70	0.0049	1.5 x 10 <sup>-3</sup>	1.1 x 10 <sup>-5</sup>	1.94	49.3	0.63	16.0	0.51	13.0	5.0	142
0.80	0.0057	8.8 x 10 <sup>-4</sup>	6.2 x 10 <sup>-6</sup>	1.94	49.3	0.63	16.0	0.50	12.7	4.3	122
1.9	0.013	4.0 x 10 <sup>-3</sup>	2.8 x 10 <sup>-5</sup>	2.47	62.7	1.25	31.8	0.47	11.9	5.0	142
1.1	0.0078	1.5 x 10 <sup>-3</sup>	1.1 x 10 <sup>-5</sup>	1.50	38.1	0.63	16.0	0.96	24.4	5.5	156
2.8	0.020	1.5 x 10 <sup>-2</sup>	1.1 x 10 <sup>-5</sup>	3.62	92.0	2.18	55.4	0.42	10.7	8.0	227
1.8	0.013	9.0 x 10 <sup>-4</sup>	6.4 x 10 <sup>-6</sup>	1.94	49.3	0.63	16.0	0.53	13.5	4.4	125
1.8	0.013	5.4 x 10 <sup>-3</sup>	3.8 x 10 <sup>-5</sup>	2.78	70.6	1.80	45.7	0.45	11.4	3.9	111
1.7	0.012	6.0 x 10 <sup>-3</sup>	4.2 x 10 <sup>-5</sup>	2.78	70.6	1.80	45.7	0.45	11.4	4.0	113
1.0	0.0071	6.0 x 10 <sup>-3</sup>	4.2 x 10 <sup>-5</sup>	3.00	76.2	1.75	44.5	0.37	9.40	4.5	128
1.5	0.011	8.6 x 10 <sup>-3</sup>	6.1 x 10 <sup>-5</sup>	3.38	85.9	2.25	57.2	0.41	10.4	5.1	145
1.0	0.0071	1.1 x 10 <sup>-3</sup>	7.8 x 10 <sup>-6</sup>	1.94	49.3	0.63	16.0	0.67	17.0	6.0	170
1.1	0.0078	6.2 x 10 <sup>-3</sup>	4.4 x 10 <sup>-5</sup>	2.81	71.4	1.00	25.4	0.63	16.0	8.8	250
1.0	0.0071	1.6 x 10 <sup>-3</sup>	1.1 x 10 <sup>-5</sup>	1.94	49.3	0.62	15.7	0.84	21.3	7.6	216
1.8	0.013	6.0 x 10 <sup>-3</sup>	4.2 x 10 <sup>-5</sup>	2.81	71.4	1.00	25.4	0.62	15.7	9.2	261
1.1	0.0078	1.5 x 10 <sup>-3</sup>	1.1 x 10 <sup>-5</sup>	1.50	38.1	0.63	16.0	0.96	24.4	5.5	156
1.0	0.0071	3.4 x 10 <sup>-3</sup>	2.4 x 10 <sup>-5</sup>	2.38	60.5	1.25	31.8	0.50	12.7	5.0	142
1.7	0.012	9.0 x 10 <sup>-3</sup>	6.4 x 10 <sup>-5</sup>	2.88	73.2	1.00	25.4	0.58	14.7	11	312
1.8	0.013	1.3 x 10 <sup>-3</sup>	9.2 x 10 <sup>-6</sup>	1.94	49.3	0.63	16.0	0.54	13.7	4.4	125
2.5	0.018	8.8 x 10 <sup>-3</sup>	6.2 x 10 <sup>-5</sup>	2.34	59.4	1.25	31.8	0.85	21.6	9.5	269
1.5	0.011	1.1 x 10 <sup>-2</sup>	7.8 x 10 <sup>-5</sup>	2.81	71.4	1.00	25.4	1.00	25.4	14	398
2.5	0.018	1.1 x 10 <sup>-2</sup>	7.8 x 10 <sup>-5</sup>	3.00	76.2	1.75	44.5	0.53	13.5	8.0	227
1.8	0.013	1.1 x 10 <sup>-2</sup>	7.8 x 10 <sup>-5</sup>	3.00	76.2	1.75	44.5	0.53	13.5	8.0	227
3.0	0.021	2.6 x 10 <sup>-3</sup>	1.8 x 10 <sup>-5</sup>	1.94	49.3	0.63	16.0	0.84	21.3	8.4	238
2.5	0.018	1.1 x 10 <sup>-2</sup>	7.8 x 10 <sup>-5</sup>	3.00	76.2	1.75	44.5	0.61	15.5	9.0	255
3.0	0.021	1.1 x 10 <sup>-2</sup>	7.8 x 10 <sup>-5</sup>	2.81	71.4	1.00	25.4	1.00	25.4	14	398
2.0	0.014	2.3 x 10 <sup>-3</sup>	1.6 x 10 <sup>-5</sup>	1.94	49.3	0.62	15.7	1.25	31.8	15	425
2.5	0.018	8.5 x 10 <sup>-3</sup>	6.0 x 10 <sup>-5</sup>	2.81	71.4	1.00	25.4	0.62	15.7	11	312
3.5	0.025	2.0 x 10 <sup>-2</sup>	1.4 x 10 <sup>-4</sup>	3.38	85.9	2.25	57.2	0.71	18.0	11	312
3.0	0.021	3.5 x 10 <sup>-3</sup>	2.4 x 10 <sup>-5</sup>	1.94	49.3	0.62	15.7	1.86	47.2	16	456
2.8	0.020	8.8 x 10 <sup>-3</sup>	6.2 x 10 <sup>-5</sup>	2.38	60.5	1.25	31.8	0.85	21.6	9.5	269
4.3	0.030	2.2 x 10 <sup>-2</sup>	1.6 x 10 <sup>-4</sup>	3.38	85.9	1.69	42.9	0.70	17.8	15	425

