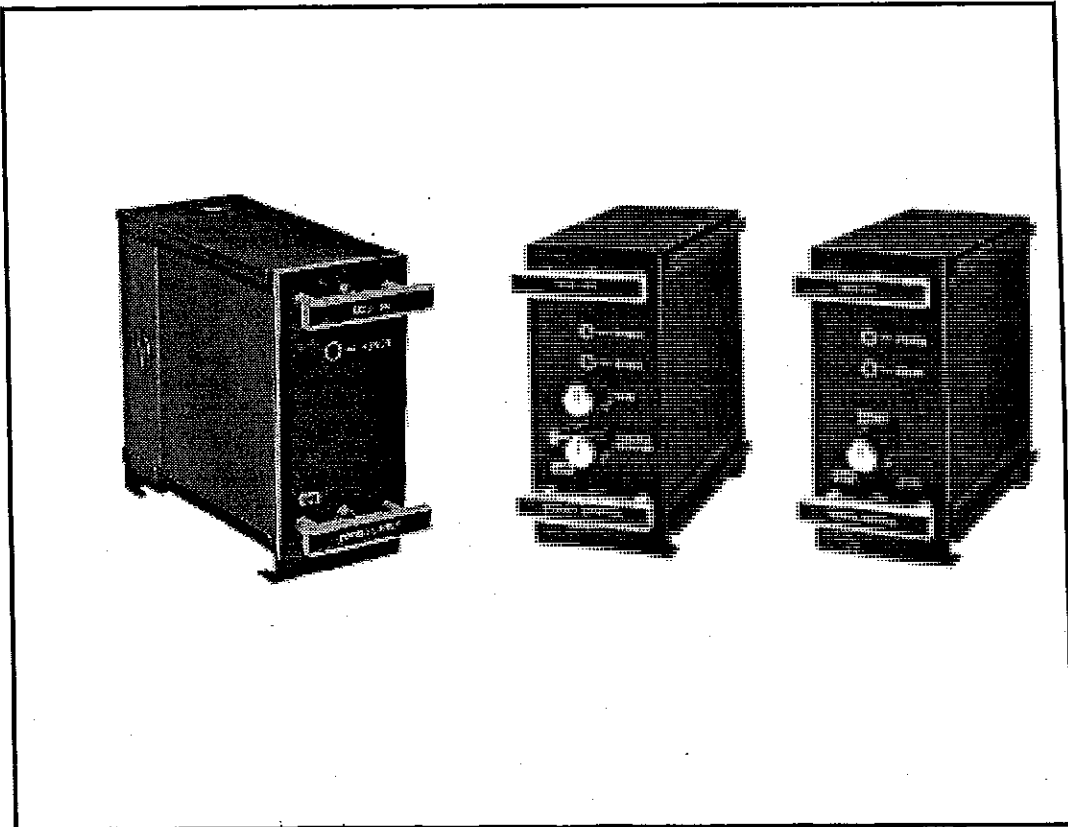


# WARNER

## INSTALLATION & OPERATION MANUAL

*Tension Control System*  
*MCS-166, MCS-203, MCS-204*



**WARNER ELECTRIC®**

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**Notes:** Installation must be made in accordance with the instructions found in this manual. Failure to do so may damage the controls and void their warranty.

**Warning:** Contact with the electrical voltages present in the controls covered in this manual can cause injury or death. To avoid these consequences, make sure all power is off during installation.

# Tension Control System Installation and Operating Instructions

## MCS-166/MCS-203/MCS-204

### INTRODUCTION

All Warner Electric Tension Control Systems are comprised of an electric tension brake, a power supply module, an electronic control module, and a sensor or input control device.

This manual has been designed to cover the full range of installation, start-up, operation, and maintenance of your tension control system. System selection and brake information can be found in Warner Electric's Tension Control Systems Catalog, P-771.

#### Power Supply

The MCS-166 Power Supply Module is designed to operate either the MCS-203 Dancer Control or the MCS-204 Remote/Analog Control. The MCS-166 accepts either 120 VAC or 220/240 VAC input power and provides 26-28 VDC output power for operation of the control modules and a brake.

#### Controls

The MCS-203 Dancer Control Module is a solid state electronic control that receives a signal from a dancer pivot-point sensor and transmits the appropriate current to the brake to maintain a stable dancer position. The MCS-203 is a closed loop control.

The MCS-204 Remote/Analog Control Module is a solid state electronic control that will accept a variety of input signals and provide an output current proportional to the input. This system is open loop and any change in output to the brake must be input to the control from the signal source. The MCS-204 can be operated by the local torque knob on its face or remotely by external potentiometer, voltage input, or current loop input.

The MCS-605-1 or TCS-605-5 Pivot Point Sensors provide the dancer position signal to the MCS-203 Dancer Control. The MCS-605-1 is coupled to the dancer pivot when rotation is no more than 60 degrees, while the TCS-605-5 covers rotation up to 300 degrees.

### SPECIFICATIONS

#### MCS-166 Power Supply Module

**Part Number:** 6910-448-013

**Input Power:** 120VAC or 220/240VAC, 50/60 Hz, 10% switch selectable

#### Ambient

**Temperature:** +32 F to +120 F (0 C to +49 C)

**Output:** 26-28VDC, unregulated, 10% 1.5 amps maximum. Over voltage protected.

**Fusing:** 3/8 amp, 250V fast-acting, type 3AG, AC input.

#### MCS-203 Dancer Control Module

**Part Number:** 6910-448-014

**Input Power:** 26-28VDC 10% 1.5 amps maximum with single brake, 3.0 amps with dual brake. From single or dual MCS-166 power supplies.

#### Ambient

**Temperature:** +32 F to +120 F (0 C to +49 C)

#### Output:

(Forward direction) 0-24VDC, pulse width modulated 3 amps maximum (Reverse direction) Anti-residual mode, 0 to 1.8VDC into 10 ohm load, or 0 to 180 ma. maximum

#### Fuses:

3 amp, 120V, fast acting, type 3AG, DC input

#### Control Input:

From MCS-605-1 or TCS-605-5 pivot point sensor

#### Protection:

Internal short circuit protection on driver output stage. Reverse polarity protection on DC input power connections.

#### Auxiliary Inputs:

Brake On - Applies full output, 24VDC, to brake. Active low.

Brake Off - Removes brake power and applies anti-residual current (reverse voltage) to brake. Active low.

Anti-Drift - Provides integrator reset function. Active low.

Switch inputs can be controlled by switch closure between input and DC common or open collector, NPN transistor to DC common.

Switch or transistor rating: 20VDC minimum, .02 amps maximum rating.

#### Adjustments: Front Panel:

**Dancer Position:** sets dancer operating position.

**Gain** - controls overall system response

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**MCS-204 Remote/Analog Control Module**

**Part Number:** 6910-448-017

**Input Power:** 26-28VDC,  $\pm 10\%$ , 1.5 amps maximum with single brake, 3.0 amps maximum with dual brake. From single or dual MCS-166 power supplies.

**Ambient Temperature:** +32°F to +120°F (0°C to +49°C)

**Output:** (Forward direction) 0-24VDC pulse width modulated 3 amps maximum. (Reverse direction) Anti-residual mode, 0 to 1.8 VDC into 10 ohm load, or 0 to 180 ma. maximum.

**Fuses:** 3 amp, 120V, fast-acting, type 3AG, DC input

**Protection:** Internal short circuit protection on driver output stage. Reverse polarity protection on DC input power connections.

**Control Input:** Via terminal strip connections in control housing, dependent on type of input control function. (Manual, remote, voltage source, current source.)

**Auxiliary Inputs:**  
Brake On - Applies full output, 24VDC, to brake. Active low.  
Brake Off - Removes brake power and applies anti-residual current (reverse voltage) to brake. Active low.  
Switch inputs can be controlled by switch closure between input and DC common or open collector, NPN transistor to DC common.  
Switch or transistor rating: 20VDC minimum, 0.02 amps maximum rating.

**Adjustments:** Front Panel:  
**Zero Adjust:** Provides for adjustment of minimum input to correspond to minimum output level.  
**Torque Adjust/Span:** Provides for either manual adjust or span adjustment when in all other modes of operation.

**General Information**

Control chassis must be considered NEMA 1 and should be kept clear of all areas where foreign material, dust, grease, or oil might affect the operation of the control. Control chassis should be electrically grounded. Neither sensor nor brake wires are at ground potential and should be considered "floating" unless both sides of the AC input power to the MCS-166 are disconnected.

**Pivot Point Sensors**  
**MCS-605-1, TCS-605-5**

**Part Numbers:** MCS-605-1, 7330-448-002, single turn  
TCS-605-5, 7330-448-003, 5-turn

**Control Element:** Precision potentiometer, 1000 ohms, 2 watts,  $\pm 5\%$  tolerance.

**Cable:** 15 ft. long, shielded, with connector

**General:** The tension sensor should be kept free from foreign material, dust, grease and oil.

**Tension Brakes**

Data and technical specifications for the TB style tension brakes can be found in Warner Electric's Master Catalog, P-137, or Tension Control Catalog, P-771.

For detailed brake installation, refer to manual P-235.

**INSTALLATION INSTRUCTIONS**

**Installation**

This Installation and Operating Manual has been arranged for the systematic installation and start-up of your Tension Control System. Please check off each step in the space provided before proceeding to the next step.

**Sample**

- Check box after completion of each step.
- Remove control logic assembly by loosening two(2) captive screws on the faceplate and slide the assembly out of its housing.

**Installation - Control Housings**

**A. Wall/Shelf Mounting**

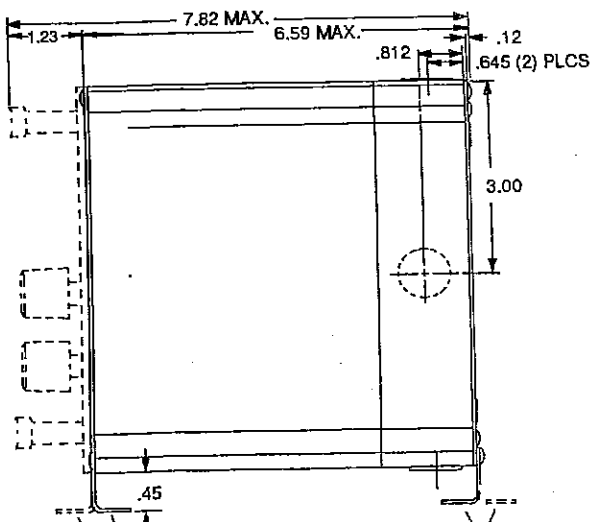
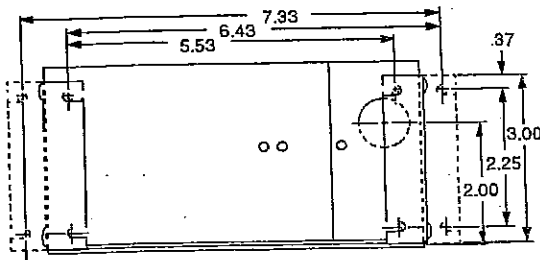
The tongue and groove joints on the sides of each housing module allow any number of them to be joined together to form one housing.

**1. Connecting the Housings**

- a. Remove the PC Board assemblies from the housings, if installed by loosening the two captive screws on each front panel and sliding the assemblies out.
- b. Loosen the latches holding the two part housings together and separate the two pieces. The latches are located on the inside tops and bottoms of the housing.
- c. Working from right to left, join the rear sections of each housing by sliding them together. Repeat the process for the front sections, but do not fasten them together yet.

