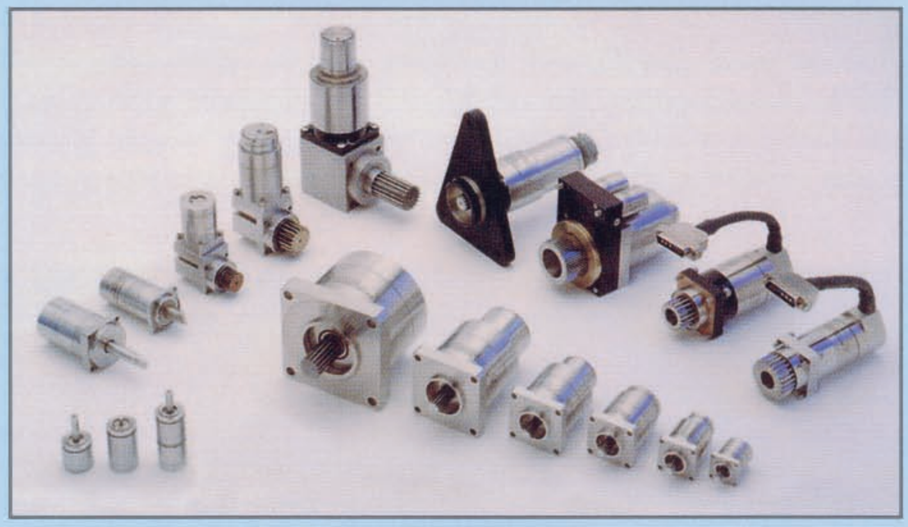
BRUSHLESS PERMANENT MAGNET MOTOR
ENGINEERING REFERENCE DATA



CDA INTERCORP

CONTROLLABLE DRIVE ACTUATORS

CDA InterCorp

INTRODUCTION

This application manual defines the performance capabilities of CDA InterCorp's Brushless Permanent Magnet Motor product line, in-line and right angle gearing, optional rotary transducers, and brakes.

The design data contained herein reflects the continuous demand for improved performance, efficiency, and reliability, while simplifying drive techniques, and minimizing size and weight. CDA InterCorp's Brushless Motors are designed to operate under the most demanding requirements of MIL-STD–810, while maintaining robust, reliable performance characteristics. These motors and similar products are used in aerospace, outer space, defense, commercial aviation, "down hole", robotic, nuclear, and high reliability industrial control applications.

With over 30 years in the industry, CDA InterCorp's core philosophy of modular standardization has withstood the test of time. Each modular design utilizes the same inventoried piece part standards, materials, processes, and construction techniques. Inherent in our standard modules are unequaled reliability and ruggedness, while maintaining flexibility in providing custom motor requirements and extremely responsive prototype and production deliveries.

CDA maintains a quality inspection system which provides traceability, product assurance, and performance. A government quality representative is available to provide source inspection, as required.

For responsive support of your specific requirements, please write, phone, fax, or e-mail CDA InterCorp directly. CDA's system application engineers are available to visit your facility to assist in the design and selection of the proper Controllable Drive Actuator for your specific application. CDA also maintains marketing personnel throughout the United States and Internationally.

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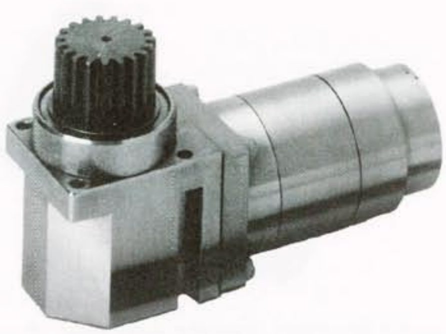
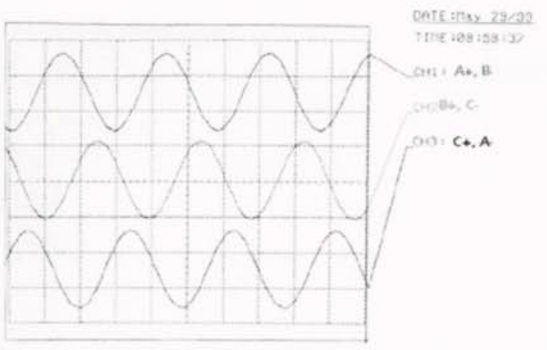


Brushless Permanent Magnet Motors

Providing the highest mechanical power output and torque per unit volume, the Brushless Permanent Magnet Motor (BPMM) is the workhorse of the motor line family. These high performance motors require an integral motor rotor position indicator in order to maximize motor performance and operation.

The rotor is constructed with durable rare earth samarium cobalt magnets for high temperature performance, stability, and durability. The electrical windings are on the outside stationary stator, providing minimal thermal resistance between the windings and the motor case.

Sinusoidal Operation: CDA may provide a sinusoidal Brushless Permanent Magnet Motor for any of our frame sizes. For ripple torque critical applications, where smooth torque control particularly at low speeds is required, CDA may provide two phase or three phase sinusoidal back emf. A sinusoidal drive uses all phases on the motor on a continuous current basis. There is no instantaneous hard switch of the current, as with the trapezoidal drive. In order to produce an actuator with smooth performance and low ripple torque, the motor back emf should match the waveform of the generated current and be 180° out of phase to operate most effectively. The scope trace below shows an actual back emf waveform of a three phase CDA InterCorp BPMM. CDA has produced BPMM actuators with less than 0.5% ripple torque.



Trapeziodal Operation is a popular method of motor control, due to it's simplicity and availability of controllers. The performance data tabulated in this catalog may also be used to approximate trapezoidal performance as well as sinusoidal performance. Trapezoidal commutation will result in lower starting torque and higher ripple torque, when compared to sinusoidal operation. Contact CDA Engineering for additional information on commutation options.

Motor Transducer Options: In order to properly control the current in a Brushless Permanent Magnet Motor reliably, position feedback is required. CDA recommends high frequency brushless Field Directors. Field Director options and performance data is tabulated on page 11.

CDA InterCorp strongly recommends Field Directors, rather than Hall Sensors for motor control. While CDA InterCorp has a Hall Sensor module within our product line, Hall Sensors have operational temperature limitations of -40° to +150° C. Further, Field Directors can withstand greater shock and vibration loads than Halls. With Hall Effect commutation, there will be degradation of motor performance, as well as increased ripple torque, due to inherent hall hysteresis. Hall sensors may only be used for trapezoidal commutation.

Optional Transducers: CDA InterCorp may offer position, velocity, or acceleration feedback of the high speed motor, or the low speed output of the actuator assembly. Several options for these rotary transducers are tabulated with application information in this catalog. Additional transducer options may be found in our Rotary Transducer Application Data brochure.

Position Transducers: Position information may be obtained through high accuracy Brushless Resolvers, or RVDT's. These devices may be integrated through a high accuracy zero-backlash gearbox to provide output shaft position information, as shown on pages 18 through 19. High accuracy position transducer information may be found in our Rotary Transducer Application Data brochure.

Velocity Transducers: High speed motor velocity information may be achieved with Brushless AC tachometers, Permanent Magnet Alternators, or op-amp integrated accelerometers. Velocity information may be used in high performance servo and velocity control systems. Information on our velocity sensors may be found in our Rotary Transducer Brochure.

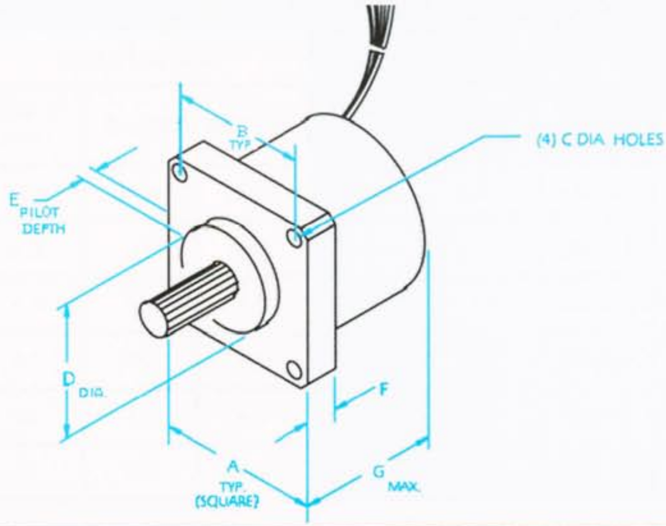
Acceleration Sensors: CDA's Rotary Accelerometers (RA's) are extremely useful for inner loop stability and high bandwidth, in high performance geared servo systems. The RA provides a higher order effect in servo compensation than damping tachometers, and require no excitation or demodulation to provide a DC output. Performance and application information on our RA's may be found on pages 12 and 23.

Friction Brakes: As with all of our other modules, CDA's friction brakes are integrally mounted with no intermediate couplings. These "fail safe" DC devices provide power off holding to a rotary or linear actuator, and allow the motor shaft to rotate freely when DC voltage is applied to the brake winding. Performance on our four frame sizes of friction brakes may be found on page 13.

Gearing Options: Pages 14 through 17 tabulate our high reliability in-line and right-angle gearboxes and composite assembly dimensions. These low backlash/high stiffness gearboxes are ideal torque multipliers for high precision servo and pointing mechanisms.

Sinusoidal Brushless Actuator with Hard Mounted Connector

Motor Mechanical Data



IMPERIAL UNITS (DIMENSIONS IN INCHES)										
MOTOR TYPE	A	B	C	D	E	F	G	WEIGHT (Oz.)	INERTIA (Oz-In-s²)	Coulomb Friction (Oz-In)
12	0.750	0.620	0.081	0.5000	0.040	0.125	0.780	1.2	9.00 E-06	0.15
16	1.000	0.828	0.110	0.6250	0.125	0.187	0.995	2.8	3.40 E-05	0.35
20	1.250	1.030	0.129	0.7500	0.125	0.250	1.280	5.0	1.00 E-04	0.60
24	1.500	1.250	0.149	0.8750	0.125	0.250	1.550	8.5	2.50 E-04	1.20
32	2.000	1.670	0.177	1.1250	0.125	0.375	1.911	19	9.60 E-04	2.00
40	2.500	2.080	0.266	1.5000	0.125	0.500	2.170	32	1.50 E-03	3.00
48	3.000	2.500	0.266	1.7500	0.125	0.500	2.500	64	2.62 E-03	5.00

SYSTEM INTERNATIONAL (DIMENSIONS IN mm)										
MOTOR TYPE	A	B	C	D	E	F	G	WEIGHT (kg)	INERTIA (kg-m²)	Coulomb Friction (Nmm)
12	19.05	15.75	2.06	12.700	1.02	3.18	19.81	0.037	6.36 E-08	1.06
16	25.40	21.03	2.79	15.875	3.18	4.75	25.27	0.078	2.4 E-07	2.47
20	31.75	26.16	3.28	19.050	3.18	6.35	32.51	0.142	7.06 E-07	4.23
24	38.10	31.75	3.78	22.225	3.18	6.35	39.37	0.241	1.77 E-06	8.47
32	50.80	42.42	4.50	28.575	3.18	9.53	48.54	0.540	6.71 E-06	14.1
40	63.50	52.83	6.76	38.100	3.18	12.70	55.00	0.91	1.01 E-05	21.2
48	76.20	63.50	6.76	44.450	3.18	12.70	63.50	1.80	1.85 E-05	35.3

Notes:

1. Pilot to pinion concentricity = 0.0007 inches [0.018 mm] TIR.
2. Flange to pinion perpendicularity = 0.0007 inches [0.018 mm] TIR.
3. Composite error of assembled pinion = 0.011 inches [0.028 mm] TIR.
4. Other mounting configurations are available on request.
5. Contact CDA's engineering department for motor thermal characteristics.

