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Description - This procedure applies only to systems with ACGD cabinets, Release 9.X software or higher, and with a ***TwinSpeed*** configuration. It is effectively repeated twice within this document to accommodate the two different gradient coils, **Whole-Body** (WB or WHOLE) and **Zoom** (ZM or ZOOM) gradients**.**

Note

If a system is calibrated with one version of the Eddy Compensation tool (Grafidy or ECMT), the same tool must be used for updates or start from beginning with different tool. If a different tool is used to compensate eddy currents the result will be bad plots.

1- THEORY

Grafidy calibrates the system for Eddy Current Compensation.

Note

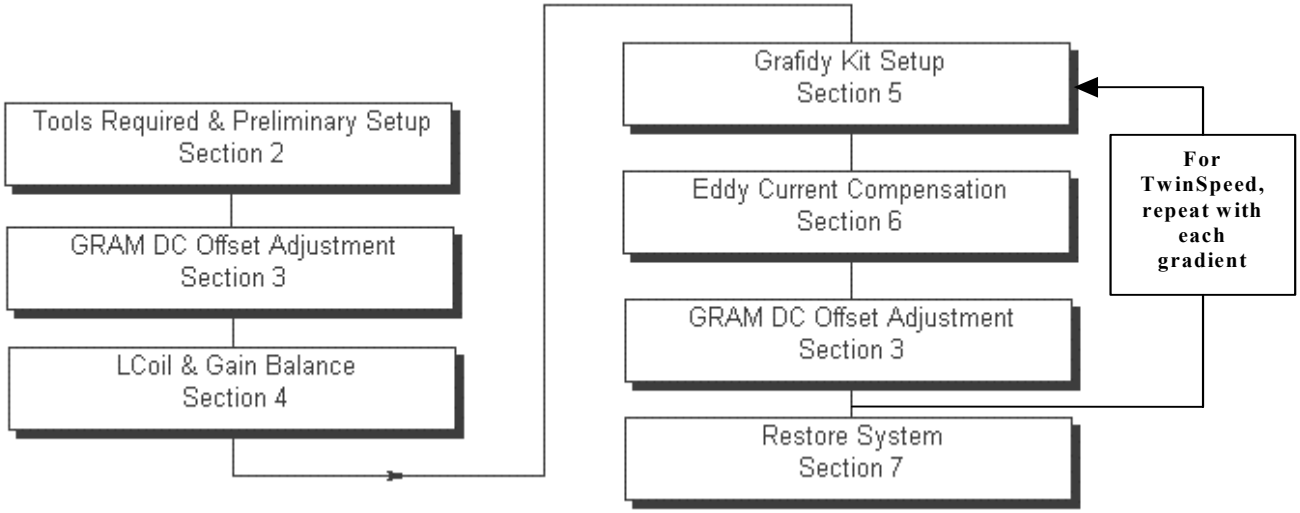
Short time constants are compensated for using default values that are in the default Grafidy calibration files. If you have any of these revisions of software, you are NOT REQUIRED to run short time constant compensation (the ability to run short time constant compensation is still available in Expert Mode).

This procedure use to tune the GRAM, however, with the ACGD cabinet the values are now set and it is no longer necessary to perform Auto LCoil. Eddy current compensation is done in 4 sections to compensate for linear long time constants, cross-term time constants, B_0 time constants, and linear short time constants (see note above). 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.

Note

For GRAM Tuning Quick Reference guide, see Section 10. Section 10 provides the necessary steps to complete GRAM tuning, but without the detailed step-by-step instructions and supporting illustrations. Obviously this section is intended for the very experienced "tuners." This quick reference can also be used to verify all the major sections have been completed. The detailed step-by-step procedure started at *Section 2, Tools Required and Preliminary Setups.*



GRAM TUNING & GRAFIDY FLOWCHART
ILLUSTRATION 1-1

2- TOOLS REQUIRED AND PRELIMINARY SETUPS

- Rotary Attenuator (10db/step), 46-255838P5
- Grafidy kit - There are several variations in the field as listed below:
  46-271417G1 – 1.5T
  46-307164G1 – 1.5T
  46-307164G2 – 1.5T
  46-307164G3 – 1.0T, 1.5T
  46-307164G4 – 1.0T, 1.5T
  46-307164G6 – 1.0T

3- GRAM DC OFFSET ADJUSTMENT

1. Select **[Diagnostics]** from the Service Desktop and select **[Start].**

2. Select **[IPG]**, **[Manual]**, **[Digital DC Offset (Whole)],** then **[Close]**.

3. Click **[Close]** on the *IPG_* window. Select **[Run Diagnostics]** ←TPS should download and you should observe the words “DC OFFSET” on IPG boards with a display.

4. When one pass of diagnostics are complete (3-4 min), repeat paragraph 3 again for **[Digital DC Offset (Zoom)].** Then exit Diagnostics by closing the *Results* window, then selecting **[Quit]** on the *Diagnostics* window. TPS will download.

5. The calibration values are stored in the */usr/g/caldir/gram_tune.dat.WHOLE* for Whole Body coil *(or gram_tune.dat.ZOOM for Zoom coil)* file. (You do not have to touch the Offset pots on the SGA’s).

4- LCOIL AND GAIN BALANCE

This adjustment takes about two minutes to run. It automatically updates the system configuration upon completion.

When doing all three axes, no errors should be reported by the system and system configuration will auto update. If a problem is detected on any axis, an error message will be posted by the system and the bad axis configuration will not be updated.

If you don't want to tune all axes, turn off power to the GRAM(s) on those axes. Note: Error messages will be posted by the system for the GRAM(s) that are off, but configuration files will be updated for the GRAM(s) that are still on.

Note

The waveform used to perform the Auto DC Offset procedure is generated locally in the gradient cabinet on the GIP Module. Therefore, it is not necessary to set gradshim currents (which originate from the IPG) to zero before invoking this procedure.

Auto LCoil Adjustment Procedure:

1. Select **[Diagnostics]** from the Service Desktop Manager. -
2. Click **[Start]**.
3. Select **[Board Level Tests - IPG]**.
4. Click **[Manual]**.
5. Select **[LCoil Adjust (Whole)]**. Close the *Manual* and *IPG* windows.
6. Select **[Run Diags]**.
7. Repeat items 5 and 6 for **[LCoil Adjust (Zoom)]**.
8. Exit diags when diagnostics have completed by closing the *Results* window and clicking on **[Quit]** in the *Diagnostics* window .

5- GRAFIDY INITIALIZATION & HARDWARE SETUP PROCEDURE FOR THE WHOLE-BODY GRADIENT

1. Go to Cal/Checks on the Service Desktop and select the **[Grafidy]** option.

2. From the ***GradModes*** Popup menu, highlight **WHOLE** and click on **OK**.

3. **Initialize Grafidy Parameters to 0** by following these Grafidy Analysis Tool instructions:

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) [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>**
Initialize linear long time constants params? (Y,N):	**Y<Enter>**
Clear Very Long linear parameters? (Y,N):	**Y<Enter>**
Clear Very Long B0 parameters? (Y,N):	**Y<Enter>**

Note

Short time constants are compensated for using default values that are in the default Grafidy calibration files. For these revisions of software, you are NOT REQUIRED to run short time constant compensation (the ability to run short time constant compensation is still available in Expert Mode. Enter “0” at the prompt).

```
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) [0] : .............        (No additional entries for now.)
```

Note

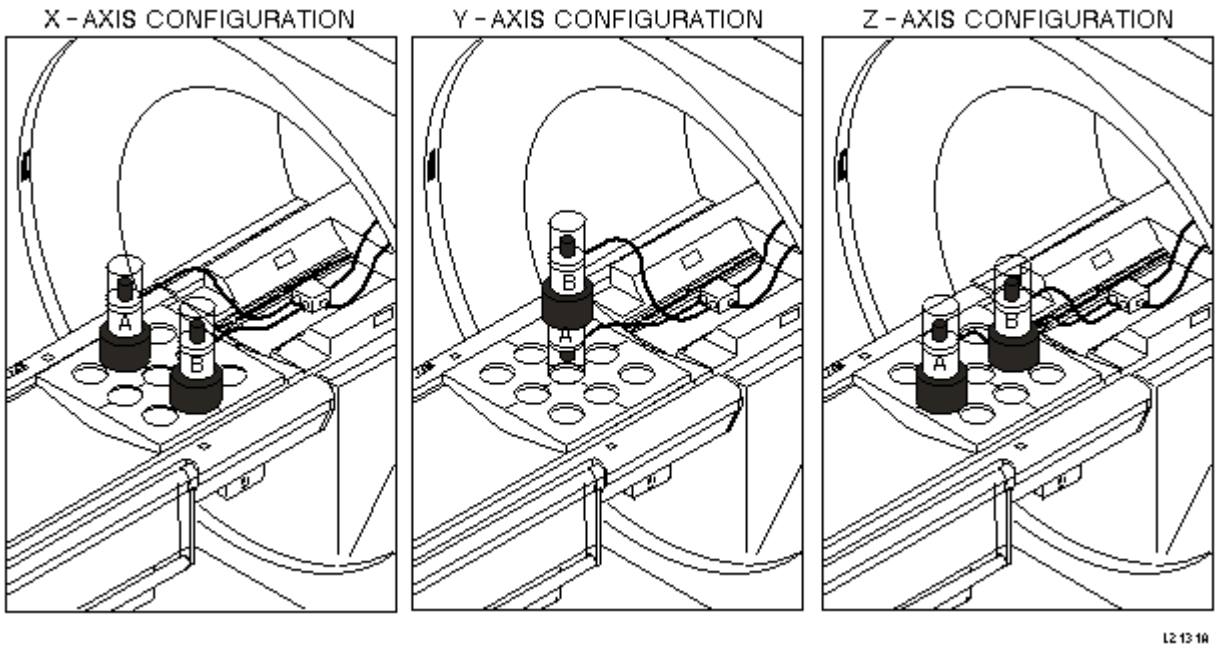
You must invoke the Grafidy Analysis Tool now because the parameters used in the eddy current compensation may already be loaded into the Digital Tuning portion of the GIP Board. By initializing the parameters, you are setting these parameters to zero. Note: Exiting Grafidy restores compensation values.

