

RMC70 Hardware Evaluation

**TESTING RMC70 HARDWARE
IN THE EVENT OF A FAILURE**

Version 1.0a

January, 2021

Overview

Use this procedure when you suspect that the RMC70 motion controller may have a hardware failure.

If the hardware fails any part of this procedure:

1. Use the checklist at the end to report which items failed. Describe the problem symptoms and test results in as much detail as possible.
2. Contact Delta Technical Support
 - support@deltamotion.com
 - +1 360-254-8688

If the hardware passes this procedure:

The problem is likely caused by something else. Items to check are:

1. The power supply.
2. Wiring.
3. Transducers.

In rare occasions, the problem may still be the RMC, even if it passes this simple test procedure. Intermittent hardware problems (such as a loose pin) or temperature-related problems may not appear in a simple test. However, you can modify the procedures to take these things into account, which will increase the chance of correctly determining whether the hardware has failed.

Required Equipment

1. **Multi-meter**

To measure voltage, current, and resistance.

2. **24 VDC power supply**

For powering the RMC.

3. **Variable-voltage power supply (0-10 V)**

If a variable-voltage power supply is not available, the Control Output can be used instead, which will slightly modify some of the tests.

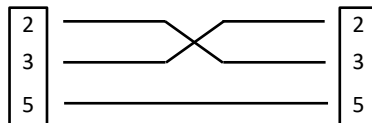
4. **Wires and terminal blocks**

5. **Ethernet cable**

For the RMC75E.

6. **Null-modem serial cable**

For the RMC75S and RM75P. If you do not have a null-modem cable, you can make a cable with two DB9 connectors, wired according to the diagram:



7. **RS-232 to RS-485 converter**

For testing RS-485 on the RMC75S only.

8. **PROFIBUS device**

Only for testing PROFIBUS on the RMC75P only. This must be a device such as a PLC that can act as a PROFIBUS master.

9. **Encoder**

For testing the QA and Q1 modules only. The encoder must have 5V differential (RS-422 driver) outputs A+, A-, B+, B-, Z+, Z-.

General Procedure

To test the entire RMC module, complete all the procedures. If you suspect a certain portion of the RMC, go to that specific procedure.

1. Disconnect all wiring from the RMC before beginning.
2. Apply 24 VDC to power the RMC on.
3. Reset Controller to Defaults:
 - a. Upload all from the RMC, then save the project file.
 - b. On the **Controller** menu, click **Reset Controller to Defaults**.

If you do not wish to reset the controller to defaults, you can still perform these procedures. However, do the following:

- Make sure the axes are not in simulate mode.
- Make sure the RMC is in Program mode.
- Make sure all the hardware is assigned to axes.

4. Perform the procedures and use the checklist at the end of the document to record the results.
5. After completing the procedures, open the saved project file and download it to the RMC.

Procedures

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CPU Modules

RMC75E CPU

1. Apply 24 VDC power.
 - a. Measure the voltage across **Vdc PS** and **PS Return**.
If the voltage is very low (such as below 5 V), the tranzorb has likely failed. This is usually caused by applying a voltage that is too high.
 - b. Measure how much current the RMC draws. This can be done with a multi-meter or a variable voltage power supply with a current readout. The current should be:

| # of Expansion Modules | RMC75E |
|------------------------|----------|
| 0 | < 200 mA |
| 2 | < 250 mA |
| 4 | < 300 mA |

2. Check the **Controller** LED.

| Controller LED State | Indicates | Action |
|-----------------------|--------------------------|---|
| Steady Off | No Power | Check power supply. Verify polarity on connector. |
| Steady Green | Run Mode | OK |
| Flashing Green | Program Mode | OK |
| Alternating Red/Green | A power glitch occurred | Check power supply and continue test. |
| Flashing Red | The RMC is in the Loader | Update firmware with RMCTools. If firmware update fails, contact Delta. |
| Steady Red | Major Fault | Contact Delta. |

