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Description - This document combines the various gradient driver functional checks that are used on Signa MR/i systems with Advanced Control Gradient Driver (ACGD) hardware.

1- SWITCHABLE GRADIENT AMPLIFIER (SGA) GRADIENT DRIVER CHECKS

Description - This document relates to Signa 8x products. This material describes the status indicators on the ACGD subsystem, and the function checks that may be used for troubleshooting.

1-1- Introduction

The ACGD gradient driver subsystem contains both fault indicators and a dedicated service tool to help you diagnose problems. LEDs on the control board of a Switchable Gradient Amplifier (SGA) indicate certain fault conditions; these are described in the next section. The Gradient Processor (GP) is specifically designed to help solve troubleshooting problems. The GP reports to the system error log, if gradient driver voltage, current, or temperature parameters are out of specification.

In addition to these built-in tools, a checklist describes symptoms and possible causes. The order of each list begins with possible causes most likely to occur, possible causes easiest to check, or possible causes least costly in terms of time and equipment. For items requiring the replacement of FRUs (field-replaceable unit), refer to the Replacement / Maintenance section of the documentation.



FATAL ELECTRIC SHOCK HAZARD!! THE ACGD ACTS AS A CONSTANT LOAD SOURCE, AND WILL SEND MAXIMUM CURRENT TO ANY LOAD (INCLUDING YOU!). TO PREVENT FATAL ELECTRIC SHOCK, USE EXTREME CARE WHEN TROUBLESHOOTING HIGH POWER COMPONENTS. ENSURE THAT POWER IS OFF TO THE ACGD BEFORE ANY COMPONENT REMOVAL, OR CONNECTOR INTEGRITY VERIFICATION.



Equipment damage possibility. The various modules may have static-sensitive components, such as boards, that can be damaged if not handled in a static-free environment. Take appropriate care (e.g., wear wrist grounding strap) when handling these modules.

1-2- SGA LEDs

TABLE1-1
 POWER MODULE STATUS INDICATORS

LED	NAME	COLOR	DESCRIPTION	Visible
DS1	Vfilt/Icoil	Yel/Grn	Intensity proportional to Vfilt/Icoil. Yel pos/Grn neg	External
DS2	Ocinst/OCave	Orange	Indicates instantaneous/Average overcurrents	External
DS3	TJOT/HSOT	Orange	Indicates Junction/HeatSink overtemperatures	External
DS4	UV/OV	Orange	On indicates undervoltage/Overvoltage fault	External
DS5	WireFault/PwrSup UV	Orange	Indicate disconnected Connector/PSundervoltage	External
DS6	Chopper Gate Drivers	Yel/ Green	Indicates Chopper gate drivers active	External
DS7	H Gate Drivers	Yel / Green	Indicates H inverter gate drivers active	External
DS8	L Gate Drivers	Yel / Green	Indicates L inverter gate drivers active	External
DS10	Enable/Fault	Green	Indicates SGA enabled/SGA faults	External
DS11	GEN	Red	On indicates GP not enabling SGA	Internal
DS12	Reset	Red	On indicates GP not resetting SGA	Internal
DS12	GateDrvPS/Tj	Yel/Green	Indicates GDPS active/Junct tmp(Grn cold/yel hot)	External

1-3- Using the SGA's Analog Signals

The GP monitors the following current, voltage, and temperature variables:

- Temperature signals from four sensors in the transistor heat sinks
- Power supply voltage (Vcc)
- Output voltage.

1-4- Power Outage Checklist

During troubleshooting, determining if power is applied in an effective way to isolate power as a source of the problem. There are many modules in the ACGD cabinet that are powered. Subsystem problems are detailed in the following sections.

1-4-1 No Power at All

If there is no power to the ACGD, check the following:

1. Check the circuit breakers at the AC source of the ACGD Power Supplies. The circuit breakers are located at the PDU.
2. Check the wiring on the inside of the ACGD cabinet. Use the Gradient Driver Block Diagram located in *Direction 2153389, Signa Horizon (Release 8.x) Block Diagrams & Supplemental Schematics*.

