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1- OVERVIEW

LVshim provides an accurate method of collecting and analyzing scan data to determine and correct magnetic field inhomogeneity. This procedure has been updated to include the Twin*Speed* (TRM) which has Whole-Body (WB) and Zoom (ZM) gradient coils. The calibration only needs to be done on the Whole-Body coil.

1-1 LVshim Comparison with Quickshim

LVshim is similar to Quickshim (Release 4.x and 5.4); however, there are some differences that make the LVshim results superior to those of Quickshim. These differences also make LVshim more complex. A few of the notable differences are discussed below.

The resultant magnetic field using LVshim is much more homogeneous over a much larger volume than it is after using Quickshim. Before Signa Horizon, mechanical plotting was used to shim a magnet on a relatively large volume (such as the C6 volume), then Quickshim was used to clean up the shim on a smaller volume (22-cm DSV). In contrast, LVshim can be used to clean up the shim on a much larger volume (45-cm DSV for 60-cm Body Coil; 40-cm DSV for 55 cm CRM Body Coil). In fact, the LVshim volume is 1.7 times larger than the C6 volume, and 8.5 times larger than the Quickshim 22-cm DSV. In effect, the 22-cm DSV "sweet spot" of Quickshim can be extended out to a 45-cm DSV (40-cm DSV for CRM and TRM/ZM) with LVshim.

LVshim automatically adjusts for most image phase wrap situations. You may recall that Quickshim notified the user of image phase wrap and suggested using a higher bandwidth and re-scanning. In contrast, LVshim can unwrap most image phase wrap problems. In the rare situations where it cannot, it will ask for a higher bandwidth.

LVshim output data is written to a file from which it can be accessed using the Report tool. This allows the Support Center - Magnet Team easy access to a site's LVshim data via modem. It also allows the site to keep a running record of the LVshim results for future reference.

1-2 Suggested Steps Before Running LVshim

There have been cases during installation where LVshim has returned invalid results (i.e., NAN, not a number) or misleading results due to some problems (reversed quadrature, gradients wired incorrectly, etc.). Since LVshim collects data in an imaging mode, certain functional checks and calibrations should be performed before LVshim is run. Follow the installation flowchart up through the Geometry Verification before running LVshim.

The steps that should be done before running LVshim are:

- Magnet should be ramped and parked.
- For LCC Magnet - Pre-Cool Shim Lead before installing.
- For LCC Magnet - Coldhead turned off for 10 minutes to dump flux build-up in S/C shield around Coldhead.
- For LCC Magnet - Pressure Controller should be installed and working.
- Shim currents entered into shim power supplies after main field has stabilized.
- All RF setup and calibrations completed.

- Longitudinal drive cal completed.
- DC Offset and Auto Lcoil portion of the GRAM Tuning procedure completed.
- X, Y and Z gradients all calibrated (i.e., Gradcal procedure complete).
- For Twin*Speed*, ensure that all the calibration procedures above have been completed for both GradModes.

Note

For LCC magnet - the magnet helium vessel pressure must be 4.0 psi (± 0.3 psi for rough shim and ± 0.1 psi for Main LVshim) before scanning. Failure to have the helium vessel at the proper pressure will result in erroneous data collection and many shim iterations. Refer to Appendix A for methods to increase vessel pressure during shimming.

Note

For a new installation of Cx or LCC magnets, all Shim currents should be installed according to the magnet ATR (Acceptance Test Report). Use recommended AX2, AX4, and AX6 currents in ATR. If the magnet was reversed ramped (red to negative, black to positive), you will have to change polarities on all shim currents. The recommended currents were calculated from an Excel spreadsheet. It can be found on the floppy disk sent with ATR. Its filename is **Cx10_15.xlw** or on the GE Web Site: ***http://3.87.118.28/optec3/tools/tools.htm*** **Cx Parking Excel spreadsheet**.

