KOFORD
ENGINEERING, LLC

5.07 inch (129mm) Series

• Short axial length, high performance slotted or slotless housed or frameless brushless motors for Industrial, military, aerospace, and medical applications.

• 10 pole slotted designs for highest rpm and output, 173 and 174 windings are slotted but have near zero cog and sinusodial back emf, 20 pole slotted design is suitable for low speed applications and the higher pole count doubles the hall feedback resolution, cog free 8 pole slotless design ideal for precision motion at low speeds and direct drive applicaitons.

• Up to 95% efficiency

• Up to 1,523 watts continuous power.

• High temperature 240°C ML insulation

• Available with hall sensors, or sensorless. Temperature sensors and thermal protection available.

• Long life premium synthetic bearing lube with -73C to 149C temperature range

• Encoders available

• Perfect sinusoidal back emf for ripple free torque at low speed when using sine wave drives with the slotless version. Ideal for direct drive applications.

• Slotless version offers linear speed torque with no saturation and no cog.

KOFORD
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5.07" (129mm) 10 pole, 48 volt Slotted Brushless motor

• 2,076 to 8,352 rpm no load **•Rated power up to 600 watts**

High power series. 10 tooth slotted motor for maximum power. 240°C ML insulation is used for the greatest possible durability. 200°C Neo magnets are used along with stainless shaft, and high temp TFE insulated lead wires. Unit are supplied either with 120° halls rated at 150°C, or sensorless versions are available. Thermal protection and temperature sensors are available. Custom windings, encoders and gearboxes are available. The 174 version has nearly zero cog along with sinusoidal back emf.

Motor Data

Winding		43	96	174
Nominal supply voltage	volts	48	48	48
No load speed	rpm±12%	2,076	4,608	8,352
Speed/torque slope	rpm/oz-in	.81	2.1	20
Peak efficiency	%	93	93	93
Continuous stall torque heat sink/no hs.	oz-in*	1,128/777	720/473	344/231
Continuous torque heat sink/no h.s.	oz-in*	1,076/699	681/410	184/150
Motor constant Km	oz-in/√w	89	61	30
Winding resistance#	ohm±15%	.124	.053	.066
Peak output	watts	922	1864	735
No load current	amp±50%	.45	1.28	.67
Damping factor	oz-in/krpm	3.3	2.4	.3
Static friction	oz-in	7.1	7.1	2.7
Velocity constant	rpm/volt±12%	43.3	96	174
Torque constant Kt	oz-in/amp	31.2	14.1	7.76
Winding inductance	mH	1.19	.21	.340
Mechanical time constant	ms	1.2	2.5	7.2
Rotor inertia	10^{-4}oz-in-sec^2	672	672	459
Thermal res. winding to housing	°C/W	.44	.32	.36
Thermal res. housing to ambient	°C/W	1.12	1.12	1.12

Ambient temperature range -73C to 149C

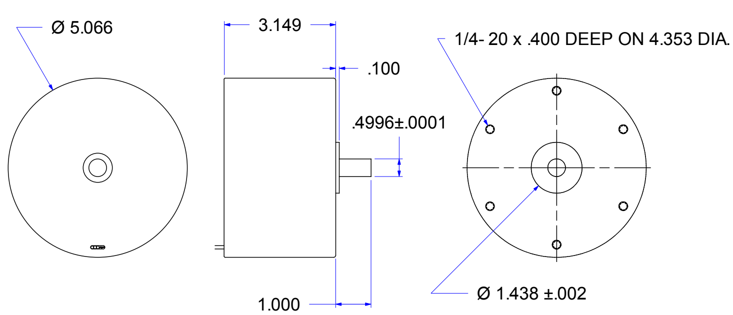
Weight 8lb. 12 oz., maximum winding temp. 200C Data is for winding and magnet temperature of 20°C

*0.3°C/W heat sink or sufficient airflow over motor for equal thermal resistance/still air and no heat sink. Continuous torque is maximum running torque at nominal supply voltage

#Lead wires resistance 4.7mΩ if used at full length

Leads are 12" minimum

Phase leads are 14 gauge, hall leads are 28 gauge, all TFE



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: mail@koford.com•phone 937-695-1275•fax 937-695-0237•www.koford.com

Example: Part Number 129 H 43 A / A20

Encoder w index A20=2000line(8,000 count)

