

Controllable Drive Actuator, Rotary Transducer and Eddy Current Damper Product Summary



CDA INTERCORP

CONTROLLABLE DRIVE ACTUATORS

CDA INTERCORP

INTRODUCTION

This application manual defines the performance capabilities of CDA InterCorp's actuator product line, in-line and right angle gearing, rotary transducers, eddy current dampers 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 entire range of products are designed to operate under the most demanding requirements of MIL-STD-810, while maintaining robust, reliable performance characteristics. These actuators and similar products are used in aerospace, space, defense, commercial aviation, "down hole", robotic, nuclear, and high reliability industrial control applications.

With over 33 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 unequalled reliability and ruggedness, while maintaining flexibility in providing custom motor requirements and extremely responsive prototype and production deliveries.

CDA's quality system is certified to ISO-9001:2000. 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.



Introduction:

CDA InterCorp's Controllable Drive Actuators, Rotary Transducers and Eddy Current Dampers are being used in many high performance critical applications for defense, aviation, space, ground support, down hole equipment tools and high reliability industrial applications. CDA's standard modular design concept provides unparalleled performance per unit volume. A substantial benefit of our modular design is the multifunction tasking capabilities within a single drive actuator. Every product within our line is an established, qualified module. A new application may derive the benefit of a custom performance and mounting configuration actuator, with "off-the-shelf-technology".

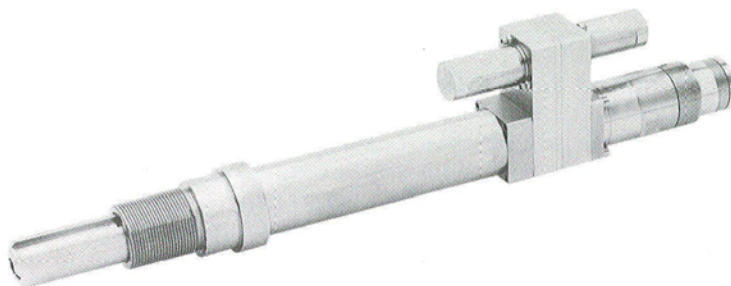
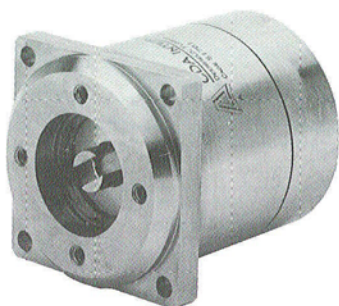
Critical materials and processes are standard, however, the external mounting configurations and electrical characteris-

tics may be tailored to satisfy specific performance and mechanical requirements. Most of our applications are mission critical, and some are even flight safety critical.

This catalog summarizes the various types of motors, gearboxes, transducers, dampers and brake modules available. We also present specific advantages of each type of module, as well as critical application information. This information is formatted to assist the design engineer to base-line a particular actuator frame size and feature options. Detailed motor, transducer and eddy current damper performance may be found in our other specific engineering manuals. While these engineering publications are designed to assist the engineer, we encourage direct contact with CDA's engineering department in the selection process for up-to-date performance and design assistance.

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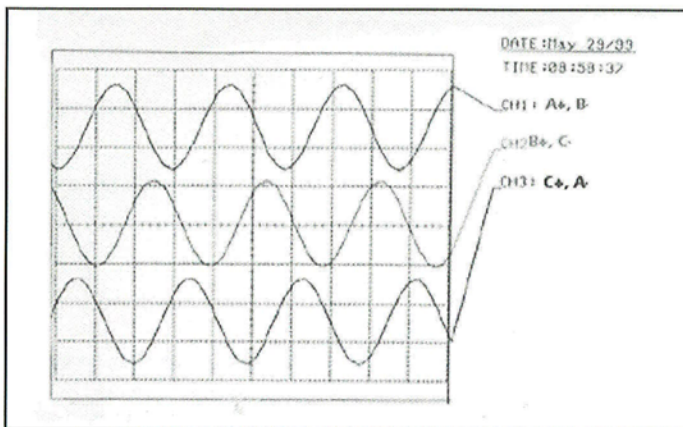
Brushless Permanent Magnet Motors

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.

Applications: Brushless motors should be used in high power output, or performance critical applications where mass and efficiency are critical. Brushless motors are also desirable in servo applications with high load inertia or friction characteristics.

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.



Two Phase or Three Phase Sinusoidal? There has been much discussion on the topic of whether a two phase or three phase motor provides the smoothest performance actuator. The answer depends on both the construction technique and drive circuitry. Assuming sinusoidal back emf and controlled through

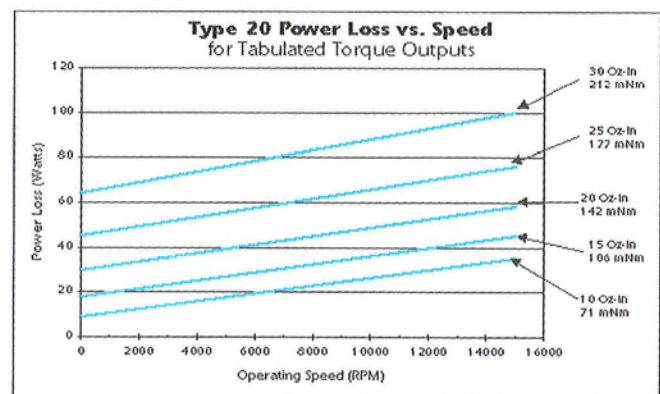
a transconductance amplifier, the two phase motor will produce less ripple torque than a three phase counterpart, IF the three phase motor is connected at the neutral. If the three phase controller uses three independent "H" bridges, then there is essentially no difference between two phase or three phase in terms of magnitude of torque ripple. There are many reasons for this phenomenon that are too numerous to discuss here. Interested parties should contact CDA Engineering for detailed information on this topic.

Trapezoidal Operation is a popular method of motor control, due to its 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 torque ripple, 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.

CDA 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.

Performance Information: For detailed performance information, refer to our Brushless Permanent Magnet Motor Application Manual. The manual contains detailed information on the motor constants, inductance, hysteresis losses, power consumption and more. The chart below shows a family of curves for motor power input for various torque magnitudes at operational velocity. This information is very useful for estimating system performance, temperature rise and efficiency.



AC Induction Motors

Applications: Induction motors are used in many applications where less reliable Brush Type DC motors or higher complexity Brushless Motors were previously used. Ideal for pump applications, velocity control applications or moderate power output servo applications the AC motor may be a lower cost solution when compared to the Brushless Permanent magnet motor application. Additionally, they are more efficient, and can drive higher load inertia than stepper motors.

CDA's high efficiency induction motors produce high torque at speed, resulting in excellent speed regulation at high frequencies. This speed-torque characteristic often allows the use of an AC induction motor, rather than a hysteresis synchronous motor, for applications which require relative constant velocities with varying loads. Additionally, CDA's motors produce high torque per watt characteristics, when driven at low frequencies. This coupled with their high torque capacity per unit volume results in a compact low power, high torque generating actuator with cost effective drive circuitry.

CDA's Induction motors feature Class H225 insulation and lubrication system, with matched CTE materials. This assures high performance and capacity per unit volume and weight. The ruggedness and reliability designed into all of our modular designs assures long life and repeatable performance.

While we may discuss and introduce different drive techniques and source voltages, all of our motor frame sizes may be wound to be driven off any frequency from 50 to 800 Hertz, and may be wound for low, moderate, or high voltage systems, and optimized for sinusoidal or square wave voltage sources.

DRIVE OPTIONS:

Fixed and Control Phase Operation: One technique of closed loop motor control is the "Fixed Phase" method of applying power to one of the motor phases continuously, and varying the magnitude and polarity of the "Control" phase, based upon the magnitude of the error signal. This method, while somewhat outdated, provides an accurate, reliable method of servo control. The magnitude of the power input of the fixed phase may be lower than the power input of the control phase, in order to reduce steady state power losses, and lower the temperature rise of the motor. While the steady state power loss of the motor is lower than a balanced fixed phase operation, the total power input will be higher. The stall power inputs tabulated in the Induction Motor Application brochure is the total power input for balanced power operation. For example, motor type 20-6-400-06 tabulates a stall power of 90 watts. For balanced power, the motor would have 45 watts per phase of power input

($P_T = P_{FB} + P_{CB}$). For unbalanced power, the product of powers would be equal to the product of powers for a balanced motor for equivalent performance. That is: $P_{FB} * P_{CB} = P_{FU} * P_{CU}$. Therefore, if we wanted to set the fixed phase for the unbalanced winding to 15 watts ($P_{FU} = 15$), and solve for the control phase winding, P_{CU} , we get: $P_{CU} = (P_{FB} * P_{CB}) \div P_{FU}$, which solves to 135 watts for the unbalanced control phase stall power. With 15 watts on the fixed phase, the motor steady state temperature rise would be lower compared to the balanced motor, but the total power input at stall is 150 watts, as compared to 90 watts for a balanced option.

Dual Winding Control: Dual Winding Control (DWC) is a more current method of closed loop operation with an AC induction motor. This method simultaneously applies the two phase voltages in proportion to the error signal input. Driving both phases is similar to Brushless Permanent Magnet Motor control techniques. Not requiring the motor fixed phase to have continuous power reduces the zero speed quiescent power loss and motor temperature rise. Additionally, the DWC allows balanced power, resulting in better torque per watt characteristics. See page 19 for additional information on DWC AC induction motors.

Square Wave Driven AC Motors: CDA can provide windings for AC motors which allow high efficiency operation from a square wave voltage source. This provides AC motor performance from SC source voltages. Stepper motor electronics which drive permanent magnet stepper motors may also be used for CDA line of AC motors designed to operate off these square wave voltages. However, AC induction motors are more efficient and have higher power output capacity when compared to stepper motors.

Some advantages of this drive technique are: Simple high efficiency drive circuitry; high efficiency operation; selection of operating frequency; wide range of Torque vs. Speed characteristics; DC source voltages; brushless design; excellent speed regulation; and variable frequency operation option.

Variable Frequency Square Wave: While the selection of a single operating frequency may provide adequate performance, variable frequency drives can significantly increase performance and efficiency per unit volume. Controlling the frequency allows high torque per watt performance at low speeds, while providing high power output and efficiency at high operational speeds.

Square wave drive electronics makes the implementation of variable frequency AC motors an easy task. Simply set the clock frequency into the square wave drive electronics to vary with the motor velocity, which is determined through an AC tachometer. See page 18 for additional information on variable frequency square wave driven AC induction motors.

STEPPER MOTORS

Applications: CDA's stepper motors provide an incremental step output depending on the excitation logic applied to the motor windings. These stepper motors provide high running torque capacity per unit weight and size. Their high performance and excellent stepping accuracy make these components ideal in open loop positioning systems, incremental rate control systems, or limited angle rotary switches. Samarium cobalt rare earth magnets, high grade stainless steel construction, and class H225 insulation system assure rugged, reliable performance under the most severe operating conditions.

Applications for stepper motors include timing devices, field of view mechanisms, rotary solenoids, electro-optics, filters, antenna drives, robotics, and pointing mechanisms. CDA's high performance, high reliability stepper motors are ideal for these and other applications where size, weight, and reliability are critical. Advantages of stepper motors include simple electronics, high torque efficiency, precision step angles, and repeatable position increments. High load inertia applications should be analyzed properly before selecting a stepper motor. A Rotary Accelerometer may be required to compensate for load inertia in some stepper motor applications. Stepper motors should not be used in high power output applications.

