

# High Speed Series

## Brushless DC Motors

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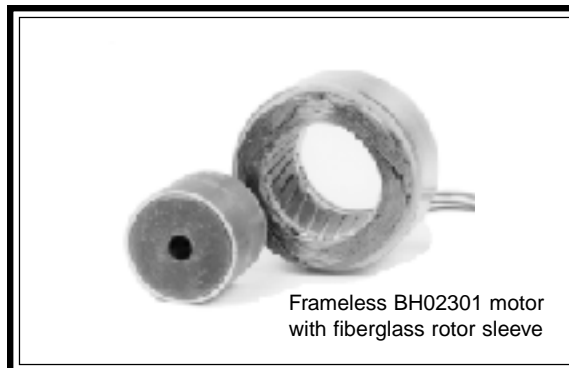
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**Heason**  
Technologies Group

## High Speed Housed and Frameless Brushless DC Motors



BH02302 housed motor with  
encoder and housed BH03401



Frameless BH02301 motor  
with fiberglass rotor sleeve

## Engineering Guide

**Hathaway**  
**Emoteq, Inc**

**Emoteq, Inc**

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# High Speed Series

## Brushless DC Motors

## Product Features

### BH Series Housed and Frameless Motors

The **BH Series** of three phase brushless motors was introduced as a family of general purpose servo motors. However, the four pole rotors and high operating efficiencies of the designs have meant that the majority of the motors supplied have been used in



BH02303 housed motor with holding brake and 1000 PPR encoder with line driver

high operating speed applications. The new Quantum Series of motors in sizes 17, 23, and 34 now satisfy requirements for small servo motors.

The BH Series motors are available in two diameters and various lengths to suit a range of applications for high speed motors. Hall effect sensors for commutation are integral to the motor and require no setup on

the part of the user.

The standard BH Series motors are available in two frame sizes of 2.3 and 3.4 inch (57.7 & 86.4mm) diameters. Additionally the motors are available in frameless configurations of 1.80 and 3.00 inch stator diameters (45.7 & 76.2mm).

BH Series motors are especially well suited to applications demanding high power density motors which minimize size, weight, inertia, and limit, through high operating efficiency, the power losses into the attached mechanical structure.

Due to the special nature of high speed systems, Emoteq usually engineers the mechanical, electrical and magnetic designs for optimum efficiency based on the application requirements. Several different magnet containment methods are employed and depend on the operating speed of the motor as well as application environment parameters.

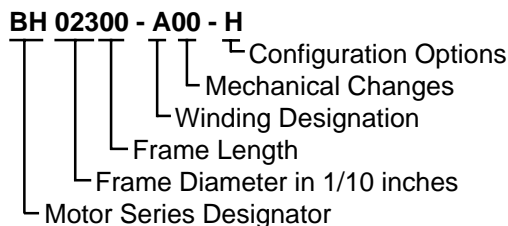
In addition to the BH Series, and to illustrate the expanding range of capabilities, data on some sample high speed motor designs is included in this engineering guide. For further assistance call 800 221 7572 USA or 918 627 1845 international.

### High Speed Motor Model Numbering

A complete model number is comprised of a series designator, a frame size, frame length, winding designator, and mechanical changes and options. Model numbers for housed and frameless motors are the same except for the -H suffix indicating a housed motor. Certain options may only be specified with housed motors.

#### Motor Series Designator

BH Brushless, high speed (standard)  
HS High Speed (high efficiency laminations)  
HSS Low hysteresis laminations (very high speed)  
SB Special versions



#### Frame Diameter

BH and QB motor housing diameters  
HT/HS frameless stator diameter (inches)

#### Frame Length

No. of stacks. Stack length varies with series

#### Windings

-A00 Standard (catalog) design  
-X00 Special winding (new design not released by engineering)  
-A0X Standard winding, special mechanical design

#### Mechanical Changes

Issued in numerical sequence. See specific drawing.

#### Configuration Options

- H Housed motor  
- HE Housed motor with encoder  
- HB Housed motor with integral brake.  
- HR Housed motor with resolver  
- T Tachometer (housed or frameless motor)

# High Speed Series

## Brushless DC Motors

## Product Features

### Design Features of Emoteq's High Speed Motors

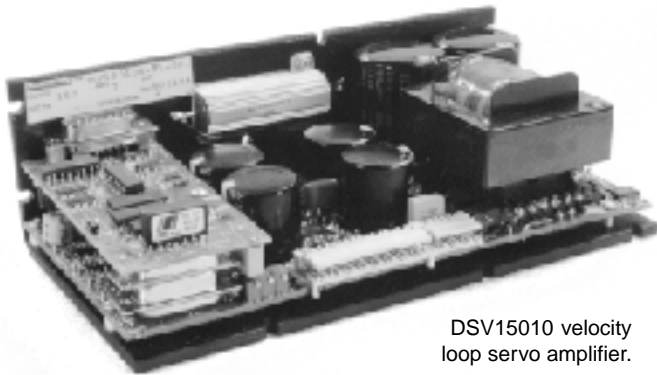
- High torque to inertia and size ratios
- High energy Neodymium Iron Boron magnets standard
- Rotor magnet sleeving incorporated into designs
- Integral Hall effect sensors for commutation
- Extensive range of standard designs
- Mechanical, electrical, and magnetic circuit changes readily undertaken
- Fast delivery on both standard and custom designs

### Applications of High Speed Motor Technology

- Printed circuit board drilling spindles
- Laser scanning heads
- Image acquisition and reproduction
- High speed machining heads
- Semiconductor deposition and cleaning systems
- Silicon wafer slicing equipment
- Optical glass grinding



Frameless SB2500 motor with magnet sleeve for high speed operation.



