Rockwell Automation

Allen-Bradley

BULLETIN 1394

GROUNDING & BONDING

APPLICATION NOTE **REVISED: JULY 21, 1997**

PURPOSE

This Application Note provides recommendations for grounding and bonding of the 1394 system, control cabinets, motors and cables. This document is to be used in conjunction with the Bulletin 1394 User Manual & other referenced publications.

FOR MORE INFORMATION

Bulletin 1394 Digital AC Multi-Axis Motion Control System
User Manual
Publication 1394-5.0

Industrial Automation Wiring & Grounding Guidelines for Noise Immunity
Publication 1770-4.1

GENERAL RECOMMENDATIONS

1. Control Cabinet Grounding
   - Follow the Grounding Interconnects per the 1394 User Manual (1394-5.0) appendix B
   - Individual PE ground wires from the modules to the PE ground bar is required (single point grounding).
   - A 12AWG (approx. 4 mm^2) wire is preferred to tie the modules PE terminal to the PE ground bar at a recommended maximum length of 2 feet (approx. 600mm).
   - For multiple drives within a cabinet or for system configurations use the Single point grounding to the PE ground bar
   - Run a single ground from the cabinet structure to the closest building structural steel. Recommend using 5AWG (approx. 16 mm^2) or equivalent.
2. Control Cabinet Bonding
   - Bond the sub panels to the control cabinet with wire braid or by metal to metal contact via paint free surfaces
   - The 1394 modules (both system and axis modules) must be bonded to the subpanel with metal to metal contact via paint free surfaces. Star washers may be used to break through painted surfaces or the paint needs to be locally removed or sanded away at contact points.
   - If standoff brackets are used to mount the 1394 system to the subpanel, bond the mounting bracket to the subpanel with wire braid or by metal to metal contact via paint free surfaces.
   - Bond every sub panel to every other sub panel with using 1" by 1/4 " (approx. 25.4 mm by 6.4 mm) wire braid or by metal to metal contact via paint free surfaces
   - Run a single PE bar across all sub panels and return it to the single point ground at the entry point of the ground to the cabinet structure. If a single PE bar can not be used across all sub panels, return each sub panel PE bar to the single point ground in a star fashion to the cabinet ground at the entry point of the ground to the cabinet structure.

3. System and Axis Module Grounding
    - Locate the 1394 system as close as possible to the PE bar
    - Use only 12AWG (approx. 4 mm^2) wire for each type of 1394 module to wire the safety ground to the PE bar
    - When more than one 1394 is installed in the cabinet make the distances to the PE bar from each 1394 as equal in length as possible, stack 1394's side to side rather than vertically on a panel.
4. System and Axis Module Bonding
    - RF grounding is achieved by bonding the 1394 modules tightly to their supporting sheet metal of the panel (or subpanel). The best bond is achieved when the 1394 is installed using tapped holes in the sub panel or cabinet whose threads are free of paint and with SEMS type mounting hardware as a bolt
    - A second acceptable bond is formed when weld studs are part of the sub panel and these are free from paint. In this instance a SEMS type nut should be used.
    - Through hole bolting is not recommended.
5. Wire Routing
    - Power (i.e. motor power), signal (i.e. motor feedback, RIO) and control (i.e. 24V logic) wiring must be separated on parallel wiring in the electrical cabinet.
    - Shielded wire should be use for sensitive low voltage circuits (i.e. Registration Inputs, etc.)
    - Motor lead wires should be routed down and to the right of the axes
    - Incoming three phase should be routed down and to the left of the system module
    - Control wiring should be routed up and to the left of the system module to provide for maximum separation of power and control.
6. Motor Bonding and Grounding
    - The motor must be bonded to the machine and the machine must be bonded to the electrical cabinets. The nearest building steel structures between the machine and control cabinets may be used to bond to.
    - If there is more than 65 feet (approx. 20 meters) between the building structural steel closest to the motor and the building structural steel closest to the control panel the ground between these two structural points should be checked and enhanced if necessary using 1" by 1/4 " (approx. 25.4 mm by 6.4 mm) wire braid or #4/0 AWG (approx. 107.2 mm^2) extra flexible welding cable.
    - If a motor is on a moving machine structure and frame ground is doubtful, a braided strap or welding cable as above is preferred to be used to tie the frame of the motor to the machine frame and the machine frame to the building structural steel.
    - Only Allen-Bradley specified cables should be used. Un-shielded cables should NEVER be used.
    - Motor cables should be continuous runs where possible
    - If motor cables are non-continuous and cable splices are made, grounded & shielded junction box terminations are required.
    - If motor cables are non-continuous and cable splices are made using connectors, connectors must be fully shielded & shields must be bonded to the connector backshells using 360 deg. termination to avoid noise.
    - When a cable is passed through a junction box, the shield drain wire must be spliced only to mating shield drain wire and not grounded at the junction box. Feedback shields must be carried through pin for pin.
    - Separate junction boxes for power and feedback or control are preferred.
    - For motor cables passing thru control cabinet walls, shield drain wire must be bonded at cabinet entry/exit point.