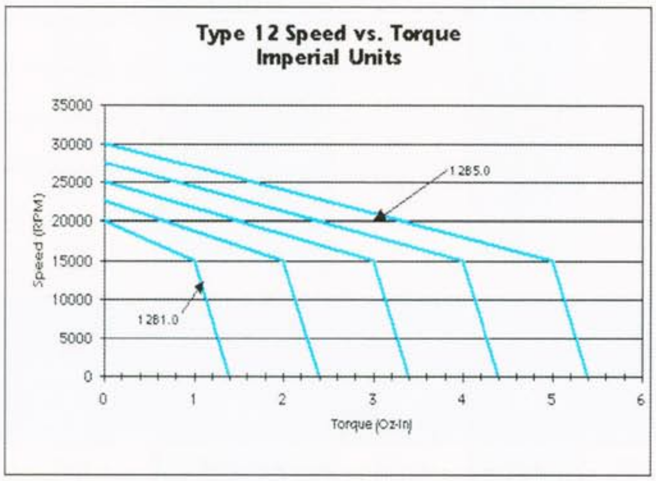
TYPE 12 BRUSHLESS PERMANENT MAGNET MOTOR

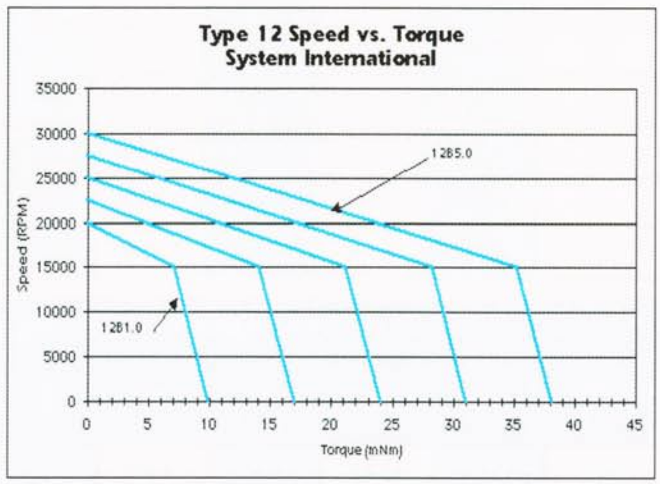
PERFORMANCE AT +25° C UNIT TEMPERATURE

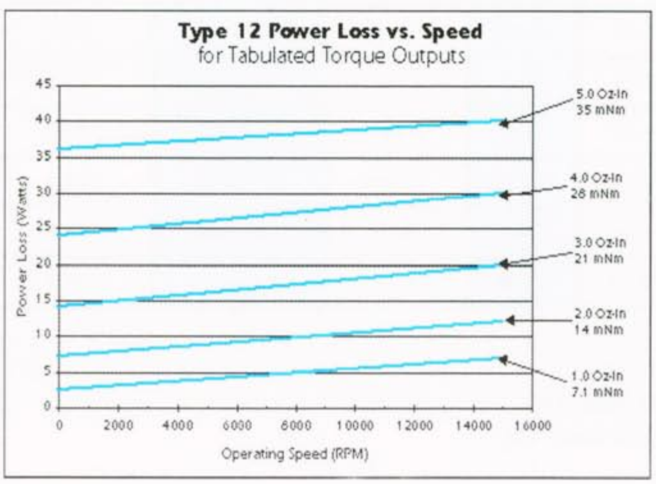
Km= 0.9

MOTOR TYPE	DATA AT MAXIMUM POWER OUTPUT					DATA AT STALL			NO LOAD SPEED	TORQUE CONSTANT	
	MOTOR TORQUE		MOTOR SPEED	POWER OUTPUT	POWER LOSS	MOTOR TORQUE		POWER LOSS		270 VOLT SUPPLY (SEE NOTE 3)	
	Oz-In	mNm	RPM	WATTS	WATTS	Oz-In	mNm	Watts	RPM	Oz-In/Amp	mNm/Amp
12B1.0	1.0	7	15000	11	7	1.4	10	2.5	22000	15.9	112
12B2.0	2.0	14	15000	22	12	2.4	17	7.1	24000	14.5	102
12B3.0	3.0	21	15000	33	20	3.4	24	14	25500	13.8	97
12B4.0	4.0	28	15000	44	30	4.4	31	24	27000	13.2	93
12B5.0	5.0	35	15000	55	40	5.4	38	36	29000	12.5	88

Notes:
1. Other performance characteristics are available on request.
2. Two phase or three phase windings as required.
3. To determine torque constant at other supply voltages, multiply the tabulated torque constant by your operational voltage, then divide this figure by 270.
4. Unit operational temperature range: -80° C to +225° C. Wider temperature ranges available.
5. See pages 14 through 17 for motor temperature rise data.







TYPE 12 CONSTANTS (@ 25° C For Reference Only)

Parameter	Symbol	Units	Value
Inertia	J_M	Oz-In-sec^2	9.00 E-06
		kgm^2	6.36 E-08
Motor Constant	K_M	Oz-In/w$^{.5}$	0.9
		mNm/w$^{.5}$	6.4
Electrical Time Constant (L/R)	τ_e	sec	1.8 E-04
Coulomb Friction	F_C	Oz-In	0.15
		mNm	1.06
Viscous Friction	B_V	Oz-In/rpm	2.67 E-05
		mNm/rpm	1.89 E-04

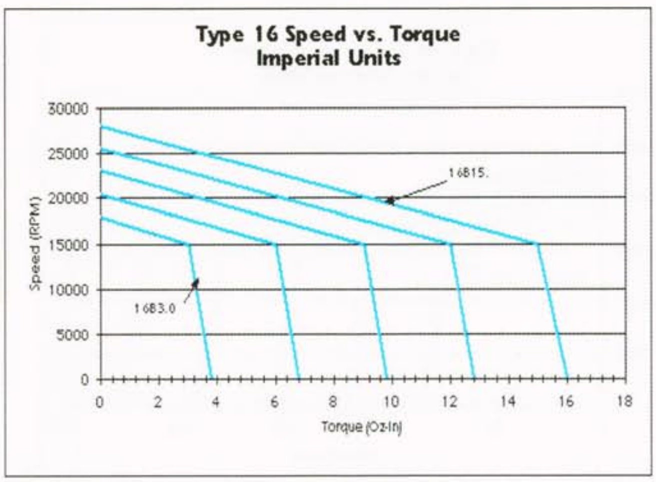
TYPE 16 BRUSHLESS PERMANENT MAGNET MOTOR

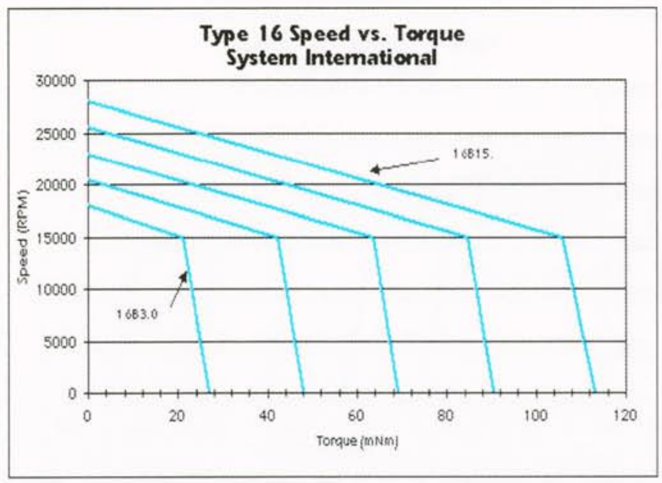
PERFORMANCE AT +25˚ C UNIT TEMPERATURE

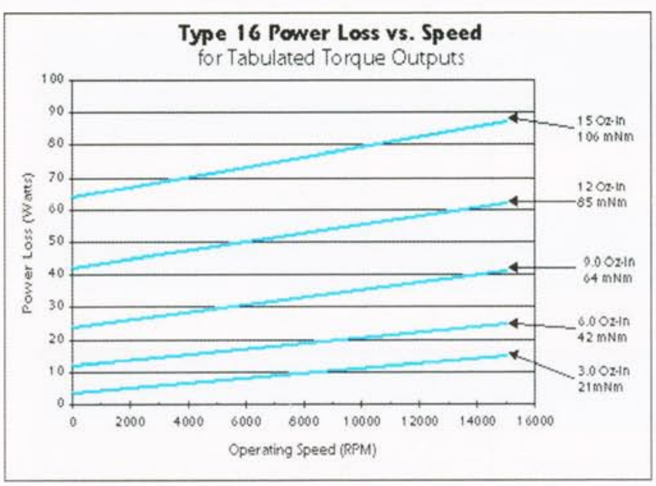
Km=2.0

MOTOR TYPE	DATA AT MAXIMUM POWER OUTPUT					DATA AT STALL			NO LOAD SPEED	TORQUE CONSTANT	
	MOTOR TORQUE		MOTOR SPEED	POWER OUTPUT	POWER LOSS	MOTOR TORQUE		POWER LOSS		270 VOLT SUPPLY (SEE NOTE 3)	
	Oz-In	mNm	RPM	WATTS	WATTS	Oz-In	mNm	Watts	RPM	Oz-In/Amp	mNm/Amp
16B3.0	3.0	21	15000	33	15	3.8	26	3.6	19000	18.7	132
16B6.0	6.0	42	15000	67	25	6.8	48	12	20000	17.7	124
16B9.0	9.0	64	15000	100	41	9.8	69	24	22500	15.8	112
16B12.	12	85	15000	133	62	13	90	42	25500	14.2	100
16B15.	15	106	15000	166	87	16	110	64	28500	12.8	90

Notes:
1. Other performance characteristics are available on request.
2. Two phase or three phase windings as required.
3. To determine torque constant at other supply voltages, multiply the tabulated torque constant by your operational voltage, then divide this figure by 270.
4. Unit operational temperature range: -80˚ C to +225˚ C. Wider temperature ranges available.
5. See pages 14 through 17 for motor temperature rise data.







TYPE 16 CONSTANTS
(@ 25˚ C - For Reference Only)

Parameter	Symbol	Units	Value
Inertia	J_M	Oz-In-sec²	3.4 E-05
		kgm²	2.4 E-07
Motor Constant	K_M	Oz-In/w .5	2.0
		mNm/w .5	14
Electrical Time Constant (L/R)	τ_e	sec	6.0 E-04
Coulomb Friction	F_C	Oz-In	0.35
		mNm	2.47
Viscous Friction	B_V	Oz-In/rpm	5.33 E-05
		mNm/rpm	3.77 E-04

TYPE 20 BRUSHLESS PERMANENT MAGNET MOTOR

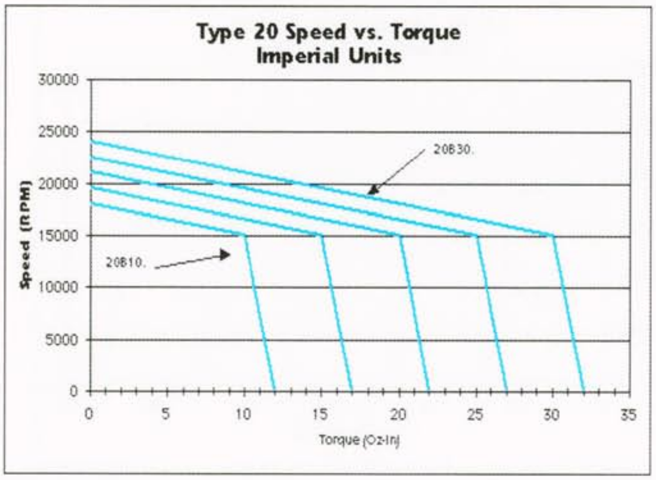
PERFORMANCE AT +25° C UNIT TEMPERATURE

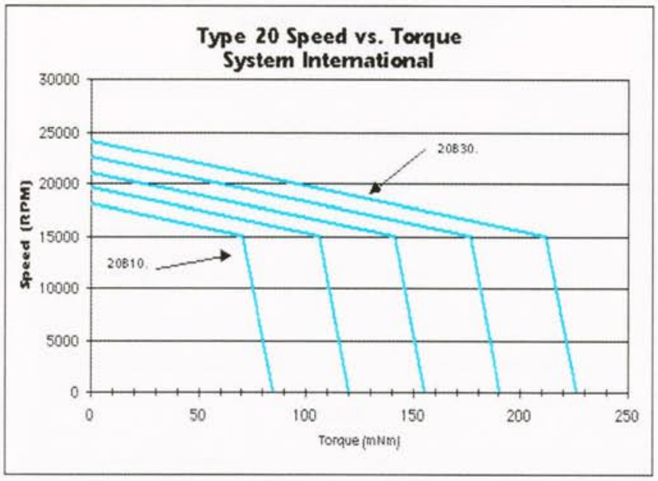
Km=4.0

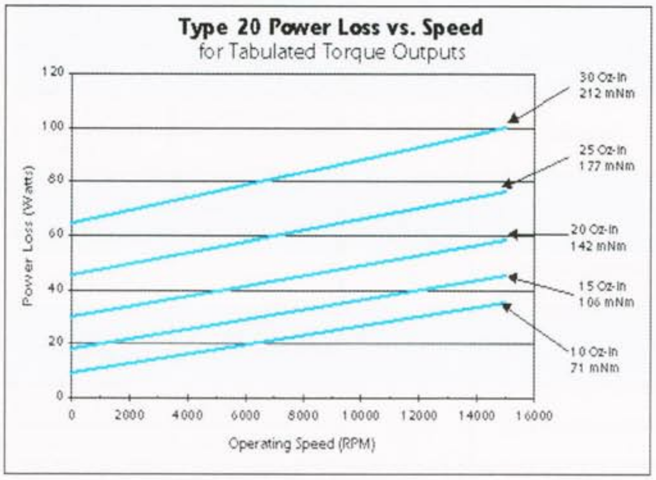
MOTOR TYPE	DATA AT MAXIMUM POWER OUTPUT						DATA AT STALL			NO LOAD SPEED	TORQUE CONSTANT	
	MOTOR TORQUE		MOTOR SPEED	POWER OUTPUT	POWER LOSS		MOTOR TORQUE		POWER LOSS		270 VOLT SUPPLY (SEE NOTE 3)	
	Oz-In	mNm	RPM	WATTS	WATTS		Oz-In	mNm	Watts	RPM	Oz-In/Amp	mNm/Amp
20B10.	10	71	15000	111	35		12	85	9	18500	19.1	135
20B15.	15	106	15000	166	45		17	120	18	19000	18.5	131
20B20.	20	141	15000	222	58		22	155	30	20000	17.4	123
20B25.	25	177	15000	277	76		27	191	45	21000	16.7	118
20B30.	30	212	15000	333	100		32	226	64	24000	15.1	107

Notes:

1. Other performance characteristics are available on request.
2. Two phase or three phase windings as required.
3. To determine torque constant at other supply voltages, multiply the tabulated torque constant by your operational voltage, then divide this figure by 270.
4. Unit operational temperature range: -80° C to +225° C. Wider temperature ranges available.
5. See pages 14 through 17 for motor temperature rise data.