1-4-2 No Power at GP

The "Power" LED on the front panel of the GP chassis will not light if power is OFF to the GP module. If there is no power to the GP, check the following:

1. Check to see if the auxiliary circuit breaker on the PDU is ON.
2. Check the cable from the PDU to the GP.

1-4-3 No 208 Vac to SGA

There are LEDs on the front of the SGA for each main board. If these are not lit, check the following:

1. Check the PDU Auxiliary Circuit Breakers.
2. Check all power cables.

1-4-4 No LED From Individual Axes on SGA

1. See section 1-4-3 No 208 Vac to SGA.

1-4-5 Circuit Breaker Trips

1. Check for short circuits.
2. Check circuit breaker functionality.

3. Inspect for arcing damage inside PDU
4. If there is no damage, turn on the breaker.
5. If damage is seen, replace the PDU.

1-5- SGA Error Checklist

1-5-1 One Axis Remains in Standby and Won't Go to Ready

1. Check the small red Standby Command LED on the SGA Control Board. Remove the SGA top cover to see the LED. The LED lights when the main board is receiving the standby command signal.
 - a. See Section 1-4-2 No Power at the GP
 - b. Check the cables and the connections between the GP and SGA.
 - c. If the LED is not lit (i.e., not receiving the standby command from the GP), and the power module remains in standby mode, the problem is in the SGA.
 - d. Check the jumpers on the main board.
 - e. Replace the main board.

1-5-2 All SGA axes remain in Standby and Won't Go to Ready

1. See section 1-6-1 Faulty Communication – All Axes.
2. See section 1-5-1 One Axis Remains in Standby and Won't Go to Ready.

1-6- Status and Control Problem Checklist

1-6-1 Faulty Communication – All Axes

1. Check the integrity and the connections of the fiber optic connections. Use the fiber optic light meter during the Class A IPG-Manual-Fiber Optics Diagnostics. See the procedure for Fiber Optic Checks.
2. See section 1-4-2 No Power at GP.
3. After the GP is switched on, allow about 15 seconds for its self-test to complete.

1-6-2 Faulty Communication – One Axis

1. See section 1-4-3 No 208 VAC to SGA
2. Check the cables and the connections between the GP and SGA.
3. Check the integrity and the connections of the fiber optic cables leading to the GP. Use the fiber optic light meter during the Class A IPG-Manual-Fiber Optics Diagnostics. See the procedure for Fiber Optic Checks.
4. Swap the control board of the faulty axis with the control board of another axis. If the problem moves, replace main board.

5. Replace the GP.

1-7- Cooling Problem Checklist

1-7-1 SGA Modules Overheat

1. Check that the fan is running correctly.
2. Check that rear doors are closed. The door should pull closed due to the vacuum created by the fan.
3. Check for clogged air filters.
4. Check for blockage of the vents.
5. Check that output power and load are within specification.
6. Replace the overheated assembly.

1-7-2 Fan Does Not Run

1. Check the circuit breaker on the front of the PDU.
2. Replace the fan.

1-7-3 Fan Runs Backward

If the fan runs backward, airflow is reduced. Correct the incorrectly wired AC phases. The PDU input phase may be reversed. The best indication of a mis-wired fan is if the vacuum created by the fan does not pull the rear door of the cabinet shut.

2- MANUAL GRADIENT DRIVER TESTS

2-1 Introduction

With the complexity of the gradient driver subsystem and its closed loop analog circuit, it is useful to be able to measure and view key test points and signals in order to help isolate a problem to a FRU, or a logical group of FRUs. Because of this, the Manual Gradient Driver Test was created to provide a visual means of viewing these key signals and test points.

2-2 Static Fault Checking

Prior to beginning the manual static test, all fault registers in the ACGD System are checked. The list of all of the fault registers (listed below) that are polled before manual static tests are started. In addition, a comparison is made between the hardware configuration specified in the `MRconfig.cfg` file and the hardware sensed by the GP board. If a mismatch is found, an error is logged and no manual static tests are performed.

The following ACGD Faults are checked:

Framing Error

Clock Stop Error

Ovrerrange Error	Rollover Error
Current Distortion Error	SGA Cable Off
SGA Wiring/Internal Power Supply Undervoltage Fault	SGA Over Temperature
SGA Over Current	SGA Over Voltage
SGA Under Voltage	SGA-PS Cable Off
SGA-PS Power Off	SGA-PS Wiring/Internal Power Supply Under Voltage Fault
SGA-PS Over Temperature	SGA-PS Over Current
SGA-PS Over Voltage	SGA-PS Under Voltage

If any of the above faults are set, an error is logged, no test signal is generated, and the axis remains in standby mode. To view the errors, turn the test off; the errors are then written to the error log.