- Do not coil excess cable of different type (i.e. motor power & feedback) together. Cable lengths should fit application.

Motor Thermal and Brake Special Recommendations

1. Motor Thermal Switch Wiring
   - Motor thermal switches inherently have the 1394 PWM coupled to them due to the location of the switches in the motor windings. These leads must only terminate at the axis.
   - Motor thermal switches must be wired to a dedicated 24Vdc power supply or 115Vac source and hard contact isolated from all logic or control inputs using interposing relays.
   - All exposed motor thermal switch wiring in the control cabinet should be shielded twisted pair wire to prevent emitting RFI noise. The shield should terminate at the PE bar.
2. Motor Brake Wiring
   - Motor brake wiring leads inherently have the 1394 PWM coupled to them due to the location of the brake coil in close proximity to the motor windings. These leads must only terminate at the axis.
   - Motor brake wiring must be wired to a dedicated 24Vdc power supply and hard contact isolated from all logic or control outputs.
   - All exposed motor thermal switch wiring in the control cabinet should be shielded twisted pair wire to prevent emitting RFI noise. The shield should terminate at the PE bar.

EMI Filter Use Special Recommendations

1. EMI Filter Mounting
   - The EMI Filter should be mounted as close to the drive as possible.
   - The EMI Filter must be mounted on the same subpanel as the drive
2. EMI Filter Bonding
   - The EMI Filter must be bonded to the enclosure and /or subpanel metal to metal See page C-4 of 1336 plus 5.0 dated December 1996
3. EMI Filter Wiring
   - The EMI Filter must wired to the drive with as short a run as possible
   - The EMI Filter must be wired to the drive using a twisted quartet of all three phases plus ground as a minimum
   - The twisted quartet preferably should be shielded.
   - Wires emerging from the filter (clean side), should be routed away from other power cables to avoid recontamination.
4. EMI Filter Selection
   - An EMI Filter per drive is preferred over a single filter per cabinet
5. EMI Filter Leakage Current
   - The RFI filter may cause significant ground leakage currents, therefore a solid ground connection must be provided per the filter specifications. Wiring between the RFI filter and the drive must be shielded.
6. EMI Filter Grounding
   - Using the optional RFI filter may result in relatively high ground leakage current - WARNING: possible electrocution hazard! Surge suppression devices are also incorporated into the filter, therefore the filter must be permanently installed and solidly bonded to the building power distribution ground. Ensure that the incoming supply neutral is solidly bonded to the same building power distribution ground.

Flex I/O Special Recommendations (if applicable)

1. Flex I/O Location
   - Flex I/O should be located to the left of the system module
   - DO NOT LOCATE DIRECTLY BELOW AXIS MODULES
2. Flex I/O Wiring
   - Flex I/O wiring must be routed away from all motor power leads
   - Flex I/O wiring should route to the left and up from the system module
3. Flex I/O Bonding
   - Flex I/O DIN rail track must be bonded to the subpanel
   - Flex I/O Cable connector must use the screw furnished with the cable and tighten into a tapped hole in the subpanel to bond the cable shield.

Remote I/O Special Recommendations (if applicable)

1. Remote I/O Location
   - All nodes on the RIO should preferably be located on the same subpanel within the cabinet as the 1394
2. Remote I/O Wiring
   - All RIO " Blue Hose " lengths should be kept as short as possible
   - Cable shield drain wire must be grounded per applicable RIO device wiring requirements.

AxisLink Special Recommendations (if applicable)