TYPE 20 CONSTANTS
(@ 25° C - For Reference Only)

Parameter	Symbol	Units	Value
Inertia	J_M	Oz-In-sec²	1.0 E-04
		kgm²	7.1 E-07
Motor Constant	K_M	Oz-In/w^.5	4.0
		mNm/w^.5	28
Electrical Time Constant (L/R)	τ_e	sec	9.0 E-04
Coulomb Friction	F_C	Oz-In	0.6
		mNm	4.2
Viscous Friction	B_V	Oz-In/rpm	1.33 E-04
		mNm/rpm	9.41 E-04

TYPE 24 BRUSHLESS PERMANENT MAGNET MOTOR

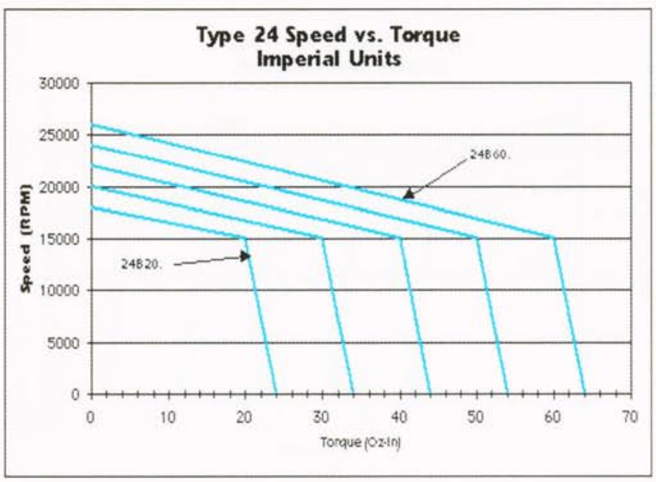
PERFORMANCE AT +25° C UNIT TEMPERATURE

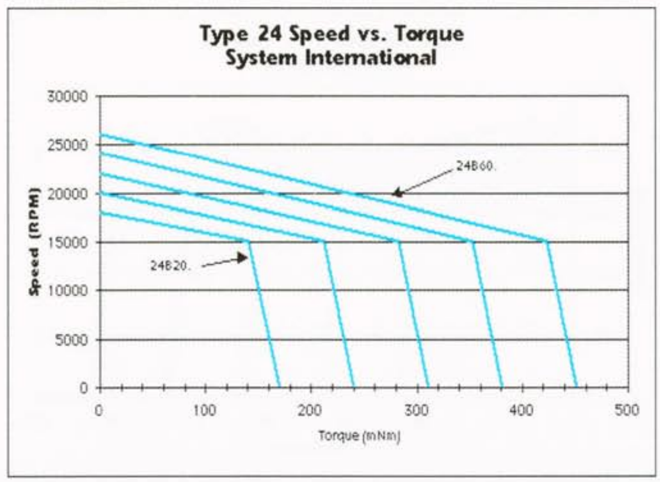
Km=6.0

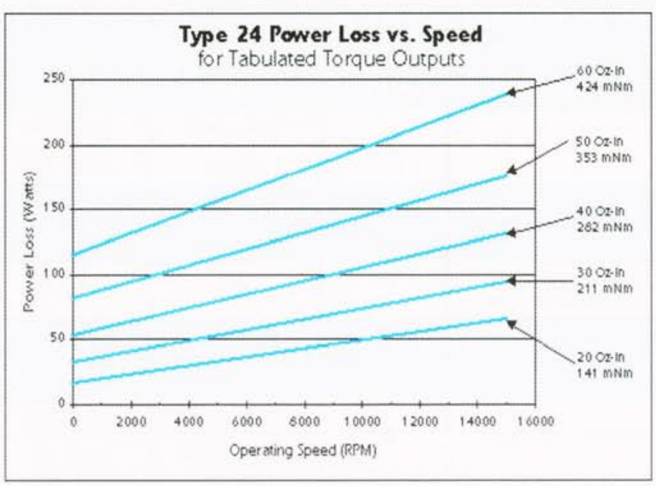
MOTOR TYPE	DATA AT MAXIMUM POWER OUTPUT					DATA AT STALL			NO LOAD SPEED	TORQUE CONSTANT	
	MOTOR TORQUE		MOTOR SPEED	POWER OUTPUT	POWER LOSS	MOTOR TORQUE		POWER LOSS		270 VOLT SUPPLY (SEE NOTE 3)	
	Oz-In	mNm	RPM	WATTS	WATTS	Oz-In	mNm	Watts	RPM	Oz-In/Amp	mNm/Amp
24B20.	20	141	15000	222	65	24	169	16	18000	19.1	135
24B30.	30	212	15000	333	94	34	240	32	19000	17.2	121
24B40.	40	282	15000	444	130	44	311	53	21000	16.1	114
24B50.	50	353	15000	555	175	54	381	81	23000	15.5	109
24B60.	60	424	15000	666	238	64	452	114	26000	13.9	98

Notes:

1. Other performance characteristics are available on request.
2. Two phase or three phase windings as required.
3. To determine torque constant at other supply voltages, multiply the tabulated torque constant by your operational voltage, then divide this figure by 270.
4. Unit operational temperature range: -80° C to +225° C. Wider temperature ranges available.
5. See pages 14 through 17 for motor temperature rise data.







TYPE 24 CONSTANTS (@ 25° C - For Reference Only)

Parameter	Symbol	Units	Value
Inertia	J_M	Oz-In-sec²	2.5 E-04
		kgm²	1.8 E-06
Motor Constant	K_M	Oz-In/w .5	6.0
		mNm/w .5	42
Electrical Time Constant (L/R)	τ_e	sec	1.2 E-03
Coulomb Friction	F_C	Oz-In	1.2
		mNm	8.5
Viscous Friction	B_V	Oz-In/rpm	2.67 E-04
		mNm/rpm	1.88 E-03

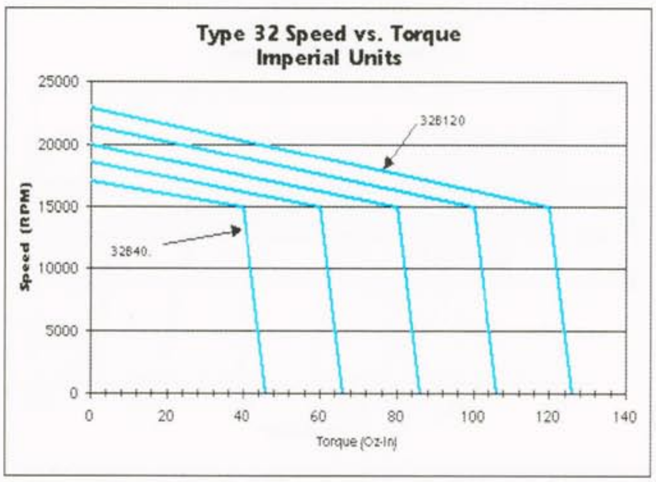
TYPE 32 BRUSHLESS PERMANENT MAGNET MOTOR

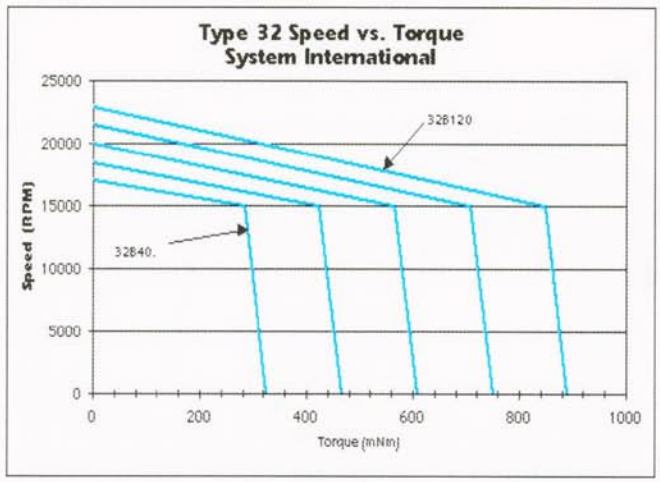
PERFORMANCE AT +25° C UNIT TEMPERATURE

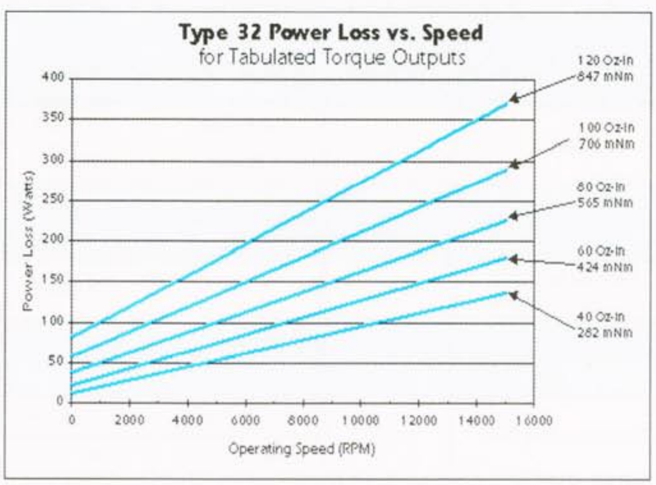
Km=14

MOTOR TYPE	DATA AT MAXIMUM POWER OUTPUT					DATA AT STALL			NO LOAD SPEED	TORQUE CONSTANT	
	MOTOR TORQUE		MOTOR SPEED	POWER OUTPUT	POWER LOSS	MOTOR TORQUE		POWER LOSS		270 VOLT SUPPLY (SEE NOTE 3)	
	Oz-In	mNm	RPM	WATTS	WATTS	Oz-In	mNm	Watts	RPM	Oz-In/Amp	mNm/Amp
32B40.	40	282	15000	444	136	46	325	11	17000	19.22	136
32B60.	60	424	15000	667	180	66	466	22	18000	18.6	131
32B80.	80	565	15000	888	225	886	607	37	19000	17.3	122
32B100	100	706	15000	1109	290	106	748	57	21000	26.5	117
32B120	120	847	15000	1331	370	126	890	81	23000	15.4	109

Notes:
1. Other performance characteristics are available on request.
2. Two phase or three phase windings as required.
3. To determine torque constant at other supply voltages, multiply the tabulated torque constant by your operational voltage, then divide this figure by 270.
4. Unit operational temperature range: -80° C to +225° C. Wider temperature ranges available.
5. See pages 14 through 17 for motor temperature rise data.