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 1.5T coils from the kit.

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 5-1.

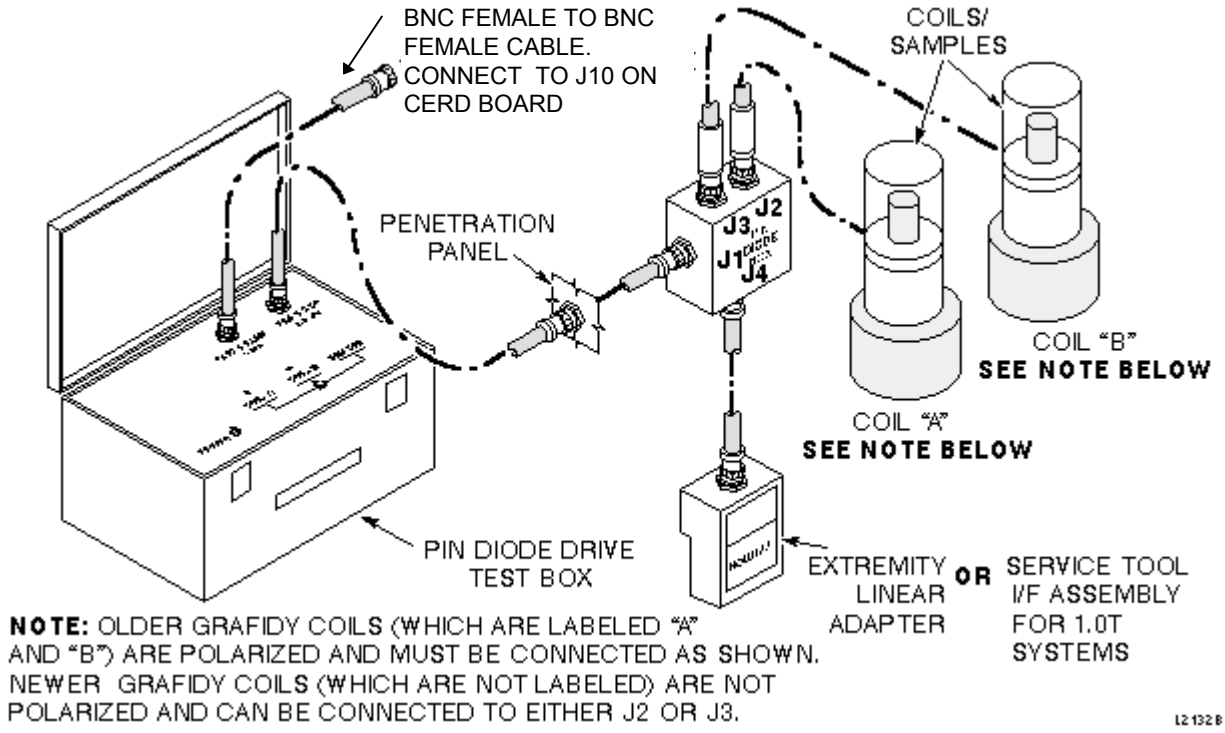


GRAFIDY PHANTOM CONFIGURATIONS
ILLUSTRATION 5-1

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.

Refer to Illustration 5-2 for steps 4 through 14.



GRAFIDY KIT SETUP
ILLUSTRATION 5-2

4. Plug the Extremity/Linear Adapter 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. 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!

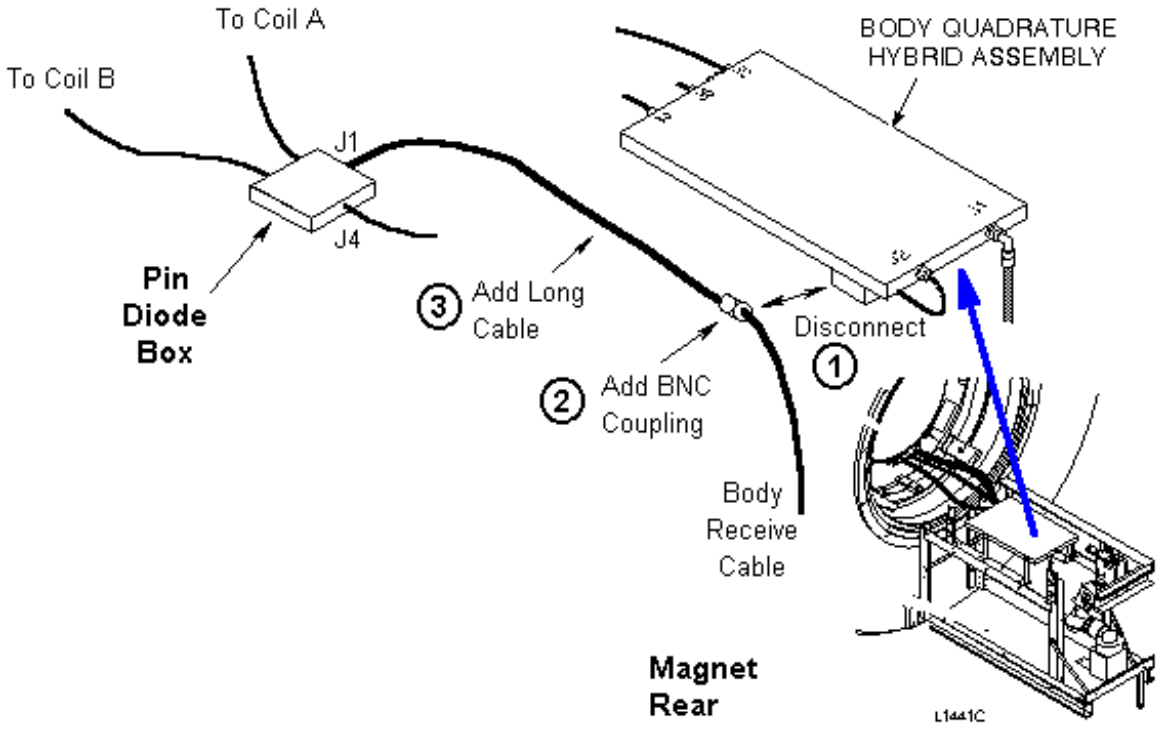
SHOCK HAZARD! THE PIN DIODE DRIVE TEST BOX SENDS 60-VOLT SIGNALS TO THE PIN DIODE BOX. VERIFY THAT THE POWER SWITCH FOR THE PIN DIODE DRIVE BOX IS OFF (DOWN POSITION) BEFORE CONNECTING CABLES.

6. Landmark on the center-line of the Grafidy coil base plate (not the coils). At the keypad on front magnet enclosure, press LANDMARK then MOVE TO SCAN.

Note

An alternate method for Steps 7 and 8 is provided here, if any difficulty is encountered with the primary method provided in the main procedure.

7. Disconnect run #262 Body Receive cable (this signal is not needed for this procedure), from the Body Hybrid Splitter at the rear of the magnet, and place a BNC coupling (not provided) on the cable end. See Illustration 5-3.



PIN DIODE DRIVE HOOKUP - MAGNET END
ILLUSTRATION 5-3

(Alternate) Connect the first long coaxial cable from J1 on Pin Diode Box to the BNC coupling on the body receive cable. This cable must be routed through the bore and out the rear of the magnet.

8. On the lower rear panel of the Systems Cabinet, disconnect the existing coaxial cable from J2 (this is the other end of the body receive line run #231T) and place a BNC coupling (not provided) on the cable end.

(Alternate) Connect a second long cable between the BNC coupling and the PIN DIODE DRIVE connector on the Pin Diode Drive Test Box.

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

10. Connect a BNC cable from the TRIGGER INPUT (called PATCH PANEL INPUT on some older boxes) connector on the Pin Diode Drive Test Box to J10 (DAB Out 6) on the CERD Board.

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

12. 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!