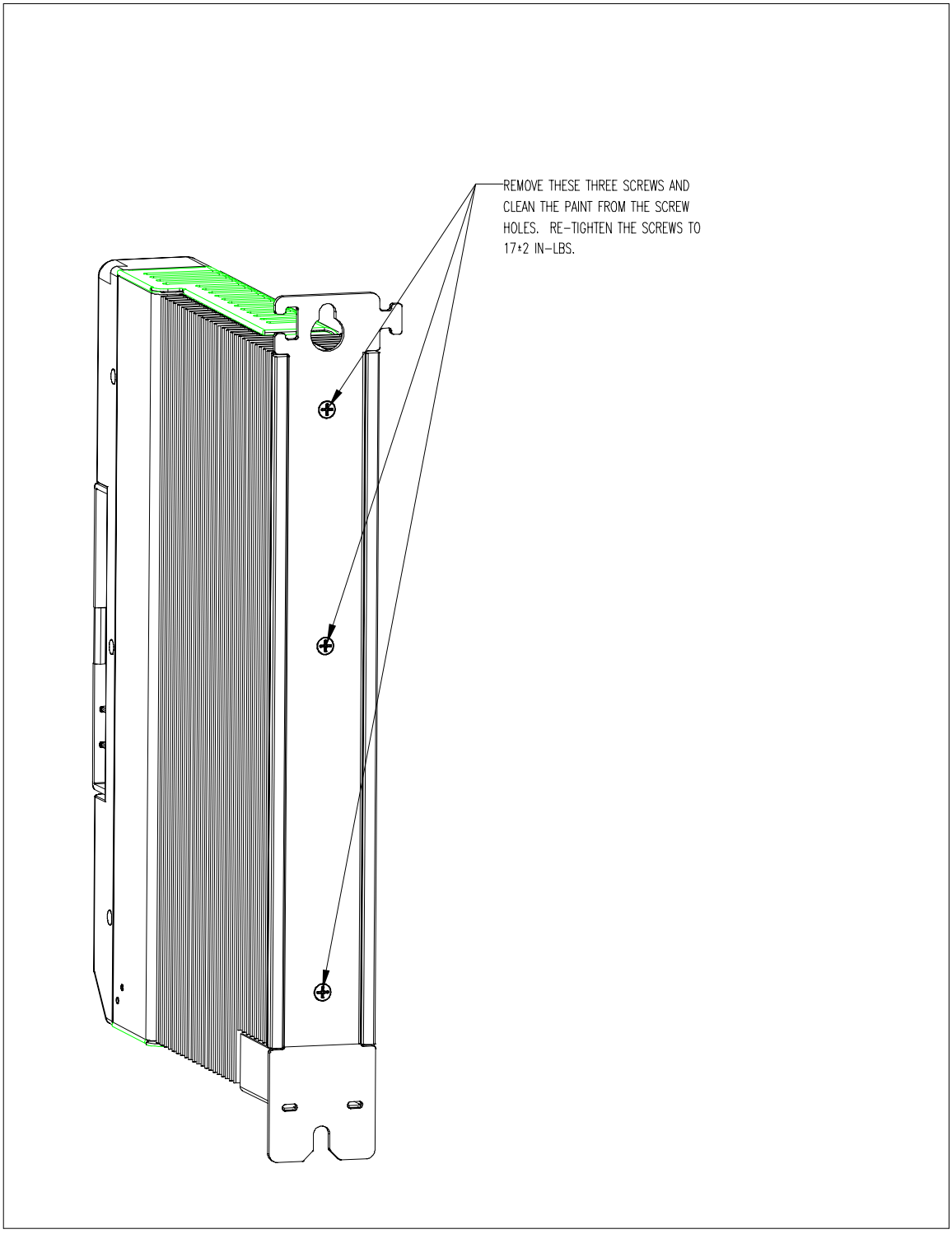
1. AxisLink Location
   - All nodes on the AxisLink should preferably be located on the same subpanel within the cabinet. If AxisLink nodes must be on separate subpanels refer to section 2 Control Cabinet Bonding. Follow the recommendations for sub panel bonding.
   - If an ALEC module is used as one of the nodes it should be mounted on a metal to metal surface via paint free surface using SEMS type mounting hardware
2. AxisLink Wiring.
   - All AxisLink "Blue Hose" lengths must be kept to the recommend 3 feet (approx. 1 meter) minimum and 82 feet (25 meter) maximum lengths. Refer to the Setup and Installation Manual for your specific controller.
   - Reference Publication 1770-4.1 Industrial Automation Wiring and Grounding Guidelines for Noise Immunity. AxisLink is a Category 2 conductor and must be routed as described in 1770-4.1

VERIFICATION OF AXIS AND SYSTEM MODULE BONDING

I. Verify chassis Grounding of the 1394 Series A **2KW (1394-AM03), 3KW (1394-AM04), and 5KW (1394-AM07)** Axis Modules (if present).

