Dynaserv
Direct Drive Brushless Servo Systems

Each Dynaserv system consists of a brushless servo motor, microprocessor-based drive, power supply, and a brushless resolver or encoder for position feedback. The primary benefit of the Dynaserv System is high accuracy and torque without speed reducers. Additional advantages include:

- Faster settling time than a traditional servo motor and speed reducer system
- Smooth rotation at slow speeds
- A flat speed/torque curve for high controllability
- Ability to operate in a position, speed or torque control mode
- Built-in test mode simplifies optimum tuning

Select from these four versions:

**DR Series — lowest cost!**
- Brushless resolver feedback
- 13 models: 6, 8 or 10 inch diameter
- Resolutions to 819,200 steps/rev
- Torques to 295 ft-lb (400 Nm)
- Repeatability of ±5 arc seconds

**DR5000 Series — highest torques and speeds!**
- Brushless resolver feedback
- 4 models, 6- or 10-inch diameter
- Resolutions to 425,984 steps/rev
- Torques to 370 lb-ft (500 Nm)
- Speeds to 4 rps

**DM Series — best accuracy and repeatability!**
- Incremental encoder feedback
- 7 models; 6 or 10 inch diameter
- Resolutions to 1,024,000 steps/rev
- Torques to 150 ft-lb (200 Nm)
- Repeatability of ±2 arc seconds
- Clean room operation

**DM1004 Series — most compact motors and drives!**
- Incremental encoder feedback
- 2 models; 4 or 6 inch diameter
- Resolution of 655,360 steps/rev
- Torque of 3 lb-ft (4 Nm)
- Maximum speed of 2.5 rps
- Clean room operation
- Axial and radial run-out of 0.01 mm, a factor 10 better than the standard DR and DM Series

**Dynaserv Accessories**
- Compumotor controllers
  The Dynaserv is compatible with all Compumotor indexers and servo controllers.
- Bases
  Mounting bases to simplify mounting to a flat surface (DR-B Series only).
- Dynamic Braking
  Capacitor type or speed-switching type for each motor size
- Precision Machining
  Axial and radial run-out of 0.01, 0.02 or 0.005 mm is available on most Dynaserv models. Standard axial and radial run-out for all motors is 0.1 mm.
- Mechanical Braking
  Most motors can be ordered with mechanical brakes for power down, or emergency use.
The Dynaserv System allows the user to operate in one of three modes of control:

- Position control – up to 1,024,000 steps/rev
- Speed control – ±10V Velocity command input
- Torque control – stable response at ±8V input

This type of flexibility combined with a high torque/weight ratio, high accuracy, faster settling times, high torque at high speed, smooth rotation, optimum tuning and clean operation all add up to cost effective high performance alternative to the traditional motor and speed reducer combinations.

**High Torque/Weight Ratio**

The Dynaserv motors are designed with a permanent magnet constructed of rare-earth metal located at the center of the stator core.

**Power/Weight Comparison**

<table>
<thead>
<tr>
<th>Diameter (µm)</th>
<th>COUNT (Count/ft • min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>5000</td>
</tr>
<tr>
<td>30</td>
<td>2000</td>
</tr>
<tr>
<td>10</td>
<td>1000</td>
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<tr>
<td>20</td>
<td>500</td>
</tr>
<tr>
<td>10</td>
<td>200</td>
</tr>
<tr>
<td>5</td>
<td>100</td>
</tr>
<tr>
<td>2</td>
<td>50</td>
</tr>
</tbody>
</table>

**High Torque at High Speed**

The torque/speed curve of the various Dynaserv models is very flat. This results in high acceleration at high speeds (4.0 rps) with good controllability.

**Smooth Rotation**

The very low velocity and torque ripple of the Dynaserv contribute to its excellent speed controllability.

**Dynaserv Velocity/Torque Ripple**

Optimum Tuning

Dynaserv systems offer the user a tuning mode that simplifies the setting of optimum parameters for the actual load. Turning on the "test" switch on the front panel of the drive produces a test signal. Utilizing an oscilloscope the gain settings are quickly optimized by adjusting the digital switches and potentiometers on the front panel.

**Clean Operation**

The Dynaserv system is brushless and gearless which results in a maintenance-free operation. With preparation, the DM Series can operate in Class 10 environments.

**Dust from Dynaserv (DM1045B)**

Measured by: LPC-101 Particle Counter
Made by: PMS Corp.
Source: He-Ne Lazor Light
Min. Resolution: 0.1 micro meter (Particle Diameter)
Sampling: 0.1 Cubic feet/min.

**Settling Time comparison in Robot Application**
The Dynaserv has provided solutions to a variety of applications such as:

**Assembly**
- Base machine
- Pick and place
- Inserter/mounter

**Robots**
- Handling
- Clean room
- Universal

**Transport**
- Turn table
- Belt conveyor
- Three-dimensional warehouse

**Material Handling**
By attaching a small arm or linkage to the Dynaserv, very high velocities can be attained. This type of design has been used on a wide variety of equipment, such as a chip mounting machine. On this machine accuracies of 30 arc-sec are maintained with very high arm speed.