**2. Wall Mounting**

- a. If bottom-entry conduit entrance is required, remove the L-shaped bracket and discard it. Reinsert the screws into the control after the bracket has been removed.



FRONT BRACKET MAY BE MOUNTED EITHER WAY AS SHOWN

BRACKET BASE MOUNT MAY BE MOUNTED EITHER WAY AS SHOWN FOR SHELF MOUNT REMOVED ENTIRELY FOR WALL MOUNT

- b. Using the dimensions shown in Figure 1, page 5, drill four (4) 13/64" mounting holes for each housing to provide clearance for #10 bolts.

- c. Apply the terminal strip label supplied with the control logic module to the PC Board as shown in Figure 2, page 6.

**CAUTION: Be sure to apply the label in the proper position with the brake (+) terminal at the top.**

- d. Mount the rear sections loosely to the mounting surface. Do not connect the front sections yet.

The controls are now ready to be wired. Proceed to the wiring section of this manual for the appropriate wiring instructions.

**3. Shelf Mounting**

- a. If bottom conduit entrance is required remove the two (2) screws attaching the brackets to the housing. Rotate the brackets to face away from the housings and reinsert and tighten the screws.

- b. Using the dimensions shown in Figure 1, page 5, drill your (4) 13/64" mounting holes for each housing to provide clearance for #10 bolts.

- c. Apply the terminal strip label supplied with the control logic module to the PC Board as shown in Figure 2, page 6.

**CAUTION: Be sure to apply the label in the proper position with the brake (+) terminal at the top.**

- d. Mount the rear sections loosely to the mounting surface. Do not connect the front sections yet.

The controls are now ready to be wired. Proceed to the wiring section of this manual for the appropriate instructions.

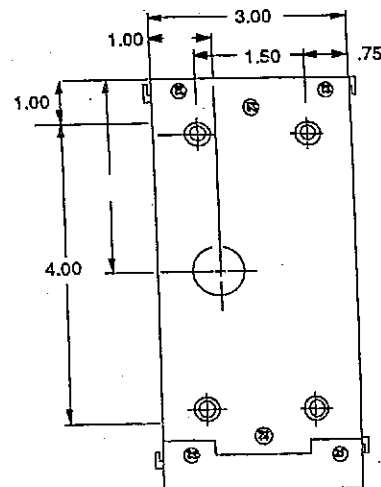


Figure 1. Wall/shelf enclosure dimensions

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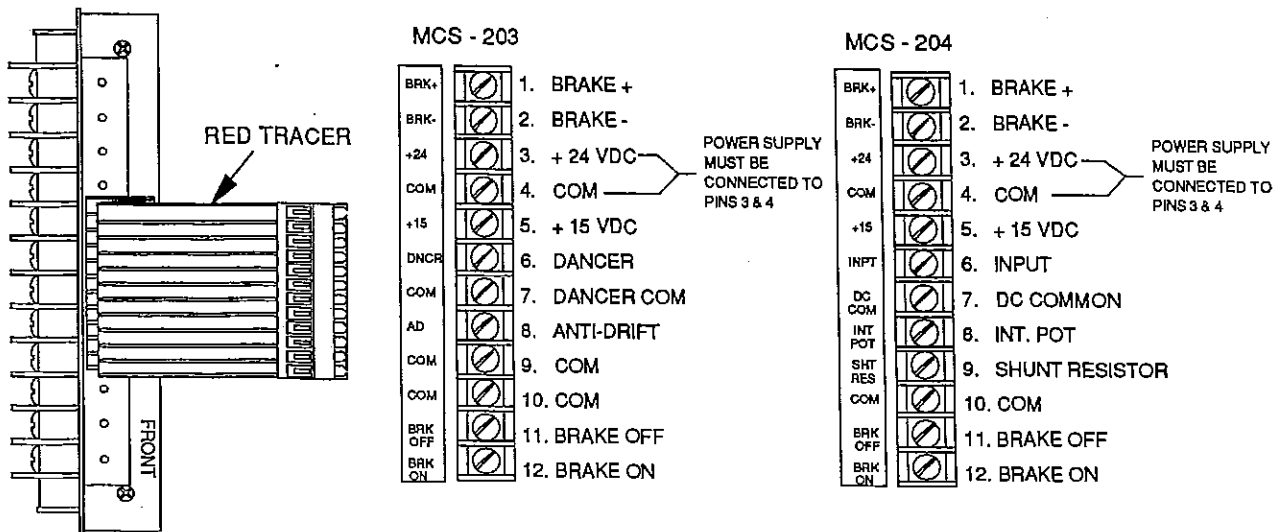


Figure 2. Terminal strip label orientation

**B. Panel Mounting**

NOTE: Panel mount housings cannot be joined together.

- 1. Insure the PC Board Assemblies have been removed from the housings if installed by loosening the two captive screws on the front panels and sliding the assemblies out.
- 2. Using the dimensions shown in Figure 3, page 6, cut an opening 3 5/16" x 6 1/16" into the mounting panel for each housing assembly.
- 3. Using the dimensions shown in Figures 3, page 6, drill four (4) 13/64" mounting holes for each housing to provide clearance for the #10 mounting studs.

- 4. Slide the housing assemblies into the mounting panel cutouts. Securely fasten the housings to the mounting panel with the four nuts on each housing.
- 5. Apply the terminal strip label to the housing panel near the terminal block as shown in Figure 5, page 7.

**CAUTION:** Be sure to apply the label in the proper position with the brake (+) terminal at the top.

The controls are now ready to be wired. Proceed to the wiring section of this manual for the appropriate instructions.

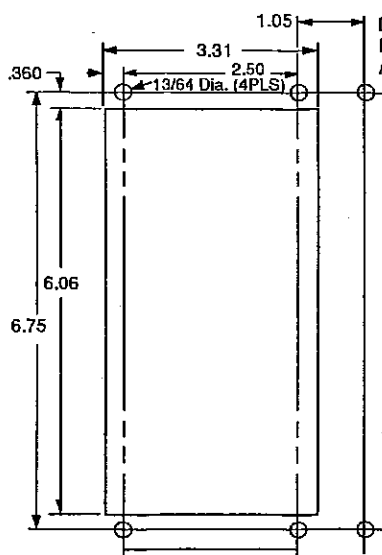


Figure 3. Panel mount cut-out dimensions

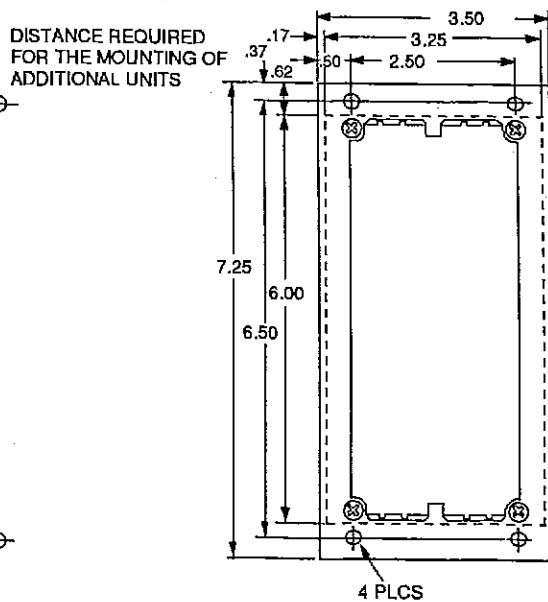
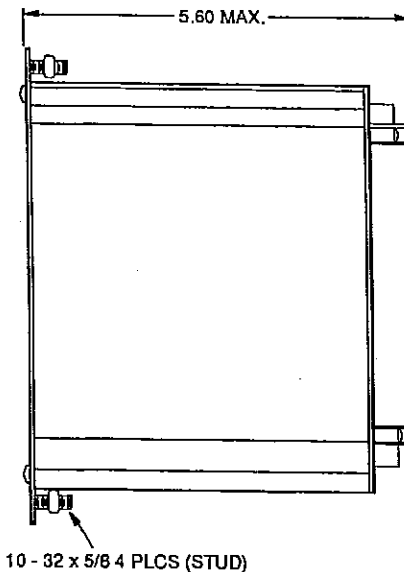


Figure 4. Panel mount housing dimensions



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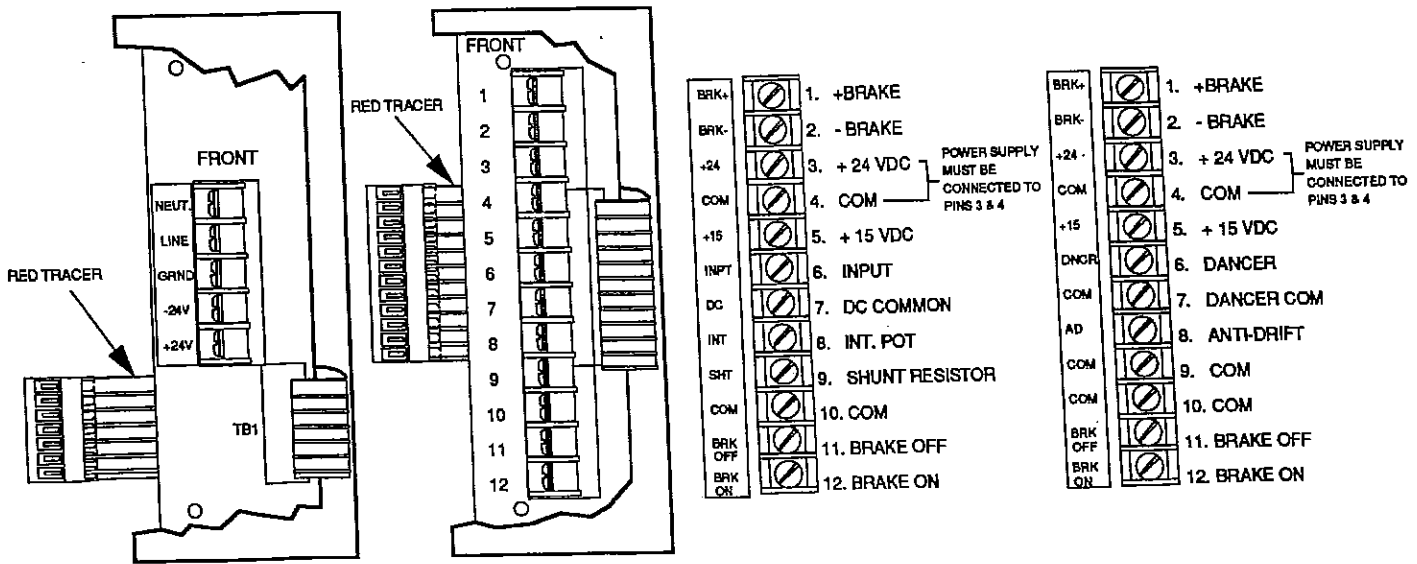
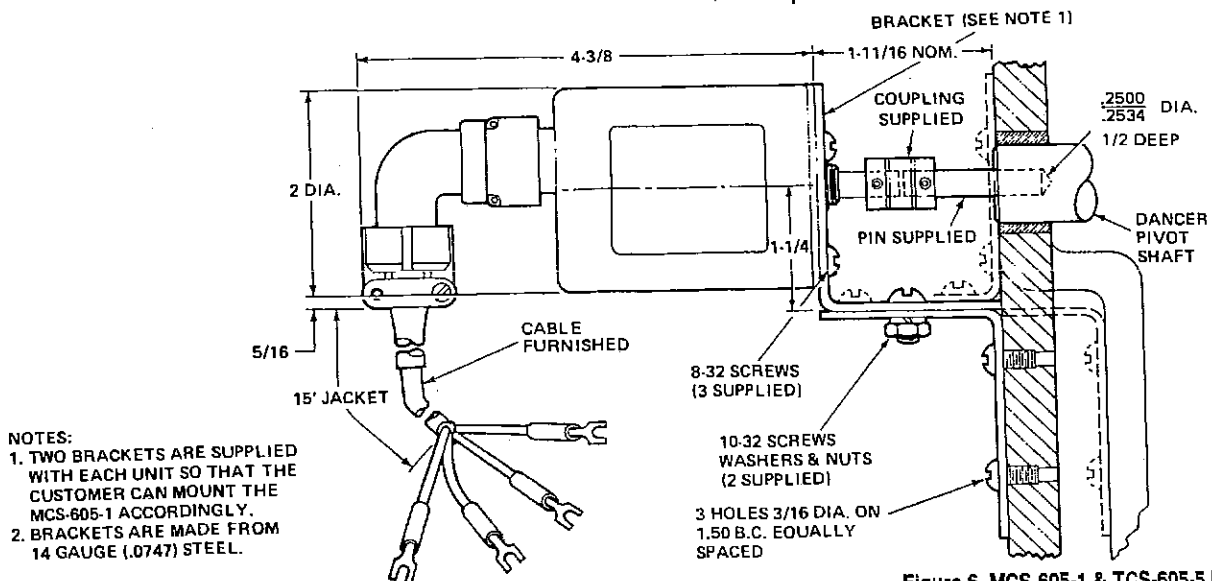


