

# KOFORD

ENGINEERING, LLC



## Generators

- Sensorless motors when driven by a power source with the output leads connected to a three phase bridge rectifier act as a generator.

- Power up to 500 watts and input rpm up to 200,000 are available, speeds up to 400,000 rpm have been achieved using a sleeved rotor in the frameless configuration.

Applications include generators for UAV's, isolated electric power from compressed air or using a standard AC motor to drive the generator using a dielectric drive shaft, and starter/generators for gas turbines.

- Sensorless motors if connected directly to a three phase load produce a three phase AC voltage equal to the input frequency times the number of pole pairs. For example for an input speed of 24,000 rpm a two pole motor will generate a 400 hz output. The voltage will depend on the rpm/v and the load. Contact the factory for more details.

- Highest power density

- High temperature ML (220°C) insulation

- Up to 95% efficiency

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

# KOFORD .86" (22mm) Slotless Brushless DC Generator

ENGINEERING, LLC

•Maximum rpm 60,000 rpm •Rated power 37 watts •2 pole

Slotless design small size, light weight, high efficiency and cool operation at high speed. ML (220°C) insulation for highest reliability. 150°C rated Neo rare earth magnets standard. The generator features a hardened precision ground 440C stainless shaft and anodize aluminum case. The standard configuration has three leads (TFE) and outputs 3 phase sine waves to be converted to DC with the customers electronics or the D1 external rectifier board is available to convert the three phase outputs of the generator to DC. For applications under 1 amp an internal rectifier can be supplied (contact factory). Options include 3mm shaft, and temperature sensor. Custom winds can be provided.



## Motor Data

Winding		1200
Ball Bearing type		stainless
Maximum rated speed	rpm	60,000
Maximum rated voltage	volts	51
Rated current 20°C/no h.s.	amps	2.7/4
Rated speed	rpm	27,920
Motor constant Km	oz-in/√w	.89
Winding Resistance	ohm±15%	1.59
Damping factor	oz-in/krpm	.010
Static friction	oz-in	.034
Velocity constant	rpm/volt	1200
Torque constant Kt	oz-in/amp	1,12
Maximum efficiency	%	78
Winding inductance	mH	.22
Rotor inertia	10 <sup>-4</sup> oz-in-sec <sup>2</sup>	.280
Thermal res. winding to case	°C/W	5
Thermal case to ambient	°C/W	12

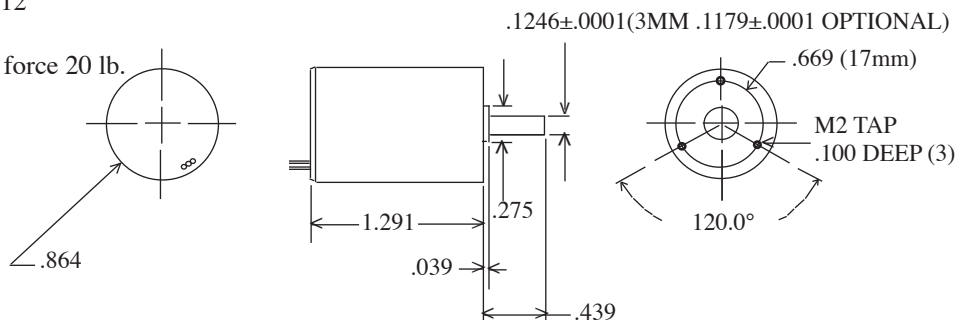
Weight 1.8 oz. Maximum winding temperature 150°C (magnet temp limited)

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

Maximum axial bearing force 20 lb.



Leads	
Blue	Phase A
White	Phase B
Brown	Phase C

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

**Example:** Part Number 22 S 1200 A

Motor dia.

Type S=sensorless

Winding number

Modifications A=none E=3mm shaft T=temp sensor

TEST DATA  
 Total System Performance  
 22S1200A Generator with D1 Diode board  
 Driven at 27,920 rpm