**Feed-to-Length**
The Dynaserv system eliminates the need for gear reduction and allows for direct control of the nip roll in most feed-to-length applications. The ability to effectively control loads up to 100 times its own rotor inertia allows the Dynaserv to be applied in a variety of machines. The net result of specifying a Dynaserv system is increased repeatability of the feed material.

**Inspection and Measuring**
- Three dimensional measuring
- Goniometer
- Non-destructive x-ray

**Work**
- Machining center work table
- Press roll feed
- Grinder table

**Commercial**
- Printing machines
- Medical equipment
- Follow-up equipment

**Indexing/Rotary Positioning**
The Dynaserv has high accelerations lending itself to high speed point-to-point positioning applications requiring low cycle time. In scanning and inspection applications the outstanding low speed performance will be of merit.

**Robotics**
Dynaserv direct drive motors were first developed to drive SCARA (Selective Compliance Assembly Robot Arm) in applications requiring repetitive and physically taxing operations.
Motor Construction and Operation

The torque is proportional to the square of the sum of the magnetic flux $\Phi_m$ of the permanent magnet rotor and the magnetic flux $\Phi_c$ of the stator windings. High torque is generated due to the following factors. First, the motor diameter is large. The tangential forces between rotor and stator act at a large radius, resulting in higher torque. Secondly, a large number of small rotor and stator teeth create many magnetic cycles per motor revolution. More working cycles means increased torque.

Direct drive systems couple the load of the system directly to the motor without the use of belts or gears. Most servo motors, brushed or brushless, often lack adequate torque or resolution to satisfy application needs. Therefore, mechanical means, such as gear reduction systems are implemented to meet system requirements. The Dynaserv can provide very high torque in a modest package size and solve many of the performance issues of the gear reducer. All this in a system that is as easy to use as a stepping motor.

Figure 1 below shows the construction of the Dynaserv DM Series direct drive motor compared to a conventional motor with a gear reducer. As shown in the figure, the gear reducer relies on frictional contact to reduce the speed of the load. This gearing effectively increases torque and resolution but sacrifices speed and accuracy. The direct drive motor is brushless and gearless so it eliminates friction from its power transmission. Since the feedback element is coupled directly to the load, system accuracy and repeatability are greatly increased and backlash is eliminated.

Conventional Motor/Gear Reducer

The motor contains precision bearings, magnetic components and integral feedback in a compact motor package. The motor is an outer rotor type, providing direct motion of the outside housing of the motor and thus the load. The cross roller bearings which support the rotor have high stiffness, to allow the motor to be connected directly to the load. In most cases is is not necessary to use additional bearings or connecting shafts.

Gear Reducer System Limitations
- Backlash limits positional accuracy
- Gearing causes a trade-off between speed and resolution
- Inefficiently transfers torque
- Friction introduces inaccuracies and non-linearities
- Gearing reduces stiffness at the load
Selecting your Dynaserv

The normal principals of servo motor sizing apply to the Dynaserv, but there are a few special considerations to keep in mind.

Peak Torque/Continuous Torque

The speed torque curves in this section represent the peak available torque. Continuous torques are approximately 2/3 of the peak value. For more information on duty cycles and sizing, please consult section A.

Inertia Matching

When selecting the right Dynaserv for your application, the inertia match between the motor and load is the critical factor. The specifications listed in this section are for a 30:1 load to rotor inertia ratio. The following table lists the maximum recommended ratios for specific application types. Actual results will depend highly on the usage, so these values are just for reference purposes. It is always a good idea to add 30-50% safety margin in sizing calculations.

Model Types

When selecting the model type, the decision comes down to a trade-off of resolution, accuracy, speed, and cost. Please use this table to match your specific application requirements to the correct direct drive motor. Keep in mind that these ratings are speculative and based only on the features of these three models. i.e. The lowest accuracy Dynaserv is still very accurate by normal motor standards.

<table>
<thead>
<tr>
<th>Application Type</th>
<th>Max K Ratio (J_load/J_motor)</th>
</tr>
</thead>
<tbody>
<tr>
<td>High throughput applications (printing machines, chip mounting)</td>
<td>5-10</td>
</tr>
<tr>
<td>General high speed applications (SCARA robot, transfer arms)</td>
<td>20-30</td>
</tr>
<tr>
<td>High speed but balanced load applications (Rotary Index, Rotary Tables)</td>
<td>50-100</td>
</tr>
<tr>
<td>High accuracy, slow speed applications (Measuring Equipment)</td>
<td>100-200</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Power</th>
<th>DM Series</th>
<th>DR Series</th>
<th>DR5000 Series</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lowest</td>
<td>Medium</td>
<td>Highest</td>
<td></td>
</tr>
<tr>
<td>Accuracy</td>
<td>Highest</td>
<td>Medium</td>
<td>Lowest</td>
</tr>
<tr>
<td>Motor Weight</td>
<td>Lowest</td>
<td>Medium</td>
<td>Highest</td>
</tr>
<tr>
<td>Resolution</td>
<td>Highest</td>
<td>Medium</td>
<td>Lowest</td>
</tr>
<tr>
<td>Cost</td>
<td>Medium</td>
<td>Lowest</td>
<td>Highest</td>
</tr>
<tr>
<td>Speed</td>
<td>Lowest</td>
<td>Medium</td>
<td>Highest</td>
</tr>
</tbody>
</table>
Application Considerations for using the Dynaserv Direct Drive Brushless Servo Systems