Figure 5. Terminal strip label orientation

**MCS-605-1 Sensing Potentiometer**

- 1. Using a No. 2 drill, drill a 1/2" deep hole in the center of the dancer pivot shaft.
- 2. Drive the supplied pin into the hole in the shaft until half its length remains exposed.
- 3. Assemble the two brackets supplied with the two 10-32 screws.
- 4. Mount the sensor to the brackets using the three 8-32 screws.
- 5. Position the sensor and bracket so that the sensor shaft and pin are aligned and separated by 5/16".
- 6. While holding the sensor and bracket in this position, mark the centers of the bracket holes on the machine.
- 7. Drill and tap three (3) holes for 8-32 screws in the machine.
- 8. Connect the sensor shaft to the pin with the supplied universal coupling. The index mark on the sensor shaft must be aligned with the index mark on the sensor face when the dancer arm is at the midpoint position.
- 9. Mount the sensor and bracket to the machine with three (3) 8-32 screws.
- 10. The sensor is now ready to be wired. Refer to the wiring section starting on page 8 of this manual for complete instructions.



NOTES:  
 1. TWO BRACKETS ARE SUPPLIED WITH EACH UNIT SO THAT THE CUSTOMER CAN MOUNT THE MCS-605-1 ACCORDINGLY.  
 2. BRACKETS ARE MADE FROM 14 GAUGE (.0747) STEEL.

Figure 6 MCS-605-1 & TCS-605-5 Mounting Details

## SYSTEM WIRING

### System Wiring Precautions

**WARNING: Contact with the electrical voltages present in the controls covered in this manual can cause injury or death. To avoid these consequences, make sure all power is off during installation.**

These wiring precautions will help you properly install and wire a trouble-free system.

1. Use proper gauge wire for all circuits.
2. If possible, segregate AC and DC power lines, brake output lines, signal lines, and switch wiring.
3. Shielded cable is recommended for sensor connections and external switching circuits.
4. Do not operate external accessories from the MCS-166, MCS-203, or MCS-204 controls.
5. Do not use controls for purposes other than those intended. Such use could damage the control and void the warranty.

### MCS-166/MCS-203

Refer to connection diagrams, Figures 7 and 8, page 9, for wiring connections.

- 1. Wire AC input power to terminals 1, 2, and 3 of the MCS-166 terminal block: Terminal 1 neutral, Terminal 2 hot, Terminal 3 earth ground.
- 2. Wire DC output from MCS-166 Terminal Block to Input Power Terminals on MCS-203 as follows:
  - MCS-166 DC Common Terminal 4 to MCS-203 DC Common Terminal 4.
  - MCS-166 (+) DC Terminal 5 of MCS-166 to (+) Terminal 3 of MCS-203.
- 3. Connect wiring from brake magnets to Terminals 1 and 2 of the MCS-203 terminal block.
- 4. Sensor Wiring
 

Determine the direction of potentiometer shaft rotation as viewed from the connector end of the pivot-point sensor.
- CW  a. For CW rotation, connect sensor wires as follows: Black to Terminal 5, green to Terminal 6, red to Terminal 7. Shield lead should be connected to Terminal 7.

CCW  b. For CCW rotation, connect sensor wires as follows: Red to Terminal 5, green to Terminal 6, black to Terminal 7. Shield lead should be connected to Terminal 7.

### 5. External Switch Connections (optional)

- a. Anti-Drift or Integrator Switch
 

Connect switching circuit between terminals 8 and 9 of MCS-203 terminal strip.

**NOTE:** The anti-drift input can be a limit switch which closes based on dancer arm position or it can be a relay circuit activated by the machine start cycle.

**CAUTION:** The switch or relay used for the anti-drift input should be open during normal running operation to prevent unpredictable reactions.

- b. Brake-Off Switch
 

Connect switch contacts between Terminals 10 and 11 of MCS-203 terminal strip.
- c. Brake-On Switch
 

Connect switch contacts between Terminals 10 and 12 of MCS-203 terminal strip.

**NOTE:** For single brake off function only, use a Single Pole-Single Throw, maintained contact switch. For both functions, a three position switch as shown in Figures 7 and 8, page 9, is recommended.

- 6. Double check all wiring connections per Figure 7 or 8. Insure all terminals are tight.
- 7. Reconnect the front housing of either wall or shelf mounting and secure the latches. If shelf mounting is used, secure the housing with the four (4) bolts for each section.
- 8. Do not insert the control modules at this time. Proceed to the MCS-166/MCS-203 start-up section of this manual.



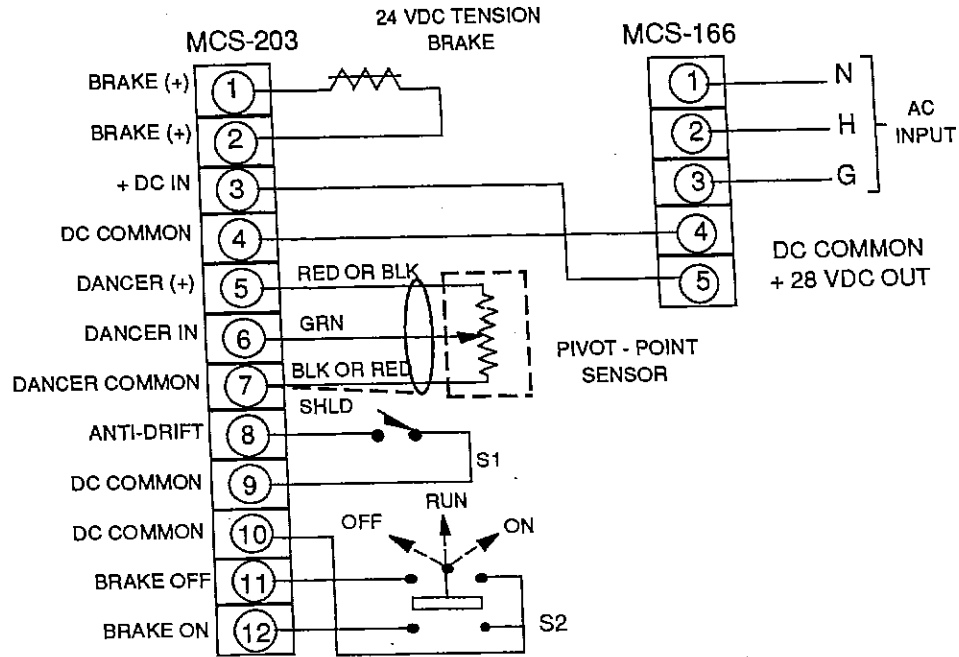
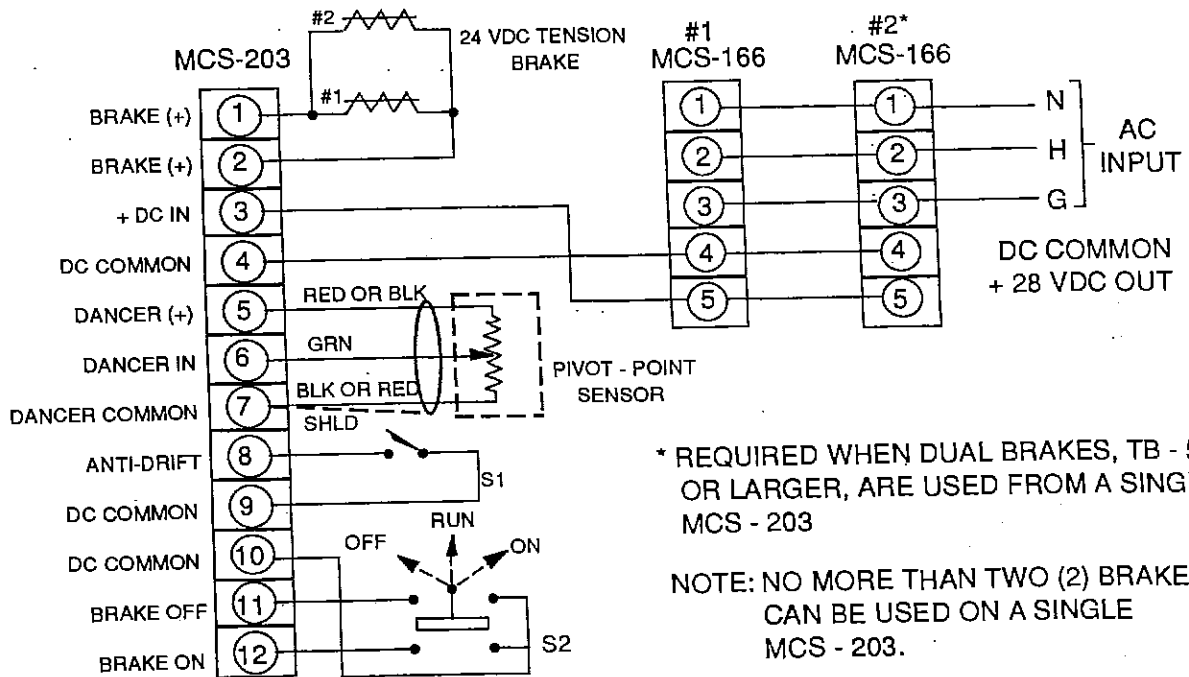


Figure 7 MCS-166/MCS-203 Wiring - Single Brake



\* REQUIRED WHEN DUAL BRAKES, TB - 500 OR LARGER, ARE USED FROM A SINGLE MCS - 203

NOTE: NO MORE THAN TWO (2) BRAKES CAN BE USED ON A SINGLE MCS - 203.

Figure 8 MCS-166/MCS-203 Wiring - Dual Brakes

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## System Wiring

### MCS-166/MCS-204

Refer to Figures 9, 10, 11, 12, pages 11 & 12, for actual wiring connections.