Performance: A stepper motor's performance is affected by load inertia. The design engineer must consider load inertia in dynamic step applications. If an application has a significant load inertia, the pulse rate may be "slewed", or increased dynamically, to obtain greater performance. In the Stepper Motor Application brochure, the tabulated "No Load Response Rate" and "Max Power Output" characteristics are tabulated for inertially small reflected loads (Inertia Factor ≈ 1.0).

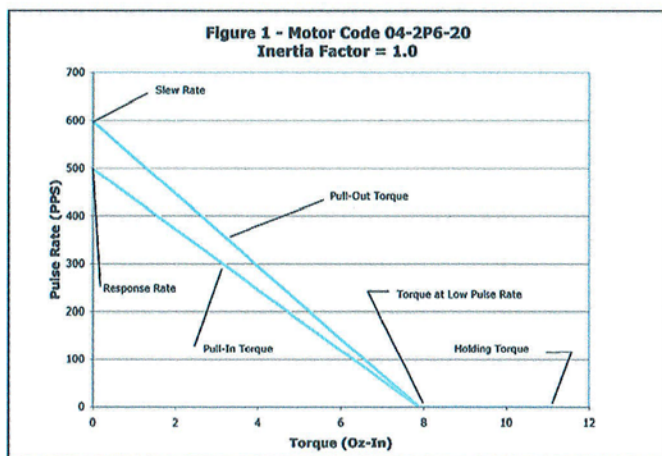


Figure 1 shows a typical pulse rate vs. torque curve. This performance is at +25° C, with a total inertia factor of 1.00 (load inertia ≈ 0). Also noted in this figure are some common terms. The Pull In Torque is the load torque which the stepper motor can pull in from rest or reverse direction of rotation, at a specific pulse rate. The pull out torque is the torque which will pull the

motor out of dynamic operation. The pull out torque falls along the "Slew" line, and is independent of load inertia.

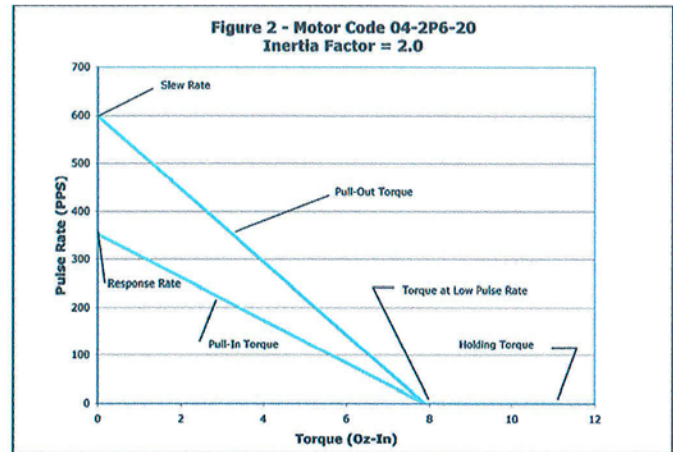
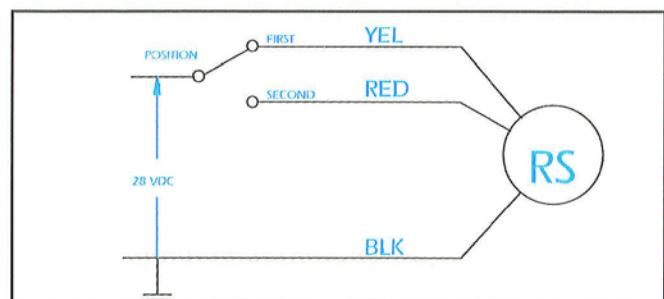


Figure 2 shows the same stepper motor at +25° C, but with a total inertia factor of 2.0. Notice how the Slew Rate, Pull Out, Low Pulse Rate, and Holding performance have not changed, but the Response Rate and Pull In Torques have been reduced. This is due to the fact that the stepper motor must accelerate and decelerate the load inertia in addition to the motor inertia. To calculate the total inertia factor, please refer to our Stepper Motor Application brochure. This publication will also provide information to simulate performance over temperature as well as characterize performance with redundant windings.

Rotary Switches: Permanent Magnet Stepper Motors may be used as Rotary Switches or Housed Limited Angle Torquers. If a limited angle of rotation is required at the mechanism output, simple excitation simple excitation of a motor winding can select a specific output position. With our InterDamp option, these devices may be ideal for limited angle position control. Applications for these rotary switches include Filter Wheel Drives, Field of View Switches, Solar Shields and Covers.



Standard switch angles are shown on page 8. However, custom step angles may be provided on request. Switch position accuracy of 3% of the step angle is standard. The schematic above represents a Rotary Switch.

Refer to our "Stepper Motor Application Data" brochure for more performance and application information.

ROTARY TRANSDUCERS

CDA InterCorp's Rotary Transducers provide high accuracy outputs for angular position, velocity, and acceleration requirements in today's advanced systems. These components deliver precise output performance in small size and weight. High grade stainless steel construction, class H220 insulation system, and brushless design assures reliable performance under the most severe operating conditions. Additional features include wide operating range of -80° C to +220° C, high vibration and shock capacity, high velocity and high acceleration capacity, high signal to noise ratio, continuous rotation, and a wide selection of output formats.

Applications for these sensing devices include aircraft antenna positional feedback, primary and secondary control surface indicators, servo stability requirements, servo control demand information, velocity servos, aircraft wheel velocity information, and virtually any system where velocity, position, force, or acceleration information is required.

CDA InterCorp Instrument has the ability to provide these components with integrally mounted geartrains, or combine components to provide "multi-function sensing", or cascade components in tandem or cluster format to provide redundancy. Additionally, CDA InterCorp may provide these devices mounted to a motor or actuator to provide reliable servo performance in a compact package. All components have been qualified to the most demanding requirements of MIL-STD-810. Historical data has proven that CDA InterCorp's rugged construction components perform reliably in extreme application environments.

POSITION TRANSDUCERS

With the advancement of digital electronics, and increased demand for high reliability, high accuracy systems, high frequency brushless position sensors are replacing brush-type synchros, resolvers, and optical encoders, for these applications. Small size, light weight, rugged construction, and ease of implementation make CDA InterCorp's line of Brushless Resolvers, and Brushless RVDT's, ideal for control and positional information in advanced systems.

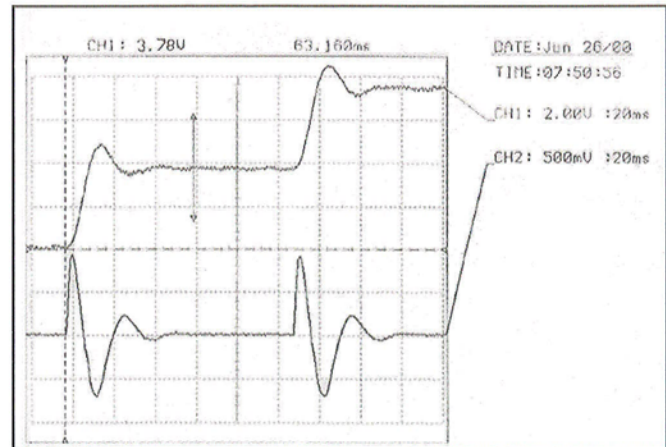
VELOCITY TRANSDUCERS

Velocity sensors are extremely useful for position and velocity control applications. AC Tachometers are designed to accommodate specific rate signal needs, to improve inner loop stability, and provide overall system damping, which is essential for closed loop control systems. Velocity control systems can benefit from high signal to noise ratios, high accuracy, and stable performance over temperature and time.

Another velocity sensor option is the Permanent Magnet Alternator (PMA). PMAs produce an output where the frequency and magnitude of voltage vary in direct proportion to the angular velocity. These devices are useful where dynamic angular positional information can also be derived by "EZing" the PMA in the system.

Additionally, "Zero Crossing" information of the output voltages is a simple method of determining positional and velocity information.

ACCELERATION TRANSDUCERS



Acceleration feedback offers a "higher" order effect on servo and stepper motor operation than other forms of rate feedback. A major advantage of our Rotary Accelerometers (RAs) is that they do not require excitation or demodulation to provide a DC output voltage in proportion to the angular acceleration ($V/\text{rad}/\text{Sec}^2$). Particularly useful in closed loop servo applications or operating a stepper motor in the slew mode, the accelerometer may be mounted directly to a motor, or sold as a stand alone module.

The scope trace above shows position and acceleration versus time of a permanent magnet stepper motor. The acceleration signal is the direct DC output of the RA. More detailed information on the description and applications of RAs are detailed on pages 9, 22 and 23.

INDEXING GEARING

CDA may provide precision "indexing gearing" with our transducer modules to increase field of operation, or increase resolution of sampling information. Indexing gears, are specifically designed to adapt to our precision rotary transducers, to provide high accuracy, low transmission error operation. As with all of CDA's products, our indexing gearing is constructed with matched CTEs for wide temperature operation.

For more detailed information on our range and performance of our Rotary Transducers and Indexing Gearing, please refer to our "Rotary Transducer Application Manual". This publication details transducer gains, impedances, electrical and mechanical characteristics. Additional information may be obtained by contacting CDA's engineering department directly.

EDDY CURRENT DAMPERS

Applications: Eddy Current Dampers (ECD's) are passive devices that regulate velocity in proportion to the torque applied to the input shaft. Ideal for flight avionics controls such as passive sticks and throttles, as well as spring loaded deployment systems, such as solar array panels, tuned damper systems or antenna and mechanism deployment systems.

CDA InterCorp's ECDs offer reliable, repeatable, and linear damping characteristics over a wide operating temperature range. These rugged devices are offered in a range of sizes and damping rates. The Eddy Current Dampers (ECD's) are complemented with single or multiple stages of high reliability gearing. Ideal for demanding applications, these devices will operate reliably at high angular rates, accelerations and radial loads.

CDA's seven standard frame size ECD's and our complementary line of gearboxes offer nearly unlimited damping rates, configurations, and torque capacities. Our compact and efficient gearboxes are so robust and compact, that we often rival the size and mass of fluid dampers for equivalent damping rates and torques; however, our ECD's are much more reliable and temperature stable than fluid dampers. ECD's are extremely linear and have low temperature coefficients, where the damping rates and performance are very stable over operating temperature ranges. Our ECD damping rates are so linear and predictable, that temperature compensation is usually not required. Where fluid dampers usually suffer from "dead band" with up to ten or more degrees of lost motion, our geared ECD's have only a few arc-minutes of lost motion, providing a more robust, controlled deployment. Our ECD's do not require, and are not dependent on seals. The elimination of seals, and no potential for leaks gives ECD's a clear advantage in performance or outgassing critical applications. Also, the ECD's performance does not change inside a vacuum. The increased reliability and performance of our ECD's typically save many hours of assembly and integration time.

Our efforts to develop a low static friction, high reliability ECD has proven successful. We can now offer low static friction values without compromising capacity or reliability. Our current line of ECD's have reduced static friction by 75% for a given frame size and damping rate. Often our geared ECD's can form fit function replace fluid dampers in deployment actuation systems with the high reliability and temperature stability inherent in our ECD modules.

