TABLE OF CONTENTS

DESCRIPTION

This procedure is not to be used as normal calibration! and is only available as a troubleshooting reference for systems with 8645/GRAM hardware.

1- OVERVIEW

GRAM tuning is a group of procedures assembled together in order to tune the entire Gradient Driver subsystem for systems with a GRAM. For more information on GRAM tuning theory, see Table 1.

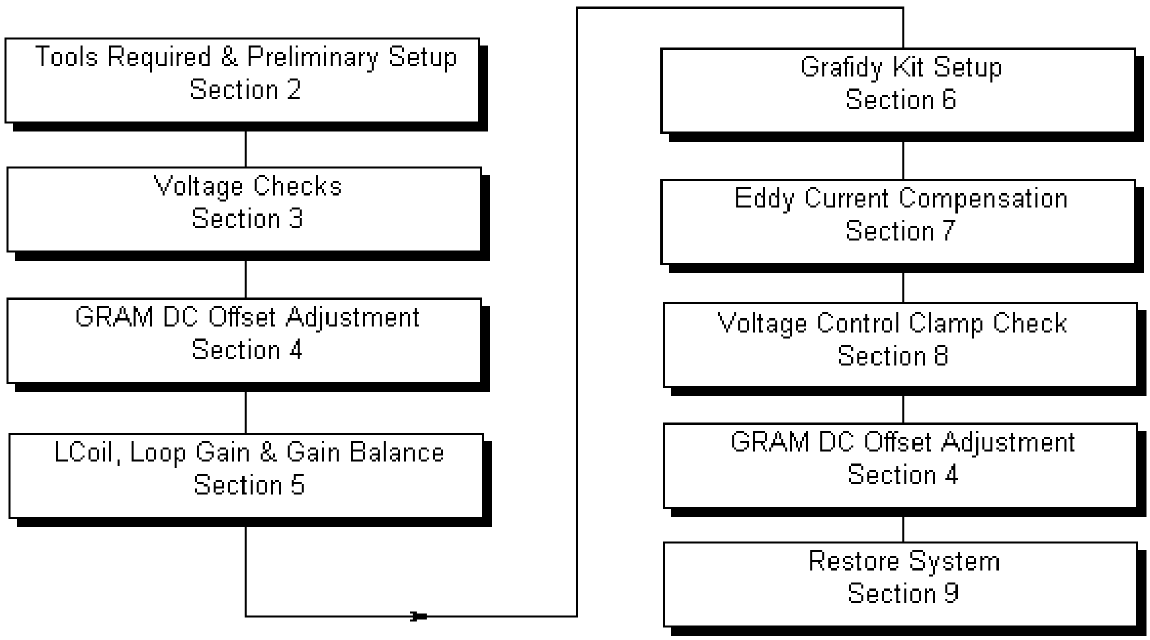
TABLE 1
GRAM TUNING THEORY

GRAM Tuning is a group of procedures assembled together in order to tune the entire Gradient Driver subsystem for systems with a GRAM. The Signa Horizon HiSpeed and the Signa Horizon EchoSpeed both have one GRAM (Gradient Ramp Accelerator Module) per axis. In addition, this procedure is specific to the digital tuning board. Those systems with a board are the **only** ones that require this GRAM Tuning procedure. Initially, all dc offsets that may be present in the Gradient Driver subsystem are adjusted to zero. Limits are set for the Pulse Width Modulation, Amp/Sec (Ampere Transitions per Second) and Bus Voltage Regulator Gain functions. The actual tuning of the GRAM is performed in the LCoil and Gain Adjustment. Eddy current compensation is now performed for linear long time constants, B_0 time constants, and linear short time constants. The PSD for Eddy Current Compensation is called *Grafidy*. The analysis tool is found under MR Tools, and is called *Grafidy Analysis*. B_0 compensation, also referred to as FRESBECC (Frequency *S*hift B_0 Eddy Current Compensation), is an automated digital method of adjusting B_0 for all three axes. All mechanical adjustments for B_0 are no longer required with the new epoxy-filled gradient coil used with the Signa Horizon product line. **FRESBECC is performed during Grafidy for B_0 eddy current time constants portion of this procedure.**

1-1 GRAM Tuning Flowchart

This procedure is not to be used as normal calibration! and is only available as a troubleshooting reference for systems with 8645/GRAM hardware.

See flowchart in Illustration L1120A for specific details on the procedure flow, and functional descriptions of each of the individual procedures performed in GRAM Tuning.



GRAM TUNING FLOWCHART
ILLUSTRATION L1120A

See Appendix A for a functional description of why that portion of the procedure is performed.

2- TOOLS REQUIRED AND PRELIMINARY SETUPS

Table 2 Preliminary Setups. See Appendix C.

3- VOLTAGE CHECKS

Table 3 Voltage Checks

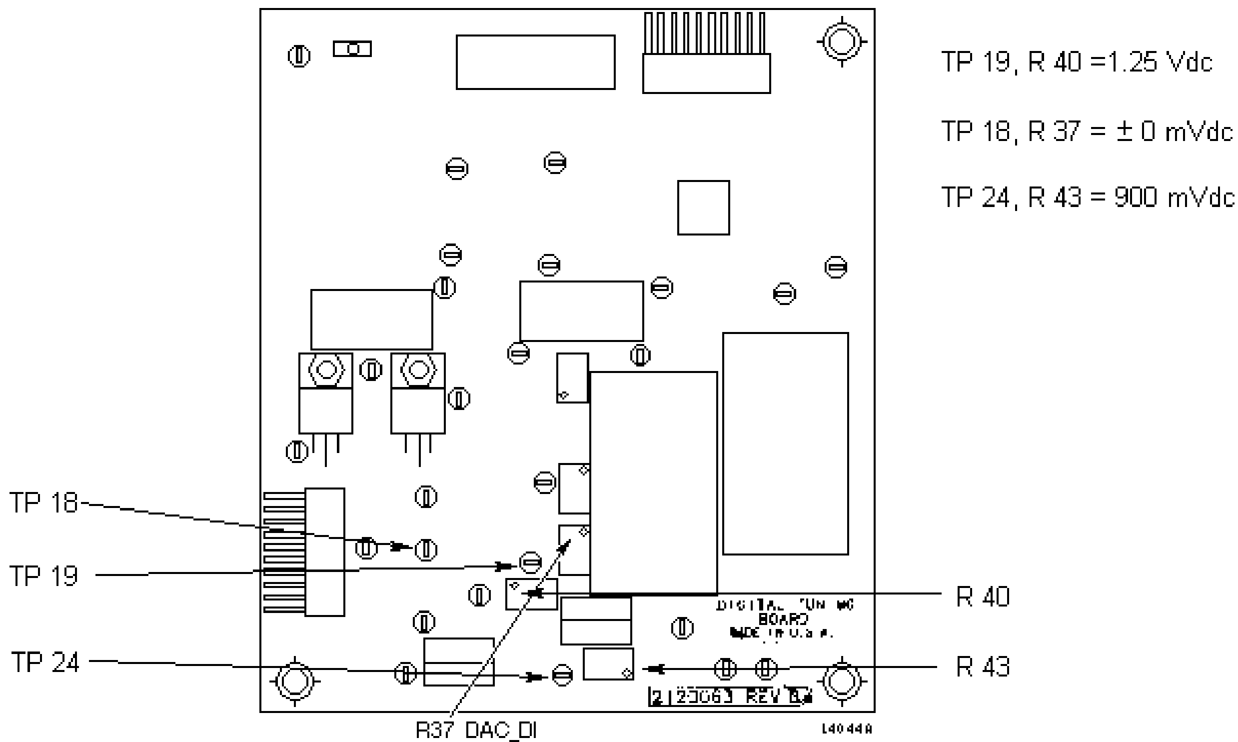
TABLE 3
TOOLS REQUIRED AND PRELIMINARY SETUPS

For all axes (if required), make the following adjustments on the Digital Tuning Board:

TP 18 DAC_DI Voltage Offset
TP 19 Pulse Width Modulation (PWM) adjustment
TP 24 Amp Transition per Second adjustment

Note: All test point measurements are in respect to ground.

TEST POINT	POT	SPEC	ILLUSTRATION
18	R37	0 ±3 mVdc	L4044A
19	F40	1.25 Vdc	L4044A
24	F43	900 mVdc	L4044A



DIGITAL TUNING BOARD
ILLUSTRATION L4044A

4- GRAM DC OFFSET ADJUSTMENT

Table 4 GRAM DC Offset. See Appendix D.

5- LCOIL, LOOP GAIN AND GAIN BALANCE

Table 5 LCoil Adjustment. See Appendix E.

6- GRAFIDY KIT SETUP

Table 6 Grafidy Setup. See Appendix F.

7- EDDY CURRENT COMPENSATION

Please note! Check the B_0 (FRESBECC) daughter board on the Exciter to ensure that the B_0 jumper is in the 5.5 position. If it is not, B_0 compensation will not work.

Table 7 Linear Long Eddy Current. See Appendix G.

Table 8 Linear Short Eddy Current. See Appendix H.

Table 4 GRAM DC Offset. See Appendix D.

Repeat Tables 7, 8, and 4 for each axis calibrated.

8- VOLTAGE CONTROL CLAMP CHECK

Table 9 Voltage Clamp Check. See Appendix I.

9- SYSTEM RESTORATION

Table 10 Restore System. See Appendix J.

10- GRAM TUNING QUICK REFERENCE

Table 11 GRAM Tuning Quick Reference. See Appendix K.

11- CHECK OF GRAFIDY HARDWARE AND COILS

Table 12, Functional Check of Grafidy hardware and Coils. See Appendix L.

12- SAVING/RESTORING COEFFICIENT FILES

This section details how to back up the ecccoeff.dat, and the gram_tune.dat files (gram_tune.dat is available only on systems with a GRAM) before a pass of Grafidy is performed. This is useful if you are in troubleshooting mode, and want to restore the system to it's original calibration.

12-1 Gradient Configuration

12-1-1 Systems Without a GRAM

The ecccoeff.dat file is the coefficient file that is downloaded to the WARP on IPG when TPS Reset is performed, and everytime the Grafidy analysis tool is run. This file contains the B_0 (zeroth order) coefficients, and the eddy current (first order) coefficients for systems without a GRAM.

12-1-2 Systems with a GRAM

The ecccoeff.dat file is also used to store the B_0 coefficients for systems with a GRAM and works in conjunction with the gram_tune.dat file.

The gram_tune.dat file is downloaded every time the GAP Board is reset, i.e., on a TPS Reset, a power cycle to the GAP Chassis, or every time the Grafidy analysis tool is run. This file contains the eddy current (first order) coefficients for systems with a GRAM.

12-2 Backing up the Files

It is possible to back up these files in one of two ways: from the Service Desktop, and from a C-shell on the Service Desktop.

12-2-1 From the Service Desktop

1. Click on [Install].
2. Place an MOD in the appropriate drive.
3. Click on [Save Info].
4. When you want to restore the files, ensure that the MOD in inserted into its drive.
5. Ensure that you are on the Service Desktop.
6. Click on [Install].
7. Click on [Restore Info], and answer the appropriate questions.

12-2-2 From a C-Shell on the Service Desktop

1. At the prompt, type

   cd /usr/g/caldir<Enter>

2. For <u>all</u> systems, type

   cp ecccoeff.dat ecccoeff.bak<Enter>

3. For systems with a GRAM, type

   cp gram_tune.dat gram_tune.bak<Enter>

12-3 Restore the Files

1. Ensure that you are in the /usr/g/caldir directory.
2. For <u>all</u> systems, type

   cp ecccoeff.bak ecccoeff.dat<Enter>

3. For systems with a GRAM, type

   cp gram_tune.bak gram_tune.dat<Enter>

12-4 System Restoration

Always perform a goodbye scan to ensure system functionality.

APPENDIX A

Preliminary Set Up Functional Description

The Preliminary Setup for GRAM Tuning is designed to ensure the state of the gradient driver subsystem. For example, if the switches and or jumpers on the GRAM control board are in the wrong location, unpredictable results will occur during this calibration.

VBUS (Bus Voltage Regulator Gain), an adjustment on the GRAM control board must be set to a preset gain. If this potentiometer cannot be adjusted, the GRAM must be replaced.

The Grafidy Coil and Grafidy Hardware are installed in this section to save time.

Voltage Checks

DAC Adjustments

This adjustment uses a DAC whose dc offset is unpredictable, and is neither controlled nor specified; therefore, there is no guarantee which value dc offset each DAC component will have. This dc offset must be eliminated so that the VControl signal receives no offset from this device. If VControl cannot be adjusted, it is probably due to a dc offset from this DAC.

VControl (VC) is = IR (drop across the coil) + Ldi/dt (drop across the coil)

DAC_I is the current command DAC, and DAC_DI is the Ldi/dt command from the GRAM.

Pulse Width Modulation Adjustments

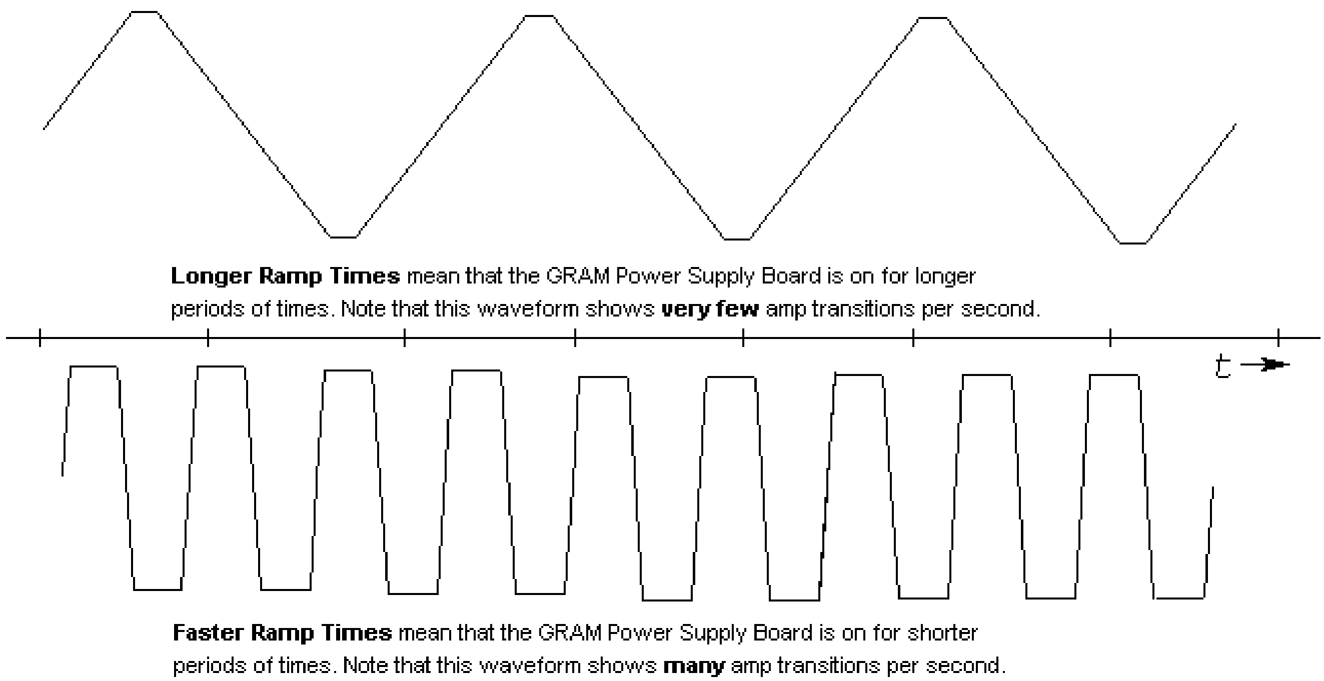
The value *%PWM* is simply the amount of time in a ramp without looking at current. Since the GRAMs are active only during the ramps, %PWM is also the amount of time that the GRAMs are PWM-ing. This adjustment sets the %PWM to 25%. If the ramp times are greater than 25%, this parameter starts to limit. The acceptable parameter is 25% PWM for approximately five seconds. This signal is filtered, so instantaneous ramp times can exceed 25%, but sustained ramps are limited.

This adjustment allows for protection for snubber circuitry. Snubber function reduces switch loss on the IGBTs.

Amp Transitions per Second Adjustment

This adjustment prevents overloading of the power supply board in the GRAM. Since switching loads down the power supply board, it is important to be sure that there are acceptable number of transitions per second so that the power supply board does not overload.

If the average EPI waveform is displayed, the number of times the waveform transitions from one polarity to another for a given amount of time is measured. If there are long ramps, the number of transitions is lower; however, the time that the power supply board is active is longer (Remember that the GRAM is active during the ramps). If there are fast ramps, the number of transitions is much higher, and the time that the power supply board is active is shorter (see Illustration L1).



AMP TRANSITIONS PER SECOND WAVEFORMS
ILLUSTRATION L1

The optimum number of transitions must be set to protect this circuitry; therefore, we manually limit these transitions with the Amp Transitions per Second Adjustment.

GRAM DC Offset Adjustment Description

GRAM DC Offset Adjustment must be performed first, or the return signal may not show up. This is due to a magnitude offset caused by a dc offset on the output of the GRAM.

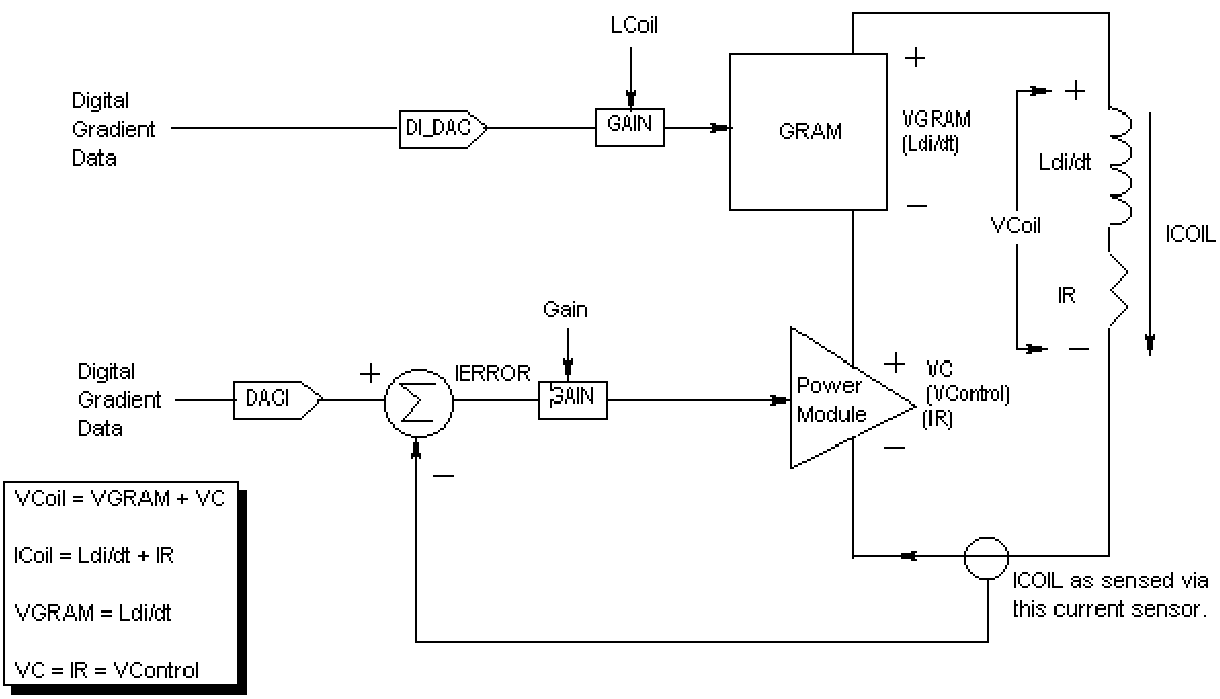
A helpful tip is to make sure that the DVM that is used to measure the GRAM dc offset has long leads. This ensures that the connection at the rear of the GRAM can be made while the DVM display is near the GRAM Control Board. The potentiometer that is used for this adjustment is located on the GRAM Control Board.

If this adjustment cannot be made, make sure the grad shim values are set to zero. If they are not, they are providing a dc offset that you cannot adjust around.

