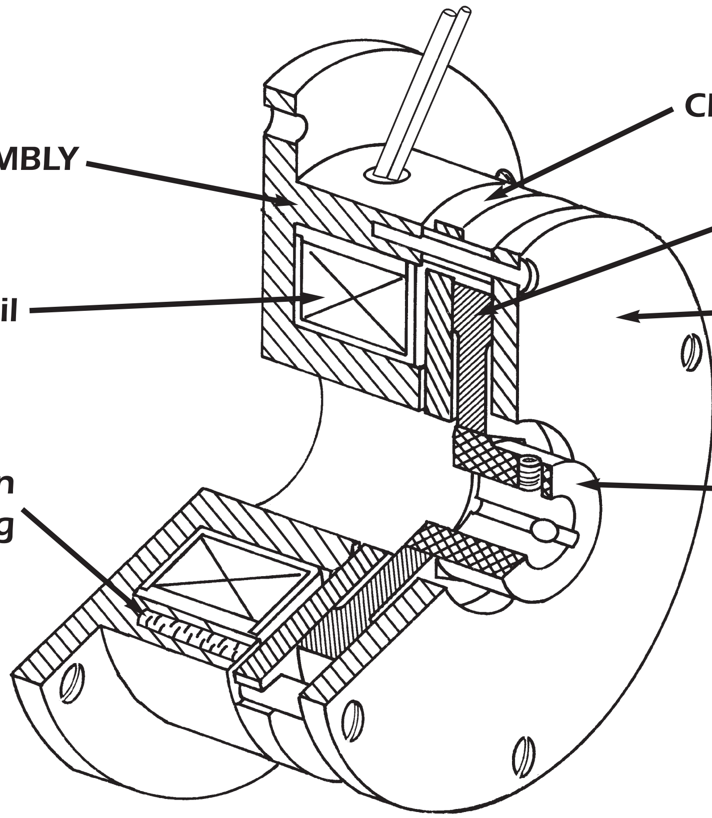


Generating the Braking Torque

Inertia Dynamics FSB/FSBR spring applied brakes are designed to decelerate or park inertial loads when the voltage is turned off, either intentionally or accidentally, as in the case of a power failure. The friction disc with the hex hub is coupled to the shaft to be braked but is capable of moving axially. Through several compression springs, the axial force acts against the axially moving clapper plate which compresses the armature (friction disc) against the pressure plate. Brake torque is generated on both faces of the friction disc.

When DC voltage is applied to the coil, the magnetic force caused by the magnetic flux pulls the clapper across the air gap against the force of the compression springs. The friction disc is released, and the brake is free of torque.

Special Features of the IDI Brake

- ☐ Several compression springs on the outermost radius of the friction disc increase the torque-to-size ratio and provide greater repeatability.
- ☐ Factory-set air gap needs no adjustments and is practically maintenance-free.
- ☐ All parts effectively protected against corrosion.
- ☐ Advanced friction material technology for long life and high torque. Always asbestos-free.
- ☐ Two mounting styles offered to accommodate your specific application.
- ☐ Manual release brakes available as standard or custom-designed for your needs.
- ☐ Metric bore sizes available upon request.

Determining the Brake Size

Static Applications

A static application is one in which there is no dynamic braking. In this mode the brake is used to hold the inertial load in a fixed or parked position. Match your required torque to the static torque rating of the brake. Be sure the brake torque exceeds your requirement. A service factor of 1.4 is recommended.

Dynamic Applications

A dynamic application is one in which the brake decelerates an inertial load. To properly size the brake you need to calculate the dynamic torque required. There are two methods that can be used.

$$T_d = \left[\frac{WR^2 \times N}{C \times t} \right] \times S.F.$$

Where:

WR^2 = Total inertia reflected to the brake, lb.–in.^{2} (kg.m^2)
N = Shaft speed at inertial load, RPM
C = Constant, use 3696 for English units and 9.55 for metric units
t = Desired stopping time, seconds
S.F. = Service Factor, 1.4 recommended
T_d = Average dynamic braking torque, lb.–in. (N–m)

Inertia Dynamics brakes are rated by static torque. Therefore, the dynamic torque rating obtained should be converted to a static torque value:

$$T_S = \frac{T_d}{0.80}$$

NOTE:
The 80% derating factor should be used as a guide only.