Linear Stroke Dampers: CDA InterCorp may also provide Linear Eddy Current Dampers (LECD's) by incorporating a high efficiency ball screw to the output of our rotary dampers. These LECD's may

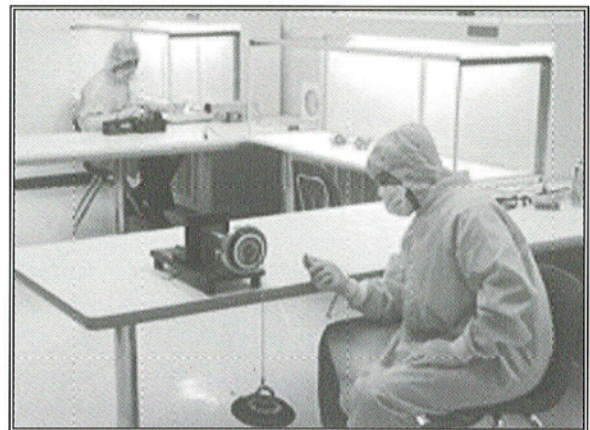
incorporate various mounting configurations for flexible system integration. For Linear ECD analysis, refer to CDA InterCorp's Product Summary brochure for rotary to linear translation equations, and linear mounting interface options.

Damping on Command: CDA may provide our ECD's with a damping enable feature which allows the damping restrictive torque to be turned off and on at will. This may offer advantages to the system or mechanism design by allowing the flexibility to command the damping. Contact CDA's engineering department for further information about Damping on Command.

System Level Calibration can also be reliably achieved on our ECD's. Unlike fluid dampers which have a screw provision which may vibrate loose and change position during launch, CDA InterCorp's ECD's can be system level calibrated by adding a proper load resistor across external leads. CDA can provide a matrix of load resistors vs. damping rate at the output of a given ECD.

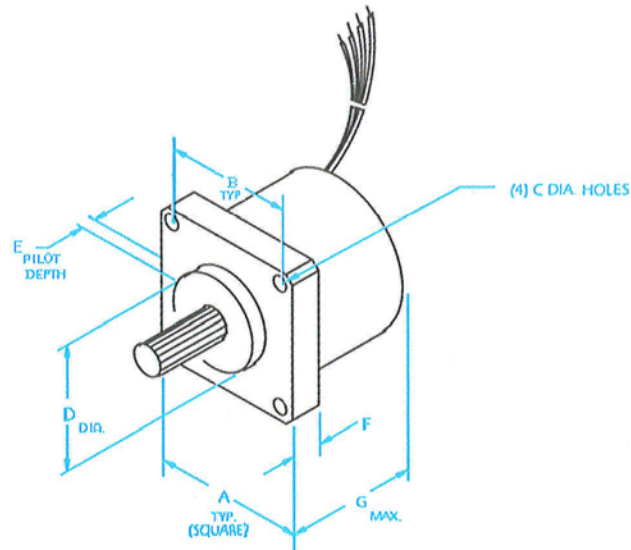
Damper Performance Simulation: An advantage of our ECDs is the wide data base of applications, extensive performance requirements over wide operating environments and our standard modular design. This extensive database of information has resulted in extremely accurate performance simulation during the design stage. Engineers interested in ECD simulation information should contact CDA's engineering department. Copies of a technical paper discussing design principles and simulation techniques is available on request.

Performance Information: For detailed design information, refer to CDA's Eddy Current Damper Application Manual. This publication details damping rates, torque components and magnitudes, as well as composite assembly performance. Contact CDA's engineering department directly for additional information on Eddy Current Dampers.



Eddy Current Damper testing in Clean Room Facility

Motor Mechanical Data



IMPERIAL UNITS (DIMENSIONS IN INCHES)									
MOTOR TYPE	A	B	C	D	E	F	G	WEIGHT (Oz.)	INERTIA (Oz-In-s ²)
03	0.750	0.620	0.081	0.5000	0.040	0.125	0.780	1.2	9.00 E-06
04	1.000	0.828	0.110	0.6250	0.125	0.187	0.995	2.8	3.40 E-05
05	1.250	1.030	0.129	0.7500	0.125	0.250	1.280	5.0	1.00 E-04
06	1.500	1.250	0.149	0.8750	0.125	0.250	1.550	8.5	2.50 E-04
08	2.000	1.670	0.177	1.1250	0.125	0.375	1.911	19	9.60 E-04
10	2.500	2.080	0.266	1.5000	0.125	0.500	1.405	37	2.0 E-03
12	3.000	2.500	0.266	1.7500	0.125	0.500	3.015	80	3.5 E-03

SYSTEM INTERNATIONAL (DIMENSIONS IN mm)									
MOTOR TYPE	A	B	C	D	E	F	G	WEIGHT (kg)	INERTIA (kg-m ²)
03	19.05	15.75	2.06	12.700	1.02	3.18	19.81	0.037	6.36 E-08
04	25.40	21.03	2.79	15.875	3.18	4.75	25.27	0.078	2.4 E-07
05	31.75	26.16	3.28	19.050	3.18	6.35	32.51	0.142	7.06 E-07
06	38.10	31.75	3.78	22.225	3.18	6.35	39.37	0.241	1.77 E-06
08	50.80	42.42	4.50	28.575	3.18	9.53	48.54	0.540	6.71 E-06
10	63.50	52.83	6.76	38.100	3.18	12.70	61.10	1.05	1.41 E-05
12	76.20	63.50	6.76	44.450	3.18	12.70	76.60	2.25	2.5 E-05

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 = 0.0011 inches [0.028 mm] TIR.
4. Other mounting configurations are available on request.
5. Contact CDA's engineering department for motor thermal characteristics.
6. Add 0.59" (15mm) to "G" dimension for Brushless Permanent Magnet Motors.
7. Note new motor code classifications for each motor type.

Motor Performance Data

BRUSHLESS PERMANENT MAGNET MOTOR REFERENCE DATA

Parameter		Type 03	Type 04	Type 05	Type 06	Type 08	Type 10	Type 12
Motor Constant (K_M) Stall Torque Data	Oz-In/ $\sqrt{\text{watt}}$	1.1	2.4	4.0	7.0	15	26	45
	Nmm/ $\sqrt{\text{watt}}$	7.8	17	28	49	106	185	315
Peak Torque	Oz-In	7.0	30	60	125	250	500	1000
	Nmm	49	210	425	900	1750	3500	7000
Peak Power Output <small>[see note B3]</small>	Watts	50	200	500	1000	2000	4000	8000

Notes:

B1. Reference Data at +25° C unit temperature.

B2. Continuous Power Output dependant on system ambient temperature, and actuator thermal coefficient.

B3. See CDA InterCorp's Brushless Permanent Magnet Motor Engineering Reference Data brochure for additional performance data information.

AC INDUCTION MOTOR REFERENCE DATA

Parameter		Type 03	Type 04	Type 05	Type 06	Type 08	Type 10	Type 12
Peak Torque	Oz-In	2.0	4.0	10	25	50	100	200
	Nmm	14	28	70	175	350	700	1400
Peak Power Output <small>[see note A2]</small>	Watts	6	22	45	130	300	600	1200

Notes:

A1. Reference Data at +25° C unit temperature

A2. Continuous Power Output dependant on system ambient temperature, and actuator thermal coefficient.

A3. See CDA InterCorp's AC Induction Motor Engineering Reference Data brochure for additional performance data information.

STEPPER MOTOR REFERENCE DATA

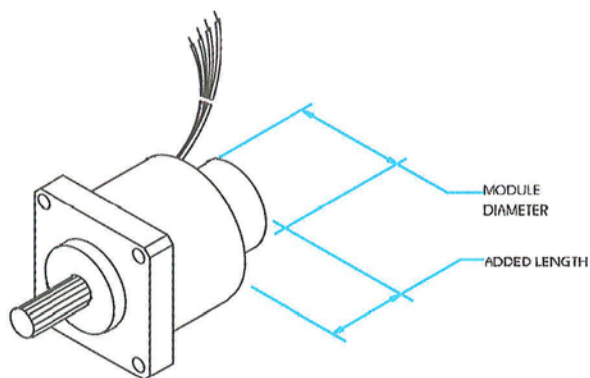
Parameter			Type 03	Type 04	Type 05	Type 06	Type 08	Type 10	Type 12
Motor Constant (K _M) Holding Torque Only	15° Stepper	Oz-In/√watt	1.1	2.9	4.1	8.2	15	26	46
		Nmm/√watt	7.8	20	29	58	106	185	325
	20° Stepper	Oz-In/√watt	0.7	1.8	3.5	5.8	11	20	32
		Nmm/√watt	5.0	13	25	41	78	140	225
	30° Stepper	Oz-In/√watt	1.1	2.5	3.9	7.4	14	26	42
		Nmm/√watt	7.8	18	28	52	100	185	300
	45° Stepper	Oz-In/√watt	0.8	2.1	3.5	5.9	12	22	38
		Nmm/√watt	5.6	15	25	42	85	155	270
	60° Stepper	Oz-In/√watt	0.6	1.3	2.1	3.3	7.2	13	21
		Nmm/√watt	4.2	9.2	15	23	51	92	150
	90° Stepper	Oz-In/√watt	0.6	1.1	1.9	3.0	6.5	12	19
		Nmm/√watt	4.2	7.8	13	21	46	85	135

Notes:

S1. Reference Data at +25° C unit temperature.

S2. See CDA InterCorp's Stepper Motor Engineering Reference Data brochure for additional performance data information.

Optional Integral Components



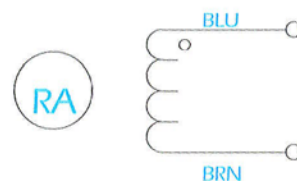
ROTARY ACCELEROMETERS

Description / Application:

Rotary Accelerometers (RA's) provide a DC output voltage in proportion to the phase and magnitude of the rotary acceleration of the motor shaft. These devices **require no excitation or input power**. RA's are ideal components to achieve high performance servo stability characteristics. The acceleration signal may be used alone, or the voltage may be op amp integrated to provide velocity damping plus acceleration information. Feedback 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 systems.

RA's may also be used in stepper motor applications, to determine the step "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. This allows the motor to operate in the higher efficiency slew region of performance while maintaining step count. Since the permanent magnet Rotary Accelerometer provides a DC signal, the output may be directly used to determine step to step integrity of the stepper motor in critical pointing mechanisms, where step integrity is paramount.

The data included herein provides greater detail of the benefits and application information of RA's in stepper and servo motor applications.



Schematic

TYPE →		03ACC	05ACC
Output Voltage	mV/kRAD/sec ²	6.0	25
Output Load	Ohms	50,000	50,000
Added Length (when integrated to motor)	Inches [mm]	0.600 [14.6]	0.600 [14.6]
Accelerometer Diameter	Inches [mm]	0.750 [19.1]	1.250 [31.8]
Added Inertia	Oz-In-sec ² [kg-m ²]	1.4 E-05 [9.9 E-08]	1.0 E-04 [7.0 E-07]
Added Weight	Oz [kg]	0.750 [0.021]	2.0 [0.056]

Notes:

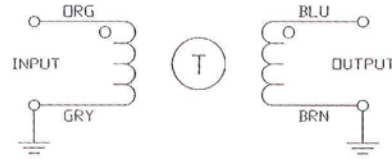
1. The information above is tabulated for an RA mounted directly to a CDA InterCorp motor assembly.
2. Tabulated performance at +25° C.

TACHOMETERS - DAMPING

Description / Applications:

AC Damping Tachometers are ideal rate transducers for high accuracy closed position loop applications where high forward loop gains and inner loop stability are critical.

The output voltage of AC tachometers are proportional to the angular velocity of the motor rotor shaft, and the voltage signal is phase sensitive to the direction of rotation. This information may be used for servo stability requirements, closed velocity applications, or control system information purposes.