Motor type

Type S=sensorless H=120°halls

Modifications A=none, T=thermistor, P=thermal protection

Winding number

Test Data
Total System Performance
129H43A Motor with H48V40A Controller at 48 Volts

Rpm	Torque Oz-in	Watts Out	Efficiency %	Amps
2018	0	0	0.0	0.5
1946	69	98	89.2	2.3
1873	137	190	87.4	4.5
1784	231	304	84.3	7.5
1697	325	406	81.9	10.3
1610	410	487	78.1	13.0
1524	496	557	74.4	15.6
1459	562	604	71.4	17.6
1394	628	646	68.4	19.7
1328	710	695	65.7	22.1
1263	785	731	62.3	24.4
1213	857	767	59.1	27.00
1163	935	802	56.8	29.4
1123	1013	839	54.4	32.1
1078	1091	867	51.5	35.1
1041	1169	897	49.4	37.8
1003	1247	922	47.2	40.7

Dyno test results of a motor and drive combination with voltage held to 48v 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. Losses include drive, motor, and motor leads. Efficiency can be improved by shortening motor leads

Test Data
Total System Performance
129H96A Motor with H48V40A Controller at 48 Volts

Rpm	Torque oz-in	Watts Out	Efficiency %	Amps
4818	0.00	0.00	0.0	1.36
4796	7.97	28.18	29.4	2.00
4747	35.41	124.38	64.8	4.00
4679	63.57	220.14	76.4	6.00
4610	91.70	312.80	81.5	8.00
4543	120.27	404.38	84.2	10.00
4475	148.77	492.74	85.5	12.00
4414	178.72	584.30	87.0	14.00
4352	209.12	673.52	87.7	16.00
4288	237.92	758.59	87.8	18.00
4225	269.44	842.54	87.8	20.00
4169	299.04	923.09	87.4	22.00
4119	328.80	1002.80	87.0	24.00
4051	361.92	1085.31	87.0	26.00
3993	392.00	1158.42	86.2	28.00
3932	421.92	1228.05	85.3	30.00

Dyno test results of a motor and drive combination with voltage held to 48v 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. Losses include drive, motor, and motor leads. Efficiency can be improved by shortening motor leads

Test Data
Total System Performance
129H174T Motor with H48V40A Controller at 48 Volts

Rpm	Torque Oz-in	Watts Out	Efficiency %	Amps
9084	0.00	0.00	0.0	0.70
8681	12.64	80.64	70.0	2.40
8198	28.16	170.72	79.0	4.50
7700	50.00	284.00	84.0	7.04
7117	76.16	400.16	87.8	9.50
6400	110.00	522.00	88.0	12.35
5767	142.88	609.76	85.8	14.80
5000	190.00	685.00	81.0	17.60
4206	237.05	735.21	74.7	20.50
3359	285.28	708.96	61.0	24.20

Dyno test results of a motor and drive combination with voltage held to 48v 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. Losses include drive, motor, and motor leads. Efficiency can be improved by shortening motor leads

KOFORD ENGINEERING, LLC

5.07" (129mm) 10 pole, 24 volt Slotted Brushless motor.

• 1,040 to 4,152 rpm no load **•Rated power up to 565 watts**

10 tooth slotted motor designed for high speed blowers and pumps and servo applications. The 173 version has nearly zero cog along with sinusoidal back emf. 240°C ML insulation is used for the greatest possible durability. 200°C Neo magnets are used along with stainless shaft, and high temp TFE insulated lead wires. Unit are supplied either with 120° halls rated at 150°C, or sensorless versions are available. Thermal protection and temperature sensors are available. Custom windings, encoders and gearboxes are available.

