.86” (22mm) Series

• High performance slotless brushless motors for military, aerospace, surgical and dental, tools, and industrial applications

•Medium and long lengths available

• Vacuum versions available, also available with gearboxes, encoders and temperature sensors (sensorless only).

• Cog free design ideal for precision motion

• 2 and 4 pole designs

•hollow shaft versions available

• Autoclavable versions for surgical/dental applications

• Highest power density

• High temperature ML (240°C) insulation, hardened and ground stainless shafts, TFE insulated lead wires. Ceramic hybrid bearings available

• Available with hall sensors, sensorless, and integral electronics

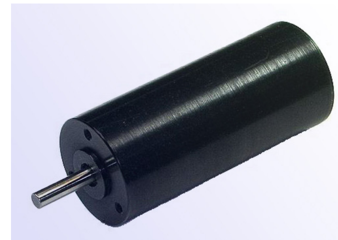
•Speeds up 200,000 rpm

• Up to 89% efficiency

KOFORD
ENGINEERING, LLC

.86" (22mm) Slotless Brushless DC motor Long length 24v windings

•Up to 50,000 rpm **•Rated power up to 50 watts** **•2 pole**

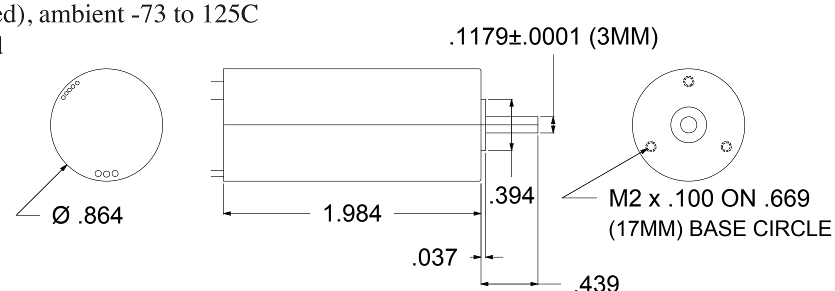


Interchanges with imported slotless brushless motors but with shorter length and lighter weight. High efficiency, speed and power. Slotless design is cog free, cost effective, and provides high efficiency and cool operation. Available with optical encoders and gearheads. 150°C rated Neo rare earth magnets standard. ML (240°C) insulation is standard for highest reliability. Available with hall sensors for positioning, reversing, or applications involving heavy inertial loads and sensorless for use with our sensorless controllers, or for use with encoder controlled commutation. These motors exhibit exceptionally smoothness at low speed when driven by encoder controlled sinusoidal drives. Custom versions available including custom windings for different no load rpm or input voltage. Modified shafts can also be provided. Winding temperature sensors (thermistor) can be provided on sensorless versions only.

Motor Data

Winding		882	699	555	440	349
Ball Bearing type		stainless	stainless	stainless	stainless	stainless
Nominal supply voltage	volts	24	24	24	24	24
no load speed	rpm ±12%	21,168	16,776	13,320	10,560	8,376
speed/torque slope	rpm/oz-in	618	610	570	545	530
Stall torque	oz-in	53	42	34	27	21.3
Continuous torque case 60°C/no h.s.	oz-in	14/5.0	14/5.2	14/5.5	14/5.5	14/5.4
Continuous current case 60°C/no h.s.	amps	9.4/3.2	7.4/2.7	5.9/2.3	4.7/1.8	3.7/1.4
Motor constant Km	oz-in/√w	1.68	1.68	1.68	1.68	1.68
Winding resistance	ohm±15%	.68	1.09	1.72	2.73	4.34
Peak output	watts	116	75	52	37	24
No load current	amp±50%	.15	.10	.08	.05	.04
Damping factor	oz-in/krpm	.007	.007	.008	.008	.008
Static friction	oz-in	.08	.08	.08	.08	.08
Velocity constant	rpm/volt	882	699	555	440	349
Torque constant Kt	oz-in/amp	1.53	1.93	2.43	3.07	3.87
Stall current	amps	35	22	14	8.8	5.5
Maximum efficiency	%	87	87	86	85	84
Winding inductance	mH	.15	.23	.38	.60	.96
Mechanical time constant	ms	1.9	1.9	1.9	1.9	1.9
Rotor inerta	10^{-4}oz-in-sec^2	.468	.468	.468	.468	.468
Thermal res. winding to case	°C/W	1	1	1	1	1
Thermal case to ambient	°C/W	8	8	8	8	8

Weight 3.4 oz Maximum winding temperature 150°C (hall and magnet temp limited), ambient -73 to 125C values based on winding and magnet temperature of 20°C Winding resistance does not include lead resistance of .052Ω. Leads are TFE 12" minimum 24 gauge phase and 28 gauge hall.



Leads	
Blue	Phase A
White	Phase B
Brown	Phase C
Red	+5 volts
Black	Ground
Yellow	Sensor A
Orange	Sensor B
Green	Sensor C

Maximum axial bearing force 20 lb

Ordering Information: Please send your order to: mail@koford.com

Example: Part Number 22L H 700 A / A3 / P4

Gearhead P4=3.7:1, P25=25.01:1, P93=92.70

Encoder A3=360 lines, A2=256 lines

Modifications A=none V=Vacuum T=temperature sensor

Motor dia.

Type S=sensorless H=120°halls

Winding number

Test Data
Total System Performance
22LH882A with H24V10A Controller at 24 volts

Rpm	Torque Oz-in	Watts Out	Efficiency %	Amps
20530	0.00	0.00	0.0	0.17
18866	2.50	35.06	76.5	1.91
17985	4.12	54.89	79.7	2.87
16844	6.00	74.80	77.3	4.03
15641	7.98	92.38	73.7	5.22
14057	10.03	104.35	66.8	6.51
12635	12.03	112.49	60.9	7.70
11266	13.90	115.70	54.2	8.90
9589	15.91	112.47	46.4	10.10

Dyno test results of a motor and drive combination with voltage held to 24v at input of drive using remote voltage sense on the power supply. Winding temperature is held below 40C by running test quickly and/or allowing motor to cool between tests. Test were conducted at room temperature ambient. Full length untrimmed motor leads were used. Total system efficiency is a function of motor efficiency, drive efficiency, and wiring losses.

Test Data
Total System Performance
22LH882A with H24V10A Controller at 12 volts

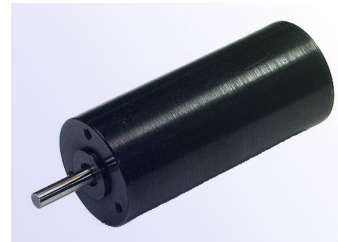
Rpm	Torque Oz-in	Watts Out	Efficiency %	Amps
10250	0.00	0.00	0.0	0.13
9589	1.03	7.29	69.0	0.88
9075	2.05	13.77	77.0	1.49
8539	3.09	19.59	76.6	2.13
8068	4.03	24.08	74.6	2.69
7524	5.01	27.87	70.4	3.30
7051	5.93	30.94	66.6	3.87
6363	6.98	32.84	60.4	4.53
5919	7.95	34.82	57.0	5.09

Dyno test results of a motor and drive combination with voltage held to 24v at input of drive using remote voltage sense on the power supply. Winding temperature is held below 40C by running test quickly and/or allowing motor to cool between tests. Test were conducted at room temperature ambient. Full length untrimmed motor leads were used. Total system efficiency is a function of motor efficiency, drive efficiency, and wiring losses.

KOFORD ENGINEERING, LLC

.86" (22mm) Slotless Brushless DC motor long length 32 and 48v windings

•Up to 46,700 rpm **•Rated power 50 watts** **•2 pole**



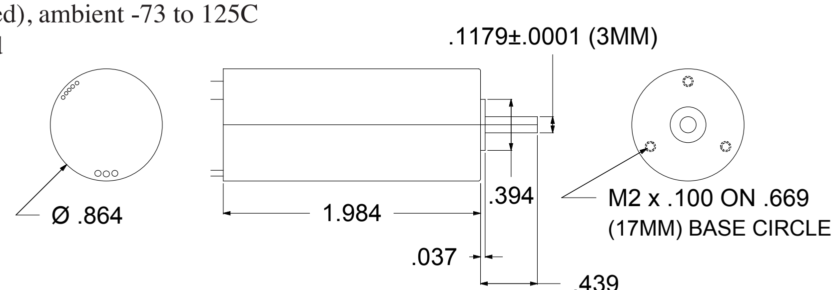
Interchanges with imported slotless brushless motors but with shorter length and lighter weight. High efficiency, speed and power. Slotless design is cog free, cost effective, and provides high efficiency and cool operation. Available with optical encoders and gearheads. 150°C rated Neo rare earth magnets standard. ML (240°C) insulation is standard for highest reliability. Available with hall sensors for positioning, reversing, or applications involving heavy inertial loads and sensorless for use with our sensorless controllers, or for use with encoder controlled commutation. These motors exhibit exceptionally smoothness at low speed when driven by encoder controlled sinusoidal drives. Custom versions available including custom windings for different no load rpm or input voltage. Modified shafts can also be provided. Winding temperature sensors (thermistor) can be provided on sensorless versions only.