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Tf		Jm		OD		ID		Length		oz	g
oz-in	N-m	oz-in-sec <sup>2</sup>	Kg-m <sup>2</sup>	in	mm	in	mm	in	mm		
3.5	0.0247	3.5 x 10 <sup>-2</sup>	2.5 x 10 <sup>-4</sup>	3.73	94.7	1.64	41.7	0.89	22.6	18	511
4.0	0.0283	4.7 x 10 <sup>-2</sup>	3.3 x 10 <sup>-4</sup>	4.59	117	3.33	84.6	0.43	10.9	9.5	269
3.3	0.0233	1.7 x 10 <sup>-2</sup>	1.2 x 10 <sup>-4</sup>	2.81	71.4	1.00	25.4	1.13	28.7	20	567
3.0	0.0212	1.9 x 10 <sup>-2</sup>	1.3 x 10 <sup>-4</sup>	2.81	71.4	1.00	25.4	1.50	38.1	25	709
3.0	0.0212	3.4 x 10 <sup>-2</sup>	2.4 x 10 <sup>-4</sup>	3.63	92.2	2.50	63.5	0.80	20.3	14	397
5.8	0.0410	9.2 x 10 <sup>-2</sup>	6.5 x 10 <sup>-4</sup>	5.13	130	4.00	102	0.58	14.7	13	369
3.5	0.0247	3.7 x 10 <sup>-3</sup>	2.6 x 10 <sup>-5</sup>	1.94	49.3	0.63	16.0	1.11	28.2	12	340
2.5	0.0177	4.4 x 10 <sup>-2</sup>	3.1 x 10 <sup>-4</sup>	3.73	94.7	1.64	41.7	1.09	27.7	24	680
5.0	0.0353	8.3 x 10 <sup>-2</sup>	5.8 x 10 <sup>-4</sup>	5.13	130	4.00	102	0.56	14.2	13	369
3.8	0.0268	6.7 x 10 <sup>-2</sup>	4.8 x 10 <sup>-4</sup>	4.09	104	2.00	50.8	1.09	27.7	26	739
8.1	0.0570	6.5 x 10 <sup>-2</sup>	4.6 x 10 <sup>-4</sup>	4.56	116	2.94	74.7	0.69	17.5	18	511
5.8	0.0407	1.1 x 10 <sup>-1</sup>	7.8 x 10 <sup>-4</sup>	5.13	130	3.50	86.5	0.65	16.5	19	540
5.8	0.0407	6.1 x 10 <sup>-2</sup>	4.3 x 10 <sup>-4</sup>	3.73	94.7	1.64	41.7	1.34	34.0	32	907