2-3 Summary of Manual Static Test

The manual static test runs five test signals in one operational modes. From the operator work space there is one test selection available: **[Ready Static Mode]**.

2-3-1 Ready Static Mode Signal Test

Clicking on **[Ready Static Mode]** plays out a constant voltage signal throughout the gradient driver subsystem. This test sets the ACGD to *local* mode, and puts out a constant value to the SGA modules. This output is based on the signal number entered in the data entry field at the operator workspace, and on the hardware configuration. Table 2-1 shows the expected output voltage at the ICOIL BNC connector.

TABLE 2-1
READY STATIC MODE HARDWARE CONFIG, SIGNAL #, AND RESULTING DAC VALUE

Hardware Configuration	Signal LM=1	Signal LM=2	Signal LM=3	Signal LM=4	Signal LM=5
ACGD-HiSlew	ICOIL (BNC)-0.625V	-0.3125V	0V	0.3125V	0.625V

2-3-2 Ready Static Mode Test

This test causes the system to play out a constant voltage with the gradient drivers set to Ready Mode. There are five possible voltage levels that can be select by entering the numbers 1 through 5 in the test parameter field (syntax: lm=1). You can then measure voltages at select test points to localize hardware problems.

If this is the first manual diagnostic test requested, the IPG diagnostic code is downloaded. Then, the MDS link is reset, the SPI diagnostic code is downloaded if necessary, and the test request with the signal number is sent to the SPI via the dual port ram. The SPI then sends a packet to the GP requesting the voltage control mode test with the selected signal number.

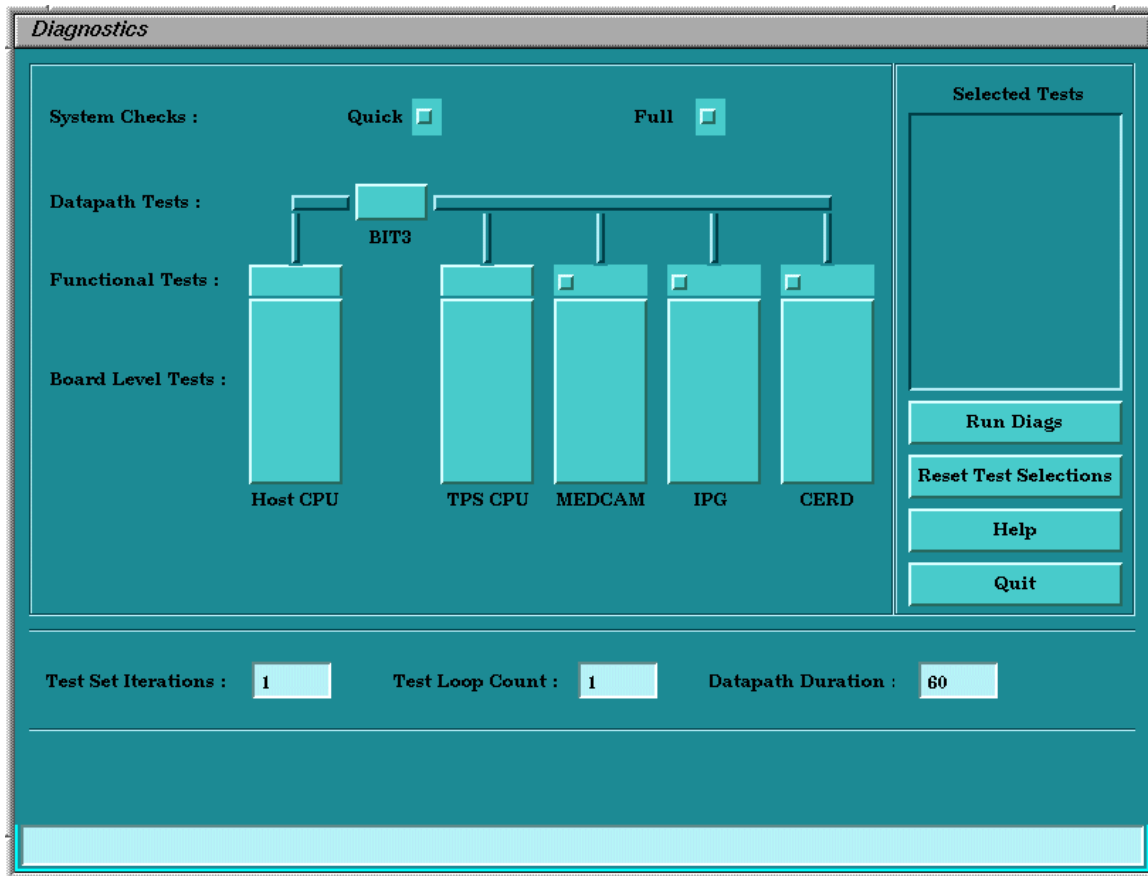
To stop the test, click on **[Ready Static Mode]** again. This sends another packet via the SPI to the GP and stops the test. Once the test has been stopped, the error queue on the GP is flushed, and error messages are displayed in the error log.