Motor Data

Winding		700	1459	701	883
Ball Bearing type		stainless	stainless	stainless	stainless
Nominal supply voltage	volts	32	32	48	48
no load speed	rpm ±12%	22,400	46,700	33,648	42,396
speed/torque slope	rpm/oz-in	620	680	650	670
Stall torque	oz-in	56	95	84	107
Continuous torque case 20°C/no h.s.	oz-in	17/5.0	14/3.7	10.8/2.7	16.8/4.4
Continuous current case 20°C/no h.s.	amps	8.8/2.6	16/4.0	8.7/2.2	11.0/2.9
Motor constant Km	oz-in/√w	1.68	1.65	1.68	1.68
Winding resistance	ohm±15%	1.09	.31	1.09	.68
Peak output	watts	128	540	270	445
No load current	amp±50%	.11	.38	.17	.24
Damping factor	oz-in/krpm	.007	.007	.007	.007
Static friction	oz-in	.08	.08	.08	.08
Velocity constant	rpm/volt	700	1459	701	883
Torque constant Kt	oz-in/amp	1.93	.92	1.25	1.53
Stall current	amps	29	103	44	70
Maximum efficiency	%	87	88	88	89
Winding inductance	mH	.23	.05	.23	.15
Mechanical time constant	ms	1.9	1.9	1.9	1.9
Rotor inertia	10^{-4}oz-in-sec^2	.468	.468	.468	.468
Thermal res. winding to case	°C/W	1	1	1	1
Thermal case to ambient	°C/W	8	8	8	8

Weight 3.4 oz Maximum winding temperature 150°C (hall and magnet temp limited), ambient -73 to 125C values based on winding and magnet temperature of 20°C Winding resistance does not include lead resistance of .052Ω. Leads are TFE 12" minimum 24 gauge phase and 28 gauge hall.

Maximum axial bearing force 20 lb



Leads	
Blue	Phase A
White	Phase B
Brown	Phase C
Red	+5 volts
Black	Ground
Yellow	Sensor A
Orange	Sensor B
Green	Sensor C

Ordering Information: Please send your order to: mail@koford.com

Example: Part Number 22L H 700 A / A1 / P4

- Motor dia. (22L)
- Type S=sensorless H=120°halls (H)
- Winding number (700)
- Modifications A=none V=Vacuum T=temperature sensor (A)
- Encoder A2=256 lines (A1)
- Gearhead P4=3.7:1, P25=25.01:1, P93=92.70 (P4)

KOFORD
ENGINEERING, LLC

.86" (22mm) Slotless Brushless DC motor.

• Medium speed series •Up to 61,500 rpm •Rated power to 16 watts •2 pole •12 or 15 volts

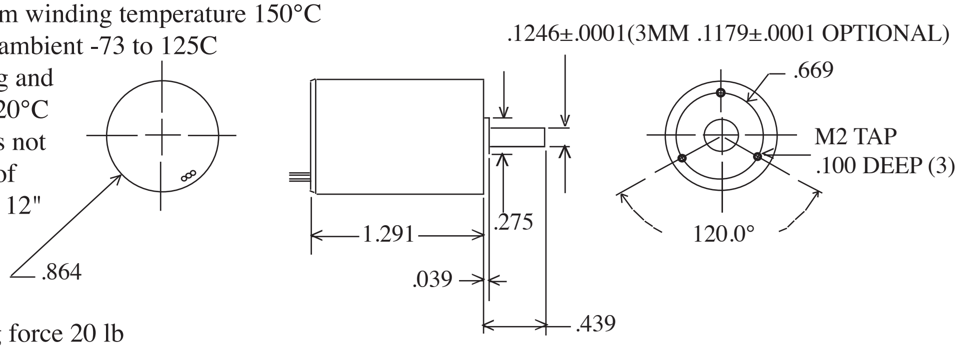
Slotless design is cog free, cost effective, and provides high efficiency and cool operation. Available with optical encoders and gearheads. 150°C rated Neo rare earth magnets standard. ML (240°C) insulation is standard for highest reliability. Available with hall sensors for positioning, reversing, or applications involving heavy inertial loads and sensorless for use with our sensorless controllers, or for use with encoder controlled commutation. These motors exhibit exceptionally smoothness when driven by encoder controlled sinusoidal drives. Custom versions available including custom windings for different no load rpm or input voltage. Modified shafts can also be provided. Winding temperature sensors (thermistor) can be provided on sensorless versions only.

Motor Data

Winding		1866	5107	933	1867
Ball Bearing type		stainless	stainless	stainless	stainless
Nominal supply voltage	volts	12	12	15	15
no load speed	rpm ±12%	22,400	61,500	14,000	28,000
speed/torque slope	rpm/oz-in	2,470	1,868	2,292	2,535
Stall torque	oz-in	10.0	47.0	6.51	12.5
Continuous torque case 20°C/no h.s.	oz-in	2.7/.9	2.1/0	2.8/1.4	2.7/.9
Continuous current case 20°C/no h.s.	amps	4.0/1.4	8.2/-	2.0/1.4	3.8/1.5
Motor constant Km	oz-in/√w	.80	1.03	.79	.83
Winding resistance	ohm±15%	.80	.066	3.2	.80
Peak output	watts	41	420	16	64
No load current	amp±50%	.19	.70	.066	.23
Damping factor	oz-in/krpm	.005	.0026	.005	.005
Static friction	oz-in	.024	.024	.024	.024
Velocity constant	rpm/volt	1866	5,107	933	1,867
Torque constant Kt	oz-in/amp	.715	.264	1.43	.715
Stall current	amps	14.1	181	4.57	17.6
Maximum efficiency	%	78	88	77	78
Winding inductance	mH	.08	.01	.31	.08
Mechanical time constant	ms	6	5	6	6
Rotor inertia	10^{-4}oz-in-sec^2	.280	.280	.280	.280
Thermal res. winding to case	°C/W	5	5	5	5
Thermal case to ambient	°C/W	12	12	12	12

Weight 1.8 oz Maximum winding temperature 150°C (magnet temp limited), ambient -73 to 125C values based on winding and magnet temperature of 20°C Winding resistance does not include lead resistance of .052Ω. Leads are TFE 12" minimum 24 gauge phase and 28 gauge hall.

Maximum axial bearing force 20 lb



Leads	
Blue	Phase A
White	Phase B
Brown	Phase C
Red	+5 volts
Black	Ground
Yellow	Sensor A
Orange	Sensor B
Green	Sensor C

<u>Ordering Information:</u> Please send your order to: mail@koford.com

Example: Part Number 22 H 100 A / A3 / S11

Motor dia. — 22
Type S=sensorless H=120°halls — H
Winding number — 100
Modifications A=none T=temperature sensor E=3mm shaft H=hollow shaft (.085±.002 hole) S=sealed bearings, V= vacuum compatible — A
Encoder A3=360 lines, A2=256 lines — A3
Gearhead S11=11.0:1 — S11

KOFORD ENGINEERING, LLC

.86" (22mm) Slotless Brushless DC motor.

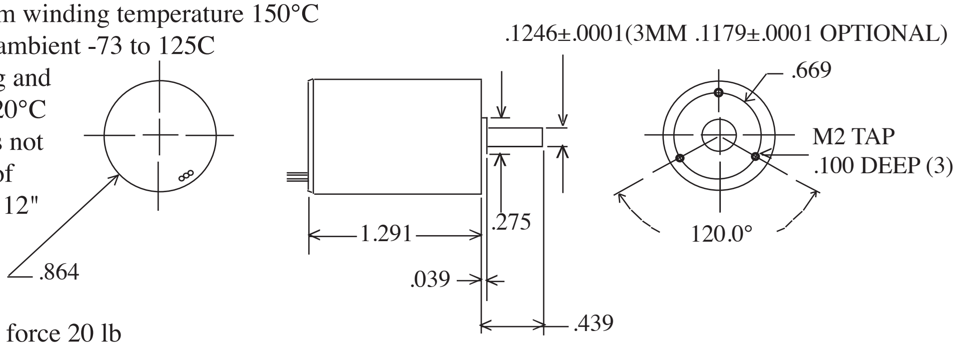
• Medium speed series •Up to 28,800 rpm •Rated power to 17 watts •2 pole •24 volts

Slotless design is cog free, cost effective, and provides high efficiency and cool operation. Available with optical encoders and gearheads. 150°C rated Neo rare earth magnets standard. ML (240°C) insulation is standard for highest reliability. Available with hall sensors for positioning, reversing, or applications involving heavy inertial loads and sensorless for use with our sensorless controllers, or for use with encoder controlled commutation. These motors exhibit exceptionally smoothness when driven by encoder controlled sinusoidal drives. Custom versions available including custom windings for different no load rpm or input voltage. Modified shafts can also be provided. Winding temperature sensors (thermistor) can be provided on sensorless versions only.