DSV15010 velocity loop servo amplifier.

### Drive Electronics for High Speed Brushless Motors

Driving high speed brushless DC motors at maximum efficiency requires specially configured drive electronics. The DSV Series of amplifiers has been engineered with a special topology to deliver energy to the motor windings at only the commutation frequency of the motor instead of with Pulse Width Modulation. PWM stator energy control adds significant losses in the stator due to the high frequency switching employed in such drives.

However, while there are several methods available to achieve stator energy delivery, it is important that the drive also be capable of correctly controlling phase currents for reliability, driving in four quadrant velocity loop control for dynamic performance, and managing regenerated energy for power stage protection. Of course the DSV Series amplifiers have all these capabilities plus a host of other standard and optional features to simplify control system integration. Please inquire about drive electronics suitable for your high speed motor application.

DSV Model	Operating Voltage	Continuous Current	Peak Current
DSV04807	48	7	12
DSV04812	48	12	20
DSV15007	150	7	12
DSV15012	150	12	20
DSV30007	300	7	12
DSV30012	300	12	20

**Hathaway**  
**Emoteq, Inc**

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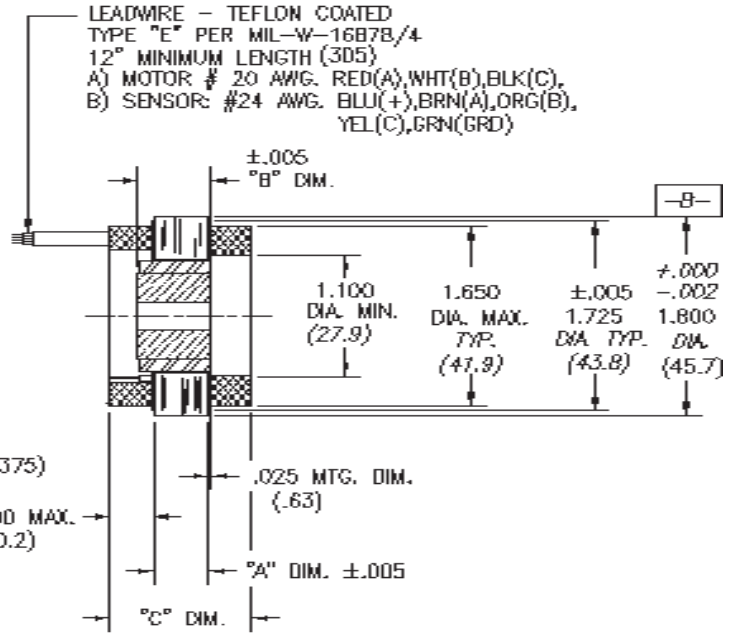
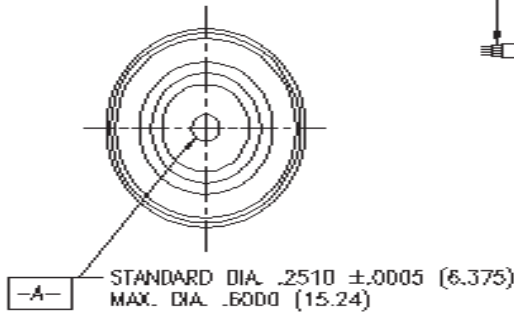
# High Speed Series

**BH02300  
Series**

## Brushless DC Motors

### Frameless BH02300 Series

MODEL	"A" DIM.	"B" DIM.	"C" DIM.
BH02300	.500 (12.7)	.680 (17.3)	1.120 (28.5)
BH02301	1.150 (29.2)	1.330 (33.8)	1.770 (45.0)
BH02302	1.800 (45.7)	1.980 (50.3)	2.420 (61.5)
BH02303	2.450 (62.2)	2.630 (66.8)	3.070 (78.0)

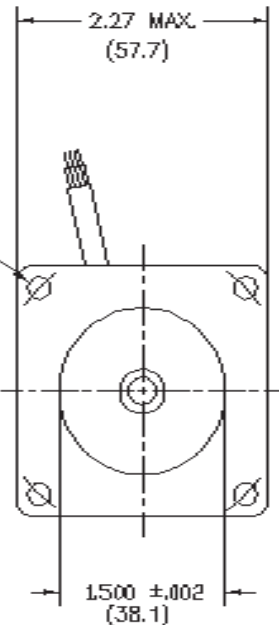


1. MOTOR SUPPLIED AS TWO SEPARATE COMPONENTS, ROTOR ASSEMBLY AND STATOR ASSEMBLY.
2. DIAMETERS "A" AND "B" TO BE CONCENTRIC WITHIN .002 WHEN MOUNTED.
3. MOUNTING SURFACE BETWEEN 1.800 AND 1.725 DIAMETERS ON BOTH SIDES.