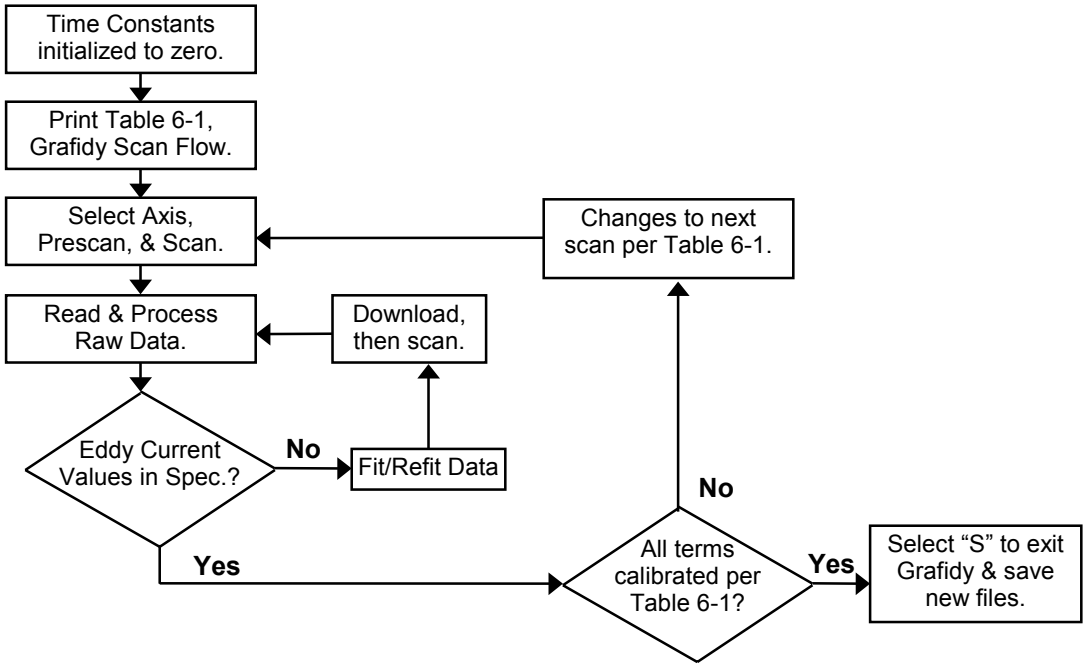
13. **RF/PDU (SRFD) or SRF Cabinets.** Install a rotary step attenuator set to 20dB between J1 on the rear of the System Cabinet (exciter output) and J1 on the fiber optic bracket at the rear of the RF/PDU. (J1 leads to the RFI input).

6- GRAFIDY PROCEDURE

Grafidy is the name of the Eddy Current Compensation procedure. This is a very involved procedure, please follow the procedure carefully. Illustration 6-1 is a general flowchart of Grafidy.

Note

Short time constants are compensated for using default values that are in the default Grafidy calibration files.



GRAFIDY FLOWCHART
ILLUSTRATON 6-1

6-1 Grafidy Scan Sequence

Table 6-1 is a Grafidy scan sequence flow. It is **strongly recommended** that you print this table as a guide to ensure that you complete all calibrations required, in the proper order. The scan order listed in the table starts with long-term time constants, followed by cross terms, then B_0 terms.

Note

VLTC FIT IS REQUIRED FOR SYSTEMS WITH SPECTROSCOPY (PROBE OR MULTI-NUCLEAR SPECTRO) and systems with a SV,SX,CX, or LCC magnet.

Hardware and Phantom Set-up

Software Set-up

TABLE 6-1
GRAFIDY SCAN SEQUENCE FLOW

LOCATION	**ILLUS. 5-1/6-2**	**THIS TABLE**	**THIS TABLE**	**SEC. 6-3**	**SEC. 6-4 (LIN.) SEC. 6-5 (B_0)**	**SPEC DATA (Absolute Values) Repeat Scan, Read and Process and Fit for each term/axis until in SPEC.**			
TERM	**AXIS SETUP**	**CV: MODE**	**CV: AXIS**	**READ & PROCESS**	**FIT**	**2.5-10 MSEC**	**10-100 MSEC**	**100-2000 MSEC**	**2-100 SEC**
*VLTC B_0	**X**	3 (VLONG)	0 (X)	B_0	B_0	-	-	-	≤ 0.10%
LONG	X	**0 (LONG)**	0 (X)	**LINEAR**	LINEAR	≤ 0.09%	≤ 0.030%	≤ 0.018%	-
B_0	X	0 (LONG)	0 (X)	**B_0**	B_0	≤ 0.10%	≤ 0.10%	≤ 0.10%	-
CROSS	X	0 (LONG)	**1 (Y)**	**LINEAR**	LINEAR	≤ 0.09%	≤ 0.030%	≤ 0.018%	-
CROSS	X	0 (LONG)	**2 (Z)**	LINEAR	LINEAR	≤ 0.09%	≤ 0.030%	≤ 0.018%	-
B_0 Recheck	X	0 (LONG)	**0 (X)**	**B_0**	B_0	≤ 0.10%	≤ 0.10%	≤ 0.10%	-
*VLTC B_0	**Y**	**3 (VLONG)**	**1 (Y)**	B_0	B_0	-	-	-	≤ 0.10%
LONG	Y	**0 (LONG)**	1 (Y)	**LINEAR**	LINEAR	≤ 0.09%	≤ 0.030%	≤ 0.018%	-
B_0	Y	0 (LONG)	1 (Y)	**B_0**	B_0	≤ 0.10%	≤ 0.10%	≤ 0.10%	-
CROSS	Y	0 (LONG)	**0 (X)**	**LINEAR**	LINEAR	≤ 0.09%	≤ 0.030%	≤ 0.018%	-
CROSS	Y	0 (LONG)	**2 (Z)**	LINEAR	LINEAR	≤ 0.09%	≤ 0.030%	≤ 0.018%	-
B_0 Recheck	Y	0 (LONG)	**1 (Y)**	**B_0**	B_0	≤ 0.10%	≤ 0.10%	≤ 0.10%	-
*VLTC	**Z**	**3 (VLONG)**	**2 (Z)**	**LINEAR**	LINEAR	-	-	-	≤ 0.018%
*VLTC B_0	Z	3 (VLONG)	2 (Z)	**B_0**	B_0	-	-	-	≤ 0.10%
LONG	Z	**0 (LONG)**	2 (Z)	**LINEAR**	LINEAR	≤ 0.09%	≤ 0.030%	_ 0.018%	-
B_0	Z	0 (LONG)	2 (Z)	**B_0**	B_0	≤ 0.10%	≤ 0.10%	≤ 0.10%	-
*VLTC (CROSS)	Z	**3 (VLONG)**	**0 (X)**	**LINEAR**	LINEAR	-	-	-	≤ 0.018%
CROSS	Z	**0 (LONG)**	0 (X)	LINEAR	LINEAR	≤ 0.09%	≤ 0.030%	≤ 0.018%	-
*VLTC (CROSS)	Z	**3 (VLONG)**	**1 (Y)**	LINEAR	LINEAR	-	-	-	≤ 0.018%
CROSS	Z	**0 (LONG)**	1 (Y)	LINEAR	LINEAR	≤ 0.09%	≤ 0.030%	≤ 0.018%	-
B_0 Recheck	Z	0 (LONG)	**2 (Z)**	**B_0**	B_0	≤ 0.10%	≤ 0.10%	≤ 0.10%	-

***** VLTC FIT IS REQUIRED FOR SYSTEMS WITH SPECTROSCOPY (PROBE OR MULTI-NUCLEAR SPECTRO) and systems with a SV,SX,CX, or LCC magnet.

NOTE 1: SELECT **[DOWNLOAD]** BEFORE PERFORMING EACH SCAN.

NOTE 2: SHORT TIME CONSTANTS ARE COMPENSATED FOR USING DEFAULT VALUES IN THE GRAFIDY CALIBRATION FILES.