Motor Data

Winding		675	1200
Ball Bearing type		stainless	stainless
Nominal supply voltage	volts	24	24
no load speed	rpm ±12%	16,200	28,800
speed/torque slope	rpm/oz-in	1,962	2535
Stall torque	oz-in	9.12	17.6
Continuous torque case 20°C/no h.s.	oz-in	3.0/1.2	2.7/.9
Continuous current case 20°C/no h.s.	amps	1.5/.66	2.5/.92
Motor constant Km	oz-in/√w	.87	1.07
Winding resistance	ohm±15%	5.2	1.11
Peak output	watts	27	72
No load current	amp±50%	.056	.12
Damping factor	oz-in/krpm	.005	.004
Static friction	oz-in	.024	.024
Velocity constant	rpm/volt	675	1200
Torque constant Kt	oz-in/amp	1.98	1.13
Stall current	amps	4.62	21.6
Maximum efficiency	%	80	86
Winding inductance	mH	.67	.22
Mechanical time constant	ms	5	5
Rotor inertia	10^{-4}oz-in-sec^2	.280	.280
Thermal res. winding to case	°C/W	5	5
Thermal case to ambient	°C/W	12	12

Weight 1.8 oz Maximum winding temperature 150°C (magnet temp limited), ambient -73 to 125C values based on winding and magnet temperature of 20°C Winding resistance does not include lead resistance of .052Ω. Leads are TFE 12" minimum 24 gauge phase and 28 gauge hall.
Maximum axial bearing force 20 lb



Leads	
Blue	Phase A
White	Phase B
Brown	Phase C
Red	+5 volts
Black	Ground
Yellow	Sensor A
Orange	Sensor B
Green	Sensor C

Ordering Information: Please send your order to: mail@koford.com

Example: Part Number 22 H 1200 A / A2 / S11

Motor dia. — 22
Type S=sensorless H=120°halls — H
Winding number — 1200
Modifications A=none T=temperature sensor E=3mm shaft H=hollow shaft (.085±.002 hole) S=sealed bearings, V= vacuum compatible — A
Encoder A3=360 lines, A2=256 lines — A2
Gearhead S11=11.0:1 — S11

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ENGINEERING, LLC

.86" (22mm) Slotless Brushless DC motor.

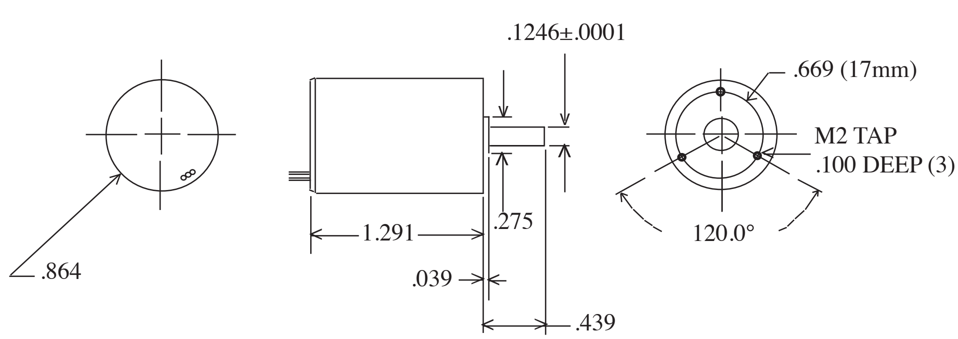
•High speed series •Up to 200,000 rpm •Sensorless •Rated power 32 watts •2 pole •24volts

Use where size or weight considerations do not allow use of the larger 48mm high speed motor. Slotless design is cog free, and provides high efficiency. High speed ceramic hybrid bearings for longest life. Intermittent duty up to 200,000 rpm and continuous operation up to 126,000 rpm with light load. The V (vacuum compatable option) is constructed using all non outgassing materials suitable for vacuum use. Water or refrigerant cooling is required for continuous vacuum operation since there is no cooling by ambient air. A winding temperature sensor is available. The motor features a hardened stainless shaft, Teflon insulated lead wires, 240°C magnet wire, precison balance, anodized machined aluminum housing. Special modifications are possible such as hollow shafts, custom shaft lengths, and custom windings. For 8333, 5284 and 6785 use S24V12A or S24V5A-4G drives. These motors can be used for autoclavable applications as long as an autoclave bag is used.

Motor Data

Winding		8333	6785	5284
Nominal supply voltage	volts	24	24	24
no load speed	rpm ±12%	200,000	162,840	126,818
speed/torque slope	rpm/oz-in	15,990	13,560	10,562
Continuous torque no heat sink	oz-in	-	-	.34
Continuous current no heat sink	amps	-	-	2.5
Maximum cont. power no heat sink	watts	-	-	28
Motor constant Km	oz-in/√w	.30	.32	.33
Winding resistance	ohm±15%	.30	.37	.62
Torque at 5 amps	oz-in	.7	.9	1.2
No load current	amp±50%	.40	.29	.21
Damping factor	oz-in/krpm	.00026	.00028	.00032
Static friction	oz-in	.012	.012	.012
Velocity constant	rpm/volt	8,333	6,785	5284
Torque constant Kt	oz-in/amp	.162	.199	.255
Maximum efficiency	%	86	87	86
Winding inductance	mH	.011	.017	.027
Rotor inerta	10^{-4}oz-in-sec^2	.111	.111	.111
Thermal res. winding to case	°C/W	5	5	5
Thermal case to ambient	°C/W	12	12	12

Weight 1.6 oz. Maximum winding temperature 150°C (magnet temp limited), ambient -73 to 125C, Values based on winding and magnet temperature of 20°C. Winding resistance does not include lead resistance of.052Ω. Leads are TFE 12" minimum 24 gauge phase and 28 gauge hall. Maximum axial bearing force 20 lb.



Leads	
Blue	Phase A
White	Phase B
Brown	Phase C
Red	+5 volts
Black	Ground
Yellow	Sensor A
Orange	Sensor B
Green	Sensor C

Ordering Information: Please send your order to: mail@koford.com

Example: Part Number 22 S 8333 A S11

Motor dia. — 22

Type S=sensorless — S

Winding number — 8333

Gearhead S11=11.0:1

Modifications A=none, V=vacuum compatible, T=thermistor
H=hollow shaft (.085±.002 hole)

KOFORD
ENGINEERING, LLC

.86" (22mm) Slotless Brushless DC motor.

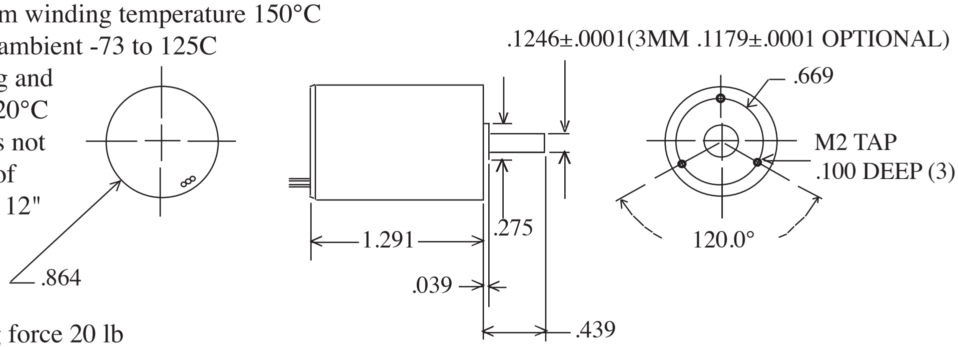
• High speed series •Up to 81,408 rpm •Rated power up to 33 watts •2 pole •24 volts

Slotless design is cog free, cost effective, and provides high efficiency and cool operation. 150°C rated Neo rare earth magnets standard. ML (240°C) insulation is standard for highest reliability. Available with hall sensors for positioning, reversing, or applications involving heavy inertial loads and sensorless for use with our sensorless controllers, or for use with encoder controlled commutation. These motors exhibit exceptionally smoothness when driven by encoder controlled sinusoidal drives. Custom versions available including custom windings for different no load rpm or input voltage. Modified shafts can also be provided. Winding temperature sensors (thermistor) can be provided on sensorless versions only. If encoders or gearboxes are added then the maximum rpm will be restricted to the limits of that device.

