Magnetic Particle Clutches and Brakes
Accurate torque control with instantaneous engagement!

Warner Electric
Precision Tork
magnetic particle
clutches and brakes are
unique because of the wide
operating torque range available.
Torque to current is almost linear
and can be controlled very
accurately. The unique features of
the magnetic particle clutches and
brakes make them ideal for tension
control, load simulation, cycling/
indexing, and soft starts and stops.

Features and Benefits

• Torque independent of slip speed
  Torque is transmitted through magnetic
  particle chains which are formed by an
  electromagnetic field. The torque is
  independent of slip speed, depending
  only on circuit current, and is infinitely
  variable from 0 (disengaged) to rated
  torque.

• Precise engagement
  Precision Tork magnetic particle
  clutches and brakes engage to transmit
torque with speed and precision.
Response of the particles to the field is
virtually instantaneous, providing
perfectly controlled, jerk-free
engagement.

• Customer specified engagement
  Engagement time may be very gradual
  or extremely fast. The frequency and
torque of the engagement/disengage-
ment sequence is limited only by the
capabilities of the control circuitry.

• No wearing parts
  There are no friction surfaces to grab
  or wear, and the units are not affected
  by changes in atmospheric or other
  environmental conditions.

• Efficient/Compact design
  High torque to size ratio and low
  consumption of electric power.

• Versatile mounting
  Convenient bolt circle for easy
  mounting. Mounting brackets available
  for all sizes. Brakes are available with
  solid shafts and through bore. Can be
  mounted horizontally or vertically to
  solve virtually any motion control
  requirement.

• Specials are our business
  • Special Shaft Configurations
    Customer specified shaft configurations
    for easy machine mounting and
    retrofitting.
  
• Wash Down Environment
  Stainless steel units available for extreme environments.

• Special Torque
  Maximum torque configurations to meet
customer specifications.

• Special Mounting Configurations
  Customer specified bolt patterns,
special mounting brackets.

• Metric units

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• Metric units
Operating Principles

The magnetic particle unit consists of four main components: 1) housing; 2) shaft/disc; 3) coil and 4) magnetic powder. The coil is assembled inside the housing. The shaft/disc fits inside the housing/coil assembly with an air gap between the two; the air gap is filled with fine magnetic powder.

Engagement

When DC current is applied to the magnetic particle unit, a magnetic flux (chain) is formed, linking the shaft/disc to the housing. As the current is increased the magnetic flux becomes stronger, increasing the torque. The magnetic flux creates extremely smooth torque and virtually no "stick-slip".

Disengagement

When DC current is removed the magnetic powder is free to move within the cavity, allowing the input shaft to rotate freely.

Cycling

By turning the current to the coil on and off a cycling effect is achieved.
Sizing

To properly size magnetic particle clutches or brakes the thermal energy (slip watts) and torque transmitted must be considered. If thermal energy and torque are known for the application select the unit from the charts to the right.

RPM

RPM must be known when calculating thermal energy (slip watts). For load simulation, torque limiting and similar applications, RPM is known. For web handling, the RPM is calculated as follows:

\[
\text{Slip RPM}^* = \frac{12 \times \text{Velocity (feet per min.)}}{\pi \times \text{Full Roll Dia.}^{**} \text{ (in.)}}
\]

*In rewind applications the motor RPM should be higher (10%) than the fastest spool RPM.
**In applications with the web running over a pulley or in a nip roll application use the pulley diameter as the roll diameter.

Thermal Energy (slip watts)

Tension applications are considered continuous slip applications. When a brake or clutch is slipping, heat is generated. Heat is described in terms of “energy rate” and is a function of speed, inertia, and cycle rate. Heat generated is usually described in terms of thermal energy or slip watts. Starting and stopping applications generate heat when the unit slips during the stopping and starting of the load.

