

TABLE OF CONTENTS

DESCRIPTION	2
1- OVERVIEW	2
1-1 EPI Calibration Prerequisites.....	2
1-2 Tools Required	2
1-3 EPI Calibration Procedure Order.....	3
2- BODY B₀ DITHER PROCEDURE.....	3
2-1 Body B ₀ Dither System Preparation.....	3
2-2 Body B ₀ Dither Procedure.....	4
3- GROUP DELAY PROCEDURE.....	10
3-1 Group Delay System Preparation.....	10
3-2 Group Delay Procedure.....	10
4- HEAD B₀ DITHER PROCEDURE.....	11
4-1 Head B ₀ Dither System Preparation	11
4-2 Head B ₀ Dither Procedure	12
5- B₀ IMAGE PROCEDURE.....	14
5-1 B ₀ Image Setup & Scan	14
5-2 B ₀ Image Analysis.....	15
REVISION HISTORY	16

DESCRIPTION

This procedure describes the manual EPI B0 Dither and Group Delay procedure. *(An alternate proprietary procedure is available for GE use and to sites with a valid Advanced Service Package Limited License. Refer to System Level Procedures: Setup and Cals: Echo Planar Test (EPT) procedure.)*

For the **TwinSpeed**, the user should select the appropriate GradMode, either WHOLE or ZOOM, and maintain the same GradMode throughout the tests. The tests can be applied to either GradMode, one at a time.

1- OVERVIEW

Short time constant eddy currents will cause phase error in the echoes of EPI scans. These phase errors will cause ghosting artifacts in EPI studies. The B₀ dither procedure will measure the amount of phase error and create a correction table used to correct for the phase errors. This procedure must be run in both the head and body modes since the amount of phase errors differs between the two.

1-1 EPI Calibration Prerequisites

Before performing the EPI calibration procedures, ensure the following system prerequisites are met. **Else, EPI calibration may be wrong, resulting in degraded EPI image quality.**

- LV Shim must be completed and in spec.
- Gradient calibrations must be completed and in spec.
- GRAM Tuning and Grafidy must be completed and in spec. This includes FRESBECC and ALL linear long and short time constant eddy currents.
- Verify that the system has no white pixel problem.

Note

B₀ Dither can have failing results if the phantom is not within 3mm of isocenter in all directions, (X,Y,Z). Check phantom centering before beginning this procedure.

Note

If Air bubbles exist in the phantom, artifacts can occur which could cause B₀ Dither to fail. Select another phantom if necessary.

1-2 Tools Required

- 100mm Sphere phantom, 46-317586G1
- EPI Foam Positioner, 2138870
- Grafidy Baseplate, 46-271410G1

1-3 EPI Calibration Procedure Order

EPI calibrations should be performed in the following order:

1. Bandpass Asymmetry Correction Characterization. (Refer to Set Up/ Calibrations, EPI BW Asymmetry Correction Char.)
2. Body B₀ Dither Calibration (in this document).
3. Group Delay Characterization (in this document).
4. Head B₀ Dither Calibration (in this document).

If any part of the gradient / GRAM subsystem, or head / body coils is changed out on the system, then run all calibrations in order. Attempting to run just individual parts to save time will only waste time.

2- BODY B₀ DITHER PROCEDURE

2-1 Body B₀ Dither System Preparation



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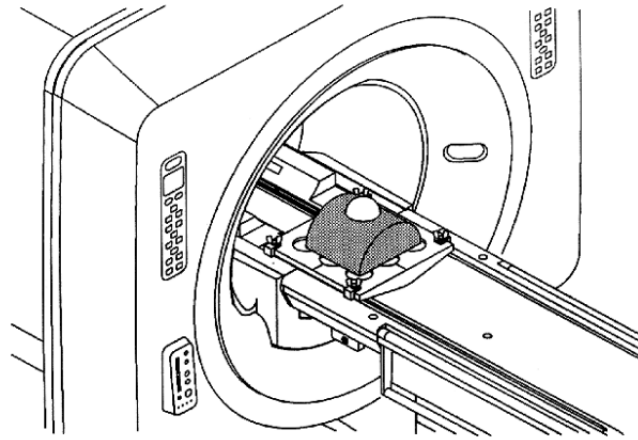


Possible equipment damage. Completely remove the quad head coil from the cradle. Failure to do so will damage the head coil T/R network.