Motor Data

Winding		1680	2668	3392
Ball Bearing type		stainless	ceramic	ceramic
Nominal supply voltage	volts	24	24	24
no load speed	rpm ±12%	40,320	64,030	81,408
speed/torque slope	rpm/oz-in	5,613	11,403	7,981
Stall torque	oz-in	10.9	11.8	6.3
Cont. torque case 60°C/no h.s. 20C	oz-in	1.2/1.1	.7/.6	.63/.60
Cont. current case 60°C/no h.s. 20C	amps	1.6/1.4	1.3/1.2	1.7/1.5
Motor constant Km	oz-in/√w	.51	.51	.33
Winding resistance	ohm±15%	2.2	1.00	1.5
Peak output	watts	48	111	153
No load current	amp±50%	.05	.11	.10
Damping factor	oz-in/krpm	.0006	.0005	.00032
Static friction	oz-in	.012	.012	.012
Velocity constant	rpm/volt	1680	2,668	3392
Torque constant Kt	oz-in/amp	.80	.506	.398
Stall current	amps	10.90	24.0	16.0
Maximum efficiency	%	80	87	85
Winding inductance	mH	.24	.12	.068
Mechanical time constant	ms	6	6	6
Rotor inerta	10^{-4}oz-in-sec^2	.111	.111	.111
Thermal res. winding to case	°C/W	5	5	5
Thermal case to ambient	°C/W	12	12	12

Weight 1.8 oz Maximum winding temperature 150°C (magnet temp limited), ambient -73 to 125C values based on winding and magnet temperature of 20°C Winding resistance does not include lead resistance of .052Ω. Leads are TFE 12" minimum 24 gauge phase and 28 gauge hall.



Leads	
Blue	Phase A
White	Phase B
Brown	Phase C
Red	+5 volts
Black	Ground
Yellow	Sensor A
Orange	Sensor B
Green	Sensor C

Maximum axial bearing force 20 lb

Ordering Information: Please send your order to: mail@koford.com

Example: Part Number 22 S 2668 A A1 S11

- Motor dia. (22)
- Type S=sensorless H=120°halls (S)
- Winding number (2668)
- Modifications A=none T=temperature sensor E=3mm shaft H=hollow shaft (.085±.002 hole) S=sealed bearings, V=vacuum compatible (A)
- Encoder A3=360 lines, A2=256 lines (A1)
- Gearhead S11=11.0:1 (S11)

Test Data
Total System Performance
22S3392A with S24V5A Controller at 24 volts

Rpm	Torque Oz-in	Watts Out	Efficiency %	Amps
80410	0.00	0.00	0.0	0.11
78848	0.13	7.71	61.3	0.50
77308	0.33	18.94	79.0	1.00
75570	0.55	30.66	85.1	1.50
74569	0.75	40.95	85.2	2.00
72798	0.97	52.04	86.7	2.50
71093	1.17	62.67	87.0	3.00
69278	1.39	73.78	87.9	3.50
67738	1.59	81.47	84.8	4.00
66429	1.80	88.17	81.7	4.50
64449	2.00	94.55	78.8	5.00

Dyno test results of a motor and drive combination with voltage held to 24v at input of drive using remote voltage sense on the power supply. Winding temperature is held below 40C by running test quickly and/or allowing motor to cool between tests. Test were conducted at room temperature ambient.

Test Data
Total System Performance
22S3392A-S11 with S24V5A Controller at 24 volts

Rpm	Torque Oz-in	Watts Out	Efficiency %	Amps
7310	0.00	0.00	0.0	0.20
7168	1.39	7.35	61.3	0.50
7028	3.48	18.04	75.2	1.00
6870	5.77	29.20	81.1	1.50
6779	7.84	39.00	81.2	2.00
6618	10.13	49.56	82.6	2.50
6463	12.22	59.69	82.9	3.00
6298	14.54	70.27	83.7	3.50
6158	16.65	77.59	80.8	4.00
6039	18.87	83.97	77.8	4.50
5859	20.96	90.05	75.0	5.00

Dyno test results of a motor and drive combination with voltage held to 24v at input of drive using remote voltage sense on the power supply. Winding temperature is held below 40C by running test quickly and/or allowing motor to cool between tests. Test were conducted at room temperature ambient.

.86" (22mm) Slotless Brushless DC motor.

KOFORD ENGINEERING, LLC

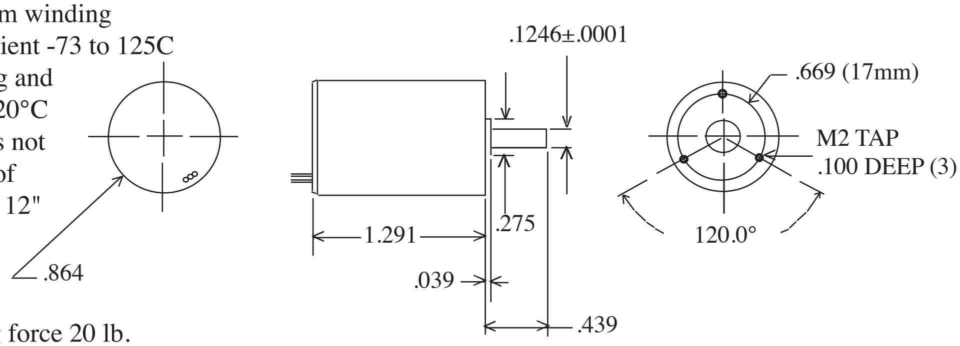
•Autoclavable series •Maximum rpm 120,000 •Peak output 122 watts •2 pole

Autoclavable high speed motor design for use in surgical or dental tools or severe environments. While the other motors in this catalog can be used for autoclavable applications as long as an a sealed autoclave bag is used, these motor can be exposed to live steam and withstand a thousand or more cycle. These motors can also operate in wet hydrogen. These motors feature a Samarium Cobalt magnet, ceramic hybrid ball bearings with Torlon® retainers, polyimide insulation (ML (240°C) wire, Kapton® ground) Teflon® insulated leads, and anodized aluminum housing. Slotless design provides cool operation at high speed and high efficiency. Sensorless S24V5A drives can be used up to 183,000 rpm and provide the coolest most efficient operation, however they are not suitable for starting very high inertia loads. H24V5Adrives are suitable for operation up to 60,000 rpm with brief operation up to 80,000 rpm and will start high inertia loads. Operating ambient temperature range is -73 to 150°C (limited by hall sensors) Sensorless versions can operate up to 160°C

Motor Data

Winding		2669	5333	10000
Ball Bearing type		ceramic	ceramic	ceramic
Nominal supply voltage	volts	15	15	12
no load speed	rpm ±12%	40,000	80,000	120,000
speed/torque slope	rpm/oz-in	7,026	10,600	21,600
Stall torque (theoretical)	oz-in	7.59	15.1	13.6
Continuous torque case 20°C/no h.s.	oz-in	1.4/.7	1.8/.6	1.3/.4
Continuous current case 20°C/no h.s.	amps	4.0/1.4	7.3/2.7	10.4/3.2
Motor constant Km	oz-in/√w	.50	.50	.39
Winding resistance	ohm±15%	1.00	.25	.12
Peak output	watts	48	96	122
No load current	amp±50%	.07	.24	.35
Damping factor	oz-in/krpm	.0006	.0004	.0003
Static friction	oz-in	.012	.012	.012
Velocity constant	rpm/volt	2,669	5333	9,999
Torque constant Kt	oz-in/amp	.506	.253	.136
Stall current	amps	15.0	60.0	100
Maximum efficiency	%	84	86	88
Winding inductance	mH	.12	.03	.008
Mechanical time constant	ms	10	10	12
Rotor inertia	10^{-4}oz-in-sec^2	.111	.111	.111
Thermal res. winding to case	°C/W	5	5	5
Thermal case to ambient	°C/W	12	12	12

Weight 1.6 oz. Maximum winding temperature 200°C ambient -73 to 125C values based on winding and magnet temperature of 20°C Winding resistance does not include lead resistance of .052Ω. Leads are TFE 12" minimum 24 gauge phase and 28 gauge hall.
Maximum axial bearing force 20 lb.



Leads	
Blue	Phase A
White	Phase B
Brown	Phase C
Red	+5 volts
Black	Ground
Yellow	Sensor A
Orange	Sensor B
Green	Sensor C

Ordering Information: Please send your order to: mail@koford.com

Example: Part Number 22 S 2669 C S11

Motor dia. (22)
Type S=sensorless H=120°halls (S)
Winding number (2669)
C=Autoclavable H=hollow shaft (.085±.002 hole) (C)
Gearhead S11=11.0:1 (S11)

KOFORD ENGINEERING, LLC

.86" (22mm) Slotless Brushless DC motor.