- 1. Wire AC input to terminals 1, 2 and 3 of the MCS-166 terminal block: terminal 1 to be AC neutral, terminal 2 AC hot, and terminal 3 earth ground.
- 2. Wire MCS-166 DC output to MCS-204 input: MCS-166 DC common terminal 4 to MCS-204 DC common terminal 4. MCS-166 (+) DC terminal 5 to MCS-204 (+) input terminal 3.
- 3. Connect brake magnet(s) wires to terminals 1 and 2 of MCS-204 Terminal Block.
- 4. External Switch Connections (optional)
  - a. Brake-Off Switch  
Connect switch contacts between terminals 10 and 11 of MCS-204 terminal strip.
  - b. Brake-On Switch  
Connect switch contacts between terminals 10 and 12 of MCS-204 terminal strip.

**NOTE:** If only a single brake-off function is used, an SPST maintained contact switch may be used. If both functions are used, a three position switch is recommended, as shown in Figure 9 and 10, page 11.

#### 5. Control Input Connections

Refer to Figures 11 and 12, page 12, for various input connection configurations.

- a. Local Torque Adjust Mode  
Connect jumper between MCS-204 terminals 6 and 8, per Figure 11B, page 12.
- b. Remote Torque Adjust/Roll Follower Pot  
Connect remote potentiometer or roll follower potentiometer to MCS-204 terminals 5, 6, and 7, per Figure 11C, page 12.

**NOTE:** Wiper will always be connected to terminal 6. End points should be connected so that turning the remote pot CCW or moving the roll follower pot toward the core will decrease voltage at terminal 6.

#### c. Voltage Source Input

Connect (+) side of external voltage source to terminal 6 and (-) side (or common) of external voltage source to MCS-204 terminal 7, per Figure 11D, page 12.

**CAUTION:** The input level from an external voltage source must not exceed 14.5 VDC. Voltage levels higher than 14.5 VDC will damage the control's input circuits.

#### d. Current Source Input

- 1. Determine the current range from the external current source and select a shunt resistor from the chart in Figure 11E, page 12. Connect the shunt resistor between MCS-204 terminals 7 and 9.
- 2. Connect the (+) side of the external current source to MCS-204 terminal 6 and the (-) side (common) to terminal 7, per Figure 11E, page 12.

#### e. Analog Photoelectric Sensor Input

Refer to Figure 12, page 12 for connection information.

- 1. Make sure the MCS-166 and MCS-204, power, and brake are connected per Figure 12, if not already done.
- 2. Connect sensor to MCS-204, 15 VDC power source: Sensor blue lead to DC common terminal 7, and sensor brown lead to +15 VDC terminal 5.
- 3. Connect sensor output (black lead) to (+) input on Iso-verter, terminal 7.
- 4. Connect (+) output of Iso-verter terminal 2 to input of MCS-204 terminal 6.
- 5. Connect MCS-204 terminal 7 (DC common) to both input and output (-) terminals 1 and 8 of the Iso-verter.
- 6. Connect a shunt resistor between terminals 7 and 9 of MCS-204 terminal strip.

**NOTE:** To prevent pick-up of stray electrical noise, connect the shield wire to terminal 7 only. Use of shielded cable is strongly recommended for sensor pot, voltage or current source input, and connection of the Iso-verter to the MCS-204 inputs.

- ❑ 6. Double check all wiring connections per Figures 9, 10, 11, or 12 for accuracy and tightness.
- ❑ 7. Reconnect the front housings if either wall or shelf mounting is used. Secure the latches. If shelf mounting is used, secure the housings with the four (4) bolts for each section.

- ❑ 8. Do not insert the control modules at this time. Proceed to the MCS-166/MCS-204 start-up section of this manual.

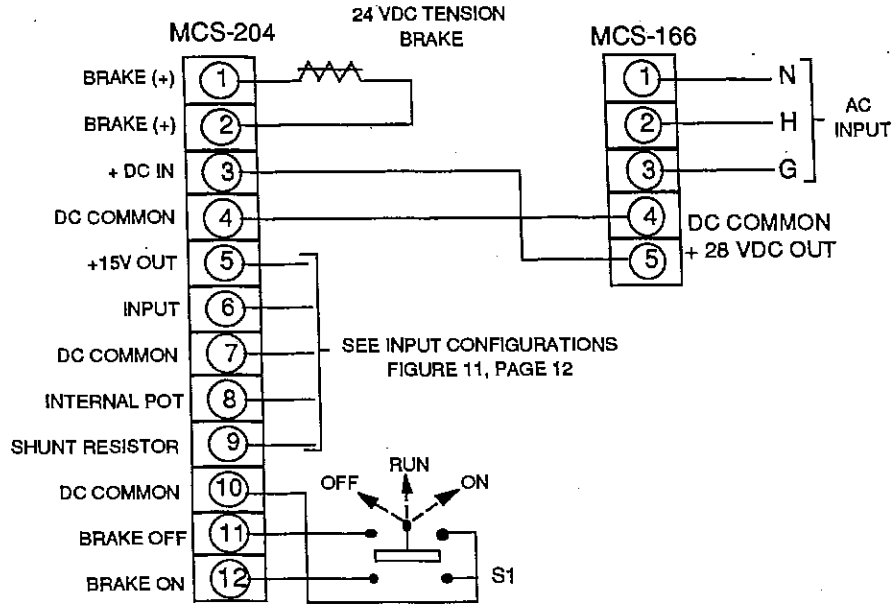


Figure 9 MCS 166/MCS - 204 Wiring - single brake

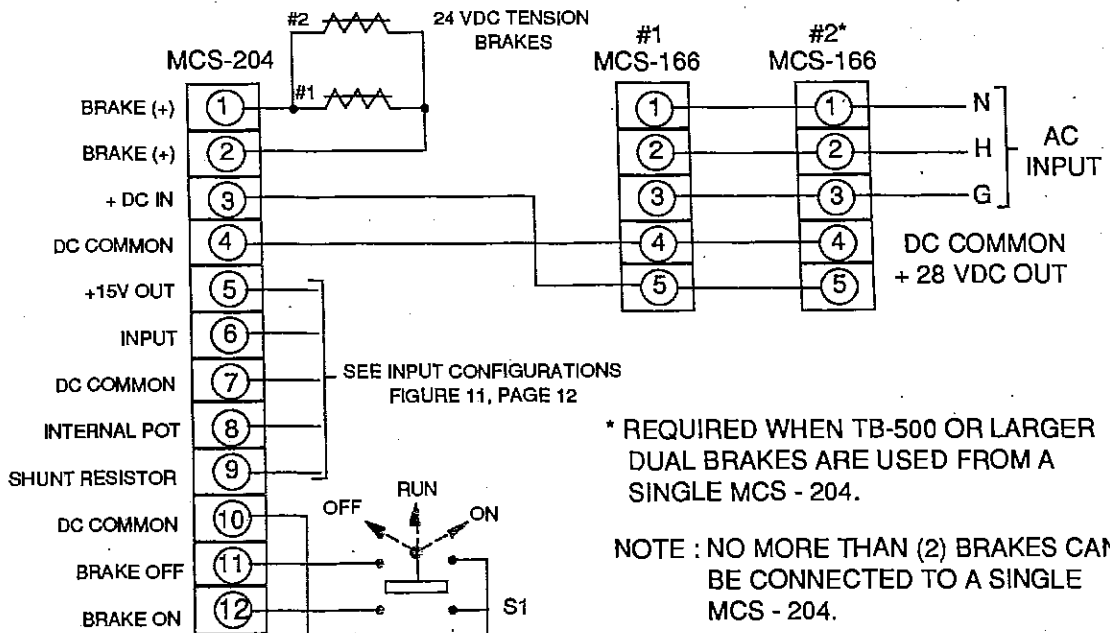
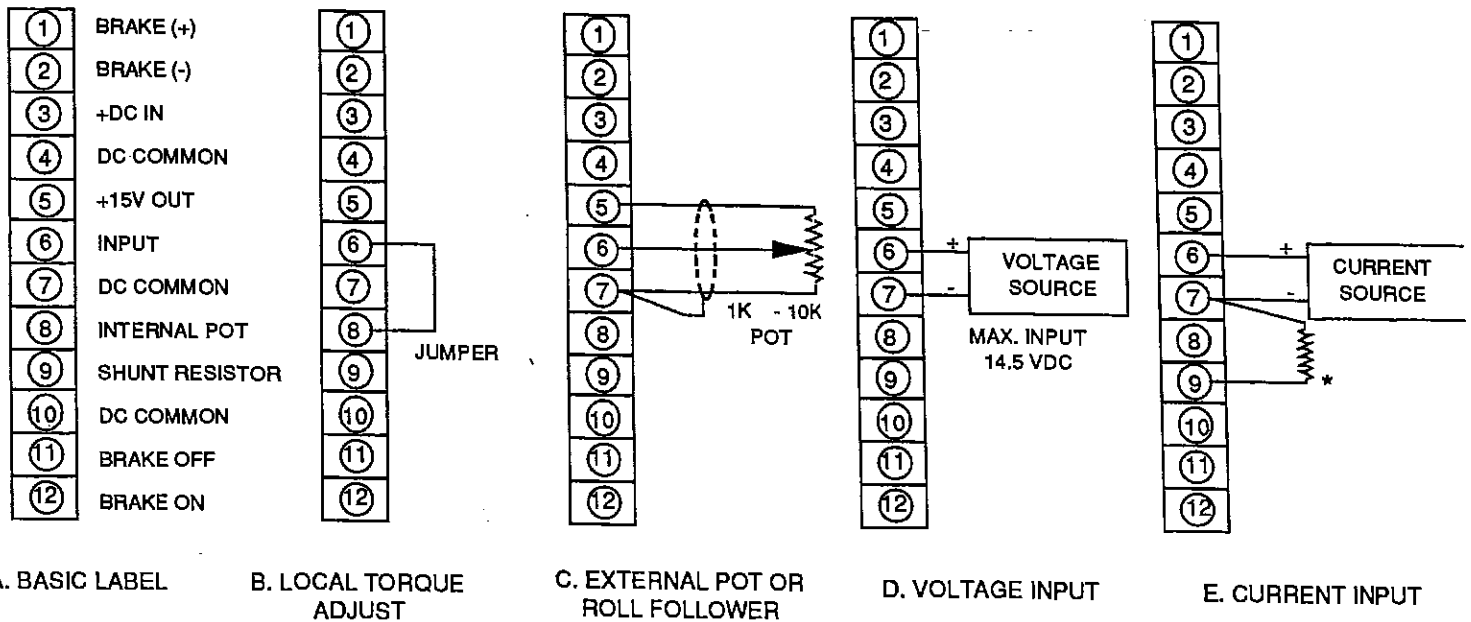


Figure 10 MCS-166/MCS-204 Wiring - Dual Brakes



**\* Shunt Resistor Selection**

CURRENT INPUT	MINIMUM RESISTANCE	MAXIMUM RESISTANCE
1 - 5 ma	470 ohms	1000 ohms
4 - 20 ma	100 ohms	220 ohms
10 - 50 ma	47 ohms	100 ohms