Output voltage in phase with excitation for CW rotation, viewing shaft

Type →		03S2.5	03S0.4	05S2.5	05S0.4
Excitation Voltage	Volts RMS	10	26	10	26
Frequency	Hertz	2500	400	2500	400
Untuned Current	Amps RMS	0.045	0.016	0.050	0.016
Tuned Current	Amps RMS	0.040	0.014	0.045	0.013
Output Voltage @ +25° C	Volts/1000 RPM	0.125	0.125	0.250	0.250
Temperature Coefficient (Output Voltage Drop/° C Rise)	%/° C	0.15	0.30	0.15	0.25
Total Null Voltage	mVolts RMS	15	15	25	25
In Phase Null Voltage	mVolts RMS	10	10	10	10
Output Load	Ohms	50,000	50,000	50,000	50,000
Added Length	Inches [mm]	0.600 [15.2]	0.600 [15.2]	0.600 [15.2]	0.600 [15.2]
Tachometer Diameter	Inches [mm]	0.750 [19.1]	0.750 [19.1]	1.250 [31.8]	1.250 [31.8]
Added Inertia	oz-in-sec ² [kg-m ²]	2.8 E-06 [2.0 E-08]	2.8 E-06 [2.0 E-08]	5.5 E-05 [3.8 E-07]	5.5 E-05 [3.8 E-07]
Added Weight	Oz [kg]	0.75 [0.021]	0.75 [0.021]	2.3 [0.065]	2.3 [0.065]

NOTES:

1. See Rotary Transducer Engineering Reference Data brochure for additional tachometer options.
2. Other voltages, frequencies, and performance data available on request.
3. Tachometers may be sold as a stand alone item, or integrally mounted to a motor assembly as shown above.
4. Phase shift compensation required for 2.5 kHz. tachometer demodulation. Contact CDA for information.

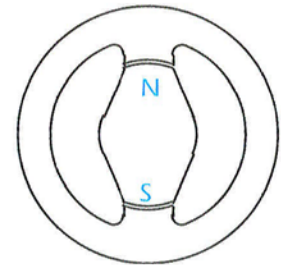
DETENT BRAKES

Description / Application:

Magnetic Detent Brakes are integrally mounted with no intermediate couplings. Primarily used on Stepper Motors, the Detent Brake requires no excitation voltage or power input to provide additional holding torque at given step angles, while the motor is at rest. This device proves very useful when power off holding torque is required. The magnitude of the detent holding torque may be calibrated up to the maximum level tabulated below.

Typical applications include launch lock or over centering switches, where the coulomb friction of the motor is not enough to overcome system loads. Extremely popular in stepper motor applications, these devices typically correspond to the step angle of the motor, however, offsetting of the motor and brake step angles have been used to obtain custom torque versus position step profiles of the motor-brake combination.

In most applications where the motor step angle and the detent torque angle coincide, there is little to no net loss in motor running torque capacity. Since half of the magnetic detent cycle the brake is working against the motor torque, and in the other half of the cycle the brake is working with the motor torque, there usually is no net loss in running torque capacity. As a general rule however, we typically recommend the detent holding torque be less than seventy percent of the motor torque at low pulse rate.



Schematic

TYPE →		08D	11D
Holding Torque	Oz-In [Nmm]	3.0 [21]	15 [105]
Detent Torque Angle	Degrees	30, 45, 90, or 120	30, 45, 90, or 120
Added Length	Inches [mm]	0.400 [10.2]	0.400 [10.2]
Brake Diameter	Inches [mm]	0.750 [19.1]	1.062 [27.0]
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]
Added Weight	Oz [kg]	1.0 [0.028]	2.0 [0.057]

Notes:

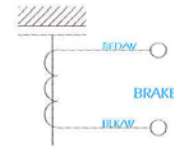
1. Other torques and performance data available on request.
2. Detent Brakes may be sold as a stand alone item, or may be integrally mounted to a motor assembly, as shown on page 9.

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 9.
3. Listed performance at +25° C.

High Torque Capacity Gearing

As with our standard motor and damper modules, CDA inventories the fundamental gear blanks and piece parts for our line of high torque gearboxes. These durable devices are manufactured with the same high precision tolerances as our other modules. The critical interface between the high speed motor shaft and the high efficiency gearbox is held to very tight tolerances. This assures high reliability performance at high velocities, maximizing efficiency, and minimizing weight, while maintaining reliable, consistent performance.

As with our other products, our gearing consists of high grade stainless steel construction with matched coefficient of thermal expansion. Our standard geared actuators have operated from 4 Kelvin (-269° C) to +250° C. High torsional and radial stiffness with low backlash are also inherent in our standard gear modules making them ideal for high torque deployment mechanisms.

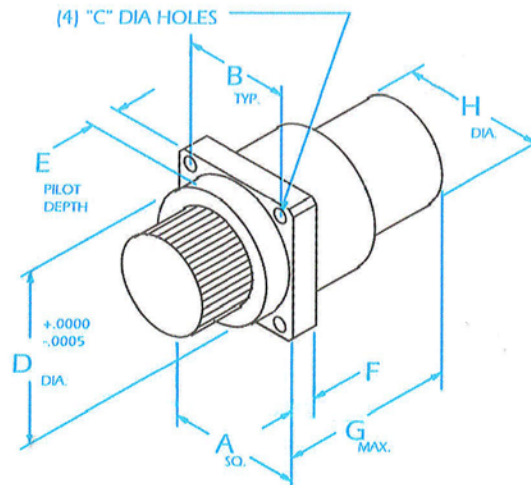
For length critical applications, CDA InterCorp has an entire line of right angle gearboxes to complement each frame size of our planetary gearboxes. Our placement of the critical right angle conversion is at the optimum ratio of torque and velocity which

results in a gearbox which has the identical torque, stiffness, and backlash ratings as the comparable in line planetary gearboxes.

Extensive field heritage and continuous endurance testing provides for a large data base of performance and reliability predictions for our geared packages. Most of our applications are mission critical, and some are even flight safety critical. We are able to accommodate all these demanding applications with our standard modular design concept. Another advantage derived from this concept is responsive prototype deliveries. Since our fundamental module piece parts are inventoried as blanks, we can accommodate fast deliveries and provide custom mounting and interface configurations. Additionally, prototype actuators are manufactured with the same materials, processes and build standards as our production hardware.

Pages 12 through 15 tabulates the torque ratings and composite assembly dimensions of our in-line and right angle drive line of gearboxes. It is important to note that the mechanical interface characteristics and output shaft configurations may be tailored to meet your specific system application requirements.

Motor - Gearhead Composite Dimensions and Performance



TYPE		RATIOS ²		Imperial Dimensions (In Inches)								WEIGHT	Temperature Coefficient ⁴
GEARHEAD ¹	MOTOR	FROM	TO	A	B	C	D	E	F	G ⁶	H	Oz	(° C/Watt Loss)
AO	03	5	10	0.750	0.620	0.081	0.6875	0.156	0.188	1.185	0.750	2.1	7.0
AA	03	25	100	0.750	0.620	0.081	0.6875	0.156	0.188	1.745	0.750	3.0	7.0
CA	03	21	100	1.000	0.828	0.110	0.9375	0.188	0.250	1.821	0.750	4.2	6.9
AO	04	5	10	1.000	0.828	0.110	0.6875	0.156	0.250	1.400	1.000	4.0	4.5
CA	04	18	100	1.000	0.828	0.110	0.9375	0.188	0.250	2.166	1.000	6.5	6.2
DC	04	20	107	1.250	1.030	0.129	1.1875	0.250	0.250	2.342	1.000	8.5	6.1
CO	05	4	10	1.250	1.030	0.129	0.9375	0.188	0.250	1.843	1.250	7.5	3.0
DC	05	26	114	1.250	1.030	0.129	1.1875	0.250	0.250	2.623	1.250	12	4.5
FD	05	20	114	1.500	1.250	0.149	1.4375	0.313	0.313	2.784	1.250	15	4.5
CO	06	5	10	1.500	1.250	0.149	0.9375	0.188	0.313	2.168	1.500	13	2.3
DC	06	26	114	1.500	1.250	0.149	1.1875	0.250	0.313	2.912	1.500	17	2.5
FD	06	20	114	1.500	1.250	0.149	1.4375	0.313	0.313	3.073	1.500	18	4.5
HD	06	22	107	2.000	1.670	0.177	1.8750	0.375	0.375	3.340	1.500	27	4.5
DO	08	4	11	2.000	1.670	0.177	1.1875	0.250	0.375	2.440	2.000	26	1.7
FD	08	20	114	2.000	1.670	0.177	1.4375	0.313	0.375	3.419	2.000	31	1.7
HD	08	22	107	2.000	1.670	0.177	1.8750	0.375	0.375	3.689	2.000	40	2.5
JF	08	30	114	2.500	2.062	0.206	2.4375	0.437	0.500	3.976	2.000	66	2.4
FO	10	5	10	2.500	2.062	0.206	1.4375	0.313	0.500	3.250	2.500	53	1.3
HD	10	22	107	2.500	2.062	0.206	1.8750	0.375	0.500	3.933	2.500	67	1.4
JF	10	20	70	2.500	2.062	0.206	2.4375	0.437	0.500	4.453	2.500	100	1.9
HO	12	5	10	3.000	2.500	0.266	1.8750	0.375	0.750	3.950	3.000	90	0.9
JF	12	20	70	3.000	2.500	0.266	2.4375	0.437	0.750	5.161	3.000	131	1.0
MH	12	18	61	3.000	2.500	0.266	2.9687	0.500	0.750	5.635	3.000	156	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 rise per watt loss, while mounted on a 6" x 6" x 0.25" black aluminum plate.
5. Dry film lubrication for cryogenic temperature operation available on request. Contact CDA's engineering department for information.
6. Add 0.575 inches to "G" dimension for Brushless Permanent Magnet Motor Actuators.

TYPE		RATIOS ²		System International Dimensions (In mm)								WEIGHT	Temperature Coefficient ⁴
GEARHEAD ¹	MOTOR	FROM	TO	A	B	C	D	E	F	G ⁶	H	kg	(° C/Watt Loss)
AO	03	5	10	19.05	15.75	2.06	17.463	3.96	4.78	30.1	19.05	0.060	7.0
AA	03	25	100	19.05	15.75	2.06	17.463	3.96	4.78	44.3	19.05	0.085	7.0
CA	03	21	100	25.40	21.03	2.80	23.813	4.78	6.35	46.3	19.05	0.119	6.9
AO	04	5	10	25.40	21.03	2.80	23.813	3.96	6.35	35.6	25.40	0.114	4.5
CA	04	18	100	25.40	21.03	2.80	23.813	4.78	6.35	55.0	25.40	0.185	6.2
DC	04	20	107	31.75	26.26	3.30	30.163	6.35	6.35	59.5	25.40	0.241	6.1
CO	05	4	10	31.75	26.16	3.30	23.813	4.78	6.35	46.8	31.75	0.213	3.0
DC	05	26	114	31.75	26.16	3.30	30.163	6.35	6.35	66.6	31.75	0.341	4.5
FD	05	20	114	38.10	31.75	3.80	36.513	7.95	7.95	70.7	31.75	0.426	4.5
CO	06	5	10	38.10	31.75	3.80	23.813	4.78	7.95	55.1	38.10	0.369	2.3
DC	06	26	114	38.10	31.75	3.80	30.163	6.35	7.95	74.0	38.10	0.423	2.5
FD	06	20	114	38.10	31.75	3.80	36.513	7.95	7.95	78.1	38.10	0.511	4.5
HD	06	22	107	50.80	42.42	4.50	49.213	9.53	9.53	84.8	38.10	0.767	4.5
D0	08	4	11	50.80	42.42	4.50	30.163	6.35	9.53	62.0	50.80	0.739	1.7
FD	08	20	114	50.80	42.42	4.50	36.513	7.95	9.53	86.8	50.80	0.881	1.7
HD	08	22	107	50.80	42.42	4.50	49.213	9.53	9.53	93.7	50.80	1.140	2.5
JF	08	30	114	63.50	52.37	5.23	61.913	11.10	12.70	101	50.80	1.880	2.4
FO	10	5	10	63.50	52.37	5.23	36.513	7.95	12.70	82.6	63.50	1.506	1.3
HD	10	22	107	63.50	52.37	5.23	49.213	9.53	12.70	100	63.30	1.905	1.4
JF	10	20	70	63.50	52.37	5.23	61.913	11.10	12.70	113	63.50	2.840	1.9
H0	12	5	10	76.20	63.50	6.76	49.213	9.53	19.05	100	76.20	2.556	0.9
JF	12	20	70	76.20	63.50	6.76	61.913	11.10	19.05	132	76.20	3.720	1.0
MH	12	18	61	76.20	63.50	6.76	75.405	12.70	19.05	144	76.20	4.430	1.7