LCoil, Loop Gain, and Gain Balance Adjustment Descriptions

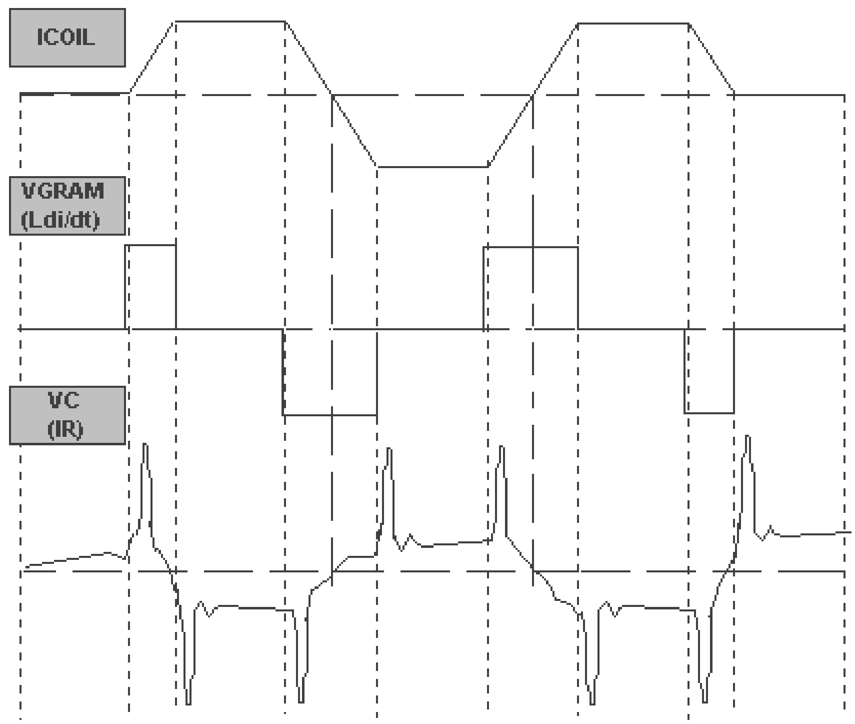
LCoil Adjustment

VCoil is equal to the IR potential from the power modules, **plus** the Ldi/dt potential from the GRAM. (V = IR + Ldi/dt). For our system, the L is the gradient coil, and this parameter is frequency dependent. Since the coil is not an ideal inductor, its frequency varies from coil to coil. Illustration L4 shows a simplified gradient driver schematic. Illustration L5 shows some important gradient driver waveshapes (ICoil, VGRAM, and VC). It is important to note that VC is VControl, and is simply equal to the voltage from the Techron power modules. Illustration L6 shows VC if the inductance of the coil is greater than VC in Illustration L5. Note that if LCoil is adjusted, this waveform looks more like the one in Illustration L5.



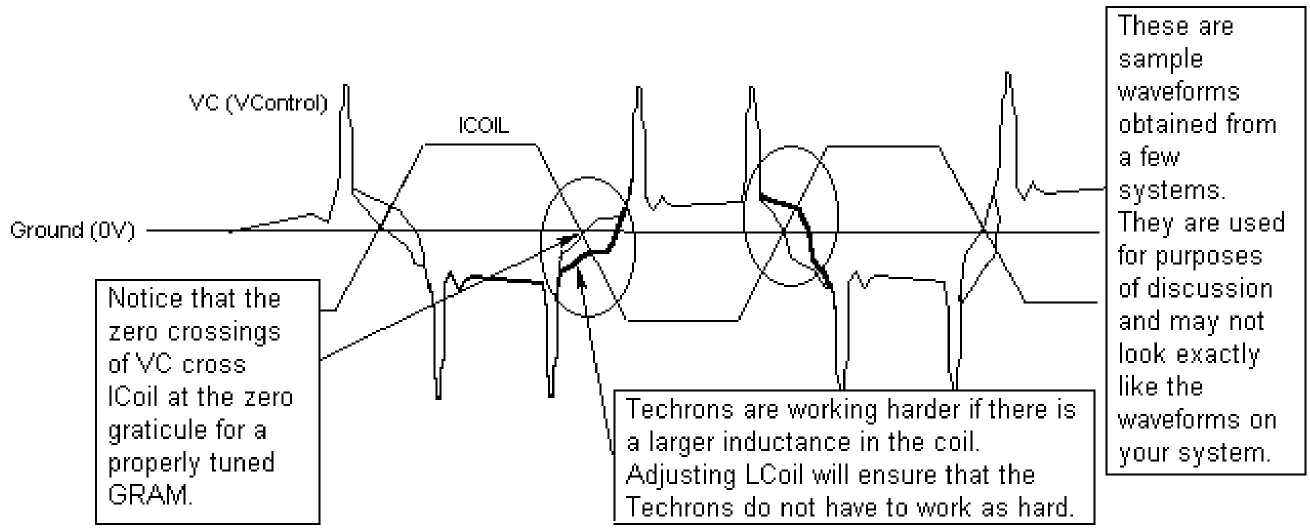
GRADIENT DRIVER SIMPLE SCHEMATIC
ILLUSTRATION L4

In order to produce the trapezoidal current, ICOIL, the combination of Ldi/dt plus IR must be present. LCoil is the gain adjustment for VGRAM. DI_DAC is the GRAM command current. Gain is the Loop Gain applied to IERROR. IERROR is the error between the requested Techron command current (DACI), and the actual current (ICOIL). The Techron power modules try to compensate for losses or instantaneous differences between the current requested and the actual current. During a ramp, the GRAMs put out a constant voltage. (Note that this voltage actually occurs BEFORE the ramp by design so that the Techrons do not have to compensate as much.) When the Techrons see the requested current does not match the actual current they play out more VC. These are the "ears" that are present in the VC waveform. When the Techrons see that the GRAM is playing out adequate voltage to produce the required current, they begin to go back to zero. Since the Inductance of the coil is different from coil to coil, an adjustment must be made to essentially match the gain of the circuit with the inductance of the coil. This adjustment is *LCoil*.



GRADIENT DRIVER WAVESHAPES
ILLUSTRATION L5

If the inductance of the coil increases, then the Techron power modules produce more voltage. This illustration shows the change in VC when the inductance of the coil increases. By adjusting LCoil, the GRAM will be producing the correct voltage, and the Techrons will not have to compensate by producing more voltage or current. Notice that if LCoil is adjusted, the zero crossings of VC and ICOIL move. The section of the waveform that is bold represents the additional voltage produced by the Techron power modules (VC) for a coil with higher inductance.



GRADIENT DRIVER WAVESHAPES
ILLUSTRATION L6

If LCoil does not seem to be able to be adjusted, there may be a coil problem. An eddy current structure could be disturbed. One such disturbance could be extra metal in the imaging area. Another problem could be because the gain is set wrong. Since LCoil and gain are interactive, if one won't come in, it could be because the other is misadjusted.

Loop Gain Adjustment

Gain, or Loop Gain, is the amount of gain necessary to amplify the error signal (IERROR) so that the output of the Techron power module(s) is correct. This parameter compensates for the differences in gain between systems with one power module per axis (Signa Horizon HiSpeed), and systems with two power modules per axis (Signa Horizon EchoSpeed). Signa Horizon base model with two power modules per axis, do not have GRAMs, and, therefore, are not adjusted for gain.

If VC is overdamped, there will not be enough gain for the Techron power modules to assist the GRAM during ramps. If VC is underdamped, the Techron power modules are too sensitive to changes in the GRAM Voltage, thus making the circuit rather unstable during the ramps.

In order to produce the correct damping, VC must be adjusted such that there is a small amount of characteristic "bump" so that the correct gain is produced by the Techrons when needed.

If the gain is not adjusted correctly, eddy current compensation for long and short time constants will not be able to converge correctly.

Gain Balance Adjustment

This adjustment is relatively easy to do if the correct areas of the waveform are used, if the correct power source is being used, and if the scope has been set up correctly before any measurements are made.

First of all, be sure that the power supplied to the oscilloscope is from the filtered outlet that comes from the base of the GRAM cabinet. The GRAM cabinet may have an extension cord plugged into this filtered outlet to bring the power out and up so that it is away from the GRAM signal cables. For oscilloscopes that do not use 120 Vac, a step-up transformer plugged into this outlet may be used to provide the correct supply voltage.

If this outlet is not used, additional noise on the signals will make it impossible to read some of the signals that need to be adjusted. In addition, if this filtered outlet is not used, then noise from outside sources can be introduced into the circuitry of the GRAM, causing failures of the GRAM.

Secondly, make sure the scope is set up correctly. Although this is really a "ball park" adjustment, it is a good idea to be sure that the scope has been calibrated to the ground potential of the GRAM control board.

DACI is the command current, and ICOIL is the actual current that the GRAM can supply. In an ideal world, there would be no losses in the circuit, and DACI would be equal to ICOIL. There would be no error signal; however, since there are no ideal components, and all components have tolerance, there are losses within the circuits, and there is an error signal. IERROR is the difference between DACI and ICOIL. (IERROR = DACI – ICOIL). This adjustment is to compensate for losses that occur in the current signal.

The two current signals are first displayed on the oscilloscope to be compared. These should look very similar. A portion of the waveform near the beginning of the trapezoidal pulse train is selected to get the most accurate picture of the losses in the beginning of that pulse train.

The % IERROR is a magnified error signal (1/10 of 1%), and is actually the output from a gain stage; therefore, what is displayed on the oscilloscope is actually much larger than the actual error signal. IERROR can be very large during a ram. Notice this effect in all of the IERROR illustrations. Also, note that there can be a ripple during the "flattop" portion on the trapezoidal waveform. This flattop region is when the Techron power modules are active; GRAMs are not active during the flattop region of the trapezoidal waveform. If there is a sinusoidal wave that the ripple is riding on, it is caused by eddy currents. Once the eddy currents have been compensated for, this sinusoidal shape should flatten out. Since the eddy currents die out over time, the IERROR waveform will come to a more level state toward the end of the flattop region. It is in this area that we are the most interested for this adjustment.

Since the scope has been calibrated to GRAM ground, the IERROR waveform should have approximately equal distance from the ground line on the oscilloscope, the positive going portion of IERROR should be approximately the same distance from ground as the negative going portion of IERROR. You may want to look at both sides of this waveform to ensure that you are as close to zero as possible, however, since this is a ball park adjustment, exact placement is not required. See Illustration L4568F.

Another note, is to compare the IERROR signal to being similar to a scope ground signal display with the scope gain turned all the way up. The resultant display is a "fuzzy" line. It is difficult to measure or adjust this waveform.

Linear Long, B_0 (FRESBECC) & Linear Short Eddy Current Compensation

For a description of eddy currents and Eddy Current Compensation, please see the procedure for Eddy Current Compensation Theory. See Appendix B.

Voltage Control Clamp Check

At first glance, this adjustment might seem complicated, but it is really quite simple. This adjustment ensures that VC (VControl), which is the Techron command voltage, is not in the positive or negative bus voltage limit. The bus voltage regulator circuitry produces four bus voltage signals. VBUS is the summation of VBUS0, VBUS1, BVUS2, and VBUS3. Since this is the supply voltage, signals, such as VC, should not exceed this value for extended periods of time. In the GRAM circuitry, this time is approximately 25 microseconds.

There are just a couple of things to watch for during this adjustment. First, it is important to be sure that you follow the instructions for the system that you are on. Because this is an impedance measurement, the GRAM must be powered off.

Use B Delay on the oscilloscope to select a portion of the VC and ICOIL waveforms toward the end of the pulse train. This is necessary because the bus voltages are beginning to lower due to the demand placed on them during the trapezoidal pulse train. Remember that there is a positive bus voltage and a negative bus voltage. Ensure that VC is not in this bus voltage region for more than 25 microseconds for both the positive lobe and the negative lobe. It is important that VC is not in this region, commonly called the *clamps*, or *rails*, to protect the GRAM circuitry. Therefore, as VC is measured and adjusted with the system powered and scanning, VC should not be in this upper or lower limit of the power supplies for more than 25 microseconds.

VBUS **is not** rechecked after VC is adjusted.

If you can't achieve the specification for this adjustment, there is a problem with the GRAM. One problem could be previous adjustments made in the GRAM tuning procedure; recheck these adjustments. The other problem could be the GRAM itself. Try running Gradient Driver Manual Tests. See the procedure for Manual Gradient Driver Tests.

APPENDIX B

Description

This is the first release of this procedure in ToolBook.

1- Introduction

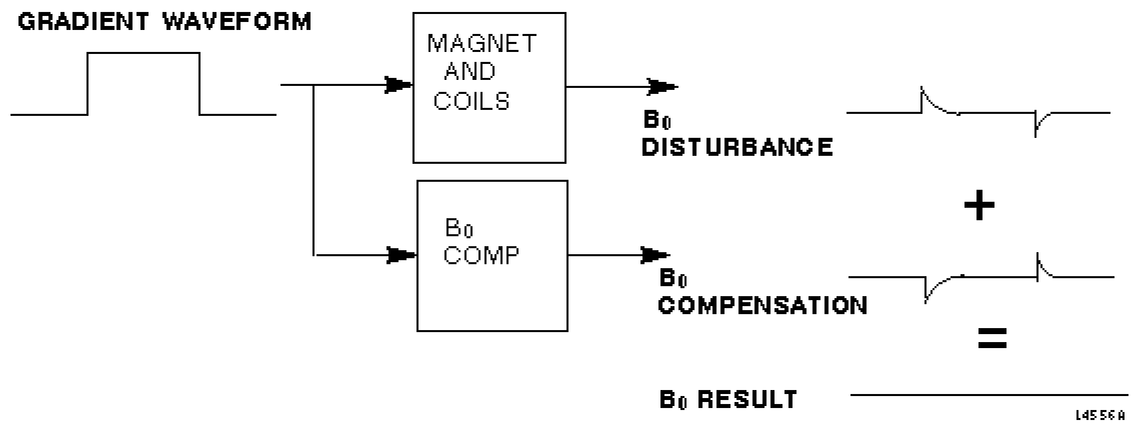
Eddy currents degrade image quality. The faster the scan, the more important eddy currents become. Eddy currents must be measured at shorter time intervals than before, due to the faster capability of the Signa Horizon product line. Eddy currents come in three categories: linear long time constant eddy currents, linear short time constant eddy currents, and B_0 eddy currents (FRESBECC, Frequency Shift B_0 Eddy Current Compensation) (see Table 1 for all three). There are different implementations for each of the different types of eddy currents.

TABLE 1
EDDY CURRENTS - LINEAR ECC

	ANALOG	ANALOG / DIGITAL	DIGITAL
Parameter	• Long time constants	• Long time constants • Short time constants	• Long time constants
Where ECC Occurs	Done with Tuning (Grafidy) Board on 8607 Master Gradient Amplifier	Done on GRAM with Digital Tuning Board or on GIP for SGD	Done on IPG-WARP
How to Perform Grafidy	VT and VA adjusted by potentiometers on the Grafidy Board	Digital potentiometers on the Digital Tuning Board controlled by software High Pass filters on the GIP for SGD that are controlled by software	VT and VA adjusted by software on IPG-WARP
Hardware & Systems Affected	• Signa Advantage Release 5.5 with 8607s • All Signa Advantage Release 5.4 Systems	• Signa Horizon Hi & Echo Speed (8645s & GRAM) • Signa Horizon Hi & Echo with SGD hardware	• Signa Horizon (8645s)

2- B_0 Eddy Currents: Zeroth-order Eddy Current Compensation

Gradient pulses induce eddy currents. Some of these eddy currents cause time-varying magnet field errors with zeroth-order, or B_0, geometry. Zeroth-order eddy current compensation, also called *B_0 eddy current compensation*, prevents image quality degradations caused by eddy currents. In prior systems, the mechanical alignment of the inner gradient coil with respect to the outer gradient coil was adjusted to minimize B_0 eddy currents. At this time, compensation is done as shown in Illustration L4556A.



B_0 EDDY CURRENT RESPONSE AND COMPENSATION FOR EPOXY-FILLED GRADIENT COIL
ILLUSTRATION L4556A

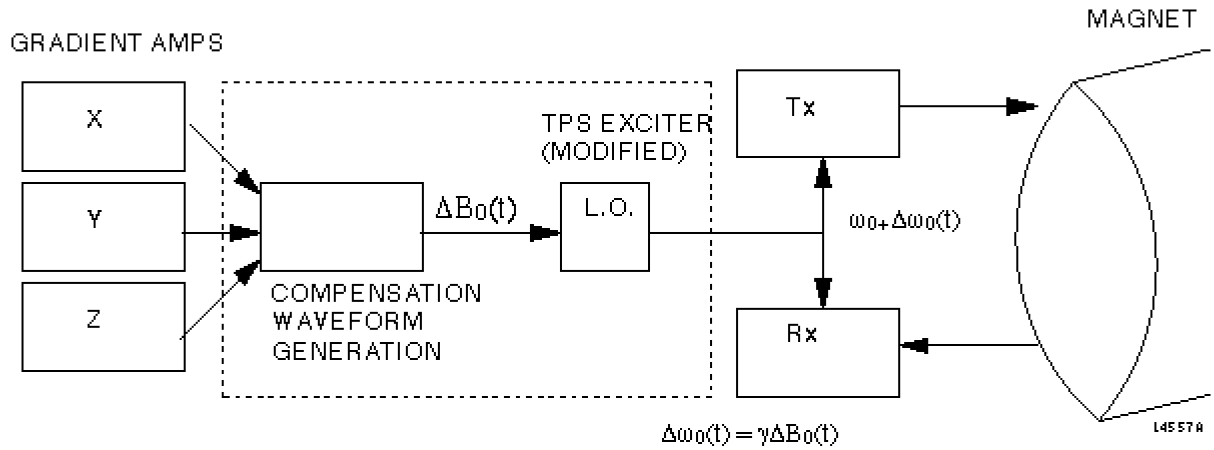
The commanded gradient waveforms are fed into a block which realizes the transfer function from gradients to B_0 field disturbance. The negative of the predicted waveform is used to null the B_0 disturbance. Past experience indicates that the transfer function from a gradient axis to the B_0 disturbance can be adequately approximated as shown in the formula in Illustration L4576A, where *N* is equal to 4. The amplitudes *Ai* and time constants *Ti* are determined when the Grafidy procedure is used. A unique set of amplitudes and time constants are needed for each gradient axis. The total B_0 disturbance derived from multiple gradient axes is the sum of the individual B_0 disturbances.

$$h_{axis}(t) = \sum_{i=1}^{N} A_i e^{-t/T_i}$$

L4576A

FORMULA
ILLUSTRATION L4576A

The B_0 disturbance caused by eddy currents can be cancelled by pulsing a special B_0 winding; however, the equivalent effect can be achieved by shifting the transceiver reference frequency to track the disturbance. Since the errors are due to the difference between the magnet frequency and the system reference frequency, the effect is the same as cancelling the field disturbance. This method is called *Frequency Shift B_0 Eddy Current Compensation* (FRESBECC). See Illustration L4557A.



B_0 EDDY CURRENT BY FREQUENCY SHIFTING
ILLUSTRATION L4557A

3- B_0 Hardware Changes

IPG hardware and software have been changed so IPG can generate frequency shift waveforms appropriate for zeroth order eddy current compensation. This requires the addition of a bit serial interface from the WARP processor to the backplane. The inputs to the WARP processor function, which generates the Frequency Shift Waveform, are:

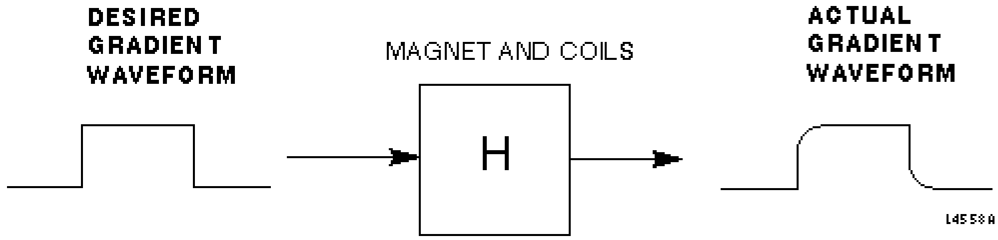
- The digital gradient commands for physical *X*, *Y*, and *Z* gradients.
- A set of calibration values.

The calibration values include four amplitudes and time constants for each axis, plus a scale factor. The output from the IPG is digital frequency shift waveform values in 16-bit C30 bit serial format. The signals are available on the chassis backplane for transfer to the TPS Exciter. The modified IPG is compatible with all 5.5 systems. It also is backward compatible with existing 4.x and 5.x systems.

The TPS Exciter has been changed to accept an additional center frequency offset signal from the chassis backplane.

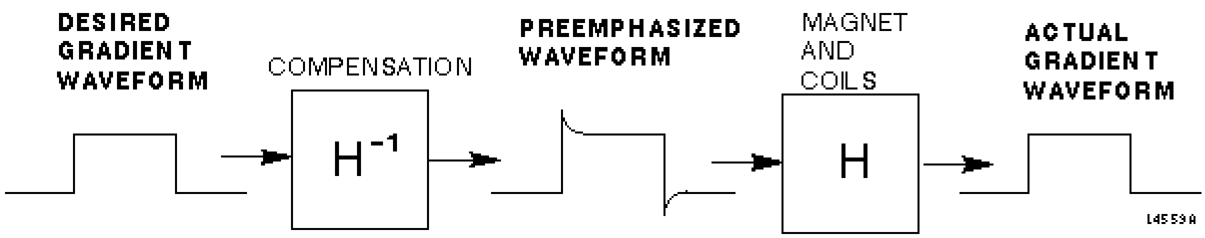
4- Linear Eddy Currents: First-order Eddy Current Compensation

Gradient pulses induce eddy currents. Some of these eddy currents cause time varying magnet field errors with the same geometry as the applied pulse. The effect is a distortion of the desired gradient pulse, as shown in Illustration L4558A. First-order eddy current compensation prevents these distortions.