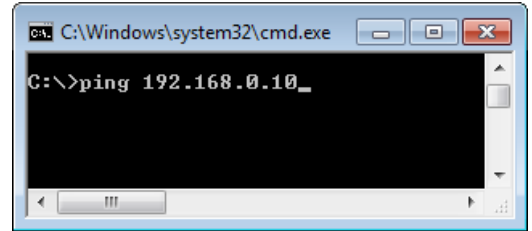
3. Check USB Communications.
 - a. Connect a USB cable from the RMC to the PC.
 - b. In RMCTools, start a new project, go online, and upload all from the controller.
 - i. If RMCTools does not go online, unplug the USB cable, plug it in again, then attempt to go online again.
 - ii. If RMCTools still does not go online, unplug the USB cable, re-install RMCTools, connect the USB cable again, then attempt to go online again.
 - iii. If RMCTools still does not go online, check to make sure other devices can connect to the PC with the same USB port. If they do, and RMCTools still does not go online, then the RMC's USB port has likely failed.
 - c. After uploading all from the RMC, **save the project**. This backup may be useful since you may change some of the parameters in the RMC during this test procedure.

4. Check Ethernet Communications.

- a. Set the RMC’s IP address so it is compatible with the PC.
- b. Connect an Ethernet cable from the RMC to the PC.
- c. In RMCTools, change the connection path to Ethernet and go online with the RMC.

If RMCTools does not go online, try to ping the RMC:

- i. In Windows, open the DOS command prompt.
- ii. Type “ping *IP address*”, where *IP address* is something like 192.168.0.10.
- iii. If the RMC returns a reply, then the Ethernet is working.



If the RMC does not return a reply, then there may be an Ethernet setup problem or the cable may be faulty. If you determine that the Ethernet is set up correctly and the cable is functional, then the RMC’s Ethernet may have failed.

d. Check the Link and Net LEDs.

- i. The Link LED should be solid green or flashing green. If it is off, the physical Ethernet link is down. Check the port the RMC is connected to. If it works with other Ethernet devices, then the RMC’s Ethernet may have failed.
- ii. The Net LED should be flashing green. If it is RED, there is another device on the network with the same IP address. This is not a problem with the RMC. Make sure all devices on the network have unique IP addresses.

RMC75S CPU

1. Apply 24 VDC power.

- a. Measure the voltage across **Vdc PS** and **PS Return**.

If the voltage is very low (such as below 5 V), the tranzorb has likely failed. This is usually caused by applying a voltage that is too high.

- b. Measure how much current the RMC draws. This can be done with a multi-meter or a variable voltage power supply with a current readout. The current should be:

| # of Expansion Modules | RMC75S, RMC75P |
|------------------------|----------------|
| 0 | < 160 mA |
| 2 | < 210 mA |
| 4 | < 250 mA |

2. Check the **Controller LED**.

| Controller LED State | Indicates | Action |
|-----------------------|--------------------------|---|
| Steady Off | No Power | Check power supply Verify polarity on connector |
| Steady Green | Run Mode | OK |
| Flashing Green | Program Mode | OK |
| Alternating Red/Green | A power glitch occurred | Check power supply and continue test. |
| Flashing Red | The RMC is in the Loader | Update firmware with RMCTools. If firmware update fails, contact Delta. |
| Steady Red | Major Fault | Contact Delta. |

3. Check the RS-232 Monitor port communications.

- a. Connect a null-modem serial cable from the RMC75S Monitor Port to the PC.
- b. In RMCTools, start a new project, go online, and upload all from the controller.
 - i. If RMCTools does not go online, make sure no other programs on the PC are using that serial port (or move the serial cable to a different port), then attempt to go online again.
 - ii. If RMCTools still does not go online, the RMC’s serial port has likely failed. However, it is also possible that the other program is still not releasing the serial port for RMCTools.
- c. After uploading all from the RMC, save the project. This backup may be useful since you may change some of the parameters in the RMC during this test procedure.
- d. Go offline.