Note

All EPI calibration procedure commands are case-sensitive. Failure to type the commands as shown in this procedure will cause the scripts to fail.

1. Completely remove the Quad Head Coil from the cradle.
2. Locate one of the 100mm spherical phantoms (if necessary, remove one of the spheres from the phased array TLT phantom) and place it in the EPI foam positioner. See Illustration 2-1.



EPI PHANTOM POSITIONING - BODY COIL
ILLUSTRATION 2-1

3. Landmark this phantom in the body coil using a Grafidy baseplate and the EPI foam positioner. See Illustration 2-1. The foam positioner places the phantom at isocenter in all three axes. Press **[LANDMARK]** and **[Advance TO SCAN]** buttons.
4. At the operator work space, prepare the system for a Body B0 Dither scan using the *Service Protocols* procedure located on the service methods CD-ROM, or for the alternate proprietary procedure, see below.

This alternate proprietary procedure is available for GE use, and to sites with a valid Advanced Service Package Limited License.

- a. Click on **[New Pt]**, and enter:
Id: **geservice**
Name: **body b0 dither**
Weight (Lb.): **111**
Set Patient Protocols to **Service**.
- b. In the Protocol field: *for Release 8.2.5:*
Type **o.46.1** (o=Other, 1= series), or
for Release 8.3 or later, type o.45.1
- c. For **TwinSpeed**, select the GradMode.

2-2 Body B₀ Dither Procedure

1. For the **TwinSpeed**, use the starting window of the LVShim function in the SDM to create the correct link for the GradMode to be used. Select LVShim, highlight either **WHOLE** or **ZOOM**, confirm this with OK, and when in the C-Shell for the LVShim function, simply quit.
2. On the Service Desktop open two C Shell windows (click **[C Shell]** two times). Size and move the windows so that both can be viewed.

3. In one window, type **cd /usr/g/bin <ENTER>**.
4. Check for existing calibration files by typing **ls -l *.esp.* <ENTER>** (this will list the head and body group delay files). Next type **ls -l b0_dither.* <ENTER>** (this will list the head and body b0dither calibration files). Finally type **ls -l b0vectors.dat.* <ENTER>** (this will list out the head and body b0 vector files).
5. Optional step (to save old files); If calibration files exist on the system, copy them to backup files by typing the followings commands (Note: Substitute in a date code for <date> such as 9_29 for a file backed up on Sept 29 - i.e b0vectors.dat.head.9_29):

mv b0vectors.dat.head b0vectors.dat.head.<date> <ENTER>

mv b0vectors.dat.body b0vectors.dat.body.<date> <ENTER>

mv delay.esp.head dely.esp.head.<date> <ENTER>

mv delay.esp.body dely.esp.body.<date> <ENTER>

mv b0_dither.cal.head b0_dither.cal..head.<date> <ENTER>

mv b0_dither.cal.body b0_dither.cal..body.<date> <ENTER>

6. Remotely log into the TPS from the other window by typing in the commands:

rlogin `hostname`-tps <ENTER> (The quote marks around the word `hostname` is found to the left of the **1** key on the keyboard.)

Log into local (l) or remote (r) VxWorks console? **local <ENTER>**

VxWorks login: **tps <ENTER>**

password: **tpsservice <ENTER>**

--> **pclog <ENTER>** (Tells recon to create the ref_fitc.dat and ref_fitl.dat files)

--> **pcgm <ENTER>** (puts recon into the EPI graph mode)

Note

When logged into the TPS, use **<Ctrl> -H** to delete a character and **<ctrl> -U** to delete an entire line.