TYPE 32 CONSTANTS
(@ 25° C - For Reference Only)

Parameter	Symbol	Units	Value
Inertia	J_M	Oz-In-sec^2	9.6 E-04
		kgm^2	6.7 E-06
Motor Constant	K_M	Oz-In/w$^{.5}$	14
		mNm/w$^{.5}$	99
Electrical Time Constant (L/R)	τ_e	sec	2.0 E-03
Coulomb Friction	F_C	Oz-In	2.0
		mNm	14
Viscous Friction	B_V	Oz-In/rpm	4.0 E-04
		mNm/rpm	2.8 E-03

TYPE 40 BRUSHLESS PERMANENT MAGNET MOTOR

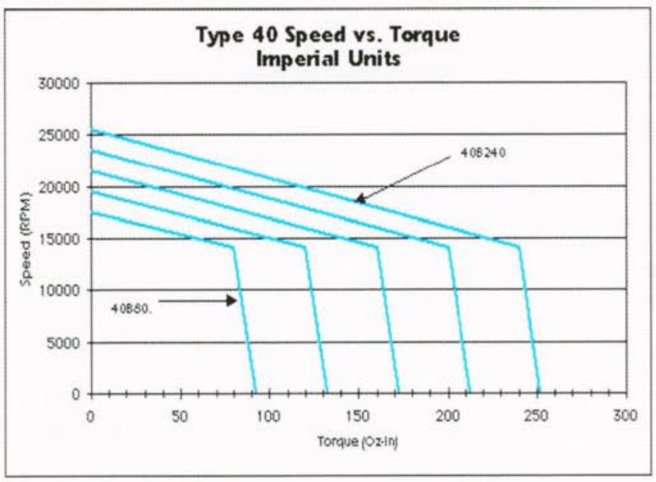
PERFORMANCE AT +25° C UNIT TEMPERATURE

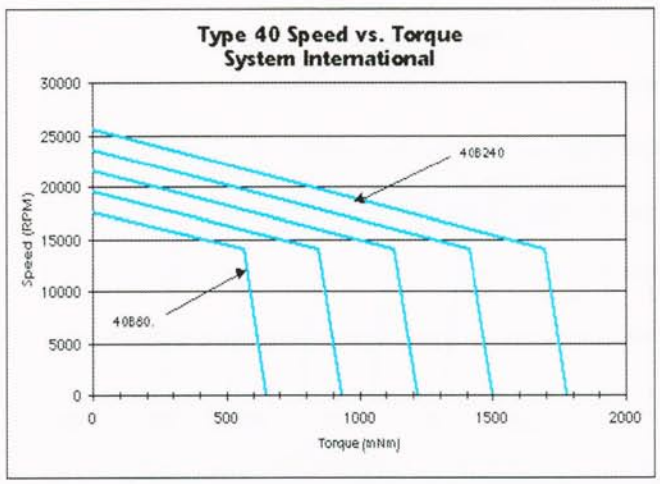
Km=21

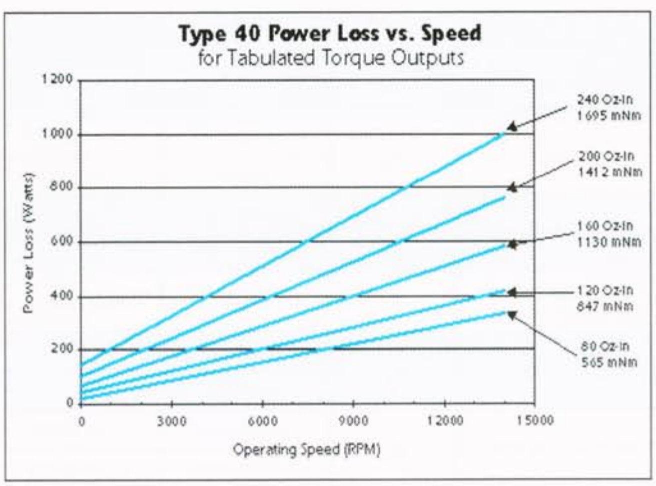
MOTOR TYPE	DATA AT MAXIMUM POWER OUTPUT					DATA AT STALL			NO LOAD SPEED	TORQUE CONSTANT	
	MOTOR TORQUE		MOTOR SPEED	POWER OUTPUT	POWER LOSS	MOTOR TORQUE		POWER LOSS		270 VOLT SUPPLY (SEE NOTE 3)	
	Oz-In	mNm	RPM	WATTS	WATTS	Oz-In	mNm	Watts	RPM	Oz-In/Amp	mNm/Amp
40B80.	80	565	14000	828	330	92	650	19	17500	20	141
40B120	120	847	14000	1242	415	132	931	39	19000	18	127
40B160	160	1130	14000	1656	580	172	1214	67	22000	16	112
40B200	200	1694	14000	2071	760	212	1496	102	23500	15	106
40B240	240	2033	14000	2485	1000	252	1779	144	25000	14	99

Notes:

1. Other performance characteristics are available on request.
2. Two phase or three phase windings as required.
3. To determine torque constant at other supply voltages, multiply the tabulated torque constant by your operational voltage, then divide this figure by 270.
4. Unit operational temperature range: -80° C to +225° C. Wider temperature ranges available.
5. See pages 14 through 17 for motor temperature rise data.







TYPE 40 CONSTANTS
(@ 25° C - For Reference Only)

Parameter	Symbol	Units	Value
Inertia	J_M	Oz-In-sec^2	1.5 E-03
		kgm^2	1.0 E-05
Motor Constant	K_M	Oz-In/w$^{.5}$	21
		mNm/w$^{.5}$	148
Electrical Time Constant (L/R)	τ_e	sec	3.0 E-03
Coulomb Friction	F_C	Oz-In	3.0
		mNm	21
Viscous Friction	B_V	Oz-In/rpm	8.57 E-04
		mNm/rpm	6.05 E-03

TYPE 48 BRUSHLESS PERMANENT MAGNET MOTOR

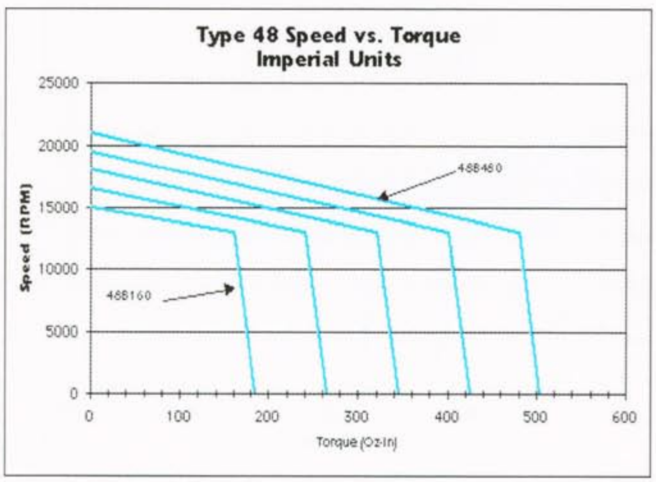
PERFORMANCE AT +25° C UNIT TEMPERATURE

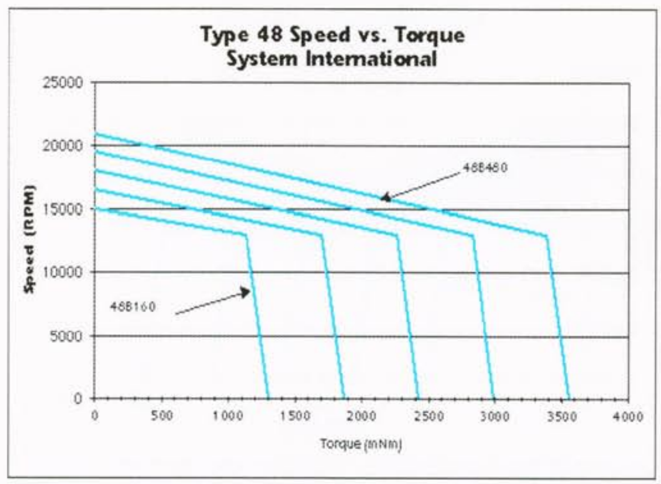
Km=32

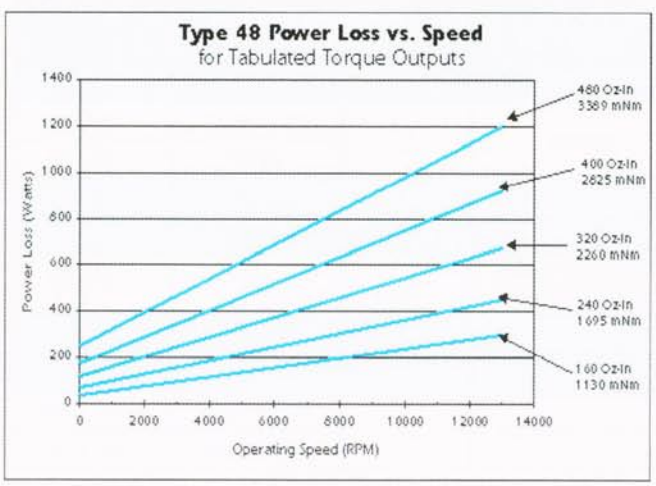
MOTOR TYPE	DATA AT MAXIMUM POWER OUTPUT					DATA AT STALL			NO LOAD SPEED	TORQUE CONSTANT	
	MOTOR TORQUE		MOTOR SPEED	POWER OUTPUT	POWER LOSS	MOTOR TORQUE		POWER LOSS		270 VOLT SUPPLY (SEE NOTE 3)	
	Oz-In	mNm	RPM	WATTS	WATTS	Oz-In	mNm	Watts	RPM	Oz-In/Amp	mNm/Amp
48B160	160	1130	13000	1538	300	184	1300	33	15000	24	169
48B240	240	1694	13000	2307	450	264	1864	68	16000	22	155
48B320	320	2260	13000	3077	670	344	2428	115	17000	21	148
48B400	400	2824	13000	3846	920	424	2993	175	19000	19	134
48B480	480	3390	13000	4615	1200	504	3558	248	21000	17	120

Notes:

1. Other performance characteristics are available on request.
2. Two phase or three phase windings as required.
3. To determine torque constant at other supply voltages, multiply the tabulated torque constant by your operational voltage, then divide this figure by 270.
4. Unit operational temperature range: -80° C to +225° C. Wider temperature ranges available.
5. See pages 14 through 17 for motor temperature rise data.







TYPE 48 CONSTANTS
(@ 25° C - For Reference Only)

Parameter	Symbol	Units	Value
Inertia	J_M	Oz-In-sec²	2.6 E-03
		kgm²	1.9 E-05
Motor Constant	K_M	Oz-In/w^.5	31
		mNm/w^.5	219
Electrical Time Constant (L/R)	τ_e	sec	4.0 E-03
Coulomb Friction	F_C	Oz-In	5.0
		mNm	35
Viscous Friction	B_V	Oz-In/rpm	1.84 E-03
		mNm/rpm	1.30 E-02

Motor Transducer Options

FIELD DIRECTORS

Description / Applications: In order to provide reliable motor rotor position information for sinusoidal or trapezoidal operation, a high frequency resolver or synchro is required. CDA Refers to these transducers as "Field Directors". CDA's Field Dierctors are constructed with the same high reliability standards as our motor modules. Our Field Directors are designed with Class H225 insulation system, and there are no intermediate couplings between the motor and position transducers. This enables direct, continuous (absolute) position feedback of the motor rotor with no lost motion or windup.

Typically, the number of poles and the number of phases of the Field Director match the pole-phase count of the motor. This allows for direct demodulation and amplification of the transducer signal to drive each phase of the motor winding. Field Directors may also be used with Resolver-to-Digital converters, allowing more options for the controller. Consequently, CDA offers a varity of Brushless Field Directors to maximize the flexibility of drive techniques, while maintaining modular design advantages.

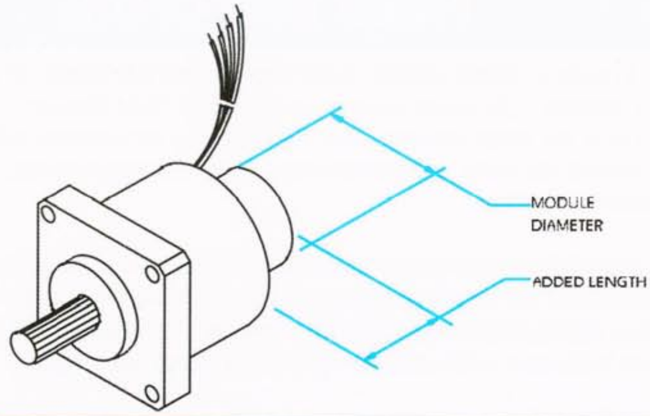
CDA strongly recommends the use of Field Directors, rather than hall sensors, for motor commutation. While we have a Hall Commutation Module, halls have temperature limitations of -40° C to +125° C, and Field Directors can withstand greater vibration, shock, and voltage transients. Additionally, with hall effect commutation, there will be a degragation in motor performance as well as increased ripple torque, due to inherent hall hysteresis. Halls can only be used for trapezoidal commutation.

	Type ——>	08FD2-2	08FD4-2	08FD4-3	08FD6-2	11FD2-2L	11FD2-2H	11FD4-3	11FD4-2	11FD6-2
Number of Phases		2	2	3	2	2	2	3	2	2
Cycles per Revolution		1x	2x	2x	3x	1x	1x	2x	2x	3x
Excitation Voltage	Vrms	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Frequency	Hz.	20,000	20,000	20,000	20,000	3,500	25,000	25,000	25,000	25,000
Untuned Current	Arms	.053	.060	0.017	.029	.077	.042	0.056	.041	.028
Tuned Current	Arms	.035	.028	0.005	.012	.045	.020	0.013	.013	.010
Output Voltage	Vrms	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Phase Shift	Degrees	-5°	+5°	-5°	+5°	+10°	0°	-5°	-5°	-2°
Output Load	kOhms	100	100	100	100	100	100	100	100	100
Transducer Diameter	Inches [mm]	0.750	0.750	0.750	0.750	1.062	1.062	1.062	1.062	1.062
Added Inertia	Oz-In-sec^2 [kg-m^2]	1.3E-05 [9.1E-08]	1.3E-05 [9.1E-08]	1.3 E-05 [9.1 E-08]	1.3E-05 [9.1E-08]	3.0 E-05 [2.4E-07]	3.0 E-05 [2.4E-07]	3.0E-05 [2.4 E-07]	3.0 E-05 [2.4E-07]	3.0 E-05 [2.4E-07]

Notes:

1. Data at +25° C unit temperature.
2. Other voltages, frequencies, and performance data available on request.
3. See General Design Data section for schematic drawings, and electrical zero alignment.
4. Redundant Field Directors may be available on request.