4. Check the RS-232 serial port communications.

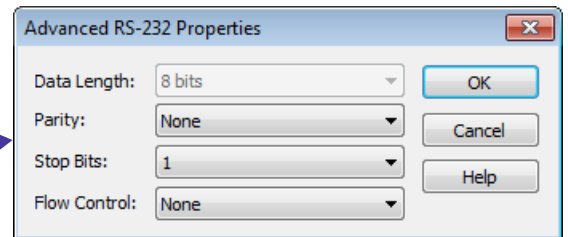
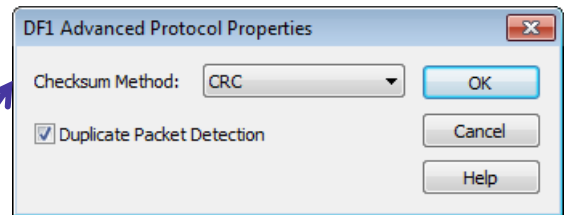
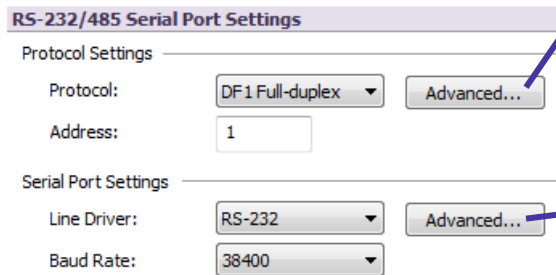
- a. In RMCTools, in the **CPU Properties**, on the **Serial** page, set the RS232/485 serial port settings:

Protocol Settings:

- **Protocol:** DF1 Full-Duplex
- **Advanced:** CRC and Duplicate Packet Detection.

Serial Port Settings:

- **Line Driver:** RS-232
- **Baud Rate:** 38400
- **Advanced:** Parity None, Stop Bits 1, Flow Control None.



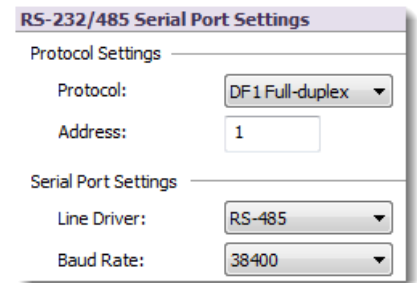
- b. Connect a serial cable from the RMC75S to the RS-232 port. Make sure no cable is connected to the Monitor Port.
 - c. In RMCTools, go online with the RMC75S.
 - i. If RMCTools does not go online, make sure no other programs on the PC are using that serial port (or move the serial cable to a different port), then attempt to go online again.
 - ii. If RMCTools still does not go online, check to make sure other devices can connect to the PC with the same serial port. If they do, and RMCTools still does not go online, then the RMC's serial port has likely failed.
5. Check the RS-485 serial port communications.
- a. In RMCTools, set the RS232/485 serial port settings:

Protocol Settings

- **Protocol:** DF1 Full-Duplex
- **Advanced:** CRC and Duplicate Packet Detection.

Serial Port Settings

- **Line Driver:** RS-485
- **Baud Rate:** 38400
- **Advanced:** Parity None, Stop Bits 1.



- a. Connect an RS-232 to RS-485 converter to the RS-485 port. Make sure no cable is connected to the Monitor Port.
- b. Connect a serial cable from the converter to the PC. Depending on the converter, the cable will need to be either straight-through or null-modem.
- c. In RMCTools, go online with the RMC75S.
 - i. If RMCTools does not go online, make sure no other programs on the PC are using that serial port (or move the serial cable to a different port), then attempt to go online again.
 - ii. If RMCTools still does not go online, check to make sure other devices can connect to the PC with the same serial port. If they do, and RMCTools still does not go online, then the RMC's serial port has likely failed.

RMC75P CPU

1. Apply 24 VDC power.

- a. Measure the voltage across **Vdc PS** and **PS Return**.

If the voltage is very low (such as below 5 V), the tranzorb has likely failed. This is usually caused by applying a voltage that is too high.