Figure 11. MCS-204 Input Configuration

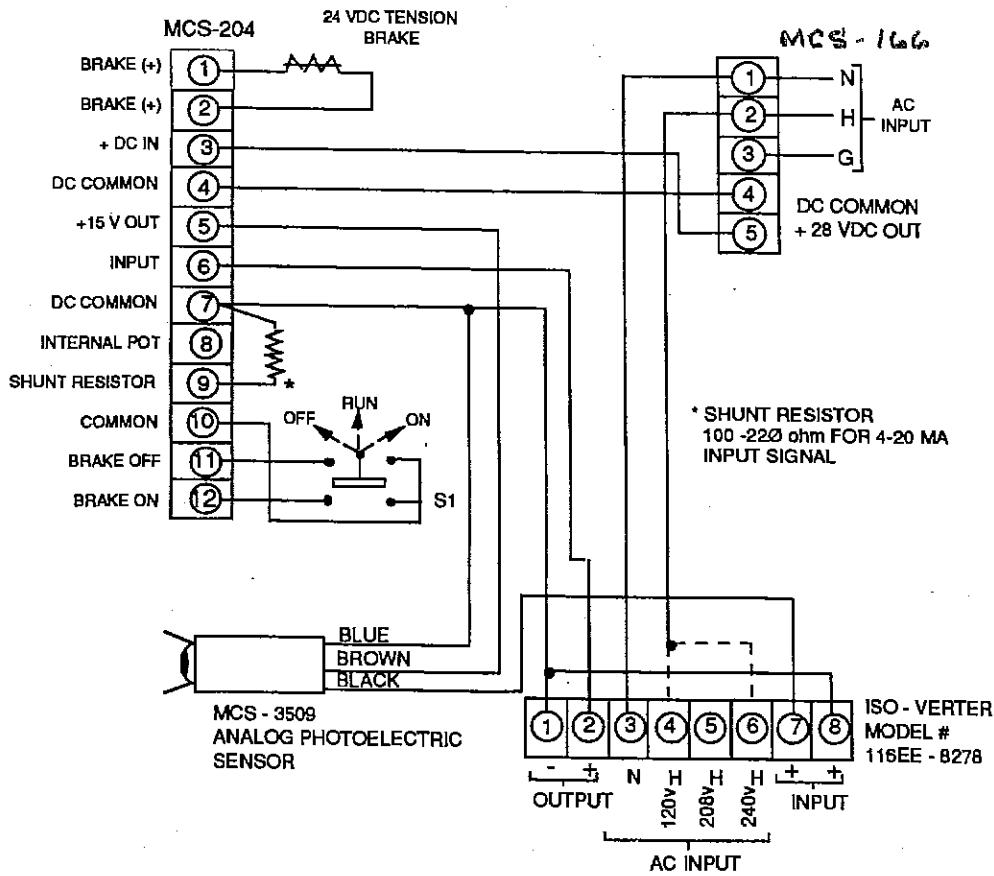


Figure 12. Analog Photoelectric - Roll Follower Wiring

## System Start-Up and Adjustment

### MCS-166/MCS-203

Once set, most MCS-166/MCS-203 adjustments should require no further attention. Exceptions are the "Dancer Position" and "Gain" controls on the MCS-203 front panel. The following start-up and adjustment procedure will provide a stable operating system.

Refer to Figure 13, page 16, for the exact location of internal adjustment potentiometers.

#### A. Preliminary Set-Up

- 1. Set voltage selector switch on MCS-166 for proper input voltage range. This will be either 120 VAC or 220/240 VAC.

**NOTE:** An additional switch has been added to the MCS-166 for selecting 220 or 240 VAC operation. This switch is labeled Low-High. For older style units with a single 120/220-240 VAC selector switch, proceed to step 5 below.

- 2. Set the Low-High Switch as follows:

- a. For 120 VAC, set to High Position.
- b. For 240 VAC, set to High Position.
- c. For 220 VAC, set to Low Position.

**NOTE:** The Low-High switch is used primarily for selecting 220 or 240 VAC operation when the line selector switch is set for 240 VAC, but it can also be used if low line input voltage exists.

- 3. Low line input: For 108 VAC input when set on 120 VAC or 198 VAC input when set on 240 VAC, set the Low-High switch to the Low position.
- 4. High line input: For 132 VAC input when set on 120 VAC or for 268 VAC input when set for 240 VAC, set the Low - High switch to the High Position.

**CAUTION:** Improperly setting the 120/240 VAC Selector Switch and the High-Low Selector Switch can damage the power supply and/or control Module and void their Warranties.

- 5. Slide the power module into the housing and secure with the two captive fasteners on the faceplate.

#### **CAUTION: (OLD STYLE BACK BOARDS ONLY)**

The connectors must mate properly when inserting the control modules into the housings. If the module does not slide in smoothly, gently rock the module from side to side until the connectors mate, but do not apply excessive force.

#### **(NEW STYLE UNITS WITH RIBBON CABLES)**

Pull the ribbon cable forward so that the connector end is in front of the housing assembly. Fasten the ribbon cable connector to the pin connector on the control module. Pin 1 (Red Tracer) on the ribbon cable must connect to pin 1 on the control module as shown. This "Red Tracer" will **ALWAYS** be toward the top of the control.

- 6. Set the "Dancer Position" to its midpoint range and the "Gain" to "5" on the MCS-203 faceplate.
- 7. Set the internal adjustments per Figure 13, page 16, as follows:
  - a. Proportional gain, "R32" fully clockwise (CW).
  - b. Integrator gain, "R24" at 60% clockwise.
  - c. Differentiator gain, "R16" at 75% clockwise.
  - d. Differentiator response switch 1 "on" and switches 2 and 3 "off."

- 8. Slide the control module into the housing and secure with the two captive fasteners on the faceplate.

#### **CAUTION: (OLD STYLE BACK BOARDS ONLY)**

The connectors must mate properly when inserting the control modules into the housings. If the module does not slide in smoothly, gently rock the module from side to side until the connectors mate, but do not apply excessive force.

#### **(NEW STYLE UNITS WITH RIBBON CABLES)**

Pull the ribbon cable forward so that the connector end is in front of the housing assembly. Fasten the ribbon cable connector to the pin connector on the control module. Pin 1 (Red Tracer) on the ribbon cable must connect to pin 1 on the control module as shown. This "Red Tracer" will **ALWAYS** be toward the top of the control.

#### B. Static Adjustment and Check Out

- 1. Apply power to the tension control system with the machine in a non-running or off mode. Check that the "power" indicators on both the MCS-166 and MCS-203 are illuminated.
- 2. Move the dancer arm to the shortest web-loop position and note that the "brake" indicator goes "off." Then move the dancer to the longest web-loop position and note that the "brake" indicator illuminates.

**NOTE:** If the "brake" indicator is the reverse of this, the Pivot-Point Sensor is wired backwards. Refer to the MCS-166/MCS-203 wiring section for correct connections.

3. Brake-On/Brake-Off Switch Check (optional)

- a. Place Brake-Off switch in brake-off mode and note that the "brake" indicator goes out.
- b. Return the Brake-Off switch to its normal run mode.
- c. If used, turn on the Brake-On switch and note that the "brake" indicator goes full on.
- d. Return Brake-On switch to its normal running position.

NOTE: If operation of the Brake-On/Brake-Off switches produced the opposite results in 3a and 3c above, the wiring is reversed. Refer to the MCS-166/MCS-203 wiring section for the proper connections.

4. Anti-Residual Adjustment

- a. Activate the Brake-Off switch (if used) or move the dancer to the shortest web-loop position.
- b. Check that the brake armature floats away from the brake magnet with no sticking.
- c. If the armature sticks to the magnet, adjust the anti-residual potentiometer CW or CCW until the armature is free with no sticking.
- d. Reapply the brake either by moving the dancer to its longest web-loop or by returning the brake-off switch to its normal run position and activating the brake-on input.
- e. Repeat steps 4a through 4d above.
- f. If brake releases freely, make no further adjustments as the anti-residual is now set.

NOTE: CCW rotation decreases the anti-residual output while CW rotation increases it. Excessive CW rotation can cause brake engagement.

5. Frequency Adjustment

The frequency adjustment changes the modulation frequency to eliminate brake "hum" or "howl" when the brake is stationary. The frequency is factory set and normally requires no adjustment.

- a. Turn CW if a low pitch hum is present or CCW if hum is high pitched.

**\*CAUTION: To set the frequency, the control must be unplugged from its housing. Do not unplug control unless power is off. Failure to turn power off before unplugging will result in damage to control module and/or power module.**

C. Start-Up and Dynamic Adjustments

- 1. Verify that power is on.

- 2. Start the machine and draw material.

- 3. After the Dancer has stabilized, adjust the front panel "Dancer Position" potentiometer for the desired dancer running position.
- 4. If the system is providing stable dancer operation, increase the "Gain" until the dancer hunts or oscillates. Note the gain position number where this occurs.
- 5. Reduce the "gain" setting from step 4 above one to two digits.
- 6. If dancer instability is apparent from initial start, reduce the gain until it becomes stable.

NOTE: This is only a preliminary gain setting. A final gain setting is required at core diameter for optimum system performance.

- 7. Run the system until the unwind roll is within two to four inches of core diameter.
- 8. If the system has been stable, re-set the front panel "gain" until dancer hunting or oscillation occurs, noting the gain setting number, then reduce the setting one or two digits.

NOTE: This is the optimum gain setting. No further adjustments are necessary.

- 9. If system stability cannot be achieved through front panel "gain" adjustment, it may be necessary to adjust gain functions internally.

**CAUTION: Internal P-I-D gain adjustments should be made only after all other attempts to achieve system stability have failed. These adjustments should be made by qualified personnel only.**

NOTE: Internal access is required for the set-up adjustments which follow. This can be accomplished with the TCS-900 set-up and diagnostic tester or by removing the side panel plate from the housing, or, on new versions with ribbon cable connectors, by sliding the control module partially out of the housing.

**CAUTION: If side panel plate on the control housing is to be removed, insure the power is off before removing the control module from the housing. Failure to disengage power before removing the module will result in damage to the control and/or power module.**

**IMPORTANT: Follow the sequence outlined below to properly adjust the P-I-D circuit gains. If the TCS-900 is used, follow the instructions included with the TCS-900.**

\*Applies only to "older style" units without ribbon cable assemblies.



**D. P-I-D Gain Adjustments**

- 1. "P" - Proportional gain adjustment, R32
  - a. Jumper the anti-drift input (terminal 8) to DC common (terminal 9) on the MCS-203 terminal block to disable the integrator circuit.
  - b. Inject a transient into the system by rapidly changing the dancer position. Suddenly changing dancer air pressure or rapidly depressing the web or dancer arm will provide the transient. Observe the dancer's response.
  - c. The dancer should stabilize within one to two cycles. If oscillations do not subside, reduce the "P" gain potentiometer, R32, CCW in small increments, observing the effects.
  - d. Repeat steps b and c above as necessary until desired response is obtained.

NOTE: "P" gain settings are a function of brake size. R32 is factory set at 100% CW. Generally, the larger the brake, the lower the R32 setting.

NOTE: If response is not obtained with "P" gain adjustment, it may be necessary to make "D" gain adjustments as well.

- 2. "D" - Differentiator gain adjustment, R16
  - a. Insure anti-drift (terminal 8) is still grounded.
  - b. Inject a transient into the web as described in step 1b above.
  - c. If dancer stability is achieved within one or two cycles, make no further adjustments.
  - d. If stability is not achieved, adjust R16 as follows:
    - 1. If response is erratic and dancer is extremely jerky, rotate R16 CCW.
    - 2. If response is sluggish and dancer hunts, rotate R16 CCW.