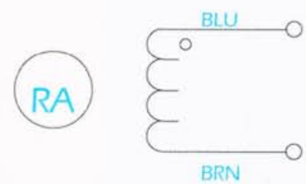
Optional Integral Components



ROTARY ACCELEROMETERS

Description / Application:
Rotary Accelerometers (RA's) provide a DC output voltage in proportion to the rotary acceleration of the motor shaft. These permanent magnet devices **require no excitation or input power**. RA's are ideal components to achieve a higher order servo stability performance characteristic. The acceleration signal may be used alone, or the voltage may be integrated to provide velocity plus acceleration information. Feeback can eliminate limited cycle oscillation in geared servo systems, and allow high forward loop gain through response shaping networks (PI OR PID), in digital or analog signal processing networks. See Page 23 for a Functional Block Diagram of a Rotary Accelerometer in a Closed Loop Servo Application

RA's may also be used in stepper motor applications, to determine the torque null "crossover" of the motor rotor during operation. This information is useful to determine optimum stepping pulse rate in high load inertia applications, or the stepper motor pulse rate may be dynamically controlled to step at the crossover point, allowing the motor to operate at the higher efficiency slew region of performance while maintaing step count. Since the permanent magnet RA provides a direct DC signal, the output may be used to determine step to step integrity of the stepper motor in critical pointing mechanisms where step integrity is paramount. See Page 22 of our Stepper Motor Engineering Rederence Data brochure for additional information on RA benefits with stepper motors.



Schematic

	TYPE —>	03ACC	05ACC
Output Voltage	V/100kRAD/sec^2	0.60	2.1
Output Load	Ohms	50,000	50,000
Added Length	Inches [mm]	0.575 [14.6]	0.575 [14.6]
Accelerometer Diameter	Inches [mm]	0.750 [19.1]	1.250 [31.8]
Added Inertia	Oz-In-sec^2 [kg-m^2]	2.8 E-06 [2.0E-08]	5.5 E-05 [3.8 E-07]
Added Weight	Oz [kg]	0.750 [0.021]	2.0 [0.056]

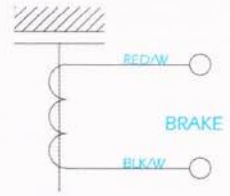
Notes:
1. See Transducer Application Data Catalog for additional accelerometer information.
2. Accelerometers may be sold as a stand alone item, or may be integrally mounted to a motor assembly as shown above.
3. Tabulated performance at +25° C.

FRICTION BRAKES

Description / Application:

Friction Brakes are integrally mounted to the motor shaft with no intermediate couplings. These devices provide holding torque when the DC power is off, and allow the shaft to rotate freely when the DC voltage is applied to the brake winding.

An advantage of CDA InterCorp's friction brake design, is our ability to calibrate the braking torque within a specified range, up to the maximum rated torque for each frame size. Our friction brake materials are carefully selected to provide reliable performance over the life of the actuator.



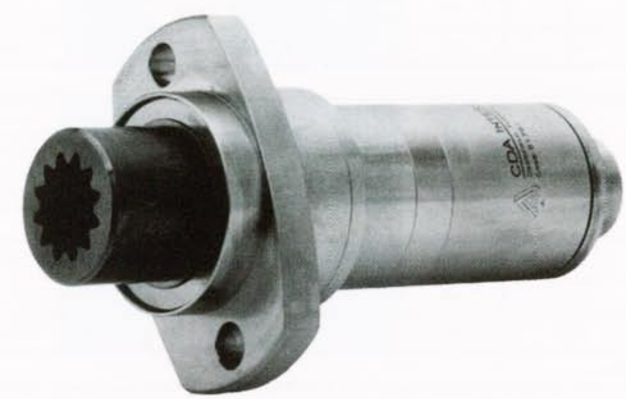
Schematic

	TYPE —>	08F	11F	15F	25F
Excitation Voltage	Volts DC	28	28	28	28
Current at 28 Volts DC	Amps DC	0.165	0.165	0.265	0.535
Pull In Voltage	Volts DC	18	18	18	18
Drop Out Voltage	Volts DC	1.0	1.0	1.0	1.0
Holding Torque	Oz-In [Nmm]	5.0 [35]	15 [105]	50 [350]	300 [2100]
Added Length	Inches [mm]	0.784 [19.9]	0.800 [20.3]	1.175 [28.8]	1.500 [38.1]
Brake Diameter	Inches [mm]	0.750 [19.1]	1.062 [27.0]	1.437 [36.5]	2.500 [63.5]
Added Inertia	Oz-In-sec^2 [kg-m^2]	2.0 E-06 [1.4 E-08]	6.6 E-06 [4.7 E-08]	2.4 E-05 [1.7 E-07]	2.2 E-04 [1.6 E-06]
Added Weight	Oz [kg]	1.0 [0.028]	2.0 [0.057]	6.0 [0.170]	24 [0.682]
Accelerometer-Brake Added Length	Inches [mm]	1.329 [33.8]	1.475 [37.5]	N/A	N/A
Accelerometer- Brake Added Inertia	Oz-In-sec^2 [kg-m^2]	5.0 E-06 [3.5 E-08]	6.1 E-05 [4.3 E-08]	N/A	N/A
Accelerometer-Brake Added Weight	Oz [kg]	2.3 [0.065]	4.5 [0.128]	N/A	N/A

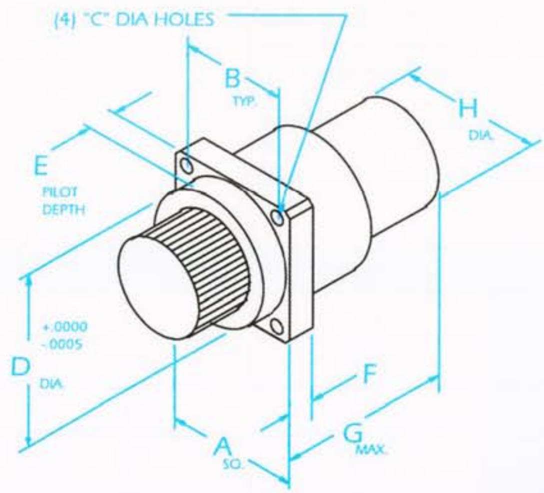
Notes:
1. Other voltages, torques, and performance data available on request.
2. Brakes may be sold as a stand alone item, or may be integrally mounted to a motor assembly, as shown on page 12.
3. Listed performance at +25° C.

Integral Component Notes:

1. Velocity sensors, and high accuracy motor rotor position sensors are available on request.
2. Refer to CDA's Rotary Transducer Engineering Reference Data brochure for additional transducer options.
3. Redundant transducer, and multiple feedback sensors available.
4. Contact CDA's engineering department for additional information.



Motor - Gearhead Composite Dimensions and Performance



TYPE		RATIOS		Imperial Dimensions (In Inches)								WEIGHT	TEMP. COEF.
GEARHEAD	MOTOR	FROM	TO	A	B	C	D	E	F	G	H	Oz	(°C/Watt Loss)
AO	12	5	10	0.750	0.620	0.081	0.6875	0.156	0.188	1.765	0.750	2.1	7.0
AA	12	25	100	0.750	0.620	0.081	0.6875	0.156	0.188	2.325	0.750	3.0	7.0
CA	12	21	100	1.000	0.828	0.110	0.9375	0.188	0.250	2.402	0.750	4.2	6.9
AO	16	5	10	1.000	0.828	0.110	0.6875	0.156	0.250	1.981	1.000	4.0	4.5
CA	16	18	100	1.000	0.828	0.110	0.9375	0.188	0.250	2.617	1.000	6.5	6.2
DC	16	20	107	1.250	1.030	0.129	1.1875	0.250	0.250	2.707	1.000	8.5	6.1
CO	20	4	10	1.250	1.030	0.129	0.9375	0.188	0.250	2.338	1.250	7.5	3.0
DC	20	26	114	1.250	1.030	0.129	1.1875	0.250	0.250	2.988	1.250	12	4.5
FD	20	20	114	1.500	1.250	0.149	1.4375	0.313	0.313	3.108	1.250	15	4.5
CO	24	5	10	1.500	1.250	0.149	0.9375	0.188	0.313	2.663	1.500	13	2.3
DC	24	26	114	1.500	1.250	0.149	1.1875	0.250	0.313	3.227	1.500	17	2.5
FD	24	20	114	1.500	1.250	0.149	1.4375	0.313	0.313	3.397	1.500	18	4.5
HD	24	22	107	2.000	1.670	0.177	1.8750	0.375	0.375	3.592	1.500	27	4.5
D0	32	4	11	2.000	1.670	0.177	1.1875	0.250	0.375	2.882	2.000	26	1.7
FD	32	20	114	2.000	1.670	0.177	1.4375	0.313	0.375	3.743	2.000	31	1.7
HD	32	22	107	2.000	1.670	0.177	1.8750	0.375	0.375	3.938	2.000	40	2.5
JF	32	30	114	2.000	2.062	0.206	2.4375	0.437	0.500	4.194	2.000	66	2.4
FO	40	5	10	2,500	2.062	0.206	1.4375	0.313	0.500	3.456	2.500	47	1.3
HD	40	22	107	2.500	2.062	0.206	1.8750	0.375	0.500	4.182	2.500	61	1.4
JF	40	20	70	2.500	2.062	0.206	2.4375	0.437	0.500	4.461	2.500	87	1.9
H0	48	5	10	3.000	3.000	0.266	1.8750	0.375	0.750	3.815	3.000	74	0.9
JF	48	20	70	3.000	3.000	0.266	2.4375	0.437	0.750	4.790	3.000	107	1.0
MH	48	18	61	3.000	3.000	0.266	2.9687	0.500	0.750	5.078	3.000	125	1.7

Notes:
1. Rate gearhead performance by the first letter of "Gearhead Type" tabulated. See the following page.
2. Other gear ratios and mounting configurations are available on request.
3. Overall Gearing efficiency = 90%.
4. Temperature coefficient is in °C per watt loss, while mounted on a 6" x 6" x 0.25" black aluminum plate.
5. Dry film lunbrication for cryogenic temperature operation available on request. Contact CDA's engineering department for information.