- b. Measure how much current the RMC draws. This can be done with a multi-meter or a variable voltage power supply with a current readout. The current should be:

| # of Expansion Modules | RMC75S, RMC75P |
|------------------------|----------------|
| 0 | < 160 mA |
| 2 | < 210 mA |
| 4 | < 250 mA |

2. Check the **Controller** LED.

| Controller LED State | Indicates | Action |
|-----------------------|--------------------------|---|
| Steady Off | No Power | Check power supply. Verify polarity on connector. |
| Steady Green | Run Mode | OK |
| Flashing Green | Program Mode | OK |
| Alternating Red/Green | A power glitch occurred | Check power supply and continue test. |
| Flashing Red | The RMC is in the Loader | Update firmware with RMCTools. If firmware update fails, contact Delta. |
| Steady Red | Major Fault | Contact Delta. |

3. Check the RS-232 Monitor port communications.

- a. Connect a null-modem serial cable from the RMC75S Monitor Port to the PC.

In RMCTools, start a new project, go online, and upload all from the controller.

- If RMCTools does not go online, make sure no other programs on the PC are using that serial port (or move the serial cable to a different port), then attempt to go online again.
- If RMCTools still does not go online, the RMC's serial port has likely failed. However, it is also possible that the other program is still not releasing the serial port for RMCTools.

- b. After uploading all from the RMC, save the project. This backup may be useful since you may change some of the parameters in the RMC during this test procedure.

4. Check the PROFIBUS communications.

- a. Connect a PROFIBUS communication device (PLC, etc.) to the RMC75P PROFIBUS port, and properly configure the device to communicate with the RMC75P.

- b. Make sure the PROFIBUS LED on the RMC75P is green. If it is not green, the PROFIBUS is either not configured properly, or the PROFIBUS port on the RMC failed.

Axis Modules

Fault Input

Do this for each control axis.

1. In the **Axis Parameters**, on the **All** tab, in the **Output** section, make sure the **Fault Input Polarity** is set to **Active High**.
2. The **En/F** LED should be steady green or flashing green.
In the **Axis Tools**, the **Fault Input** status bit should be off.
3. Apply 24 V across the **Flt In+** and **Flt In-** pins.
4. The **En/F** LED should be red.
In the **Axis Tools**, the **Fault Input** status bit should be on.

Enable Output

Do this for each control axis.

1. In the **Axis Parameters**, on the **All** tab, in the **Output** section, make sure the **Enable Output Polarity** is set to **Active Closed**.
2. Send the **Set Enable Output (67)** command to **Disable** the output.
The **En/F** LED should be flashing green.
In the **Axis Tools**, the **Enable Output** status bit should be off.
3. Measure the resistance between the **+Enable Out** and **-Enable Out** pins.
The resistance should be high (open circuit).
4. Send the **Set Enable Output (67)** command to **Enable** the output.
The **En/F** LED should be steady green.
In the **Axis Tools**, the **Enable Output** status bit should be on.
5. Measure the resistance between the **+Enable Out** and **-Enable Out** pins.
The resistance should be between 5 and 50 Ohms.

Control Output

Do this for each control axis.

1. In the **Axis Parameters**, uncheck the **Invert Output Polarity**.
2. In the **Axis Parameters**, set the Output Bias to zero.
3. For each of the voltages [-10, -5, 0, 5, 10], do the following:
 - a. Send a **Direct Output (9)** command with the voltage. Use a large ramp rate, such as 100.
 - b. Measure the voltage between the **Control Out** and **Cmn** pins and verify that the voltage is within 0.1 V of the commanded voltage.

AA1/AA2 Feedback

Do this for each analog input.

1. In the **Axis Parameters**, on the **Setup** tab, set the **Positive Travel Limit** to 100 and the **Negative Travel Limit** to -100.
2. With no wiring connected to the axis, the corresponding Axis LED should be solid red or flashing red.
3. Check Voltage.
 - a. In the **Axis Parameters**, set the **Input Type** to **±10V**.
 - b. Install a wire jumper between **Anlg In-** and **Cmn**.
 - c. For each of the voltages [-9.9, -5, 5, 9.9], do the following:
 - i. Apply the voltage across the **Anlg In+** and **Anlg In-** pins.
 - ii. With a voltmeter, measure the voltage between **Anlg In+** and **Anlg In-**.
 - iii. In the **Axis Status Registers**, on the **All** tab, make sure the **Actual Voltage** register is within 0.1 V of the measured voltage.
 - d. Remove the applied voltage, then install a wire jumper between the **Anlg In+** and the **Anlg In-** pins (this will force the input to 0 V). Make sure to leave the jumper between **Anlg In-** and **Cmn** installed.
 - e. In the **Axis Status Registers**, on the **All** tab, make sure the **Actual Voltage** register is between -0.1 and +0.1 V.
 - f. Send a **Clear Faults (4)** command and verify that the Axis LED is now solid green or flashing green.
 - g. Remove the jumper between the **Anlg In+** and the **Anlg In-** pins (do not remove the jumper between **Anlg In-** and **Cmn**).