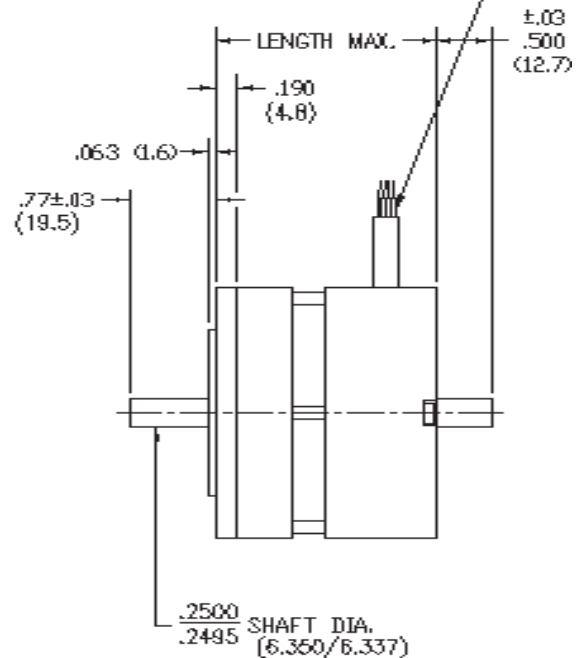
### Housed BH02300 Series

MODEL	LENGTH
BH02300	1.991 (50.6)
BH02301	2.641 (67.1)
BH02302	3.291 (83.8)
BH02303	3.941 (100.1)

(5.2)  
.205 ±.010 DIA. THRU. 4 PLCS.  
EQ. SP. ON A 2.625 DIA. B.C.  
(66.7)



LEADWIRE - TEFLON COATED  
TYPE "E" PER MIL-W-16878/4  
12" MINIMUM LENGTH (305)  
A) MOTOR: # 20 AWG. RED(A), WHT(B), BLK(C),  
B) SENSOR: #24 AWG. BLU(+), BRN(A), ORG(B),  
YEL(C), GRN(GRD)



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Tel 01273 390800  
Fax 01273 301060

# High Speed Series

## BH02300 Series

### Brushless DC Motors

Size Constants						
PARAMETER	SYMBOL	UNIT	BH02300	BH02301	BH02302	BH02303
Max Cont. Stall Torque	$T_C$	oz.in. Nm	14.3 0.101	29.8 0.21	43.1 0.30	56.1 0.39
Max Rated Torque, 25%	$T_R$	oz.in. Nm	161 1.14	340 2.40	522 3.69	699 4.94
Max Cont. Output Power	$P_{out}$	Watts	113	185	229	272
Motor Constant,	$K_M$	oz.in./V Nm/A	3.78 0.027	7.21 0.051	9.71 0.068	11.97 0.084
Electrical Time Constant	$T_E$	msec	0.32	0.53	0.63	0.71
Mechanical Time Constant	$T_M$	msec	8.48	4.55	3.65	3.22
Thermal Resistance	TPR	°C/Watt	4.18	3.55	3.16	2.81
Viscous Damping	$F_V$	oz.in./rpm Nm/rpm	3.2E-5 18	6.5E-5 4.6E-7	9.7E-5 6.9E-7	12.9E-5 9.1E-7
Max Cogging Torque	$T_F$	oz.in. Nm	1.56 0.011	2.07 0.0147	2.49 0.0176	2.84 0.0201

Mechanical Constants						
Frameless Motor Inertia	$J_M$	oz.in.s <sup>2</sup> Kg.m <sup>2</sup>	7.6E-4 5.4E-6	1.5E-3 1.1E-5	2.3E-3 1.6E-5	3.1E-3 2.2E-5
Frameless Motor Weight	Wt	oz Kg	8 0.22	14 0.40	20 0.57	26 0.74
Housed Motor Inertia	$J_M$	oz.in.s <sup>2</sup> Kg.m <sup>2</sup>	8.3E-4 5.9E-6	1.61E-3 1.1E-5	2.39E-3 1.7E-5	3.17E-3 2.2E-5
Housed Motor Weight	Wt	oz Kg	18 0.51	24 0.68	30 0.85	36 1.02
Number of Poles	-	-	4	4	4	4

Winding Constants														
Winding Designation	-	-	A	B	C	A	B	C	A	B	C	A	B	C
Design Voltage	$V_p$	Volts	24	43	130	24	43	130	24	43	130	24	43	130
Peak Torque	$T_p$	oz.in. Nm	85 0.60	106 0.75	133 0.94	175 1.23	245 1.73	340 2.40	172 1.22	309 2.18	522 3.69	263 1.85	472 3.33	650 4.58
Peak Current	$I_p$	Amperes	21.8	19.3	9.6	25.5	27.8	20.3	13.5	24.1	25.8	20.7	37.2	23.9
Torque Constant, ±10%	$K_T$	oz.in./A Nm/A	3.91 0.027	5.54 0.039	13.85 0.09	6.88 0.05	8.82 0.06	16.81 0.11	12.85 0.09	12.85 0.09	20.24 0.14	12.69 0.09	12.69 0.09	27.2 0.19
No Load Speed	$S_{NL}$	RPM Rad/s	8220 861	10410 1090	12600 1319	4690 491	6550 686	10420 1091	2500 262	4500 471	8650 906	2540 266	4560 478	6440 674
BEMF Constant, ±10%	$K_B$	V/KRPM V/rad/s	2.89 0.03	4.09 0.04	10.24 0.09	5.08 0.05	6.52 0.06	12.45 0.11	9.51 0.09	9.51 0.09	14.99 0.14	9.39 0.09	9.39 0.09	20.11 0.19
Terminal Resistance, ±12%	$R_M$	Ohms	1.10	2.23	13.5	0.94	1.55	5.65	1.78	1.78	4.54	1.16	1.16	5.44
Terminal Inductance, ±30%	$L_M$	mH	0.35	0.71	4.42	0.49	0.81	2.96	1.13	1.13	2.80	0.82	0.82	3.75

**Continuous Duty Speed/Torque Curves for 115°C Rise**

Speed/torque curves are provided as a guide to motor performance capability. The curves depict the maximum continuous speed and torque combinations based upon a winding temperature rise of 115°C. Typically the standard windings do not allow utilization of all of the performance envelope mainly because of the low  $K_T$  of higher speed windings. However, if required, standard motors can be driven to higher speeds if higher voltages are applied.