Notes:

1. Rate gearhead performance by the first letter of "Gearhead Type" tabulated. See performance below.

2. Other gear ratios and mounting configurations are available on request.

3. Overall gearing efficiency = 90%.

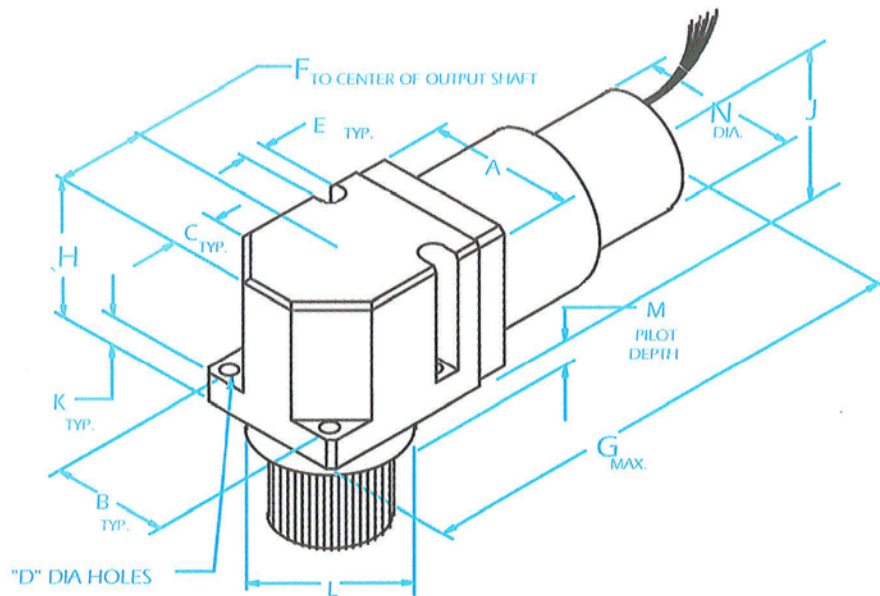
4. Temperature coefficient is °C rise per watt loss, while mounted on a 150 x 150 x 6 mm black aluminum plate.

5. Dry film lubrication for cryogenic temperature operation is available on request. Contact CDA's engineering department for information.

6. Add 15 mm to "G" dimension for Brushless Permanent Magnet Motor Actuators.

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	12	1.4	20	2.3	6.0 E+03	6.8 E+02
C	1.000	25.40	50	5.6	100	11	1.6 E+04	1.8 E+03
D	1.250	31.75	180	20	360	41	2.5 E+04	2.8 E+03
F	1.500	38.10	400	45	800	90	4.3 E+04	4.7 E+03
H	2.000	50.80	1000	112	2000	225	7.4 E+04	8.4 E+03
J	2.500	63.50	2000	225	4000	450	1.8 E+05	2.0 E+04
M	3.000	76.20	4000	450	8000	900	6.0 E+05	6.8 E+04
N	4.000	101.60	8000	900	16000	1800	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 ⁷	H	J ⁶	K	L	M	N	WEIGHT	TEMP. COEF. ⁴
GEARHEAD ¹	MOTOR	FROM	TO														OZ.	C/WATT LOSS
ARA	03	46	187	0.750	0.620	0.229	0.081	0.140	0.375	2.129	0.833	0.436	0.188	0.7350	0.250	0.750	4.3	7.1
CRA	03	46	187	1.000	0.828	0.300	0.110	0.194	0.500	2.464	1.170	0.594	0.250	0.9750	0.400	0.750	8.0	7.0
CRA	04	46	187	1.000	0.828	0.300	0.110	0.194	0.500	2.680	1.170	0.594	0.250	0.9750	0.400	1.000	10	6.2
DRC	04	46	198	1.275	1.030	0.400	0.129	0.219	0.637	2.920	1.287	0.622	0.250	1.2500	0.450	1.000	16	6.1
DRC	05	16	198	1.275	1.030	0.400	0.129	0.219	0.637	3.318	1.287	0.622	0.250	1.2500	0.450	1.250	17	5.2
FRD	05	42	212	1.525	1.250	0.440	0.149	0.272	0.763	3.723	1.540	0.790	0.375	1.5000	0.500	1.250	25	5.0
HRD	05	45	200	2.000	1.670	0.585	0.177	0.316	1.000	4.202	2.062	1.062	0.375	1.9750	0.675	1.250	40	4.7
FRD	06	42	212	1.525	1.250	0.440	0.149	0.272	0.763	3.985	1.540	0.790	0.375	1.5000	0.500	1.500	28	3.0
HRD	06	45	200	2.000	1.670	0.585	0.177	0.316	1.000	4.422	2.062	1.062	0.375	1.9750	0.675	1.500	43	2.9
HRD	08	45	200	2.000	1.670	0.585	0.177	0.316	1.000	4.702	2.062	1.062	0.375	1.9750	0.675	2.000	52	2.3
JRF	08	30	129	2.500	2.060	0.750	0.206	0.430	1.250	5.467	2.562	1.312	0.500	2.4750	0.800	2.000	85	2.3
JRF	10	30	129	2.500	2.060	0.750	0.206	0.430	1.250	5.877	2.562	1.312	0.500	2.4750	0.800	2.500	130	2.0
MRH	10	33	130	3.313	2.750	1.062	0.265	0.600	1.656	6.763	3.188	1.688	0.687	3.2500	1.175	2.500	185	2.0
MRH	12	33	130	3.313	2.750	1.062	0.265	0.600	1.656	7.362	3.188	1.688	0.687	3.2500	1.175	3.000	225	1.7

Notes:

1. Rate gearhead performance by the "Gearhead Type" tabulated. See following page.
2. Other gear ratios and mounting configurations are available on request.
3. Overall gearing efficiency = 85%.
4. Temperature coefficient is in °C rise per watt loss, while mounted on a 6" x 6" x 0.25" black aluminum plate.
5. Dry film lubrication 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.
7. Add 0.575" to "G" dimension for Brushless Permanent Magnet Motors.

SYSTEM INTERNATIONAL - (DIMENSIONS IN mm)																		
TYPE		RATIOS (SEE NOTE 2)		A	B	C	D	E	F	G ⁷	H	J ⁶	K	L	M	N	WEIGHT	TEMP. COEF. ⁴
GEARHEAD ¹	MOTOR	FROM	TO														kg	'C/WATT LOSS
ARA	03	46	187	19.05	15.75	5.82	2.06	3.56	9.35	54.1	21.16	11.07	4.78	18.669	6.4	19.05	.122	7.1
CRA	03	46	187	25.4	21.03	7.62	2.79	4.93	12.70	62.6	29.72	15.09	6.35	24.765	10.0	19.05	.227	7.0
CRA	04	46	187	25.4	21.03	7.62	2.79	4.93	12.70	68.1	29.72	15.09	6.35	24.765	10.0	25.40	.284	6.2
DRC	04	46	198	32.39	26.16	10.16	3.28	5.56	16.18	74.2	32.69	16.81	6.35	31.750	11.5	25.40	.455	6.1
DRC	05	46	198	32.39	26.16	10.16	3.28	5.56	16.18	84.3	32.69	16.81	6.35	31.750	11.5	31.75	.483	5.2
FRD	05	42	212	38.73	31.75	11.18	3.78	6.91	19.38	94.6	39.12	20.07	9.53	38.100	12.7	31.75	.710	5.0
HRD	05	45	200	50.80	42.42	14.86	4.50	8.03	25.40	107.0	52.37	26.97	9.53	50.165	17.1	31.75	1.14	4.7
FRD	06	42	212	38.73	31.75	11.18	3.78	6.91	19.38	101.2	39.12	20.07	9.53	38.100	12.7	38.10	.795	3.0
HRD	06	45	200	50.80	42.42	14.86	4.50	8.03	25.40	112.3	52.37	26.97	9.53	50.165	17.1	38.10	1.22	2.9
HRD	08	45	200	50.80	42.42	14.86	4.50	8.03	25.40	119.3	52.37	26.97	9.53	50.165	17.1	50.80	1.48	2.3
JRF	08	30	129	63.50	52.32	19.05	5.23	10.92	31.75	139.0	65.07	33.32	12.70	62.865	20.3	50.80	2.41	2.3
JRF	10	30	129	63.50	52.32	19.05	5.23	10.92	31.75	149.3	65.07	33.32	12.70	62.865	20.3	63.50	3.69	2.0
MRH	10	33	130	84.15	69.85	26.97	6.73	15.24	42.06	172.0	80.97	42.87	17.44	82.550	30.0	63.50	5.26	2.0
MRH	12	33	130	84.15	69.85	26.97	6.73	15.24	42.06	187.0	80.97	42.87	17.44	82.550	30.0	76.20	6.39	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 rise per watt loss, while mounted on a 150 x 150 x 6 mm black aluminum plate.
5. Dry film lubrication 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.
7. Add 15 mm to "G" dimension for Brushless Permanent Magnet Motors.

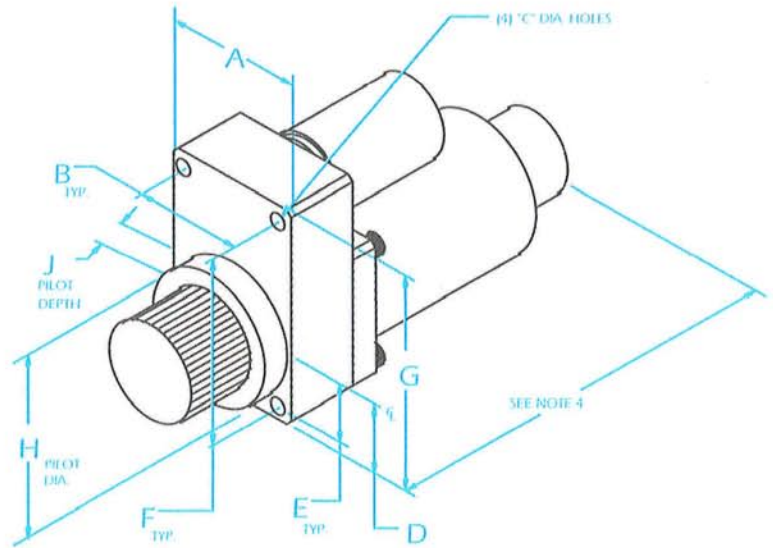
RIGHT ANGLE GEARHEAD RATINGS								
Gearhead Type	"A" Basic Size		Torque Capacity				Torsional Spring Constant	
			Continuous		Intermittent			
	Inches	mm	Lb-In	Nm	Lb-In	Nm	Lb-In	Nm/Rad
ARA	0.750	19.05	12	1.4	20	2.3	6.0 E+03	6.8 E+02
CRA	1.000	25.40	50	5.6	100	11	1.6 E+04	1.8 E+03
DRC	1.250	31.75	180	20	360	41	2.5 E+04	2.8 E+03
FRD	1.500	38.10	400	45	800	90	4.3 E+04	4.7 E+03
HRD	2.000	50.80	1000	112	2000	225	7.4 E+04	8.4 E+03
JRF	2.500	63.50	2000	225	4000	450	1.8 E+05	2.0 E+04
MRF	3.000	76.20	4000	450	8000	900	6.0 E+05	6.8 E+04

Rotary Actuators with High Accuracy Position Feedback

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.