NOTE: If proper response is not achieved with R16 at maximum CW setting, the next higher differentiator response range should be used.

**CAUTION:** When switching to higher response ranges, R16 should be set full CCW.

*FACTORY SETTINGS:*

"P" (R32) = 100% C.W.

"I" (R24) = 60-70% C.W.

"D" (R-16) = 75% C.W.

*DIP SWITCH-#1 ON (ONLY)*

- e. Repeat steps b through d above to insure optimum response.

NOTE: To insure optimum performance, the system should be checked at or near full roll diameter.

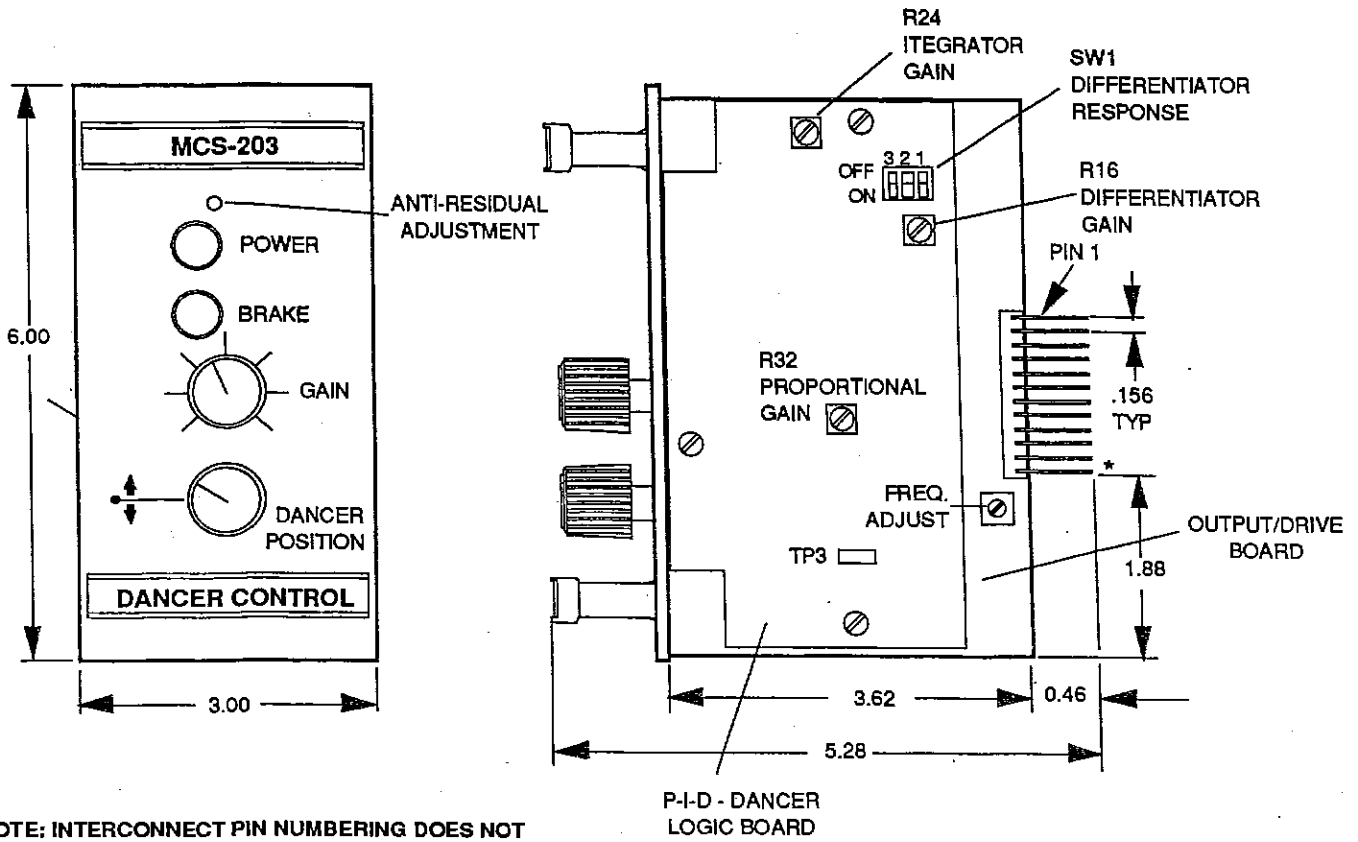
- f. Remove jumper on anti-drift input (connecting terminal to DC common terminal 9).
- 3. "I" - Integrator gain adjustment, R24.

**CAUTION:** The "I" gain adjustment controls how far the dancer must move to compensate for unwind roll diameter changes. Any adjustment must be made strictly in accordance with the instructions below:

- a. With the system running and stabilized, observe the amount of dancer movement.
- b. If the dancer arc is less than 5 degrees and movement is smooth, do not make any adjustments.
- c. If dancer arc is greater than 10 degrees, but movement is smooth, adjust the "I" gain potentiometer CW in small increments, observing the results, until stability is achieved.
- d. If dancer arc is within 5 to 10 degrees, but movement is choppy and rough, adjust the "I" gain potentiometer CCW in small increments, observing the results, until stability is obtained.
- 4. After completing P-I-D adjustments, recheck main gain adjustments per steps C4 through C8.

This completes the start-stop and adjustment of the MCS-166/MCS-203 Dancer Control System.

If difficulties are encountered which cannot be resolved using this manual, contact your local Warner Electric Representative or the factory.



NOTE: INTERCONNECT PIN NUMBERING DOES NOT CORRESPOND TO TERMINAL BLOCK NUMBERING.

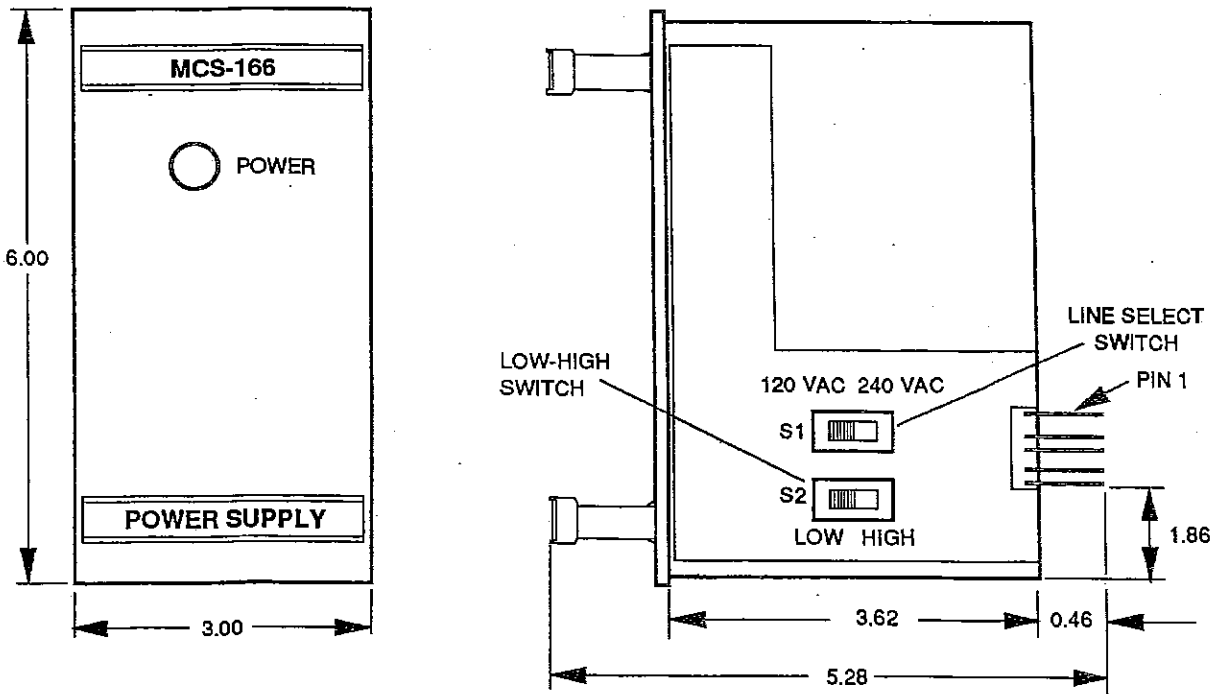


Figure 13 Control Adjustment Locations, MCS-166/MCS-203

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## System Start-Up and Adjustment

### MCS-166/MCS-204

Once set, most MCS-166/MCS-204 adjustments require no further attention. The exception is the torque/span adjust which sets the maximum output limit. Please follow the set-up and adjustment procedure below for trouble free start-up.

Refer to Figure 14, page 19, for exact location of adjustments and indicators.

#### A. Preliminary Set-Up

- 1. Set voltage selector switch on MCS-166 for proper input voltage range, either 120 VAC or 220/240 VAC.

NOTE: An additional switch has been added to the MCS-166 for selecting 220 or 240 VAC operation. This switch is labeled Low-High. For older style units with a single 120/220-240 VAC selector switch, proceed to step 5 below.

- 2. Set the Low-High Switch as follows:

- a. For 120 VAC, set to High Position.
- b. For 240 VAC, set to High Position.
- c. For 220 VAC, set to Low Position.

NOTE: The Low-High switch is used primarily for selecting 220 or 240 VAC operation when the line selector switch is set for 240 VAC, but it can also be used if low line input voltage exists.

- 3. Low line input: For 108 VAC input when set on 120 VAC or 198 VAC input when set on 240 VAC, set the Low-High switch to the Low position.
- 4. High line input: For 132 VAC input when set on 120 VAC or for 268 VAC input when set for 240 VAC, set the Low - High switch to the High Position.

**CAUTION: Improperly setting the 120/240 VAC Selector Switch and the High-Low Selector Switch can damage the power supply and/or control Module and void their Warranties.**

- 5. Slide power module into its housing and secure with the two captive fasteners on the faceplate.

#### CAUTION: (OLD STYLE BACK BOARDS ONLY)

The connectors must mate properly when inserting the control modules into the housings. If the module does not slide in smoothly, gently rock the module from side to side until the connectors mate, but do not apply excessive force.

#### (NEW STYLE UNITS WITH RIBBON CABLES)

Pull the ribbon cable forward so that the connector end is in front of the housing assembly. Fasten the ribbon cable connector to the pin connector on the control module. Pin 1 (Red Tracer) on the ribbon cable must connect to pin 1 on the control module as shown. This "Red Tracer" will **ALWAYS** be toward the top of the control.

- 6. Slide the MCS-204 Control Module into its housing and secure with the two captive fasteners on the faceplate.

#### CAUTION: (OLD STYLE BACK BOARDS ONLY)

The connectors must mate properly when inserting the control modules into the housings. If the module does not slide in smoothly, gently rock the module from side to side until the connectors mate, but do not apply excessive force.

#### (NEW STYLE UNITS WITH RIBBON CABLES)

Pull the ribbon cable forward so that the connector end is in front of the housing assembly. Fasten the ribbon cable connector to the pin connector on the control module. Pin 1 (Red Tracer) on the ribbon cable must connect to pin 1 on the control module as shown. This "Red Tracer" will **ALWAYS** be toward the top of the control.