Motor Data

Winding		42	95	173
Nominal supply voltage	volts	24	24	24
No load speed	rpm±12%	1,040	2,280	4,152
Speed/torque slope	rpm/oz-in	.47	1.23	10.6
Maximum efficiency	%	92	91	93
Continuous stall torque heat sink/no hs.	oz-in*	1,128/777	720/473	344/231
Continuous torque heat sink/no h.s.	oz-in*	1,109/749	680/408	322/230
Motor constant Km	oz-in/√w	89	61	30
Winding resistance#	ohm±15%	.124	.053	.066
Peak output	watts	390	740	355
No load current	amp±50%	.34	.95	.51
Damping factor	oz-in/krpm	3.3	2.7	.3
Static friction	oz-in	7.1	7.1	2.7
Velocity constant	rpm/volt±12%	43	95	173
Torque constant Kt	oz-in/amp	31.2	14.1	7.72
Winding inductance	mH	1.2	.21	.34
Mechanical time constant	ms	1.2	2.5	7.2
Rotor inertia	10^{-4}oz-in-sec^2	672	672	459
Thermal res. winding to housing	°C/W	.44	.32	.36
Thermal res. housing to ambient	°C/W	1.12	1.12	1.12

Ambient temperature range -73C to 149C

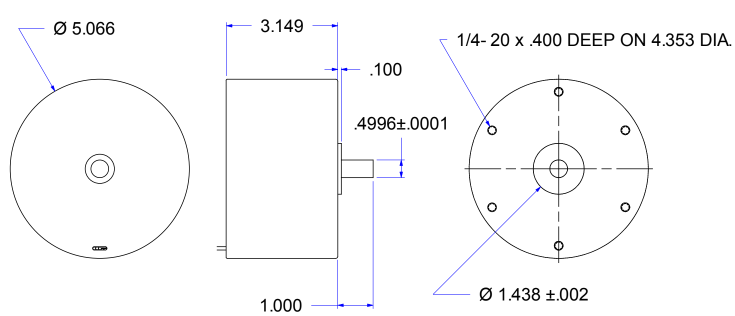
Weight 7lb. 3 oz., maximum winding temp. 200C Data is for winding and magnet temperature of 20°C

*0.3°C/W heat sink or sufficient airflow over motor for equal thermal resistance/still air and no heat sink. Continuous torque is running torque at nominal supply voltage at 150°C winding temperature.

#Lead wires resistance 4.7mΩ if used at full length

Leads are 12" minimum

Phase leads are 14 gauge, hall leads are 28 gauge, all TFE



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: mail@koford.com•phone 937-695-1275•fax 937-695-0237•www.koford.com

Example: Part Number 129 H 42 A / A20

Motor type — 129

Type S=sensorless H=120°halls — H

Winding number — 42

Modifications A=none, T=thermistor, P=thermal protection — A

Encoder w index A20=2000line(8,000 count)

Test Data
Total System Performance
129H42A Motor with H24V40A Controller at 24 Volts

Rpm	Torque oz-in	Watts Out	Efficiency %	Amps
1008	0	0	0.0	0.4
929	139	95	82.8	4.8
839	323	200	80.7	10.3
761	489	274	73.8	15.5
693	632	322	65.5	20.5
641	745	352	58.0	25.3
598	843	372	52.5	29.5
565	929	387	48.3	33.4

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. Losses include drive, motor, and motor leads. Efficiency can be improved by shortening motor leads

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Test Data
Total System Performance
129H95A Motor with H24V40A Controller at 24 Volts

Rpm	Torque oz-in	Watts Out	Efficiency %	Amps
2414	0.00	0.00	0.0	0.99
2381	13.18	23.14	48.2	2.00
2338	41.66	71.78	74.8	4.00
2307	69.23	117.77	81.8	6.00
2273	97.15	163.42	85.1	8.00
2232	125.78	207.81	86.6	10.00
2192	154.83	251.22	87.2	12.00
2154	184.16	293.62	87.4	14.00
2117	214.08	335.66	87.4	16.00
2078	244.16	375.63	87.0	18.00
2046	273.92	414.77	86.4	20.00
2010	303.68	451.81	85.6	22.00
1976	334.08	488.74	84.9	24.00
1943	364.00	523.33	83.9	26.00
1911	394.40	558.02	83.0	28.00
1878	424.16	589.60	81.9	30.00
1826	467.10	628.94	79.6	32.90
1804	487.00	647.84	78.7	34.30
1766	524.96	686.16	77.1	37.10

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. Losses include drive, motor, and motor leads. Efficiency can be improved by shortening motor leads

Test Data
Total System Performance
129H173T Motor with H24V20A Controller at 24 Volts

Rpm	Torque oz-in	Watts Out	Efficiency %	Amps
4542	0.00	0.00	0.0	0.55
4424	7.68	25.12	69.8	1.50
3995	36.16	106.88	89.1	5.00
3700	60.00	162.00	89.0	7.60
3458	81.92	209.12	88.0	9.90
3200	110.00	260.00	86.2	12.60
2954	137.92	301.60	83.8	15.00
2670	170.00	333.00	79.0	17.60
2432	197.60	355.68	74.8	19.80

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. Losses include drive, motor, and motor leads. Efficiency can be improved by shortening motor leads

KOFORD ENGINEERING, LLC

5.07" (129mm) 10 pole, 96 and 160 volt, slotted High Power Brushless motor.