EFFECT OF FIRST-ORDER EDDY CURRENTS
ILLUSTRATION L4558A

The method used to compensate gradient waveforms for distortion is to apply the inverse of the transfer function, which causes the distortion, prior to playing out the pulse. When the resultant pre-emphasized pulse is played, the final output is the desired gradient pulse, as shown in Illustration L4559A. Past experience indicates that the transfer function from gradient command input to actual gradient output axis can be adequately approximated as the formula in Illustration L4576B shows, where *N* is equal to 4. The amplitudes *Ai* and time constants *Ti* are determined when the Grafidy procedure is used. A unique set of amplitudes and time constants are needed for each gradient axis.



FIRST-ORDER EDDY CURRENT COMPENSATION
ILLUSTRATION L4559A

$$h_{axis}(t) = 1 - \sum_{i=1}^{N} A_i e^{-t/T_i}$$

L4576B

FORMULA
ILLUSTRATION L4576B

In previous products, pre-emphasis was applied by means of analog circuitry on each gradient amplifier (the Grafidy boards). Currently, pre-emphasis is applied either by using similar circuitry on the Gradient Ramp Accelerator Module (GRAM) Tuning Board in system configurations using GRAMs, or by using digital pre-emphasis in the systems cabinet in system configurations with 8645 gradient amplifiers, and without GRAMs. See Table 1 for the type of linear eddy current compensation for each configuration.

5- Linear Eddy Current Hardware Changes

IPG hardware and software have been changed so that IPG can add pre-emphasis to the generated physical gradient waveforms before they are sent to the gradient amplifiers. The inputs to the WARP processor function, which generates the pre-emphasis, are:

- The digital gradient commands for physical *X*, *Y* and *Z* gradients
- A set of calibration values

The calibration values include four amplitudes and time constants for each axis. The amplitudes are expressed as a percentage of the desired gradient command. The time constants are in milliseconds. The output from IPG is digital gradient command waveforms with pre-emphasis added, if required for the present system configuration.

APPENDIX C

Tools Required

The Magnetic Shield (46-317725G10), used with the RF Measurements Kit, is required if the scope display is affected by the magnetic field.

A 100-mHz scope and a DVM with alligator clips is required for this procedure.

There are several Grafidy kit variations in the field. The contents of each is itemized in the tables listed below.

- Rotary Attenuator (10db/step), 46-255838P5

Table 20: 46-271417G1 – 1.5T

Table 21: 46-307164G1 – 1.5T

Table 22: 46-307164G2 – 1.5T

Table 23: 46-307164G3 – 1.0T, 1.5T

Table 24: 46-307164G4 – 1.0T, 1.5T

Table 25: 46-307164G6 – 1.0T

TABLE 20
GRAFIDY KIT 46-271417G1 – 1.5T

ITEM	DESCRIPTION	PART NUMBER	QUANTITY
1	Base Coil	46-271410G1	1
2	Coil, 1.5T	46-271411G1	1
3	Coil, 1.5T	46-271411G2	1
4	Collar	46-271456P1	1
5	Spacer	46-271457P1	2
6	Pin Diode Switch	46-271476G1	1
7	Pin Diode Drive	46-271472G1	1
8	Cable, BNC, 8 ft.	46-251920G22	1
9	Cable, BNC, 50 ft.	46-251920G23	1
10	Cable, BNC, 90 ft.	46-251920G24	1
Note: Female SMB to BNC cable, 46-301549P5 (part of TPS RF Service Kit, 46-301927G1) also required for Grafidy Kit 46-271417G1.			

TABLE 21
GRAFIDY KIT 46-307164G1 – 1.5T

ITEM	DESCRIPTION	PART NUMBER	QUANTITY
1	Coil, 1.5T	46-271411G1	1
2	Coil, 1.5T	46-271411G2	1
3	Collar	46-271456P1	1
4	Spacer	46-271457P1	2

ITEM	DESCRIPTION	PART NUMBER	QUANTITY
5	Pin Diode Switch	46-288240G1	1
6	Pin Diode Drive	46-271472G1	1
7	Cable, BNC, 8 ft.	46-282803G15	1
8	Cable, BNC, 30 ft.	46-282803G14	4
9	Cable, BNC, Female SMB to BNC	46-301549P5	1
10	Adapter, BNC Coupling	46-282886P1	3
11	Quick Disconnect (Extremity/Linear Adapter), 1.5T	46-282468G3	1

TABLE 22
GRAFIDY KIT 46-307164G2 – 1.5T

ITEM	DESCRIPTION	PART NUMBER	QUANTITY
1	Coil, 1.5T	46-271411G1	1
2	Coil, 1.5T	46-271411G2	1
3	Collar	46-271456P1	1
4	Spacer	46-271457P1	2
5	Pin Diode Switch	46-288240G1	1
6	Pin Diode Drive	46-271472G1	1
7	Cable, BNC, 8 ft.	46-282803G15	1
8	Cable, BNC, 30 ft.	46-282803G14	4
9	Cable, BNC, Female SMB to BNC	46-301549P5	1
10	Adapter, BNC Coupling	46-282886P1	3
11	Quick Disconnect (Extremity/Linear Adapter), 1.5T	46-282468G3	1

TABLE 23
GRAFIDY KIT 46-307164G3 – 1.0T, 1.5T

ITEM	DESCRIPTION	PART NUMBER	QUANTITY
1	Coil, 1.5T	46-271411G1	1
2	Coil, 1.5T	46-271411G2	1
3	Collar	46-271456P1	1
4	Spacer	46-271457P1	2
5	Pin Diode Switch	46-288240G1	1
6	Pin Diode Drive	46-271472G1	1
7	Cable, BNC, 8 ft.	46-282803G15	1
8	Cable, BNC, 30 ft.	46-282803G14	4
9	Cable, BNC, Female SMB to BNC	46-301549P5	1
10	Adapter, BNC Coupling	46-282886P1	3
11	Coil, 1.0T	46-307804G2	2
12	Quick Disconnect (Extremity/Linear Adapter), 1.5T	46-282468G3	1

TABLE 24
GRAFIDY KIT 46-307164G4 – 1.0T, 1.5T

ITEM	DESCRIPTION	PART NUMBER	QUANTITY
1	Coil, 1.5T	46-271411G1	1
2	Coil, 1.5T	46-271411G2	1
3	Coil, 1.0T	46-307804G2	2
4	Collar	46-271456P1	1
5	Spacer	46-271457P1	2
6	Pin Diode Switch	46-288240G1	1
7	Pin Diode Drive	46-271472G1	1
8	Cable, BNC, 8 ft.	46-282803G15	1
9	Cable, BNC, 30 ft.	46-282803G14	4

ITEM	DESCRIPTION	PART NUMBER	QUANTITY
10	Cable, BNC, Female SMB to BNC	46-301549P5	1
11	Adapter, BNC Coupling	46-282886P1	3
12	Quick Disconnect (Extremity/Linear Adapter), 1.5T	46-282468G3	1
13	Quick Disconnect (Extremity/Linear Adapter), 1.0T	46-317222G2	1

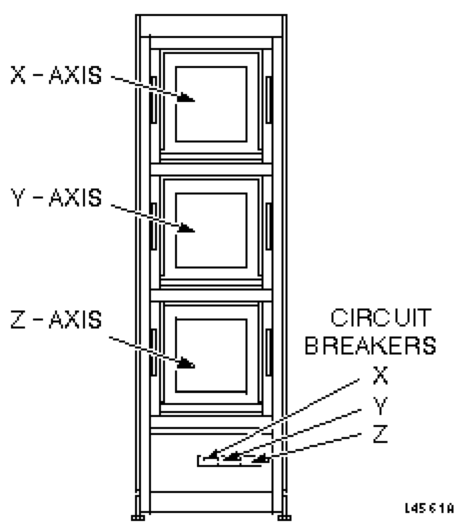
TABLE 25
GRAFIDY KIT 46-307164G6 – 1.0T

ITEM	DESCRIPTION	PART NUMBER	QUANTITY
1	Coil, 1.0T	46-307804G2	2
2	Collar	46-271456P1	1
3	Spacer	46-271457P1	2
4	Pin Diode Switch	46-288240G1	1
5	Pin Diode Drive	46-271472G1	1
6	Cable, BNC, 8 ft.	46-282803G15	1
7	Cable, BNC, 30 ft.	46-282803G14	4
8	Cable, Female SMB to BNC	46-301549P5	1
9	Adapter, BNC Coupling	46-282886P1	3
10	Quick Disconnect (Extremity/Linear Adapter), 1.0T	46-317222G2	1
Note: A female BNC to female BNC adapter is required on mobile systems for Grafidy Kits 46-307164G1 through G6.			

Preliminary Setup

If this is the first time you are performing this procedure, take a moment, before beginning, to read the procedure from beginning to end to become familiar with the steps required.

1. Turn off power to the GRAM cabinet using the circuit breakers located at the lower front of the GRAM cabinet for all three GRAM modules (see Illustration L4561A).



GRAM CABINET - FRONT VIEW
ILLUSTRATION L4561A

2. Remove the front cover of the GRAM cabinet.

3. Remove the cover on each GRAM module for each axis being calibrated.

Note

There are test points and resistors, located under the GRAM Tuning Board, that are accessed during this procedure. Therefore, it is necessary to relocate the GRAM Tuning Board.

CAUTION

Equipment damage possibility. Do not pull the circuit board off. The nylon standoffs are quite brittle and will break. Push the top of the standoff away from the circuit board one by one. If they do not push off of the circuit board at first, work on the other standoffs one by one.

CAUTION

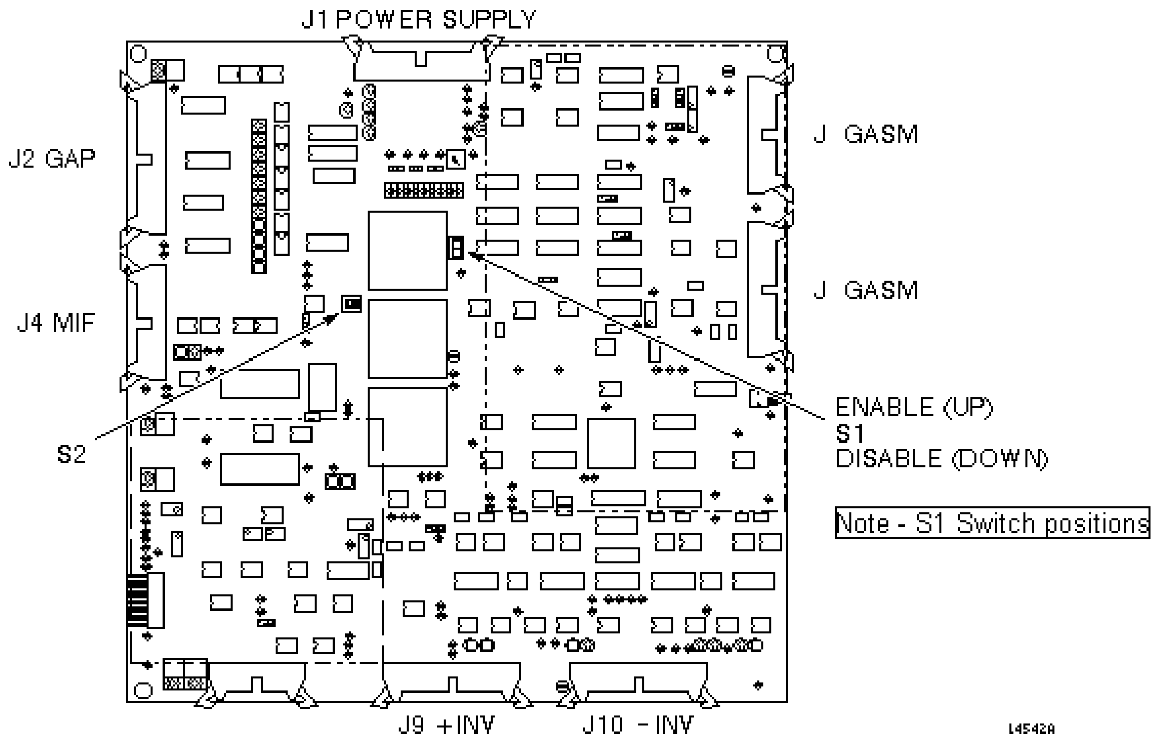
Equipment damage possibility. It is important to verify that all switches and jumpers on the GRAM Control Board and the Digital Tuning Board are set to the proper position. Failure to do so will cause adjustments to be inaccurate.

4. Verify the settings of all jumpers and switches on the GRAM Control Board and the GRAM Power Supply Board for each axis being tuned.

a. See Table 26 and Illustration L4542A for proper switch settings for the GRAM Control Board.

TABLE 26
GRAM CONTROL BOARD SWITCH SETTINGS

NUMBER	POSITION	SETTING	SWITCH NAME AND POSITION DEFINITION
1	N/A	Up	GRAM Enabled – When S1 is down, the GRAM is disabled
2	1	Down	(RES) Reserved – not used
3	2	Down	(HV) High Voltage Enable – Under software control
4	3	Down	(FW) Free Wheel – Enables PWM mode under software control. Up is Freewheel mode, no PWM.
5	4	Down	(MAN) Manual Ready – This is controlled by GAP. Up is Troubleshooting, it forces the GRAM to Manual Ready. (S1 must also be up, or enabled when MAN is up.)



GRAM CONTROL BOARD SWITCH LOCATIONS
ILLUSTRATION L4542A

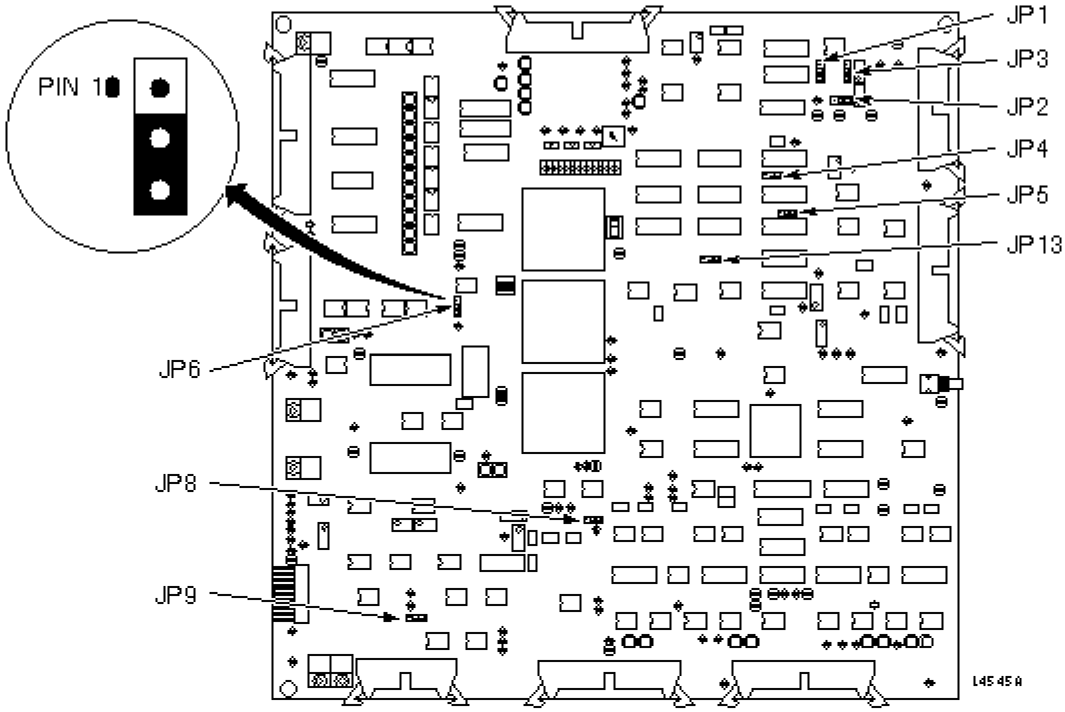
Note

The only label that is visible on this board is S1 Enable. Be sure to use the up position for enable and the down position for disable.

b. See Table 27 and Illustration L4545A for proper jumper settings for the GRAM Control Board.

TABLE 27
GRAM CONTROL BOARD JUMPER SETTINGS

NAME	POSITION	SETTING
JP1	2&3	
JP2	2&3	
JP3	2&3	
JP4	2&3	(V/**D**) Voltage or Digital to Analog converter – DAC selected
JP5	2&3	(AN/**DIG**) Analog or Digital – Digital selected
JP6	2&3	(DIS/**EN**) Disable or Enable – Enable selected
JP13	2&3	(AN/**DIG**) Charge mode
JP8	2&3	(TST/**NRM**) Test or Normal – Normal selected
JP9	2&3	Sets up one current sensor. JP9 is located under the tuning board

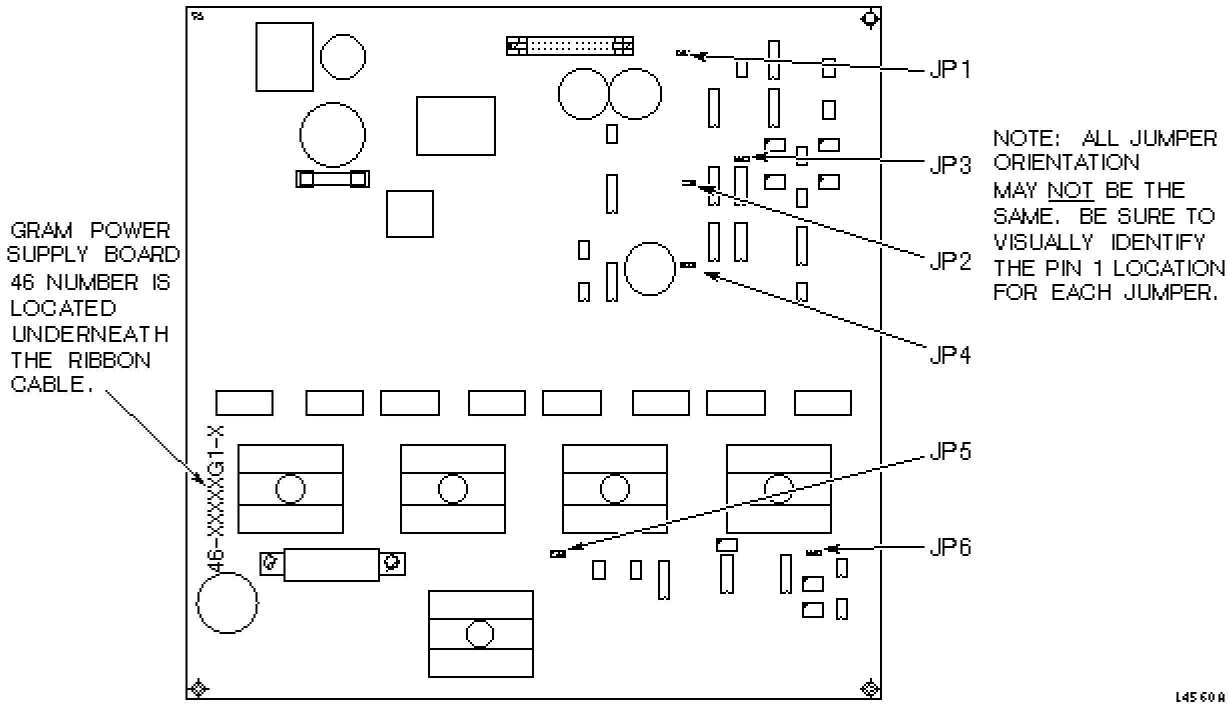


GRAM CONTROL BOARD JUMPER LOCATIONS
ILLUSTRATION L4545A

c. See Table 28 and Illustration L4560A for proper jumper settings for the GRAM Power Supply Board.