Friction		Rotor Inertia		Physical Dimensions						Weight	
Tf		Jm		OD		ID		Length		lb	kg
lb-ft	N-m	lb-ft-sec <sup>2</sup>	Kg-m <sup>2</sup>	in	mm	in	mm	in	mm		
0.02	0.0271	2.9 x 10 <sup>-4</sup>	3.9 x 10 <sup>-4</sup>	3.73	94.7	1.64	41.7	1.34	34.0	2.2	1.0
0.05	0.0678	6.1 x 10 <sup>-4</sup>	8.3 x 10 <sup>-4</sup>	4.56	116	2.94	74.7	0.88	22.4	1.9	0.86
0.04	0.0542	1.4 x 10 <sup>-4</sup>	1.9 x 10 <sup>-4</sup>	2.81	71.4	0.88	22.4	2.51	63.8	3.0	1.4
0.04	0.0542	8.6 x 10 <sup>-4</sup>	1.2 x 10 <sup>-3</sup>	6.13	156	4.50	114	0.67	17.0	1.2	0.54
0.03	0.0407	4.0 x 10 <sup>-4</sup>	5.4 x 10 <sup>-4</sup>	4.09	104	2.00	50.8	1.34	34.0	2.4	1.1
0.04	0.0542	6.2 x 10 <sup>-4</sup>	8.4 x 10 <sup>-4</sup>	5.13	130	3.50	88.9	0.78	19.8	1.5	0.68
0.03	0.0407	3.3 x 10 <sup>-4</sup>	4.5 x 10 <sup>-4</sup>	3.73	94.7	1.64	41.7	1.59	40.4	2.5	1.1
0.04	0.0542	8.7 x 10 <sup>-4</sup>	1.2 x 10 <sup>-3</sup>	5.13	130	2.39	60.7	1.25	31.8	2.9	1.3
0.12	0.163	1.5 x 10 <sup>-3</sup>	2.0 x 10 <sup>-3</sup>	6.13	156	4.50	114	1.17	29.7	3.0	1.4
0.05	0.0678	5.4 x 10 <sup>-3</sup>	7.3 x 10 <sup>-3</sup>	9.69	246	7.94	202	0.81	20.6	4.5	2.0
0.30	0.0407	6.0 x 10 <sup>-3</sup>	8.1 x 10 <sup>-3</sup>	8.50	216	6.88	175	1.30	33.0	7.3	3.3
0.05	0.0678	3.6 x 10 <sup>-4</sup>	4.9 x 10 <sup>-4</sup>	4.50	114	2.67	67.8	0.69	17.5	1.3	0.59
0.05	0.0678	1.6 x 10 <sup>-4</sup>	2.2 x 10 <sup>-4</sup>	3.18	80.8	1.44	36.6	1.55	39.4	1.9	0.86
0.04	0.0542	4.1 x 10 <sup>-4</sup>	5.6 x 10 <sup>-4</sup>	3.73	94.7	1.64	41.7	1.24	31.5	2.0	0.91
0.06	0.0814	2.0 x 10 <sup>-4</sup>	2.7 x 10 <sup>-4</sup>	3.18	80.8	1.00	25.4	1.53	38.9	2.4	1.1
0.06	0.0814	5.7 x 10 <sup>-4</sup>	7.7 x 10 <sup>-4</sup>	3.73	94.7	1.64	41.7	1.70	43.1	3.1	1.4
0.05	0.0678	1.4 x 10 <sup>-3</sup>	1.9 x 10 <sup>-3</sup>	5.13	130	2.39	60.7	1.75	44.5	5.6	2.5
0.10	0.136	9.8 x 10 <sup>-4</sup>	1.3 x 10 <sup>-3</sup>	4.10	104	2.00	50.8	1.80	45.7	4.0	1.8
0.20	0.271	6.3 x 10 <sup>-3</sup>	8.5 x 10 <sup>-3</sup>	7.73	196	5.25	133	0.94	23.9	4.2	1.9
0.16	0.217	6.3 x 10 <sup>-3</sup>	8.5 x 10 <sup>-3</sup>	7.00	178	4.73	120	1.29	32.8	6.3	2.9
0.12	0.163	1.5 x 10 <sup>-3</sup>	2.0 x 10 <sup>-3</sup>	5.13	130	3.25	93.9	1.25	31.8	3.0	1.4
0.10	0.136	7.2 x 10 <sup>-4</sup>	9.8 x 10 <sup>-4</sup>	4.50	114	2.68	68.1	1.07	27.2	2.6	1.2
0.10	0.136	4.0 x 10 <sup>-4</sup>	5.4 x 10 <sup>-4</sup>	3.18	80.8	1.14	29.0	2.35	59.7	3.5	1.6
0.15	0.203	1.9 x 10 <sup>-3</sup>	2.6 x 10 <sup>-3</sup>	6.13	156	4.50	114	1.17	29.7	2.9	1.3
0.20	0.271	6.5 x 10 <sup>-3</sup>	8.8 x 10 <sup>-3</sup>	7.20	183	3.95	100	1.32	33.5	7.0	3.2
0.25	0.339	1.1 x 10 <sup>-2</sup>	1.5 x 10 <sup>-2</sup>	8.69	220	5.94	151	1.26	32.0	7.5	3.4
0.09	0.122	5.0 x 10 <sup>-3</sup>	6.8 x 10 <sup>-3</sup>	7.20	183	3.95	100	1.63	41.4	7.3	3.3