• 1,040 to 4,157 rpm no load **•Rated power up to 1523 watts**

High power series. 10 tooth slotted motor for maximum power. 240°C ML insulation is used for the greatest possible durability. 200°C Neo magnets are used along with stainless shaft, and high temp TFE insulated lead wires. Unit are supplied either with 120° halls rated at 150°C, or sensorless versions are available. Thermal protection and temperature sensors are available. Custom windings, encoders and gearboxes are available.

Motor Data

Winding		44	30	23	31	45
Nominal supply voltage	volts	96	96	160	160	160
No load speed	rpm±12%	4,157	2,840	3,614	4960	6,620
Speed/torque slope	rpm/oz-in	1.6	1.1	1.3	1.7	2.7
Maximum efficiency	%	94	93	94	94	95
Continuous stall torque heat sink/no hs.	oz-in*	1128/777	852/612	1128/777	852/ 612	1128/777
Continuous torque heat sink/no h.s.	oz-in*	968/516	775/497	1002/578	676/320	745/367
Motor constant Km	oz-in/√w	92	79	89	79	92
Winding resistance#	ohm±15%	.124	.334	.455	.334	.124
Peak output	watts	1991	1351	1731	2668	4579
No load current	amp±50%	.47	.32	.32	.41	.65
Damping factor	oz-in/krpm	2.0	2.6	3.3	2.34	2.1
Static friction	oz-in	7.1	7.1	7.1	7.1	7.1
Velocity constant	rpm/volt±12%	41.3	30	104	31	45
Torque constant Kt	oz-in/amp	32.6	45.6	12.98	45.6	32.6
Winding inductance	mH	1.19	2.55	3.99	2.55	1.19
Mechanical time constant	ms	1.2	1.5	1.2	1.5	1.2
Rotor inertia	10^{-4}oz-in-sec^2	672	672	672	672	672
Thermal res. winding to housing	°C/W	.44	.32	.44	.32	.44
Thermal res. housing to ambient	°C/W	1.12	1.12	1.12	1.12	1.12

Ambient temperature range -73C to 149C

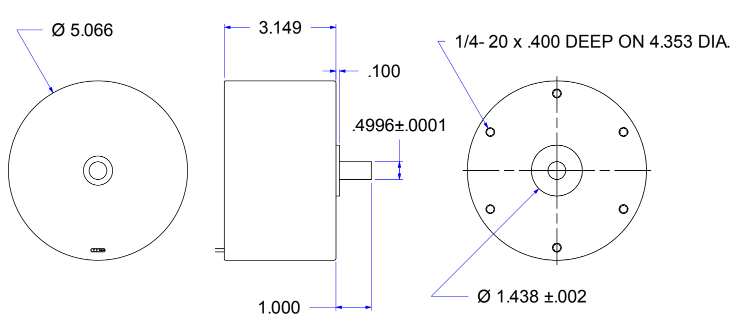
Weight 8lb. 12 oz., maximum winding temp. 200C Data is for winding and magnet temperature of 20°C

*0.3°C/W heat sink or sufficient airflow over motor for equal thermal resistance/still air and no heat sink. Continuous torque is running torque at nominal supply voltage

#Lead wires resistance 4.7mΩ if used at full length

Leads are 12" minimum

Phase leads are 14 gauge, hall leads are 28 gauge, all TFE



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: mail@koford.com•phone 937-695-1275•fax 937-695-0237•www.koford.com

Example: Part Number 129 H 43 A / A24

Encoder w index A20=2000line(8,000 count)

Motor type

Type S=sensorless H=120°halls

Winding number

Modifications A=none, T=thermistor, P=thermal protection

Test Data
Total System Performance
129H45T Motor with H160V10A Controller at 160 Volts