- For continuous slip applications, such as tension control in an unwind or rewind application slip watts are calculated using the following formula:

\[
\text{Slip Watts} = 0.0118 \times \text{Torque (lb.in.)} \times \text{Slip RPM}
\]

- For cycling applications heat is generated intermittently, and is calculated using the following formula:

\[
\text{Watts} = 2.67 \times \text{Inertia (lb.in.}^2) \times \text{RPM}^3 \times \text{F cycle} \times \text{min.}
\]

Duty Cycle

The average heat input must be below the clutch or brake’s heat dissipation rating. If the application generates intermittent heat dissipation, use the average speed for the thermal energy (slip watts) calculations.

Quick Selection Charts

**MPB2/MPC2**

Heat dissipation curves based on maximum of 10 watts

**MPB15/MPC15**

Heat dissipation curves based on maximum of 20 watts

**MPB70/MPC70**

Heat dissipation curves based on maximum of 100 watts

**MPB120/MPC120**

Heat dissipation curves based on maximum of 140 watts

**MPB240**

Heat dissipation curves based on maximum of 200 watts

Torque

Tension applications calculate torque as a function of roll radius and tension. Soft/controlled stopping applications calculate torque as a function of inertia, speed and desired time to stop the load. Torque limiting applications calculate torque as the allowable drive through torque. Calculate the torque requirement based on the formulas for the different applications:

- To calculate torque for a web handling application, determine the inertia (WR²), and apply it to the formula below:

\[
\text{Torque (lb.in.)} = \frac{\text{Inertia (lb.in.}^2) \times \text{RPM}^3 \times \text{time(s)}}{3,690 \times \text{RPM}^3}
\]

Inertia (WR²) = \([\text{weight of body} \times \text{radius of gyration}]^2\)

*to calculate for a cylinder about its axis:

Solid cylinder = \(R^2 = \frac{1}{2}r^2\)

Hollow cylinder = \(R^2 = \frac{1}{2}(r_1^2 + r_2^2)\)

*Use full roll diameter. In applications with the web running over a pulley or in a nip roll application use the pulley diameter as the roll diameter.
Selection

Reflected Inertia (rotational)

In mechanical systems, it is common for the rotating parts to operate at different speeds. In clutch and brake applications, the \( WR^2 \) is calculated for each part operating at different speeds, then reduced to an equivalent \( WR^2 \) at the clutch or brake mounting shaft speed. All the rotating parts' \( WR^2 \) are added together and treated as a unit.

The formula for determining the equivalent \( WR^2 \) of a rotating part referred to the clutch or brake shaft is as follows:

\[
WR^2_e = WR^2 \times \left( \frac{N}{N_{cb}} \right)^2
\]

Where:
- \( WR^2 \) = inertia of the rotating part at \( N \) (RPM)
- \( N \) = speed (RPM) of the rotating part
- \( N_{cb} \) = speed (RPM) of the clutch or brake shaft

Reflected Inertia (linear)

In complex systems involving both linear and rotating motion, the linearly moving parts can be reduced to the clutch or brake speed by the following equation:

\[
WR^2_e = W \times \left( \frac{V}{2\pi N} \right)^2
\]

Where:
- \( W \) = Weight of body
- \( V \) = Velocity in feet per minute
- \( N \) = RPM of the clutch or brake shaft

This equation can only be used when the linear speed has a continuous fixed relation to the rotating speed, such as a conveyor driven by a motor.

- To determine torque in an overload protection, torque limiting or soft start application, use the following equation:

\[
\text{Torque (lb.in.)} = \frac{\text{HP} \times 63,000}{\text{RPM}}
\]

Calculating Web Tension

For sizing brakes on applications in which the applied web tension is unknown, use the following information to determine the approximate tension value.

\[
\text{Applied Web Tension (lbs.)} = \text{Approx. Material Tension (lb.in.)} \times \text{Roll Width (in.)}
\]

Example:

The tension for a twelve inch wide roll of 20# paper stock is unknown. What is the prescribed tension?

Solution:

The approximate tension value as noted in the chart above for 20# paper stock is 0.75 lb.in.; thus the tension for this application is 

\[
(0.75 \text{ lb.in.} \times 12) = 9 \text{ lb}
\]
Applications

Warner Electric Precision Tork magnetic particle clutches and brakes are the ideal solution for controlling and maintaining torque. If the application is tensioning, load simulation, torque limiting, or soft starts and stops the magnetic particle unit is the preferred torque controlling device.