This step verifies the axis module chassis hanger bonding to PE ground terminations. By design the PE terminal is the safety ground. The PE terminal is intimately connected to the heat sink, and chassis of the axis module. The chassis is intended as the Radio Frequency (RF) ground point. Three screws hold the hanger plate to the chassis, in some instances these screws do not make proper contact to the plate. To determine what if any corrective action is needed the following steps must be taken:

1. Remove the Series A Axis Module from the control cabinet
2. Insert a #10 AWG (approx. 5.3 $mm^{2)}$ 2 " long wire into the PE
3. Using a low ohms meter 4 digit or better capable of resolving 10 milli ohms measure from this wire to the heads of the three screws indicated in figure 1, resistance should be less than 100 milli ohms.
   - If a low ohms meter is not available, use a standard ohm meter and first determine the meter lead wire resistance by the connecting both leads to the wire inserted in the PE terminal.
   - Connection to the screw heads of the mounting plate is good if the meter reading is the same as the lead wire resistance previously measured.
4. Measure from the PE terminal to the mounting plate allowing the lead to pierce the paint of the mounting foot. The resistance measurement should not increase from the measurement in step 3.
5. If there has been no increase in the measurement, then the series A axis module mounting plate is making a good electrical connection. You must then insure that the axis module is correctly bonded from the mounting plate to the control cabinet.
   - Install the axis module into the control cabinet using a SEMS screw into a tapped hole in the sub-panel or the cabinet. Make sure that the threads of the hole are free of paint
   - Make sure that the SEMS screw breaks through the paint of the axis module hanger
   - Using the meter measure the resistance from the PE terminal to a paint free portion of the sub-panel or cabinet, if the resistance has increased from the reading in step 4 repeat step 5 after cleaning the threaded hole and removing paint from the hanger.
   - **If SEMS screws are not available internal tooth star washers may be used**
   - **If tapped holes or weld studs were not used in the panel (through hole construction) then paint must be removed from the panel and the series A axis module hanger plate.**
6. If the measurement in step 4 is increased from the measurement in step 3, then place the axis module face down and one at a time remove the screws shown in figure 1, clean the paint from the screw holes, and re-tighten to 17 ± 2 in-lb (1.92 ± .2 N-m) .
7. Reverify the check in step 3.