Sizing and Selection Considerations

- All Speed vs. Torque curves shown in Compumotor’s Catalog and Dynaserv User Guide show peak torque. Use two-thirds of peak torque to calculate the available continuous torque.
- If you require more than two-thirds of peak torque for short periods of time (low duty cycle applications), calculate RMS (room mean square) torque. Make sure RMS torque is less than 2/3 of peak torque.
- Friction torque should not exceed 30% of a motor’s peak torque.
- Dynaservs operate most efficiently with a balanced load. Overhung loads cannot exceed 148 ft-lbs for the DR-B and DM-B series motors. Overhung loads cannot exceed 295 ft-lbs for DR-E, DR-A and DM-A series motors. These values should be derated by 33% for constant loads and 80–90% for intermittent loads (fatigue) to incorporate a safety margin.
- Always calculate the load-to-rotor inertia ratio before selecting a motor. The acceptable ratio is application- and motor-dependent. Applications requiring low cycle times and high accelerations need a lower ratio than slow-speed, continuous velocity applications. Refer to the acceptable inertia values for different application types on the previous page.
- Axial Compression and Tension Load Limits:

<table>
<thead>
<tr>
<th>Compression</th>
<th>Tension</th>
</tr>
</thead>
<tbody>
<tr>
<td>DR-B Series</td>
<td>6744 lbs</td>
</tr>
<tr>
<td>DR-E, DR-A</td>
<td>8992 lbs</td>
</tr>
<tr>
<td>DM-B</td>
<td>6600 lbs</td>
</tr>
<tr>
<td>DM-A</td>
<td>8800 lbs</td>
</tr>
</tbody>
</table>

These limits should be derated to incorporate a safety margin. If the load is intermittent and repetitive, derate these values by 80–90%.
- If the motor is used with oscillating rotation movements with a small angle (50° or less), then perform a running-in operation with back-and-forth movements about 10 times, each move exceeding an angle of at least 90°. The running-in operation must be carried out every 10,000 times of back-and-forth oscillation movements in order to ensure proper lubrication of the bearings.

Cabling Considerations

- The Dynaserv is not shipped with a power cable. This cable must be provided by the end user. The Dynaserv is shipped with a 50-pin Honda connector. Use this connector to construct a cable between the Indexer, Servo controller, or other input/output devices.
- The motor and feedback cables cannot exceed 30 meters in length.

Mounting and Environmental Considerations

- Do not drill holes into the Dynaserv motor.
- The Dynaserv is an outer rotor motor. The rotating load must be mounted to the upper mounting surface (the rotor). The lower stator surface must be mounted to the rigid and stationary machine base.
- Install the motor in an appropriate location as the motor is not dust proof, watertight, or oil proof.
LED Diagnostics
A seven-segment LED is mounted on the front panel of both the DR and DM Series drives to display the normal/abnormal status of the motor and drive. The following is a summary of the display codes.

- Normal status
  - Servo Off
- Normal status
  - Servo On
- Overspeed warning
  - Servo Off
- Overspeed warning
  - Servo On
- RAM Error
  - (Drive in need of repair)
- Encoder Error—not receiving pulses
  - Check cabling, encoder malfunction
- Control power supply error
  - Connect problem (may need repair)
- Counter overflow warning—position error is greater than 32,768 steps
- ROM Error
  - (Drive in need of repair)
- Main power supply failure—burnt fuse
  - Check cabling, power and fuse
- CPU Stop
  - (Drive in need of repair)
- Watchdog timer error—illegal interrupt, computation overflow
- Power amp error—overvoltage, motor short phase-to-phase or phase-to-ground
- Overload condition
  - Average current exceeded.

Servo Compensation

The position control system is adjusted while in the Test Mode with the actual load attached to the motor. Turning on the test switch at the front panel causes the drive to generate a 2.5 Hz square wave position signal. The actual motor position can be monitored by connecting a scope to the position monitor output on the front panel. As in the figure, the tuning parameters are adjusted until the waveform is optimized. After the tuning is complete, turn off the test switch and the system is ready for operation. If a scope is not available there is a procedure for tuning without a scope in the system user guide.

Characteristics Frequency (fc)
The value of this switch represents system bandwidth. This gain will effect rise time and system responsiveness. Too large a value will cause excessive overshoot and ringing, while too small a value will result in a sluggish, unresponsive system.

Integral Limiter (ILIM)
The value of this switch represents the limit of the digital integrator during servo compensation. The larger the switch setting, the larger the limited value. With a smaller limited value the settling time will be decreased, but if the setting is too low, the motor output torque is limited.

DC Gain (DC)
This variable resistor sets the DC Gain adjustment from 0.5 to 110. The DC Gain should be set as high as possible without causing the system to go unstable. The DC Gain will help dampen out ringing and over-shoot.