6-2 Setup Scan, Select Axis, Prescan, Scan for the Whole-Body Gradient

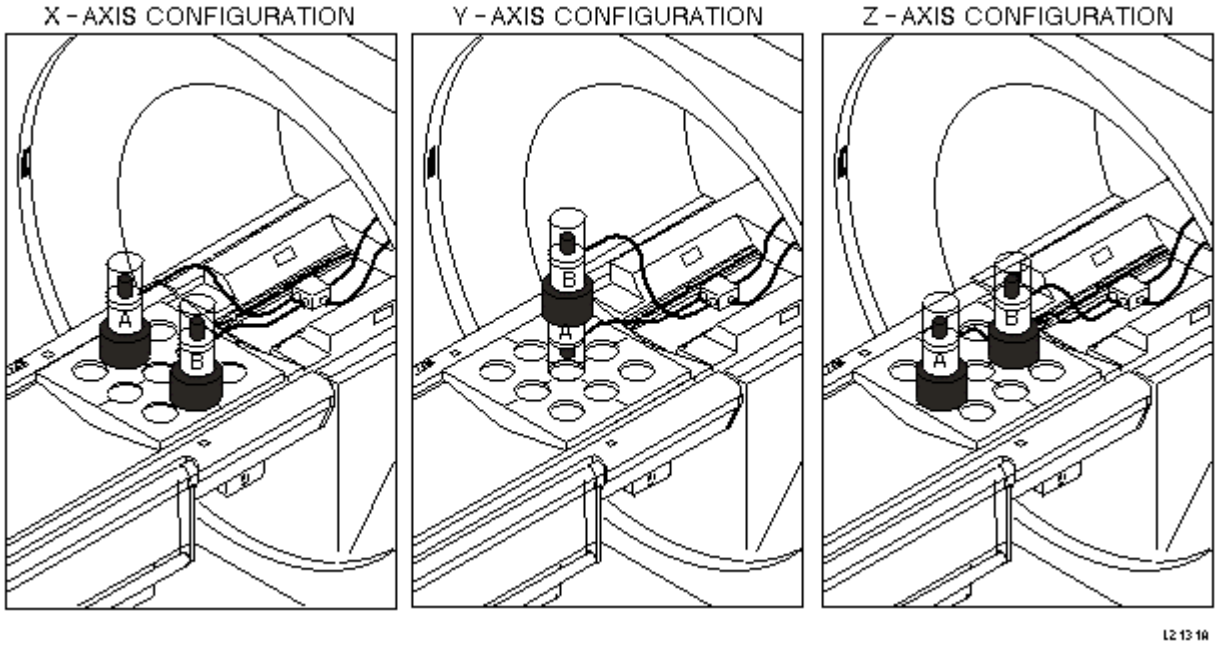
1. At the operator work space, prepare the system for a Grafidy scan using the scan protocol shown in the "Service Protocols" procedure located under **[Software Utilities]** menu on the service methods CD-ROM, or for the alternate proprietary procedure, see below.

   Alternative proprietary procedure:
   a. Click on **[New Patient]** , and enter **geservice**
   b. Name: **Grafidy**
   c. Weight (lb.): **111**
   d. Setup Patient Protocols to **Service**
   e. In the protocol field, type **o.5** (o= other, 1= series number) to load the protocol.
   f. Check the **GradMode** field is set to **WHOLE**.
   g. Select: **[Save Series]**.

2. Do the following for each term:
   - Configure the phantom for axis to be calibrated. See Illustration 6-2.
   - Set ***Axis*** **CV** per Table 6-1 (This selects the physical axis. Right click on **[Research Operation]**. Select **[Display CVs]**. In the CV Name field type 0 for X, 1 for Y, or 2 for Z Axis).
   - Set ***mode*** **CV** to **3** for VLTC, or **0** for Long time constants.

Note

Short time constants are compensated for using default values that are in the default Grafidy calibration files.



GRAFIDY PHANTOM CONFIGURATIONS
ILLUSTRATION 6-2

3. Select [**Research Operations]**. From Menu, select **[Download]**.

4. Right click on **[Research Operations]** and select **[Setup Params]** from the Scan Operations list. Enter the values listed in Table 6-2.

TABLE 6-2
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]

Note

ACGD systems: The waveform used to perform the Auto DC Offset procedure is generated locally in the gradient cabinet on the GIP Module. Therefore, it is not necessary to set gradshim currents (which originate from the IPG) to zero before invoking this procedure.

5. Click on **[Manual Prescan]** and setup Twin Plot mode. See Table 6-3.

TABLE 6-3
MANUAL PRESCAN

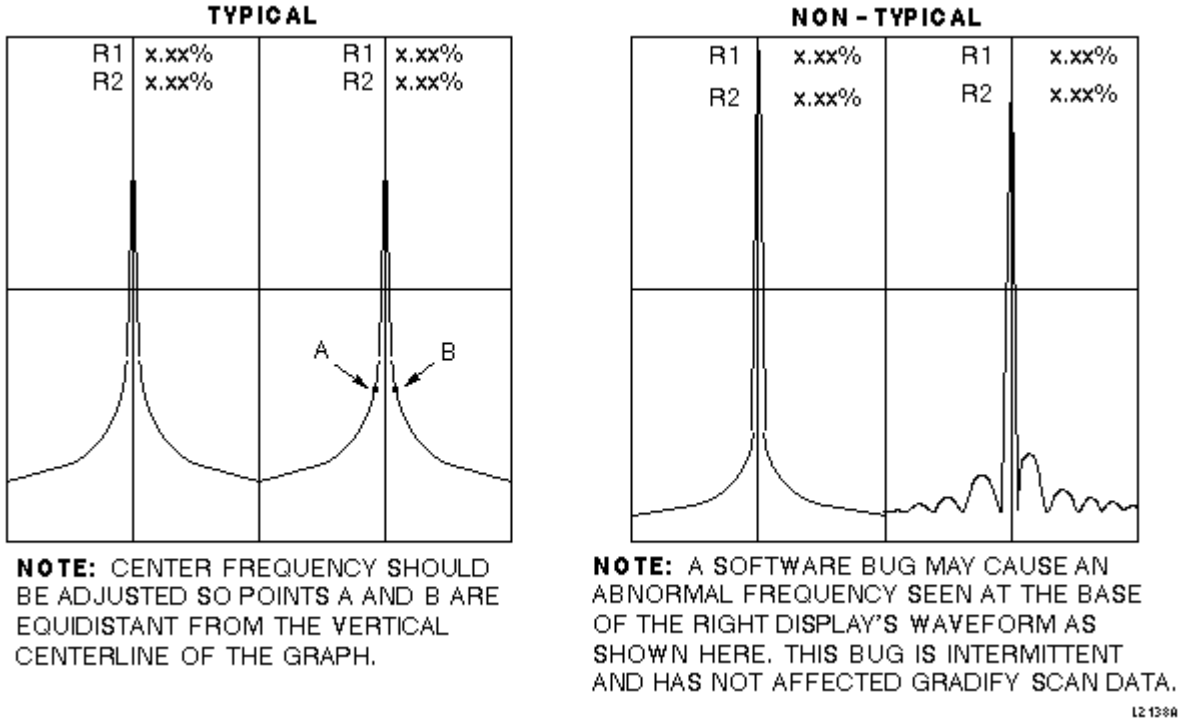
PULL DOWN MENU	**[Windows]**
Select:	**Two Windows**
WINDOW ONE	
Type:	**P. Spect**
Plot Gain:	**1**
WINDOW TWO	
Type:	**P. Spect**
Plot Gain:	**1**

Note

If you DO NOT get TWO PEAKS as indicated in Illustration 6-3, switch to **Center Frequency FINE, and then toggle back to Center Frequency COARSE.** The Power Spectrums should appear similar in amplitude, and general size. If not, you may have a setup problem; check your setup by referring to Section 8.

. Perform center frequency check. Adjust TG to peak as usual for transmit power. Record the TG value for next pass re-use. The R1% number on the power spectrum at peak power must be $\geq$ 15% to ensure stable results. If not, verify the Grafidy vial has enough fluid and replace as necessary.

An example of a typical and an atypical prescan display are shown in Illustration 6-3. Examine the typical example and verify that your display is somewhat similar. Peaks of two waveforms need not be exactly equal.



GRAFIDY PRESCAN
ILLUSTRATION 6-3

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 8, Functional Check of Grafidy Hardware.

If the IP screen goes blank, select **[Back Up]** and re-enter **[Manual Prescan]**.