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.

CDA may provide the linear conversion in an "open frame" type design, where the ball screw is accessible to the customer, or in an enclosed container, with integral end stops and interfaces. The tabulated chart below delineates some of our more popular ball screw sizes. We also show some typical mounting arrangements for enclosed linear actuators.

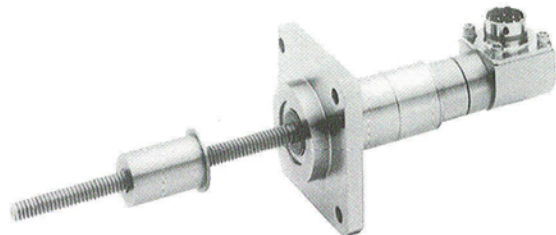
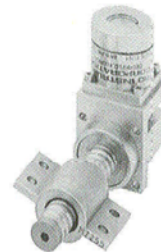
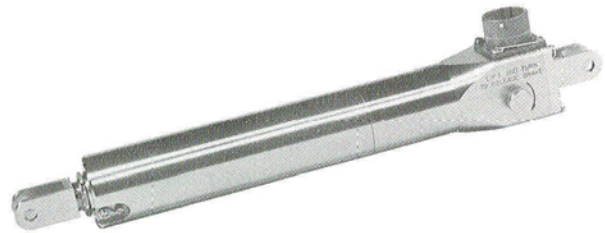
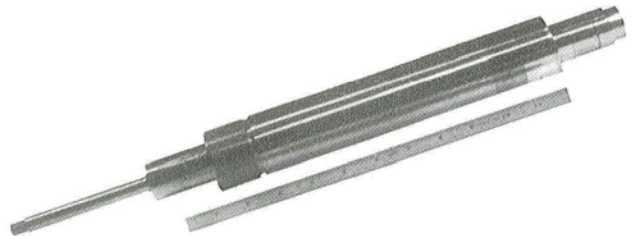
In addition to ball screw configurations, we may provide ACME leadscrews or planetary roller screws for the linear conversion. Each configuration has their advantages and disadvantages in terms of cost and performance. Contact CDA's Engineering Department for additional information.

Since each linear application is unique in terms of mounting configurations, stroke length and loading characteristics, it is difficult to tabulate standard configurations as we have presented for our rotary actuators. We recommend the design engineer contact CDA directly to establish configuration and performance characteristics for each linear application.

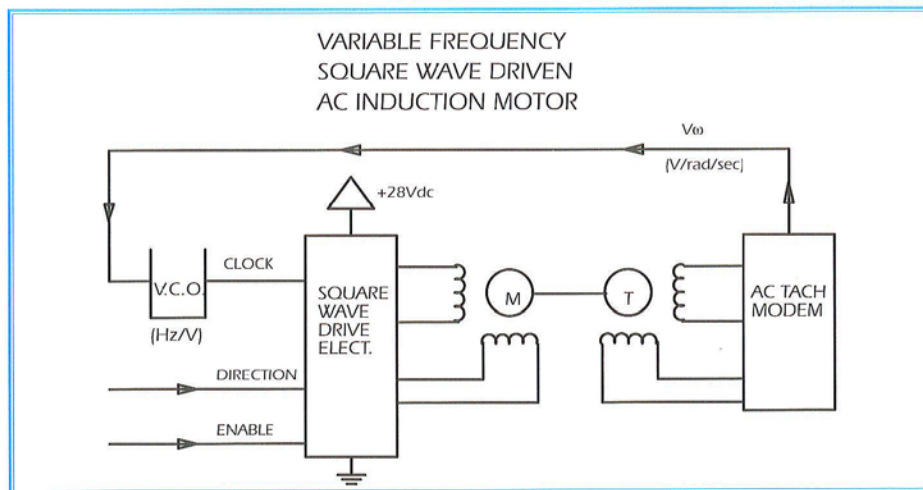
The photos shown to the right are some examples of linear actuators with various mounting and linear conversion options.

Features:

- Optional Position Feedback
- Cryogenic operation available
- In-Line or Right Angle Power Drive Options
- End Stop impact capability
- High power output capacity
- Linear conversion options
- Optional integral high speed rotary transducer
- Optional integral friction or detent brake
- High compression/tension capacity
- High Grade Stainless Steel Construction



Variable Frequency, Square Wave Driven AC Induction Motors



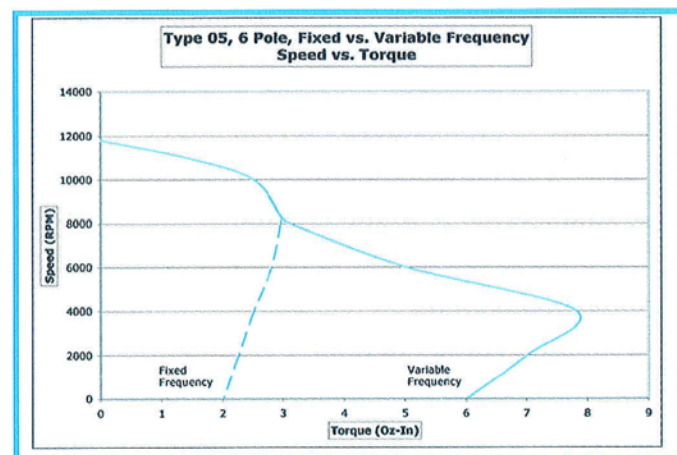
Variable Frequency, Square Wave Driven AC Induction Motors can significantly increase motor efficiency, torque capacity, and mechanical power output within a given motor frame size, while maintaining simple, cost efficient, high efficiency control electronics. This drive technique is recommended in moderate power output servo and open loop applications, as a cost effective alternative to Brushless P.M. motors, or a high reliability alternative to Brush type DC motors.

The schematic above shows velocity feedback of the motor rotor via the AC Tachometer. This velocity information is used to determine the operating frequency of the motor via the Voltage Control Oscillator (VCO). This simple variable frequency topology allows the actuator to operate at high frequencies at high speeds for high power output capacity, and low frequencies at low speeds for high torque per watt capacity.

The design engineer may select the frequency range of operation to optimize performance for a specific application. For instance, to obtain high power output capacity, the high end speed may operate to 600 Hz, while the low speed frequency may be limited to 100 Hz.

An important aspect of this drive scenario is the increase in power input as the speed reduces. Because the impedance of AC motors reduces as the frequency reduces, the power input at a constant voltage will increase, as the frequency and speed decreases. This characteristic effect may be minimized or eliminated by limiting the current to a predetermined value. This requires square wave drive power stages to have current limit capabilities, which most drivers have as an option.

Figure VFO is an actual Speed vs. Torque curve for a Type 05, 6 pole AC motor operated from 600 Hz. down to 100 Hz. The variable frequency drive in this example has provided 200% more stall torque, at 25% less power input, than a fixed frequency 600 Hz drive would provide. Additionally, the variable frequency provision achieves nearly 15 times the mechanical power output as compared to fixed frequency 100 Hz. operation. As shown in this curve, current limiting is recommended since the impedance of the motor decreases with decreasing frequency, the stall power might be too high for a given application. Other performance benefits are realized in this

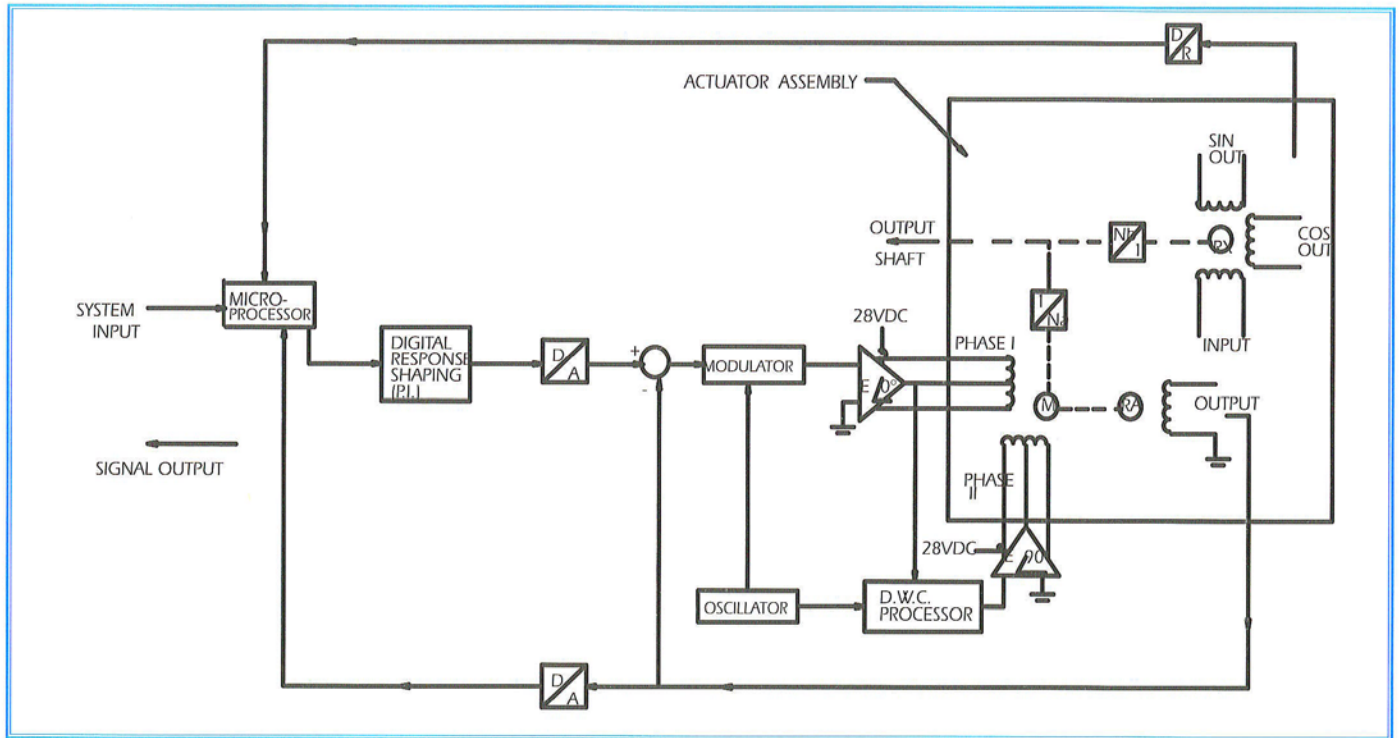


example, such as maximum power output, peak torque, motor maximum efficiency, and motor effectiveness. Clearly, this simple drive circuitry provides considerable benefits over other AC drive methods, while using simple, high efficiency control electronics, with DC source voltages. This control method is a viable alternative to Brushless Permanent Magnet actuators and control requirements.

A tabulated comparison of the key characteristics of the variable frequency operation example over a fixed frequency 600 Hz and 100 Hz application. Call CDA's engineering department for a complete test report and additional information on variable frequency operation.