7. Go back to the scan desktop and insure the scan protocol is loaded.
8. **[Modify CVs]** and verify the **cv pw_gxwl2 = 0** (for the first scan only). A total of 30 scans will be taken. For each scan the **cv pw_gxwl2** will be changed based on Table 2-1. Verify the **cv exp** corresponds to the appropriate **pw_gxwl2** value for your equipment type.

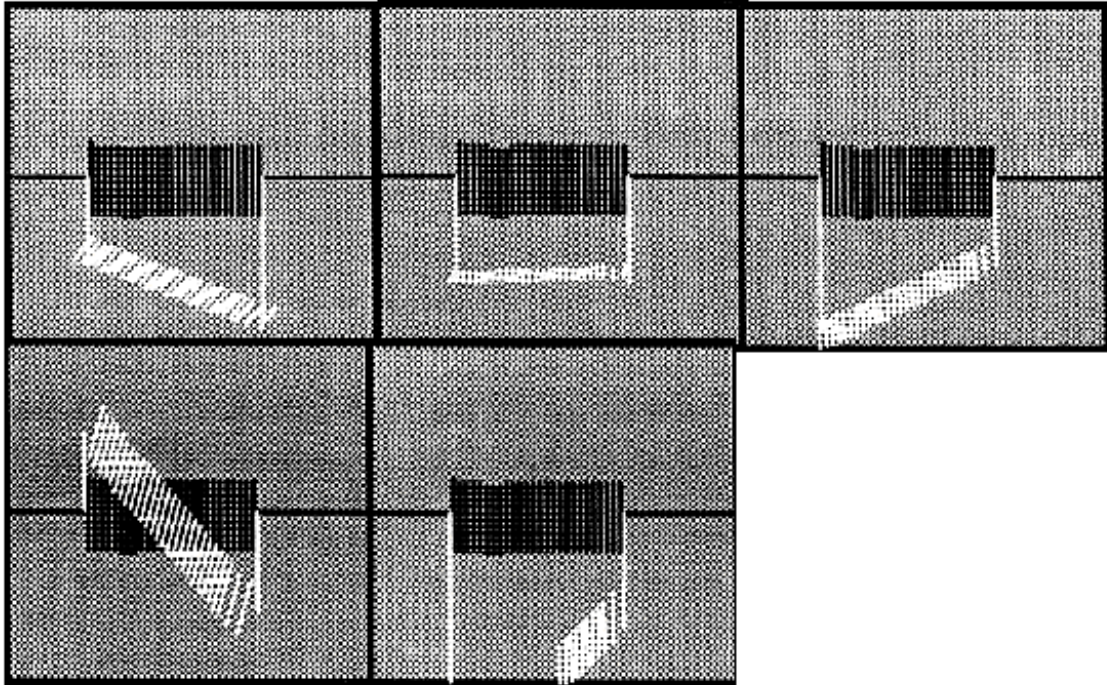
Note

You must download after every modification. Right-click on **[Research Operations]** and select **[download]**.

TABLE 2-1
CV SETTING FOR PW_GXWL2

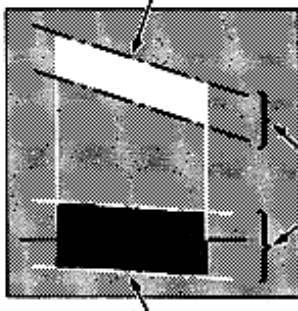
pw_gxwl2 (uS)
0
32
64
96
128
160
192
224
256
288
320
352
384
416
448
480
512
544
576
608
640
672
704
736
768
800
832
864
896
928

9. [Auto Prescan].
10. [Reference Scan].
11. Press **[Scan]**. The system scans and creates a total of 3 image plots, (one for each plane). Compare the plots to the Typical Plot Examples (see Illustration 2-2 and 2-3. If plots look similar to the typical plots shown, continue on to the next step. Otherwise, for Troubleshooting Tips, see Illustration 2-4.