7. When Transmit Gain has been peaked properly , select **[Done].**

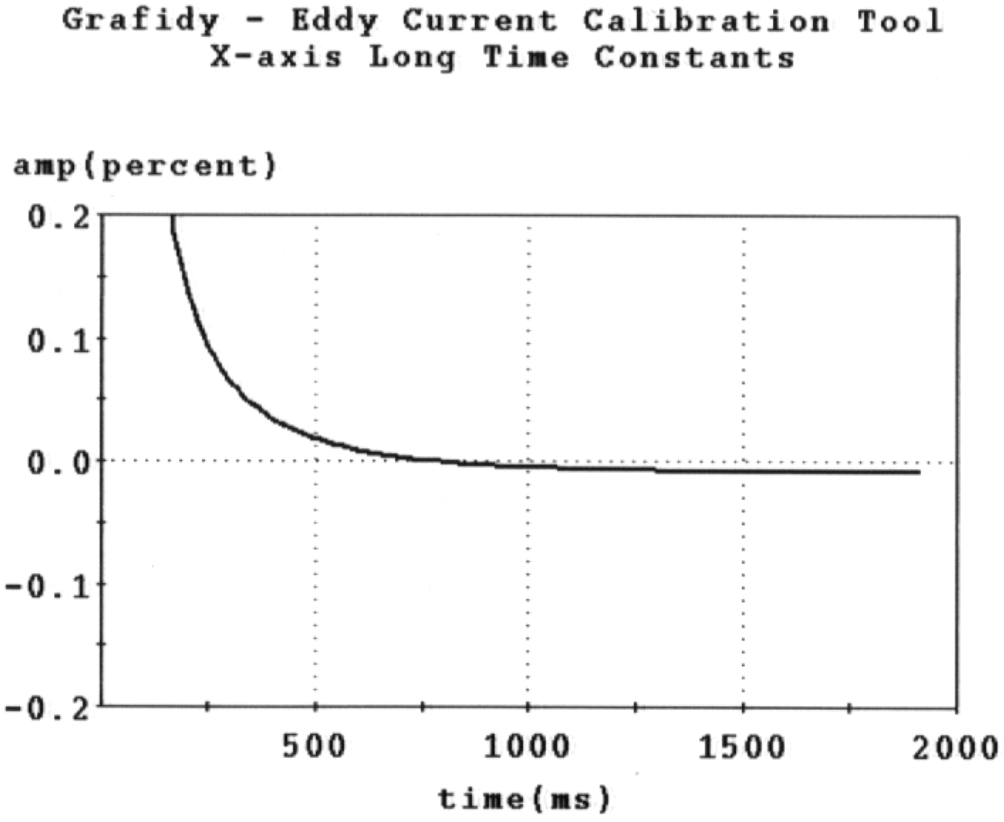
8. Select **[Scan].**

9. When the scan is finished, continue at *Section 6-3, Read and Process Raw Data*.

6-3 Read and Process Raw Data

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..5) [1] :	**1 <Enter>**
Please enter runfile number : 1024	**<Enter>** (Read/process data from most recent scan.)
Coils Along ()axis Coil A Position: a.aaaaa cm Coil B Position: a.aaaaa cm	

See Illustr... Current response t...



UNCOMPENSATED LINEAR LONG TIME CONSTANT EDDY CURRENT RESPONSE PLOT
ILLUSTRATION 6-4

```
 Linear Eddy Current Performance:
  Max Deviation:
   2000ms to 200000ms /
```

<-- **Record Very Long Time Constant Linear eddy current values on Data Sheet in back of this procedure.** If values *are* in spec then continue at next term in *Section 6-2; Select Axis, Prescan, Scan.*

_____

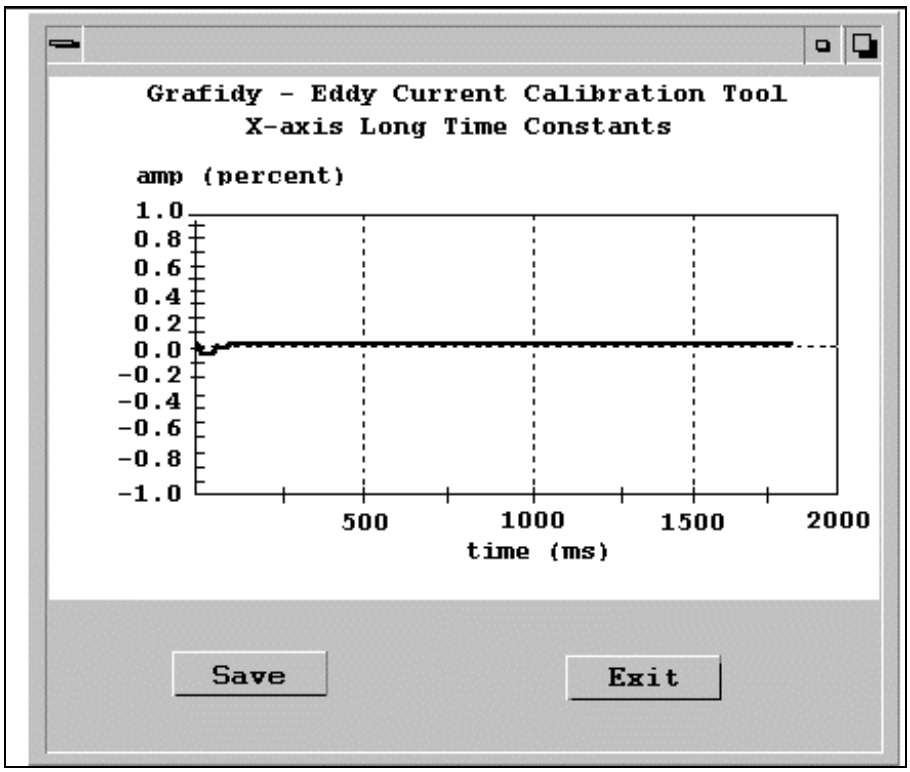
```
B0 Eddy Current Performance:
  Max Deviation:
   2000.00ms to 200000ms /
```

Record B_0 values on Data Sheet at end of this procedure if doing B0 terms. If values *are* in spec then continue at next term in Section *6-2; Select Axis, Prescan, Scan*.
If you are doing B0 terms and the values *are not* in spec, continue at *Section 6-5, Fit/Refit B0 Terms*.

_____

Note

If Linear eddy current values are not in spec, continue at Section 6-4 and 6-5 Fit/Refit Very Long Time Constant B0 terms. See Illustration 6-5 for an example of the B_0 Eddy Current response that is displayed at this point. (There is no need to *save* the B_0 display to a postscript file; Select **[Exit]** and continue**)**.



BO EDDY CURRENT RESPONSE PLOT
ILLUSTRATION 6-5

6-4 Fit/Refit Linear Terms

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	(**S** will SAVE calculation and exit.) (**Q** will QUIT without saving calculation.)
Enter Choice: (0..4) [1] :	**2<Enter>** (Select Fit.)
GRAFIDY - Fit Menu	Note: "Fit B0 Data" choice is not present during cross terms and short terms. Also, “Fit Linear Data” is not an available choice for VLTCs. Only applicable fit data choices are displayed.
2 - Fit B0 Data	
S or Q - Exit to Tools Menu	(**S** will SAVE calculation and exit.) (**Q** will QUIT without saving calculation.)
Enter Choice: (1..2) [1] :	**1<Enter>** (Select Linear)
Initial fit (or Refit): Hit enter to continue, s or q	to return to main menu: ..

```
Initial fit (or Refit)in progress..
*****************
  Long TC Linear Fit Results:
     tau[1]=  18.98 ms alpha[1]=0.01 percent
     tau[2]=  40.96 ms alpha[2]=0.00 percent
     tau[3]= 212.28 ms alpha[3]=0.00 percent
     tau[4]= 463.84 ms alpha[4]=0.00 percent
Do you want to plot linear data? (Y,N) [N] : ....... Y<Enter>
```

Y<Enter> (Plot the data and view it on the image display. Accept all default parameters for the plots.)

```
Do you want to accept new fit parameters?(Y,N)[N]:..
```

Y <Enter> to save the new parameters to a file. Then from **Research Operations** select **[Download]** to write these parameters to the IPG. Then select **[Scan]** to collect raw data using the new parameters.
(Select **N** only if the plot looks unexpectedly bad).

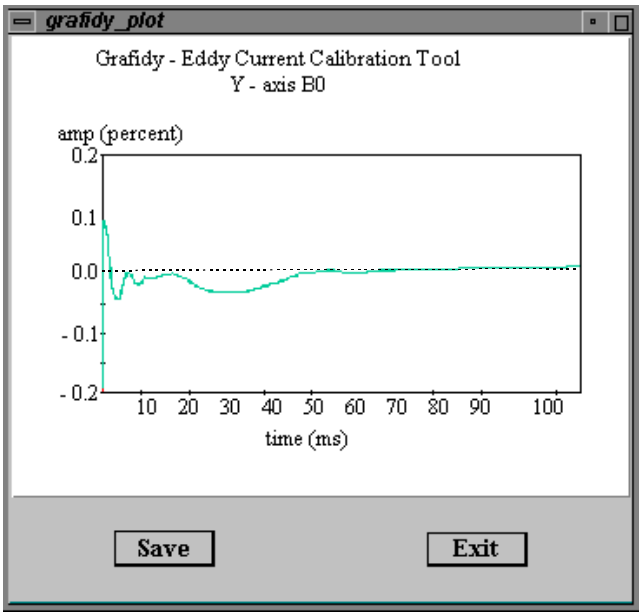
```
WARP Coefficients Updated From working Parameter Set.
```

Return to *Section 6-3, Read and Process Raw Data* to process the new raw data after the scan completes to get the linear eddy current response.

6-5 Fit/Refit B_0 Terms

Note

X and Y B0 axes calibrations may fail to meet spec for magnet types: Oxford, S-V, Cx, and LCC. If failure is being caused from the steep slope in the beginning of the graph shown in Illustration 6-6, ignore failure, image quality will not be affected. If failure is a result of something else, calibrate axes as close to spec as possible.