Parameter	Units	Variable Frequency Operation	Fixed 600 Hz. Operation	Fixed 100 Hz. Operation
Stall Torque	Oz-In	6.0	2.0	6.0
	mNm	42	14	42
Stall Power (for torque noted above)	Watts	33	44	33
Maximum Power Output	Watts	25	25	1.7

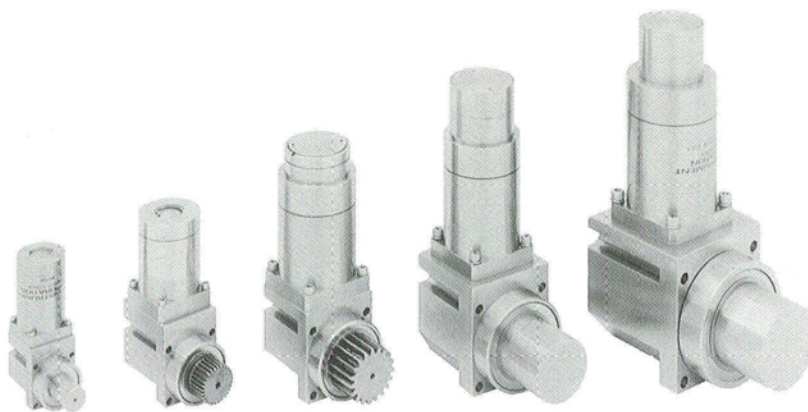
Dual Winding Control AC Induction Motors



This functional block diagram is shown as a digital system. However, the concept and functionality of the Dual Winding Control (DWC) AC Induction Actuator will also work in an analog control system. In low to moderate power output servo systems, this concept will be more cost effective than a Brushless Permanent Magnet Actuator system. Additionally, this system will be more efficient than a Fixed Phase AC Induction Actuator.

The DWC processor, shown in the block diagram, is simply a full wave bridge to keep a constant polarity of the signal going into the Phase II amplifier. This provides phase sensitive actuation, so the actuator will reverse direction of rotation on command.

The block diagram also represents a servo actuator with integral load feedback information, and high-speed rotary acceleration feedback.



Rotary Accelerometer Applications for Stepper Motor Actuators

Rotary Accelerometers (RA's) have many practical uses for stepper motor applications. CDA InterCorp's RA's do not require excitation, and provide a DC output in proportion to the motor rotor acceleration. There is no need for external power input or output demodulation to process the signal. With excellent output gain, RA's provide high signal to noise ratio giving robust feedback signals. Typical benefits or applications with stepper motors include step crossover switching, unit step integrity feedback, inertial compensation, and dynamic speed vs. torque operation.

Crossover Switching is used to operate the stepper motor in the high speed slew region of performance. The output of the RA can be used to detect the crossover, or step angle, of the stepper motor. When the accelerometer output goes to zero, the unit step angle has been achieved, and the unit may be pulsed to the next step. Quite simply, set the "clock" input of the stepper motor to step when the accelerometer output goes to zero, this allows the motor to be stepped at the optimum pulse rate while maintaining pulse count, and eliminating overshoot oscillations.

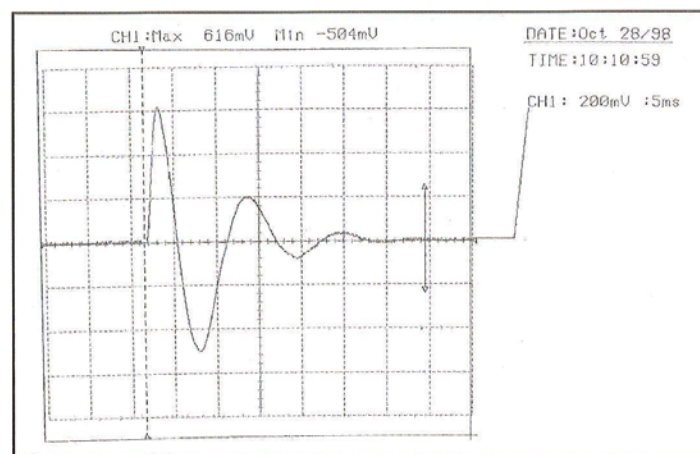
This type of stepper motor control may offer many benefits to the performance of a stepper motor. This technique automatically slews the motor to the maximum allowable pulse rate for a given torque load, or it may also be "clocked" to limit the pulse rate to a specific limit. One disadvantage of conventionally driven stepper motors is the fact that if pull out torque capacity is reached in an application, the motor will lose all torque capacity and fall out of operation. However, with Crossover Switching, if the pull out torque capacity is reached at a specific pulse rate, the motor does not lose torque capacity, but rather simply reduces pulse rate automatically - significantly increasing torque margin capacity of a motor without increasing power input.

Unit Step Integrity Feedback may be obtained by looking at the magnitude of the output of the RA. For each given step output, the RA will produce an output signal in response to each pulse. This information is useful in determining whether or not the motor has stepped in response to the pulse. Additionally, this may be used in indexing, or initializing, a stepper motor against a stop in order to "zero" the motor step count. An RA can provide the information to determine if steps have been missed, or if an end stop has been reached.

Inertial Compensation may be derived by feeding the acceleration signal back to a power stage amplifier, to minimize the effect of overshoot and resonant situations. If current feedback is available in the stepper motor controller, the RA's output may be used as feedback into a current loop, which may eliminate high inertial load resonances and torque reduction areas. For a simpler approach, RA's may be used to determine optimum stepping rate for a specific application. By analyzing the accelerometer output, it can be easily determined where the ideal stepping rate is, within a given range, by assuring that the motor is stepping in the proper region of operation. With the characteristic overshoot and bounce inherent in stepper motors, there are some pulse rates which result in an increase in torque capacity, and some pulse rates which result in a reduction of torque capacity. It is easily determined from the output of an RA where these operational pulse rates occur. This information is very beneficial for minimization of power consumption, or system simulation purposes.

Below is an actual scope trace which shows the output of a type

03ACC RA, on the back of a type 16-2P6-20 stepper motor. This is a classic acceleration profile for a single step of a stepper motor. From this direct output you can determine crossover time, overshoot, settling time, desired optimum pulse rate for maximum dynamic torque, and unit step integrity. For performance critical applications, the RA output may be utilized to determine mechanism integrity through the acceleration output. There will be a direct indication from the RA if torque or friction levels of the load or mechanism increases. The brushless DC output provides the ultimate in simplicity, reliability, and effectiveness.

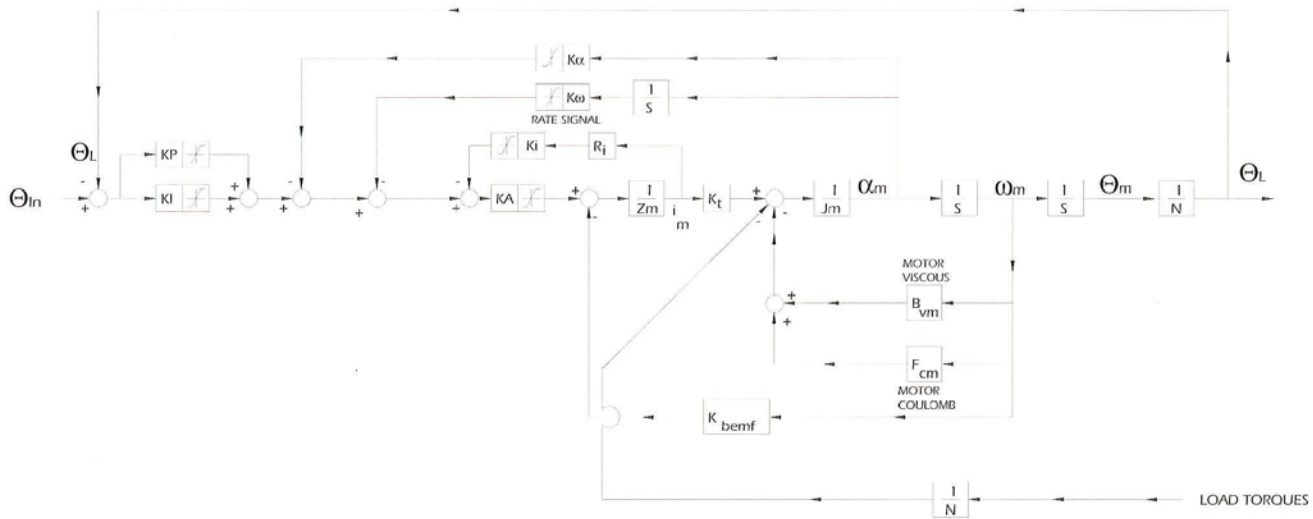


Dynamic Speed vs. Torque Operation may be obtained with a stepper motor with RA feedback. As mentioned under the Crossover Switching section, a stepper motor with RA feedback may obtain dynamic speed vs torque characteristics. Without the RA, stepper motors are usually driven at a fixed operational clock, or pulse rate. Once the pull out torque capacity of such a stepper motor is reached for a given pulse rate, the stepper motor will not continue to run, and the motor will lose all torque capacity. Conversely, with the RA feedback, once the pull out torque capacity has been reached, the motor simply slows down to a lower pulse rate, rather than pull out of operation. This increases torque margin and capacity tremendously, as the stepper motor now performs more like a servo motor, without the complicated electronics. The following information shows the benefits of Dynamic Speed vs. Torque Operation for specific examples, and other performance enhancing characteristics of an RA.

Soft Stepping: In high inertia applications structure borne resonances can be avoided or minimized through a technique called "Soft Stepping". Soft Stepping uses the acceleration signal to attenuate the peak torque transients created at the start of a step, and significantly reduce overshoot and settling time without reducing torque margin. Contact CDA's engineering department for more information on Soft Stepping.

Motor Performance and System Characterization: Another significant advantage of incorporating an RA on a stepper motor actuator is the ability to determine motor output torque, resonant frequency, harmonic disturbances and even load inertia and friction characteristics. Since acceleration and torque are proportional, the output of an RA may be directly analyzed to determine torque characteristics. CDA has authored a technical paper on this subject, and a copy may be obtained by contacting CDA engineering or customer support directly.

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



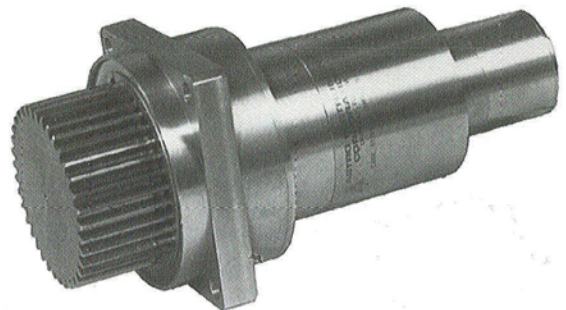
Where:

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_{LN} = Load Position Command

K_i = Integration Gain of Error Signal
 K_{ω} = Velocity Signal Gain
 K_A = Power Amplifier Gain
 Z_M = Motor Impedance ($R_o + j\omega L$)
 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.



Equations of Motion

Use the equations below to determine maximum velocity, acceleration and position at a particular point in time. Units for analysis are Radians, Rad/sec, and Rad/sec².