EXAMPLE TYPICAL (GOOD) B₀ PLOTS
ILLUSTRATION 2-2

CONSTANT PHASE
CORRECTION WAVEFORM

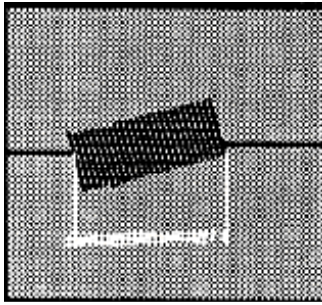


THE OUTER
EDGES OF
EACH PLOT
SHOULD BE
PARALLEL TO
EACH OTHER.

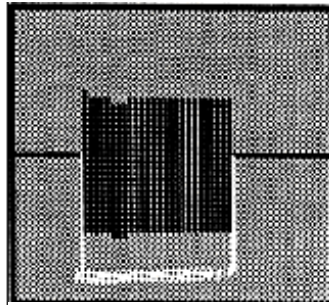
Note that when looking at the plots, one of the most important characteristics is that the top and bottom borders of the plot appear virtually parallel. Width is not as important as the absence of a bow-tie appearance in the waveforms.

LINEAR PHASE
CORRECTION WAVEFORM

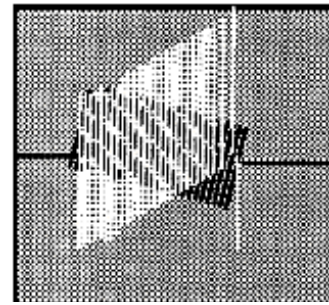
UNDERSTANDING EPI CALIBRATION PLOTS
ILLUSTRATION 2-3



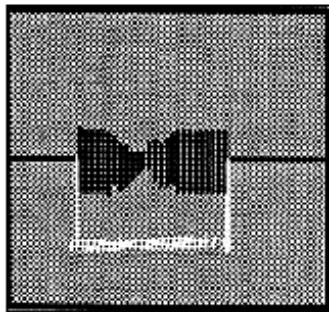
Shim is off. Check shim and or autoshim.



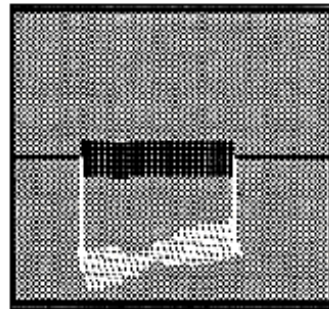
Group delay wrong. Check psd_grd_wait or warp b0.



Excessive Dither. Verify that GRAMs are tuned and Grafidy B0 is in spec.



Box-tie in linear. Verify that GRAMs are tuned and Grafidy B0 is in spec.



Box-tie in constant. Verify that GRAMs are tuned and Grafidy B0 is in spec.

EXAMPLE OF (BAD B₀) PLOTS WITH TROUBLESHOOTING TIPS
ILLUSTRATION 2-4

After scan #1: execute the command **b0 d <ENTER>** from the non-TPS command window. This generates the b0vectors.dat and delay .esp files. For scans #2-8 if the plots are acceptable, execute the command **b0 <ENTER>** (Not **b0 d**, as this will delete your previous work). This will append data to the files b0vectors.dat and delay.esp. Go back to step 8 of this procedure until all 8 scans are complete.

After scans for all values for **pw_gxwl2** setting have been collected, execute the following from the C Shell window: **fitepic <ENTER>** (Accept the default field name of b0vectors.dat when prompted). This creates the file b0_dither.cal. (This takes several minutes per axis to run, so be patient.)

The program then analyzes the b0 vector data. As each axis is analyzed, a series of numbers is output to the screen. Record the Max. Error value for each axis for future ref.