Where:

T_S = Static torque
0.80 = derating factor

The brake size can also be determined using the selection charts. Find the intersection of the prime mover horsepower (HP) and shaft speed at the brake using the selection charts. (Fig. A & B). The relationship between the horsepower and speed to determine the dynamic torque required is expressed as:

$$T_d = \left[\frac{63{,}025 \times P}{N} \right] \times S.F.$$

Where:

T_d = Average dynamic torque, lb.–in.
P = Horsepower, HP
N = Shaft speed at the brake
S.F. = Service Factor
63,025 = Constant

Additional formulas and conversion charts are found on pages 38 and 72.

Fig. A

Type FSBR Series Selection

	SHAFT SPEED AT BRAKE (RPM)																			
HP	100	200	300	400	500	600	700	800	900	1000	1100	1200	1500	1800	2000	2400	3000	3600	4000	5000
1/50																				
1/20																				
1/12											7									
1/8																				
1/6											15									
1/4																				
1/3																				
1/2											35									
3/4											50									
1																				
1 1/2											100									
2																				
3																				
5																				
7 1/2																				
10																				

Fig. B.

Type FSB Series Selection

Torque Rating vs. RPM (Sizes 001 through 007) – Selection Chart

TORQUE LB.–IN.*	SHAFT SPEED AT BRAKE (RPM)																			
	100	200	300	400	500	600	700	800	900	1000	1100	1200	1500	1800	2000	2400	3000	3600	4000	5000
.50											001									
.75																				
1.0																				
2.0											003									
2.5																				
2.75																				
3.0																				
5.0																				
6.25											007									
6.5																				
6.75																				
7.0																				

*Slightly higher torque ratings may be allowable for some speeds. Consult Inertia Dynamics.

HP vs. RPM (Sizes 15 thru 100) – Selection

HP	SHAFT SPEED AT BRAKE (RPM)																			
	100	200	300	400	500	600	700	800	900	1000	1100	1200	1500	1800	2000	2400	3000	3600	4000	5000
1/50																				
1/20																				
1/12											15									
1/8																				
1/6																				
1/4																				
1/3											35									
1/2																				
3/4											50									
1																				
1 1/2											100									
2																				
3																				
5																				
7 1/2																				
10																				

Selection Considerations

The required size is determined mostly from the brake torque needed. The inertia to be braked, the speed, the braking times, duty cycle, and life requirements are all considerations in brake sizing. Other conditions to be considered are ambient temperatures, humidity, dust, and contaminants which may affect the brake performance. For these reasons, brake performance should be evaluated under actual application conditions.

Brake Location

Whenever possible, the brake should be mounted to the highest-speed shaft. This will allow a brake with the lowest possible torque to be used. However, the maximum allowable shaft speed should not be exceeded.

120 VAC Operation

All brakes include full wave rectification.

Maintenance

Inertia Dynamics brakes are virtually maintenance-free. The air gap is set at the factory and requires no adjustments. The friction faces must be kept free of grease and oil for proper operation.

Response Time - Standard Power-Off Brakes

The following is a list of typical "Pick" and "Drop" times for standard power-off brakes.
"Pick" is defined as time to electrically energize and free the brake of torque.
"Drop" is defined as time to electrically de-energize and produce torque.

SERIES	PICK TIME	DROP TIME WITH DIODE ARC SUPPRESSION	DROP TIME WITH MOV ARC SUPPRESSION
001	8	14	7
003	26	30	14
007	39	88	30
015	30	92	35
035	60	205	70
050	68	60	32
100	100	140	50
20	30	92	40
90	45	75	25
180	40	140	40
400	85	160	45
1200	138	170	50

All times are measured in milliseconds.

NOTES:

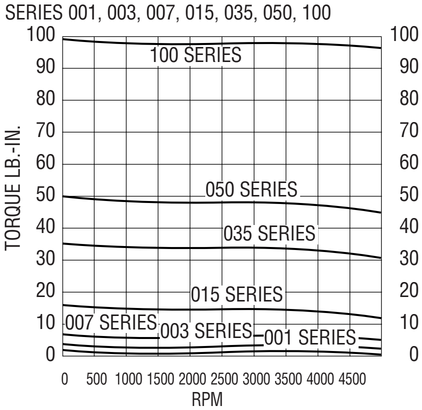
1. Brakes tested at 72°F and at nominal voltage and air gap.
2. The Pick and Drop values are typical and should only be used as a guide.
3. For special applications consult Inertia Dynamics engineering.