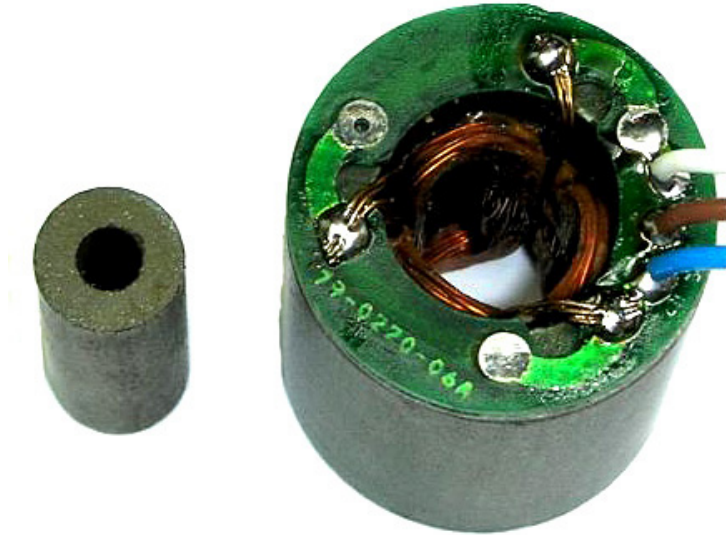
Voltage (V)	Current (A)	Power (watts)
24.00	0.00	0.00
21.25	0.58	12.33
21.15	0.64	13.54
21.03	0.7	14.72
20.84	0.77	16.05
20.63	0.86	17.74
20.45	0.97	19.84
20.17	1.12	22.59
19.69	1.31	25.79
19.20	1.60	30.72
18.37	2.05	37.66

TEST DATA  
 Total System Performance  
 22S1200A Generator with D1 Diode board  
 Driven at 14,086 rpm

Voltage (V)	Current (A)	Power (watts)
12.00	0.00	0.00
10.48	0.29	3.04
10.43	0.31	3.23
10.36	0.34	3.52
10.29	0.38	3.91
10.26	0.42	4.31
10.10	0.48	4.85
9.97	0.55	5.48
9.80	0.65	6.37
9.55	0.79	7.54
9.17	1.02	9.35

TEST DATA  
 Total System Performance  
 22S1200A Generator with D1 Diode board  
 Driven at 5,990 rpm

Voltage (V)	Current (A)	Power (watts)
5.00	0.00	0.00
4.20	0.12	0.50
4.18	0.13	0.54
4.16	0.14	0.58
4.11	0.15	0.62
4.10	0.17	0.70
4.01	0.19	0.76
3.98	0.22	0.88
3.90	0.26	1.01
3.88	0.32	1.24
3.60	0.40	1.44



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 housed 22mm motors are also available in the frameless configuration. The customer should epoxy the supplied rotor magnet to their magnetic shaft (440C or 416 stainless recommended) and then dynamically balance the assembly to tolerances appropriate 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 break the magnet.

The part number of a frameless motor is the same as a housed motor except 22 is replaced by 21. For example a 22S9999A becomes a 21S9999A in the frameless configuration.

## 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**

$^{\circ}\text{F} - 32 \div 1.8 = ^{\circ}\text{C}$  example:  $212^{\circ}\text{F} = 100^{\circ}\text{C}$ ,  $^{\circ}\text{C} \times 1.8 + 32 = ^{\circ}\text{F}$  example:  $100^{\circ}\text{C} = 212^{\circ}\text{F}$ ,  $\text{in} \times 25.40 = \text{mm}$ ,  
 $\text{mm} \times 0.03937 = \text{in.}$ ,  $\text{oz} \times 28.3495 = \text{g}$ ,  $\text{oz-in} \times 7.06 = \text{mNm}$ ,  $\text{mNm} \times .142 = \text{oz-in}$ ,  $\text{Nm} \times .142 = \text{oz-in}$ ,  
 $\text{Ncm} \times 1.42 = \text{oz-in}$ ,  $\text{rpm} \times .1047 = \text{rad s}^{-1}$ ,  $\text{V/R/S} \times .1047 = \text{volts/rpm}$ ,  $746 \text{ watts} = 1\text{hp}$ ,  $\text{lb-in}^2 \times$   
 $.04144 = \text{oz-in-sec}^2$

### **Generator 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. The data sheet lists continuous current with a  $20^{\circ}\text{C}$  ( $68^{\circ}\text{F}$ ) ambient. Two values are listed, the first with the motor case cooled to  $20^{\circ}\text{C}$  and the second with no cooling in still air. Most applications will fall somewhere between these two extremes. If the ambient temperature is above  $20^{\circ}\text{C}$  then the continuous current is reduced. Generators 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. 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 than 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  $20^{\circ}\text{C}$  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  $20^{\circ}\text{C}$ .

### **Frameless generators**

Frameless generators are useful for certain specialized applications where housed generators cannot be used. These include air bearing or magnetic bearing generators.

### **Generator hook up**

The output wires should be trimmed as short as possible to reduce EMI and power losses. Where electrical noise is a consideration the wires may be twisted or braided with each other or enclosed in a shielded jacket.

### **System efficiency**

The system efficiency is different than the generator efficiency. The system efficiency takes into account generator losses, lead wire losses, and three phase bridge losses. Additional losses can occur if the generator is not isolated from a DC to DC converter and the current is not continuous. Most DC to DC converter designs will have input filtering such as input caps and or inductors that will avoid this additional losses. If heat rise is an issue and there is significant current ripple at the pwm frequency of the DC to DC converter then additional filtering may be advised.