From the non-TPS command window, rename the b0vectors.dat, delay.esp, b0dither.cal and plot files to make them body specific files before proceeding to Group Delay calibration:

```
mv b0vectors.dat b0vectors.dat.body <Enter>
```

```
mv delay.esp delay.esp.body <Enter>
```

```
mv b0_dither.cal b0_dither.cal.body <Enter> (Type carefully; this is the file the psd uses!)
```

```
mv b0vectors.dat.xyz b0vectors.datb.xyz <Enter>
```

mv delay.esp.xyz delay.espb.xyz <Enter>

Note

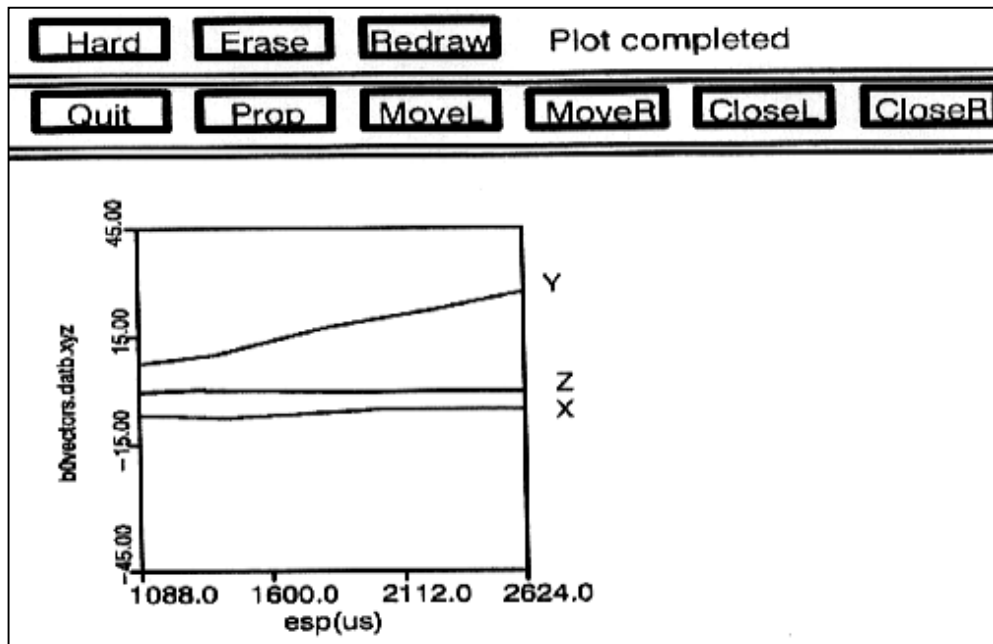
For **TwinSpeed**, remember that these actions move linked files with extensions, .WHOLE and .ZOOM.

Display plots of the b0vectors.dat on the system screen by typing each plot command. (The plots may slope considerably or have a high offset, but each axis plot should look fairly smooth. For example, see Illustration 2-5).

pl -b0vectors.datb.xyz q <Enter> (Plots the body b0 dither Vs echo spacing for all 3 axes.)

pl -delay.espb.xyz q <Enter> (Plots the body gldelay Vs echo spacing for all 3 axes.)

pl -delay.fst.xyz q <Enter> (Echo speed system only! Plots the group delay Vs bandwidth.)



EXAMPLE B₀ DITHER DATA PLOT
ILLUSTRATION 2-5

3- GROUP DELAY PROCEDURE

3-1 Group Delay System Preparation

This procedure assumes that you have just completed the B₀ Dither body procedure. The system is still set up per the system preparations for B₀ Dither. Start a new series using the **Body B₀ Dither** scan protocol from Section 2-1.

For **TwinSpeed**, select the same GradMode used in section 2.

3-2 Group Delay Procedure

1. **[Modify CVs]** and verify `cv pw_gxwl2 = 0`.
2. **[Auto Prescan]**, **[Done]** then **[Scan]**.
3. The system scans and creates a total of 3 image plots, (one for each plane). Compare the plots to the Typical Plot Examples (Illustration 2-2 and 2-3). If plots look similar to the typical plots shown, continue on to the next step. Otherwise see the Troubleshooting Tips (Illustration 2-4).
4. After the scan is complete, execute the command **gd std d <Enter>** from the command window that is not logged into the TPS. This generates the file `delay.std` for the physical X, Y, and Z axes for the standard receiver.

For systems with Fast Receiver option, perform all remaining steps. Otherwise go to step 11.