If the voltage readings are significantly out of spec, contact Delta.

4. Check Current.
 - a. In the **Axis Parameters**, set the **Input Type** to **4-20 mA**.

- b. Install a jumper between the **Anlg In+** and **Jumper** pins (do not remove the jumper between **Anlg In-** and **Cmn**).
- c. Apply approximately 4.9 V across the **Anlg In+** and **Anlg In-** pins.
- d. With a current meter, measure the current.
- e. In the **Axis Status Registers**, on the **All** tab, in the **Feedback** section, make sure the **Current** register is within 0.1 mA of the measured current.
- f. Apply approximately 1.1 V across the **Anlg In+** and **Anlg In-** pins.
- g. With a current meter, measure the current.
- h. In the **Axis Status Registers**, on the **All** tab, make sure the **Actual Current** register is within 0.1 mA of the measured current.

If the current readings are slightly out of spec, you can redo the axis Scale and Offset to compensate for the error. If the current readings are significantly out of spec, contact Delta.

5. Check 10V Exciter Output.
 - a. Measure the voltage between **10V Exciter +** and **Cmn**. It should be between 9.98 and 10.02 volts.
6. Remove all wiring from the inputs.

MA1/MA2 Feedback

Do this for each input.

1. With no wiring connected to the axis, the corresponding Axis LED should solid red or flashing red.
2. In the **Axis Parameters**, set the **Feedback Type** to **MDT**.
3. In the **Axis Parameters**, set the **MDT Type** to **PWM**.
4. Remove all wires from the MA module.
5. Connect **Int/Clock +** to **Ret/Data +** and connect **Int/Clock -** to **Ret/Data -**.
6. Send a **Clear Faults (4)** command and verify that the Axis LED is now solid green or flashing green.
7. In the **Axis Error Bits**, make sure the **No Transducer** and **Transducer Overflow** error bits are off.
8. In the **Axis Status Registers**, on the **All** tab, make sure the **Counts** value is between 375 and 427.
9. Disconnect **Int/Clock -** from **Ret/Data -**.
10. Send the **Clear Faults (4)** command to the axis.
11. In the **Axis Error Bits**, make sure the **No Transducer** and **Transducer Overflow** error bits are off.
12. In the **Axis Status Registers**, on the **All** tab, make sure the **Counts** value is between 375 and 427.
13. Disconnect **Int/Clock +** from **Ret/Data +**.
14. Connect **Int/Clock -** to **Ret/Data -**.
15. Send the **Clear Faults (4)** command to the axis.

-
16. In the **Axis Error Bits**, make sure the **No Transducer** and **Transducer Overflow** error bits are off.
 17. In the **Axis Status Registers**, on the **All** tab, make sure the **Counts** value is between 375 and 427.
 18. Remove all wiring from the inputs.

If the count values are not within the specified range, the MA module has failed.

QA1/QA2 Feedback, Home, and Reg Inputs

Do this for each input.