Torque Data

SPRING APPLIED BRAKES			
SERIES	TYPICAL OUT-OF-BOX TORQUES LB. – IN.	RATED STATIC TORQUES LB. – IN.	TYPICAL TORQUES AFTER BURNISHING LB. – IN.
001	1	1	1.5
003	3	3	4
007	7	7	9
015	15	15	18
035	35	35	42
050	50	50	60
100	100	100	120

Dynamic Torque Curve

SERIES 001, 003, 007, 015, 035, 050, 100



Maximum Recommended/ Safe Input RPM

(Note: Consult Inertia Dynamics Engineering for Special Applications)

Type: FSB and FSBR

SIZE	MAX. INPUT RPM
001 003	9,000
007 015	7,500
035 050	7,000
100	5,000

FSB Allowable Cycles/Minutes*

MODEL NO.	RPM	INERTIA (LB. – IN.^{2}) 1	5	10	50	MODEL NO.	RPM	INERTIA (LB. – IN.^{2}) 10	50	100	500
001	1800	60	12	6	1	035	1800	25	5	2.5	5
	3600	15	3	1.5	–		3600	5	1	.5	–
003	1800	80	16	8	2	050	1800	25	5	2.5	.5
	3600	20	4	2	–		3600	5	1	.5	–
007	1800	150	30	15	3	100	1800	50	10	5	1
	3600	150	30	15	3		3600	12	2.5	1.2	–
015	1800	150	30	15	3						
	3600	40	8	4	.8						

*Chart intended as a guide. For other speeds and inertias, consult Inertia Dynamics.

FSBR Allowable Cycles/Minute*

MODEL NO.	RPM	INERTIA (LB. – IN.^{2}) 5	10	50	100
007	1800	30	15	3	–
	3600	8	4	.8	–
015	1800	30	15	3	–
	3600	8	4	.8	–
035	1800	50	25	5	2.5
	3600	10	5	1	.5
050	1800	50	25	5	2.5
	3600	10	5	1	.5
100	1800	100	50	10	5
	3600	25	12	2.5	1.2

*Chart intended as a guide. For other speeds and inertias, consult Inertia Dynamics.

Burnishing

Burnishing is a wearing-in or mating process which will ensure the highest possible output torques. Burnishing is accomplished by forcing the brake to slip rotationally when energized. Best results are obtained when the unit is energized at 30-40% of rated voltage and forced to slip for a period of 2-3 minutes at a low speed of 100-200 RPM Units in applications with high inertial loads and high speed will usually become burnished in their normal operating mode. Whenever possible, it is desirable to perform the burnishing operation in the final location so the alignment of the burnished faces will not be disturbed. For additional information on burnishing procedures ask for burnishing spec. #040-1069.

Hi-Pot Testing

All brakes are tested 100% for Hi-Pot failures. Typical tests are at 1500 volts RMS. Do not Hi-Pot AC rectified units, since this will potentially damage the rectifiers and cause failure. For specific testing procedures, ask for Hi-Pot spec. #040-10122.

Torque

$$T_d = \frac{63{,}025 \times P \times S.F.}{N}$$

Where:

- T_d = Dynamic Torque (lb.–in.)
- P = Horsepower (hp)
- N = RPM = shaft speed
- S.F. = Service Factor
- 63,025 = Constant

Reflected Inertia

$$\text{Equivalent } WR_A^2 = WR_B^2 \left(\frac{N_B}{N_A}\right)^2$$

Where:

- WR_A^2 = Inertia of rotating load reflected to the clutch or brake shaft (lb.–in.^{2})
- WR_B^2 = Inertia of rotating load (lb.–in.^{2})
- N_B = Shaft speed at load (RPM)
- N_A = Shaft speed at clutch or brake (RPM)

Linear Inertia

$$\text{Equivalent } WR_A^2 = W \left(\frac{V}{2\pi N_A}\right)$$

Where:

- WR_A^2 = Inertia of linear moving load reflected to the clutch or brake shaft (lb.–in.^{2})
- V = Linear velocity of load (in./min.)
- W = Weight of linear moving load (lb.)
- N_A = Shaft speed at clutch or brake (RPM)
- 2π = Constant