5. **[Modify CVs]** and set:
fast_rec=1 <Enter> (Enables the fast Receiver)
fast_rec_lpf=1 <Enter> (Uses Fast Receiver 100KHz low pass filter)
6. Press **[Scan]**. The system scans and again create three image plots.
7. After the scan has completed, execute the command **gd fst d <Enter>** from the C Shell window that is not logged into the TPS. This generates the file `delay.fst` for the physical X, Y and Z axes for the Fast Receiver 100KHz low pass filter.
8. Press **[Modify CVs]** and set **fast_rec_lpf=2 <Enter>** (Uses Fast Receiver 200KHz low pass filter)
9. Press **[Scan]**. After the scan has completed, execute the command **gd fst <Enter>** (no d in the command this time) from the command window that is not logged into the TPS. This generates the file `delay.fst` for the physical X, Y and Z axes for the Fast Receiver 200KHz low pass filter.
10. Repeat steps 8 and 9 for each setting of `cv fast_rec_lpf = 3, 4, and 5`.

11. When all values of cv fast_rec_lpf have been scanned, execute the following command from the C Shell window: **fproc delay <Enter>**. This creates the file delay.dat that is read by the epi psd when the cv ditheron=1 is used in the psd.

12. Execute the following command from the command window: **fproc dedit <Enter>**

Enter fstdelay in usec [default= 2.8] Press **<Enter>**

Enter fstdelay for vfg in usec [default= 3.1] Press **<Enter>**

Enter stddelay un usec [default= -19.6] Press **<Enter>**

4- HEAD B₀ DITHER PROCEDURE

4-1 Head B₀ Dither System Preparation



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Possible data loss. It is important to press the <Enter> key after you type in any command including any <Enter> associated with displaying or finding results files.

This procedure assumes that you have just finished the Group Delay Procedure.

1. At the operator workspace, prepare the system for a Head B₀ Dither scan using the *Service Protocols* procedure located on the service methods CD-ROM, or for the alternate proprietary procedure, see below.

This alternate proprietary procedure is available for GE use, and to sites with a valid Advanced Service Package Limited License.