Y-AXIS B_0 PLOT
ILLUSTRATION 6-6

Fit B_0 Constant Raw Data (Use for B_0 terms only) as follows:

OUTPUT/PROMPTS	INPUTS/COMMENTS
GRAFIDY - Eddy Current Analysis	
1 - Read and Process Raw Data 2 - Fit 3 - Initialize Parameters 4 - System Status	
	(**S** will SAVE calculation and exit.)
S or Q - Exit to Tools Menu	(**Q** will QUIT without saving calculation.)
Enter Choice: (0..4) [1] :	**2<Enter>** (select Fit) Note: "Fit B0 Data" choice is not present during cross terms and short terms. Also, “Fit Linear Data” is not an available choice for VLTCs. Only applicable fit data choices are displayed.
GRAFIDY - Fit Menu	
1 - Fit Linear Data 2 - Fit B0 Data	
	(**S** will SAVE calculation and exit.)
S or Q - Exit to Tools Menu	(**Q** will QUIT without saving calculation.)
Enter Choice: (1..2) [1] :	**2<Enter>** (Select B_0.)
Initial fit (or Refit): Hit enter to continue, s or q to return to main menu:	**<Enter>** (to continue)
Initial fit (or Refit) in progress.. ********	("Refit" is shown for second and additional iterations.)
Long Time-Constant B0 Fit Results: tau[1] = 6.38 ms alpha[1] = 0.08 percent tau[2] = 26.62 ms alpha[2] = -0.02 percent tau[3] = 234.67 ms alpha[3] = 0.00 percent tau[4] = 1.00 ms alpha[4] = -1.46 percent	
Do you want to plot B0 data? (Y,N) [N] :	**Y<Enter>** (Plot the data and view it on the image display. Accept the default parameters for the plot.)
Do you want to accept new fit parameters?(Y,N)[N]:..	**Y<Enter>** to save the new parameters to a file. Then from **Research Operations,** select **[Download]** to write these parameters to the IPG. Then select **[Scan]** to collect raw data using the new parameters. (Select **N** only if the plot looks unexpectedly bad.)

OUTPUT/PROMPTS	INPUTS/COMMENTS
WARP Coefficients Updated From Working Parameter Set	

Note

Review Linear eddy current values when processing B0 Raw Data to verify linear data does not become out of spec. Otherwise, you will have start over on that axis.

Return to *Section 6-3, Read and Process Raw Data* to process the new raw data after the scan completes to get the B0 eddy current response.

6-6 Select *S* to Exit Grafidy

Select *S* to exit Grafidy and save the new files created during this procedure. If you select *Q* to exit Grafidy, you will **LOSE** the files created since the last save. You will also have the option to clean up all intermediate working files. Answer "Y" at the prompt to delete the working files.

6-7 Repeat GRAM DC Offset Adjustment

The Grafidy process applies a DC voltage which must be removed after Grafidy is complete. Repeat the DC Offset Adjustment described in Section 3.

6-8 Repeating Grafidy for the Zoom Gradient

Repeat the Grafidy procedure again from section 5 up to and including 6-7, selecting the **ZOOM** mode in the Grafidy popup menu, and as the **GradMode** field in the Service o.5 protocol (section 6-2).

The Grafidy kit should still be set-up at this stage, so most of section 5 need not be repeated.

If this section is being run on a different occasion, repeat all the set-up in section 5.

7- SYSTEM RESTORATION

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. Reconnect Body Receive line to Body Pre-amp Output if you used this method.

2. Remove the Grafidy Kit from the system.

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

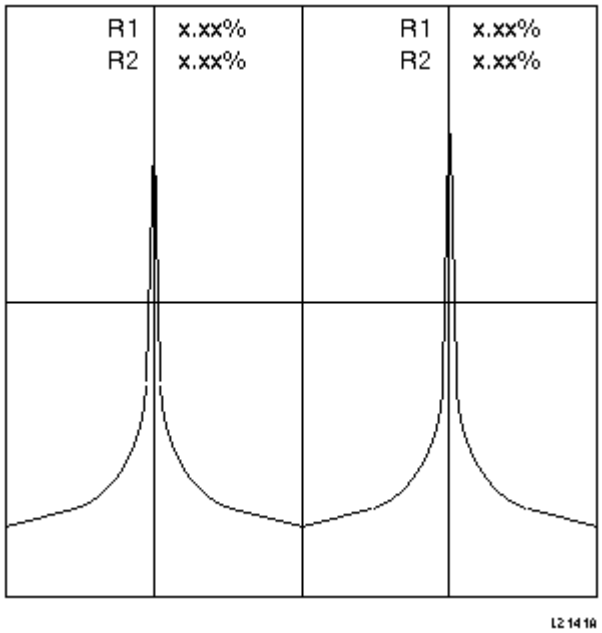
4. Replace ACGD cabinet front cover.

8- CHECK OF GRAFIDY HARDWARE AND COILS

8-1 Functional Check of Grafidy Hardware

1. Start manual prescan using the Grafidy hardware. Verify that the display is similar to the display in Illustration 6-6. If it is not, check the following items:

   - Are all cables, including the coil/samples, connected per Illustration 5-2 and 5-3?
   - 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 (DAB Out) on the CERD module (alternating from 0 volts to 2.5–4.0 volts)?



TYPICAL GRAFIDY PRESCAN
ILLUSTRATION 6-6

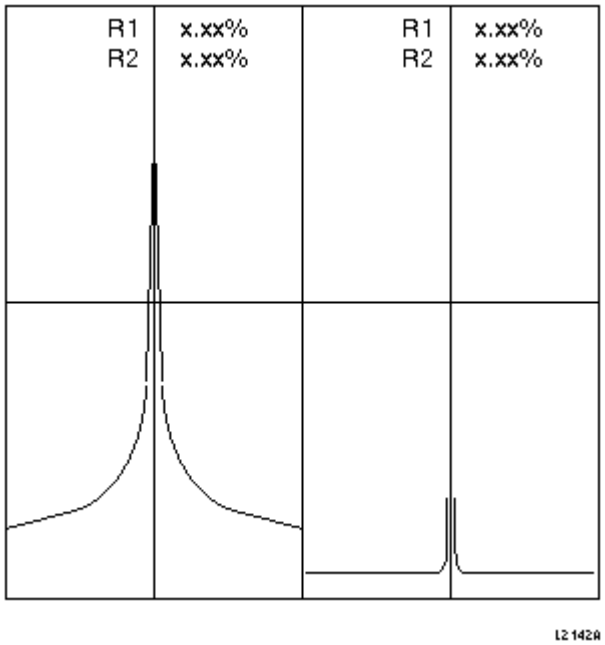
2. Select **[Done]**

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 6-7. 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 6-7

8-2 Functional Check/Maintenance of Grafidy Coil

8-2-1 1.5T Coil Impedance Check

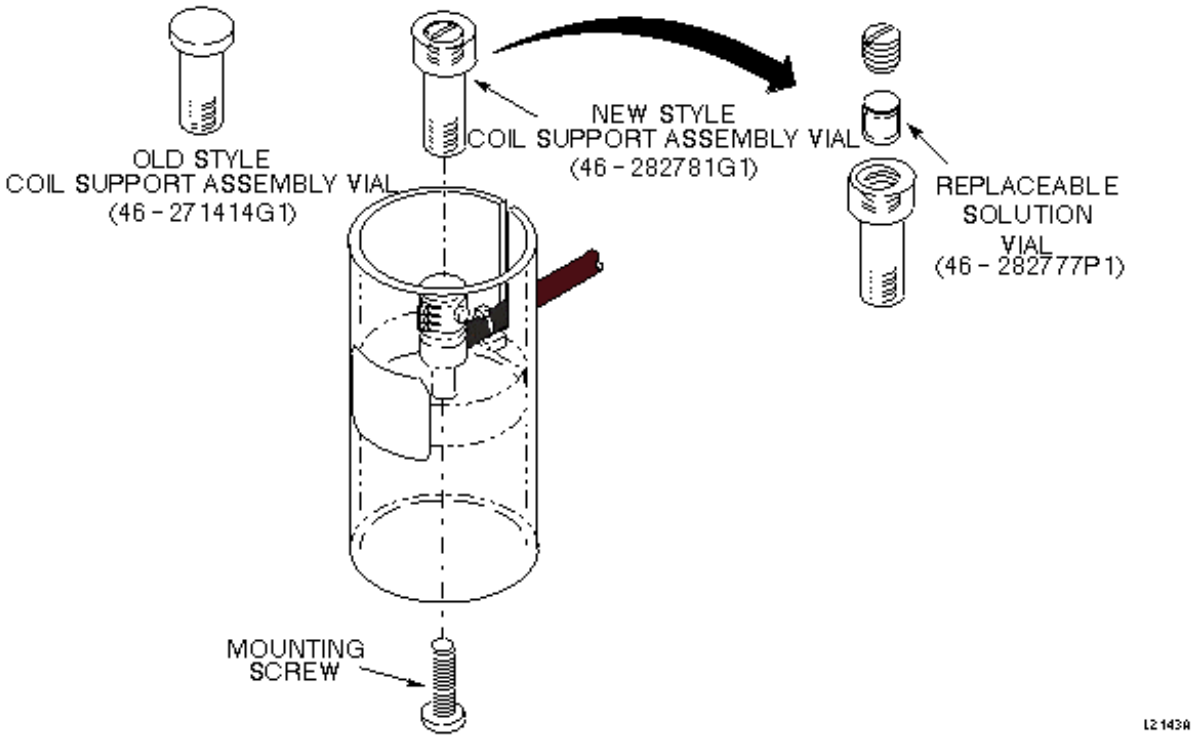
1. To verify the functionality of the 1.5T Grafidy coil, measure the impedance. To do this, the pin diode must be forward biased. Use a BNC tee adapter to inject a 10-mA dc current at the point where the impedance meter probe mates with the quarter wavelength cable. A 1000-ohm resistor, driven by a 10-volt 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

8-3 Solution Vial Replacement

1. The Grafidy coils have replaceable solution vials; see Illustration 6-8 for assembly and part number information.



GRAFIDY COIL/SAMPLE REPLACEMENT
ILLUSTRATION 6-8

9- SAVING/RESTORING COEFFICIENT FILES

This section details how to back up the ecccoeff.dat, and the gram_tune.dat files before a pass of Grafidy is performed. This is useful if you are in troubleshooting mode, and want to restore the system to its original calibration. There is a file for each gradient coil as follows:
ecccoeff.dat.WHOLE and *gram_tune.dat.WHOLE*
ecccoeff.dat.ZOOM and *gram_tune.dat.ZOOM*

The ecccoeff.dat files are also used to store the B_0 (zeroeth order) coefficients for each coil and work in conjunction with the gram_tune.dat files. The gram_tune.dat files for the selected coil is downloaded at the beginning of a scan, when Grafidy is run, or when Gradient Diagnostics are run. This file contains the eddy current (first order) coefficients.