#### B. Static Adjustments and Check Out

- 1. Apply power to the Tension Control System with the machine stationary. Check that the "Power" indicators on both the MCS-166 and MCS-204 are illuminated.
- 2. Set the front panel "Torque/Span Adjust" potentiometer to its full CCW positioning.
- 3. Brake-off/brake-on switch checks (optional)
  - a. Set brake-off switch to off position and note that the "brake" indicator is off. The 0-100% indicator may be on at this time.
  - b. Return the brake-off switch to its normal running position.
  - c. Place the brake-on switch (if used) in the brake-on position and note that the "brake" indicator is on. The 0-100% indicator may also be on at this time.
  - d. Return the brake-on switch to its normal running position.

NOTE: If operation of the brake-off and brake-on is reversed, the wiring is reversed. Refer to MCS-166/MCS-204 wiring section for proper wiring connections.

4. Anti-residual adjustment

- a. Activate the brake-off switch, if used, or jumper the brake-off terminal to DC common.
- b. Check that the brake armature floats away from the magnet with no sticking.
- c. If the armature sticks, adjust the anti-residual potentiometer CW or CCW until the armature is free with no sticking.
- d. Reapply the brake by either activating the brake-on switch or jumpering the brake-on input to DC common. Brake-off input must be open.
- e. Repeat steps 4a through 4d above.
- f. If brake releases freely, the anti-residual is set.

NOTE: CCW adjustment decreases anti-residual output while CW adjustment increases it. Setting the anti-residual too far CW can cause brake engagement.

5. Frequency adjust

The frequency adjust changes the modulation frequency to eliminate brake "hum" or "howl" when the brake is stationary. The frequency is factory set and normally requires no adjustment.

- a. Turn CW if a low pitch hum is present or CCW if the hum is high pitched.

**\*CAUTION: To set the frequency, the control must be unplugged from its housing. Do not unplug control unless power is off. Failure to turn power off before unplugging will result in damage to control module and/or power module.**

C. Input Calibration

NOTE: The following calibration procedures assume that the maximum input corresponds to the maximum (24VDC) output to the brake. An accurate digital voltmeter is required to properly set up this system.

1. Local torque adjust mode

- a. Insure power is on and torque adjust/span is set fully CCW.
- b. Set the "zero adjust" potentiometer (through front panel) so the 0-100% indicator illuminates. This is a true zero output to the brake.
- c. Now rotate the "torque/span" potentiometer toward its maximum setting. As the pot is turned, the 0-100% indicator goes out and the "brake" indicator comes on. At 100% output (24VDC), the 0-100% indicator will come on.

NOTE: Depending on the accuracy of the initial "zero" setting, steps a through c above may have to be repeated to achieve full range adjustment of the "torque/span" potentiometer.

2. Remote torque adjust

- a. Insure that power system is on.
- b. Set the remote torque adjust potentiometer to maximum.
- c. Set the front panel "torque/span adjust" to maximum output (24VDC). The 0-100% indicator will be illuminated.
- d. Set the remote torque adjust potentiometer to minimum.
- e. Set the "zero adjust" potentiometer so the 0-100% indicator illuminates.
- f. Repeat steps b through e above as these two adjustments will interact on each other.

NOTE: When the remote torque adjust pot is at minimum, the brake should be fully released. When the pot is set to maximum, the brake should be fully on.

- g. After the proper "span" adjustment is obtained, remove the "torque/span" knob and insert the cap plug into the hole to prevent tampering.

3. Current source adjust

- a. Insure that system power is on.
- b. Adjust the external current source for minimum input current, based on the operating range selected.
- c. Adjust the "zero adjust" potentiometer so the 0-100% indicator is illuminated.
- d. Set the external current source to maximum input based on the operating range selected.
- e. Adjust the "torque/span" potentiometer for full output (24 VDC) and 0-100% indicator illumination.
- f. Repeat steps b through e to insure there is no interaction between adjustments.

NOTE: Set-up adjustment is the same for all three current range inputs.

- g. After set-up has been completed, the "torque/span" knob should be removed and the hole plugged with the insert provided.

4. Voltage source adjust

- a. Insure that system power is on.
- b. Set the external voltage source for maximum input level.

**WARNING: The maximum input level must not exceed 14.5 VDC or damage may occur to control logic circuits.**

\*Applies only to "older style" units without ribbon cable assemblies.

- c. Adjust the "torque/span" potentiometer for maximum output (24VDC) as indicated by the 0-100% indicator illumination.
- d. Adjust the external voltage source for the minimum input level to be used.
- e. Set the "zero adjust" potentiometer or zero output until the 0-100% indicator illuminates.
- f. Repeat steps b through e until no interaction is seen between the two adjustments.
- g. After set up adjustments have been completed, the "torque/span" knob should be removed and the hole plugged with the insert provided.

#### 5. Roll follower adjustment

- a. Insure that system power is on.
- b. Connect a DC voltmeter between the wiper and DC common on the follower potentiometer.
- c. Adjust the roll follower arm for a true zero position which corresponds to the exact center of the roll shaft. Adjust the roll follower potentiometer to provide a DC input reading of  $0.5 \text{ VDC} \pm 0.1 \text{ VDC}$ .
- d. Remove the meter from the follower potentiometer and connect across the brake magnet.
- e. Set the roll follower arm to correspond to the maximum roll diameter.
- f. Adjust the "torque/span" potentiometer to provide the desired output level to the brake as indicated by the voltmeter.

- g. Set the roll follower arm back to its true zero position.
- h. Set the "zero adjust" potentiometer for a zero output as indicated by the 0-100% indicator illumination.
- i. Repeat steps e through h until no interaction is evident between the two adjustments.

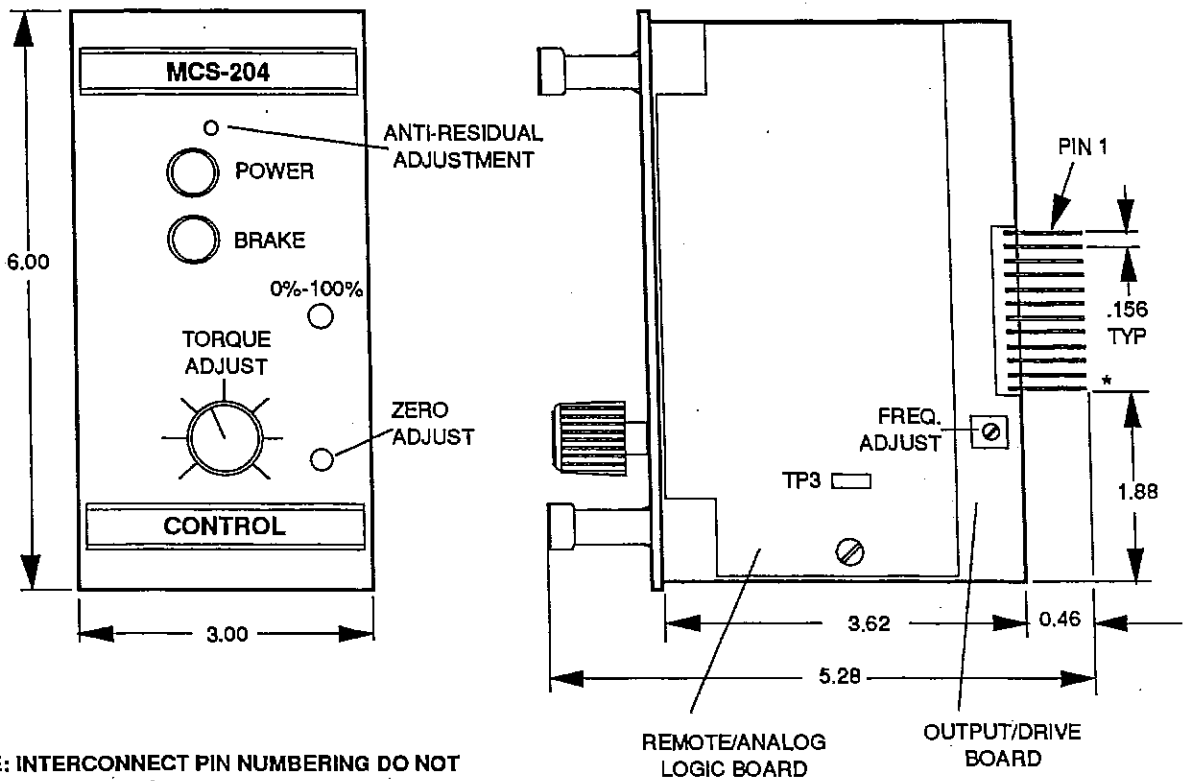
NOTE: At maximum roll diameter, the output of the MCS-204 should be set for the required tension. This may not correspond to the full output level of the control, depending on tension, speed, and torque available.

#### D. Dynamic Adjustments

- 1. Remove any meter connections, etc., that were made during set-up adjustments.
- 2. Start system and draw web through the machine.
- 3. Make any adjustment necessary to provide the required tensions based on the type of input used.

This completes the start-up and adjustment of the MCS-166/MCS-204 Remote/Analog Control System.

If any difficulties are encountered that cannot be resolved through this manual, contact your local Warner Electric Representative or the factory.



NOTE: INTERCONNECT PIN NUMBERING DO NOT CORRESPOND TO TERMINAL BLOCK NUMBERING.

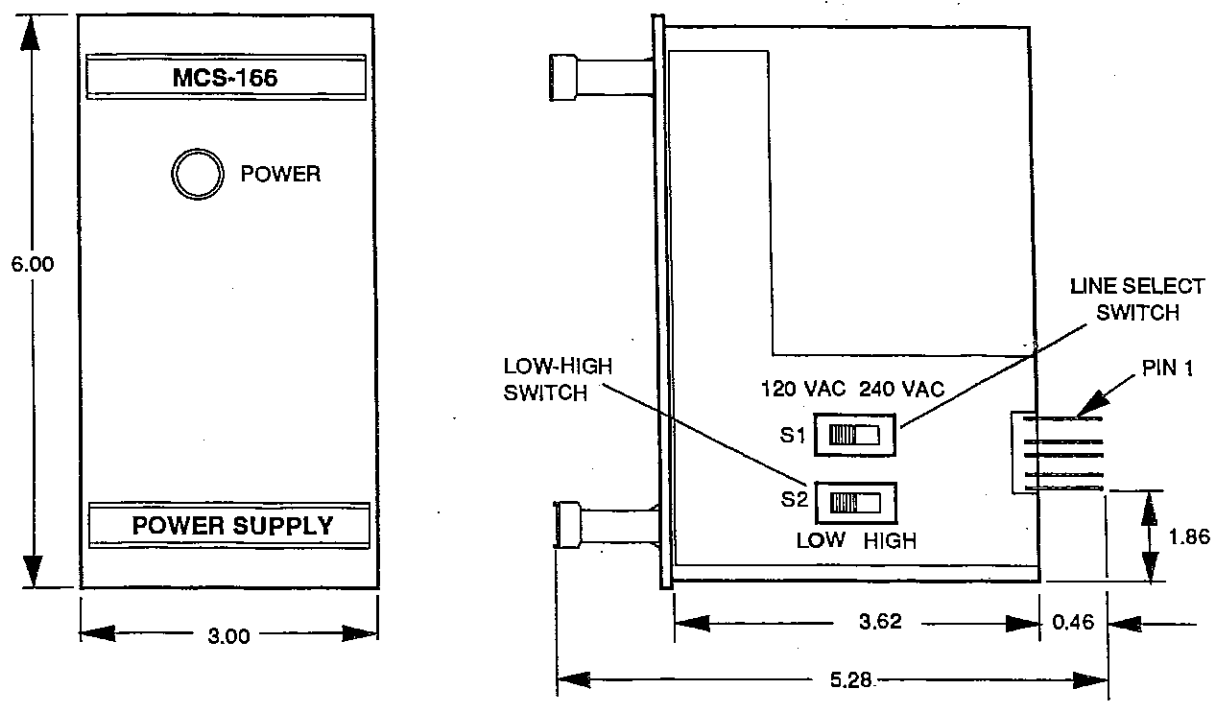


Figure 14 Control Adjustment Locations, MCS-166/MCS204

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**TROUBLESHOOTING**

**Applies to MCS-203 Control, MCS-166, Power Supply,  
 and MCS-605-1 or TCS-605-5 Pivot Point Sensor**

**General:** The chart below will be helpful when isolating exact problems which may occur in the control system. The chart will also prove helpful when encountering problems with the initial start-up of the system. When the system has been running for some time, the chart will also be helpful when checking for worn, broken or frayed wires; bent or broken control system parts; blown fuses;\* loose terminal connections and wire connections; loose or broken sensor couplings; worn or loose mechanical parts for the tension stand (bearing, couplings, etc.); and dust or dirt accumulation inside the control which has caused components to overheat.

