KOFORD
ENGINEERING, LLC

3.5 inch (89 mm) Series

- High performance slotless brushless servomotors for military, aerospace, medical, and industrial applications.
- Highest power density
- Up to 91% efficiency
- 10 pole housed, and frameless designs
- Up to 12,692 rpm and 1,239 W continuous power
- TFE lead insulation
- Available with in hall and sensorless configurations
- Long life premium synthetic bearing lube with -73C to 149C temperature range
- Housing has cooling fins for higher continuous power

KOFORD
ENGINEERING, LLC

3.5" (89mm) Brushless Motor 10 pole, 12V, 18V, 24V, 36V and 48V

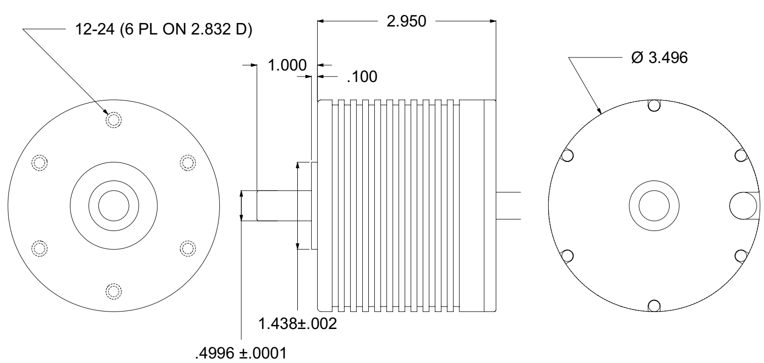
• Up to 12,720 rpm no load •up to 1,239 watts continuous

High power density high efficiency 10 pole slotted motor using class H 180°C insulation for ruggedness. 180°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 in sensorless configuration. Thermal protection and temperature sensors are available. Custom windings, encoders and gearboxes are available on special order.

Motor Data

Winding		264	265	266	267	268
Rated supply voltage	volts	12	18	24	36	48
No load speed	rpm±12%	3,184	4,776	6,360	9,548	12,728
Speed/torque slope	rpm/oz-in	4.7	5.8	7.1	11.6	15
Maximum efficiency	%	88	90	90	90	91
Rated torque heat sink/no h.s.	oz-in*	199/223	205/232	204/231	161/161	158/158
Rated power no fan/fan	watts*	323/345	519/565	713/777	917/917	1,239/1,239
Speed at rated power	rpm	2,214/2,108	3,478/3,345	4,773/4,600	7,672/7,672	10,530/10,530
Rated current	amps	36 /40	36/40	36/40	30/30	30/30
Motor constant Km	oz-in/√w	27.2	27.2	27.2	27.2	27.2
Winding resistance#	ohm±15%	.035	.035	.035	.035	.035
No load current	amp±50%	1.24	1.47	1.69	2.12	2.50
Damping factor	oz-in/krpm	.72	.72	.72	.71	.68
Static friction	oz-in	4.0	4.0	4.0	4.0	4.0
Velocity constant	rpm/volt±12%	265	265	265	265	265
Torque constant Kt	oz-in/amp	5.09	5.09	5.09	5.09	5.09
Winding inductance	mH	.068	.068	.068	.068	.068
Mechanical time constant	ms	3.1	.3.1	3.1	3.1	3.1
Rotor inertia	10^{-4}oz-in-sec^2	165	165	165	165	165
Thermal res. winding to housing	°C/W	.17	.17	.17	.17	.17
Thermal res. housing to ambient	°C/W	.38	.38	.38	.38	.38

Ambient temperature range -73C to 149C
Weight 3 lb. 13 oz., maximum winding temp. 150C Data is for winding and magnet temperature of 20°C
*still air and no heat sink, aluminum mounting bracket 20°C ambient.
#Lead wires resistance 4.7 mΩ 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: contact us at mail@koford.com

Example: Part Number 89 H 266 A

Motor type (89)
Type S=sensorless H=120°halls (H)
Winding number (266)
Modifications A=none, T=thermistor (A)

Test Data
Total System Performance
89H264A with H24V40A Controller at 12 Volts

Rpm	Torque oz-in	Watts Out	Efficiency %	Amps
3184	0.00	0.00	0.0	1.27
3121	5.10	11.79	39.3	2.50
3082	13.30	30.32	63.2	4.00
3024	23.90	53.50	74.3	6.00
2970	34.56	75.98	79.2	8.00
2891	45.87	98.14	81.8	10.00
2842	56.72	119.28	82.8	12.00
2786	68.81	139.82	83.2	14.00
2739	80.10	159.78	83.2	16.00
2687	92.15	179.90	83.3	18.00
2636	103.70	197.33	82.2	20.00
2586	115.32	217.10	82.2	22.00
2541	127.06	232.38	80.7	24.00
2484	138.82	249.33	79.9	26.00
2433	151.26	267.28	79.5	28.00
2386	162.88	280.38	77.9	30.00
2324	174.72	294.24	76.6	32.00
2264	187.20	311.06	76.2	34.00
2214	199.36	323.81	75.0	36.00
2163	211.68	333.82	73.2	38.00
2108	223.84	345.95	72.1	40.00
2044	235.68	355.17	70.5	42.00
1990	248.00	365.25	69.2	44.00
1954	259.84	375.86	68.1	46.00
1910	272.00	386.58	67.1	48.00
1861	283.68	392.99	65.5	50.00
1809	296.16	398.70	63.9	52.00
1743	308.32	403.98	62.3	54.00
1699	319.20	411.38	61.2	56.00
1644	331.84	418.66	60.2	58.00
1589	341.92	412.22	57.3	60.00