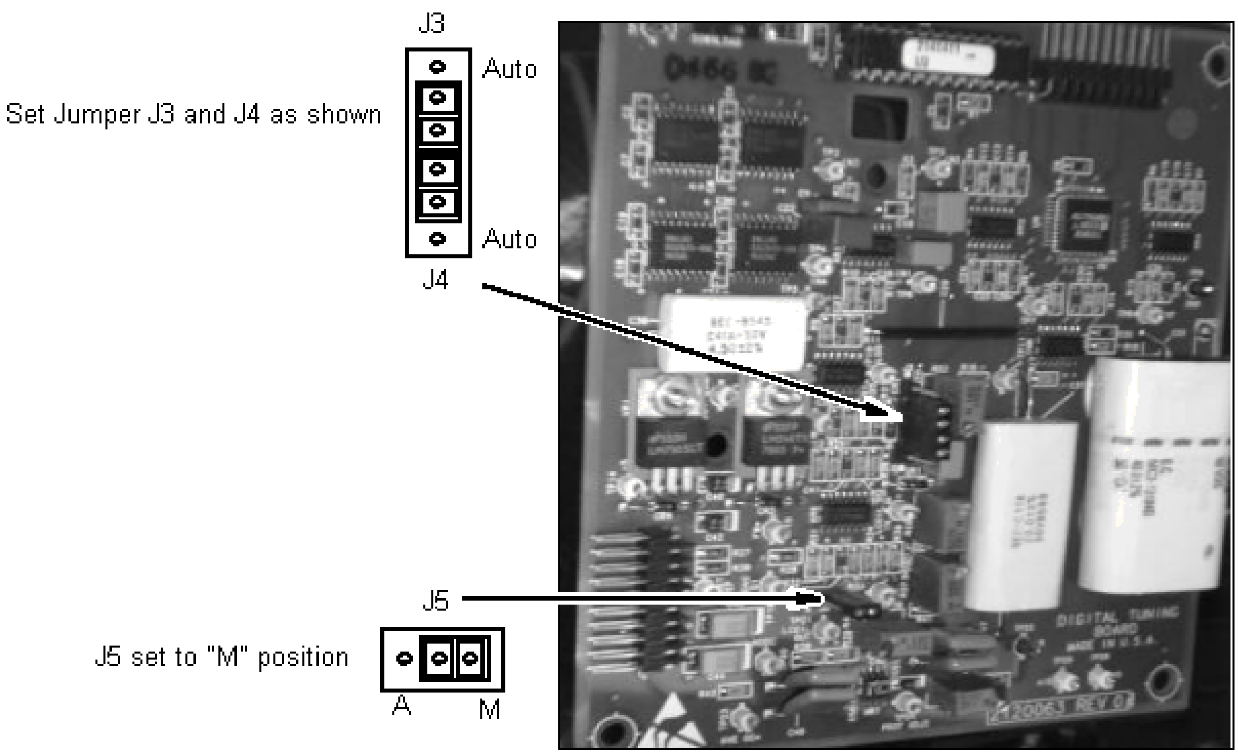
TABLE 28
GRAM POWER SUPPLY BOARD JUMPER SETTINGS

NAME	POSITION JP2 PRESENT	POSITION NO JP2	SETTING NOTE - PIN 1 LOCATION
JP1	2 & 3	2 & 3	Triangle Enable
JP2	1 & 2	–	Connects LGND to AGND
JP3	1 & 2	2 & 3	High Voltage Enable
JP4	2 & 3	2 & 3	Under Voltage Enable
JP5	1 & 2	2 & 3	High Voltage Enable
JP6	1 & 2	2 & 3	NORM – Normal Mode
Note: Two versions of power supplies boards may be found in the field. The older version can be identified by the presence of a jumper labeled JP 2. The newer revision boards will not have a JP 2 jumper.			



GRAM POWER SUPPLY BOARD JUMPER LOCATIONS
ILLUSTRATION L4560A

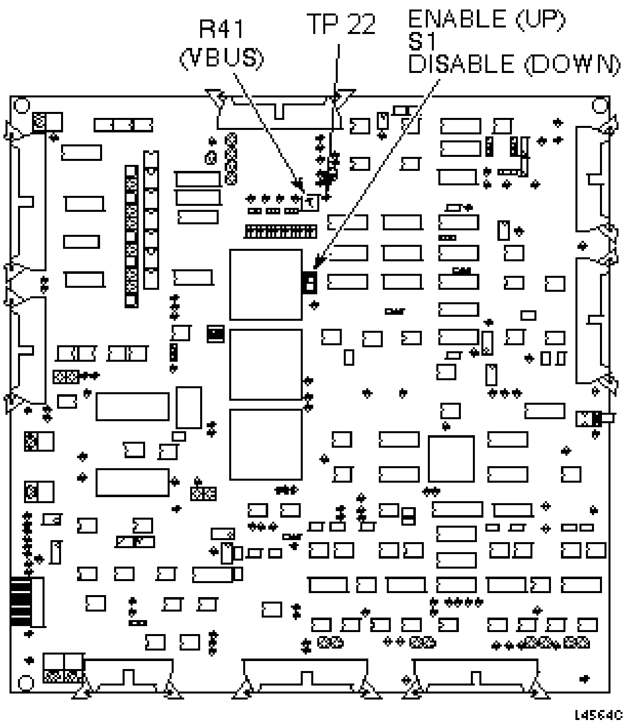
d. See Illustration L9900 for proper jumper settings for the GRAM Digital Tuning Board.



DIGITAL TUNING BOARD JUMPER LOCATIONS / SETTINGS
ILLUSTRATION L9900

5. Verify that the revision of the IPG board is at least 2112565-3.

6. Locate and set R41 (VBUS) on the GRAM Control Board (see Illustration L4564C).



At TP 22 adjust R41 for:

For EchoSpeed;
Adjust to 1000 ohms ± 25 ohms.

For HiSpeed;
Adjust to 300 ohms ± 7.5 ohms.

Both settings are in respect to ground.

GRAM CONTROL BOARD: S1 & R41 LOCATIONS
ILLUSTRATION L4564C

7. If other axes are to be tuned, repeat steps 4 through 6 for each axis.

8. Turn on power to the GRAM cabinet, using the circuit breakers located at the lower-front of the GRAM cabinet for all three GRAM modules.

APPENDIX D

Perform the GRAM DC Offset Adjustment now (or again), or the return signal may not show up, due to a magnitude offset caused by a DC offset on the output of the GRAM.

Attention!! Initialize Grafidy Parameters See Screen 100.

SCREEN 100

EXPERT MODE AND INITIALIZING B_0 & LINEAR LONG TC PARAMETERS

OUTPUT/PROMPTS	INPUTS/COMMENTS
`GRAFIDY - Eddy Current Analysis`	

`1 - Read and Process Raw Data`
`2 - Fit`
`3 - Initialize Parameters`
`4 - System Status`
`5 - Free IP for Prescan`
`6 - Plot Processed Data`	

`0 - Turn Expert Mode OFF` `S or Q - Exit to Tools Menu`	
`Enter Choice: (0..5) [0] :................`	**3 <ENTER>**
`Enter axis to clear (0=x,1=y,2=z,3=All):(0..3) [0]:.`	*****<ENTER>***** If all axes are being calibrated, select **3 <ENTER>** to initialize all axes at once. Otherwise, select the axis currently being calibrated.
`Initialize B0 parameters ? (Y,N) [N] : .............`	**Y <ENTER>**
Note This is the first and only time that B0 and Linear Long Time Constant and Linear Short Time Constant parameters are initialized—once per axis!! Initialize B0 and Linear Long Time Constant and Linear Short Time Constant Parameters now.	
`Initialize linear long time constants parameters ? (Y,N) [N] : ....`	**Y <ENTER>**
`Initialize linear short time constants parameters ? (Y,N) [N] : ....`	**Y <ENTER>**
`The K values written were` (Data scrolls here for K values.)	
`WARP SF = 2.200000e-01 and B0 shift = 5.500000e-02`	
`New WARP coefficients created.`	
`GRAFIDY - Eddy Current Analysis`	

OUTPUT/PROMPTS	INPUTS/COMMENTS
1 - Read and Process Raw Data 2 - Fit 3 - Initialize Parameters 4 - System Status 5 - Free IP for Prescan 6 - Plot Processed Data 0 - Turn Expert Mode OFF S or Q - Exit to Tools Menu Enter Choice: (0..5) [0] :	**Return to step 1 on Table 4.**

1. Install the Grafidy phantom holder.

2. Landmark on the center line of the Grafidy phantom holder.

3. At keypad on front magnet enclosure, press LANDMARK and MOVE TO SCAN.

4. Prepare system to scan using Protocol #5.1, **Grafidy**, and the parameters shown in the Service Protocol List under Signa Help, or for alternate proprietary procedure, use Table 100.

Note

It is necessary to set the grad shim values to zero in order to ensure that there are no additional offsets in the circuit. This ensures an accurate calibration. Remember to restore the grad shim values after this GRAM Tuning procedure is complete.

5. Go to manual prescan. Record grad shim values for *x*, *y*, and *z* axes. If values are not set to 0, set them by moving the slide bar to 0 at this time.

6. Select **[Done]** to exit manual prescan. This is important so that the scanner is ready, but not scanning.

DANGER!!

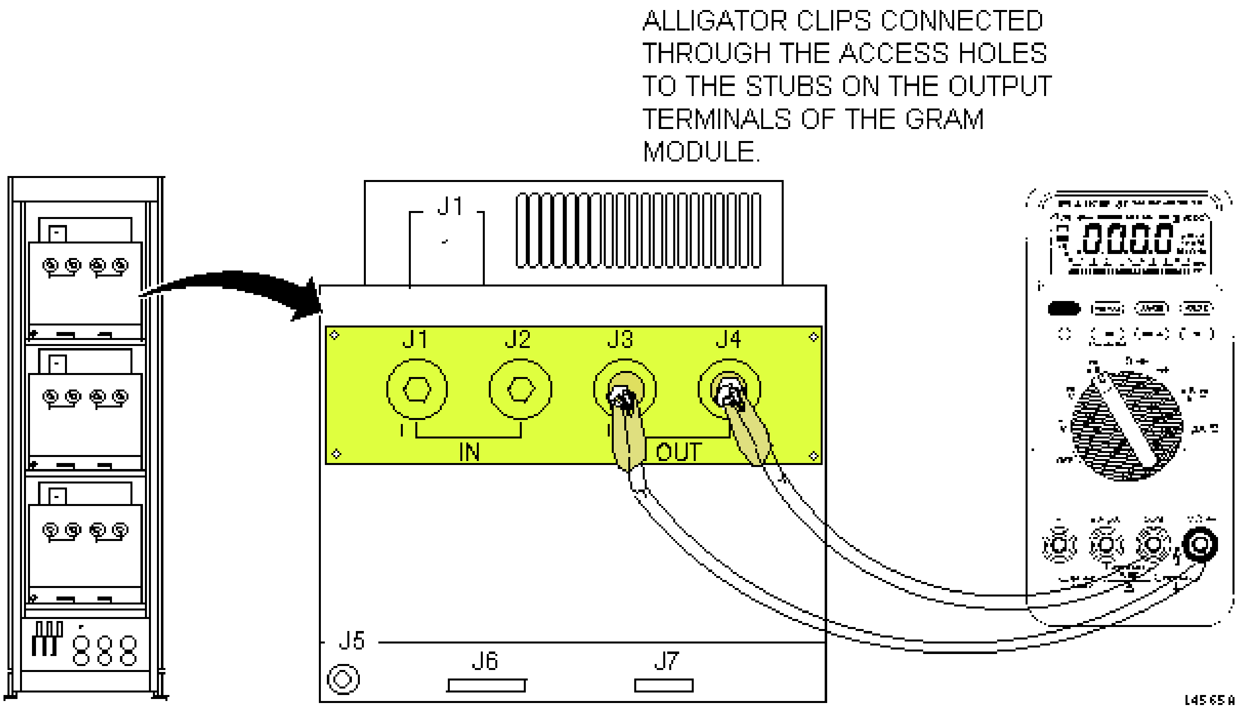
FATAL ELECTRIC SHOCK HAZARD!! GRAM MODULES GENERATE FATAL ELECTRICAL CURRENTS. SCANNING OR PRESCANNING DURING THIS MEASUREMENT MAY CAUSE A FAILURE TO THE GRAM, AND EXPLOSION OF THE VOLTMETER. <u>DO NOT</u> SCAN OR PRESCAN DURING THIS MEASUREMENT AND ADJUSTMENT.

7. At the GRAM Control Board, prepare to perform the GRAM DC Current Offset Adjustment to null any offset currents to zero.

Note

Always use ESD precautions when working on any of the electronic hardware for the protection of the circuit boards.

8. Using voltmeter leads with alligator clips, connect a voltmeter at the rear of the GRAM chassis across J3 (+OUT) and J4 (–OUT). The voltmeter should be set to DC millivolts (see Illustration L4565A).



GRAM CHASSIS – REAR VIEW WITH VOLTMETER ACROSS THE OUTPUT
ILLUSTRATION L4565A

Note

Using longer leads for the voltmeter allows viewing the voltmeter as the adjustment is performed because the potentiometer to be adjusted is on the front of the GRAM Module on the GRAM Control Board.

9. On the GRAM Control Board, locate and adjust R151 (Offset Null), so that the voltmeter reads 0 mVdc $\underline{+}$10 mVdc. R151 is accessible through a hole in the digital tuning board (located between two voltage regulators).

Note

GRAM DC Offset Adjustment must be done with the system in Ready. If the fans in the 8645 Gradient Cabinet slow down while performing the GRAM DC Offset Adjustment, GAP has put the power modules in Standby. Select [Download], and GAP commands the power modules to Ready.

10. If all three axes are to be tuned, repeat steps 7 through 9 for each axis. If one or two axes are to be tuned, repeat steps 7 through 9 for the axis being tuned.

APPENDIX E

2-9-1 LCoil Initial Setup

1. Go to Utilities desktop and select the **[Grafidy]** Option.

2. Follow the Grafidy Analysis Tool instructions in Screen 20.

SCREEN 20
EXPERT MODE AND INITIALIZING B_0 & LINEAR LONG & SHORT TC

OUTPUT/PROMPTS	INPUTS/COMMENTS
GRAFIDY - Eddy Current Analysis 1 - Read and Process Raw Data 2 - Fit 3 - Initialize Parameters 4 - System Status S or Q - Exit to Tools Menu	
Enter Choice: (0..4) [1] :	**0<Enter>** (Entering 0 puts you in Expert Mode.)
GRAFIDY - Eddy Current Analysis 1 - Read and Process Raw Data 2 - Fit 3 - Initialize Parameters 4 - System Status 5 - Plot Processed Data 0 - Turn Expert Mode OFF S or Q - Exit to Tools Menu	
Enter Choice: (0..5) [0] :.................	**3<Enter>**
Enter axis to clear (0=x,1=y,2=z,3=All):(0..3) [0]:.	*****<Enter>***** If all axes are being calibrated, select **3 <Enter>** to initialize all axes at once. Otherwise, select the axis currently being calibrated.
Initialize B0 parameters ? (Y,N) [N] :	**Y<Enter>**
Note This is the first and only time that B_0 and Linear Long Time Constant and Linear Short Time Constant parameters are initialized—once per axis!! Initialize B_0 and Linear Long Time Constant and Linear Short Time Constant Parameters now.	
Initialize linear long time constants parameters ?	

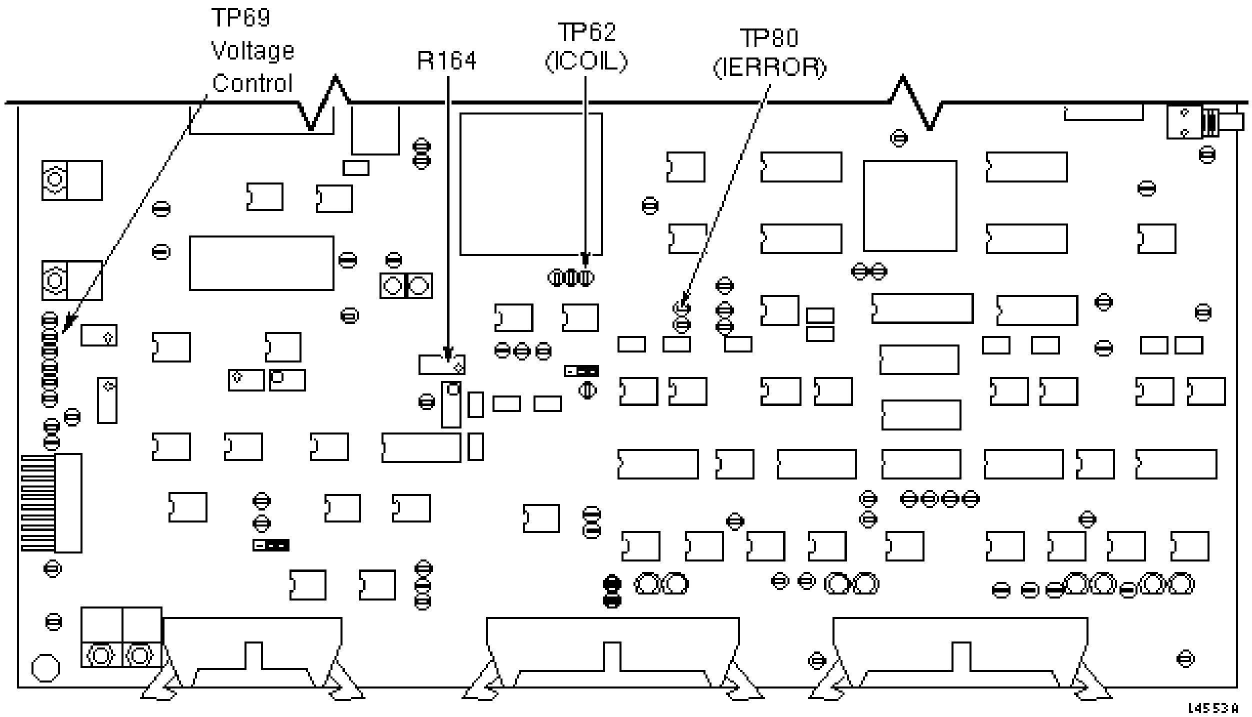
OUTPUT/PROMPTS	INPUTS/COMMENTS
(Y,N) [N] :	**Y<Enter>**
Initialize linear short time constants parameters ?	
(Y,N) [N] :	**Y<Enter>**
The K values written were	(Data scrolls here for K values.)
WARP SF = 2.200000e-01 and B0 shift = 5.500000e-02	
New WARP coefficients created.	
GRAFIDY - Eddy Current Analysis	
1 - Read and Process Raw Data 2 - Fit 3 - Initialize Parameters 4 - System Status 5 - Plot Processed Data	
0 - Turn Expert Mode OFF S or Q - Exit to Tools Menu	
Enter Choice: (0..5) [0] :	(No additional entries for now.)

Note

When you use the digital tuning boards, you must invoke the Grafidy Analysis Tool because the parameters used in the eddy current compensation may already be loaded into the Digital Tuning Board. By initializing the parameters, you are setting these parameters to zero, which is essentially the same as making sure that all of the jumpers are removed from the analog tuning boards.

LCoil Adjustment

1. With the calibrated scope leads, set Channel 1 to 2 Volts/Div with DC Coupling and Channel 2 to 2 Volts/Div with DC Coupling. The time sweep should be set at 20 msec/div. Select Channel 2 as the scope Trigger. See Illustration L4553B for test point locations on the GRAM Control board.



GRAM CONTROL BOARD (LOWER): TP62, TP69, TP80, & R164
ILLUSTRATION L4553B

a. Channel 2 displays ICOIL. Connect Channel 2 to TP 62 on the GRAM Control Board.

b. Channel 1 displays VC. Connect Channel 1 to TP 69 on the GRAM Control Board.

c. Connect the ground leads to a ground test point on the GRAM Control Board.

2. Under Research Operations, with the right mouse button select Display **CV's**.

a. Find the CV **axis**.

b. Select Modify, then type **0 <Enter>** for *x*,

or **1 <Enter>** for *y*,

or **2 <Enter>** for *z*.

c. Find the CV **mode.**

d. Select Modify, then type **2<Enter>** for GRAM Tuning.

e. Select **[Accept]**, **[Accept]**.

3. Prescanning:

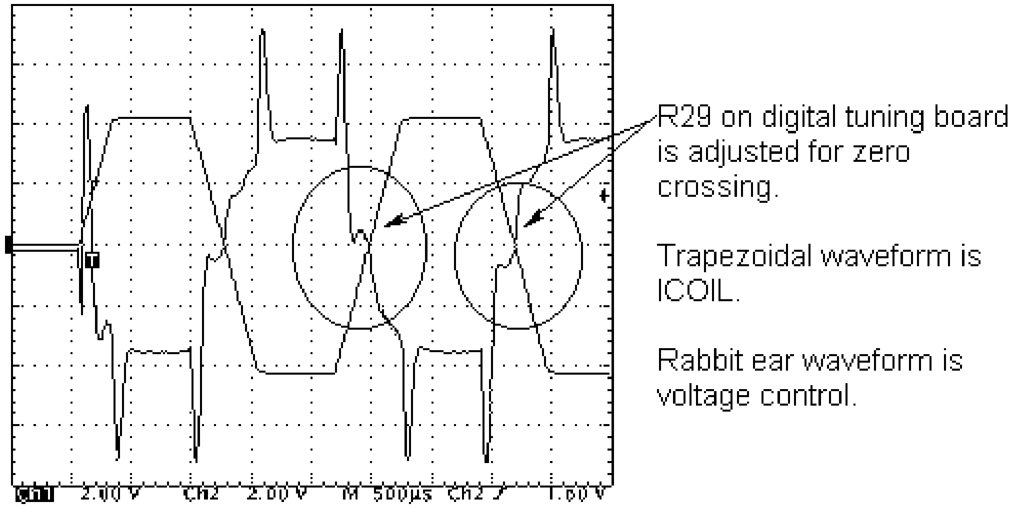
a. Select **[Manual Prescan]** to temporarily enter prescan.

b. Then select **[Done]** to stop prescanning.