2-4 Executing Manual Tests



POSSIBLE EQUIPMENT DAMAGE OR PERSONAL INJURY! THIS TEST GENERATES CURRENTS AND VOLTAGES. TAKE MEASUREMENTS FOR THE DESIGNATED SIGNALS AND SIGNAL LOCATIONS ONLY. DO NOT TOUCH THE OUTPUTS OF THE GRADIENT DRIVER AT ANY TIME DURING THIS TEST. DO NOT TOUCH THE INPUTS TO THE EPOXY-FILLED GRADIENT COIL AT ANY TIME DURING THIS TEST.

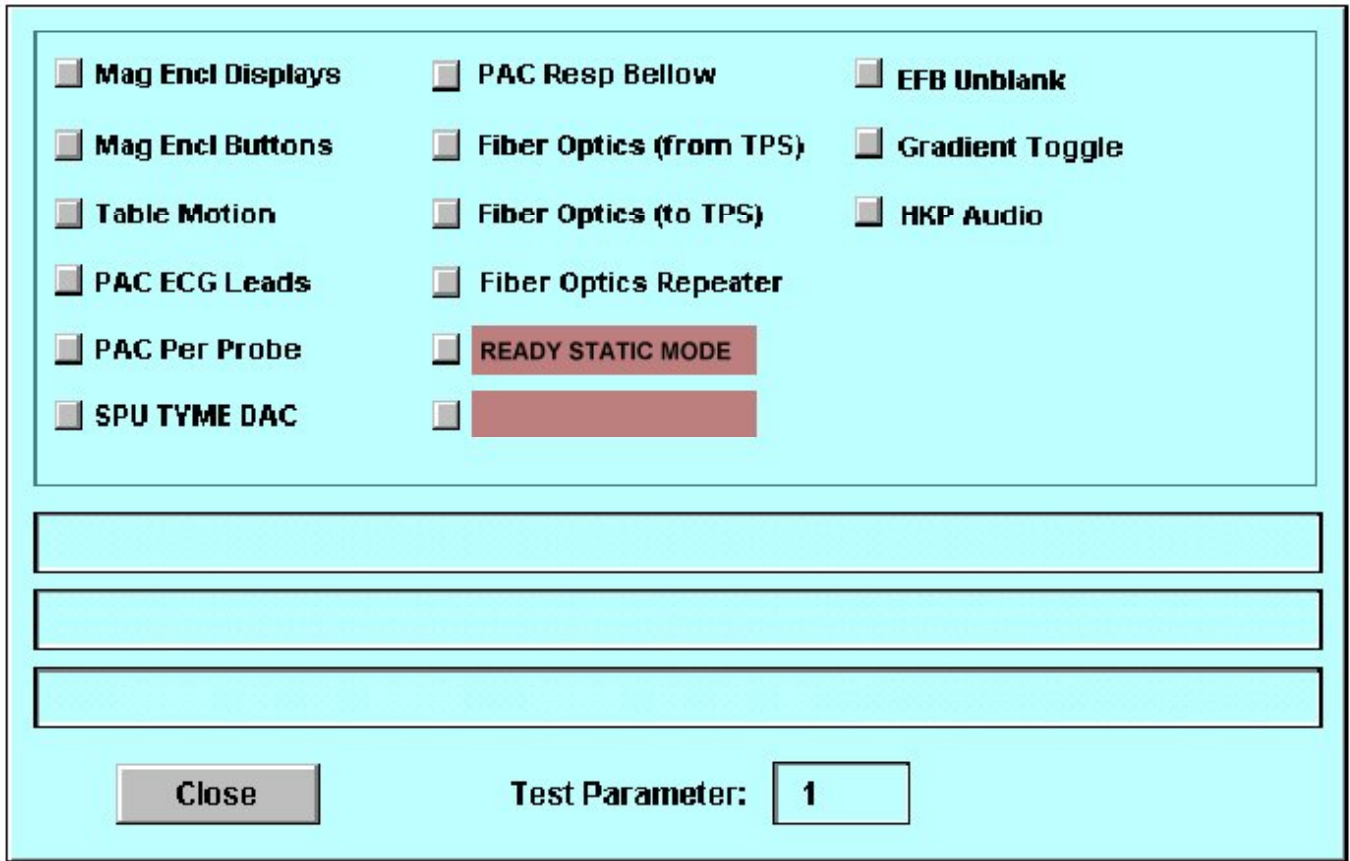
1. Select the **Diags Main Menu** from the **[Diagnostics]** menu on the Service Desktop, then click **[Start]**.
2. Wait for the Diagnostics Main Menu to appear, as shown in Illustration 2-1.