Thermal Capacity

$$TC = \frac{WR^2 \times N_A \times n}{4.63 \times 10^8}$$

Where:

- TC = Thermal capacity required for rotational or linear moving loads (hp–sec./min.)
- WR^2 = Total system inertia reflected to the clutch or brake shaft (lb.–in.^{2})
- N_A = Shaft speed at clutch or brake (RPM)
- n = Number of stops or starts per minute, not less than one
- 4.63×10^8 = Constant

Linear Velocity

$$IPM = PD \times N \times \pi$$

Where:

- IPM = Velocity of object (inches per minute)
- PD = Pitch diameter of object (inches)
- N = Speed of shaft at the object (RPM)
- π = Constant

Inertia – (WR^2)

To calculate the inertia for a cylinder, the formula is:

$$WRz^2 = \frac{\pi}{32} \times D^4 \times L \times \rho$$

Where:

- WR^2 = Inertia – lb.–in.^{2} (kg–m^2)
- D = Diameter – inches (meters)
- L = Length – inches (meters)
- ρ = Density – lb./in.^{3} (kg/m^3)

Approximate values for ρ are:

- Steel – .284 (7860)
- Aluminum – .098 (2700)
- Plastic – .047 (1300)
- Rubber – .047 (1300)

For steel shafting, refer to the inertia chart, Fig. A.

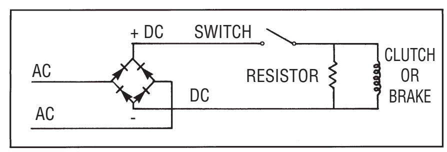
Arc Suppression

When the clutch or brake is de-energized, a reverse voltage is generated in the coil. The reverse voltage can be very high and may cause damage to the coil and switch in the circuit. To protect the coil and switch, the voltage should be suppressed using an arc suppression circuit. Arc suppression does not affect the clutch or brake engagement time.

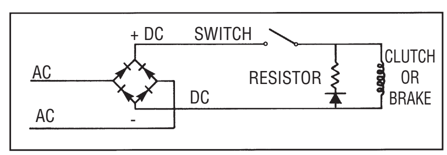
Resistor/Diode/Zener Diode –

Normal Disengagement Time

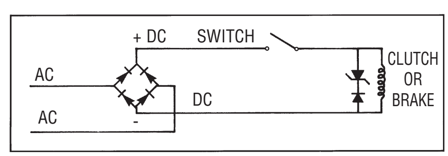
For most applications, a resistor connected in parallel with the clutch/brake coil is adequate. The resistor should be rated at six times the coil resistance and approximately 25% of the coil wattage.



To eliminate the added current draw, a diode may be added as shown below.



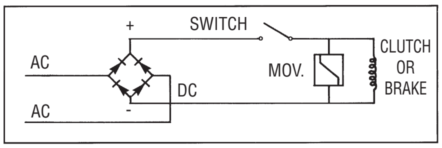
For faster release, use a zener diode with a rating two times the coil voltage.



Metal Oxide Varistor (MOV) –

Fast Disengagement Time

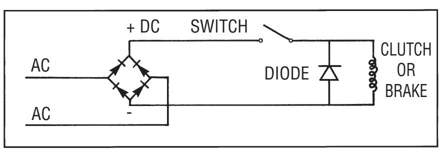
For applications requiring fast clutch or brake disengagement, an MOV connected in parallel with the clutch/brake coil should be used.



Diode

Slow Disengagement Time

For applications where a delayed disengagement is desired, a diode should be used in parallel with the clutch/brake coil or switch the AC side of the circuit.