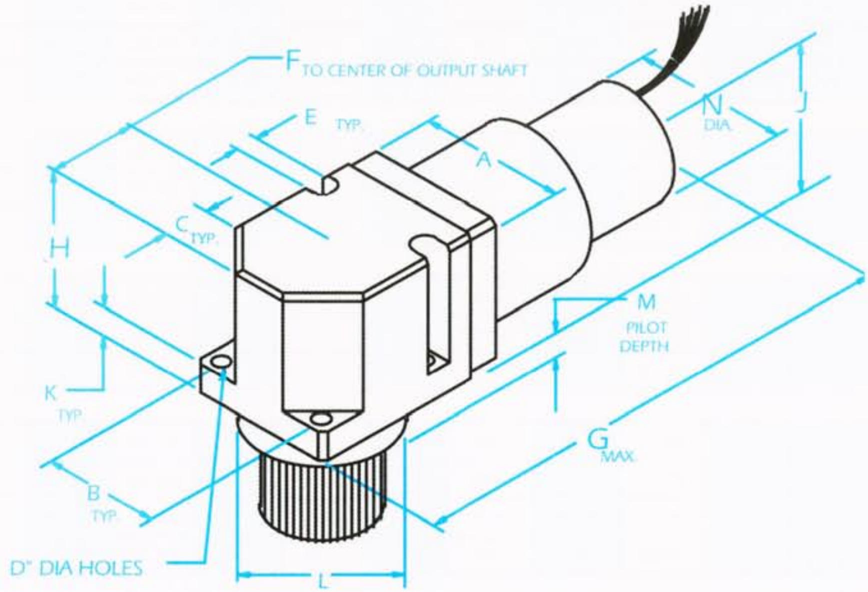
TYPE		RATIOS		System International Dimensions (In mm)								WEIGHT	TEMP.COEF.
GEARHEAD	MOTOR	FROM	TO	A	B	C	D	E	F	G	H	kg	(°C/Watt Loss)
AO	12	5	10	19.05	15.75	2.06	17.463	3.96	4.78	44.84	19.05	0.060	7.0
AA	12	25	100	19.05	15.75	2.06	17.463	3.96	4.78	59.06	19.05	0.085	7.0
CA	12	21	100	25.40	21.03	2.80	23.813	4.78	6.35	57.02	19.05	0.119	6.9
AO	16	5	10	25.40	21.03	2.80	23.813	3.96	6.35	50.32	25.40	0.114	4.5
CA	16	18	100	25.40	21.03	2.80	23.813	4.78	6.35	66.48	25.40	0.185	6.2
DC	16	20	107	31.75	26.26	3.30	30.163	6.35	6.35	68.76	25.40	0.241	6.1
CO	20	4	10	31.75	26.16	3.30	23.813	4.78	6.35	59.39	31.75	0.213	3.0
DC	20	26	114	31.75	26.16	3.30	30.163	6.35	6.35	75.90	31.75	0.341	4.5
FD	20	20	114	38.10	31.75	3.80	36.513	7.95	7.95	78.95	31.75	0.426	4.5
CO	24	5	10	38.10	31.75	3.80	23.813	4.78	7.95	67.64	38.10	0.369	2.3
DC	24	26	114	38.10	31.75	3.80	30.163	6.35	7.95	83.54	38.10	0.423	2.5
FD	24	20	114	38.10	31.75	3.80	36.513	7.95	7.95	86.29	38.10	0.511	4.5
HD	24	22	107	50.80	42.42	4.50	49.213	9.53	9.53	91.24	38.10	0.767	4.5
D0	32	4	11	50.80	42.42	4.50	30.163	6.35	9.53	73.44	50.80	0.739	1.7
FD	32	20	114	50.80	42.42	4.50	36.513	7.95	9.53	95.08	50.80	0.881	1.7
HD	32	22	107	50.80	42.42	4.50	49.213	9.53	9.53	100.0	50.80	1.14	2.5
JF	32	20	70	63.50	52.37	5.23	61.913	11.10	12.70	106.6	50.80	1.88	2.4
FO	40	5	10	63.50	52.37	5.23	36.513	7.95	12.70	87.78	63.50	1.33	1.3
HD	40	22	107	63.50	52.37	5.23	49.213	9.53	12.70	106.2	63.30	1.73	1.4
JF	40	20	70	63.50	52.37	5.23	61.913	11.10	12.70	113.3	63.50	2.45	1.9
H0	48	5	10	76.20	63.50	6.76	49.213	9.53	19.05	96.90	76.20	2.10	0.9
JF	48	20	70	76.20	63.50	6.76	61.913	11.10	19.05	121.7	76.20	3.09	1.0
MH	48	18	61	76.20	63.50	6.76	75.405	12.70	19.05	129.0	76.20	3.55	1.7

Notes:
1. Rate gearhead performance by the first letter of "Gearhead Type" tabulated. See data below.
2. Other gear ratios and mounting configurations are available on request.
3. Overall Gearing efficiency = 90%.
4. Temperature coefficient is in °C per watt loss, while mounted on a 150 x 150 x 6 mm lack aluminum plate.
5. Dry film lunbrication for cryogenic temperature operation available on request. Contact CDA's engineering department for information.

GEARHEAD RATINGS

Gearhead Type	"A" Basic Size		Torque Capacity				Torsional Spring Constant	
			Continuous		Intermittent			
	Inches	mm	Lb-In	Nm	Lb-In	Nm	Lb-In/Rad	Nm/Rad
A	0.750	19.05	7.2	0.81	18	2.03	6.0 E+03	6.8 E+02
C	1.000	25.40	48	5.4	84	9.5	1.6 E+04	1.8 E+03
D	1.250	31.75	84	9.5	168	19	2.5 E+04	2.8 E+03
F	1.500	38.10	168	19	456	52	4.2 E+04	4.7 E+03
H	2.000	50.80	300	34	744	84	7.4 E+04	8.4 E+03
J	2.500	63.50	744	84	1500	170	1.8 E+05	2.0 E+04
M	3.000	76.20	1200	136	3000	340	6.0 E+05	6.8 E+04
N	4.000	101.60	3600	407	6900	780	3.6 E+06	4.1 E+05

Motor / Right Angle Gearhead Composite Dimensions and Performance



IMPERIAL UNITS - DIMENSIONS IN INCHES																		
TYPE		RATIOS (SEE NOTE 2)		A	B	C	D	E	F	G	H	J	K	L	M	N	WEIGHT	TEMP. COEF.
GEARHEAD	MOTOR	FROM	TO														OZ.	°C/WATT LOSS
ARA	12	46	187	0.750	0.620	0.229	0.081	0.140	0.375	2.711	0.833	0.436	0.188	0.7350	0.250	0.750	4.3	7.1
CRA	12	46	187	1.000	0.828	0.300	0.110	0.194	0.500	3.045	1.170	0.594	0.250	0.9750	0.313	0.750	8.0	7.0
CRA	16	46	187	1.000	0.828	0.300	0.110	0.194	0.500	3.261	1.170	0.594	0.250	0.9750	0.313	1.000	10	6.2
DRC	16	46	198	1.275	1.030	0.400	0.129	0.219	0.637	3.424	1.287	0.622	0.250	1.2500	0.313	1.000	16	6.1
DRC	20	16	198	1.275	1.030	0.400	0.129	0.219	0.637	3.813	1.287	0.622	0.250	1.2500	0.313	1.250	17	5.2
FRD	20	42	212	1.525	1.250	0.440	0.149	0.272	0.763	4.174	1.540	0.790	0.375	1.5000	0.375	1.250	25	5.0
HRD	20	45	200	2.000	1.670	0.585	0.177	0.316	1.000	4.584	2.062	1.062	0.375	1.9750	0.475	1.250	40	4.7
FRD	24	42	212	1.525	1.250	0.440	0.149	0.272	0.763	4.436	1.540	0.790	0.375	1.5000	0.375	1.500	28	3.0
HRD	24	45	200	2.000	1.670	0.585	0.177	0.316	1.000	4.873	2.062	1.062	0.375	1.9750	0.475	1.500	43	2.9
HRD	32	45	200	2.000	1.670	0.585	0.177	0.316	1.000	5.153	2.062	1.062	0.375	1.9750	0.475	2.000	52	2.3
JRF	32	30	129	2.500	2.060	0.750	0.206	0.430	1.250	5.921	2.562	1.312	0.500	2.4750	0.562	2.000	85	2.3
JRF	40	30	129	2.500	2.060	0.750	0.206	0.430	1.250	6.331	2.562	1.312	0.500	2.4750	0.562	2.500	110	2.0
MRH	40	33	130	3.313	2.750	1.062	0.265	0.600	1.656	7.142	3.188	1.688	0.687	3.2500	0.750	2.500	160	2.0
MRH	48	33	130	3.313	2.750	1.062	0.265	0.600	1.656	7.741	3.188	1.688	0.687	3.2500	0.750	3.000	192	1.7

Notes:
1. Rate gearhead performance by th e"Gearhead Type" tabulated. See following page.
2. Other gear ratios and mounting configurations are avaiioable on request.
3. Overall gearing efficiency = 85%.
4. Temperature coefficient is in °C per watt loss, while ounted on a 6" x 6" x 0.25" black aluminum plate.
5. Dry film lunbrication for cryogenic temperature operation available on request. Contact CDA's engineering department for information.
6. "J" dimension is from mounting surface to the centerline of the motor body diameter.

SYSTEM INTERNATIONAL - (DIMENSIONS IN mm)

TYPE		RATIOS (SEE NOTE 2)		A	B	C	D	E	F	G	H	J	K	L	M	N	WEIGHT	TEMP. COEF.
GEARHEAD	MOTOR	FROM	TO														kg	°C/WATT LOSS
ARA	12	46	187	19.05	15.75	5.82	2.06	3.56	9.35	68.86	21.16	11.07	4.78	18.669	6.35	19.05	.122	7.1
CRA	12	46	187	25.4	21.03	7.62	2.79	4.93	12.70	77.34	29.72	15.09	6.35	24.765	7.95	19.05	.227	7.0
CRA	16	46	187	25.4	21.03	7.62	2.79	4.93	12.70	82.82	29.72	15.09	6.35	24.765	7.95	25.40	.284	6.2
DRC	16	46	198	32.39	26.16	10.16	3.28	5.56	16.18	86.97	32.69	16.81	6.35	31.750	7.95	25.40	.455	6.1
DRC	20	46	198	32.39	26.16	10.16	3.28	5.56	16.18	96.85	32.69	16.81	6.35	31.750	7.95	31.75	.483	5.2
FRD	20	42	212	38.73	31.75	11.18	3.78	6.91	19.38	105.3	39.12	20.07	9.53	38.100	9.53	31.75	.710	5.0
HRD	20	45	200	50.80	42.42	14.86	4.50	8.03	25.40	116.4	52.37	26.97	9.53	50.165	12.07	31.75	1.14	4.7
FRD	24	42	212	38.73	31.75	11.18	3.78	6.91	19.38	112.7	39.12	20.07	9.53	38.100	9.53	38.10	.795	3.0
HRD	24	45	200	50.80	42.42	14.86	4.50	8.03	25.40	123.8	52.37	26.97	9.53	50.165	12.07	38.10	1.22	2.9
HRD	32	45	200	50.80	42.42	14.86	4.50	8.03	25.40	130.9	52.37	26.97	9.53	50.165	12.07	50.80	1.48	2.3
JRF	32	30	129	63.50	52.32	19.05	5.23	10.92	31.75	150.4	65.07	33.32	12.70	62.865	14.27	50.80	2.41	2.3
JRF	40	30	129	63.50	52.32	19.05	5.23	10.92	31.75	160.8	65.07	33.32	12.70	62.865	14.27	63.50	2.84	2.0
MRH	40	33	130	84.15	69.85	26.97	6.73	15.24	42.06	181.4	80.97	42.87	17.44	82.550	19.05	63.50	4,55	2.0
MRH	48	33	130	84.15	69.85	26.97	6.73	15.24	42.06	196.6	80.97	42.87	17.44	82.550	19.05	76.20	5.50	1.7

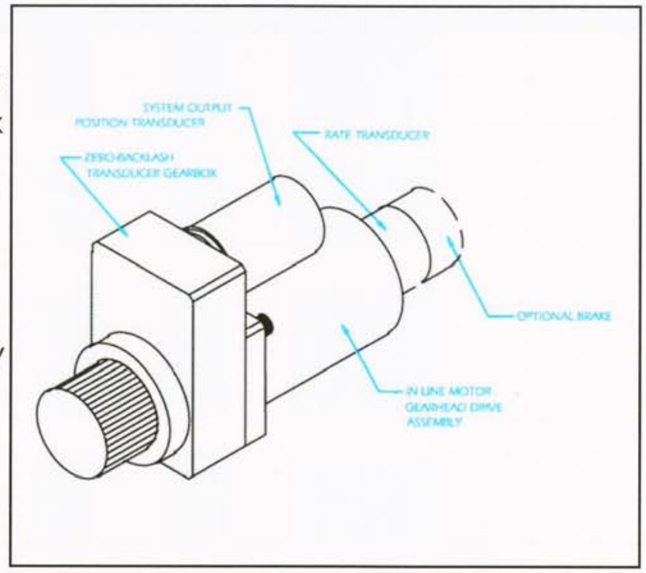
Notes:
1. Rate gearhead performance by the "Gearhead Type" tabulated. See performance below.
2. Other gear ratios and mounting configurations are available on request.
3. Overall gearing efficiency = 85%.
4. Temperature coefficient is in °C per watt loss, while ounted on a 150 x 150 x 6 mm black aluminum plate.
5. Dry film lunbrication for cryogenic temperature operation available on request. Contact CDA's engineering department for information.
6. "J" dimension is from mounting surface to the centerline of the motor body diameter.