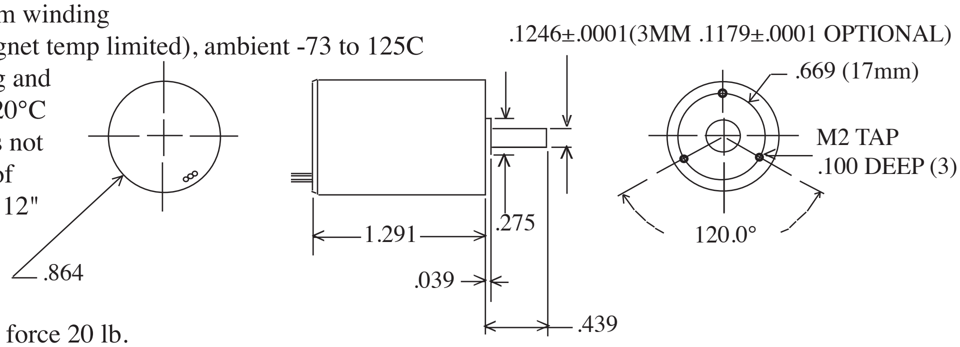
•Low speed windings •Maximum rpm 9,220 rpm •Rated power 8 watts •2 pole

Slotless design is cog free, cost effective, and provides high efficiency and cool operation at high speed. ML (240°C) insulation for highest reliability. 150°C rated Neo rare earth magnets standard. Available with hall sensors, sensorless or with integral 16 volt maximum, 1 amp electronics. Winding temperature sensors (thermistors) are available on sensorless models only. Hall sensors are recommended for positioning and reversing applications and sensorless motors for pump, blowers and beam choppers applications in conjuction with our sensorless controllers, or for use with encoder controlled commutation. Integral electronics is suitable for 6-12 volt applications with low torque such as filter wheels and small pumps or blowers. These motors are suitable for use with sine drives (also known as brushless AC) and exhibit exceptionally smoothness when driven by encoder controlled sinusoidal drives. Custom windings and shafts can be provided.

Motor Data

Winding		221	383	674	222	384
Ball Bearing type		stainless	stainless	stainless	stainless	stainless
Nominal supply voltage	volts	12	12	12	24	24
no load speed	rpm ±12%	2,660	4,596	8,100	5,320	9,220
speed/torque slope	rpm/oz-in	1,727	1,760	1,830	1,790	1,871
Stall torque	oz-in	1.54	2.71	4.56	3.09	5.42
Continuous torque case 20°C/no h.s.	oz-in	1.5/1.5	2.7/2.0	3.5/1.9	3.6/2.0	3.6/1.9
Motor constant Km	oz-in/√w	.89	.89	.87	.89	.89
Winding Resistance	ohm±15%	46.6	15.7	5.2	46.6	15.5
Peak output	watts	.7	2.1	6.0	1.4	9.0
No load current	amp±50%	.010	.020	.037	.013	.026
Damping factor	oz-in/krpm	.010	.008	.006	.008	.006
Static friction	oz-in	.034	.034	.024	.034	.034
Velocity constant	rpm/volt	221	383	674	222	384
Torque constant Kt	oz-in/amp	6.08	3.52	1.98	6.08	3.50
Stall current	amps	.26	.76	2.31	.52	1.55
Maximum efficiency	%	65	70	76	71	76
Winding inductance	mH	6	3	5	6	3
Mechanical time constant	ms	5	5	5	5	5
Rotor inertia	10^{-4}oz-in-sec^2	.280	.280	.280	.280	.280
Thermal res. winding to case	°C/W	5	5	5	5	5
Thermal case to ambient	°C/W	12	12	12	12	12

Weight 1.8 oz. Maximum winding temperature 150°C (magnet temp limited), ambient -73 to 125C values based on winding and magnet temperature of 20°C Winding resistance does not include lead resistance of .052Ω. Leads are TFE 12" minimum 24 gauge phase and 28 gauge hall.
Maximum axial bearing force 20 lb.



Leads	
Blue	Phase A
White	Phase B
Brown	Phase C
Red	+5 volts
Black	Ground
Yellow	Sensor A
Orange	Sensor B
Green	Sensor C

Ordering Information: Please send your order to: mail@koford.com

Example: Part Number 22 H 384 A / A3 / P25

Motor dia.
Type S=sensorless H=120°halls
D=integral electronics
Winding number
Modifications A=none E=3mm shaft T=temp sensor
H=hollow shaft (.085±.002 hole) S=sealed bearings, V= vacuum
Encoder A3=360 lines, A2=256 lines
Gearhead P4=3.7:1, S11=11.0:1, P25=25.01:1, P93=92.70

Test Data
Total System Performance
22H384A with H24V5A Controller at 24 volts

Rpm	Torque Oz-in	Watts Out	Efficiency %	Amps
9520	0.00	0.00	0.00	0.06
8377	1.00	6.14	75.20	0.34
7942	1.25	7.34	72.80	0.42
7530	1.50	8.36	69.70	0.50
6999	1.79	9.29	66.73	0.58
6579	2.07	10.10	62.80	0.67
5718	2.54	10.75	54.62	0.82
5040	2.95	10.78	47.80	0.94
3940	3.45	10.07	38.10	1.10
2927	3.95	8.74	29.13	1.25
1710	4.50	5.67	16.30	1.45

Dyno test results of a motor and drive combination with voltage held to 24v at input of drive using remote voltage sense on the power supply. Winding temperature is held below 40C by running test quickly and/or allowing motor to cool between tests. Test were conducted at room temperature ambient.

KOFORD ENGINEERING, LLC

.86" (22mm) Slotless Brushless DC motor.

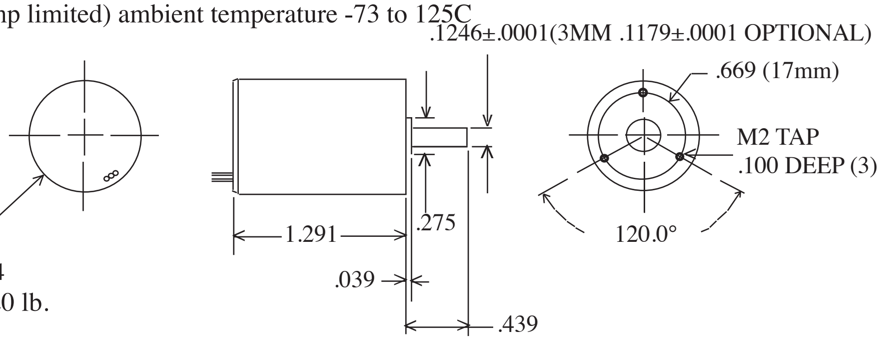
•4 pole •Maximum rpm 17,640 rpm •Rated power 33 watts

4 pole design doubles resolution of hall sensor velocity feedback compared to 2 pole designs and increases power and efficiency. Slotless design is cog free, cost effective, and provides high efficiency. ML (240°C) insulation for highest reliability. 150°C rated Neo rare earth magnets standard. Available with hall sensors, sensorless or with integral 16 volt maximum, 1 amp electronics. Hall sensors are recomended for positioning and reversing applications and sensorless for use with our sensorless controllers, or for use with encoder controlled commutation. Integral electronics is suitable for 6-12 volt in applications with low torque such as filter wheels and small pumps or blowers. These motors are suitable for use with sine drives and exhibit exceptionally smoothness when driven by encoder controlled sinusoidal drives. Custom versions including, hollow shafts, frameless, can be provided. Application include accuators, minature servo systems, filter wheels, medical pumps, and blowers

Motor Data

Winding		331	477	735
Ball Bearing type		stainless	stainless	stainless
Nominal supply voltage	volts	24	24	24
no load speed	rpm ±12%	7,944	11,448	17,640
speed/torque slope	rpm/oz-in	800	950	838
Stall torque	oz-in	13.2	18.3	28.5
Continuous torque case 20°C/no h.s.	oz-in	5.8/2.9	5.8/2.9	5.7/2.9
Motor constant Km	oz-in/√w	1.60	1.47	1.48
Winding Resistance	ohm±15%	7.38	3.71	1.21
Peak output	watts	12	26	68
No load current	amp±50%	.04	.05	.09
Damping factor	oz-in/krpm	.018	.009	.007
Static friction	oz-in	.034	.034	.034
Velocity constant	rpm/volt	331	477	735
Torque constant Kt	oz-in/amp	4.08	2.83	1.84
Stall current	amps	3.25	6.47	19.9
Maximum efficiency	%	79	83	87
Winding inductance	mH	1.0	.49	.22
Mechanical time constant	ms	1.5	1.5	1.5
Rotor inertia	10^{-4}oz-in-sec^2	.240	.240	.240
Thermal res. winding to case	°C/W	5	5	5
Thermal case to ambient	°C/W	12	12	12

Weight 1.8 oz. Maximum winding temperature 150°C (magnet temp limited) ambient temperature -73 to 125C values based on winding and magnet temperature of 20°C Winding resistance does not include lead resistance of .052Ω. Leads are TFE 12" minimum 24 gauge phase and 28 gauge hall.
Maximum axial bearing force 20 lb.