DIAGNOSTIC MAIN MENU
ILLUSTRATION 2-1

3. Click on **IPG**, then **[Manual...]**.

4. Select the Manual Gradient Driver Tests: **[Ready Static MODE]**. See Illustration 2-2.



MANUAL TEST MENU
ILLUSTRATION 2-2

5. Set **Test Parameter** value between 1 and 5 (e.g., **1<Enter>**). Click on **[Close]**, then **[Close]** again.

Note

Levels of amplitude - These diagnostics were designed to invoke a signal at five different levels. Starting at the highest power helps isolate only those signals that are out of tolerance. If the main input and output are correct, it is not necessary to proceed further; however, if a signal is out of tolerance, further testing will localize to the FRU

6. Click on **[Run Diags]**. A *Results* window appears, along with a status message indicating that the TPS is resetting. Once the TPS reset is complete, the selected diagnostic test automatically commences. To halt the test, click on **[Stop Diags]**.

Note

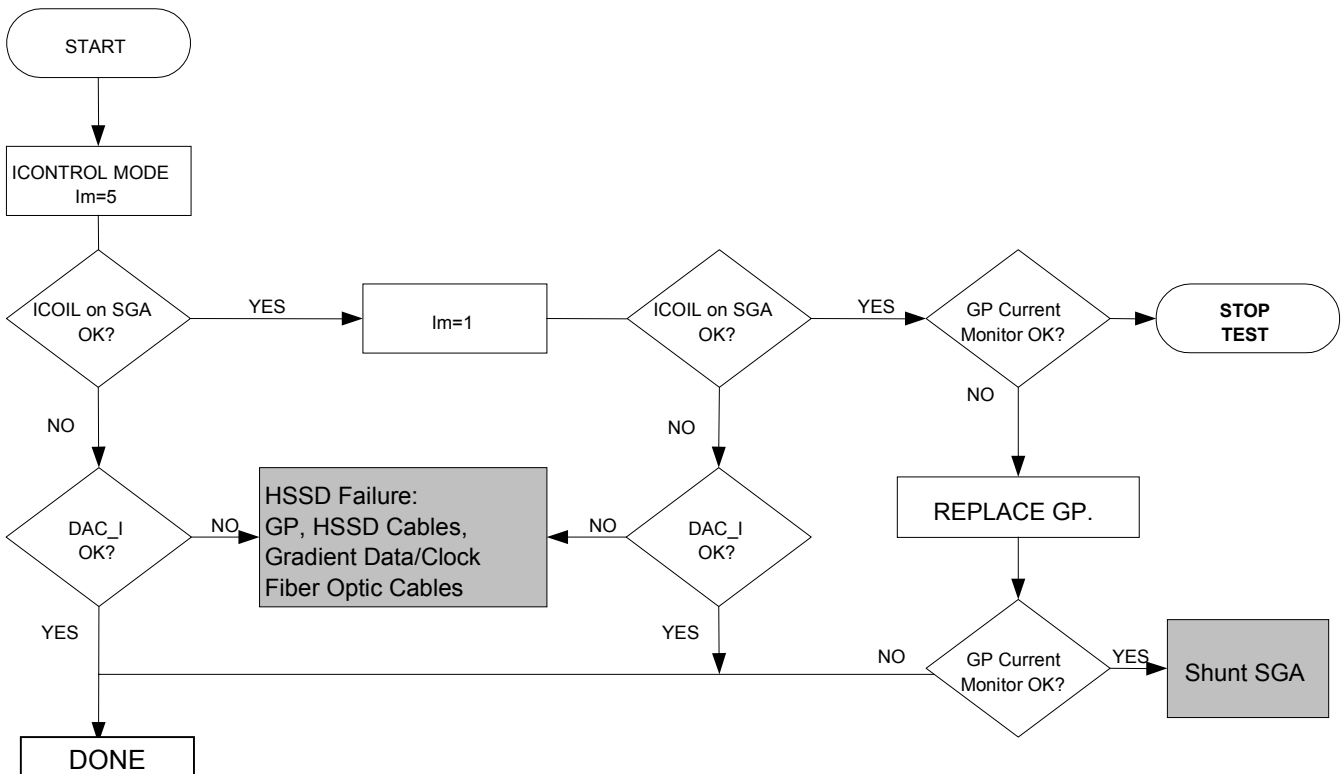
If the signal disappears - This diagnostic is designed to play out a signal for fifteen minutes at a time. If the signals suddenly go away during a measurement, see if the hardware has gone from Ready to Standby. This is an indication that the Manual Gradient Driver Tests have timed out. Execute the level command to restart the diagnostic