Note: Metric conversions provided for reference only.



# Direct Drive DC Torque Motors

## FRAMELESS TORQUER SELECTION GUIDE

Model Number	Peak Torque @ Stall			Motor Constant		Theoretical No Load Speed v NL rad/sec	Electrical Time Constant Te msec
	Tp oz-in	N-m	Pp Watts	oz-in / <input type="text"/>	Km N-m / <input type="text"/>		
T-2967	100	0.706	68	12.2	0.086	95	1.2
QT-4101	100	0.706	76	11.5	0.081	107	0.14
T-2215	108	0.763	41	16.9	0.12	54	1.7
T-2171	120	0.847	50	17.0	0.12	57	1.5
QT-3104	150	1.06	97	15.2	0.11	92	0.38
T-4601	154	1.09	200	10.9	0.077	184	0.47
QT-1406	157	1.11	347	8.42	0.059	313	.28
T-2955	163	1.15	77	18.6	0.13	67	1.6
QT-4602	163	1.15	211	11.3	0.080	183	0.27
T-3203	192	1.36	87	20.5	0.14	63	2.3
T-3910	192	1.36	50	26.9	0.19	36	0.84
T-4436	192	1.36	70	23.0	0.16	51	0.70
T-2987	211	1.49	113	20.0	0.14	75	2.1

Model Number	Peak Torque @ Stall			Motor Constant		No Load Speed v NL rad/sec	Electrical Time Constant Te msec
	Tp lb-ft	N-m	Pp Watts	lb-ft / <input type="text"/>	Km N-m / <input type="text"/>		
T-2950	1.2	1.63	79	0.135	0.183	48	2.13
T-3912	1.2	1.63	35	0.201	0.273	22	1.25
NT-2146	1.3	1.76	75	0.150	0.203	42	1.50
T-5403	1.3	1.76	120	0.119	0.161	68	0.67
T-3208	1.5	2.03	113	0.140	0.190	56	3.00
T-4412	1.5	2.03	120	0.139	0.189	58	0.84
T-2959	1.7	2.31	110	0.160	0.217	47	2.50
T-4036	1.8	2.40	88	0.190	0.258	36	1.79
T-5406	2.0	2.71	52	0.280	0.380	19	1.50
T-8902	2.1	2.85	61	0.270	0.366	22	0.40
QT-7602	2.1	2.85	17	0.514	0.697	5.9	0.58
QT-3801	2.4	3.25	187	0.175	0.237	58	0.58
T-2406	2.5	3.39	285	0.150	0.203	84	1.75
QT-3102	2.5	3.39	263	0.154	0.209	77	1.20
QT-2404	3.0	4.07	260	0.190	0.258	64	1.04
QT-3103	3.3	4.47	190	0.240	0.325	39	1.52
T-4076	3.6	4.88	127	0.320	0.434	26	2.70
QT-3403	4.0	5.42	126	0.357	0.484	23	2.10
QT-7004	4.0	5.42	58	0.524	0.710	11	2.00
QT-6302	4.2	5.69	67	0.510	0.692	12	1.44
QT-4402	4.2	5.69	160	0.335	0.454	28	1.10
QT-3802	4.8	6.51	256	0.300	0.407	39	0.84
QT-2603	5.0	6.78	313	0.280	0.380	46	2.10
QT-5404	5.0	6.78	227	0.330	0.447	33	0.60
T-6204	6.0	8.13	103	0.590	0.800	13	2.49
T-7501	6.5	8.81	177	0.490	0.664	20	1.60
T-5730	7.0	9.49	261	0.433	0.587	28	3.13