Inertia Conversion Chart

To determine the inertia of a rotating member of a material other than steel, multiply the inertia of the steel diameter from Fig. A at right by:

MATERIAL	MULTIPLIER
Bronze	1.05
Steel	1.00
Iron	.92
Powdered Bronze	.79
Powdered Metal Iron	.88
Aluminum	.35
Nylon	.17

Fig. A

Inertia Chart

I = WR^2 of Steel (per inch of length)

DIA. (IN.)	WR^2 (LB. – $IN.^2$)
1/4	.00011
5/16	.00027
3/8	.00055
7/16	.00102
1/2	.00173
9/16	.00279
5/8	.00425
11/16	.00623
3/4	.00864
13/16	.01215
7/8	.01634
15/16	.02154
1	.0288
1 1/4	.0720
1 1/2	.144
1 3/4	.288
2	.432
2 1/4	.720
2 1/2	1.152
2 3/4	1.584
3	2.304
3 1/2	4.176
3 3/4	5.472
4	7.056
4 1/4	9.072
4 1/2	11.376
5	17.280
5 1/2	25.488
6	36.000
6 1/4	42.624
6 1/2	49.680
6 3/4	57.888
7	66.816

NOTE:

1. To determine WR^2 of a given shaft, multiply the WR^2 given above by the length of the shaft or the thickness of the disc in inches.
2. For hollow shafts, subtract WR^2 of I.D. from WR^2 of O.D. and multiply by length.

INERTIA		
TO CONVERT FROM	TO	MULTIPLY BY
g – cm^2	lb.–in.^{2}	3.417 x 10^{-4}
g – cm^2	lb.–ft.^{2}	2.373 x 10^{-6}
kg – cm^2	lb.–in^2	3.417 x 10^{-1}
kg – cm – sec^2	lb.–in.^{2}	335.1
N – m – sec^2	lb.–in.^{2}	3417
kg – m^2	lb.–in.^{2}	3417
N – m^2	lb. – in.^{2}	348.47
lb. – in.^{2}	kg – cm^2	2.926
lb. – in.^{2}	kg – m^2	2.9265 x 10^{-4}
lb. – in.^{2}	N – m^2	2.870 x 10^{-3}
lb. – in.^{2}	lb. – in. – sec.^{2}	2.590 x 10^{-3}
lb. – in.^{2}	lb. – ft.^{2}	6.944 x 10^{-3}
lb. – in.^{2}	oz. – in.^{2}	16
lb. – ft.^{2}	lb. – in.^{2}	144
lb. – ft.^{2}	oz. – in.^{2}	2304
lb. – ft.^{2}	oz. – in. – sec.^{2}	5.969
oz. – in.^{2}	oz. – in. – sec.^{2}	2.590 x 10^{-3}
oz. – in.^{2}	lb. – in.^{2}	6.25 x 10^{-2}
oz. – in. – sec.^{2}	oz. – in.^{2}	3.8609 x 10^{-2}
oz. – in. – sec.^{2}	lb. – in.^{2}	24.125

MISCELLANEOUS		
TO CONVERT FROM	TO	MULTIPLY BY
horsepower	ft.–lb./min.	33,000
kilograms	pounds	2.2
meters	millimeters	1000
millimeters	inches	3.937 x 10^{-2}
Newtons	pounds	.225
radians	degrees	57.30
revolutions	radians	6.283
revolutions/min.	degrees/sec.	6
square–inches	square–millimeters	645.2
temp. (°C) + 17.78	temp. (°F)	1.8
temp. (°F) – 32	temp. (°C)	$^5/_9$

TORQUE		
TO CONVERT FROM	TO	MULTIPLY BY
kg–m	lb.–in.	.6026
N–m	lb.–in.	8.850
N–m	oz.–in.	141.69
lb.–in.	g–cm	1152
lb.–in.	kg–cm	1.152
lb.–in.	kg–m	1.6596
lb.–in.	N–m	.1130
lb.–in.	oz.–in.	16.0
lb.–in.	lb.–ft.	.083
lb.–ft.	lb.–in.	12.0

Acceleration Time– The amount of time to move a load from zero to full speed once the spring is wrapped down.

Actuator Limit Stop – The actuator limit stop is a pin or plate that prevents the actuator from bottoming out on the solenoid and causing wear. The actuator is used on DCB models.

Anti-Backup (AB) – This spring prevents oscillation between the clutch and brake springs and prevents the output load from reversing. If stopping accuracy is required, this modification must be specified in the part number.

Anti-Overrun (AOR) – This spring prevents an overhauling load from overrunning the input. The anti-overrun applies when an eccentric load is encountered, maintaining the same output speed as the constant input speed. This spring must be specified in the part number.

Anti-Rotation Slot – A slot in the mounting plate of DCB products. The mounting plate should be retained by a loose-fitting tab or pin through the slot to prevent radial rotation of the clutch/brake.