Note

Measuring test points - It is important to measure all test points with respect to analog ground unless stated otherwise.

2-4-1 Gradient Driver Troubleshooting Flowchart

1. Follow the flowcharts in Illustration 2-3 for Signa 8x systems.



ACGD MANUAL GRADIENT DRIVER TESTS FLOWCHART
ILLUSTRATION 2-3

2-4-2 Exiting Diagnostics

Click on **[Quit]** to exit the Diags Main Menu, this will reset the TPS.

3- LOAD CONTINUITY TEST

3-1 Introduction

This procedure measures the continuity, or impedance, of the load, or the output of the gradient driver subsystem components. The epoxy-filled gradient coil is the load for the gradient driver subsystem. However, between the output of that subsystem and the epoxy-filled gradient coil are interface panels, a gradient filter on the penetration panel, and a terminal strip at the rear of the magnet.

This procedure can be used with all of the Signa product options. However, since hardware configuration varies from product to product, verify that the system is the same as the reference section to ensure that the correct procedure is being referred to.

It is useful to reference the Signa 8x block diagrams for complete signal path information.

3-2 Preliminary Setup



FATAL ELECTRIC SHOCK HAZARD!! THE ACGD AMPLIFIERS ACT AS CONSTANT LOAD SOURCES AND WILL SEND MAXIMUM CURRENT TO ANY LOAD (INCLUDING YOU!). TO PREVENT FATAL ELECTRIC SHOCK, ENSURE THAT THE POWER IS OFF BEFORE CONTINUING WITH THIS PROCEDURE.

1. Perform lock out tag out by securing the PDU circuit breaker for the ACGD cabinet with the lock out tag out devices. Verify that all power has dissipated by measuring incoming power to the SGA Power Supply at J-10, and incoming power to the SGA Power Supply at J-10.
2. Verify that power is off by connecting a DVM across the input leads (J1, J2) and output leads (J3, J4) at rear of each SGA module. Make sure that the DVM reads 0V.

3-3- Gradient Driver Subsystem Load Continuity Test

Measurements for load continuity are made at three locations for the gradient driver subsystem: the ACGD cabinet, both sides of the penetration panel, and the terminal strip at the rear of the magnet.

3-3-1 Signa MR/i ACGD Systems

1. Using a DVM set to *ohms*, measure the resistance across the + and – input studs, and then across the + and – output studs of each SGA module.
2. OPEN LOAD TEST: The resistance measured across the + and – SGA IN should be greater than 1 k Ω . The resistance measured across the + and – SGA OUT should be less than 1 Ω . If greater than 1 Ω , then the load may be an open circuit.
3. Measure the resistance from the + and – input studs to ground, and then the + and – output studs to ground of the GRAM module. The –IN to ground measurement should be less than one Ω . All other studs to ground must measure greater than 1k Ω .