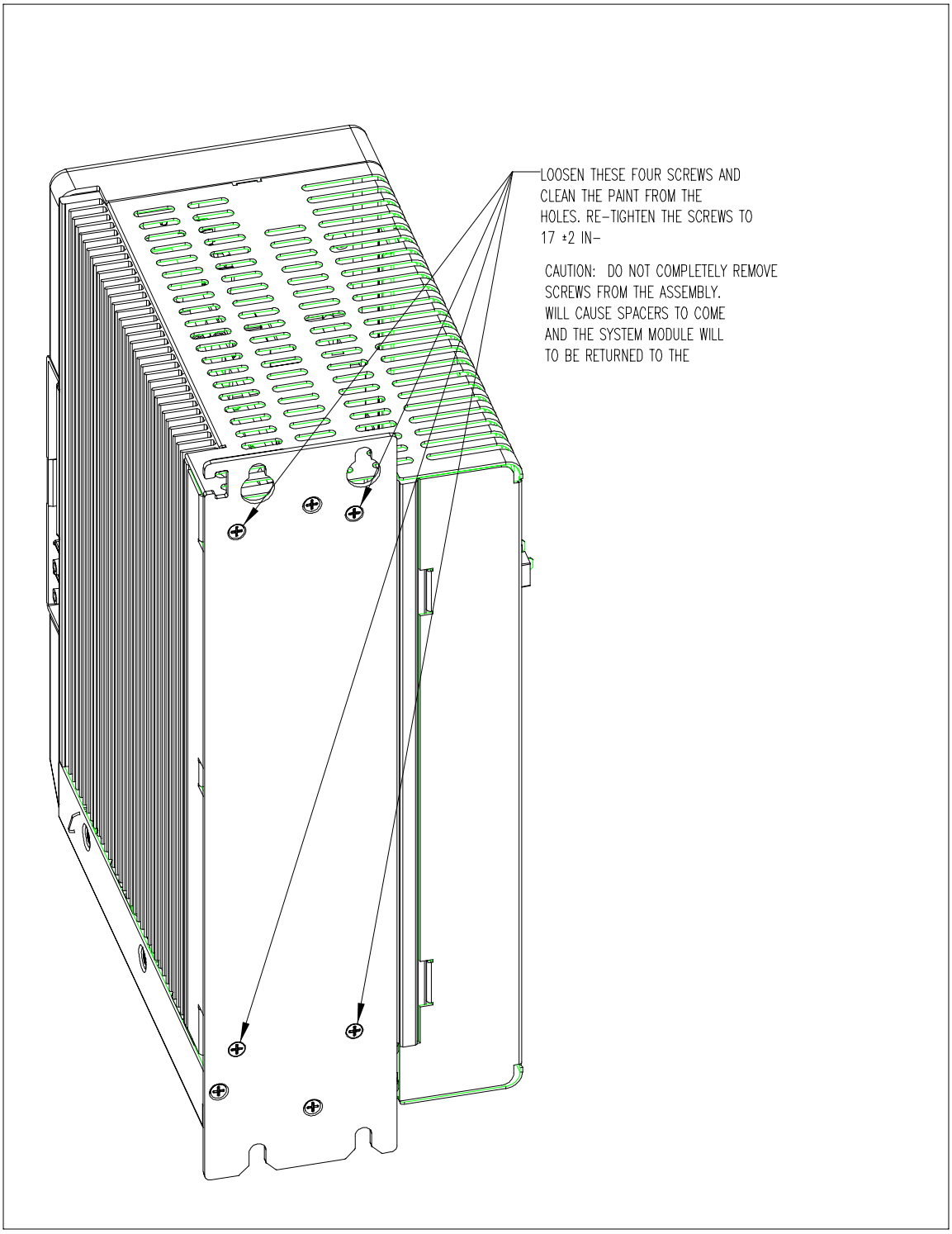


II. Verify chassis Grounding of the 1394 System Module.

This step verifies the system module chassis hanger bonding to PE ground terminations. By design the PE terminal is the safety ground , it is also intended as the low signal ground point for the control system. The PE terminal is intimately connected to the heat sink, and chassis of the system module. The chassis is intended as the Radio Frequency (RF) ground point. Four screws hold the hanger plate to the chassis, in some instances these screws do not make proper contact to the plate.

To determine what if any corrective action is needed the following steps must be taken:

1. Remove the System Module from the control cabinet
2. Insert a #10 AWG (approx. 5.3 mm^2) 2 " long wire into the PE
3. Using a low ohms meter 4 digit or better capable of resolving 10 milli ohm measure from this wire to the heads of the four screws indicated in figure 1, resistance should be less than 100 milli ohms
   - If a low ohms meter is not available, use a standard ohm meter and first determine the meter lead wire resistance by the connecting both leads to the wire inserted in the PE terminal.
   - Connection to the screw heads of the mounting plate is good if the meter reading is the same as the lead wire resistance previously measured.
4. Measure from the PE terminal to the mounting plate allowing the lead to pierce the paint of the mounting foot. The resistance measurement should not increase from the measurement in step 3.
5. If there has been no increase in the measurement, then the system module mounting plate is making a good electrical connection. You must then insure that the system module is correctly bonded from the mounting plate to the control cabinet.
   - Install the system module into the control cabinet using a SEMS screw into a tapped hole in the sub-panel or the cabinet. Make sure that the threads of the hole are free of paint
   - Make sure that the SEMS screw breaks through the paint of the system module hanger
   - Using the meter measure the resistance from the PE terminal to a paint free portion of the sub-panel or cabinet, if the resistance has increased from the reading in step 4 repeat step 5 after cleaning the threaded hole and removing paint from the hanger.
   - **If SEMS screws are not available internal tooth star washers may be used**
   - **If tapped holes or weld studs were not used in the panel (through hole construction) then paint must be removed from the panel and the system module.**
6. If the measurement in step 4 is increased from the measurement in step 3, then place the system module face down and one at a time loosen the screws shown in figure 1, clean the paint from the screw holes, and re-tighten to 17 ± 2 in-lb (1.92 ± .2 N-m). **CAUTION DO NOT COMPLETELY REMOVE THE SCREWS AS SPACERS WILL COME LOOSE AND THE SYSTEM MODULE WILL NEED TO BE RETURNED TO THE FACTORY FOR REPAIR AND RE-ASSEMBLY.**
7. If the measurement in step 3 is open circuit. The screws are not making contact to the heatsink or the PE is not making contact to the heatsink then and only then should the system module be returned to the factory.



III. Verify chassis Grounding of the 1394 **10KW (1394-AM50), 15KW (1394-AM75)** Axis Modules (if present). This step is only required if the previous checks failed to correct the noise problems.

This step verifies the axis module chassis hanger bonding to PE ground terminations. An enhancement was made to the 10KW and 15KW axis modules to create a better bond from the axis module hanger to the modules PE ground. A ground wire was added internally. This may reduce RFI from the axis module. This change is now implement on production units. The date this took effect was:

- 9708

This date code can be found on the name plate on the side of the axis module. The module will have to be removed to read the name plate.

If the previous steps were completed and the faults still persist, an upgrade kit can be ordered and field installed. Performing the upgrade without proper installation bonding and grounding will not correct the problem, so it's important the previous steps were completed properly. The upgrade kit part number is:

- SP-74102-247-51