a. Click on **[New Pt]**, and enter

Id: **geservice**

Name: **head b0 dither**

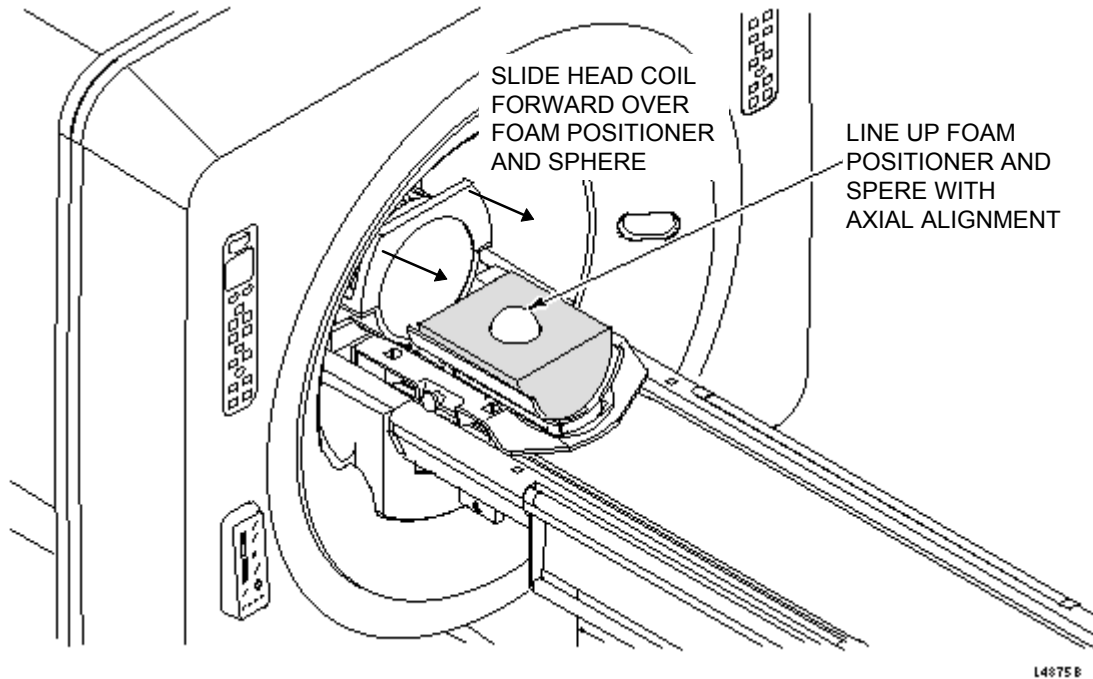
Weight (Lb.): **111**

Set Patient Protocols to **Service**.

b. In the Protocol field, type **o.44.1** (o=Other, 1= series).

c. For **TwinSpeed**, select the same GradMode used in section 2.

2. Place the EPI Foam phantom holder and 100 mm sphere in the Head Coil as shown in Illustration 4-1. Landmark on the center of the Head Coil, adjust positioner / sphere to axial alignment light, and press ADVANCE TO SCAN button.



EPI PHANTOM POSITIONING - HEAD COIL
ILLUSTRATION 4-1

4-2 Head B₀ Dither Procedure

1. [Auto Prescan].
2. **[Modify CVs]** and verify the **cv pw_gxwl2 = 0** (for the first scan only). A total of 8 scans will be taken. For each scan the **cv pw_gxwl2** will be changed based on Table 2-1. Verify the **cv exp** corresponds to the appropriate **pw_gxwl2** value for your equipment type.
3. Press **[Scan]**. The system scans and creates a total of 3 image plots, (one for each plane). Compare the plots to the Typical Plot Examples (Illustration 2-2 and 2-3). If plots look similar to the typical plots shown, continue on to the next step. Otherwise see the Troubleshooting Tips (Illustration 2-4).
4. After scan #1: execute the command **b0 d <Enter>** from the right (non-TPS) command window. This generates the b0vectors.dat and delay .esp files. For scans #2-30 if the plots are acceptable, execute the command **b0 <Enter>** (**Not b0 d, as this will delete your previous work**). This will append data to the files b0vectors.dat and delay.esp. Go back to step 2 of this procedure until all 30 scans are complete.

5. After scans for all values for **pw_gxwl2** setting have been collected, execute the following from the C Shell window: **fitopic <Enter>** (Accept the default field name of b0vectors.dat when prompted). This creates the file b0_dither.cal. (This takes several minutes per axis to run, so be patient)
6. The program then analyzes the b0 vector data. As each axis is analyzed, a series of numbers is output to the screen. Record the Max. Error value for each axis for future ref.
7. From the right C Shell window (non-TPS), Rename the b0vectors.dat, delay.esp, b0dither.cal and plot files to make them Head specific files before proceeding to Group Delay calibration:

```
mv b0vectors.dat b0vectors.dat.head <Enter>
```

```
mv delay.esp delay.esp.head <Enter>
```

```
mv b0_dither.cal b0_dither.cal.head <Enter> (Type carefully; this is the file the psd uses!)
```

```
mv b0vectors.dat.xyz b0vectors.dath.xyz <Enter>
```

```
mv delay.esp.xyz delay.esph.xyz <Enter>
```

For **TwinSpeed**, remember that these actions move linked files with extensions, .WHOLE and .ZOOM.

8. From the right command window, display plots of the b0vectors.dat on the desk top by typing each plot command. (The plots may slope considerably or have a high offset, but each axis plot should look fairly smooth. For example, see Illustration 2-5).

```
pl -b0vectors.dath.xyz q <Enter> (Plots the body b0 dither Vs echo spacing for all 3 axes.)
```

```
pl -delay.esph.xyz q <Enter> (Plots the body gldelay Vs echo spacing for all 3 axes.)
```

```
pl -delay.fst.xyz q <Enter>
```

9. Re open the (TPS) command window and type:

```
==> pcdef <Enter> (This releases the TPS.)
```

```
==> logout <Enter> (This Logs the command Window out of the TPS.)
```

Close the command windows by pressing [**Cancel**] in the windows. Remove the phantom and test the system.