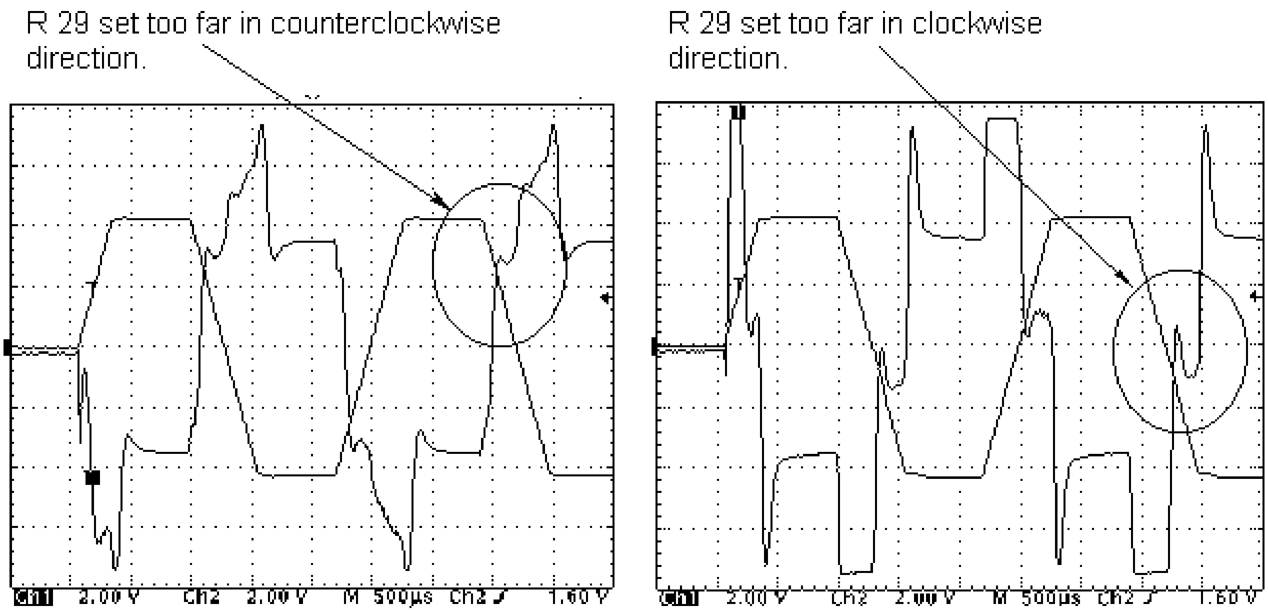
4. Select **[Scan]**.

5. Waveform adjustments repeat this step for all axes being adjusted.

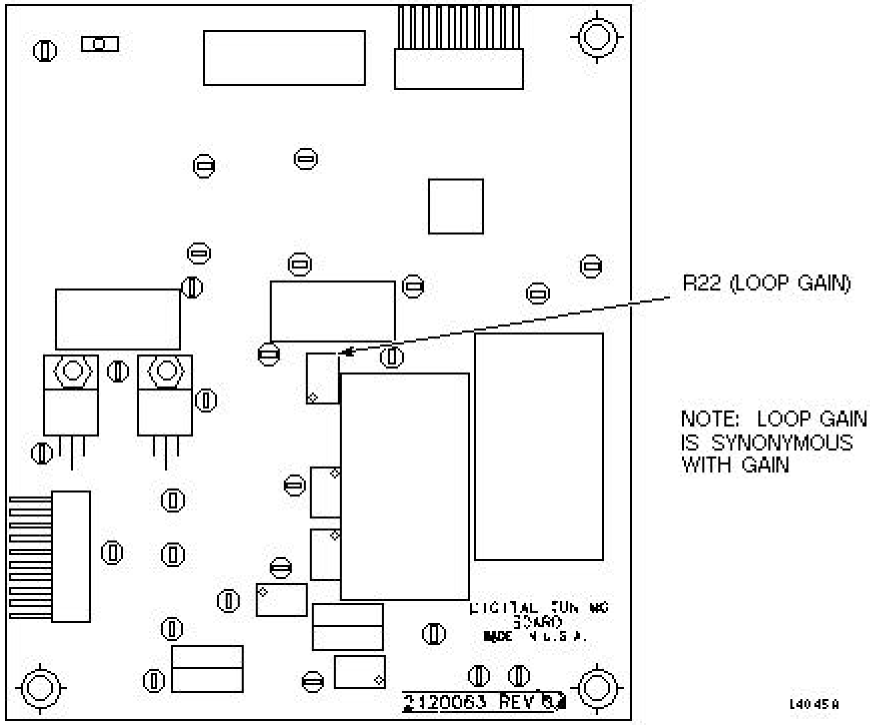
   a. LCoil Adjustment refer to Illustration L4700A.



LCOIL ADJUSTMENT

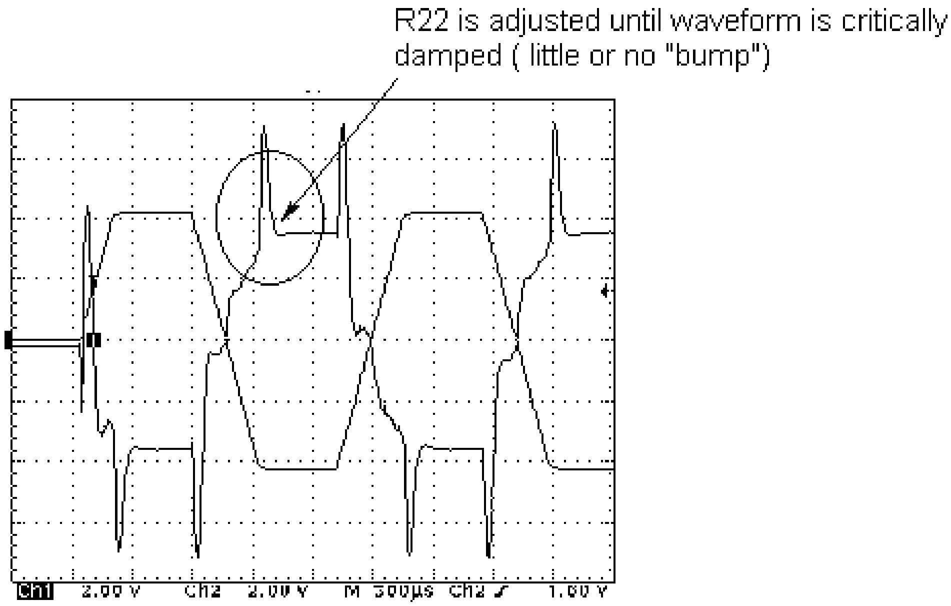


LCOIL MISADJUSTMENTS

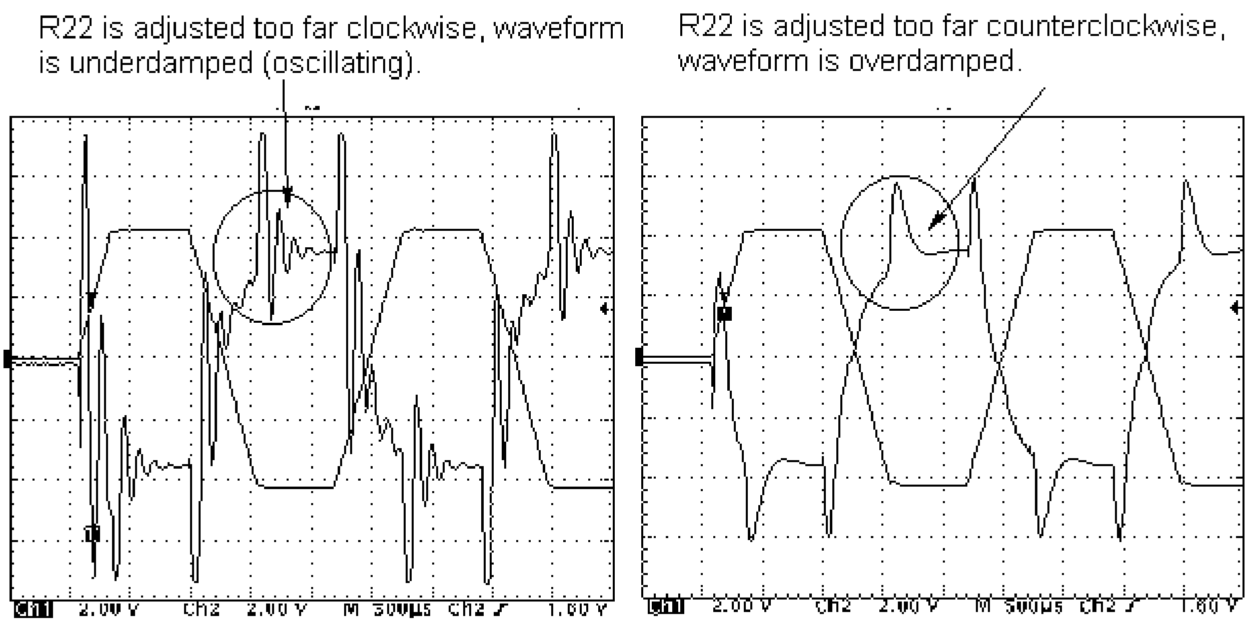


DIGITAL TUNING BOARD: R22 & R29 LOCATIONS
ILLUSTRATION L4700A

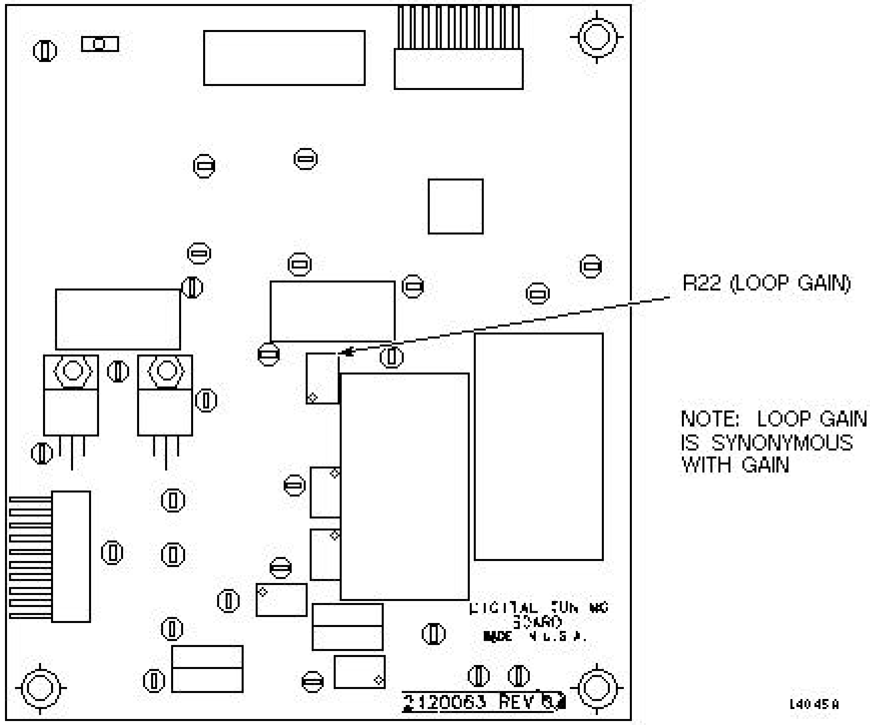
b. Loop Gain Adjustment refer to Illustration L4701A.



LOOP GAIN ADJUSTMENT



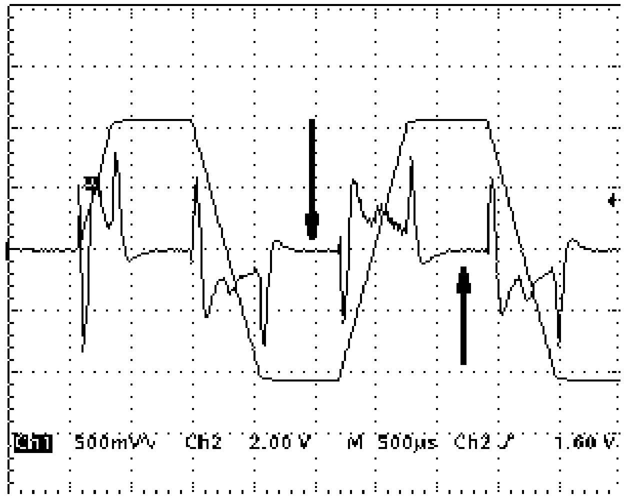
LOOP GAIN ADJUSTMENT



DIGITAL TUNING BOARD
ILLUSTRATION L4701A

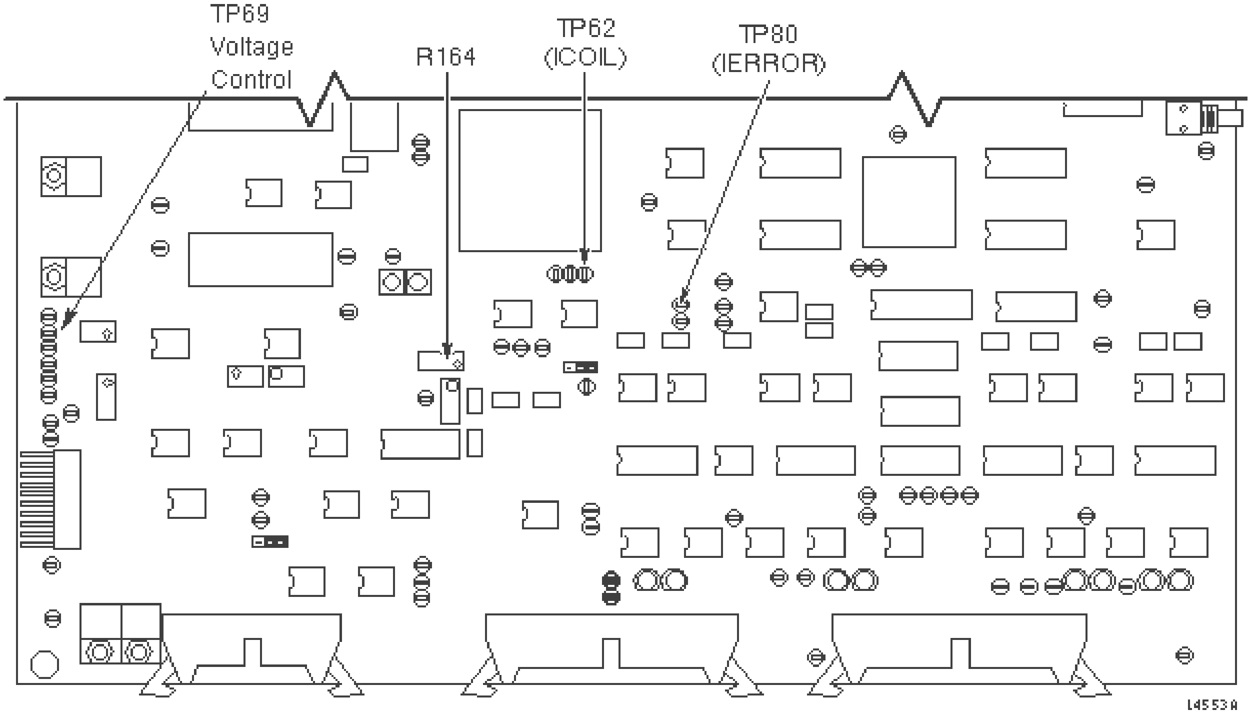
c. Verify that LCoil has not changed after Loop Gain Adjustment.

d. Gain Balance Adjustment refer to Illustration L4702A.



Move channel 1 scope probe to TP 80, set scope coupling to ac and Volts/Div to 500 mVdc. R164 is adjusted so that both dc portions of the waveforms converge at zero. It may be necessary to adjust the Chan 1 position so the dc (flat) portion of IERROR is equidistant from zero.

GAIN BALANCE



GRAM CONTROL BOARD (LOWER): TP62, TP69, TP80, & R164
ILLUSTRATION L4702A

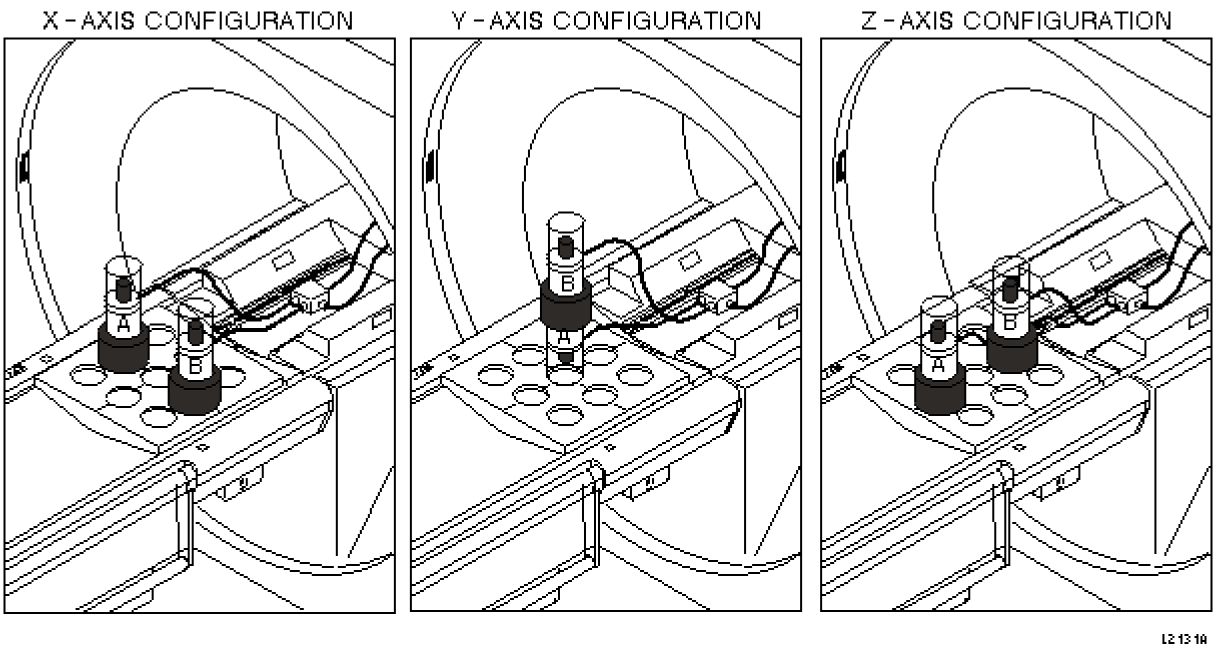
APPENDIX F

Set up the Grafidy Kit for the first axis to be calibrated, using the following instructions.

1. Remove the head coil and holder from the cradle.

2. Select the proper coil for the system to be tested (1.5T or 1.0T).

3. Place the phantom holder on the cradle. Configure the Grafidy coil/samples and collars appropriately for the first axis on which you will perform Grafidy (see Illustration L2131A).