When it not possible to use a standard winding, a new winding can easily be designed.

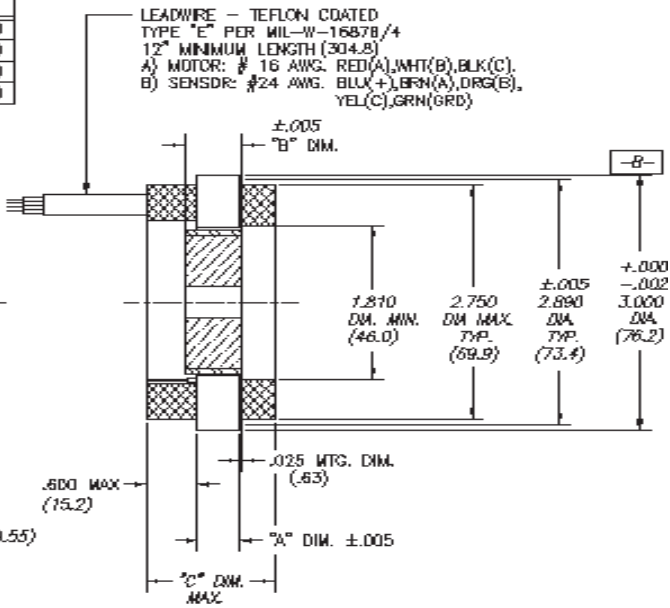
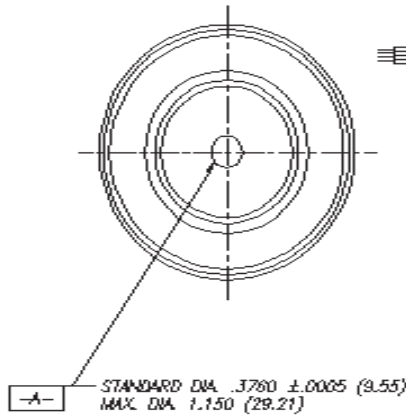
# High Speed Series

## Brushless DC Motors

# BH03400 Series

### Frameless BH03400 Series

MODEL	"A" DIM.	"B" DIM.	"C" DIM.
BH03400	.500 (12.7)	.680 (17.3)	1.500 (38.1)
BH03401	1.150 (29.2)	1.330 (33.8)	2.150 (54.0)
BH03402	1.800 (45.7)	1.980 (50.3)	2.800 (71.1)
BH03403	2.450 (62.2)	2.630 (66.8)	3.450 (87.6)



LEADWIRE - TEFLON COATED  
 TYPE "E" PER MIL-W-16878/4  
 12" MINIMUM LENGTH (304.8)  
 A) MOTOR: #16 AWG. RED(A), WHT(B), BLK(C).  
 B) SENSOR: #24 AWG. BLU(+), BRN(A), ORG(B),  
 YEL(C), GRN(GRD)

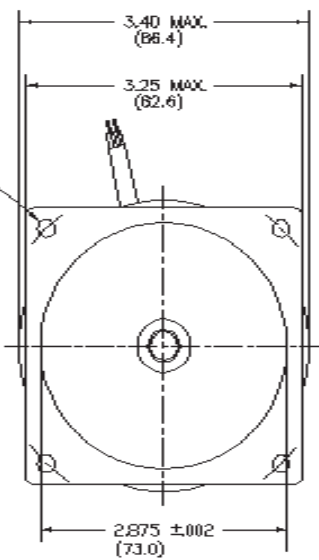
1. MOTOR SUPPLIED AS TWO SEPARATE COMPONENTS, MAGNET ASSY AND ARMATURE/SENSOR ASSY.
2. DIAMETERS -A- AND -B- TO BE CONCENTRIC WITHIN .002 WHEN MOUNTED.
3. MOUNTING SURFACE BETWEEN 3.000 AND 2.890 DIAMETERS ON BOTH SIDES.

### Housed BH03400 Series

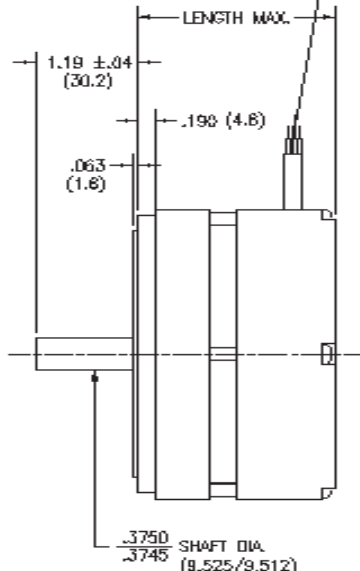
#### BH03400 SERIES HOUSED

MODEL	LENGTH
BH03400	2.300 (58.4)
BH03401	2.850 (74.3)
BH03402	3.600 (91.4)
BH03403	4.250 (108)

(5.66)  
 .223 ±.010 DIA THRU. 4 PLCS.  
 EQ. SP. ON A 3.875 DIA B.C.  
 (98.4)



LEADWIRE - TEFLON COATED  
 TYPE "E" PER MIL-W-16878/4  
 12" MINIMUM LENGTH (304.8)  
 A) MOTOR: #16 AWG. RED(A), WHT(B), BLK(C).  
 B) SENSOR: #24 AWG. BLU(+), BRN(A), ORG(B),  
 YEL(C), GRN(GRD)