5- B₀ IMAGE PROCEDURE

B₀ Image is used to quantify EPI image quality and calibrations. Eight scans are taken that collect 24 total images.

The ghost-to-image ratios are calculated to measure the IQ outcome of the new b0 dither interpolation method.

5-1 B₀ Image Setup & Scan

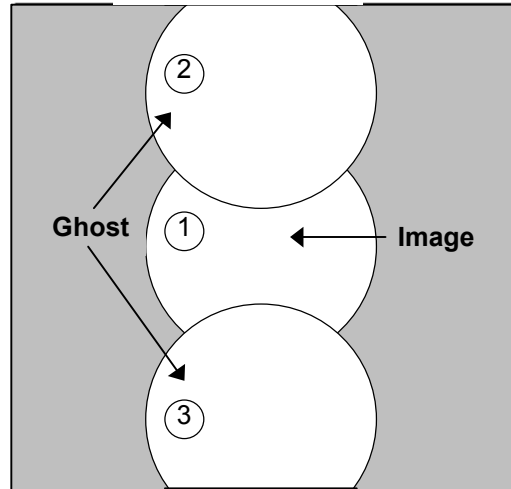
1. Use the same phantom used in the Body B0 Dither procedure (refer to Section 2-1).
2. Set up the scan protocol per Section 2-1. For **TwinSpeed**, select the same GradMode as in section 2.
3. [Auto Prescan].
4. Right click on **[Research Options]** and select **[User CVs]**. Verify the CV **pw_gxwl2 = 0** (for the first scan only).
5. Make a reference scan by pressing **[Reference Scan]**.
6. Press **[Scan]**. The system scans and creates a total of 3 images, (one for each plane). A total of 8 scan (24 images) will be taken. Prior to each scan the CV **pw_gxwl2** must be changed based on Table 5-1. After changing the CV, make a reference scan by pressing **[Reference Scan]**.

TABLE 5-1
CV "ESP" VALUE FOR CV "PW_GXWL2"

pw_gxwl2 [uS]	EchoSpeed esp [uS]	HighSpeed esp [uS]	Base exp [uS]
0	768	1600	3200
96	960	1792	3392
192	1152	1948	3548
288	1344	2176	3766
384	1536	2368	3968
480	1728	2560	4160
576	1920	2752	4352
672	2112	2944	4544

5-2 B₀ Image Analysis

1. Make a measurement of the ghosting levels. Take three ROI measurements at the locations shown in Illustration 5-1. Measure and record the ghost mean as shown. Measure the image mean as shown.



GHOSTING MEASUREMENTS
ILLUSTRATION 5-1

To calculate ghosting levels:

1. Using circular ROI at approximate location shown - left of center of image (or right of center of image, whichever shows more ghosting). However, avoid ghosting created by bubbles in the phantom.
2. Take 3 ROI measurements as shown.
3. Calculate as follows:

$$[\text{Mean}(2) \text{ divided by Mean}(1)] \times 100$$

$$[\text{Mean}(3) \text{ divided by Mean}(1)] \times 100$$

Note

Levels of ghosting must be $\leq 5\%$.

4. Verify the following specifications for each of the 24 images:

$$(\text{Ghost Mean} / \text{Image Mean}) \times 100 < 5\%$$

REVISION HISTORY

REV	DATE	AUTHOR	PRIMARY REASONS FOR CHANGE
0	July 28, 1998	L. Loehrer	Initial conversion to Word.
1	Oct. 2, 1998	Mike Keber	Updated for latest software releases and style guide format.
2	May 21, 1999	S.M.Atladottir	Updated Procedure References for New GUI
3	Oct 18, 1999	J. Wolak	Added Release 8.3 protocol number change
4	Jan. 4, 2001	M. Jones	Made changes to Section 2-2 per M. Files.
5	July 16, 2001	S. Nahmani J.Gerber	Updated for TwinSpeed scanner for 9.0 release.