Note

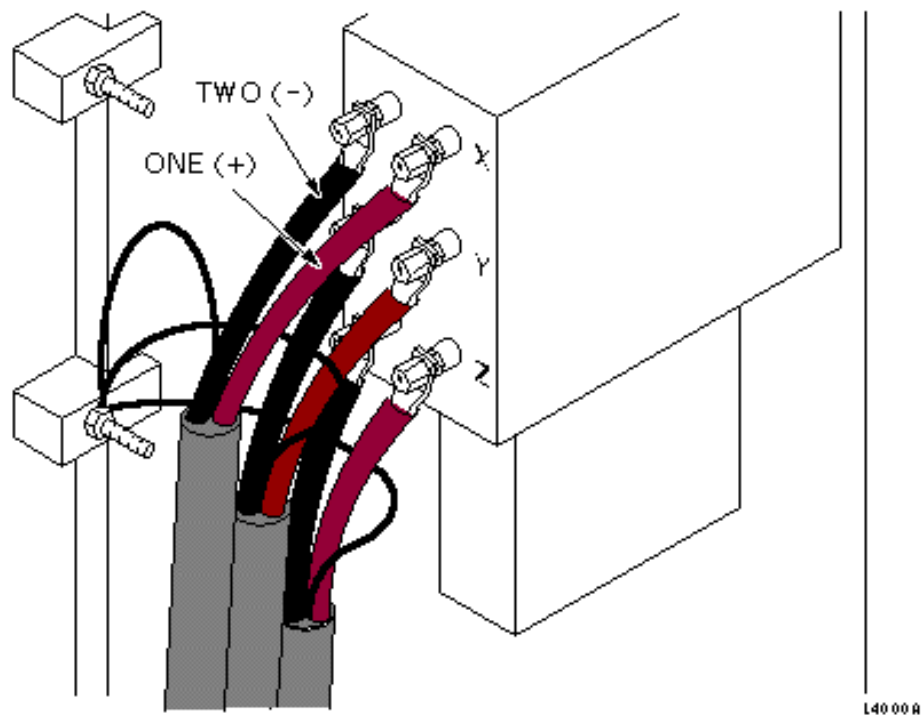
SGA IN to SGA OUT measurement - Measuring resistance from SGA IN to SGA OUT at the rear of the GRAM measures the coil resistance.

- 4. An open load to ground should measure as follows: + to – SGA out will measure greater than 1 Ω . From + or – to ground should measure less than 1 k Ω .

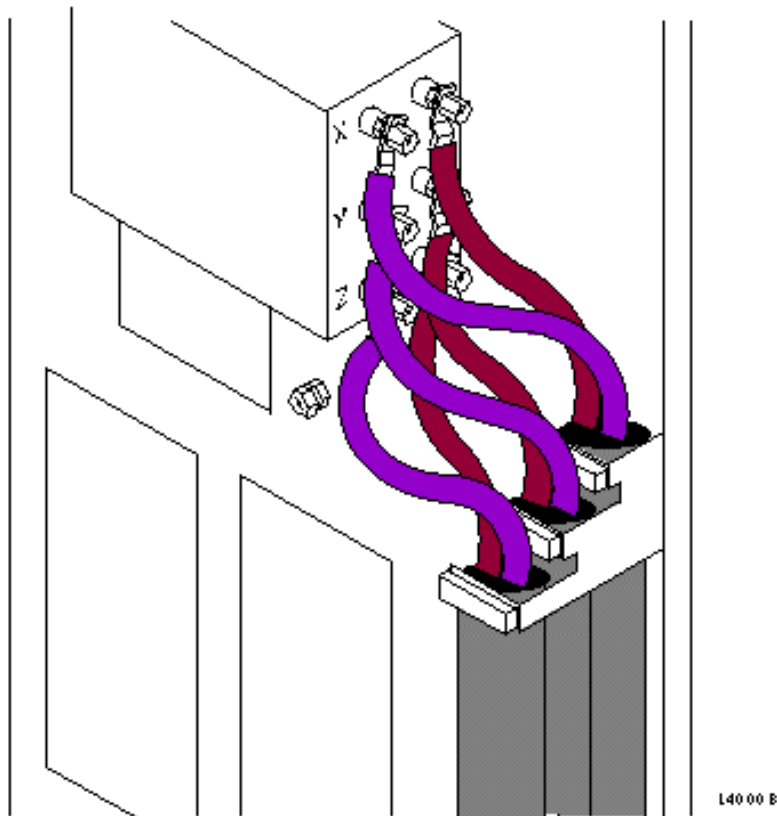
Continue with measurements at the Penetration Panel, Section 6-3-2 Penetration Panel/Gradient Filter Box Measurements.