1. With no wiring connected to the axis, the corresponding Axis LED should solid red or flashing red.
2. Locate a known good encoder with 5V differential output (RS-422 driver), and wire it to the **A+**, **A-**, **B+**, **B-**, **Z+**, **Z-**, and **Cmn** pins.
3. Send a **Clear Faults (4)** command and verify that the Axis LED is now solid green or flashing green.
4. In the **Axis Status Registers**, on the **All** tab, look at the **Counts**.
5. Turn the encoder in one direction, and make sure the counts change smoothly.
6. Turn the encoder in the other direction, and make sure the counts change smoothly in the other direction.
7. Test the Registration Inputs:
 - a. In the **Axis Status Registers**, on the **All** tab, in the **Registration** section, the **RegX/PosLim Input** and **Reg Y/NegLim Input** should be off.
 - b. Apply 24 VDC across **RegX In+** and **RegX In-**. Now the **RegX Input** status register should be on.
 - c. Apply 24 VDC across **RegY In+** and **RegY In-**. Now the **RegY Input** status register should be on.
8. Test the Z input:
 - a. Send the **Arm Home (50)** command with the following parameters:
 - i. **Home Pos:** 0
 - ii. **Trigger Type:** Z
 - iii. **Repeat Mode:** Single
 - b. In the **Axis Status Registers**, on the **All** tab, in the **Home** section, **Home Armed** should be on.
 - c. Turn the encoder more than one revolution.
 - d. **Home Armed** should now be off, and **Home Latched** should be on. This means the Z input is working correctly.
9. Remove all wiring from the inputs.

If any step fails, the QA module has failed.

Expansion Modules

A2/AP2

Do this for each analog input.

1. Using the Axis Definitions Wizard, assign each analog input to an axis if they are not already assigned. The analog input can be assigned to a control or reference axis.
2. With no wiring connected to the module, the corresponding Input LED should be red.
3. In the **Axis Parameters**, on the **Setup** tab, set the corresponding **Positive Travel Limit** to 100 and the **Negative Travel Limit** to -100.
4. Check Voltage.
 - b. In the **Axis Parameters**, set the **Input Type** to **±10V**.
 - c. Install a wire jumper between the **Input -** and **Cmn** pins.
 - d. For each of the voltages [-9.9, -5, 5, 9.9], do the following:
 - i. Apply the voltage across the **Input +** and **Input -** pins.
 - ii. With a voltmeter, measure the voltage between **Input +** and **Input -**.
 - iii. In the **Axis Status Registers**, on the **All** tab, make sure the **Actual Voltage** register is within 0.1 V of the measured voltage.
 - e. Remove the applied voltage, then install a wire jumper between the **Input +** and the **Input -** pins (this will force the input to 0 V). Make sure to leave the jumper between **Input -** and **Cmn** installed.
 - f. In the **Axis Status Registers**, on the **All** tab, make sure the **Actual Voltage** register is approximately 0 volts (between -0.1 and 0.1 V).
 - g. Send a **Clear Faults (4)** command and verify that the corresponding Input LED is now solid green or flashing green.
 - h. Remove the wire jumper between the **Input +** and the **Input-** pins (do not remove the jumper between **Input -** and **Cmn**).

If the voltage readings are significantly out of spec, contact Delta.

5. Check Current.
 - a. In the **Axis Parameters**, set the **Input Type** to **4-20 mA**.
 - b. Install a jumper between the **Input +** and **Jumper** pins.
 - c. Apply approximately 4.9 V across the **Input +** and **Input -** pins.
 - d. With a current meter, measure the current.
 - e. In the **Axis Status Registers**, on the **All** tab, make sure the **Actual Current** register is within 0.1 mA of the measured current.
 - f. Apply approximately 1.1 V across the **Input +** and **Input -** pins.

-
- g. With a current meter, measure the current.
 - h. In the **Axis Status Registers**, on the **All** tab, make sure the **Actual Current** register is within 0.1 mA of the measured current.

If the current readings are significantly out of spec, contact Delta.

6. Check 10V Exciter Output (A2 module only).
 - a. Measure the voltage between **10V Exciter +** and **Cmn**. It should be between 9.98 and 10.02 volts.