GRAFIDY PHANTOM CONFIGURATIONS
ILLUSTRATION L2131A

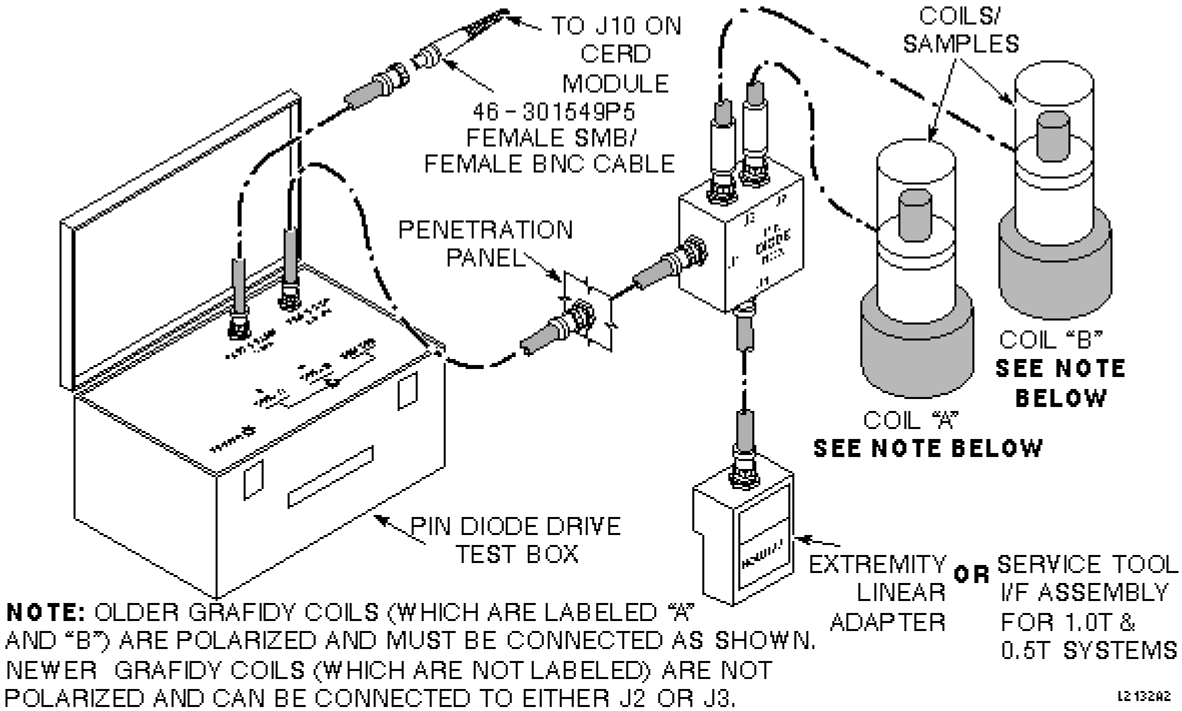
Note

In the x and z configurations, the coil/sample is placed with the sample at the top. In the y configuration, the top coil/sample is placed with the sample on top, while the lower coil/sample is inverted so that the sample is on the bottom. Also in the y configuration, no collars are used beneath the bottom sample.

Note

Older Grafidy coils (which are labeled A and B) are polarized, and must be connected as shown in Illustration L2132A. Newer Grafidy coils (which are not labeled) are not polarized, and can be connected to either J2 or J3 on the pin diode switch.

Refer to Illustration L2132A for steps 5 through 12.



GRAFIDY EQUIPMENT SETUP
ILLUSTRATION L2132A

4. Plug the Extremity/Linear Adapter **(for 1.0T systems, use Service Tool I/F Assm. supplied with Grafidy kit)** into Quad Head Coil Carriage Assembly. Connect 2-ft coaxial cable from Extremity/Linear Adapter BNC to J4 on pin diode box.

Note

There are multiple lengths of cables used for this portion of this procedure. The short cable is the 2-ft cable, the medium length cable is either an 8-ft or a 5-ft cable, and the long cable is any cable length that will accommodate the long cable runs, the 90-ft cable, a combination of 30-ft cables, or a custom cable that you may have created.

5. Connect cable as follows, depending on type of system:

   a. **For 1.5T systems and fixed site 1.0T systems:** Connect the long coaxial cable from J1 on pin diode box to a SERVICE coaxial feed-through on the Penetration Panel (exam room side). Cable must be routed through the bore of the magnet, exiting at the rear.

   Note

   It is not necessary to use a 90-ft cable. This length is usually supplied in some Grafidy kits. Other kits are supplied with three 30-ft cables. Use the length of cable that best suits your particular site.

   b. **For mobile systems:** Disconnect cable at J8 of Penetration Panel (this is the body receive line, which is not needed for this procedure). Connect the long coaxial cable from J1 on Pin Diode Box to J8 on Penetration Panel.

CAUTION

Equipment damage possibility. Do not run the coaxial cable under the RF door. The RF door can cut the outer cable jacket, exposing the braided shield, and grounding it to the RF door. These two grounds are not at the same potential and will adversely affect your calibration.

WARNING!

SHOCK HAZARD! THE PIN DIODE DRIVE TEST BOX SENDS 60-VOLT SIGNALS TO THE PIN DIODE BOX. VERIFY THAT THE POWER SWITCH FOR THE PIN DIODE DRIVE BOX IS OFF (DOWN POSITION) BEFORE CONNECTING CABLES.

6. Connect cable as follows, depending on type of system:

   a. **For 1.5T systems and fixed site 1.0T systems:** Connect a long coaxial cable from the other end of the SERVICE feed through (used in step 18) to the Pin Diode Drive connector on the Pin Diode Drive Test Box.

   b. **For mobile systems:** Disconnect coaxial cable from J2 on back of systems cabinet. Using a BNC coupling (not provided) and a long coaxial cable, connect this cable to the Pin Diode Drive connector on the Pin Diode Drive Test Box.

7. Verify that the switch on the Pin Diode Drive Test Box is in the Remote position.

8. Connect SMB-to-BNC cable from the Trigger Input (called *patch panel input* on some older boxes) connector on the Pin Diode Drive Test Box to J10 on the CERD board.

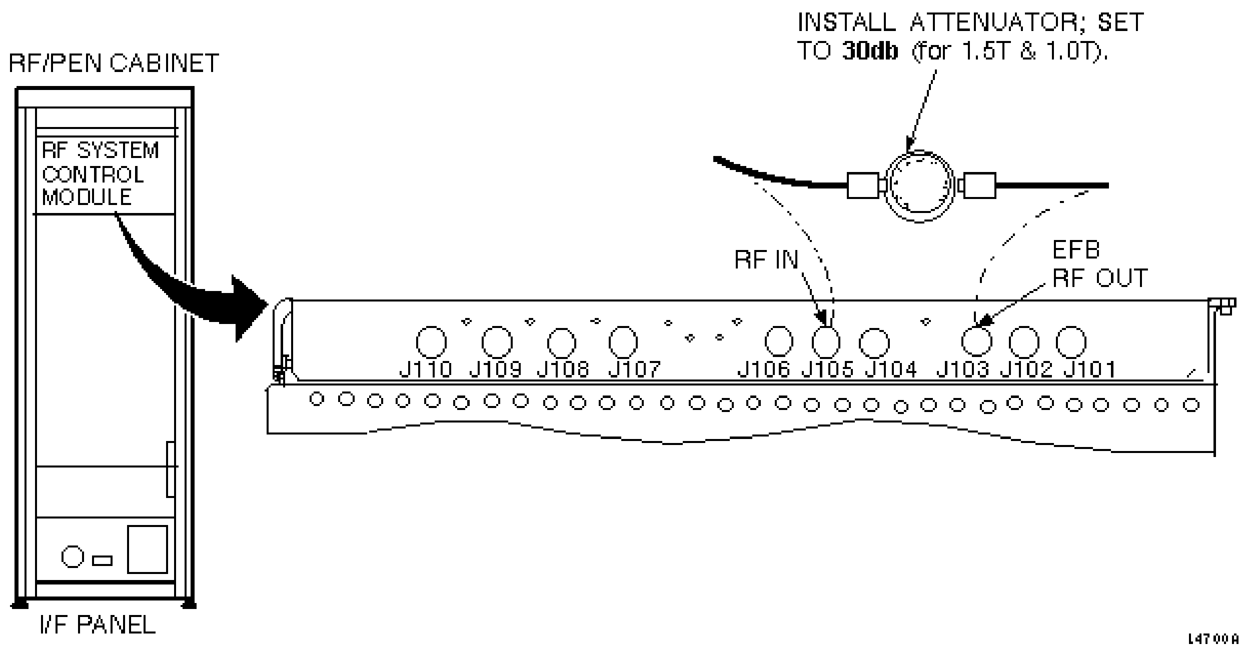
9. Plug in the power cord for the Pin Diode Drive Test Box.

10. Place the power switch for the Pin Diode Drive Test Box in the *on* position (referred to as (1) on the Pin Diode Drive Test Box.

CAUTION

Equipment damage possibility. The coils used in the Grafidy phantoms require low RF power and can be damaged if the appropriate attenuation is not used.

11. Install an attenuator to bypass envelope feedback circuitry at the RF amplifier. Disconnect BNC from EFB RF Out, and disconnect BNC from RF In. Add a 30-dB attenuator in-line between the two BNCs, as shown in Illustration L4703A.



RF SYSTEM CONTROL MODULE WITH EFB BYPASSED
ILLUSTRATION L4703A

APPENDIX G

Linear Long Time Constant Eddy Current Performance and FRESBECC

Note

It is very important to change the CV Mode to zero. If this step is not performed, Linear Short Time Constant ECC will be performed instead of Linear Long Time Constant ECC. Remember to press <Enter> after each CV parameter that is modified.

1. From Research Operations, Select **[Display CVs]**

   a. Find the CV **mode.** Select **Modify** and then type **0 <Enter>**

   b. Find the CV **axis**

   c. Select **Modity** and then type **0<Enter>** for *x*,

      or **1<Enter>** for *y*,

      or **2<Enter>** for *z*.

   d. Select **[Accept]**, **[Accept]**.

------- Prescan and Data Collection -------

1. Right click on **[Research Operations]** and select **Setup Params** from the Scan Operations list. Enter the values listed in Table 8A.

TABLE 8A
GRAFIDY SETUP PARAMETERS

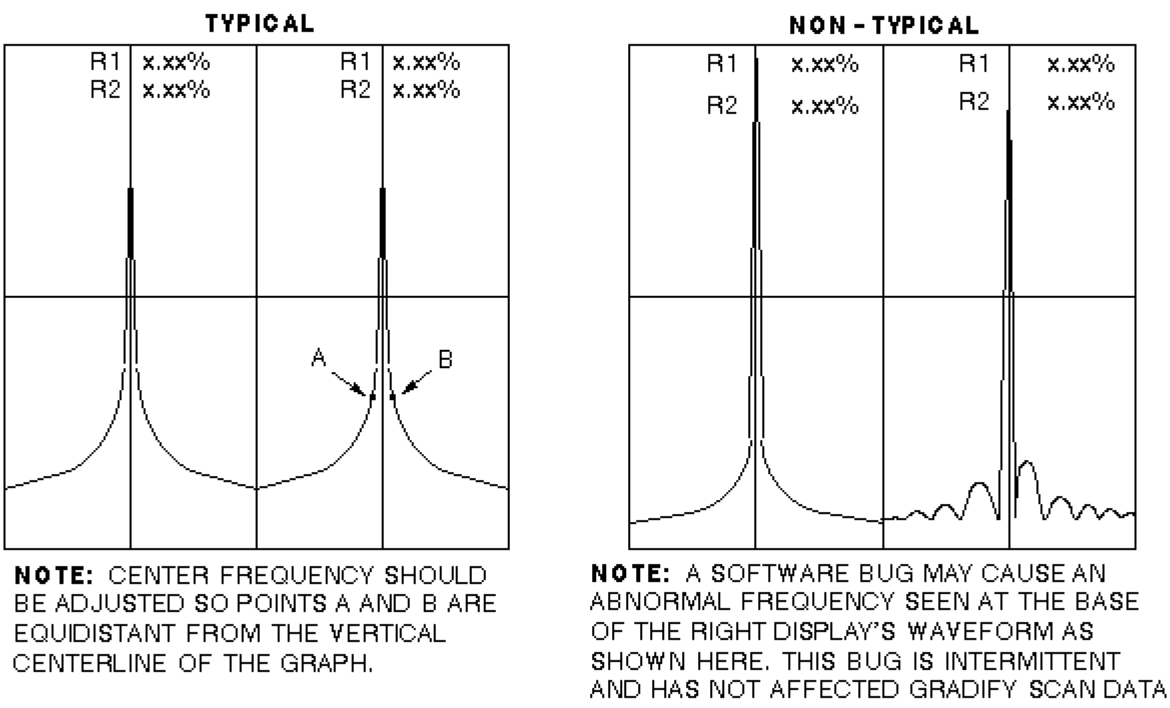
SETUP PARAMETERS	
R1 =	13
R2 =	14
TG =	0 *(TG must be set to 0.)*
Number of Frames:	**4 <Enter>**
WINDOW ONE	
Frame:	**1 <Enter>**
Frame:	**0 <Enter>**
WINDOW TWO	
Frame:	**3 <Enter>**
Frame:	**0 <Enter>**
	[Done]

2. Click on **[Manual Prescan]** and setup Twin Plot mode. See Table 9A. Perform center frequency check. Adjust TG to peak as usual for transmit power. Record the TG value for next pass reuse.

TABLE 9A
MANUAL PRESCAN

PULL DOWN MENU	**[Windows]**
Select:	**Two Windows**
WINDOW ONE	
Type:	**P. Spect**
Plot Gain:	**1**
WINDOW TWO	
Type:	**P. Spect**
Plot Gain:	**1**

An example of a typical and an atypical prescan display are shown in Illustration L2138A. Examine the typical example and verify that your display is somewhat similar before continuing. The peaks of the two waveforms need not be exactly equal.



GRAFIDY PRESCAN
ILLUSTRATION L2138A

Note

When the system is scanning, the *A* and *B* LEDs on the Pin Diode Drive Box flicker, indicating alternating coil selection. If there is any doubt whether the Grafidy test tools are working correctly, perform the procedure in Section 5-1, Functional Check of Grafidy Hardware.

Note

If the Manual Prescan window quits, reenter **[Manual Prescan]**.

Note

When the system is scanning, the LEDs (marked A and B) on the Pin Diode Drive Box flicker, indicating alternating coil selection. If you doubt whether the Grafidy test tools are working correctly, perform the procedure in section 2-16, Functional Check of Grafidy Hardware.

Note

If the IP screen goes blank, select [Back Up] and reenter [Manual Prescan].

3. Select **[Done]**
4. Select **[Scan]**
5. When the scan is finished, follow the instructions for the Grafidy Analysis tool in Screen 2.

SCREEN 2

READ AND PROCESS EDDY CURRENT DATA

OUTPUT/PROMPTS	INPUTS/COMMENTS

```
           GRAFIDY - Eddy Current Analysis

           1 - Read and Process Raw Data
           2 - Fit
           3 - Initialize Parameters
           4 - System Status
           5 - Plot Processed Data

           0 - Turn Expert Mode OFF
           S or Q - Exit to Tools Menu

           Enter Choice: (0..5) [3] : ..............1<ENTER>
Last run number used was : 4608

Please enter runfile number [4608] :................<ENTER> (Read/process
                                                     data from most recent scan.)
Max signal in frame=154.029218

      Coil A Position: X=a.aaaaa cm  y=a.aaaa cm  Z=a.aaaaa cm
      Coil B Position: X=a.aaaaa cm  y=a.aaaa cm  Z=a.aaaaa cm

      Coil A = -9.876543 cm :
      Coil B =  9.876543 cm :

Linear Eddy Current Performance:
  Max Deviation:
  2.50ms to 10.00ms/ 10.00ms to 100.00ms/ 100.00ms to 2000.00ms/

      1.278              1.002                0.449 <--(Record Linear Values on
                                                     the Data Sheet.)
```

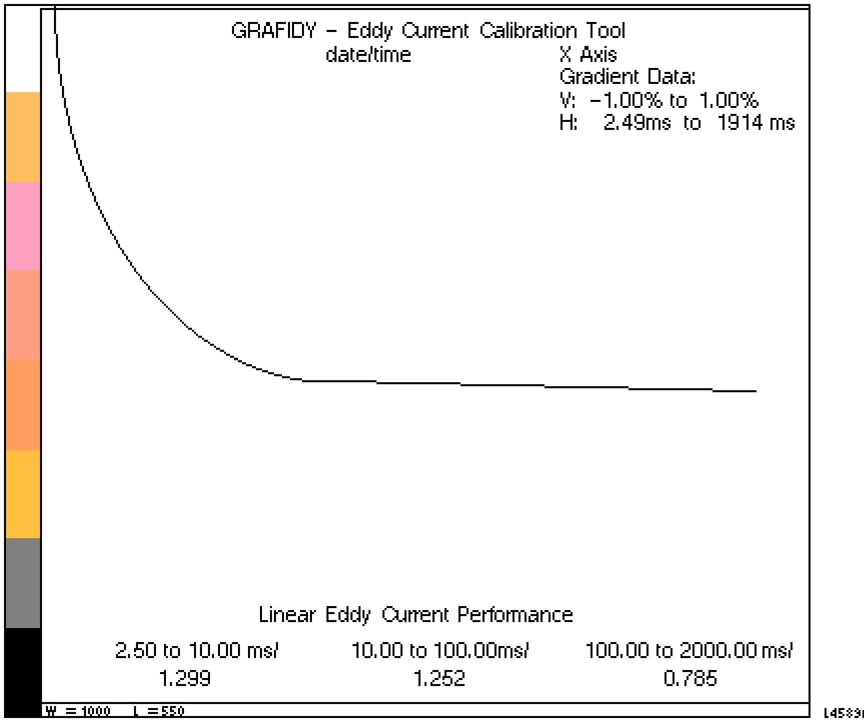
OUTPUT/PROMPTS	INPUTS/COMMENTS
	Linear Long Eddy Current response should appear on the Image Screen/Display. See Illustration L4589A.

`B0 Eddy Current Performance:`
`  Max Deviation:`
`  2.50ms to  10.00ms/ 10.00ms to 100.00ms/ 100.00ms to 2000.00ms/`
 	
`     -0.299             0.060                0.009`
	<-Record Values on the Data Sheet. If Linear Long & B_0 data are in spec for this axis, continue with Step 7.

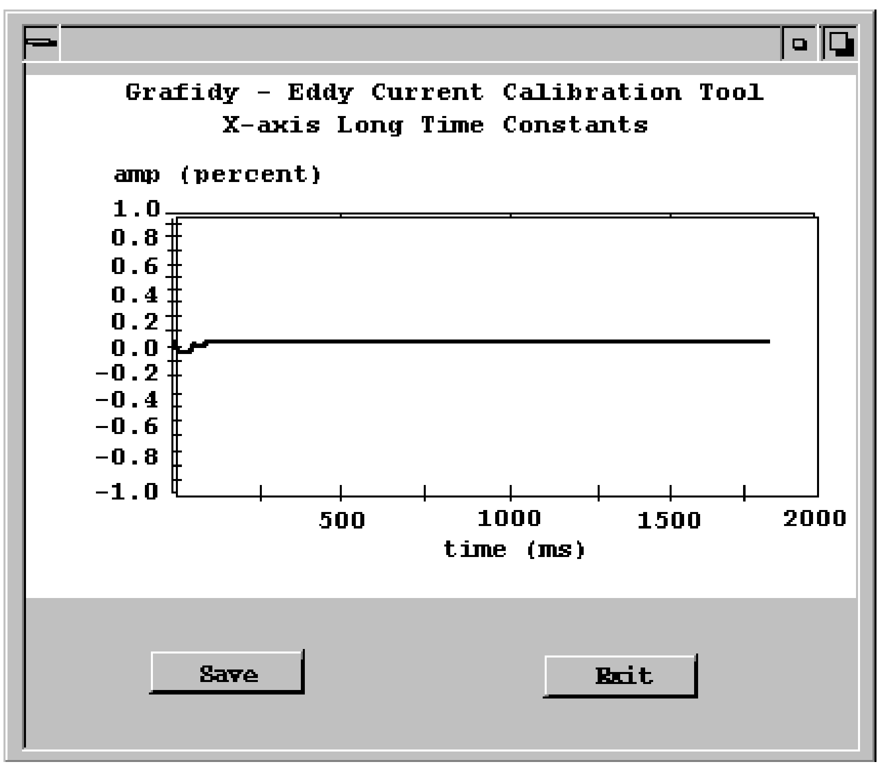
{Attention: If this is the first fit, after the initial fit, and the numbers are diverging from the spec, the grafidy.config file must be edited. Please See <u>Screen 39</u> for directions.}	
	B_0 Eddy Current response should appear on the Image Screen/Display. See Illustration L4589B.

`GRAFIDY - Eddy Current Analysis`
 	
`1 - Read and Process Raw Data`
`2 - Fit`
`3 - Initialize Parameters`
`4 - System Status`
`5 - Plot Processed Data`
 	
`0 - Turn Expert Mode OFF`
`S or Q - Exit to Tools Menu`
 	
`Enter Choice: (0..5) [3] :`
	Stop here and continue on to Step 6.

NOTE: AXIS REFERENCE WILL REFLECT THE AXIS BEING TUNED.