Leads	
Blue	Phase A
White	Phase B
Brown	Phase C
Red	+5 volts
Black	Ground
Yellow	Sensor A
Orange	Sensor B
Green	Sensor C

Ordering Information: Please send your order to: mail@koford.com

Example: Part Number 22 H 331 A / A3 / S11

- 22: Motor dia.
- H: Type S=sensorless H=120°halls D=integral electronics
- 331: Winding number
- A: Modifications A=none E=3mm shaft T=temp sensor H=hollow shaft (.085±.002 hole) S=sealed bearings, V=vacuum
- A3: Encoder A3=360 lines, A2=256 lines
- S11: Gearhead P4=3.7:1, S11=11.0:1, P25=25.01:1, P93=92.70

Test Data
Total System Performance
22H331A with H24V5A Controller at 24 volts

rpm	torque oz-in	watts out	efficiency %	amps
7425	0.00	0.0	0	0.1
6856	0.67	3.4	71	0.2
6585	1.00	4.9	72	0.3
6200	1.50	7.0	73	0.4
5840	2.00	8.6	72	0.5
5430	2.50	9.9	69	0.6
5020	3.00	11.2	58	0.8
4590	3.50	11.8	55	0.9
4070	4.00	12.2	51	1.0
3750	4.50	12.4	47	1.1
3300	5.00	11.3	43	1.2
3010	5.50	12.5	40	1.3
2538	6.10	11.5	32	1.5
2146	6.50	9.3	24	1.6
1560	7.10	8.2	21	1.7

Dyno test results of a motor and drive combination with voltage held to 24v at input of drive using remote voltage sense on the power supply. Winding temperature is held below 40C by running test quickly and/or allowing motor to cool between tests. Test were conducted at room temperature ambient.

Test Data
Total System Performance
22H477A with H24V5A Controller at 24 volts

RPM	Torque oz-in	Watts out	Efficiency %	Amps
10986	0.00	0.00	0.0	0.07
10242	0.90	6.80	76.6	0.37
9830	1.54	11.15	81.5	0.57
9471	2.03	14.18	82.0	0.72
9127	2.53	17.10	81.0	0.88
8781	3.00	19.46	79.5	1.02
8437	3.52	21.92	77.4	1.18
8106	4.01	24.00	74.6	1.34
7477	4.90	27.11	69.3	1.63
6772	5.85	29.29	62.3	1.96
6267	6.60	30.62	57.7	2.21

Dyno test results of a motor and drive combination with voltage held to 24v at input of drive using remote voltage sense on the power supply. Winding temperature is held below 40C by running test quickly and/or allowing motor to cool between tests. Test were conducted at room temperature ambient.

Test Data
Total System Performance
22S735A with S24V5A Controller at 24 volts

RPM	Torque oz-in	Watts out	Efficiency %	Amps
17,640	0	0	0	0.07
16177	1.75	20.91	81.4	1.07
15993	2.00	23.68	82.9	1.19
15773	2.25	26.22	82.1	1.33
15592	2.50	28.69	81.9	1.46
15113	3.02	33.74	81.7	1.72
14207	4.09	43.02	78.9	2.27
13246	5.24	51.35	75.3	2.84

Dyno test results of a motor and drive combination with voltage held to 24v at input of drive using remote voltage sense on the power supply. Winding temperature is held below 40C by running test quickly and/or allowing motor to cool between tests. Test were conducted at room temperature ambient.

Test Data
Total System Performance
22S735A-S11 with S24V5A Controller at 24 volts

Rpm	Torque Oz-in	Watts Out	Efficiency %	Amps
1685	0.00	0.00	0.00	0.12
1669	0.43	0.52	10.90	0.20
1569	14.32	16.62	69.30	1.00
1442	30.45	32.50	67.70	2.00
1269	46.02	43.24	60.10	3.00

Dyno test results of a motor and drive combination with voltage held to 24v at input of drive using remote voltage sense on the power supply. Winding temperature is held below 40C by running test quickly and/or allowing motor to cool between tests. Test were conducted at room temperature ambient.

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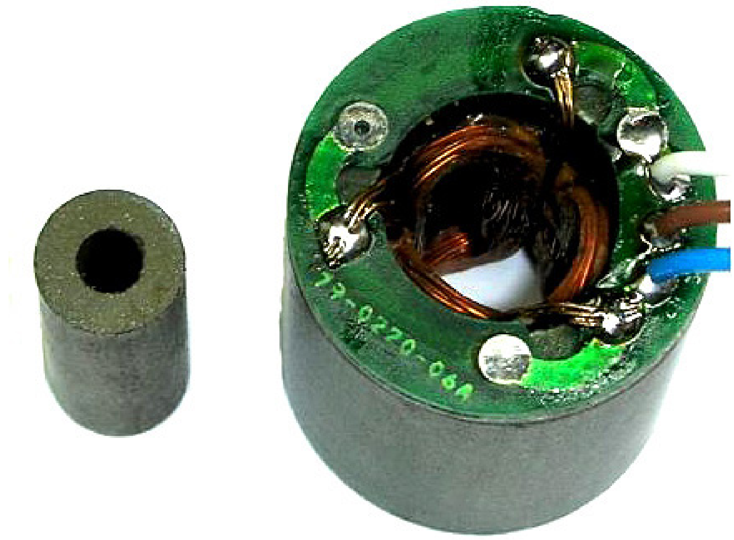
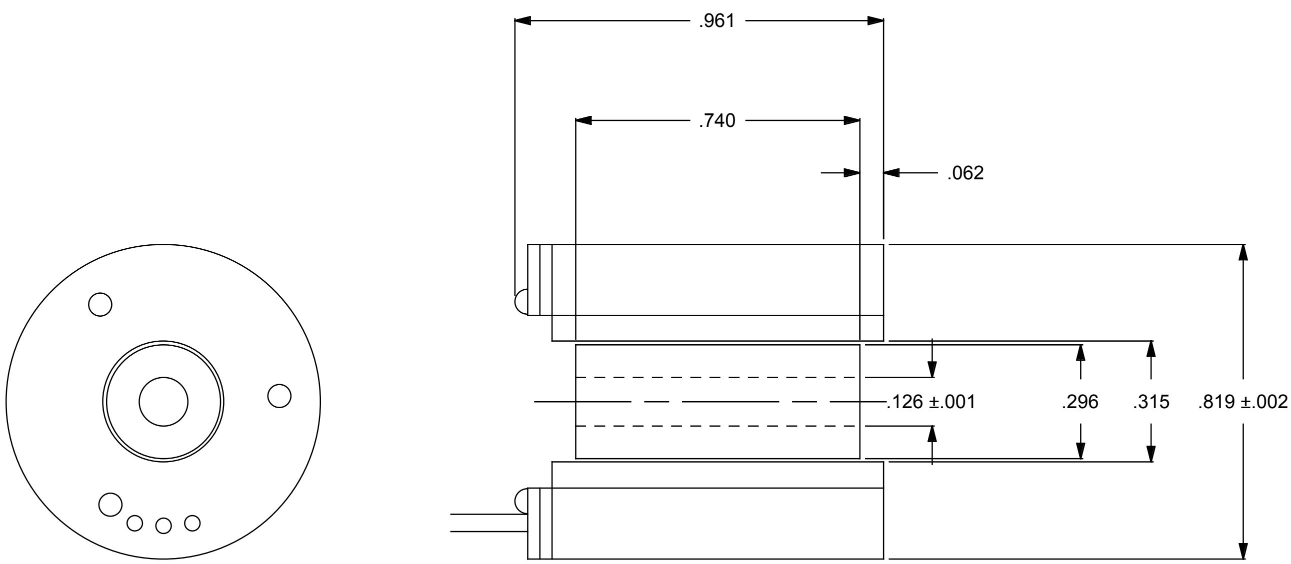
.82" (21mm) Frameless Slotless Brushless motor.



Frameless version of the .86” (22mm) housed motor. The standard configuration is with a magnetized two pole rotor and a sensorless stator. Winding numbers listed under “high speed series” housed 22mm motors are available in the frameless configuration.
The customer should epoxy the supplied rotor magnet to their magnetic shaft (440C or 416 stainless recomended) and then dynamically balance the assembly to tolerances appropiate to their rpm and bearing system. Suitable heat cure epoxies can be found under the “epoxy” section at Koford.com. The cure temperature should not exceed 150°C. Do not attempt press fitting as this will damage the magnet.

The part number of a frameless motor is the same as a housed motor except F is added. For example a 22S9999A becomes a 22FS9999A in the frameless configuration.



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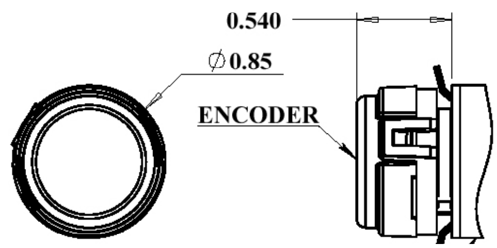
Optical Encoders

A2=256 lines, A3=360 lines. A and B channels in quadrature. Combined this gives 1024 or 1440 counts per shaft revolution. Supplied with mating connector and 12 in leads. Hook up red=5v, blue=channel A, brown =ground, yellow=channel B. If you wish to make your own cable use Molex 51021-0400/50079-8025 . Supply voltage 5±.5V. Max rpm A2=23,437, A3=16,666. Inertia .07 x10^{-4}oz-in-sec^2, Temperature rating -20 to 100°C.