Continued on adjacent page.

Note: Metric conversions provided for reference only.

# Direct Drive DC Torque Motors

## FRAMELESS TORQUER SELECTION GUIDE

Model Number	Peak Torque @ Stall			Motor Constant		Theoretical No Load Speed √ NL rad/sec	Electrical Time Constant Te msec
	Tp lb-ft	N-m	Pp Watts	lb-ft / <input type="text"/>	N-m / <input type="text"/>		
QT-7201	9.0	12.2	490	0.410	0.560	40	0.79
T-6205	10	13.6	113	0.940	1.27	8.0	2.8
QT-6202	11	14.9	330	0.610	0.830	22	1.8
T-7202	11	14.9	325	0.610	0.830	22	3.2
T-15602	11	14.9	198	0.780	1.06	13	2.2
QT-12901	12	16.3	135	1.05	1.42	8.2	0.37
T-11306	12	16.3	260	0.770	1.04	16	1.0
T-8905	14	19.0	666	0.530	0.720	36	1.4
T-5745	14	19.0	357	0.740	1.00	18	5.3
T-13301	14	19.0	256	0.900	1.22	13	1.0
QT-6301	20	27.1	576	0.830	1.13	21	2.1
QT-9704	20	27.1	235	1.30	1.76	8.6	1.5
T-9901	20	27.1	400	1.00	1.36	15	4.0
T-11308	20	27.1	218	1.35	1.83	8.0	1.4
T-7203	22	29.8	530	0.960	1.30	18	5.7
QT-11302	22	29.8	194	1.58	2.14	6.5	1.1
QT-7802	23	31.2	620	0.920	1.25	20	2.5
QT-6205	25	33.9	627	1.00	1.36	19	2.4
QT-7003	25	33.9	520	1.10	1.49	15	2.4
QT-6401	26	35.3	657	1.01	1.37	19	3.3
T-7250	28	40.0	582	1.14	1.55	15	6.5
T-15603	30	40.7	450	1.41	1.91	11	3.6
T-10036	35	47.5	740	1.28	1.74	16	3.5
QT-6207	40	54.2	655	1.56	2.12	12	3.0
T-9902	40	54.2	512	1.77	2.40	9.5	6.3
QT-7801	46	62.4	800	1.63	2.21	13	3.8
QT-11301	50	67.8	331	2.75	3.73	4.9	1.2
QT-17301	54	73.2	386	2.75	3.73	5.3	1.6
QT-7809	60	81.4	615	2.42	3.28	7.6	4.4
T-9908	70	94.9	720	2.61	3.54	7.8	6.4
T-10020	100	136	942	3.30	4.47	7.0	7.4
T-10035	100	136	1040	3.10	4.20	7.7	5.8
QT-11303	100	136	499	4.50	6.10	3.6	0.76
QT-12506	123	167	794	4.36	5.91	4.8	3.2
T-10071	150	203	1470	3.90	5.29	7.2	6.6
QT-12505	200	271	1100	6.04	8.19	4.0	3.8
T-12008	201	273	2630	3.93	5.33	9.6	8.3
T-18002	300	407	1450	7.85	10.6	3.6	20
QT-23502	700	949	1310	19.0	25.8	1.4	4.8
T-18004	900	1220	3440	15.3	20.7	2.8	25
T-24005	1000	1360	7000	12.0	16.3	5.0	13
T-36010	1500	2030	4940	21.3	28.9	2.4	14
T-18031	1600	2170	5600	21.4	39.0	2.6	23
T-36001	3000	4070	6300	37.8	51.3	1.6	22

Continued on adjacent page.