Typical Applications

- Wire Processing (winding, hooking, cutting)
- Paper/Foil/Film Processing
- Labeling Applications
- Textile Processing
- Material Processing
- Load profile simulation on:
  - Exercise Equipment
  - Flight Simulators
  - Healthcare Equipment
- Life testing on:
  - Motors
  - Gears
  - Pulleys
  - Belts
  - Chains
  - Many other Rotating Devices
- Conveyors
- Bottle Capping

Controlled Acceleration/Deceleration

Controlled soft stop

Particle brakes and the MCS-153 control provide soft stopping of large rotating loads. By controlling the input current, the load is decelerated in a controlled manner without torque spikes, shock, or vibration.

Application Example:

Information Required:
- RPM: 1,000
- Time to Stop: 3 seconds
- Inertia*: 400 lb.in.²

How to Size:

Maximum Torque (lb.in.) =
\[ \frac{\text{Inertia (lb.in.}^2\text{) \times RPM}}{3,690 \times \text{time(s)}} \]
= \[ \frac{400 \times 1,000}{3,690 \times 3} \]
= 36 lb-in

Select a brake that exceeds the maximum torque requirements from the Specification Chart – MPB70.

Controlled soft start

Particle clutches and the MCS-153 control provide soft controlled acceleration to prevent tipping or shock during start up.

Application Example:

Information Required:
- RPM: 500
- Time to Start: 4 sec.
- Inertia*: 50 lb.in.²

How to Size:

Maximum Torque (lb.in.) =
\[ \frac{\text{Inertia (lb.in.}^2\text{) \times RPM}}{3,690 \times \text{time(s)}} \]
= \[ \frac{50 \times 500}{3,690 \times 4} \]
= 1.7 lb.in

Select a clutch that exceeds the maximum torque requirements from the Specification Chart – MPC2.
Rewind stand under dancer control

Particle clutches and the MCS-203 control provide accurate closed loop tension control for rewind applications.

Application Example:
Information Required:
Core Diameter: 3 inches
Full Roll Diameter: 9 inches
Tension: 5 lbs.
Velocity: 300 fpm
Input RPM: 500 RPM*

Maximum Torque (lb.in.) = $\frac{\text{tension (lbs.)} \times \text{full roll diameter (in.)}}{2}$
$= \frac{5 \times 9}{2}$
$= 23$ lb-in

Core RPM = $\frac{12 \times \text{Velocity (fpm)}}{\pi \times \text{(core diameter)}}$
$= \frac{12 \times 300}{\pi \times 3}$
$= 382$ RPM

Full Roll RPM = $\frac{12 \times \text{Velocity (fpm)}}{\pi \times \text{Full Roll Dia.}}$
$= \frac{12 \times 300}{\pi \times 9}$
$= 127$ RPM

Slip RPM = Input RPM – Full Roll RPM
$= 500 – 127$
$= 372.68$

Thermal Energy (slip watts) = $0.0118 \times \text{Torque (lb.in.)} \times \text{RPM}$
$= 0.0118 \times 22 \times 373$
$= 99$ watts

Select a clutch that exceeds the maximum torque and thermal energy requirements from the Quick Selection Chart – MPC120.

*T to maximize tension control and minimize heat generated, select a drive system that will result in an actual input speed as close to, but not less than, 30 RPM greater than the core RPM. In this example, 382 + 30 = 412, would be ideal but 500 RPM was more readily available.

Tensioning

Magnetic Particle clutches and brakes offer smooth controlled torque for tensioning in both the unwind zone and rewind zone. Torque produced from the magnetic particle clutches and brakes is independent of slip speed, offering a distinct advantage over competing technologies. Since torque can be varied infinitely by varying the input current, the magnetic particle clutches and brakes are ideal in an open loop system. To close the loop in the tensioning system, combine the magnetic particle clutch or brake with a Warner® sensor and control, resulting in more precise control of tension.