**Symptom A: Dancer will not raise from bottom position.**

Probable Cause	Suggested Solution
Incorrect Dancer Position setting	Adjust dancer position setting until dancer moves to normal running position.
Dancer is not free to move because of obstruction.	Remove obstruction, release any holding devices or safety locks.
No DC power to the control.	Check for power LED illumination on MCS-203 Check for power LED illumination on MCS-166 Check fuses Check proper DC input connections to control (refer to tension control hookup instructions). Check AC power input to MCS-166 if used.
Brake is not engaging.	Check to be sure lead wires to the brake are at the brake terminals 1 and 2 of the control. Check to see if sensor is connected. Using a voltmeter, check for approximately -1.8 to +28VDC between the brake terminals. If there is no voltage, check for approximately -1.8 to +28VDC between terminals 1 and 2 of the control. If the voltage is present at the control and not at the brake, wires to the brake are open. If there is no voltage at terminals 1 and 2 of the control, replace the printed circuit board assembly. If there is voltage at the brake terminal, check the brake coil resistance with an ohmmeter for shorted brake magnets or wrong coil voltage. Check for proper pivot sensor alignment. Terminals 6 and 7 on MCS-203=7.5VDC ± 0.1VDCw/dancer control: 6.1VDC - shortest web loop. 8.9VDC -longest web loop. Check to see that brake is wired properly. Check to see that brake-off input is not activated.
Brake does not have the torque capacity required for the application.	Verify that the correct brake was selected by repeating the selection procedure.

**Symptom B: Dancer moves to and remains at upper limit during initial systems start-up.**

NOTE: Refer to symptom C if dancer moved to upper limit after it had been running normally at the proper position.

Probable Cause	Suggested Solution
Incorrect Dancer Position setting	Adjust dancer position setting until dancer moves to normal running position.
Roll shaft not free to rotate with control off.	Brake and shaft must be free to rotate with control off.
Sensor incorrectly connected to control terminals.	Verify sensor connections.

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Using a voltmeter, check the DC voltage at the brake terminals as follows: Slowly raise the dancer and observe that the voltage decreases- then slowly lower the dancer and observe that the voltage increases. If the voltage indications are the opposite, reverse the sensor leads at terminals 5 and 7 of the control (see sensor wiring).

If no voltage change occurs, check sensor cable connections (check pivot point coupling connection if MCS-605-1 or TCS-605-5 sensor is used).

If no voltage change occurs, be sure that the brake wires are not grounded to machine.

Brake is not releasing as dancer is raised (even though voltage decreases).

Check the mechanical parts of the brake to assure they are in good operating condition and properly installed. Check to see if Brake-On input is activated.

**Symptom C: Dancer moves to and remains at upper limit after operating in a normal running position for a period of time.**

Probable Cause	Suggested Solution
Incorrect Dancer Position setting	Adjust dancer position setting until dancer moved to normal running position.
Dancer pivot point sensor coupling has slipped	If dancer position adjustment lowers the arm near its normal running position, realign pivot point sensor (see sensor mounting).
Faulty P.C. Board	With dancer position and gain at minimum setting, check that the voltage on the brake terminal reduces to less than two volts as the dancer arm is raised. If voltage does not reduce to less than two volts, replace printed circuit board assembly.
(Problem occurs near roll core only) Residual torque of the unwind stand exceeds the minimum torque allowable for the application.	With dancer position and gain at minimum setting, check that the DC voltage at the brake terminals reduces to 0 and reverses polarity as the dancer arm is slowly raised. If the voltage reduces and reverses polarity, check to be sure that the brake is in good operating condition and properly installed (see tension brake maintenance-torque loss). Also check to be sure that the unwind stand friction is not excessive for the application. Check the brake selection procedure to be sure the brake being used does not exceed the minimum allowable torques. If the voltage did reduce to zero but did not reverse polarity, adjustment of the antiresidual may be necessary. If adjustment of the antiresidual does not cause the brake voltage to reverse polarity in the off state, replace the PC Board Assembly.

**Symptom D: Dancer moves erratically - appears to hunt or oscillate.**

Probable Cause	Suggested Solution
Incorrect Dancer Gain setting	Adjust dancer gain setting CCW until dancer stops hunting.
Nonuniform system friction	If the hunting coincides with each revolution of the web parent roll, check faulty bearings or mismounted brake.
Improperly installed sensor	When an MCS-605-1 Sensor is being used, check to be sure the index mark on the sensor shaft is aligned with the index mark on the sensor body when the dancer is at the mid-travel position. Also, be sure there is no lag between the movement of the dancer pivot point and the shaft of the sensor - the sensor shaft must move when the dancer pivot moves. With dancer centered, voltage at terminals 6 and 7 should be 7.5 VDC ±0.1 VDC (refer to the sensor mounting section).
Loose or faulty sensor and cable assembly.	Check to be sure that all connections to the control terminal block and the brake wire connections are secure. Check electrical connector at sensor to be sure it is not loose. Using a DC voltmeter connected between control terminals 6 and 7, check to be sure the voltage variation is smooth as the dancer is slowly moved through its travel limits. If the voltage variation is not relatively smooth, either the sensor or cable assembly is faulty. To isolate the fault to the cable or the sensor, turn off power and disconnect the cable from the sensor and connect an ohmmeter between the middle pin and one of the remaining pins on the sensor receptacle. The resistance indication should vary smoothly as the dancer is moved through its travel limits. If the indication is erratic, the sensor should be replaced; if the indication is not erratic, the cable assembly should be replaced. If above steps seem normal, recheck dancer arm length (most applications require a dancer arm at least 12" long).

## TROUBLESHOOTING

**Applies to MCS-204 Control,  
MCS-166 Power Supply**

With the exception of the dancer input, general MCS-166/MCS-204 system troubleshooting is quite similar to troubleshooting the MCS-166/MCS-203. The chart below will be helpful in isolating problems causes.

Probable Cause	Suggested Solution
No DC power to the control.	Check for power LED illumination on MCS-204. Check for power LED illumination on MCS-166 Check fuses. Check proper DC input connections to control (refer to tension control hookup instructions). Check AC power input to MCS-166, if used.
Brake is not engaging.	Check to be sure lead wires to the brake are at the brake terminals and at terminals 1 and 2 of the control. Check to see if input is properly connected. Using a voltmeter, check for approximately -1.8 to +28 VDC between the brake terminals. If there is no voltage, check for approximately -1.8 to +28 VDC between terminals 1 and 2 on the control. If the voltage is present at the control and not at the brake, wires to the brake are open. If there is no voltage at terminals 1 and 2 of the control, replace the printed circuit board assembly. If there is voltage at the brake terminal, check the brake coil resistance with an ohmmeter for shorted brake magnet or wrong magnet voltage. Check for proper input signal. Check to see that brake is wired properly. Check to see that Brake-Off input is not activated.
Brake does not have the torque capacity required for the application.	Verify that the correct brake was selected by repeating the selection procedure.
Brake is not releasing as input level decreases	Check the mechanical parts of the brake to assure they are in good operating condition and properly installed. Check to see if Brake-On input is activated.
Roll shaft not free to rotate with control off.	Brake and shaft must be free to rotate with control off.
Inputs incorrectly connected to control terminals.	Verify input connections.
If brake LED off?	Using a voltmeter, check the DC voltage at the brake terminals as follows. Slowly reduce the input level and observe that the voltage decreases - then slowly increase the input level and observe that the voltage increases.
(Problem occurs near roll core only) Residual torque of the unwind stand exceeds the minimum torque allowable for the application.	With input level at minimum settings, check that the DC voltage at the brake terminals reduces to 0 and reverses polarity. If the voltage reduces and reverses polarity, check to be sure that the brake is in good operating condition and properly installed (see tension brake maintenance-torque loss). Also check to be sure that the unwind stand friction is not excessive for the application. Check the brake selection procedure to be sure the brake being used does not exceed the minimum allowable torques. If the voltage did reduce to zero but did not reverse polarity, adjustment of the antiresidual may be necessary. If adjustment of the antiresidual does not cause the brake voltage to reverse polarity in the off state, replace the PC Board Assembly.

## REPLACEMENT PARTS LISTING

MCS-166 Power Module .....	6910-448-013
MCS-166 Housing, Panel Mount.....	6910-448-018
MCS-166 Housing, Wall/Shelf Mount.....	6910-448-019
Rear P/C Board Assy. MCS-166 P/M encl. ...	6910-101-022*
Rear P/C Board Assy. MCS-166 W/S encl. ..	6910-101-020*
Fuse, 1 Amp, 250 Volt, Fast Acting .....	458-8001-017
MCS-203 Dancer Module, Complete .....	6910-448-014
MCS-203 P-I-D Logic Board .....	6910-448-021
MCS-203 Output/Driver Board .....	6910-448-020
MCS-203 Housing, Panel Mount.....	6910-448-015
MCS-203 Housing, Wall/Shelf Mount.....	6910-448-016
Rear P/C Board Assy. MCS-203 P M encl. ...	6910-101-023*
Rear P/C Board Assy. MCS-203 W/S encl. ..	6910-101-021*
Fuse, 3 Amp, 250 Volt, Fast Acting .....	458-8001-006
MCS-204 Remote/Analog Module, Complete	6910-448-017
MCS-204 Remote/Analog Logic Board .....	6910-448-022
MCS-204 Output/Driver Board .....	6910-448-023
MCS-204 Housing, Panel Mount.....	6910-448-015
MCS-204 Housing, Wall/Shelf Mount.....	6910-448-016
Rear P/C Board Assy. MCS-204 P/M encl. ...	6910-101-023*
Rear P/C Board Assy. MCS-204 W/S encl. ..	6910-101-021*
Fuse, 3 Amp, 250 Volt, Fast Acting .....	458-8001-006
MCS-605-1 Pivot-Point Sensor, Single Turn	7330-448-002
TCS-605-5 Pivot-Point Sensor, 5 Turn .....	7330-448-003
Replacement Cable Assy. for MCS-605-1, TCS-605-5.....	7330-101-001
Coupling .....	284-8000-003

\* New style back board assembly w/ribbon cable connector assembly.

## LISTING OF FIGURES AND ILLUSTRATIONS

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- Figure 2 ..... Terminal strip label orientation
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- Figure 11 ..... MCS-204 input configurations
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- Figure 13 ..... Control adjustment locations, MCS-166/MCS-203
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