Where:

$\Delta\theta$ = Total Change in Position

$\theta\alpha$ = Change in Position during Acceleration

θc = Change in Position during Constant

Velocity

θd = Change in Position during Deceleration

$t\alpha$ = time during acceleration

$t c$ = time during Constant Velocity

$t d$ = time during Deceleration

ω_{max} = Maximum Velocity

θ_t = Position at time "t"

θ_o = Position at initial analysis point "o"

ω_o = Velocity at initial analysis point "o"

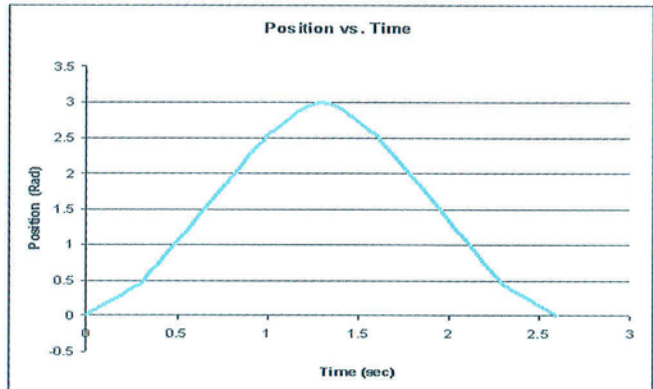
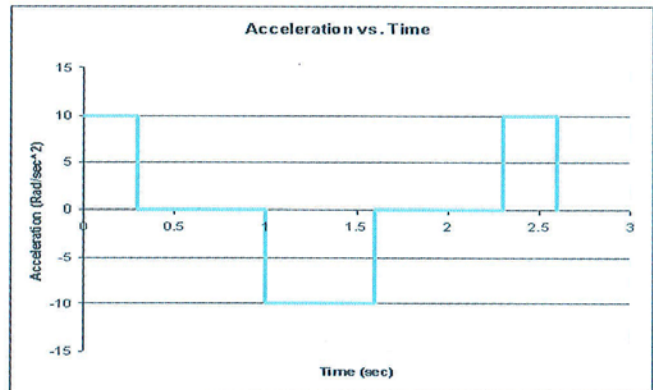
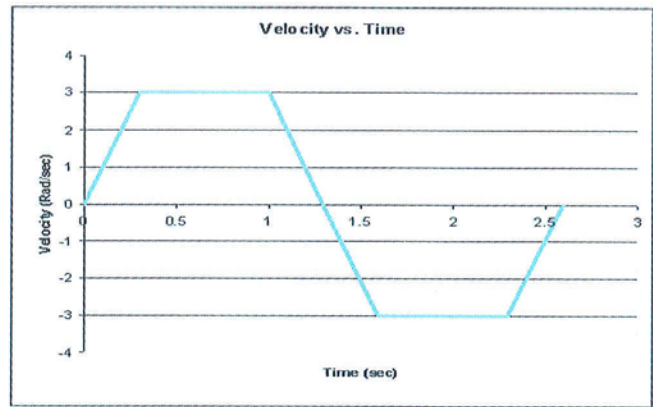
$$\Delta\theta = \theta\alpha + \theta c + \theta d$$

$$\Delta\theta = \omega_{max} \cdot \left(\frac{t\alpha}{2} + t c + \frac{t d}{2} \right)$$

$$\omega_{max} = \frac{\Delta\theta}{\left(\frac{t\alpha}{2} + t c + \frac{t d}{2} \right)}$$

$$\alpha = \frac{\omega_{max}}{t\alpha}$$

$$\theta_t = \theta_o + \omega_o \cdot t + \frac{1}{2} \alpha t^2$$

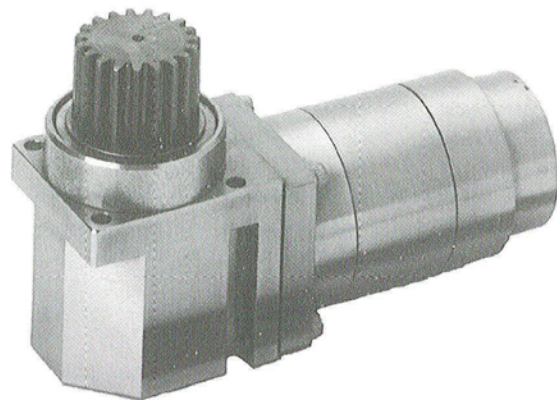


Notes & Tips:

Our curves show a trapezoidal velocity profile that returns to the initial position. This is referred to as a "scan" profile. If you require a "step" input, that is move from position "A" to Position "B", no negative velocity is required. A triangular velocity profile ($t c = 0$) results in the minimum power consumption for a given application requirement.

In calculating torque requirements, reflect all your inertias to a particular point, and calculate your maximum acceleration. Don't forget that friction and mass imbalance can actually help you decelerate or accelerate with gravity assist. Additionally, gearbox efficiency should NOT be added to the torque required to accelerate the motor rotor.

These curves and equations are for analysis of servo applications. The equations are not applicable for stepper motor applications, as stepper motors accelerate and decelerate at each step. Refer to CDA's "Stepper Motor Engineering Reference" brochure for stepper motor performance analysis.



CONVERSION TABLE

TORQUE							
GIVEN UNITS	A \ B	Oz-In	Lb-Ft	Dyne-cm	Nm	p-cm	kp-m
	Oz-In	1	5.21 E-03	7.06 E04	7.06 E-03	72	7.2 E-04
	Lb-Ft	192	1	1.36 E07	1.36	1.38 E04	0.1383
	Dyne-cm	1.42 E-05	7.38 E-08	1	1.0 E-07	1.02 E-03	1.02 E-08
	Nm	142	0.7376	1.0 E07	1	1.02 E04	0.1020
	p-cm	1.39 E-02	7.23 E-05	981	9.81 E-05	1	1.0 E-05
	kp-m	1389	7.23	9.81 E07	9.81	1.0 E05	1

INERTIA							
GIVEN UNITS	A \ B	Oz-In-sec ²	Oz-In ²	slug-ft ²	Lb-Ft ²	gm-cm ²	kg-m ²
	Oz-In-sec ²	1	386	5.21 E-03	0.1676	7.06 E04	7.06 E-03
	Oz-In ²	2.59 E-03	1	1.35 E-05	4.34 E-04	183	1.83 E-05
	slug-ft ²	192	7.41 E-04	1	32.2	1.36 E07	1.36
	Lb-Ft ²	5.97	2304	3.11 E-02	1	4.21 E05	4.2 E-02
	gm-cm ²	1.42 E-05	5.47 E-03	7.38 E-08	2.37 E-06	1	1.0 E-07
	kg-m ²	142	5.47 E04	0.738	23.8	1.0 E-07	1

POWER							
GIVEN UNITS	A \ B	Watts	Hp	Oz-In-rpm	Lb-Ft/sec	Joules/sec	Nm/sec
	WATTS	1	1.34 E-03	1352	0.7376	1	1
	Hp	746	1	1.01 E06	550	746	746
	Oz-In-rpm	7.40 E-04	9.92 E-07	1	5.45 E-04	7.4 E-04	7.4 E-04
	Lb-Ft/sec	1.36	1.82 E-03	1833	1	1.36	1.36
	Joules / sec	1	1.34 E-03	1352	3.41	1	1
	Nm/sec	1	1.34 E-03	1352	3.41	1	1

ENERGY							
GIVEN UNITS	A \ B	Joules	Ergs	kwhr	Calories	Lb-Ft	BTU
	Joules	1	1.0 E07	2.78 E-07	0.2388	0.7376	9.48 E-04
	Ergs	1.0 E-07	1	2.78 E-14	2.39 E-08	7.38 E-08	9.48 E-11
	kwhr	3.6 E06	3.6 E13	1	8.6 E05	2.66 E06	3413
	Calories	4.19	4.19 E07	1.16 E-06	1	3.09	3.97 E-03
	Lb-Ft	1.36	1.36 E07	3.77 E-07	0.3239	1	1.29 E-03
	BTU	1055	1.06 E10	2.93 E-04	252	778	1

FORCE AND WEIGHT				
GIVEN	A \ B	Oz	Dynes	Newtons
	Oz	1	2.78 E04	0.2778
	Dynes	3.6 E-05	1	1.0 E-05
	Newtons	3.6	1.0 E05	1

DISTANCE			
GIVEN	A \ B	In	mm
	In	1	25.4
	mm	3.94 E-02	1

To convert from A to B, multiply A by the entry in the table. Conversions are approximate.

Actuation Performance Equations

Mechanical Output Equations

Symbol	Description	Units	Equation	
P _o	Mechanical Power Output Imperial Units	Watts	P _o = (T _L * ω _L)/1352	(T _L in Oz-In, ω _L in RPM)
P _o	Mechanical Power Output System International	Watts	P _o = T _L *ω _L	(T _L in Nm, ω _L in Rad/sec)
T _L	Torques Referred to the Load	Lb-In or Nm	T _{Lmax} = (J _L α _L +J _m N ² α _L + B _L ω _L +K _L θ _L +F _c +Mg _L)max	
N	Gear Ratio	-	N = ω _M / ω _{Lmax}	
f	Angular Velocity for Response Frequency	Hz	ω _{Lmax} = θ _{Lmax} (2πf _{max})	Where: f _{max} = (2π) ⁻¹ (α _{Lmax} /θ _{Lmax}) ^{0.5}
α _L	Angular Acceleration for Response Frequency	Rad / sec ²	α _{Lmax} = θ _{Lmax} (2πf _{max}) ² = ω _{Lmax} (2πf _{max})	
f _n	Natural Circular Resonant Frequency	Hz	f _n = (2π) ⁻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 _{Lmax} = (J _L α _L +J _m N ² (α _L +α _v) + B _L (ω _L +ω _v) +K _L (θ _L +θ _v) +F _c +Mg _L)max	

Where:

J_L = Load Inertia in Oz-In-s² or kgm²
 α_v = Vehicle Angular Acceleration
 B_L = Viscous Friction at the Load
 ω_M = Motor Velocity

J_M = Motor Inertia in Oz-In-s² or kgm²
 ω_v = Vehicle Angular Velocity
 K_L = Spring Constant of Load
 F_c = Coulomb Friction Torque

ω_L = Load Angular Velocity
 θ_v = Vehicle Angular Rotation
 K_G = Gearhead Spring Constant
 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-sec ² or kgm ²	$J_{LRO} = (W_L / g) * (2 \pi P)^{-2}$	Where: W_L = Weight of load in Lbs or N g = gravity acceleration constant (386 in/s ² or 9.8 m/s ²)
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		<input type="checkbox"/> Yes	<input type="checkbox"/> No	Friction Brake		<input type="checkbox"/> Yes	<input type="checkbox"/> No
Velocity Feedback		<input type="checkbox"/> Yes	<input type="checkbox"/> No	Brake Torque Magnitude			
Load Position Feedback		<input type="checkbox"/> Yes	<input type="checkbox"/> No	Motor Redundancy		<input type="checkbox"/> Yes	<input type="checkbox"/> No
Open Loop Rotary Actuator							
Output Torque	T_L			Output Velocity	ω_L		
Duty Cycle	-						
Options:							
Friction Brake		<input type="checkbox"/> Yes	<input type="checkbox"/> No	Brake Torque Magnitude			
Motor Redundancy		<input type="checkbox"/> Yes	<input type="checkbox"/> No	Detent Brake		<input type="checkbox"/> Yes	<input type="checkbox"/> 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		<input type="checkbox"/> Yes	<input type="checkbox"/> No	Friction Brake		<input type="checkbox"/> Yes	<input type="checkbox"/> No
Velocity Feedback		<input type="checkbox"/> Yes	<input type="checkbox"/> No	Brake Torque Magnitude			
Load Position Feedback		<input type="checkbox"/> Yes	<input type="checkbox"/> No	Motor Redundancy		<input type="checkbox"/> Yes	<input type="checkbox"/> No
Open Loop Linear Actuator							
Output Torque	T_L			Output Velocity	ω_L		
Duty Cycle	-			Stroke Length	θ_L		
Options:							
Friction Brake		<input type="checkbox"/> Yes	<input type="checkbox"/> No	Brake Torque Magnitude			
Motor Redundancy		<input type="checkbox"/> Yes	<input type="checkbox"/> No	Detent Brake		<input type="checkbox"/> Yes	<input type="checkbox"/> 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 design manual brochures.



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