UNCOMPENSATED LINEAR LONG TIME CONSTANT EDDY CURRENT RESPONSE PLOT
ILLUSTRATION L4589A



B_0 EDDY CURRENT RESPONSE PLOT
ILLUSTRATION L4589B

SCREEN 39

EDITING THE GRAFIDY.CONFIG FILE

OUTPUT/PROMPTS	INPUTS/COMMENTS
1. To edit the grafidy.config file, open a C-Shell (accessed via the Service Desktop).	
lx-13 3# **cd /usr/g/caldir<Enter>**	
lx-13 4# lx-13 4# **vi grafidy.config<Enter>**	
edit the first parameter after the warp_lin_sign = to the space after the first **=**	(using the **J** key, cursor down to **warp_lin_sign**. Use the **L** key to cursor over sign. Type **a -** if there is no negative sign before the first 1.000000 parameter. This will force the polarity of the first parameter only to negative, which will cause the B0 eddy currents to start converging.)

```
"grafidy.config" 135 lines, 4796 characters # grafidy.config - This file
contains configuration parameters unique to grafidy
.
#
# WARP parameters:
warp_period=   64.000000
warp_shift=    96.000000
warp_scale=    0.220000
warp_b0_sign=  1.000000 -1.000000 -1.000000
warp_lin_sign= 1.000000 1.000000 1.000000
#
# Linear Fitting Parameters:
mode= 0
#
#  Long Time Constants:
   slmode= 0
#
#  8607 Gradient Amplifiers:
   type= 3
#
 ncoefs= 4# number of time constants on grafidy board
  use_tc= 1 1 1 1     # use time constant flags
  use_constraints= 1  # constraint fitting to hw limits
#  hardware time constant ranges
  tau_lower_lim= 2.0 9.4 40.0 200.0# lower limits in ms
  tau_upper_lim= 52.0 244.4 1040.0 5200.0 # upper limits in ms
#
#  hardware amplitude ranges
  alpha_lower_lim= 0.0 0.0 0.0 0.0# lower limits in %
  alpha_upper_lim= 28.0 28.0 28.0 28.0    # upper limits in %
#
# additional grafidy board hardware parameters
  hw_parms1= 10.0 100.0# Vref (volts) and Rref (kohms)
  hw_parms2= 0.1e6 0.47e6 2.0e6 10.0e6 # caps in pF
```

6. Continue with the Grafidy Analysis, and perform a Fit of the Raw Data for B_0 Raw Data. See Screen 3.

SCREEN 3
FIT B_0 RAW DATA

OUTPUT/PROMPTS	INPUTS/COMMENTS

```
           GRAFIDY - Eddy Current Analysis

           1 - Read and Process Raw Data
           2 - Fit
           3 - Initialize Parameters
           4 - System Status
           5 - Plot Processed Data

           0 - Turn Expert Mode OFF
           S or Q - Exit to Tools Menu

           Enter Choice: (0..5) [3]:....................2<ENTER> Select Fit

Please enter file name for processed data:
                        [/usr/g/caldir/grafidyxl.pdf1]: .....    <ENTER>

          GRAFIDY - Fit Menu

           1 - Fit Linear Data
           2 - Fit B0 Data

           S or Q - Exit Fit Menu

      Enter Choice: (1..2) [1] : ..................... 2<ENTER>  (Select B0)


  Initial fit: Hit enter to continue, s or q to
                                            return to main menu: ....
                                                     <ENTER>
  Initial fit in progress..
**********
  B0 Fit Results:
     tau[1]=6.70 ms     alpha[1]=-0.61 percent
     tau[2]=43.73 ms    alpha[2]=0.12 percent
     tau[3]=278.52 ms   alpha[3]=-0.02 percent
     tau[4]=478.05 ms   alpha[4]=0.03 percent

Do you want to specify time interval to plot? Y,N)[N]:. <ENTER>
   Enter Minimum Y Value (-100.000..100.000) [-1.000]:. <ENTER>
   Enter Maximum Y Value (-1.000..100.000) [1.000]: ... <ENTER>

Do you want to accept new fit parameters ?(Y,N)[N]: ... Y<ENTER>  (Accept
                                                     new parameters only when out
                                                     of specification.  They will be
                                                     written to the IPG.

 The K values written were:                          (Many K parameters will scroll
                                                     at this point.)
```

OUTPUT/PROMPTS	INPUTS/COMMENTS
WARP SF = 2.200000e-01 and B0 shift = 5.500000e-02 New WARP coefficients created. GRAFIDY - Eddy Current Analysis 1 - Read and Process Raw Data 2 - Fit 3 - Initialize Parameters 4 - System Status 5 - Plot Processed Data 0 - Turn Expert Mode OFF S or Q - Exit to Tools Menu Enter Choice: (0..5) [1] :	(Stop here and continue with Step 7.)

7. Continue with the Grafidy Analysis, and perform a Fit of the Raw Data for Linear Long Time Constant Raw Data. See Screen 4.

SCREEN 4
FIT LINEAR LONG TIME CONSTANT RAW DATA

OUTPUT/PROMPTS	INPUTS/COMMENTS
GRAFIDY - Eddy Current Analysis 1 - Read and Process Raw Data 2 - Fit 3 - Initialize Parameters 4 - System Status 5 - Plot Processed Data 0 - Turn Expert Mode OFF S or Q - Exit to Tools Menu Enter Choice: (0..5) [3] :	**2<ENTER>** Select Fit.
Please enter file name for processed data: [/usr/g/caldir/grafidyxl.pdf1]:	**<ENTER>**
GRAFIDY - Fit Menu 1 - Fit Linear Data 2 - Fit B0 Data S or Q - Exit Fit Menu Enter Choice: (1..2) [1] :	**<ENTER>**(Select Linear Long Time Constant Data)

OUTPUT/PROMPTS	INPUTS/COMMENTS
`Initial fit: Hit enter to continue, s or q to return to main menu: ...`	**<ENTER>**
`Initial fit in progress..`	
`**********`	
`Long TC Linear Fit Results:`	
`tau[1]=   3.64 ms alpha[1]=0.37 percent`	
`tau[2]=  28.83 ms alpha[2]=0.43 percent`	
`tau[3]= 148.29 ms alpha[3]=0.44 percent`	
`tau[4]= 785.62 ms alpha[4]=0.69 percent`	
`Do you want to specify time interval to plot?(Y,N)[N]:`	**<ENTER>**
`Enter Minimum Y Value(-100.000..100.000)[-1.000]:`	**<ENTER>**
`Enter Maximum Y Value(-1.000..100.000)[1.000]:`	**<ENTER>**
`Do you want to accept new fit parameters? (Y,N) [N]:`	**Y<ENTER>** (Accept new parameters only when out of specification. They will be written to the IPG.)
`The K values written were:`	Many K values scroll by.)
`WARP SF = 2.200000e-01 and B0 shift = 5.500000e-02`	
`New WARP coefficients created.`	
`GRAFIDY - Eddy Current Analysis`	
`1 - Read and Process Raw Data`	
`2 - Fit`	
`3 - Initialize Parameters`	
`4 - System Status`	
`5 - Plot Processed Data`	
`0 - Turn Expert Mode OFF`	
`S or Q - Exit to Tools Menu`	
`Enter Choice: (0..5) [1] :`	Stop here and continue with Step 8.

8. From **Research Operations**, select **[Download]** so that the digital tuning values are downloaded to the IPG.

9. If the axis is not within spec, continue with steps 4 through 8 until it is; otherwise go on to the next section.

APPENDIX H

1. From Research Operations, select **[Display CVs]**
   a. Find the CV **mode**, then select Modify and type **1 <Enter>**
   b. Select **[Accept]**, **[Accept]**.
2. Select **[Scan]**
3. When the scan has finished, perform a Read and Process of the Raw Data for Linear Short Time Constants (see Screen 6).

SCREEN 6
READ & PROCESS RAW DATA FOR LINEAR SHORT TIME CONSTANTS

OUTPUT/PROMPTS	INPUTS/COMMENTS
GRAFIDY - Eddy Current Analysis 1 - Read and Process Raw Data 2 - Fit 3 - Initialize Parameters 4 - System Status 5 - Plot Processed Data 0 - Turn Expert Mode OFF S or Q - Exit to Tools Menu Enter Choice: (0..5) [3] :	**1<ENTER>**
Last run number used was : 4608 Please enter runfile number [4608] :	**<ENTER>** (Read/process data from most recent scan.)
Max signal in frame=154.029218 Coil A Position: X=a.aaaaa cm y=a.aaaa cm Z=a.aaaaa cm Coil B Position: X=a.aaaaa cm y=a.aaaa cm Z=a.aaaaa cm Coil A = -9.876543 cm : Coil B = 9.876543 cm : Linear Eddy Current Performance: Max Deviation: 2.50ms to 10.00ms/ 10.00ms to 100.00ms/ 100.00ms to 2000.00ms/ 1.278 1.002 0.449	**<--** (Record Linear Values on the Data Sheet.)
	Linear Long Eddy Current

OUTPUT/PROMPTS	INPUTS/COMMENTS
	response should appear on the Image Screen/Display. See Illustration L4589A.

`B0 Eddy Current Performance:`
`  Max Deviation:`
`  2.50ms to  10.00ms/ 10.00ms to 100.00ms/ 100.00ms to 2000.00ms/`	

`-0.299    0.060    0.009`	**<-** Record Values on the Data Sheet. If Linear Long & B_0 data are in spec for this axis, continue with Step 7.
	B_0 Eddy Current response should appear on the Image Screen/Display. See Illustration L4589B.

`GRAFIDY - Eddy Current Analysis`
 	
`1 - Read and Process Raw Data`
`2 - Fit`
`3 - Initialize Parameters`
`4 - System Status`
`5 - Plot Processed Data`
 	
`0 - Turn Expert Mode OFF`
`S or Q - Exit to Tools Menu`	

`Enter Choice: (0..5) [3] :`	Stop here and continue on to Step 2.

4. Continue with the Fit of Linear Short Time Constants (see Screen 7).

SCREEN 7

FIT LINEAR SHORT TIME CONSTANT

OUTPUT/PROMPTS	INPUTS/COMMENTS

`GRAFIDY - Eddy Current Analysis`
 	
`1 - Read and Process Raw Data`
`2 - Fit`
`3 - Initialize Parameters`
`4 - System Status`
`5 - Plot Processed Data`
 	
`0 - Turn Expert Mode OFF`
`S or Q - Exit to Tools Menu`	

`Enter Choice: (0..6) [1] : ..............`	**2<Enter>** (select Fit)

OUTPUT/PROMPTS	INPUTS/COMMENTS
Please enter runfile number [4608] :	**<ENTER>** (Read/process data from most recent scan.)
Max signal in frame=154.029218	
GRAFIDY - Fit Menu 1 - Fit Linear Data 2 - Fit B0 Data S or Q - Exit Fit Menu	
Enter Choice: (1..2) [1] :	**1<Enter>** (Fit linear short time constant data.)
Do you want to plot linear data? (Y,N) [N] :	**Y<Enter>** (Plot the data and view it on the image display.)
(Accept all default parameters for the plots.)	
Initial fit: Hit enter to continue, s or q to return to main menu: ..	**<Enter>**
Initial fit in progress.. *** Short TC Linear Fit Results: tau[1]= 0.00 us alpha[1]=0.00 percent tau[2]= 13.14 us alpha[2]=0.00 percent tau[3]= 334.24 us alpha[3]=0.02 percent tau[4]=3992.01 us alpha[4]=1.51 percent	
Do you want to specify time interval to plot? (Y,N) [N]: ..	**<Enter>**
Enter Min Y Value (-100.000..150.000)[-5.000]: ..	**<Enter>**
Enter Max Y Value (-5.000..150.000) [125.000]: ..	**<Enter>**
Do you want to accept new fit parameters? (Y,N)[N]:.	**Y<Enter>** (Accept new parameters only when out of specification. They will be written to the IPG.)
GRAFIDY - Eddy Current Analysis 1 - Read and Process Raw Data 2 - Fit 3 - Initialize Parameters 4 - System Status 5 - Plot Processed Data 0 - Turn Expert Mode OFF S or Q - Exit to Tools Menu	
Enter Choice: (0..6) [1] :	(Stop here and continue with step 5.)

5. From Research Operations, select **[Download]** so that the Digital Tuning Values are downloaded to the IPG.

6. Continue with steps 2 through 5 until this axis is within specification.

7. If all three axes are to be tuned, continue with step 8 for each axis. If all axes are within specification and complete, skip to step 9.

8. Follow the instructions in Screen 8 for additional axes.

SCREEN 8
CONTINUING WITH ADDITIONAL AXES

OUTPUT/PROMPTS	INPUTS/COMMENTS
GRAFIDY - Eddy Current Analysis 1 - Read and Process Raw Data 2 - Fit 3 - Initialize Parameters 4 - System Status 5 - Free IP for Prescan 0 - Turn Expert Mode OFF S or Q - Exit to Tools Menu	
Enter Choice: (0..5) [2] :	**3<Enter>**(Initialize parameters.)
Enter axis to clear(0=x,1=y,2=z,3=All):(0..3)[0]: ..	***<Enter> ***Initialize the parameters for the axis being tuned. **Do not** initialize the axis or axes that have been calibrated!
Initialize linear short time constants parameters ? (Y,N) [N] :	***<Enter>
The K values written were (Data scrolls here for K values.)	
WARP SF = 2.200000e-01 and B0 shift = 5.500000e-02	
New WARP coefficients created.	
GRAFIDY - Eddy Current Analysis 1 - Read and Process Raw Data 2 - Fit 3 - Initialize Parameters 4 - System Status 5 - Free IP for Prescan 0 - Turn Expert Mode OFF S or Q - Exit to Tools Menu	

OUTPUT/PROMPTS	INPUTS/COMMENTS
`Enter Choice: (0..5) [3] : .............`	(Continue with step 9.)

9. If all axes are within spec, exit Grafidy Analysis by typing **s<Enter>** to save your results and exit.

APPENDIX I

This procedure assumes that the scan protocol Grafidy is already loaded.

1. From **Research Operations**. select **[Display CVs]**

   a. Find the CV **mode**, then select **Modify** and type **2 <Enter>** (When mode=2, a gradient train of trapezoidal pulses is played out during the scan.)

   b. Find the CV **axis.**

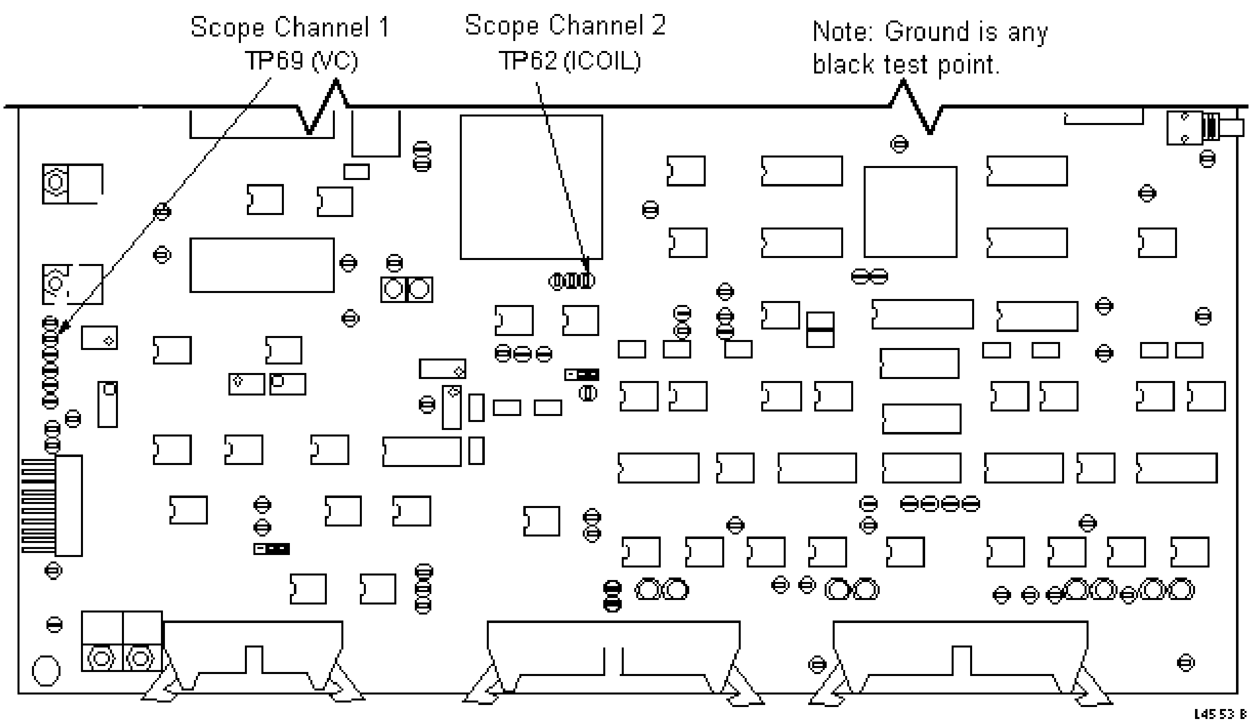
   c. Select Modify and type **0 <Enter>** for x

      or **1 <Enter>** for y

      or **2 <Enter>** for z

2. Select **[Accept]**, **[Accept]**.

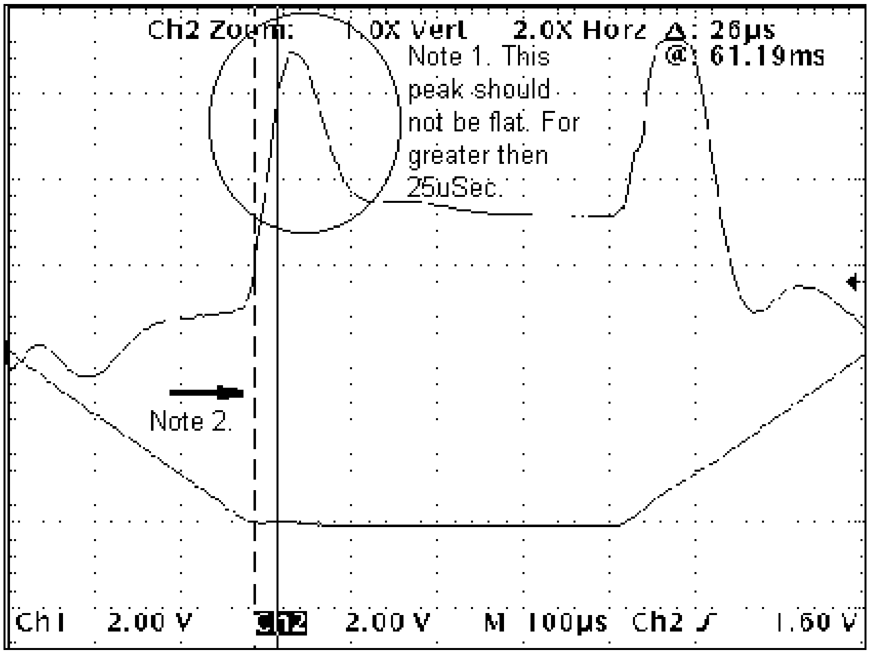
3. See Illustration L4553Bc for test point locations on the Rev E GRAM Control board



GRAM CONTROL BOARD (LOWER HALF): TP62 AND TP69 LOCATIONS
ILLUSTRATION L4553BC

4. Select **[Scan]**

5. Voltage control clamp verification (see Illustration L4800).

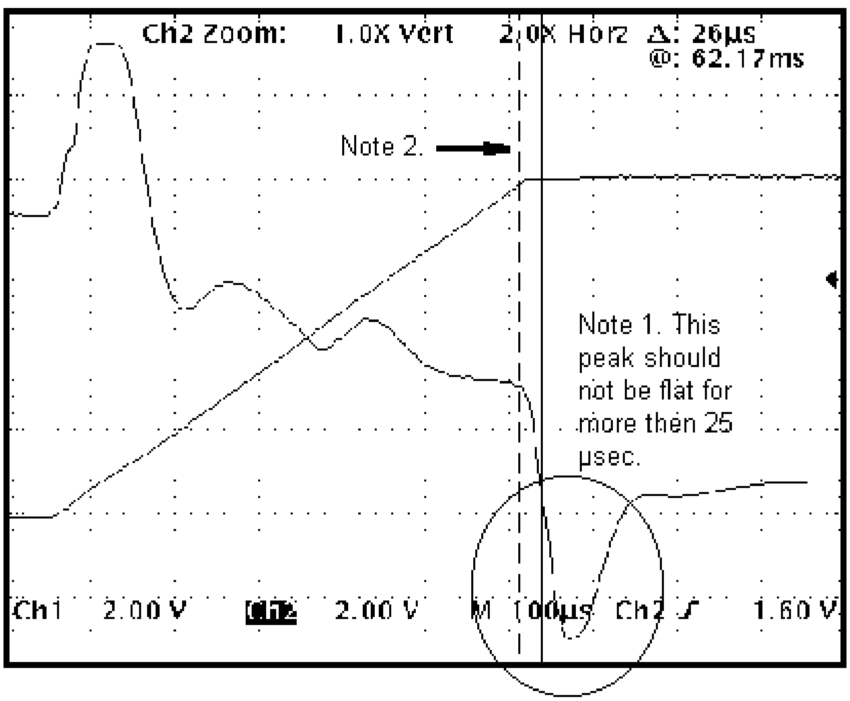


Use delay scope trigger to view waveform 60 to 70 msec after first ramp.