Note: Metric conversions provided for reference only.

# Direct Drive DC Torque Motors

## FRAMELESS TORQUER SELECTION GUIDE

Friction		Rotor Inertia		Physical Dimensions						Weight	
Tf		Jm		OD		ID		Length		lb	Kg*
lb-ft	N-m	lb-ft-sec <sup>2</sup>	Kg-m <sup>2</sup>	in	mm	in	mm	in	mm		
0.15	0.203	5.6 x 10 <sup>-3</sup>	7.6 x 10 <sup>-3</sup>	8.20	208	5.94	151	1.09	27.7	4.0	1.8
0.50	0.678	9.0 x 10 <sup>-3</sup>	1.2 x 10 <sup>-2</sup>	7.20	183	3.95	100	1.97	50.0	10	4.5
0.18	0.244	5.8 x 10 <sup>-3</sup>	7.9 x 10 <sup>-3</sup>	7.20	183	3.95	100	1.24	31.5	6.2	2.8
0.15	0.203	1.0 x 10 <sup>-2</sup>	1.4 x 10 <sup>-2</sup>	9.00	229	5.38	137	1.63	41.4	10	4.5
0.25	0.339	8.0 x 10 <sup>-2</sup>	0.11	16.5	419	13.9	353	1.34	34.0	13	5.9
0.40	0.542	2.4 x 10 <sup>-2</sup>	3.3 x 10 <sup>-2</sup>	13.6	345	12.1	307	1.10	27.9	5.0	2.3
0.37	0.502	2.0 x 10 <sup>-2</sup>	2.7 x 10 <sup>-2</sup>	12.0	304	10.3	262	1.00	25.4	7.2	3.3
0.22	0.298	1.5 x 10 <sup>-2</sup>	2.0 x 10 <sup>-2</sup>	9.69	246	7.63	194	1.47	37.3	9.9	4.5
0.15	0.203	8.0 x 10 <sup>-3</sup>	1.1 x 10 <sup>-2</sup>	7.20	183	3.95	100	2.38	60.5	15	6.8
0.40	0.542	3.2 x 10 <sup>-2</sup>	4.3 x 10 <sup>-2</sup>	14.0	356	12.3	312	1.05	26.7	8.5	3.9
0.25	0.339	1.0 x 10 <sup>-2</sup>	1.4 x 10 <sup>-2</sup>	7.00	178	4.73	120	1.99	50.6	9.0	4.1
0.72	0.976	2.5 x 10 <sup>-2</sup>	3.4 x 10 <sup>-2</sup>	11.0	279	8.00	203	1.56	39.6	11	5.0
0.25	0.339	2.5 x 10 <sup>-2</sup>	3.4 x 10 <sup>-2</sup>	12.0	305	8.00	203	1.75	44.5	15	6.8
0.71	0.963	3.0 x 10 <sup>-2</sup>	4.1 x 10 <sup>-2</sup>	12.0	305	10.1	257	1.27	32.3	9.0	4.1
0.25	0.339	1.9 x 10 <sup>-2</sup>	2.6 x 10 <sup>-2</sup>	9.00	229	5.16	131	2.56	65.0	18	8.2
1.0	0.136	3.0 x 10 <sup>-2</sup>	4.1 x 10 <sup>-2</sup>	12.0	305	10.1	257	1.28	32.5	8.7	4.0
0.37	0.502	1.6 x 10 <sup>-2</sup>	2.2 x 10 <sup>-2</sup>	9.00	229	5.37	136	1.65	41.9	10	4.5
0.35	0.475	1.0 x 10 <sup>-2</sup>	1.4 x 10 <sup>-2</sup>	7.20	183	3.95	100	1.99	50.6	12	5.5
0.35	0.475	1.3 x 10 <sup>-2</sup>	1.8 x 10 <sup>-2</sup>	7.73	196	5.25	133	1.94	49.3	10	4.5
0.40	0.542	1.2 x 10 <sup>-2</sup>	1.6 x 10 <sup>-2</sup>	7.75	197	4.25	108	2.10	53.3	13	5.9
0.21	0.285	2.3 x 10 <sup>-2</sup>	3.1 x 10 <sup>-2</sup>	9.00	229	5.16	131	2.94	74.7	23	10
0.35	0.475	0.14	0.19	16.5	419	13.9	35.3	1.84	46.7	22	10
0.50	0.678	6.0 x 10 <sup>-2</sup>	8.1 x 10 <sup>-2</sup>	13.9	348	3.50	88.9	3.80	96.5	53	24
0.60	0.814	2.0 x 10 <sup>-2</sup>	2.7 x 10 <sup>-2</sup>	7.20	183	3.95	100	3.50	88.9	24	11
0.65	0.881	5.0 x 10 <sup>-2</sup>	6.8 x 10 <sup>-2</sup>	12.0	305	8.00	203	2.50	63.5	32	15
0.50	0.678	2.8 x 10 <sup>-2</sup>	3.8 x 10 <sup>-2</sup>	9.00	229	5.16	131	2.40	61.0	20	9.1
1.6	2.17	6.0 x 10 <sup>-2</sup>	8.1 x 10 <sup>-2</sup>	12.0	305	10.1	257	2.40	61.0	18	8.2
1.2	0.163	0.13	0.18	18.3	465	15.8	401	1.30	33.0	18	8.2
0.83	1.13	4.1 x 10 <sup>-2</sup>	5.6 x 10 <sup>-2</sup>	9.00	229	5.16	131	3.40	86.4	31	14
0.60	0.814	0.11	0.15	12.0	305	7.75	197	3.62	92.0	50	23
2.0	2.71	0.18	0.24	13.7	348	3.50	88.9	6.12	155	110	50
1.0	0.114	0.18	0.24	13.3	338	3.38	85.9	5.31	135	96	44
2.5	3.39	0.11	0.15	12.3	312	10.1	257	4.60	117	39	18
1.2	1.63	0.17	0.23	14.0	356	10.5	267	3.00	76.2	42	19
1.8	2.44	0.22	0.30	13.7	348	3.50	88.9	7.45	189	150	68
1.6	2.17	0.27	0.37	14.0	356	10.5	267	4.48	114	67	30
1.0	1.36	0.50	0.68	19.0	483	6.00	152	7.50	191	190	86
3.0	4.07	1.4	1.9	23.7	602	10.4	264	5.94	151	300	140
7.0	9.49	2.9	3.9	25.5	648	20.6	523	6.00	152	230	110
4.0	5.42	3.1	4.2	26.5	673	9.38	238	10.6	269	650	300
5.0	6.78	8.0	11	30.0	762	18.0	457	8.00	203	730	330
10	13.6	15	20	41.8	1060	27.8	706	6.75	172	820	370
6.0	8.14	4.2	5.7	26.5	673	9.38	238	14.8	376	850	390
12	16.3	26	35	45.0	1140	25.7	653	10.3	262	1400	620