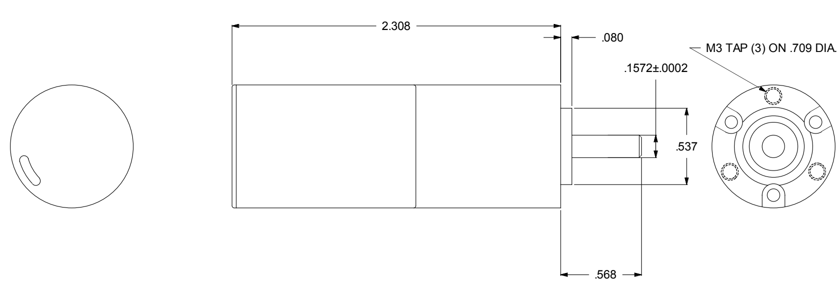


Spur Gearheads

S11 is a 11.0:1 ratio all ball bearing autoclavable spur gearbox The maximum input speed is 81,000 rpm. The ambient temperature range is -73°C to 150°C.

S11 13 oz-in continuous, 40 oz-in peak, 85% eff.

Weight .8 oz
Max backlash 1.5°
Inertia 10^{-4} oz-in-sec^2 = .06

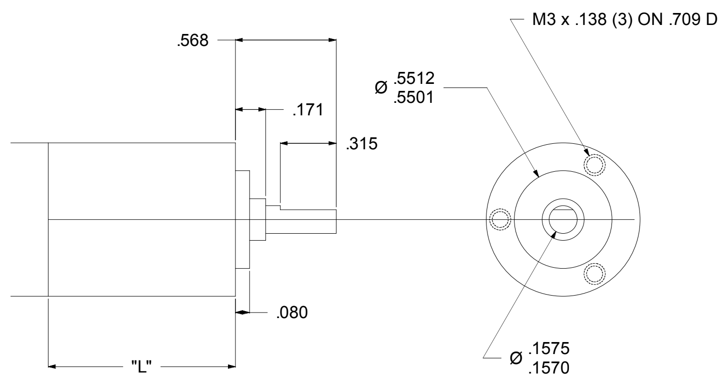


Ordering Information: Please send your order to: mail@koford.com

Planetary Gearheads

P4,P25, P93 are planetary gearboxes with nitrided alloy steel gears, and double sheilded ball bearings on output. Input speed for best life is 6,000 rpm or lower. Bearing lube rated for -35C to 140C. Low temp lube rated for -60 to 130C available on special order. Other ratios are available on special order.

3.70:1 L=1.054 127 oz-in peak 85 oz-in cont. 90% eff.
25.01:1 L=1.431 149 oz-in peak 99 cont. 80% eff.
92.70:1 L=1.695 168 oz-in peak 112 cont. 70% eff.
Weight 3.70:1=1.4 oz, 25.01:1=2.0 oz, 92.70:1=2.6 oz
Max backlash 3.70:1=1.5°, 25.01:1=2°, 92.70:1=2.5°
Inertia 10^{-4} oz-in-sec^2 = .05



Ordering Information: Please send your order to: mail@koford.com

Thermistor resistance for Koford motors

Temp [degree C]	Temp [degree F]	Rt/R25	Temp Coef [%/C]	Resistance [ohm]
-50	-58	66.970	7.10	334850
-45	-49	47.250	6.86	236250
-40	-40	33.740	6.62	168700
-35	-31	24.370	6.40	121850
-30	-22	17.800	6.19	89000
-25	-13	13.130	5.99	65650
-20	-4	9.776	5.80	48880
-15	5	7.347	5.63	36735
-10	14	5.570	5.46	27850
-5	23	4.257	5.30	21285
0	32	3.279	5.10	16395
5	41	2.550	4.95	12750
10	50	1.998	4.81	9990
15	59	1.576	4.68	7880
20	68	1.252	4.55	6260
25	77	1.000	4.43	5000
30	86	0.804	4.31	4019
35	95	0.650	4.20	3249
40	104	0.528	4.09	2641
45	113	0.432	3.99	2158
50	122	0.355	3.74	1773
55	131	0.295	3.63	1474
60	140	0.247	3.54	1233
65	149	0.207	3.44	1035
70	158	0.175	3.35	874
75	167	0.148	3.26	741
80	176	0.126	3.18	631
85	185	0.108	3.10	539
90	194	0.092	3.03	462
95	203	0.080	2.95	398
100	212	0.069	2.86	344
105	221	0.060	2.78	299
110	230	0.052	2.70	261
115	239	0.046	2.63	228
120	248	0.040	2.56	200
125	257	0.035	2.50	177
130	266	0.031	2.44	156
135	275	0.028	2.37	138
140	284	0.025	2.31	123
145	293	0.022	2.26	110
150	302	0.020	2.20	98

Unit conversions

°F -32 ÷1.8=°C example: 212°F=100°C, °C x1.8+32=°F example: 100°C=212°F, in x 25.40=mm, mm x.03937= in., oz x 28.3495=g, oz-in x 7.06=mNm, mNm x .142=oz-in, Nm x 142=oz-in, rpm x .1047=rad s^{-1}, V/R/S x .1047=volts/rpm, 746 watts=1hp, lb-in^2 x .04144=oz-in-sec^2

Understanding Data Sheets

When comparing Koford motors to data sheets for other motors be careful to note the conditions associated with the rated torque listed. For example many manufactures list continuous torque at stall or at rpm less then the maximum. This specsmanship results in unrealistically high continuous torque ratings for these motors. Attempting to operate these motors continuously at the nominal operating voltage will often result in overheating even if the motor is unloaded.

Hall Sensors

Hall sensors have the wide speed range, sensorless drives have a much narrower speed range especially at no or low load. If sensorless operation is desired and a wide speed range is required the S24V12A drive should be used. If quick start up and rapid speed changes are required then hall sensors should be used. Typically hall sensors are used for positioning applications and sensorless motors are used for applications like blower and fans.

Hall Sensor precautions

Like other semiconductor components hall sensors are electrostatic sensitive. Hall motors are supplied in electrostatic safe packaging and should be kept in the packaging until use. When trimming wire length, adding connectors, and hooking up motors, workers should be grounded to prevent electrostatic damage to the sensors.

Balancing

Components attached to the motor shaft should be dynamically balanced to G6.3 or better and located as close to the motor body as possible. This is especially critical over 20,000 rpm. G6.3 is equal to 0.64 x weight (oz.)/rpm=unbalance in milli oz-in. If the components have appreciable length they must be balance in 2 planes.

Motor technology

The Koford 22mm brushless series of motors are slotless sintered rare earth permanent magnet motors with unique technology. Compared to brush motors they have much longer life (up to 25,000 hours +), much higher speed capability (200,000+rpm), can operate in a vacuum, and will not introduce contamination from brush dust. Compared to conventional slotted bonded rare earth magnet with the same no load speed and phase resistance Koford motors are smaller, lighter, have higher efficiency, higher peak torque (equal to stall torque), and are cog free. Compared to other slotless motors they have higher speed capabilities, better efficiency, lighter weight and more durable construction (ML Class 220C wire insulation bonded with solventless Class 205 thermoset resin) compared to the low temp bondable wire used in other slotless motors which will soften and fail under thermal overload.

Operating speed

Motors can be operated at any lower voltage and also at somewhat higher voltages and speeds then shown on the data sheet. For example 24 volt motors can be run on 28 volt system. Running a 24 volt motor on a 36 volts system is not recommended. Hall drives

Motor selection

Motors for continuous duty applications such as pumps, blowers etc. Should in most cases be selected to operate at about 10% of stall torque. This point is close to peak efficiency. Keep in mind that the drive used has a great effect on motor operating temperature. The lowest motor temperature rise will occur with the drive pwm duty cycle at 100% (maximum speed). Using a higher speed winding then necessary and reducing the speed through the drive will result in higher motor and drive operating temperatures then if a winding is selected that will run as close as possible to full speed. During variable speed operation, when the motor is operating at less then full speed, both the motor and drive operating temperature will be influenced by the drive frequency. Drive pwm frequencies of 37kHz or higher are recommended for best performance. H

For variable speed applications where the motor does not operate continuously, the safest approach is to specify the motor with the continuous operating torque equal to the maximum load. If the maximum load is not known then the continuous motor current rating should be more then the current limit of the drive. This will prevent the possibility of overload. For example if the current rating of the drive is 5 amps, the motor Kt is 3.0 and the no load current is 1.0 amps, continuous torque rating should be more then (5-1.0) x 3.0=12 oz-in. If the duty cycle is known then the equivalent continuous torque can be estimated. Keep in mind that the resistance losses are a function of the current squared so reducing the duty cycle to fifty percent will only allow the torque to be increased by 41% not 100%.