Verify that voltage control is not in the clamps for more than 25 µsec.

Note 1. Clamp = ± 7.5 Vdc flat waveform without ripple.

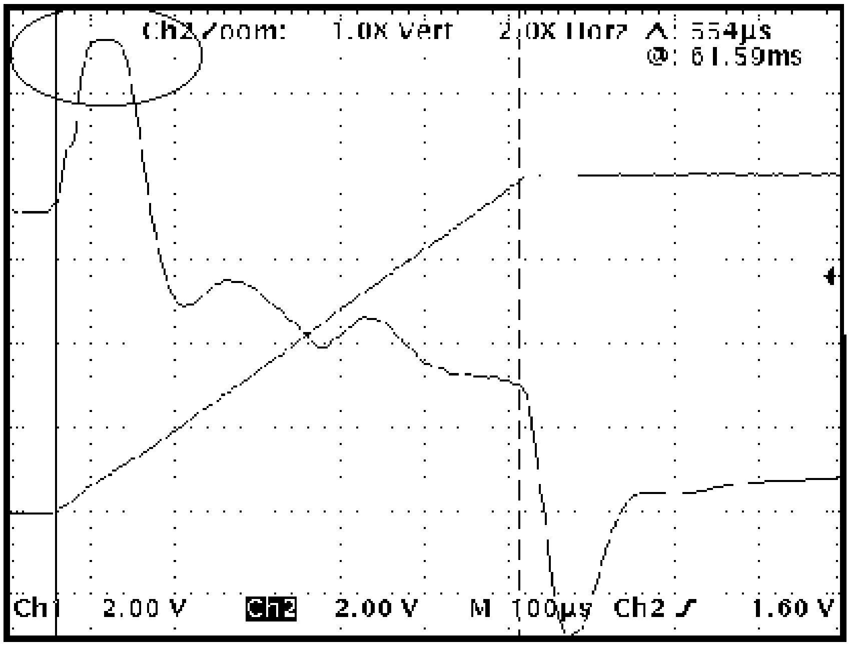
Note 2. Ramp to flat top transition define start time measurement



Verify voltage control are not in the clamps for greater than 25 µsec.

Note 1. Clamp = ± 7.5 Vdc flat waveform without ripple.

Note 2. Ramp to flat top transition define start time measurement



Voltage Control signal clamping is OK on the ramps. More predominant in HiSpeed than EchoSpeed.

VOLTAGE CLAMP CHECKS
ILLUSTRATION L4800

Note

Remember that this system has positive and negative power supply limits; therefore, when performing this adjustment, be sure to look at both.

6. You must now redo DC Offsets, refer to Section 4- GRAM DC Offset Adjustment.

APPENDIX J

1. Remove the in-line attenuator (which bypasses Envelope Feedback) in the RF cabinet, added at the start of this procedure, and reconnect the BNC connectors to the original locations.

2. Remove the Grafidy Kit from the system.

3. Replace Patient Comfort Module at rear of body coil, if necessary.

4. Using proper ESD precautions, reposition the GRAM Tuning Boards on each axis.

CAUTION

Equipment damage possibility. Do not push the circuit board on. The nylon standoffs are quite brittle and will break. Push the top of the standoff away from the circuit board one by one. If they do not push off of the circuit board at first, work on the other standoffs one by one.

5. Replace the cover on each GRAM module.

CAUTION

Equipment damage possibility. EMI interference will cause the GRAMs to function incorrectly. It is important that all screws are in place on the GRAM module cover to control EMI emissions in or out of the module.

6. Replace GRAM cabinet front cover.

7. Restore the grad shim values if they were changed at the beginning of this procedure.

APPENDIX K

Digital GRAM Tuning

The GRAM "ears" waveforms are not normal on a retune since Grafidy compensation is added; therefore, start this procedure by initializing *x*, *y*, & *z* parameters to zero.

Preliminary Steps

1. Power off
2. Check jumpers. All GRAM control board jumpers are set to pins 2 and 3.
3. All jumpers on the digital tuning board should be in the Manual position.
4. Set R41 (VBUS) to 1000 ±25 ohms (for EchoSpeed), or 300 ±7.5 ohms (for HiSpeed).
5. Adjust Bus Voltage Regulator Gain (on GRAM control board. This is the only time that R41 is adjusted during this procedure.).
6. Power on
7. Set up Grafidy hardware. Note: 30dB attenuation reduces the chance of getting a 180-degree flip angle.

GRAM DC Offset

Keep in mind that initializing (zeroing) *x*, *y*, and *z* in Grafidy changes this offset.

1. Set up scan protocol **Grafidy**.
2. Use Manual Prescan to set all grad shim values to 0; save, and then Done to stop pulsing.
3. Measure GRAM out J3 (+ out) to J4 (– out) with a DVM (digital volt meter).
4. Adjust R151 (offset null under digital tuning board, through a hole) for 0 mVdc, ±10 mv dc.

Voltage Offset Adjustment

1. Measure TP18 (DAC_DI on the digital tuning board) to ground with DVM.
2. Adjust R37 (DAC_DI Offset on the digital tuning board) until TP18 reads 0 mVdc ±3 mVdc.

PWM Limit

1. Measure TP19 (PWM Limit on digital tuning board) to ground using DVM.

2. Adjust R40 (on digital tuning board), until TP19 equals 1.25 Vdc.

Amp Transitions per Sec Limit

1. Use DVM to measure TP24 (Amp/Sec limit at bottom of digital tuning board) to ground.

2. Adjust R43 until TP24 equals 900 mVdc: (C48 & C49 are marked *475*)

LCOIL

1. Start Grafidy Analysis tool (which downloads correct values to digital boards). Digital tuning board values need to be initialized or disabled if you are just verifying values.

2. Set up scope: channel 1 and channel 2 = 2 V/div and dc coupling, T = 20 msec/div, Trigger = channel 2.

3. Leave channel 2 on TP62 (ICOIL); connect channel 1 to TP68 (DACI on GRAM control board, under digital tuning board). (This is a repeat.)

4. Connect a scope ground to GRAM ground (any black test point). Modify the CV axis for *x*, *y*, or *z*. Remember to press <Enter>, after each CV parameter that is modified.

5. Start scan. DACI and ICOIL should appear to be approximately equal.

6. Move channel1 from TP68 to TP69 (VC, or voltage control, located just below TP68).

7. Adjust channel 2 vertically, so that ICOIL is symmetrical above and below the zero reference.

8. Adjust channel 1 vertically, so that the flat part of the VC waveform is symmetrical above and below the zero reference.

9. Adjust R29 (LCOIL) so that VC and ICOIL cross the zero reference at the same point.

10. A lower priority adjustment goal for R29 is to make the "ears" of VC approximately the same amplitude.

11. Allow scan to continue for next adjustment; there is no need to stop.

Loop Gain Adjustment

1. Use same test points as in LCOIL section above.

2. Adjust R22 (Loop Gain, on GRAM tuning board) so that VC has minimal underdamping. When you adjust R22, you will see a small characteristic bump. Adjust counterclockwise until the characteristic bump just disappears. (Clockwise = underdamped (ringing), counterclockwise = damped (smooth).)

Gain Balance

1. Plug scope into filtered service outlet.
2. Calibrate/set up scope: channel 2 = 2 V/div dc coupled, channel 1 = 50 mV/div ac coupled, T = 20 msec/div, Trig = channel 2.
3. Measure TP62 (ICOIL) with channel 2; measure TP68 (DACI under digital tuning board) with channel 1. Connect ground to ground.
4. Set CV: **mode <Enter>**, **2 <Enter>** (GRAM tuning). Start scan. DACI and ICOIL should appear to be approximately equal.
5. Adjust trigger to near left side of the waveform (use B delay).
6. Move channel 1 to TP80 (IERROR on GRAM control board near TP62). Set scope to 500 µsec/div, and 500 mV/div.
7. Adjust R164 (on GRAM control board, under digital tuning board) until flat part of IERROR at TP80 is at the zero reference.
8. Stop scan

Linear Long Time Constant Eddy Current Performance & FRESBECC

Attention! Perform this, and the next two sections, for one axis before continuing on to the next.

1. Use protocol #52 for Grafidy. Set CVs: mode = 0 <Enter>, axis = 0, 1, 2, R1=7, R2=14, 4 frames, 3,0,1,P, 4,0,1,P. Setting CV mode = 0 <Enter> is for long time constant and B_0.

Remember to press <Enter> after each CV parameter that is modified.

2. Manual prescan, peak TG as usual
3. Scan
4. Read and process raw data, use defaults, record max dev values.
5. Fit B_0 data, select B_0 data, plot it, use defaults or enter 0 for expert mode.
6. Fit linear data, use defaults, accept suggested values.
7. Download digital tuning values to IPG
8. Keep scanning until the system reaches the correct specification.

Linear Short Time Constant Eddy Current Performance

1. Set CV: mode=1 (short time constant) Remember to press <Enter> after each CV parameter that is modified.
2. Scan
3. Read and process, record results.
4. Fit linear short time constants.
5. Select **[Download]** so that the digital tuning values are downloaded to the IPG.
6. Rescan to repeat this, if you like, but the short time constants do not converge at this time, so do only one fit.

GRAM DC Offset

1. Adjust R151 (offset null under digital tuning board, through a hole) for 0 mVdc, ±10 mVdc.

The Grafidy process causes a dc voltage to be applied, so this must now be removed. Check and set Offset after performing Grafidy on each axis. The dc offset introduced from one axis may cause the sample position of the next axis to be less than desired.

Clamp Verification

1. Set CVs: mode=2, axis=0, 1, 2 Remember to press <Enter> after each CV parameter that is modified.
2. Set up scope: channel 1 = 2 v/div, dc coupled, channel 2 = trigger, Time = 20 msec/div
3. Measure TP62 (ICOIL) with channel 2, measure TP69 (VC) with channel 1, ground leads to ground.
4. Scan. Look at the end of the burst (64 msec later for EchoSpeed, approximately 70 msec later for HiSpeed.)
5. Verify that voltage control is not in the clamps during the flat top of ICOIL for longer than 25 µsec. If greater than 25 µsec, the cause could be one or more of these: excessive Grafidy iterations, improper VBUS adjustment, Loop Gain is underdamped, and/or LCOIL is severely out of adjustment.
6. Stop scanning.

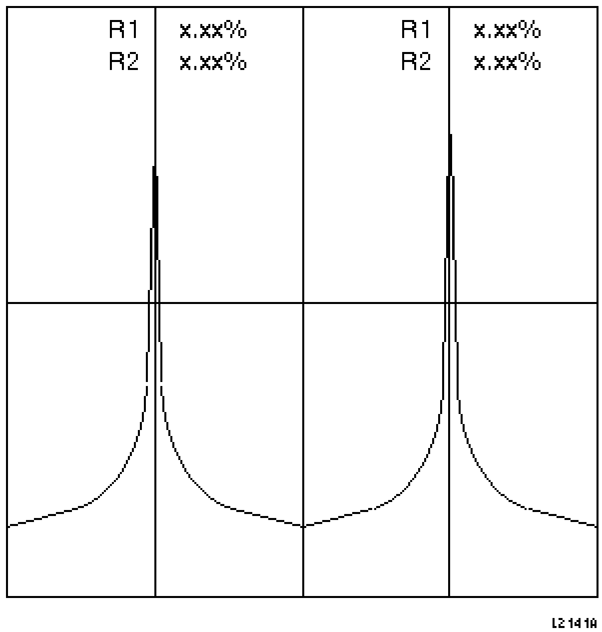
Put everything back

Restore the system.

APPENDIX L

Functional Check of Grafidy Hardware

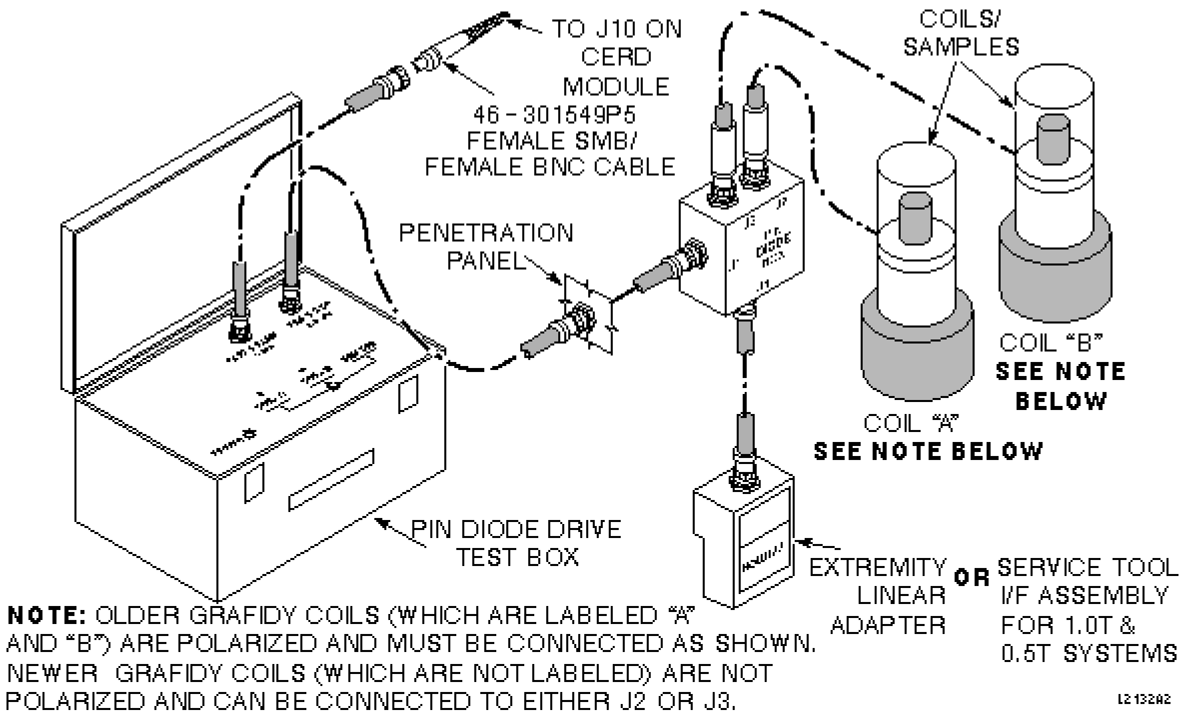
1. Start manual prescan using the Grafidy hardware. Verify that the display is similar to the display in Illustration L2141A.



TYPICAL GRAFIDY PRESCAN
ILLUSTRATION L2141A

If it is not, some things to check include:

- Are all cables, including the coil/samples, connected per Illustration L2132A?
- Is the Pin Diode Drive Test Box plugged into a good power source with the switch in the *1* position?
- Is a signal present at J10 on the DAB module (alternating from 0 volts to 2.5–4.0 volts)?



GRAFIDY EQUIPMENT SETUP
ILLUSTRATION L2132A

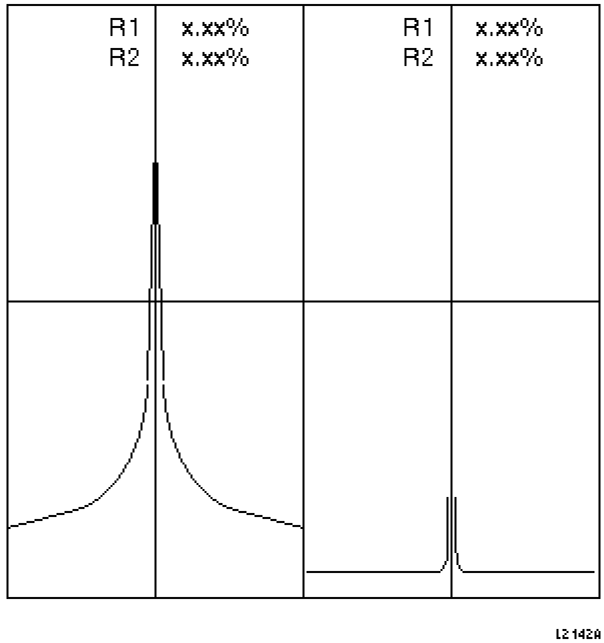
2. Select **[Done]**

3. Turn off the Pin Diode Drive Test Box.

4. Disconnect one of the coil/samples from the hardware by removing cable from J3 of the pin diode box.

5. Place the power switch for the Pin Diode Drive Test Box in the *1* position.

6. Select **[Manual Prescan]** again, and verify that one of the signals has been eliminated (see Illustration L2142A). At this point, you can be fairly sure that the Grafidy hardware works. It is important that only one waveform be eliminated when a coil is disconnected; which one is not important.



PRESCAN MINUS ONE COIL/SAMPLE
ILLUSTRATION L2142A

Functional Check/Maintenance of Grafidy Coil

1.5T Coil Impedance Check

1. To verify the functionality of the 1.5T Grafidy coil, measure the impedance. To do this, the pin diode must be forward biased. Use a BNC tee adapter to inject a 10-mA dc current at the point where the impedance meter probe mates with the quarter wavelength cable. A 1000-ohm resistor, driven by a 10-volt power supply, produces the necessary current with only a small additional load on the desired input impedance. Forward bias the pin diode as described above.

2. Set the vector impedance meter at 63.86 mHz, and measure the input impedance of the coil.

3. Fine tune the variable trim capacitor, P10, to get nearly 50 ohms at 0º phase. Acceptance values are:

   Magnitude: 38 to 65 ohms

   Phase Angle: –15º to 15º

1.0T Coil Impedance Check

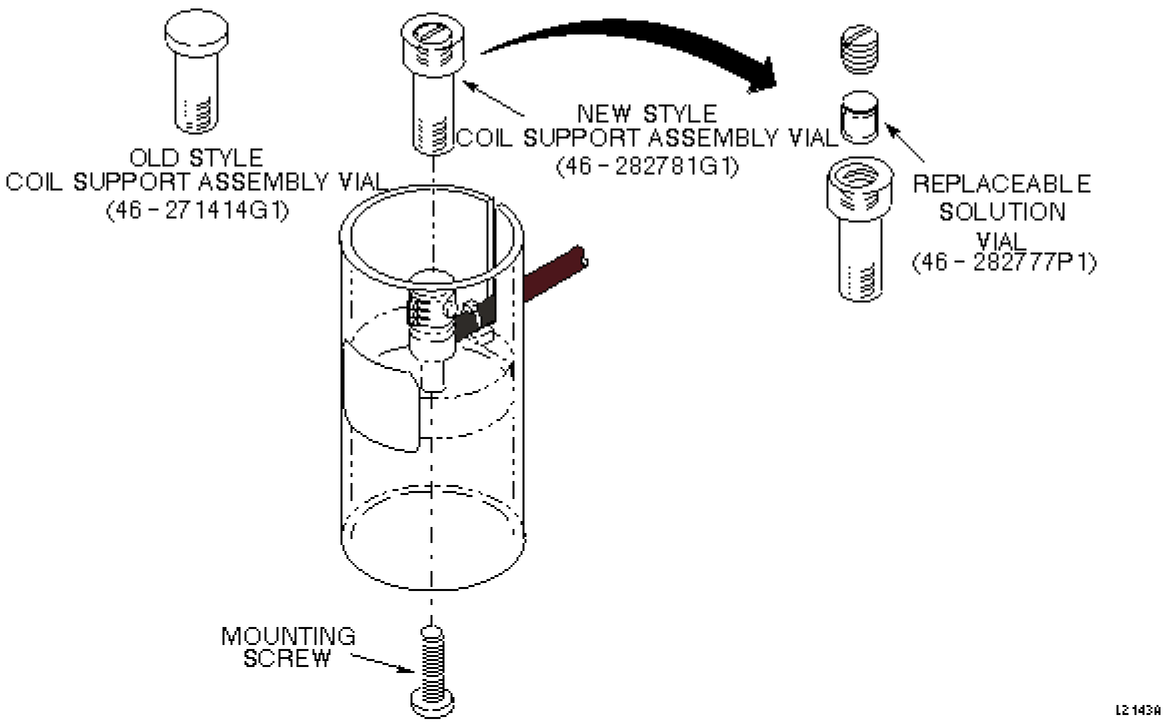
1. Place Grafidy coil assembly on a non-conductive stand at least three feet from any conducting surfaces. Set vector impedance meter at 42.68 mHz, and measure the input impedance of the coil. Acceptance values are:

Magnitude: 38 to 65 ohms

Phase Angle: –15º to 15º

Solution Vial Replacement

1. The Grafidy coils have replaceable solution vials; see Illustration L2143A for assembly and part number information.



GRAFIDY COIL/SAMPLE REPLACEMENT
ILLUSTRATION L2143A

REVISION HISTORY

REV	DATE	AUTHOR	PRIMARY REASONS FOR CHANGE
0	Jul 16, 1998	L. Loehrer	Converted Toolbook document to MS Word 7.0