Control Tang – A tang on either end of the wrap spring which will engage and disengage the input and output hubs.

Deceleration Time – The amount of time required to bring a load to rest once the spring has unwrapped.

Overrunning (OR) – A function of SC clutches. The clutch transmits torque in one direction and allows the load to overrun when the input is stopped or reversed.

Overtravel Stop (OTS) – Disengages the output at a predetermined position every cycle, absorbing a portion of the load. Combined with AB, will provide 20% braking capacity.

Single Revolution (SR) – Control function that results in the output rotating one revolution and stopping in the same position. In SC units, the stopping accuracy is a function of output loads. DCB units maintain ±1° stopping accuracy (noncumulative) independent of output load conditions.

Start Stop (SS) – Control function that results in the output rotating one revolution and then coasting to a stop.

Static Torque – The maximum torque the clutch can generate statically when the wrap spring is completely wrapped down before slipping or damage occurs.

Stop Collar – The stop collar has detent positions to control the clutch or brakes engagement and disengagement. The standard stop collar has one detent, but special collars are available with up to twenty-four detents, or stops, per revolution.

Wrap Spring – The high tensile strength coiled wire in clutches and brakes which allows transfer of a high amount of torque when wrapped tightly around two hubs.

Acceleration Time – The amount of time required to change the speed of an inertial load, from the instant an electrical signal is applied to the time the system is at full speed.

Air Gap – The space between the armature and field when the clutch or brake is disengaged.

Brake-Power Off – Unit used to stop a load when turned off electrically.

Brake-Power On – Unit used to stop a load when turned on electrically.

Build Up Time – The time required to build up 90% of the flux which yields 80% of the rated torque.

Burnishing – A "wearing in" process of the mating friction surfaces for maximum torque.

Clutch – Unit used to couple two parallel shafts via pulleys, gears, or sprockets.

Clutch Coupling – Unit used to couple two in-line shafts.

Decay Time – The time required to decay to 10% of the flux which yields 10% of the rated torque.

Deceleration Time – The amount of time required to stop an inertial load, from the instant an electrical signal is applied to the time the system is at rest.

Dynamic Torque – Torque measured at instant of clutch or brake engagement when one friction member is rotating and the other is stationary or rotating at a different speed. Approximately 80% of static torque.

Field – Coil and housing assembly which forms part of the electromagnet.

Flange – Mounting plate located on brake magnets and clutch fields.

Frictional Torque – The torque required to overcome static friction in the system.

Friction Material – Composition material (nonasbestos) inserted between poles of clutch or brake magnet, used to retard wear rate of iron poles and armature.

Inertia – The property of matter that causes an object to remain at rest or in motion until acted on by an outside force.

Inertial Torque – The torque generated by accelerating or decelerating a load.

Moment of Inertia – WR^2 = Weight of an object times its radius of gyration squared.

Overexcitation – Applying a high voltage for a brief time period to shorten the engagement time. Sometimes referred to as "spiking."

Positive Engagement – An engagement with no slip.

Radial Bearing Load – The maximum load that can be applied to a clutch at maximum speed without causing premature wear.

Residual Magnetism – A condition in magnets where low levels of magnetism remain after electric current is removed.

Rotor – The rotating component of a stationary field clutch that carries the friction material.

Spline Drive – Heavy duty clutch or brake drive comprised of mating armature and hub splines.

Static Torque – Torque measured at instant of breakaway when both friction members are locked in at the same speed or at rest.

Thermal Capacity – Brake rating that takes into consideration number of stops/minute, total inertia, and brake rotational speed.

Time to Speed – The amount of time required to change the speed of an inertial load, from the instant an electrical signal is applied to the time the system is at full speed.

Time to Zero Speed – The amount of time required to stop an inertial load, from the instant an electrical signal is removed to the time the system is at rest.

Torque – The action of a force producing rotation. Torque is comprised of a force (lb.) acting upon a lever arm of length (in.). The product of the force and lever arm is pound–inches (lb.–in.) used to express torque. See "static" and "dynamic" torque.

UL – Underwriters Laboratories – An organization which tests electrical equipment for product safety.

Zero Backlash Armature – A spring mounted armature used to eliminate backlash and dragging of the armature against the field magnet.