Dyno test results of a motor and drive combination with voltage held to 12v 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. Motor leads were left at full length and not shortened to minimum length to increase efficiency. Test were conducted at 24°C.

Test Data
Total System Performance
89H265A with H24V40A Controller at 18 Volts

Rpm	Torque oz-in	Watts Out	Efficiency %	Amps
4776	0.00	0.00	0.0	1.50
4701	6.88	23.92	44.3	3.00
4651	12.34	42.46	59.0	4.00
4566	22.86	77.28	71.6	6.00
4497	33.58	111.81	77.6	8.00
4418	44.50	145.49	80.8	10.00
4341	56.10	180.21	83.4	12.00
4263	67.18	211.95	84.1	14.00
4183	79.71	245.01	85.1	16.00
4122	91.49	275.71	85.1	18.00
4060	103.70	306.99	85.3	20.00
3986	115.50	336.45	85.0	22.00
3916	127.63	365.17	84.5	24.00
3839	139.34	391.82	83.7	26.00
3766	152.02	420.27	83.4	28.00
3702	164.48	447.30	82.8	30.00
3633	176.96	470.66	81.7	32.00
3549	190.24	495.86	81.0	34.00
3478	202.72	518.93	80.1	36.00
3401	215.52	542.50	79.3	38.00
3345	228.32	565.28	78.5	40.00
3289	241.28	587.52	77.7	42.00
3222	253.92	605.71	76.5	44.00
3159	268.48	627.97	75.8	46.00
3087	280.48	641.06	74.2	48.00
3035	293.44	659.30	73.3	50.00
2972	306.08	673.47	72.0	52.00
2910	318.40	685.95	70.6	54.00
2831	331.04	698.77	69.3	56.00
2772	342.56	708.03	67.8	58.00
2703	355.52	721.79	66.8	60.00

Dyno test results of a motor and drive combination with voltage held to 18v 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. Motor leads were left at full length and not shortened to minimum length to increase efficiency. Test were conducted at 24°C.

Test Data
Total System Performance
89H266A with H24V60A Controller at 24 Volts

Rpm	Torque oz-in	Watts Out	Efficiency %	Amps
6360	0.00	0.00	0.0	1.72
6264	7.31	33.92	41.6	3.40
6252	10.37	47.98	50.0	4.00
6158	20.88	95.14	66.1	6.00
6047	31.92	142.82	74.4	8.00
5941	42.91	188.67	78.6	10.00
5840	54.10	233.79	81.2	12.00
5736	65.73	278.98	83.0	14.00
5639	78.07	321.63	83.8	16.00
5540	91.07	365.18	84.5	18.00
5471	103.26	407.79	85.0	20.00
5375	115.73	449.86	85.2	22.00
5296	127.50	491.33	85.3	24.00
5211	140.46	530.96	85.1	26.00
5134	152.94	570.18	84.8	28.00
5046	166.32	610.24	84.8	30.00
4938	177.80	642.53	83.7	32.00
4857	191.08	679.30	83.2	34.00
4773	204.04	713.10	82.5	36.00
4689	217.00	746.08	81.8	38.00
4600	230.76	777.46	81.0	40.00
4500	243.52	811.46	80.5	42.00
4437	256.64	843.17	79.8	44.00
4357	270.56	872.70	79.0	46.00
4281	283.68	898.99	78.0	48.00
4202	297.60	925.68	77.1	50.00
4134	310.56	950.32	76.1	52.00
4047	324.00	970.88	74.9	54.00
3938	338.16	999.04	74.3	56.00
3864	350.80	1023.12	73.5	58.00
3779	364.56	1038.80	72.1	60.00

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. Motor leads were left at full length and not shortened to minimum length to increase efficiency. Test were conducted at 24°C.

Test Data

Total System Performance

89H267A with H48V40A Controller at 36 Volts

Rpm	Torque oz-in	Watts Out	Efficiency %	Amps
9548	0.00	0.00	0.0	2.15
9306	10.67	73.46	44.4	4.60
9203	18.86	128.45	59.5	6.00
9077	29.44	197.71	68.7	8.00
8952	40.11	265.76	73.8	10.00
8830	51.39	335.87	77.7	12.00
8724	62.50	403.50	80.1	14.00
8559	74.67	472.98	82.1	16.00
8430	86.38	538.96	83.2	18.00
8312	98.10	603.39	83.8	20.00
8185	110.13	667.07	84.2	22.00
8005	123.57	732.06	84.7	24.00
7892	136.40	796.64	85.1	26.00
7793	148.80	858.24	85.1	28.00
7672	161.44	917.28	84.9	30.00

Dyno test results of a motor and drive combination with voltage held to 36v 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. Motor leads were left at full length and not shortened to minimum length to increase efficiency. Test were conducted at 24°C.