When comparing Koford motors to data sheets for other motors be careful to note the conditions associated with the rated torque listed. For example many manufactures list continuous torque at stall or at 10,000 rpm. Usually this is because these motors will overheat if run continuously at full speed even with no load.

Selection of Hall, Sensorless, or integral electronics

The most common motor configuration is the hall sensor design. They will operate down to zero speed and have no start up delay. Sensorless motors have only three leads which can be helpful in applications where the motor must be hundred or thousands of feet away from the drive. It also makes for a more flexible cable for surgical or dental handpieces. In addition sensorless motors operate with higher efficiency especially at speeds above 60,000 rpm. In certain frameless hermetic pump applications hall sensor designs are not possible and sensorless motors must be used. Integral electronic motors are available in some larger sizes and simplify connection and mounting. In general integral electronic motors will have a lower power rating for a given motor size.

Linear characteristics

Koford motors exhibit highly linear behavior. This is not the case with slotted motors and even some slotless motors. A slotted motor with the same rpm and phase resistance may only be capable of less then half of the peak torque of a Koford motor with the same specifications. The stall torque of Koford motors is equal to the Kt times the current. However keep in mind that at stall the winding will heat up rapidly increasing the resistance so the full stall torque may only be available for a fraction of a second. In most cases the current limit of the drive is much less then the stall current so this is not an issue.

Speed torque calculations

A motors no load speed is equal to the supply voltage times the velocity constant (rpm/v). Under load the rpm will drop. To determine the approximate speed, use dyno data if listed, or use the speed torque slope from the data sheet. For example if the supply voltage is 28 volts and the rpm/volt is 500 then the no load speed will be 14,000 rpm. If the speed torque slope is 800 rpm/oz-in and a 5 oz-in load is applied to the shaft then the speed will be 14,000-(5 x 800) = 10,000 rpm. If there is extra wiring between the drive and the motor, or the supply and the drive, then the speed will drop at a more rapid rate due to the voltage drop in the wiring. A design margin of at least 15% should be used to allow for motor tolerances, so for example with the above motor the rpm can be expected to be at least 8,500 rpm.

Motor cooling

The continuous output torque which can be achieved from a motor is limited by the allowable maximum temperature. This in turn is determined by the cooling provided by the user, and the ambient temperature. In the case of some high speed motors the continuous output torque is shown as zero if the motor does not have heat sinking. In these cases the motor can only be used in intermittent duty applications unless appropriate heatsinking is used. The data sheet lists continuous torque with a 20°C (68°F) ambient and full rated voltage with 100% duty cycle and block commutation. Two values are listed, the first with the motor case cooled to 20°C and the second with no cooling in still air. Most applications will fall somewhere between these two extremes. If the ambient temperature is above 20°C then the continuous duty torque is reduced. Sensorless motors are available with temperature sensors and this can be useful during prototyping to evaluate cooling. The actual limitation is the rotor (magnet) temperature, but since the windings surround the rotor, the temperature can be assumed to be the same in most cases. One exception is in pump applications (frameless or housed) if the motor is immersed in refrigerant. In these applications the rotor temperature can be expected to closely follow the fluid temperature. For applications in air the allowable output torque can be increased by mounting the motor to a thick aluminum plate with surface area several times larger then the surface area of the motor. Further improvements can be obtained with the use of a fan directed at the body of the motor. Even higher performance can be obtained by the use of a refrigerant cooled sleeve around the outside diameter of the motor coupled with heatsink grease. If the motor housing can be cooled below 20°C then improved performance above data sheet values can be obtained. If only natural convection is used and the motor is mounted to plastic or a low thermal conductivity material such as steel then consideration should be given to ensuring free flow of air over the motor. Placing the motor in a small enclosed space with poor thermal connection to the outside ambient can result in considerable reduction in the amount of output power possible without overheating. When performing temperature rise calculations remember that the resistance of the copper windings increases with temperature. You must use the resistance at the operating temperature not at 20C.

Frameless motors

Frameless motors are useful for certain specialized applications where housed motors cannot be used. These include air bearing or magnetic bearing motors, and pump applications where the rotor and impeller are part of a single assembly with the working fluid inside of the motor. All Koford motors can withstand continuous exposure to refrigerants. Frameless motors should be avoided for any application where a housed motor can be used. The use of water without corrosion inhibitors inside the motor requires special magnets. In many cases sleeve bearings are used with water instead of ball bearings so as to prevent corrosion and the possibilities of particles from jamming the ball bearings. Contact the factory if your application requires a frameless version of one of the motors listed in the catalog.

Motors for surgical and dental tools

Surgical and dental tool motors typically operate at high speed so high efficiency is important to prevent the tool from heating up excessively in the users hand. Sensorless motors are popular for this application due to cooler operation especially over 60,000 rpm, and since only three wires are required, the cord to the tool can be smaller and more flexible. However there is approximately a 0.25 seconds of delay in start up with a sensorless motor. Also the speed range is approximately 35% to 100% of maximum. If these characteristics are not acceptable then a hall sensor motor should be used. If the design of the tool requires the motor to withstand being placed in a sterilizer (autoclave) then an autoclavable motor is recommended. Because high pressure steam is highly corrosive a standard motor will only withstand about 100 autoclave cycles of twenty minutes at temperature. The number of cycles will increase when the motor is placed in an housing. The greater thermal mass the housing has, the more the motor is sealed against steam pressure, and the shorter the autoclave cycle used the more cycles that can be obtained. For long life eg. 1000 cycles an autoclavable motor should be used. This is option C which is available on a number of motors. These motors are made with highly corrosion resistant magnet, shaft and lamination materials and the polymeric materials are polyimide, Teflon®, or high performance heat cured epoxy.

Vacuum Applications

All Koford motors are suitable for low vacuum applications. For high vacuum applications (option V) contact the factory. Vacuum grade motors are made with low outgassing material and baked before shipping. A vacuum bake by the customer immediately prior to use may be desirable to reduce pump down time. An important consideration is that in a vacuum there is no heat removal by air contacting the motor housing. Therefore the mounting of the motor should be made of highly thermally conductive material, such as copper or aluminum, should be of as heavy a cross section as possible, and should connect to a large surface exposed to the outside air.

Motor hook up

Koford hall sensor motors typically separate the phase and sensor wires. These wires should be kept apart and away from other wires. The leads should be trimmed as short as possible to reduce EMI and power losses. Where electrical noise is a consideration the phase wires may be twisted or braided with each other or enclosed in a shielded jacket. The same can be done with the hall leads to prevent their picking up EMI from noise sources.

EMI

Koford drives and motors have low levels of emi relative to other motors but in sensitive applications the following steps are suggested. First keep the phase wires as short as physically possible and twist or braid them together and if necessary add a shield jacket terminated at one end. Add a 5,000μF cap at the input to the drive along with a common mode inductor. Add small inductors to each of the phase wires. If possible vary the input voltage to the drive rather then using the speed control. Place the drive and motor as close together as possible. Also consider enclosing the drive or motor and drive in a metal enclosure.

Sine Drives

Koford motors are especially suitable for sine drives due to their exceptionally low harmonic distortion (typically well under 1%). Sine drives are useful for very accurate motion around zero speed. At higher speeds e.g. above 3,000 rpm there in not any noticeable difference in noise/vibration/velocity accuracy with sine drives. The use of Sine drives results in lower power output and reduced efficiency compared to standard drives (block commutation) when compared with the same motor.

Permanent Magnet Synchronous motors, DC Brushless motors, AC Permanent Magnet motors

These are all different names for the same type of motor.

System efficiency

The system efficiency is different then the motor efficiency. The system efficiency takes into account motor losses, drive losses, wiring losses, and gearbox losses. The choice of a drive will make a large difference in the total system efficiency. The data sheet value for maximum motor efficiency is at maximum speed. At less then 100% speed efficiency will be reduced. For example if a motor is operated at 12 volts with the speed control turned all of the way up, the efficiency will be better then if the motor is operated with 24 volts into the drive and the speed set at 50%. Although the motor speed is the same, there are additional losses in the drive and motor to drop the 24 volts down to 12 volts. The amount of these losses is determined by the drive and motor design. High frequency drives (37 kHz or above) provide slightly better overall efficiency then 18khz drives. Drives with a pwm frequency below 18kHz are not recommended for slotless motors.

PWM basics

Variable speed drives operate using PWM where the voltage to the motor is rapidly turned on and off. This is the same as a switching power supply where the motor is the filter. A PWM drive operates like a transformer, for example if the motor pulls 20 amps at 12 volts and the input to the drive is 36 volts then the input current to the drive will be 12/36 x 20 or 6.66 amps (neglecting losses). A drive rated at 20 amps will only pull 20 amps from the power supply or battery if the speed is turned all of the way up (no PWM).