Rpm	Torque oz-in	Watts Out	Efficiency %	Amps
6620	0.00	0.00	0.0	0.68
6591	10.51	51.26	32.0	1.00
6479	44.22	212.03	66.3	2.00
6380	78.30	369.73	77.0	3.00
6277	114.45	531.63	83.1	4.00
6180	150.40	687.94	86.0	5.00
6077	188.32	847.57	88.3	6.00
5991	226.08	1003.01	89.6	7.00
5897	260.32	1136.27	89.2	7.96
5810	303.20	1303.98	90.2	9.04
5743	338.56	1439.26	90.6	9.93

Dyno test results of a motor and drive combination with voltage held to 160v 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. Losses include drive, motor, and motor leads. Efficiency can be improved by shortening motor leads

Test Data
Total System Performance
129H31T Motor with H160V10A Controller at 160 Volts

Rpm	Torque oz-in	Watts Out	Efficiency %	Amps
4730	0.00	0.00	0.0	0.41
4651	27.28	93.89	58.7	1.00
4548	75.02	252.50	78.9	2.00
4442	126.67	416.48	85.6	3.04
4347	176.80	568.98	88.9	4.00
4253	228.64	719.89	89.8	5.01
4170	279.36	862.66	90.2	5.98
4083	337.76	1020.75	90.9	7.02
3998	395.36	1170.18	90.7	8.06
3924	449.44	1305.26	90.5	9.01
3846	506.88	1443.01	90.0	10.02

Dyno test results of a motor and drive combination with voltage held to 160v 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. Losses include drive, motor, and motor leads. Efficiency can be improved by shortening motor leads

Test Data
Total System Performance
129H44T Motor with H160V10A Controller at 96 Volts

Rpm	Torque oz-in	Watts Out	Efficiency %	Amps
3970	0.00	0.00	0.0	0.51
3929	16.56	48.14	50.2	1.00
3869	50.78	145.44	75.4	2.01
3800	85.54	240.61	83.3	3.01
3741	121.23	335.66	87.2	4.01
3677	156.37	425.57	89.0	4.98
3621	194.56	521.47	90.4	6.01
3567	231.36	610.82	91.2	6.98
3509	273.12	709.20	91.9	8.04
3457	311.52	796.98	92.0	9.02
3406	351.68	886.83	92.2	10.02
3384	368.80	923.94	92.0	10.46

Dyno test results of a motor and drive combination with voltage held to 96v 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. Losses include drive, motor, and motor leads. Efficiency can be improved by shortening motor leads

Test Data
Total System Performance
129H31T Motor with H160V10A Controller at 96 Volts

Rpm	Torque oz-in	Watts Out	Efficiency %	Amps
2840	0.00	0.00	0.0	0.32
2789	32.02	66.08	68.2	1.01
2721	80.14	161.36	84.0	2.00
2652	129.52	254.19	88.3	3.00
2589	180.96	346.94	90.1	4.01
2526	234.08	437.60	91.0	5.01
2473	285.28	522.22	90.8	5.99
2412	345.28	616.51	90.8	7.07
2362	398.08	695.90	90.3	8.03
2316	452.48	775.46	89.8	9.00
2265	511.04	856.75	88.9	10.04

Dyno test results of a motor and drive combination with voltage held to 96v 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. Losses include drive, motor, and motor leads. Efficiency can be improved by shortening motor leads

KOFORD ENGINEERING, LLC

5.07" (129mm) 20 pole Brushless motor.

• 1,336 to 5,334 rpm no load **•Rated power up to 600 watts**

20 tooth slotted motor for 50% less cog then high power 10 tooth version. Excellent for lower speed applications. Higher pole count provies higher resolution when halls are used for speed/positon feedback. 240°C ML insulation is used for the greatest possible durability. 200°C Neo magnets are used along with stainless shaft, and high temp TFE insulated lead wires. Unit are supplied either with 120° halls rated at 150°C, or sensor-less versions are available. Thermal protection and temperature sensors are available. Custom windings, encoders and gearboxes are available.