# High Speed Series

## Brushless DC Motors

## BH03400 Series

### Size Constants

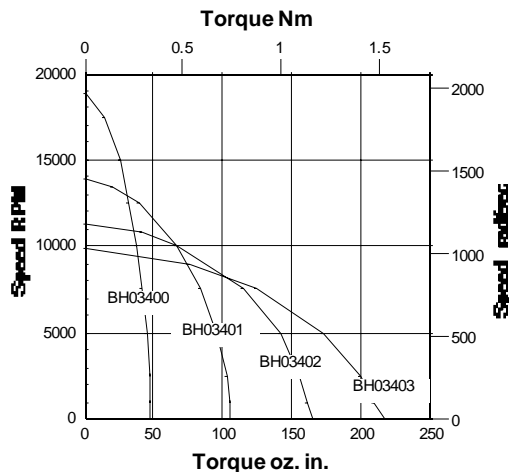
PARAMETER	SYMBOL	UNIT	BH03400	BH03401	BH03402	BH03403
Max Cont. Stall Torque	$T_C$	oz.in.	47.5	106	165	217
			Nm	0.34	0.75	1.16
Max Rated Torque, 25%	$T_R$	oz.in.	293	704	1022	1304
			Nm	2.07	4.97	7.22
Max Cont. Output Power	$P_{out}$	Watts	359	540	670	783
			Motor Constant, $K_M$	oz.in./V	9.1	18.3
		Nm/A	0.064	0.129	0.189	0.239
Electrical Time Constant	$T_E$	msec	0.66	1.19	1.63	1.97
Mechanical Time Constant	$T_M$	msec	11.15	5.44	3.78	3.05
Thermal Resistance	TPR	°C/Watt	2.44	2.00	1.84	1.65
Viscous Damping	$F_V$	oz.in./rpm	1.12E-4	2.41E-4	3.69E-4	4.97E-4
			Nm/rpm	8.0E-7	1.7E-6	2.6E-6
Max Cogging Torque	$T_F$	oz.in.	2.83	4.07	5.01	5.78
			Nm	0.020	0.028	0.035

### Mechanical Constants

Frameless Motor Inertia	$J_M$	oz.in.s <sup>2</sup>	6.3E-3	1.3E-2	1.9E-2	2.6E-2
		Kg.m <sup>2</sup>	4.4E-5	9.1E-5	1.3E-4	1.8E-4
Frameless Motor Weight	Wt	oz	19	35	50	65
		Kg	0.53	0.99	1.42	1.84
Housed Motor Inertia	$J_M$	oz.in.s <sup>2</sup>	6.4E-3	1.3E-2	2.0E-2	2.7E-2
		Kg.m <sup>2</sup>	4.5E-5	9.2E-5	1.4E-4	1.9E-4
Housed Motor Weight	Wt	oz	37	53	69	85
		Kg	1.05	1.50	1.95	2.4
Number of Poles	-	-	4	4	4	4

### Winding Constants

Winding Designation	-	-	A			B			C			A			B			C		
			24	43	130	24	43	130	24	43	130	24	43	130	24	43	130	24	43	130
Design Voltage	$V_P$	Volts	24	43	130	24	43	130	24	43	130	24	43	130	24	43	130	24	43	130
Peak Torque	$T_P$	oz.in.	155	277	293	365	655	704	815	832	1022	1253	769	1304	8.85	5.43	9.2	8.85	5.43	9.2
		Nm	1.09	1.95	2.07	2.58	4.63	4.97	5.75	5.87	7.22	8.85	5.43	9.2	8.85	5.43	9.2	8.85	5.43	9.2
Peak Current	$I_P$	Amperes	12.2	21.9	14.3	16.9	28.6	18.2	39.7	22.3	14.8	57.4	11.7	18.4	57.4	11.7	18.4	57.4	11.7	18.4
Torque Constant, ±10%	$K_T$	oz.in./A	12.65	12.65	20.43	21.70	22.91	38.58	20.53	37.32	69.04	21.86	65.57	70.66	21.86	65.57	70.66	21.86	65.57	70.66
		Nm/A	0.089	0.089	0.144	0.153	0.161	0.272	0.144	0.263	0.487	0.154	0.463	0.499	0.154	0.463	0.499	0.154	0.463	0.499
No Load Speed	$S_{NL}$	RPM	2540	4570	8570	1490	2530	4540	1570	1550	2540	1480	880	2480	1480	880	2480	1480	880	2480
		Rad/s	266	479	897	156	265	475	164	162	266	155	92	260	155	92	260	155	92	260
BEMF Constant, ±10%	$K_B$	V/KRPM	9.35	9.35	15.11	16.05	16.94	28.53	15.18	27.60	51.05	16.16	48.48	52.25	16.16	48.48	52.25	16.16	48.48	52.25
		V/rad/s	0.089	0.089	0.144	0.153	0.161	0.272	0.144	0.263	0.487	0.154	0.463	0.499	0.154	0.463	0.499	0.154	0.463	0.499
Terminal Resistance, ±12%	$R_M$	Ohms	1.96	1.96	5.02	1.42	1.50	4.49	0.60	1.93	6.70	0.42	3.66	4.31	0.42	3.66	4.31	0.42	3.66	4.31
Terminal Inductance, ±30%	$L_M$	mH	1.29	1.29	3.38	1.69	1.88	5.36	0.96	3.19	10.92	0.80	7.23	8.39	0.80	7.23	8.39	0.80	7.23	8.39



### Continuous Duty Speed/Torque Curves for 115°C Rise

Speed/torque curves are provided as a guide to motor performance capability. The curves depict the maximum continuous speed and torque combinations based upon a winding temperature rise of 115°C. Typically the standard windings do not allow utilization of all of the performance envelope mainly because of the low  $K_T$  of higher speed windings. However, if required, standard motors can be driven to higher speeds if higher voltages are applied.