Unwind stand under load cell control

Particle brakes and the TCS-240 load cell control with precision load cell sensors provide closed loop tension control.

Application Example:
Information Required:
Full Roll Diameter: 20 inches
Tension: 5 lbs.
Velocity: 400 fpm

How to Size:
Maximum Torque (lb.in.) = $\frac{\text{Full roll diameter (in.)} \times \text{tension (lbs.)}}{2}$
$= \frac{20 \times 5}{2}$
$= 50$ lb.in.

Slip RPM = $\frac{\text{Velocity (fpm)} \times 12}{\text{Full roll diameter} \times \pi}$
$= \frac{400 \times 12}{20 \times \pi}$
$= 76$ RPM

Thermal Energy (Slip Watts) = $0.0118 \times \text{Torque (lb.in.)} \times \text{RPM}$
$= 0.0118 \times 50 \times 76$
$= 45$ Watts

Select a brake that exceeds the maximum torque and thermal energy requirements from the Quick Selection Chart – MPB70.
Torque Limiting/Overload Protection

The magnetic particle clutches and brakes combined with a Warner® CBC control are effective means to providing protection in the case of jam ups. The magnetic particle clutch and the CBC control can provide precise adjustable torque in torque limiting applications.

Application Example

Information Required:
- Motor HP: 1 HP
- Motor RPM: 700 RPM

How to Size:

Maximum Torque (lb.in.) = \( \frac{HP \times 63,000}{RPM} \)

\[ \begin{align*}
&= \frac{1 \times 63,000}{700} \\
&= 90 \text{ lb.in.}
\end{align*} \]

Select a clutch that exceeds the maximum torque requirements from the Selection Chart – MPC120.

Load Simulation

By combining the magnetic particle brake with a microprocessor control, virtually any load simulation can be obtained. The control is programmed with the profile or condition that is to be simulated. The control then feeds the profile to the magnetic particle brake in terms of input current. The brake reads the input current and provides load torque to simulate the condition.

If the application requires programming load profiles, adjusting load torque, or simulating friction or drag loads, the magnetic particle clutches and brakes are the ideal solution.

Exercise Equipment

Brake models provide a smooth controllable resistance for exercise machines. When integrated with a microprocessor control, programming load profiles is possible.
## Dimensions

<table>
<thead>
<tr>
<th>Model</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G (Output)</th>
<th>H (Input)</th>
<th>I</th>
<th>J</th>
<th>K</th>
</tr>
</thead>
<tbody>
<tr>
<td>MPC2</td>
<td>2.11</td>
<td>0.750/0.749</td>
<td>3.82</td>
<td>1.86</td>
<td>0.06</td>
<td>1.14</td>
<td>0.88</td>
<td>0.88</td>
<td>0.2497/0.2492</td>
<td>(3) #6-32 on 1.350 BC</td>
<td>Flat</td>
</tr>
<tr>
<td>MPC15</td>
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<td>1.125/1.124</td>
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<td>1.67</td>
<td>1.00</td>
<td>1.00</td>
<td>0.4997/0.4992</td>
<td>(3) #8-32 on 2.000 BC</td>
<td>Flat</td>
</tr>
<tr>
<td>MPC70</td>
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<td>1.625/1.624</td>
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<td>0.10</td>
<td>2.08</td>
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<td>0.7497/0.7492</td>
<td>(4) #10-32 on 4.228 BC</td>
<td>0.188 Keyway</td>
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<tr>
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<td>1.625/1.624</td>
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<td>4.00</td>
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<td>2.40</td>
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<td>0.7497/0.7492</td>
<td>(4) #1/4-20 on 4.812 BC</td>
<td>0.188 Keyway</td>
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## Specifications