Motor Data

Winding		55	56	27	57	13
Nominal supply voltage	volts	24	48	48	96	160
No load speed	rpm±12%	1,336	2,667	1,280	5,334	2,136
Speed/torque slope	rpm/oz-in	1.7	3.3	1.6	6.5	2.6
Maximum efficiency	%	93	94	93	95	94
Continuous stall torque heat sink/no hs.	oz-in*	879/605	879/605	879/605	879/605	879/605
Continuous torque heat sink/no h.s.	oz-in*	867/588	847/558	868/589	777/445	853/569
Motor constant Km	oz-in/√w	69	69	69	69	69
Winding resistance#	ohm±15%	.124	.124	.538	.124	2.15
Peak output	watts	193	396	185	807	317
No load current	amp±50%	.26	.36	.12	.55	.08
Damping factor	oz-in/krpm	1.8	1.8	1.8	1.8	1.8
Static friction	oz-in	3.9	3.9	3.9	3.9	3.9
Velocity constant	rpm/volt±12%	55.6	55.6	26.7	55.6	13.3
Torque constant Kt	oz-in/amp	24.3	24.3	50.6	24.3	101
Stall current	amps	193.5	387	89	774	74
Winding inductance	mH	1.19	1.19	5.16	1.19	20.8
Mechanical time constant	ms	1.5	1.5	1.5	1.5	1.5
Rotor inertia	10^{-4}oz-in-sec^2	672	672	672	672	672
Thermal res. winding to housing	°C/W	.44	.44	.44	.44	.44
Thermal res. housing to ambient	°C/W	1.12	1.12	1.12	1.12	1.12

Ambient temperature range -73C to 149C

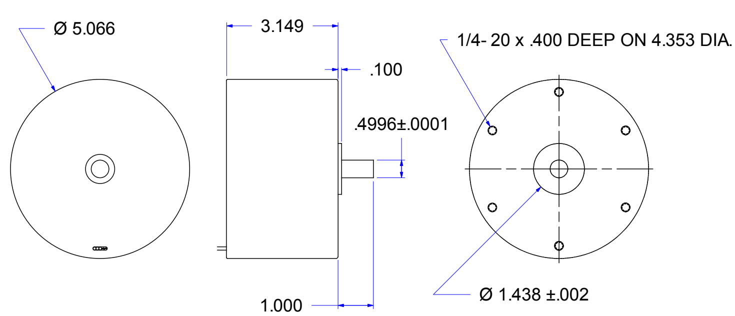
Weight 8lb. 12 oz., maximum winding temp. 200C Data is for winding and magnet temperature of 20°C

*0.3°C/W heat sink or sufficient airflow over motor for equal thermal resistance/still air and no heat sink. Continuous torque is running torque at nominal supply voltage

#Lead wires resistance 4.7mΩ if used at full length

Leads are 12" minimum

Phase leads are 14 gauge, hall leads are 28 gauge, all TFE



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: mail@koford.com•phone 937-695-1275•fax 937-695-0237•www.koford.com

Example: Part Number 129 H 56 A / A24

Motor type — 129

Type S=sensorless H=120°halls — H

Winding number — 56

Modifications A=none, T=thermistor, P=thermal protection — A

Encoder w index A20=2000line(8,000 count) — A24

KOFORD
ENGINEERING, LLC

5.07" (129mm) 8 pole Slotless Brushless motor.

• 1,278 to 2,439 rpm no load **•Rated power up to 440 watts**

Cog free, slotless, low inductance design for highest performance, perfect for direct drive applications and other precision servo applications. 240°C ML insulation is used for the greatest possible durability. 150°C Neo magnets are used along with stainless shaft, and high temp TFE insulated lead wires. Unit are supplied either with 120° halls rated at 150°C, or sensorless versions are available. Thermal protection and temperature sensors are available. Custom windings, encoders and gearboxes are available. Sine back emf.

Motor Data

Winding		53	54
Nominal supply voltage	volts	24	48
No load speed	rpm±12%	1,278	2,439
Speed/torque slope	rpm/oz-in	.51	.61
Maximum efficiency	%	85	88
Continuous stall torque heat sink/no hs.	oz-in*	567/381	567/381
Continuous torque heat sink/no h.s.	oz-in*	537/337	487/250
Motor constant Km	oz-in/√w	58	58
Winding resistance#	ohm±15%	.188	.188
Peak output	watts	602	1054
No load current	amp±50%	.81	1.03
Damping factor	oz-in/krpm	12.7	8.5
Static friction	oz-in	4.4	4.4
Velocity constant	rpm/volt±12%	53.3	53.4
Torque constant Kt	oz-in/amp	25.4	25.4
Stall current	amps	128	255
Stall torque (theoretical)	oz-in	3,234	6,468
Winding inductance	mH	.307	.307
Mechanical time constant	ms	8.2	8.2
Rotor inertia	10^{-4}oz-in-sec^2	2000	2000
Thermal res. winding to housing	°C/W	.39	.39
Thermal res. housing to ambient	°C/W	1.12	1.12
Ambient temperature range -73C to 149C			