RIGHT ANGLE GEARHEAD RATINGS

Gearhead Type	"A" Basic Size		Torque Capacity				Torsional Spring Constant	
			Continuous		Intermittent			
	Inches	mm	Lb-In	Nm	Lb-In	Nm	Lb-In/Rad	Nm/Rad
AR_	0.750	19.05	7.2	0.81	18	2.03	6.0 E+03	6.8 E+02
CR_	1.000	25.40	48	5.4	84	9.5	1.6 E+04	1.8 E+03
DR_	1.275	32.39	84	9.5	168	19	2.5 E+04	2.8 E+03
FR_	1.525	38.73	168	19	456	52	4.2 E+04	4.7 E+03
HR_	2.000	50.80	300	34	744	84	7.4 E+04	8.4 E+03
JR_	2.500	63.50	744	84	1500	170	1.8 E+05	2.0 E+04
MR_	3.500	88.90	1200	136	3000	340	6.0 E+05	6.8 E+04

Rotary Actuators with High Accuracy Position Feed\back

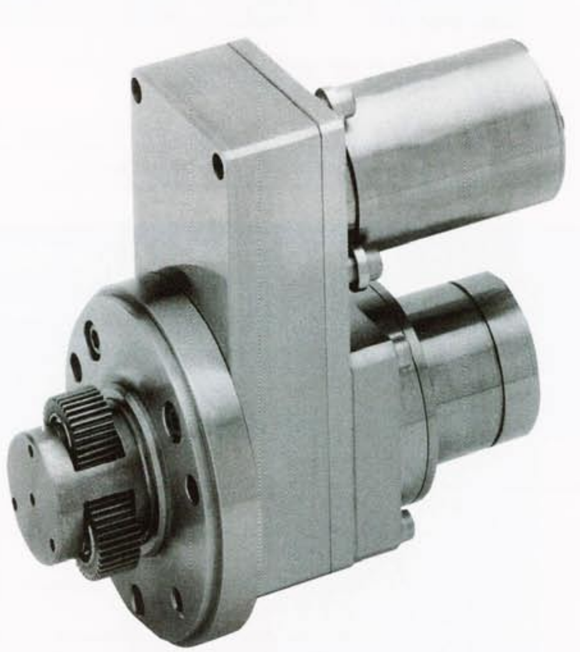
CDA InterCorp offers a line of high reliability position feedback gearboxes which adapt directly to our in line or right angle rotary actuators. These rugged devices incorporate output or load position feedback within a single package solution. The high accuracy position feedback transducer gearboxes also offer wide operating temperature range, and compact size.



CDA has the ability to incorporate high speed rotary transducers, such as resolvers or accelerometers, which are integrally mounted to the motor. This information, coupled with the load position feedback, may provide enhanced motor performance, or "multiple speed" position information.

The flexibility of CDA's standard modular design concept allows the incorporation of multifunction controllable drive actuators, with application proven ruggedness and reliability. These actuator packages offer unlimited design features within standard inventoried piece parts and design concepts.

Features:



* Zero-backlash precision gearing to high accuracy position transducer.

* -80° C to +225° C operating temperature range (wet lube).

* System load position sensing and rate matching through zero-backlash gearing

* Three arc-minute brushless resolver availability.

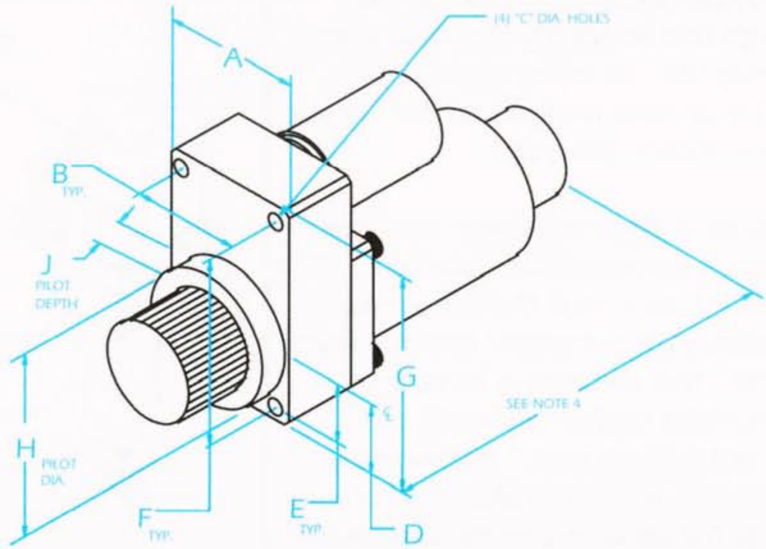
* Multiple sensor capability.

* Optional integral high speed rotary transducer.

* Optional integral brake.

* Refer to CDA InterCorp's Rotary Transducer Application Data catalog for sensor options and

Rotary Actuators with High Accuracy Position Feedback

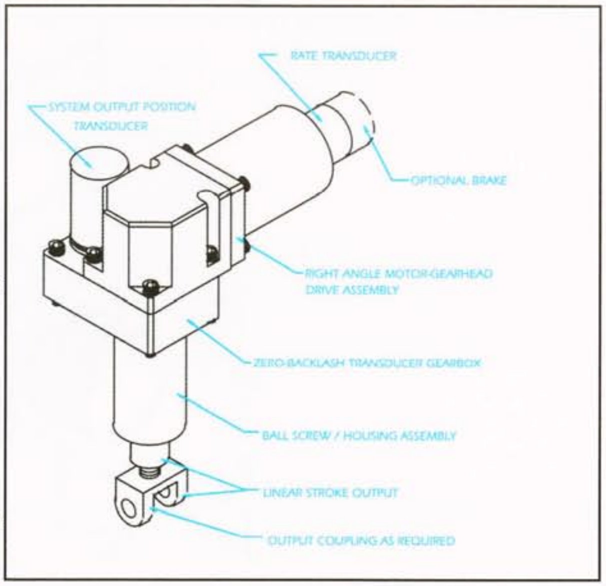


Imperial Units (In Inches)									
Gearbox Type	A	B	C	D	E	F	G	H	J
AT	0.750	0.620	0.081	0.375	0.310	1.937	2.110	0.6875	0.125
CT	1.000	0.828	0.113	0.500	0.414	1.953	2.125	0.9375	0.125
DT	1.250	1.030	0.140	0.625	0.515	1.864	2.062	1.1875	0.156
FT	1.500	1.250	0.150	0.750	0.625	2.125	2.375	1.4375	0.250
HT	2.000	1.670	0.175	1.000	0.835	2.686	3.016	1.8750	0.250
JT	2.500	2.062	0.210	1.250	1.031	3.062	3.500	2.4375	0.250

System International (In mm)									
Gearbox Type	A	B	C	D	E	F	G	H	J
AT	19.05	15.75	2.06	9.53	7.87	49.20	53.59	17.463	3.18
CT	25.40	21.03	2.87	12.70	10.52	49.61	53.98	23.813	3.18
DT	31.75	26.16	3.36	15.88	13.08	47.35	52.37	30.163	3.96
FT	38.10	31.75	3.81	19.05	15.86	53.98	60.33	36.513	6.35
HT	50.80	42.42	4.45	25.20	21.21	68.22	76.61	47.625	6.35
JT	63.50	52.37	5.27	31.75	26.19	77.77	88.90	61.913	6.35

Linear Actuators

CDA InterCorp can provide linear actuation to our rotary actuators through the adaptation of ball screw or ACME lead screw outputs. In many applications, the linear screw may be ground integral to the output cage of the high torque rotary geartrain.



CDA may also incorporate a high accuracy rotary position transducer through a zero-backlash gearbox. This transducer may be geared such that the full stroke of the linear output translates to just under one full revolution of the transducer. This method is inherently more accurate, and provides higher reliability than using LVDT's or linear potentiometers. Additionally, high speed rate transducers and/or brakes may also be incorporated to provide full motion control capabilities in a single actuator package.

CDA has extended our modular design concepts for our rotary components to establish the same high standards for our linear actuators. These assemblies are extremely flexible in accommodating wide variations of linear stroke, force, and mounting configurations, within these standards. The utilization of rotary actuators with our standard linear design results in unparalleled reliability and performance. Most importantly, custom configurations and performance requirements can be accomplished with "off-the-shelf-technology". Fast prototype lead times and historical reliability and performance databases are also inherent in this design concept.

FEATURES:

* Optional position feedback through zero-backlash gearing.

* -80° C to +225° C operating temperature range (wet lube).

* High Accuracy Brushless Resolver, Synchro, or RVDT position transducer options.

* In-line or right angle power drive options.

* Optional integral high speed transducer.

* Optional integral Friction or Detent Brake.

* High power output capacity.

* High thrust / pull force capacity.

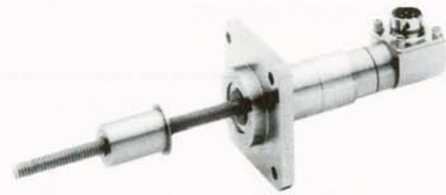
CDA InterCorp may provide many mounting configurations for our linear actuators, while maintaining standard modules, materials, processes, and assembly techniques. The two basic mounting requirements are for the stationary mechanical ground, and the linear stroke output configuration. The mechanical ground may be flange mounted, as shown here to the right, or we may provide double ended clevis mounting, with some options shown below.

MALE CLEVIS FEMALE CLEVIS ROD END

Shown to the left, are three options for the stroke output and / or mechanical ground mounting configurations. Male or female threads may also be provided for customer interface for either end of the actuator. The drawing above shows a male thread provided on the linear stroke output.

Other mechanical options include:

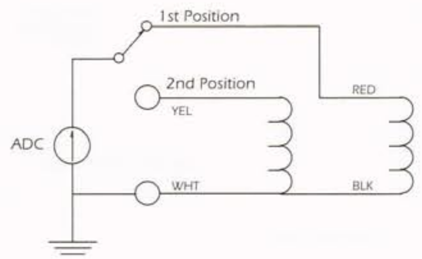
* Anti-rotation provision
* Ball screw with nut only
* ACME Lead Screw with nut only
* In-line, right angle, or "U" power drive configuration
* Hard mounted connector



More options are shown in these photos. All of these custom end item configurations, start with our standard motors, gearboxes, and thrust adapters. These mechanical "embellishments" allow flexibility for integration and installation of our standard products, in a unique system application.

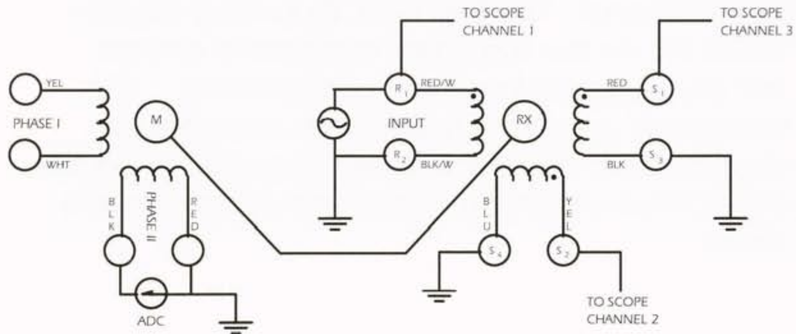
BRUSHLESS MOTOR PHASING DIAGRAMS

TWO PHASE SINUSOIDAL PHASING



CCW ROTATION, VIEWING SHAFT

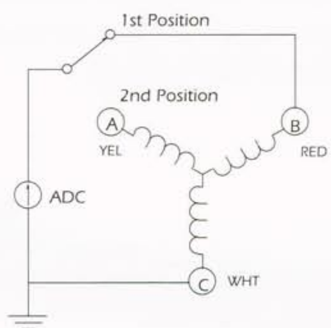
MOTOR PHASING



Notes:
1. Excite motor as shown with fixed DC current
2. Field Director Phasing and S_{2-4} Null required with motor excited as shown.
3. Viewing shaft output, S_{2-4} positive for CW rotation form E-Z shown.

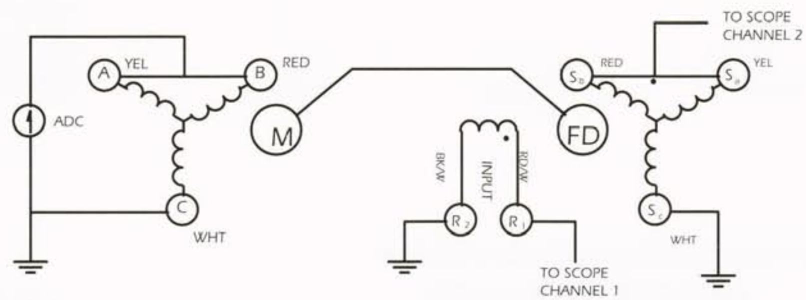
FIELD DIRECTOR PHASING

THREE PHASE SINUSOIDAL PHASING



CW ROTATION, VIEWING SHAFT

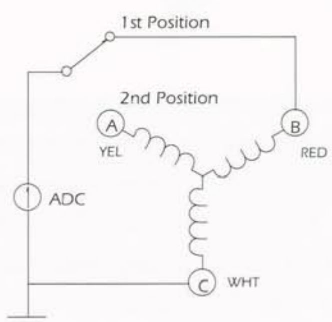
MOTOR PHASING



Notes:
1. Excite motor as shown with fixed DC current
2. Field Director Phasing and S_{ab-c} Null required with motor excited as shown.
3. Viewing shaft output, S_{ab-c} positive for CCW rotation form E-Z shown.