When it not possible to use a standard winding, a new winding can easily be designed.

# High Speed Series

## Brushless DC Motors

## Example Designs

### Example Designs of High Speed Brushless Motors

The motors whose specifications are published on these two pages, are used in the following applications (in no particular order):

- Printed circuit board drilling spindles
- Laser scanning heads
- Image acquisition and reproduction
- High speed machining heads
- Semiconductor deposition and cleaning systems
- Silicon wafer slicing equipment
- Optical glass grinding

The loadpoint curves published below are provided to serve as a guide to motor capabilities. Details of the output powers of the motors is tabulated on the opposite page.

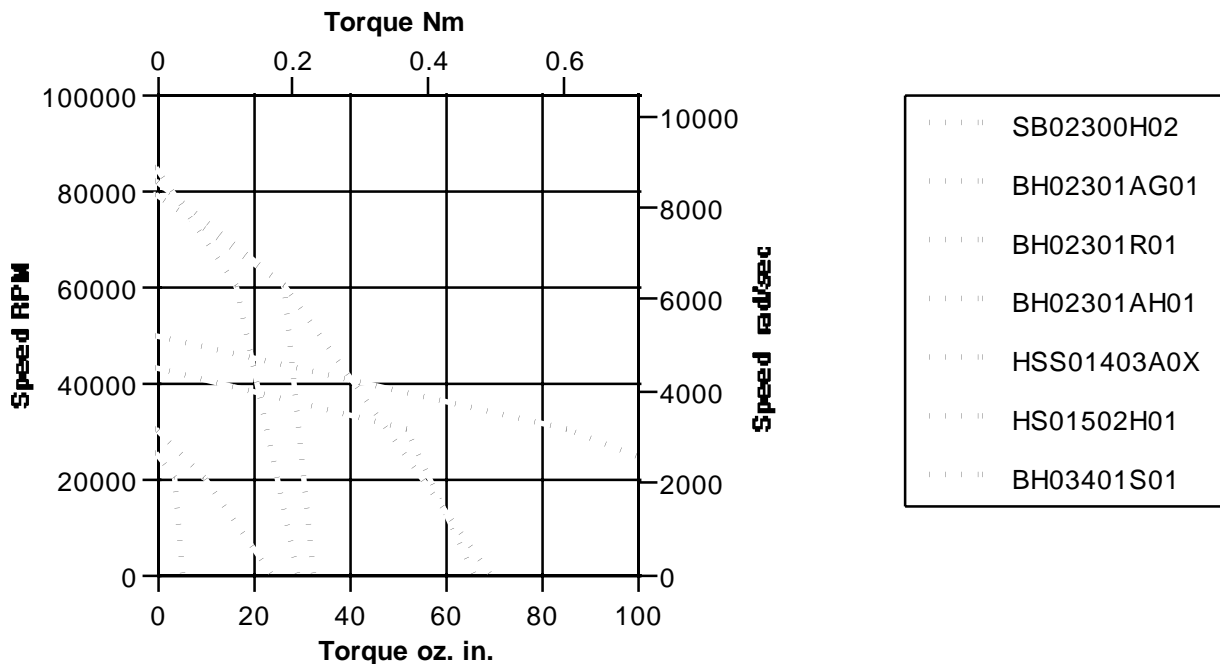
### Application and Design Engineering

Generally, designing motors for high speed applications requires consideration of all parameters of the application including the loadpoint (speed and torque or output power), power supply, the mechanical constraints, and the environmental conditions.

Emoteq is organized with applications and design engineers who can assist in defining a motor to suit your requirements. Further, we can quickly deliver motors to meet your needs through our special products group.

Once prototype testing and production design release has been finalized, then our standard product manufacturing group takes over to provide cost effective motors and assure uniformly high quality.

### Loadpoint curves for design examples



# High Speed Series

## Brushless DC Motors

## Example Designs

<b>Size Constants</b>									
Parameter	Symbol	Unit	SB02300	BH02301	BH02301	BH02301	HS01502	HSS01403	BH03401
Max Cont. Stall Torque	$T_C$	oz.in. Nm	5.9 0.042	24.1 0.170	66.5 0.470	69.8 0.493	29.6 0.209	33.0 0.233	253 1.79
Max Rated Torque, 25%	$T_R$	oz.in. Nm	76.8 0.543	234 1.65	351 2.48	237 1.67	113 0.799	225 1.594	535 3.784
Motor Constant,	$K_M$	oz.in./V Nm/V	1.96 0.014	5.70 0.040	7.06 0.050	5.34 0.038	3.42 0.024	4.50 0.032	19.49 0.138
Electrical Time Constant	$T_E$	msec	0.236	0.616	0.719	0.529	0.536	0.316	2.527
Mechanical Time Constant	$T_M$	msec	8.58	4.98	3.746	5.393	2.456	2.662	4.178
Thermal Resistance	TPR	°C/Watt	8.5	3.55	0.74	0.44	1.00	1.12	0.40
Viscous Damping	$F_V$	oz.in./rpm Nm/rpm	2.0E-5 1.5E-7	4.8E-5 3.4E-7	6.7E-5 4.7E-7	4.7E-5 3.3E-7	1.6E-5 1.1E-7	1.4E-5 1.0E-7	2.6E-4 1.9E-6
Max Cogging Torque	$T_F$	oz.in. Nm	0.50 0.003	2.07 0.015	2.07 0.015	2.07 0.015	1.80 0.013	2.0 0.014	4.07 0.029