Test Data
Total System Performance
89H268A with H48V40A Controller at 48 Volts

Rpm	Torque oz-in	Watts Out	Efficiency %	Amps
12728	0.00	0.00	0.0	2.53
12382	16.30	148.82	51.7	6.00
12148	26.82	241.09	62.8	8.00
11977	38.10	337.71	70.4	10.00
11820	49.38	431.89	75.0	12.00
11662	60.69	523.86	78.0	14.00
11476	72.90	619.07	80.6	16.00
11314	84.02	703.52	81.4	18.00
11144	96.14	792.98	82.6	20.00
10971	108.93	884.48	83.8	22.00
10825	120.96	968.98	84.1	24.00
10654	134.62	1061.39	85.0	26.00
10512	147.04	1143.90	85.1	28.00
10354	159.81	1224.58	85.0	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. Motor leads were left at full length and not shortened to minimum length to increase efficiency. Test were conducted at 24°C.

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.

Balancing

Components attached to the motor shaft should be dynamicially 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 balanced in 2 planes.

Motor technology

The Koford 60mm 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 (25,000+rpm), can operate in a vacuum, and will not introduce comtamination 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 240C wire insulation bonded with high temperature epoxy 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 at 28 volts. Running a 24 volt motor at 36 volts is not recommended.

Motor selection

Motors for continuous duty applications such as pumps, blowers etc. should in most cases be selected to operate at rated torque with no heat sink. For elevated ambient temperatures the torque will need to be reduced. Higher torque level can be achieved with forced air cooling or by mounting the motor to a thick aluminum mounting plate with a large surface area. For prototyping ordering a motor with a temperature sensor is recommended to ensure that the maximum motor operating temperature is not exceeded. 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 is 100% at maximum load. 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. In that case a torque less then the rated continuous torque must be used. 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. Drives which operate at lower frequencies may need to be operated at slightly reduced load due to higher motor operating temperatures.

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 equal or 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. Using such values on their data sheet allows manufactures to claim high power and torque values that cannot be reliably reached in actual use.

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 are very popular for pumps and blowers as they are lower in cost and have only three leads which can be helpful in applications where the motor must be located a distance from the drive, it also reduces the labor required to connector the motor and reduces motor cost. Integral electronics mounted on the end of the motor are also offered which can simplify wiring and assembly. Contact the factor for more information.

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 use of slotted motors with sensorless drives is especially problematic and reduced torque capabilities should be expected. 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. Also when calculating stall torque the resistance value to use is the total resistance of the motor, drive and all associated wiring. Some drives do not apply full voltage to the drive so that must be considered also. 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 a minimum of 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 shown must be reduced. Many Koford motors are available with temperature sensors and this can be especially 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 oil, 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 higher 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 or oil. Frameless motors should be avoided for any application where a housed motor can be used. The use of water inside the motor requires special magnets or the magnets must be canned in stainess steel. In many cases ceramic 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

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 or an off the shelf EMI line filter. Also consider enclosing the drive or motor and drive in a metal enclosure. If even better results are required then a custom EMI filter designed for the spec requirments and the load may be used.

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 is 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. The maximum no load speed is reduced by about 12% and the peak efficiency is reduced by about 6%

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

These are all different names for the same motor.

These are different from an AC motor (also know as an AC induction motor) which is a motor which can run from utility 60 hz AC voltage without any electronics. These motors do not have permanant magnets and their power density and performance is less then brushless motors. Unlike AC motors all of the motors listed above are powered by DC voltage including the ones with AC in their name.

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. If the speed is turned down then 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. The motor operates at a lower temperature but the drive runs at higher temperature. 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, so the motor voltage is lower then the power supply voltage unless the speed pot it turned to maximum in which case they are the same. For example if the power supply voltage is 36 volts and the speed is turned down to 1/3 of maximum, then the motor voltage is12 volts. If a load is applied to the motor shaft which results in a 20 amp motor current then the input current to the drive will be 12/36 x 20 or 6.66 amps (neglecting losses). Because of this when using for example a 20 amp drive, the 20 amps can be pulled from the power suppply only when the speed pot is set to maximum. In general the power supply rating should be slightly higher then the drive rating. Koford drives are designed to deliver slightly above the rated current. If a power supply is used which has foldback current limiting and the current rating is the same as the drive rating the power supply may shut down durring acceleration because the current limit has been slightly exceeded. To prevent nuisance shuts offs specify use a power supply with a current rating about 5-10 amps above the rated current of the drive.