9-1 Backing up the Files

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

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 is inserted in 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.

From a C-Shell on the Service Desktop:

1. At the prompt, type: **cd /usr/g/caldir <Enter>**
2. For all systems, type:
   cp ecccoeff.dat.WHOLE ecccoeff.dat.WHOLE.bak <Enter>
   cp ecccoeff.dat.ZOOM ecccoeff.dat.ZOOM.bak <Enter>
   cp gram_tune.dat.WHOLE gram_tune.dat.WHOLE.bak <Enter>
   cp gram_tune.dat.ZOOM gram_tune.dat.ZOOM.bak <Enter>

9-2 Restore the Files

1. Ensure that you are in the */usr/g/caldir* directory.
2. Type:
   cp ecccoeff.dat.WHOLE.bak ecccoeff.dat.WHOLE <Enter>
   cp ecccoeff.dat.ZOOM.bak ecccoeff.dat.ZOOM <Enter>
   cp gram_tune.dat.WHOLE.bak gram_tune.dat.WHOLE <Enter>
   cp gram_tune.dat.ZOOM.bak gram_tune.dat.ZOOM

9-2 System Files Restoration

Perform a check scan to verify system functionality.

10- QUICK REFERENCE SECTION FOR GRAM TUNING

How to Use This Quick Reference Section

This section provides the necessary steps to complete GRAM tuning, but without the detailed step-by-step instructions and supporting illustrations. Obviously this section is intended for the very experienced "tuners." This quick reference can also be used to verify all the major sections have been completed. The detailed step-by-step procedure started at *Section 2, Tools Required and Preliminary Setups.*

10-1 GRAM DC Offset

Select **[Diagnostics]**, then select **[IPG], [Manual], [Digital DC Offset (Whole)], [Run Diagnostics].** Repeat for **[Digital DC Offset (Zoom)].**

10-2 LCoil Adjustments

Select **[Diagnostics], [Start], [Board Level Tests - IPG], [Manual], [LCoil Adjust (Whole)].** Then select **[Run Diags].** Repeat for **[LCoil Adjust (Zoom)].**

10-3 Grafidy Procedure

1. Start Grafidy Analysis tool. Highlight **WHOLE** or **ZOOM** coil. Select "Initialize Parameters" to clear all axes and time constant parameters to zero.

2. Install the Grafidy phantoms for axis to be calibrated.

Note

Short time constants are compensated for using default values that are in the default Grafidy calibration files (these systems no longer run short time constant compensation).

3. The sequence to perform Grafidy is set forth in Table 10-1. It is important to select the same **GradMode** in the scan as was highlighted for the Grafidy Tool.

Note

VLTC FIT IS REQUIRED FOR SYSTEMS WITH SPECTROSCOPY (PROBE OR MULTI-NUCLEAR SPECTRO) and systems with a SV,SX,CX, or LCC magnet.

In the next step, you will change the CV values as indicated. Depending on which Release you are using, see the User Interface Tutorial for specific help with User CVs.

4. Set CVs for the axis and term being calibrated:
   axis=**0** (for *x*), 1 (for *y*), 2 (for *z*),
   mode=**0** (for long, cross, & B_0 terms), **1** for (short terms)
   [Setup Params] TG=**0**, R1=**13**, R2=**14**, 4 frames, 1,0; 3,0
   Two Windows; One: P.Spect,1 Window Two: P.Spect,1

5. **[Manual Prescan]**, peak TG as usual.

6. **[Scan].**

7. Read and process raw data, use defaults, record max dev values.

8. If performing Grafidy for linear long, cross term, or short term time constants do a Linear Fit of the data. For B_0 terms, do a B_0 Fit of the data; use defaults, accept suggested values.

9. Accept the new parameters and then **[Download]** them to the IPG.

10. **[Scan]** with the new parameters, then repeat Read and Process to see the results. Continue doing Refits until the parameters are in spec. Then record on data sheet.

11. Set up the phantoms and CVs for the next axis or term. **[Manual Prescan],** adjust TG and **[Scan].**

12. Continue calibrations in the order set forth in Table 10-1.

13. Select **S** to exit Grafidy and save the new files created during this procedure.

10-4 GRAM DC Offset (again)

1. The Grafidy process applies a DC voltage which must be removed after Grafidy is complete. Repeat the DC Offset Adjustment described in Section 3.

10-5 Repeating the procedure for all gradients

The Grafidy Scan and Analysis Tool must be run separately for each gradient coil of the ***TwinSpeed***.

Hardware and Phantom Set-up

Software Set-up

TABLE 10-1
GRAFIDY SCAN SEQUENCE FLOW

LOCATION	**ILLUS. 5-1/6-2**	**THIS TABLE**	**THIS TABLE**	**SEC. 6-3**	**SEC. 6-4 (LIN.) SEC. 6-5 (B_0)**	**SPEC DATA (Absolute Values) Repeat Scan, Read and Process and Fit for each term/axis until in SPEC.**			
TERM	**AXIS SETUP**	**CV: MODE**	**CV: AXIS**	**READ & PROCESS**	**FIT**	**2.5-10 MSEC**	**10-100 MSEC**	**100-2000 MSEC**	**2-100 SEC**
*VLTC B_0	**X**	3 (VLONG)	0 (X)	B_0	B_0	-	-	-	≤ 0.10%
LONG	X	**0 (LONG)**	0 (X)	**LINEAR**	LINEAR	≤ 0.09%	≤ 0.030%	≤ 0.018%	-
B_0	X	0 (LONG)	0 (X)	**B_0**	B_0	≤ 0.10%	≤ 0.10%	≤ 0.10%	-
CROSS	X	0 (LONG)	**1 (Y)**	**LINEAR**	LINEAR	≤ 0.09%	≤ 0.030%	≤ 0.018%	-
CROSS	X	0 (LONG)	**2 (Z)**	LINEAR	LINEAR	≤ 0.09%	≤ 0.030%	≤ 0.018%	-
B_0 Recheck	X	0 (LONG)	**0 (X)**	**B_0**	B_0	≤ 0.10%	≤ 0.10%	≤ 0.10%	-
*VLTC B_0	**Y**	**3 (VLONG)**	**1 (Y)**	B_0	B_0	-	-	-	≤ 0.10%
LONG	Y	**0 (LONG)**	1 (Y)	**LINEAR**	LINEAR	≤ 0.09%	≤ 0.030%	≤ 0.018%	-
B_0	Y	0 (LONG)	1 (Y)	**B_0**	B_0	≤ 0.10%	≤ 0.10%	≤ 0.10%	-
CROSS	Y	0 (LONG)	**0 (X)**	**LINEAR**	LINEAR	≤ 0.09%	≤ 0.030%	≤ 0.018%	-
CROSS	Y	0 (LONG)	**2 (Z)**	LINEAR	LINEAR	≤ 0.09%	≤ 0.030%	≤ 0.018%	-
B_0 Recheck	Y	0 (LONG)	**1 (Y)**	**B_0**	B_0	≤ 0.10%	≤ 0.10%	≤ 0.10%	-
*VLTC	**Z**	**3 (VLONG)**	**2 (Z)**	**LINEAR**	LINEAR	-	-	-	≤ 0.018%
*VLTC B_0	Z	3 (VLONG)	2 (Z)	**B_0**	B_0	-	-	-	≤ 0.10%
LONG	Z	**0 (LONG)**	2 (Z)	**LINEAR**	LINEAR	≤ 0.09%	≤ 0.030%	_ 0.018%	-
B_0	Z	0 (LONG)	2 (Z)	**B_0**	B_0	≤ 0.10%	≤ 0.10%	≤ 0.10%	-
*VLTC (CROSS)	Z	**3 (VLONG)**	**0 (X)**	**LINEAR**	LINEAR	-	-	-	≤ 0.018%
CROSS	Z	**0 (LONG)**	0 (X)	LINEAR	LINEAR	≤ 0.09%	≤ 0.030%	≤ 0.018%	-
*VLTC (CROSS)	Z	**3 (VLONG)**	**1 (Y)**	LINEAR	LINEAR	-	-	-	≤ 0.018%
CROSS	Z	**0 (LONG)**	1 (Y)	LINEAR	LINEAR	≤ 0.09%	≤ 0.030%	≤ 0.018%	-
B_0 Recheck	Z	0 (LONG)	**2 (Z)**	**B_0**	B_0	≤ 0.10%	≤ 0.10%	≤ 0.10%	-

***** VLTC FIT IS REQUIRED FOR SYSTEMS WITH SPECTROSCOPY (PROBE OR MULTI-NUCLEAR SPECTRO) and systems with a SV,SX,CX, or LCC magnet.