<table>
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<td>303</td>
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<td>1.33 x 10⁻³</td>
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<td>9.4 x 10⁻²</td>
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<td>1,000</td>
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<td>0.40</td>
<td>15</td>
<td>90</td>
<td>1501</td>
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<td>9.4 x 10⁻²</td>
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<tr>
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<td>35</td>
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<td>70</td>
<td>8.84 x 10⁻²</td>
<td>100</td>
<td>1,000</td>
<td>17</td>
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<tr>
<td></td>
<td>1.00</td>
<td>70</td>
<td>90</td>
<td>613</td>
<td>0.147</td>
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<td>8.84 x 10⁻²</td>
<td>100</td>
<td>1,000</td>
<td>17</td>
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<td>33</td>
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<td>90</td>
<td>3.82 x 10⁻¹</td>
<td>140</td>
<td>1,000</td>
<td>22</td>
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<tr>
<td></td>
<td>2.00</td>
<td>120</td>
<td>90</td>
<td>475</td>
<td>0.190</td>
<td>90</td>
<td>3.82 x 10⁻¹</td>
<td>140</td>
<td>1,000</td>
<td>22</td>
</tr>
</tbody>
</table>

## Optional Mounting Bracket (for mounting MPB Brakes and MPC Clutches)

- **Model**: MPB-2B
  - Fits Sizes: 2
  - Dimensions: (6.9, 123.8) (9.9, 152.4) (123.8, 158.2)
- **Model**: MPB-15B
  - Fits Sizes: 7.15, 35
  - Dimensions: (6.9, 123.8) (9.9, 152.4) (123.8, 158.2)
- **Model**: MPB-70B
  - Fits Sizes: 70
  - Dimensions: (6.9, 123.8) (9.9, 152.4) (123.8, 158.2)
- **Model**: MPB-120B
  - Fits Sizes: 120
  - Dimensions: (6.9, 123.8) (9.9, 152.4) (123.8, 158.2)
- **Model**: MPB-240B
  - Fits Sizes: 240
  - Dimensions: (6.9, 123.8) (9.9, 152.4) (123.8, 158.2)

All dimensions are nominal unless otherwise noted. ( ) denotes (mm)
Brakes

Dimensions

<table>
<thead>
<tr>
<th>Model</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>I (Shaft)</th>
<th>J (Bore)</th>
<th>K</th>
<th>L</th>
</tr>
</thead>
<tbody>
<tr>
<td>MPB2-1</td>
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<td>0.750/0.749</td>
<td>2.23</td>
<td>1.15</td>
<td>0.06</td>
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<td>0.88</td>
<td>–</td>
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<td>Solid Shaft</td>
<td>(3) #6-32 on 1.350 BC</td>
<td>1 Flat</td>
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<td>MPB15-1</td>
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<td>0.86</td>
<td>1.35</td>
<td>–</td>
<td>0.3747/0.3742</td>
<td>Solid Shaft</td>
<td>(3) #8-32 on 2.000 BC</td>
<td>1 Flat</td>
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<tr>
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<td>0.07</td>
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<td>0.4997/0.4992</td>
<td>Solid Shaft</td>
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<td>1 Flat</td>
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<td>MPB70-1</td>
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<td>0.18</td>
<td>0.749</td>
<td></td>
<td>0.500/0.501</td>
<td>0.125 Thru Hole</td>
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<tr>
<td>MPB70-2</td>
<td>4.48</td>
<td>1.625/1.624</td>
<td>3.37</td>
<td>1.76</td>
<td>0.10</td>
<td>0.98</td>
<td>1.25</td>
<td>–</td>
<td>0.7497/0.7492</td>
<td>Solid Shaft</td>
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<td>0.188 Keyway</td>
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<td>MPB120-2</td>
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<td>1.625/1.624</td>
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<td>2.17</td>
<td>0.10</td>
<td>1.18</td>
<td>1.50</td>
<td>–</td>
<td>0.7497/0.7492</td>
<td>Solid Shaft</td>
<td>(4) #1/4-20 on 4.812 BC</td>
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<tr>
<td>MPB240-1</td>
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<td>0.10</td>
<td>1.46</td>
<td>1.65</td>
<td>–</td>
<td>0.7497/0.7492</td>
<td>Solid Shaft</td>
<td>(4) #1/4-20 on 5.875 BC</td>
<td>0.188 Keyway</td>
</tr>
<tr>
<td>MPB240-2</td>
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<td>3.51</td>
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<td>1.46</td>
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<td>0.875/0.876</td>
<td>0.4997/0.4992</td>
<td>0.250 Shallow Keyway</td>
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<td>0.50</td>
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<td>1.377</td>
<td>1.000/1.001</td>
<td>0.4997/0.4992</td>
<td>0.250 Shallow Keyway</td>
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Specifications