<b>Mechanical Constants</b>									
Stator Diameter	D	in mm	1.800 45.720	1.800 45.720	1.800 45.720	1.800 45.720	1.488 37.795	1.400 35.560	3.000 76.200
Stator Length	L	in mm	0.250 6.35	1.150 29.21	1.150 29.21	1.150 29.21	1.050 26.67	1.450 36.83	1.150 29.21
Length over coils	OL	in mm	0.870 22.09	1.77 44.95	1.77 44.95	1.77 44.95	1.90 48.26	2.16 54.91	2.15 54.61
Frameless Motor Inertia	$J_M$	oz.in.s <sup>2</sup> Kg.m <sup>2</sup>	2.3E-4 1.6E-6	1.1E-3 8.0E-6	1.3E-3 9.3E-6	1.1E-3 7.7E-6	2.0E-4 1.4E-6	3.8E-4 2.7E-6	1.1E-2 7.9E-5
Frameless Motor Weight	Wt	oz Kg	3.0 0.09	10.9 0.31	11.1 0.32	10.7 0.304	6.5 0.185	8.0 0.228	33.9 0.962
Number of Poles	-	n	4	4	4	4	4	4	4

<b>Winding Constants</b>									
Winding Designation	-	-	H02	AG01	R01	AH01	H01	A0X	S01
Design Voltage	$V_p$	Volts	21.2	110	180	300	120	150	300
Peak Torque	$T_p$	oz.in. Nm	70 0.49	234 1.65	351 2.48	237 1.67	113 0.79	225 1.59	535 3.78
Peak Current	$I_p$	Amperes	56.2	47.3	61.3	43.2	57.7	87.2	64.7
Torque Constant, ±10%	$K_T$	oz.in./A Nm/A	1.16 0.008	4.95 0.035	5.73 0.040	5.00 0.035	1.92 0.014	2.58 0.018	8.27 0.058
No Load Speed	$S_{NL}$	RPM Rad/s	24675 2584	30003 3149	42458 4446	81116 8494	84433 8841	78383 8208	49039 5135
BEMF Constant, ±10%	$K_B$	V/KRPM V/rad/s	0.85 0.008	3.66 0.035	4.24 0.040	3.69 0.035	1.42 0.014	1.91 0.018	6.118 0.058
Terminal Resistance, ±12%	$R_M$	Ohms	0.352	0.756	0.658	0.875	0.315	0.330	0.180
Terminal Inductance, ±30%	$L_M$	mH	0.083	0.465	0.473	0.463	0.169	0.104	0.455
Loadpoint data									
Speed	S	RPM	20000	20000	30000	60000	60000	60000	30000
Torque	T	oz.in. Nm	3.9 0.028	10.2 0.072	52.7 0.372	27.2 0.192	17.0 0.121	27.0 0.191	85.7 0.606
Output Power	P	Watts	57.7	151.5	1168	1208	757	1200	1903
Temp Rise	$T_{rise}$	°C	118	89	115	73	87	113	96
Voltage	$V_{terminal}$	VDC	21.2	110	180	300	120	150	300
DC link current	I	Amps	3.37	1.60	7.35	4.5	7.0	8.7	7.1
Efficiency	-	%	80.6	85.7	88.2	87.8	89.7	92.2	88.7
Cooling	-	-	still air	still air	water	water	water	water	water

### Brushless DC Motors

#### Size Constants

These parameters are dependent upon the size and shape of the motor but are largely independent of the winding used. However, special designs incorporating different lamination and magnet materials as well as design modifications such as increased magnetic air gaps can change these parameters. In such instances, a specific set of design data will be provided.

**Maximum Continuous Stall Torque ( $T_C$ )** is the amount of torque produced at zero speed which results in a 75°C rise in temperature. Generally, the highest operating temperature that should be allowed is 150°C and is a combination of the ambient temperature and the temperature rise for a given operating condition.

**Maximum Rated Torque ( $T_R$ )** is the amount of torque that the motor can produce without danger of demagnetizing the rotor. This torque is only available for short durations. Also, it may not be possible to produce the Maximum Rated Torque because of limitations of voltage and current (see Peak Torque).

**Motor Constant ( $K_M$ )** is the ratio of the peak torque to the square root of the input power at stall with 25°C ambient temperature. This ratio is useful during the initial selection of a motor because it indicates the ability of the motor to convert electrical power into torque.

$$K_M = T_P (\text{Peak Torque}) / \sqrt{P_P (\text{Peak Input Power})}$$

or

$$K_M = K_T (\text{Torque Constant}) / \sqrt{R_M (\text{Term. Resistance})}$$

**Electrical Time Constant ( $T_E$ )** is the ratio of inductance  $L_M$  in Henries, to the resistance  $R_M$  in Ohms. This is the inductance and resistance as measured across any two phases in a delta or wye configuration.

$$T_E = L_M / R_M$$

**Mechanical Time Constant ( $T_M$ )** is the time required to reach 63.2% of the motors maximum speed after the application of constant DC voltage through the commutation electronics, ignoring friction, windage, and core losses.

$$T_M = J_M * R_M / K_T * K_B$$

**Thermal Resistance (TPR)** correlates winding temperature rise to the average power dissipated in the stator winding. The published TPR assumes that a housed motor is mounted to an aluminum heatsink of specific dimensions. Additional cooling from forced air, water jacketing, or increased heatsinking decreases the motor Thermal Resistance allowing higher power outputs than the published data.