D8

1. In RMCTools, configure all the discrete I/O on the D8 module as **Outputs**.
2. Turn off all the discrete outputs on the D8 module (use the DI/O Monitor). Make sure the DI/O LEDs are all off.
3. Measure the resistance between **Output Cmn** and each **I/O** point. The resistance should be high (open circuit).
4. Turn on all the discrete outputs on the D8 module (use the DI/O Monitor). Make sure the DI/O LEDs are all green.
5. Measure the resistance between **Output Cmn** and each **I/O** point. The resistance should be approximately 20-50 Ohms (measuring resistance may be best done directly on the pins without a terminal block installed)
6. Configure all the discrete I/O on the D8 module as **Inputs**.
7. Make sure all the I/O point LEDs are off when the voltage is applied, and make sure the **I/O Monitor** in RMCTools indicates the inputs are all off.
8. For each I/O point, apply about 1 VDC between the **I/O** point and **Input Cmn**. Slowly increase the voltage until the input turns on. It should turn on between 3.5 and 7 volts and remain on as the voltage is increased up to 24 VDC. If you do not have an adjustable power supply, just apply 24 VDC to the input.

When the input turns on, the corresponding LED should be green

If any step fails, the D8 module has failed.

Q1

1. Using the Axis Definitions Wizard, assign the input to an axis if it is not already assigned. The input can be assigned to a control or reference axis.
2. Verify that the Quad LED is solid red or flashing red.

3. Locate a known good encoder with 5V differential output (RS-422 driver), and wire it to the **A+**, **A-**, **B+**, **B-**, and **Cmn** pins.
4. Send a **Clear Faults (4)** command and verify that the Quad LED is now solid green or flashing green.
5. In the **Axis Status Registers**, on the **All** tab, look at the **Counts**.
6. Turn the encoder in one direction, and make sure the counts change smoothly.
7. Turn the encoder in the other direction, and make sure the counts change smoothly in the other direction.
8. In the **Axis Status Registers**, on the **All** tab, in the **Registration** section, the **Reg Input** should be off. The **Reg** LED should also be off.
9. Apply 24 VDC across **Reg In+** and **Reg In-**. Now the **Reg Input** status register should be on. The **Reg** LED should also be yellow.

If any step fails, the Q1 module has failed.

Checklist

P = pass, F = fail, N/A = does not apply

RMC75E CPU

| P | F | N/A | Procedure | Notes |
|---|---|-----|---------------------------|-------|
| | | | Power Voltage and Current | |
| | | | Controller LED | |
| | | | USB Communications | |
| | | | Ethernet Communications | |

RMC75S CPU

| P | F | N/A | Procedure | Notes |
|---|---|-----|------------------------------------|-------|
| | | | Power Voltage and Current | |
| | | | Controller LED | |
| | | | Serial Monitor Port Communications | |
| | | | Serial RS-232/485 Communications | |

RMC75P CPU

| P | F | N/A | Procedure | Notes |
|---|---|-----|------------------------------------|-------|
| | | | Power Voltage and Current | |
| | | | Controller LED | |
| | | | Serial Monitor Port Communications | |
| | | | PROFIBUS | |

AA1 or AA2 Axis Module

| P | F | N/A | Procedure | Notes |
|---|---|-----|--------------------|-------|
| | | | Fault Input | |
| | | | Enable Output | |
| | | | Control Output | |
| | | | Voltage Input | |
| | | | Current Input | |
| | | | 10V Exciter Output | |

MA1 or MA2 Axis Module

| P | F | N/A | Procedure | Notes |
|---|---|-----|----------------|-------|
| | | | Fault Input | |
| | | | Enable Output | |
| | | | Control Output | |
| | | | Feedback Input | |

QA1 or QA2 Axis Module

| P | F | N/A | Procedure | Notes |
|---|---|-----|---------------------|-------|
| | | | Fault Input | |
| | | | Enable Output | |
| | | | Control Output | |
| | | | Quadrature Feedback | |
| | | | Registration Inputs | |
| | | | Z Input | |

A2, AP2 Expansion Modules

| P | F | N/A | Procedure | Notes |
|---|---|-----|--------------------|-------|
| | | | Voltage Input | |
| | | | Current Input | |
| | | | 10V Exciter Output | |

D8 Expansion Modules

| P | F | N/A | Procedure | Notes |
|---|---|-----|-------------|-------|
| | | | Outputs 0-7 | |
| | | | Inputs 0-7 | |

Q1 Expansion Module

| P | F | N/A | Procedure | Notes |
|---|---|-----|----------------|-------|
| | | | Feedback Input | |
| | | | Reg Input | |