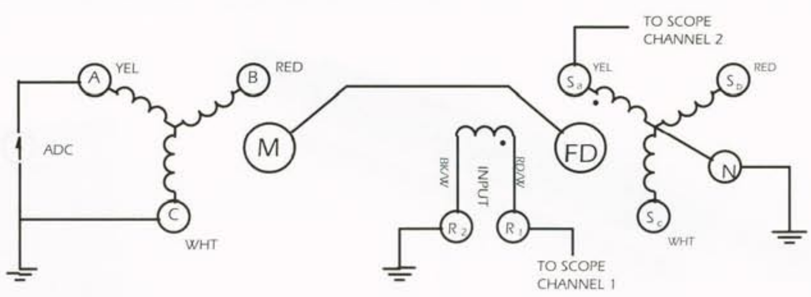
FIELD DIRECTOR PHASING

THREE PHASE TRAPEZOIDAL PHASING



CW ROTATION, VIEWING SHAFT

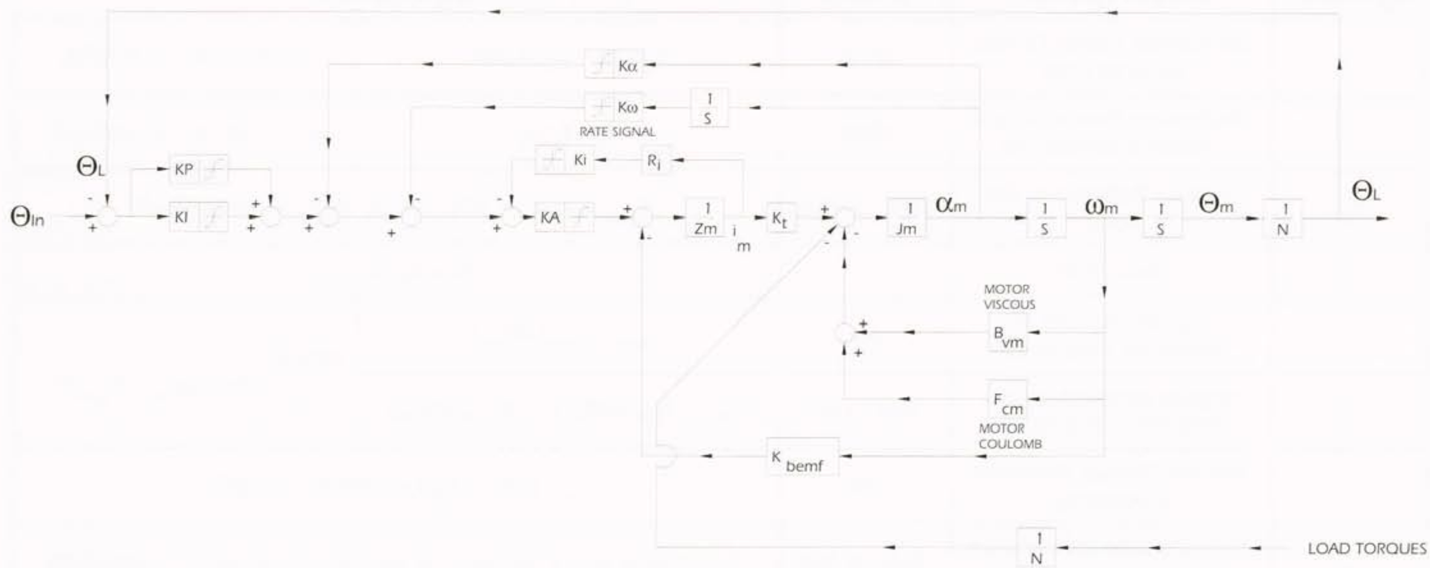
MOTOR PHASING



Notes:
1. Excite motor as shown with fixed DC current
2. Field Director Phasing and S_{a-n} Null required with motor excited as shown.
3. Viewing shaft output, S_{a-n} positive for CCW rotation form E-Z shown.

FIELD DIRECTOR PHASING

Functional Block Diagram
Brushless Permanent Magnet Servo Motor
with Rotary Accelerometer Feedback
and Integrated Velocity Damping



Where:

K_P = Proportional Gain of Error Signal
K_α = Acceleration Signal Gain
K_i = Current Feedback Gain
R_i = Current Sense Resistor
K_t = Motor Torque Constant
B_{VM} = Motor Viscous Damping
K_{bemf} = Motor Back emf Constant
i_M = Motor Current
α_M = Motor Acceleration
θ_M = Motor Position
θ_{IN} = Load Position Command

K_I = Integration Gain of Error Signal
K_ω = Velocity Signal Gain
K_A = Power Amplifier Gain
Z_M = Motor Impedance (Ro+jwL)
J_M = Motor Inertia
F_{CM} = Motor Coulomb Friction
s = Laplace Operator
N = Gearhead Ratio
ω_M = Motor Velocity
θ_L = Load Position
J_L = Load Inertia

The Rotary Accelerometer (RA) is an extremely useful component in high performance and / or high load inertia servo actuator systems. Since the RA requires no excitation or demodulation, the DC output may be directly Op-Amp integrated for an angular rate damping signal of the motor. This information, along with the angular acceleration signal provides tremendous flexibility in contouring the system response, and controlling the transfer function.

The Rotary Accelerometer can make the motor rotor inertia electronically "look" larger or smaller through this feedback technique. This electronic technique is like adding a variable electronic "flywheel" to the system, and provides a higher order effect, as compared to electronic damping through tachometer feedback. This may provide high forward loop gain, while maintaining a stable servo system. The electronic flywheel may be controlled to provide these characteristics dynamically in the system. Other advantages include acceleration control, and disturbance attenuation. Contact CDA InterCorp's engineering department for additional information on RA benefits in servo systems.

Actuation Performance Equations

Mechanical Output Equations

Symbol	Description	Units	Equation	
P_o	Mechanical Power Output Imperial Units	Watts	$P_o = (T_L * \omega_L)/1352$	(T_L in Oz-In, ω_L in RPM)
P_o	Mechanical Power Output System International	Watts	$P_o = T_L * \omega_L$	(T_L in Nm, ω_L in Rad/sec)
T_L	Torques Referred to the Load	Lb-In or Nm	$T_{L\,max} = (J_L\alpha_L + J_m N^2\alpha_L + B_L\omega_L + K_L\theta_L + F_C + Mg_L)max$	
N	Gear Ratio	-	$N = \omega_M / \omega_{L\,max}$	
f	Angular Velocity for Response Frequency	Hz	$\omega_{Lmax} = \theta_{Lmax}(2\pi f_{max})$	Where: $f_{max} = (2\pi)^{-1}(\alpha_{Lmax}/\theta_{Lmax})^{0.5}$
α_L	Angular Acceleration for Response Frequency	Rad / sec²	$\alpha_{Lmax} = \theta_{Lmax}(2\pi f_{max})^2 = \omega_{Lmax}(2\pi f_{max})$	
f_n	Natural Circular Resonant Frequency	Hz	$f_n = (2\pi)^{-1} * [K_G(J_L + J_m N^2)/(J_L * J_m N^2)]^{0.5}$	
T_{LG}	Torques Referred to Load (Gimballed Applications)	Oz-In or Nm	$T_{L\,max} = (J_L\alpha_L + J_m N^2(\alpha_L + \alpha_V) + B_L(\omega_L + \omega_V) + K_L(\theta_L + \theta_V) + F_C + Mg_L)max$	

Where:

J_L = Load Inertia in Oz-In-s² or kgm²
J_M = Motor Inertia in Oz-In-s² or kgm²
ω_L = Load Angular Velocity
α_V = Vehicle Angular Acceleration
ω_v = Vehicle Angular Velocity
θ_v = Vehicle Angular Rotation
B_L = Viscous Friction at the Load
K_L = Spring Constant of Load
K_G = Gearhead Spring Constant
ω_M = Motor Velocity
F_C = Coulomb Friction Torque
θ_L = Angular Rotation at Load

Linear Conversion Equations

Symbol	Description	Units	Equation	
P_o	Mechanical Power Output Imperial	Watts	$P_o = (F_L * V_L) * (0.113)$	F_L in Lbs, V_L in In/sec
P_o	Mechanical Power Output System International	Watts	$P_o = (F_L * V_L)$	F_L in N, V_L in m/sec
J_{LRO}	Inertia of the load, reflected to the rotary output	Lb-In-sec² or kgm²	$J_{LRO} = (W_L/g) * (2\pi P)^{-2}$	Where: W_L = Weight of load in Lbs or N; g = gravity acceleration constant (386 in/s² or 9.8 m/s²)
V_L	Velocity of Linear Output	In/sec or mm/sec	$V_L = \omega_{RO} / (P * 60)$	
ω_{RO}	Velocity at the Rotary Output	RPM	$\omega_{RO} = 60 * V_L * P$	
F_L	Force at Load	Lbs or N	$F_L = T_{RO} * (2\pi P \eta_{bs})$	
T_{RO}	Torque at the Rotary Output	Lb-In or Nm	$T_{RO} = F_L / (2\pi P \eta_{bs})$	

Where:
P = Pitch of Ball Screw (Revs/inch or Revs/m) - Note the Pitch = 1/Lead
η_{bs} = Ball Screw Efficiency (Typically 0.95)

Note - Be careful not to mix units!

FAX COVER SHEET				
To:	**Company:**	CDA INTERCORP	**Phone No:**	954-698-6000
	Attention:	Application Engineering	**Fax No:**	954-698-6011
	Date:		**Reference:**	
FROM:	**Company:**		**Phone No.:**	
	Name:		**FAX No.:**	
	Mail Stop:		**e-mail:**	
Subject	Request for Information			

Fill in known data and fax this sheet directly to CDA InterCorp for an immediate response. Be sure to include preferred units.

Application Data Sheet							
Parameter	Symbol	Data	Units	Parameter	Symbol	Data	Units
Supply Voltage	V_S			Ambient Temperature Range	t		
Closed Loop Rotary Actuator							
Load Inertia	J_L			Acceleration at Load	α_L		
Max Load Velocity	ω_L			Load Coulomb Friction	F_{CL}		
Load Viscous Losses	B_{VL}			Mass Unbalance at max. g	M_{gl}		
Load Angular Rotation	θ_L			Bull Gear Ratio	N_B		-
Options:							
Acceleration Feedback		[ ] Yes	[ ] No	Friction Brake		[ ] Yes	[ ] No
Velocity Feedback		[ ] Yes	[ ] No	Brake Torque Magnitude			
Load Position Feedback		[ ] Yes	[ ] No	Motor Redundancy		[ ] Yes	[ ] No
Open Loop Rotary Actuator							
Output Torque	T_L			Output Velocity	ω_L		
Duty Cycle	-						
Options:							
Friction Brake		[ ] Yes	[ ] No	Brake Torque Magnitude			
Motor Redundancy		[ ] Yes	[ ] No	Derent Brake		[ ] Yes	[ ] No
Closed Loop Linear Actuator							
Load Weight	W_L			Acceleration at Load	α_L		
Max Load Velocity	ω_L			Load Coulomb Friction	F_{CL}		
Load Viscous Losses	B_{VL}			Stroke Length	θ_L		
Options:							
Acceleration Feedback		[ ] Yes	[ ] No	Friction Brake		[ ] Yes	[ ] No
Velocity Feedback		[ ] Yes	[ ] No	Brake Torque Magnitude			
Load Position Feedback		[ ] Yes	[ ] No	Motor Redundancy		[ ] Yes	[ ] No
Open Loop Linear Actuator							
Output Torque	T_L			Output Velocity	ω_L		
Duty Cycle	-			Stroke Length	θ_L		
Options:							
Friction Brake		[ ] Yes	[ ] No	Brake Torque Magnitude			
Motor Redundancy		[ ] Yes	[ ] No	Detent Brake		[ ] Yes	[ ] No

CDA InterCorp Products

Motor Modules:
- Brushless Permanent Magnet Motors
- AC Induction Motors
- Stepper Motors
- Square Wave Driven AC Motors
- Damped Rotary Switches
- Housed Limited Angle Torquers
- Synchronous Motors

Eddy Current Dampers:
- Rotary
- Linear
- In Line or Right Angle
- Damping "enable" option

Gearing Modules:

Rotary:
- High Torque Planetary
- Right Angle Gearing
- High Accuracy Zero Backlash Gearing
- Precision Indexing Drive Gearing

Linear:
- Ball Screw Actuation
- ACME Lead Screw Actuation
- In-line, Right-angle, or U-drive

Brakes:
- DC Friction Brakes
- Permanent Magnet Detent Brakes
- DC Magnetic Induction Brakes

Transducers:

Position Transducers:
- Brushless Resolvers
  - Single Speed
  - Multiple Speed
  - Tandem or Cluster Redundant
  - With or without Gearing
  - OnAxis Resolvers
- RVDT's
  - Tandem or Cluster Redundancy
  - With or without Gearing
  - OnAxis RVDT

Velocity Transducers:
- AC Tachometers
  - Damping Tachs
  - Rate Tachs
- Permanent Magnet Alternators
  - Single Speed
  - Multiple Speed
  - With or without Gearing

Acceleration Transducers:
- Brushless DC Rotary Accelerometers
- DC Excited Rotary Accelerometers

CDA InterCorp can combine these standard modules into multi-function integrated actuators and assemblies. Call CDA InterCorp directly for application engineering assistance, or to request a complete set of engineering reference data brochures.

CDA InterCorp

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