NOTE 1: SELECT **[DOWNLOAD]** BEFORE PERFORMING EACH SCAN.

NOTE 2: SHORT TIME CONSTANTS ARE COMPENSATED FOR USING DEFAULT VALUES IN THE GRAFIDY CALIBRATION FILES.

APPENDIX A - GRAFIDY DATA SHEETS

Whole-Body / Zoom Gradient

VERY LONG TIME CONSTANTS (Cross-term, Linear, Bo)					
Axis	**Time Interval (M Sec)**	**Run # _____ Max. Deviation**	**Run # _____ Max. Deviation**	**Run # _____ Max. Deviation**	**Specifications**
X (Coil) Bo axis = 0 (X)	2000-200,000				≤ 0.10% (B0)
Y (Coil) Bo axis = 1 (Y)	2000-200,000				≤ 0.10% (B0)
Z (Coil) Bo axis = 2 (Z)	2000-200,000				≤ 0.10% (B0)
Z (Coil) Linear axis = 2 (Z)	2000-200,000				≤ 0.018% (Linear)
Z(Coil) Cross-term axis = 0 (X)	2000-200000				≤ 0.018% (Cross-Term)
Z(Coil) Cross-term axis = 1(y)	2000-200000				≤ 0.018% (Cross-Term)

LINEAR LONG TIME CONSTANTS

X-Axis *CV "axis"=0(x)*	**Max. Deviation**		
Time Interval:	**2.5 – 10.00ms**	**10.00 – 100.00ms**	**100.00 – 2000.00ms**
Run #_____(baseline)			
Run #_____			
Run #_____			
Run #_____			
Specification:	≤0.09%	≤0.03%	≤0.018%

Y-Axis *CV "axis"=1(y)*	**Max. Deviation**		
Time Interval:	**2.5 – 10.00ms**	**10.00 – 100.00ms**	**100.00 – 2000.00ms**
Run #_____(baseline)			
Run #_____			
Run #_____			
Run #_____			
Specification:	≤0.09%	≤0.03%	≤0.018%

Z-Axis *CV "axis"=2(z)*	**Max. Deviation**		
Time Interval:	**2.5 – 10.00ms**	**10.00 – 100.00ms**	**100.00 – 2000.00ms**
Run #_____(baseline)			
Run #_____			
Run #_____			
Run #_____			
Specification:	≤0.09%	≤0.03%	≤0.018%

Whole-Body / Zoom Gradient

B0 TIME CONSTANTS

X-Axis *CV "axis"=0(x)*	**Max. Deviation**		
Time Interval:	**2.5 – 10.00ms**	**10.00 – 100.00ms**	**100.00 – 2000.00ms**
Run #_____(baseline)			
Run #_____			
Run #_____			
Run #_____			
Specification:	≤0.10%	≤0.10%	≤0.10%

Y-Axis *CV "axis"=1(y)*	**Max. Deviation**		
Time Interval:	**2.5 – 10.00ms**	**10.00 – 100.00ms**	**100.00 – 2000.00ms**
Run #_____(baseline)			
Run #_____			
Run #_____			
Run #_____			
Specification:	≤0.10%	≤0.10%	≤0.10%

Z-Axis *CV "axis"=2(z)*	**Max. Deviation**		
Time Interval:	**2.5 – 10.00ms**	**10.00 – 100.00ms**	**100.00 – 2000.00ms**
Run #_____(baseline)			
Run #_____			
Run #_____			
Run #_____			
Specification:	≤0.10%	≤0.10%	≤0.10%

Whole-Body / Zoom Gradient

LINEAR CROSS-TERM TIME CONSTANTS

X-Axis *CV "axis"=1(y)*	**Max. Deviation**		
Time Interval:	**2.5 – 10.00ms**	**10.00 – 100.00ms**	**100.00 – 2000.00ms**
Run #_____(baseline)			
Run #_____			
Run #_____			
Run #_____			
Specification:	≤0.09%	≤0.03%	≤0.018%

X-Axis *CV "axis"=2(z)*	**Max. Deviation**		
Time Interval:	**2.5 – 10.00ms**	**10.00 – 100.00ms**	**100.00 – 2000.00ms**
Run #_____(baseline)			
Run #_____			
Run #_____			
Run #_____			
Specification:	≤0.09%	≤0.03%	≤0.018%

Y-Axis *CV "axis"=0(x)*	**Max. Deviation**		
Time Interval:	**2.5 – 10.00ms**	**10.00 – 100.00ms**	**100.00 – 2000.00ms**
Run #_____(baseline)			
Run #_____			
Run #_____			
Run #_____			
Specification:	≤0.09%	≤0.03%	≤0.018%

Y-Axis *CV "axis"=2(z)*	**Max. Deviation**		
Time Interval:	**2.5 – 10.00ms**	**10.00 – 100.00ms**	**100.00 – 2000.00ms**
Run #_____(baseline)			
Run #_____			
Run #_____			
Run #_____			
Specification:	≤0.09%	≤0.03%	≤0.018%

Z-Axis *CV "axis"=0(x)*	**Max. Deviation**		
Time Interval:	**2.5 – 10.00ms**	**10.00 – 100.00ms**	**100.00 – 2000.00ms**
Run #_____(baseline)			
Run #_____			
Run #_____			
Run #_____			
Specification:	≤0.09%	≤0.03%	≤0.018%

Z-Axis *CV "axis"=1(y)*	**Max. Deviation**		
Time Interval:	**2.5 – 10.00ms**	**10.00 – 100.00ms**	**100.00 – 2000.00ms**
Run #_____(baseline)			
Run #_____			
Run #_____			
Run #_____			
Specification:	≤0.09%	≤0.03%	≤0.018%

Whole Body / Zoom Gradient

B0 RECHECK

X-Axis *CV "axis"=0(x)*	**Max. Deviation**		
Time Interval:	**2.5 – 10.00ms**	**10.00 – 100.00ms**	**100.00 – 2000.00ms**
Run #_____(baseline)			
Run #_____			
Run #_____			
Run #_____			
Specification:	≤0.10%	≤0.10%	≤0.10%

Y-Axis *CV "axis"=1(y)*	**Max. Deviation**		
Time Interval:	**2.5 – 10.00ms**	**10.00 – 100.00ms**	**100.00 – 2000.00ms**
Run #_____(baseline)			
Run #_____			
Run #_____			
Run #_____			
Specification:	≤0.10%	≤0.10%	≤0.10%

Z-Axis *CV "axis"=2(z)*	**Max. Deviation**		
Time Interval:	**2.5 – 10.00ms**	**10.00 – 100.00ms**	**100.00 – 2000.00ms**
Run #_____(baseline)			
Run #_____			
Run #_____			
Run #_____			
Specification:	≤0.10%	≤0.10%	≤0.10%

Note: Short time constants are compensated for using values in the default Grafidy calibration file.

Whole-Body / Zoom Gradient

REVISION HISTORY

REV	DATE	AUTHOR	PRIMARY REASONS FOR CHANGE
1	Sep 17, 2000	J.Gerber	Modified specifically for TwinSpeed
2	July 17, 2001	J.Gerber	Updated for TwinSpeed scanner for 9.0 release
3	Aug. 9, 2001	J. Wolak	Updated to merge changes from Milwaukee's published versions 6 & 7 of predecessor procedure (sysscar1) including: K. Keshena's note specifying that calibration must be maintained with original tool otherwise complete recalibration is required. Also M. Jones delete note in section 5, Updated Illus 6-4, Clarified, sec 6-7 and 10-4, Removed Linear Shorts data sheet. Also Added .WHOLE and .ZOOM extensions to file in sec. 3 step 5. Removed section 5-1 regarding 8.2.5 software. Deleted references to 1.0T and old RF cabinets. Updated section 9 to cover WB & Zoom files.
4	Jan. 31, 2002	K.Keshena	Changed all notes stating that VLTC are only necessary for Systems using Spectro to read as follows: VLTC FIT IS REQUIRED FOR SYSTEMS WITH SPECTROSCOPY (PROBE OR MULTI-NUCLEAR SPECTRO) and systems with a SV,SX,CX, or LCC magnet.