3-3-2 Penetration Panel/Gradient Filter Box Measurements

The gradient cables are attached to a gradient filter, on both sides of the Penetration Panel. See Illustration 3-1 and Illustration 3-2.



EQUIPMENT ROOM VIEW OF THE GRADIENT FILTER BOX
ILLUSTRATION 3-1

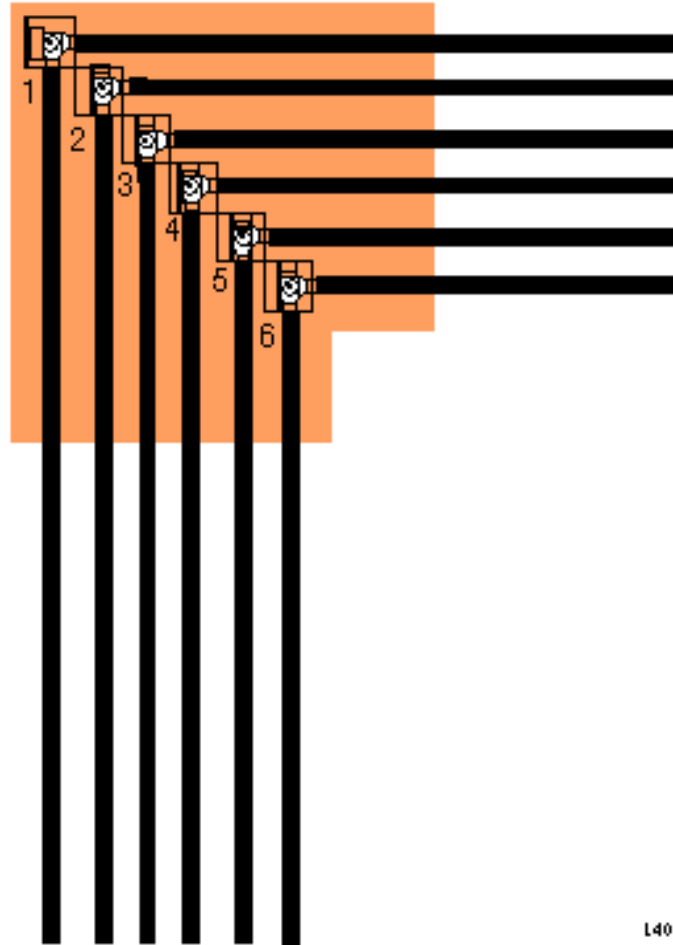


SCAN ROOM SIDE VIEW OF THE GRADIENT FILTER BOX
ILLUSTRATION 3-2

1. Using a DVM set to *ohms*, measure the resistance across the +X and -X load.
2. The resistance measured at this point should not exceed 1 Ω .
3. Continue measuring the resistance across the Y load and then the Z load.
4. Repeat steps 1, 2, and 3 for the scan room side of the Penetration Panel. See Illustration 3-3.

3-3-5 Gradient Cable Terminal Strip Measurements

The gradient cables are attached to a terminal strip, at the rear of the magnet. Terminal number 1 is +X and terminal number 2 is -X. Terminal number 3 is +Y and terminal number 4 is -Y. Terminal 5 is +Z and terminal 6 is -Z (see Illustration 3-3).



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GRADIENT CABLE TERMINAL STRIP
ILLUSTRATION 3-3

1. Using a DVM set to *ohms*, measure the resistance across the +X and -X load.
2. The resistance measured at this point should not exceed 1 Ω .
3. Continue measuring the resistance across the Y load and the Z load.
4. Measure the resistance from X to Y, X to Z, and Y to Z for both polarities. In all of these cases, the resistance should be greater than 1 k Ω .

3-4- System Restoration

If any of the measurements were not in spec, then replace that component or module. To restore the system to specifications.

1. Ensure that all connections are tight.
2. Measure for open circuit load and short to ground. The Field Engineer will disconnect load cables at measurement points as he continues to isolate opens and shorts.
3. Enable power at the PDU by removing the lock out tag out devices.
4. Apply power to the ACGD.
5. Replace all the covers on the cabinets.
6. Perform a body or head scan to ensure system functionality.

REVISION HISTORY

RE V	DATE	AUTHOR	PRIMARY REASONS FOR CHANGE
A	Sept. 18, 2000	K.Keshena	Preliminary version.
0	Oct. 20, 2000	K. Keshena	Initial release.