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**Adjustable Torque**

**TCS-200-1 Manual/Analog**

The TCS-200-1/-1H single channel controls are selectable voltage or current controlled power supplies designed to power up to a 16-magnet Electro Disc tension brake system, Electromagnetic Particle Brakes, TB Series brakes, or Advanced Technology tension brakes. These controls operate from a switch-selectable power source of 115 or 230 VAC. They can be operated manually from the front panel or remotely via an analog voltage input, a current input, a remote pot, or a roll follower. External inputs are also provided for remote brake Off, Run, and Stop functions, as well as front panel control of these functions.

**Features**

- Input: 115/230 VAC, 50/60 Hz
- Output: -1, 0–24 VDC adjustable, 4.25 Amps continuous
- -1H, 0–24 VDC adjustable, 5.8 Amps continuous
- Front panel torque adjust
- Front panel brake mode stop switch

**Modes:** Stop – Brake Full On
Run – Normal Operation
Off – Brake Off

- Remote brake mode switch (same functions as mentioned above)
- Remote torque adjust
- Roll follower input
- 0–10 VDC analog voltage input
- 4–20mA analog current input

**System Control**

The MCS2000-CTDA/CTLC are digital web tension controllers. They are especially designed for user applications. The units are equipped with a power supply, control (PID) logic, front face keypad and display for programming. The MCS2000-ECA is the OEM version controller without the power supply and display. It has the same function and features as the user version. All the controller units can be used in open-loop, closed-loop and open + superimposed closed-loop for very precise tension control applications. The -CTDA and -ECA work with dancer systems and the -CTLC is for load cell systems. The -CTLC will accept one or two load cells that output anywhere between 5mV and 10VDC. It will sum and amplify any load cell available on the market.

The MCS2000-PSDRV works with the controller to provide two 0–24 VDC outputs for electric tension brakes. It is powered with 115/230 VAC at 1.4 Amps continuous or 3 Amps peak per channel.

**Features**

- Input: 115/230 VAC
- Output: Two 0–10V outputs
- Scaleable tension readout
- Password protected
- Eight different output options
- Fully digital
- Multi-purpose
- RS-232 communications
- Memory card for storing up to two full programs
- Windows programming software
- Integral terminal reset
- Two output channels
- Automatic sensor scaling
- External set point change
- Programmable output configuration
- Output sensor information
- Automatic or imposed PID correction

**MCS2000 Digital Web Tensioning**

The MCS2000-CTDA/CTLC are digital web tension controllers. They are...

**Dancer/Remote Analog Control**

**MCS-203/MCS-204/ MCS-166**

The MCS-203 is a basic dancer control that automatically controls web tension through the use of a dancer roll and sensor. It is single channel, but can operate two 24 VDC tension brakes in parallel when using two MCS-166 power supplies.

The MCS-204 is a basic remote analog control that can also be operated manually via a front panel tension adjustment potentiometer. It is also single channel with the possibility of operating two 24 VDC tension brakes in parallel when using two MCS-166 power supplies.

**Features**

- Input: 115/230 VAC, 50/60 Hz
- Output: 0–24 VDC at 3 Amps max.

**MCS-203 (only)**

- Full P-I-D adjustment
- System gain display

**MCS-204 (only)**

- Front panel torque adjustment
- Remote potentiometer adjustment
- Roll follower input
- Remote voltage or current analog signal following
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Warner Electric
Industrial Products Division
South Beloit, IL 61080-3771

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