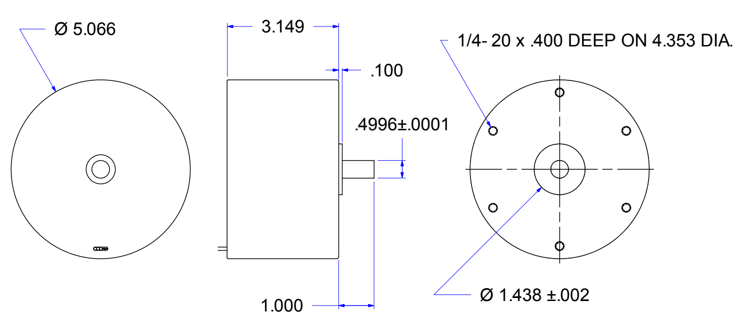
Weight 9lb. 7 oz., maximum winding temp. 200C Data is for winding and magnet temperature of 20°C

*0.3°C/W heat sink or sufficient airflow over motor for equal thermal resistance/still air and no heat sink. Continuous torque is running torque at nominal supply voltage

#Lead wires resistance 4.7mΩ if used at full length

Leads are 12" minimum

Phase leads are 14 gauge, hall leads are 28 gauge, all TFE



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: mail@koford.com•phone 937-695-1275•fax 937-695-0237•www.koford.com

Example: Part Number 129 H 53 A / A24

Motor type — 129

Type S=sensorless H=120°halls — H

Winding number — 53

Modifications A=none, T=thermistor, P=thermal protection — A

Encoder w index A20=2000line(8,000 count) — A24

KOFORD
ENGINEERING, LLC

5.07" (129mm) Frameless Slotted Brushless motor.

The frameless configuration can be used for direct drive applications where the motor is integrated into the product and the rotor is directly mounted onto the spindle or shaft of the product. This can reduce size and increase rigidity of the product.

The rotor can be attached to the customers shaft by axial clamping or with a suitable epoxy. Press fitting should not be used.

Mounting of the stator using heat shrinking is recommended as this will will provide good heat transfer. For heat shrinking usually an aluminum housing would be used. If this is not practical then axial clamping can be used.

The housing for the motor should be designed so that there is as much gap as possible between the magnet and the metal of the housing. This will reduce eddy current losses at higher rpm.

If epoxy is used then the minimum bondline of the epoxy must be considered as some materials contain large particle fillers. The recommended adhesive for room temperature cure is 3M DP460 (don't use static mixer and dispense a large enough quantitiy of material that the correct amount from both components is dispensed) The stator and rotor may be mounted using heat cured epoxy. Koford E-114 is recommended for heat cure.

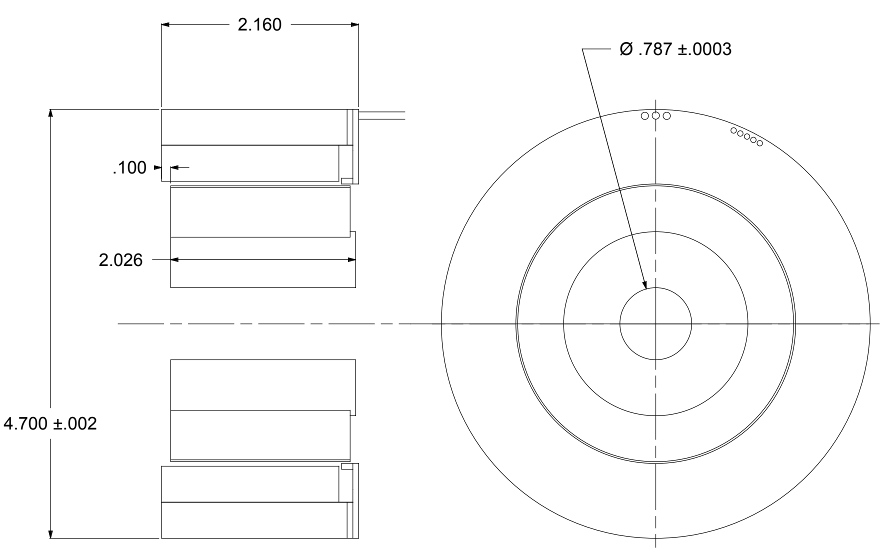
The weight of the frameless motor is 7lb.