**Viscous Damping (F)** represents the losses in the motor which are proportional to speed with an infinite source impedance. Such losses include windage, friction, and eddy currents.

**Maximum Cogging Torque ( $T_C$ )** is principally the static friction torque felt as the motor is rotated at low speed. The published value does not include the bearing friction of a housed motor.

#### Winding Constants

The winding constants are the parameters that vary with the number of wire turns per coil and the wire size. These parameters are collected under an alphabetical winding designation. A single frame size and length of motor will have several different windings. Special windings receive new designations in the sequence by which they are designed and released to production.

**Design Voltage ( $V_p$ )** is the nominal voltage required to produce the peak torque when the rotor speed is zero and the winding temperature is 25°C. As such,  $V_p$  is the product of  $I_p$  and  $R_M$ . At any temperature greater than 25°C, the required voltage to produce peak torque increases due to the increase in winding resistance. The design voltage is not a limit but a reference point for the data.

**Peak Torque ( $T_p$ )** is the nominal value of developed torque with the rated current  $I_p$  applied to the windings. For each winding specified the product of peak current ( $I_p$ ) and nominal torque sensitivity ( $K_T$ ) gives  $T_p$  unless the maximum rated torque ( $T_R$ ) is reached.

**Peak Current ( $I_p$ )** is the rated current used to obtain the nominal peak torque from the motor with nominal torque sensitivity ( $K_T$ ).  $I_p$  is generally the design voltage divided by the terminal resistance ( $R_M$ ).

# High Speed Series

## Connection Diagrams

### Brushless DC Motors

**Torque Sensitivity ( $K_T$ )** is the ratio of the developed torque to the applied current for a specific winding.  $K_T$  is related to the BEMF Constant  $K_B$ .

**No Load Speed ( $S_{NL}$ )** is the theoretical no load speed of the motor with the design voltage applied.

**BEMF Constant ( $K_B$ )** is the ratio of voltage generated in the winding to the speed of the rotor.  $K_B$  is proportional to  $K_T$ .

**Terminal Resistance ( $R_M$ )** is the winding resistance measured between any two leads of the winding in either a delta or wye configuration at 25°C.

**Terminal Inductance ( $L_M$ )** is the winding inductance measured between any two leads of the winding in either delta or wye configuration at 25°C.

### Mechanical Data

**Rotor inertia ( $J_M$ )** is the moment of inertia of the rotor about its axis of rotation.

**Motor Weight (W)** is the weight of the standard motor.

**Number of Poles ( $N_p$ )** is the number of permanent magnet poles of the rotor. For the standard BH Series motors this is four poles (two pole pairs).

### Speed-Torque Curves

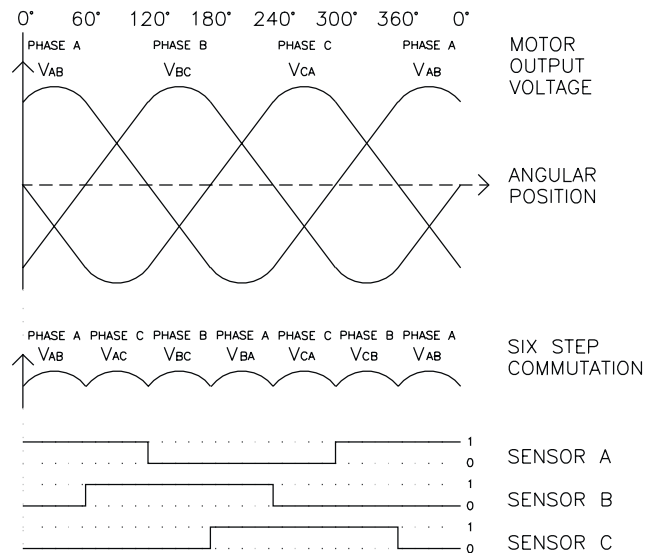
BH Series curves are for the standard catalog designs. The curves are based upon a 115°C rise over the ambient temperature.

The temperature rise of the example motors for a particular loadpoint is given in the tabulated data and differs from model to model.

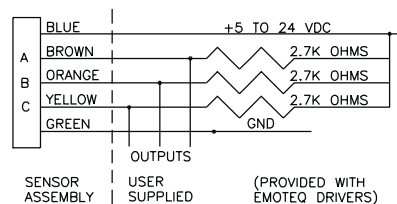
### Motor Connections and Commutation Logic

MOTOR EXCITATION SEQUENCE AND SENSOR OUTPUT LOGIC FOR CW ROTATION VIEWING LEADWIRE END.

EXCITATION STEP		1	2	3	4	5	6	1
MOTOR LEADS	(RED) A	+	+	-	-	+	+	
	(WHT) B	-	+	+	-	-	+	
	(BLK) C	-	-	+	+	-	-	
SENSOR OUTPUTS	(BRN) A	1	1	0	0	1	1	
	(ORG) B	0	1	1	1	0	0	
	(YEL) C	0	0	0	1	1	1	



### HALL EFFECT CONNECTION DIAGRAM



# High Speed Series

## Brushless DC Motors

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All data subject to specific tolerances. All critical design data should be verified before final design. Errors due to rounding may exist in the data. Emoteq reserves the right to make changes without notice.

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