\*Note: Metric weight expressed in Kg.

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## TABLE OF STANDARD OPTIONS

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These standard options allow our customers to modify existing catalog motors to achieve the features as described below. Please consult factory for application information.

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### Higher Torque

Magnet Materials	Alnico Neodymium-Iron-Boron Samarium Cobalt
Lamination Materials	Silicon Steel Vanadium Permedur
Magnetic pole Count	Up to 2 times the catalog model. <i>Consult factory</i>

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### Higher Power

Stack Length Increase (Magnets & Laminations)	0.25 inches to 3 inches (motor length increases the same as the stack length)
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### Speed/Torque Changes

Winding Wire Gages	#20 - 28 AWG ( <i>standard</i> ) #00-48 AWG
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### Installation Features

Shaft Geometry	Round ( <i>standard</i> ) Hollow, keyway, flat or integral gear
Mounting	Bolt hole diameter and circumferential pattern ( <i>customer specified</i> )
Lead Length	18 inches ( <i>standard</i> ) 7 to 48+ inches ( <i>customer specified</i> )
Lead Color	Red/White/Black ( <i>standard</i> ) Colors to be specified by customer

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### Durability

Varnishes or Encapsulation	115°C ( <i>standard</i> ) 200°C
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Kollmorgen enjoys a reputation of excellence based on constant endeavors to update products. Information in this brochure is subject to change.

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