The part number for a frameless motor is the same as a housed motor except that F follows the 129. For example:

housed motor: 129H43T

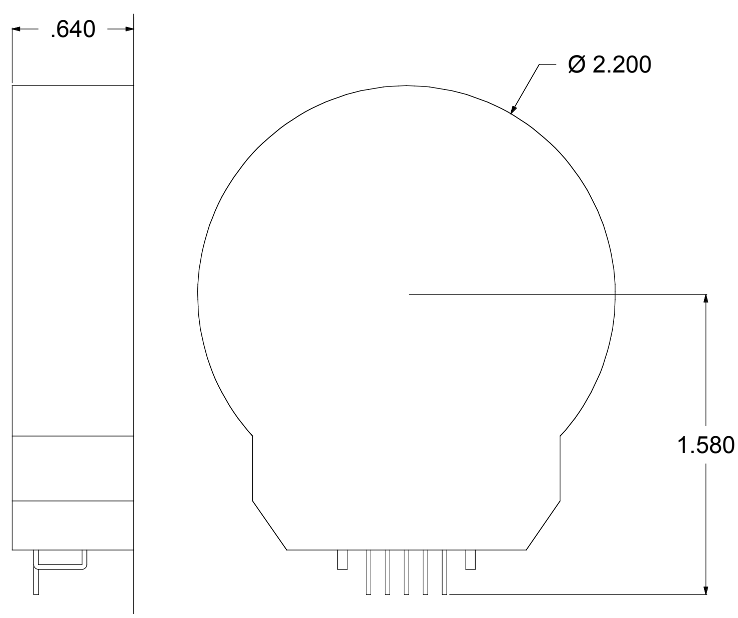
frameless version: 129FH43T

Encoders are not available on a frameless motor. The cross section of a sensorless frameless motor is shown below, the slotted version is the same except for an overall length of 2.238. Put anti-stat zip lock bag over hall leads



Optical Encoder

Mating connector AMP 103977-4. Supply voltage is 5±.5V. Rpm 9,000 max.



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. Usually this is because these motors will overheat if run continuously at full speed even with no load.

Hall Sensors

Like other semiconductor components hall sensors are electrostatic sensititive. 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.

Motor technology

The Koford 119mm brushless series of motors are slotless sintered rare earth permanent magnet motors with unique technology. 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 torque density, better efficiency, lighter weight and more durable construction (ML Class 220C wire insulation bonded with solventless Class 205 thermoset resin) provides the highest durability possible.

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 56kHz or higher are recommended for best performance. Drives which use ASIC's for transistor switching will perform better then drives which use DSP's or Micro's for this function due to more accurate phase switching. For the highest performance Koford drives are recommended. Drives which have a pwm frequency of less then 56kHz will need inductors for proper drive operation and to prevent overheating when used with higher speed motor. Koford drives do not require inductors.

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 rpm below full speed.

Selection of Hall, or Sensorless Configuration

The most common motor configuration is the hall sensor design. For positioning applications either hall must used or encoders or resolvers which will provide the drive with commutation information must be used. For pumps or similar applications sensorless motors can be used.

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. If the ambient temperature is above 20°C then the continuous duty torque is reduced. Many 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) where the interior of the motor is filled with refrigerant or water/glycol. 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. For example at 150°C the winding resistance is 1.51 times the resistance at 20°C, so this higer value must be used when calculating copper losses.

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 119mm motor is not suitable for use in water, however water glycol mistures with corrosion inhibitors may be possible. 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.

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

Phase and sensor wires should be routed seperately and away from other wires to reduce electrical interference. The leads should be cut 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 noticable 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. Higher frequency drives will slightly increase overall efficiency.

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).