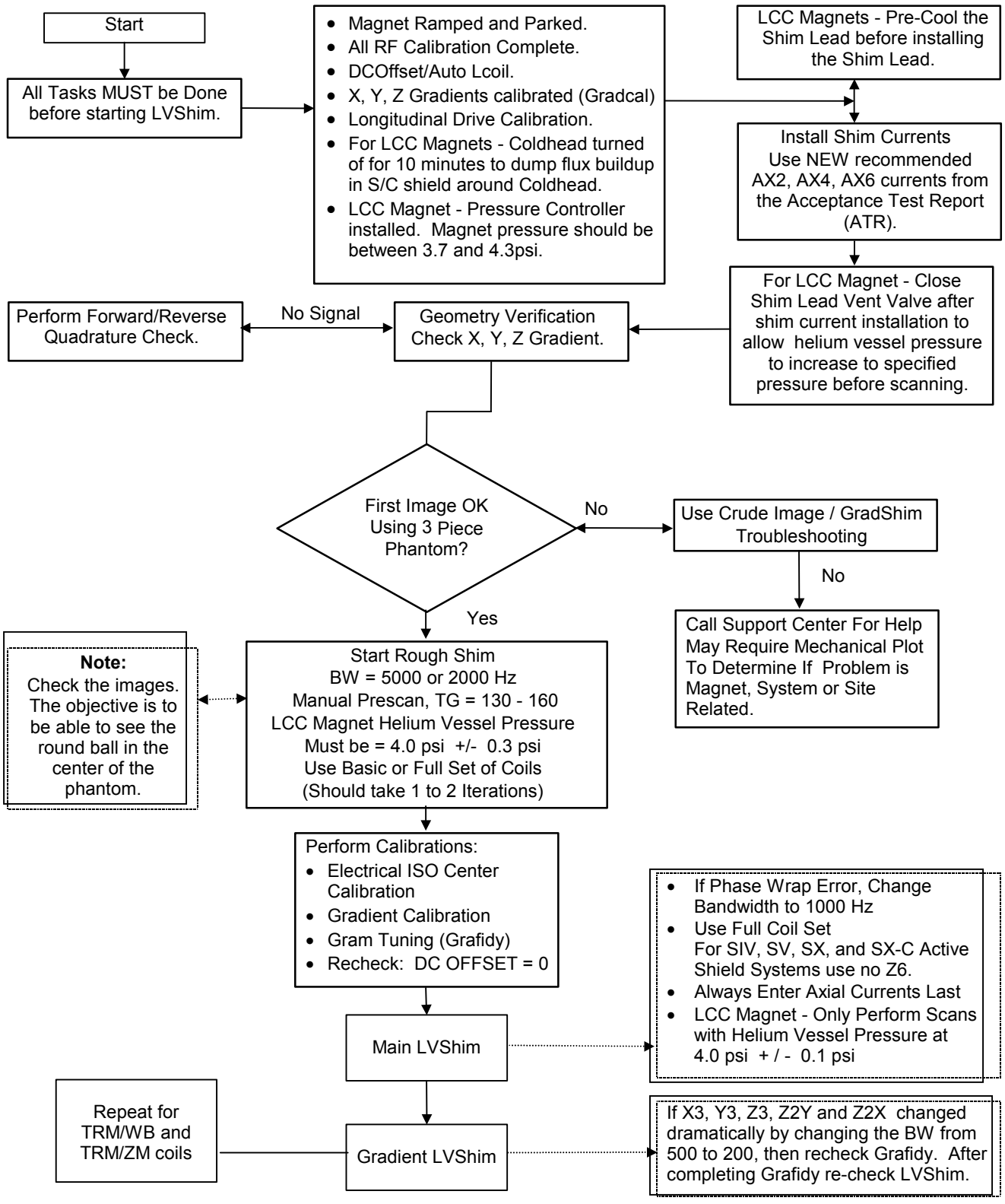
2- LVSHIM PROCESS – SHORT VERSION

For the experienced Field Engineer familiar with the shimming tools and process, see Illustration 2-1, LVSHIM FLOWCHART, for the basic steps. For the inexperienced Field Engineer, refer to Section 3 - *LVshim Process – Long Version*, which gives all the detailed information.

Important! Refer to Section 3-8, *Troubleshooting and Solutions*, when problems are encountered during the shimming process.

DANGER!!

POISON HAZARD! THE PHANTOM CONTAINS NICKEL, A SUSPECT CARCINOGEN. DO NOT INGEST! DISPOSE OF AS A HAZARDOUS WASTE ACCORDING TO STATE AND FEDERAL REGULATIONS.



VSHIM FLOWCHART
ILLUSTRATION 2-1

3- LVSHIM PROCESS – LONG VERSION

CAUTION

Incorrect data possibility. Before any LVshim is performed on a Signa Horizon system with a GRAM, the DC Offset and Auto Lcoil portion of the GRAM Tuning procedure must be performed. Failure to do so will cause errors in the LVshim results, and will increase the time it takes to shim the magnet.

3-1 LVshim Process Overview

LVshim consists of four procedures: Rough, Main, Gradient and Passive Shim.

Rough - The objective is to improve the homogeneity to the point where Grafidy and other calibrations can be performed. Use the three-piece LVshim phantom and the LVshim PSD with a starting bandwidth range of 2000 - 5000 Hz. The Rough shim process continues until the sampling diameter has been increased to 45-cm DSV (40-cm DSV for CRM Body Coil) and the bandwidth decreased to 1000 Hz. In most cases this should take about 3 iterations.

Main - The following system calibrations must be performed before starting the Main LVshim process: ISOCenter Calibration, Gradient Calibration, and Grafidy. LVshim is very eddy current sensitive; lack of calibration results in erroneous harmonic data. During the Main LVshim process the bandwidth is further reduced to 500 Hz, and remains there until the specifications at 45-cm DSV (40-cm DSV for CRM Body Coil) are achieved. All shim coils are used during this phase, however, coil groups can be selectively used based on the harmonic errors.

Note

When doing LV shim as the result of an upgrade, the recommendation is to re-enter the last set of shim currents into the magnet and start with Main LV shim. You should not have to do rough LV shim if the initial system had a reasonable shim prior to the upgrade.

Gradient - Gradient LVshim is used to clean up the 22-cm DSV by using offsets in gradients and performing the scan at a bandwidth of 200Hz.

Passive - S-V AND SXc_2 ONLY

The S-V and SXc_2 magnets do not have shim coils to compensate for the xy (2, -2) and x^2-y^2 (2, 2) harmonics. The compensation is achieved by taking a 12-plane LVshim scan, running the LVshim tool and selecting "Passive" for the shim type. The LVshim program will calculate the amount of passive shim required and will show the appropriate drawer number and shim locations for steel placement.

3-2 Tools Required

- LVshim Phantom Assembly, 2125245
- Nesting Plate Assembly, 2125247

Note

Foreign material (such as staples, metal filings, dirt, etc.) on the LVshim phantom or nesting plate will alter shim harmonics, resulting in shim divergence. Therefore, before using the phantom and nesting plate, be sure that all foreign material has been cleaned off.

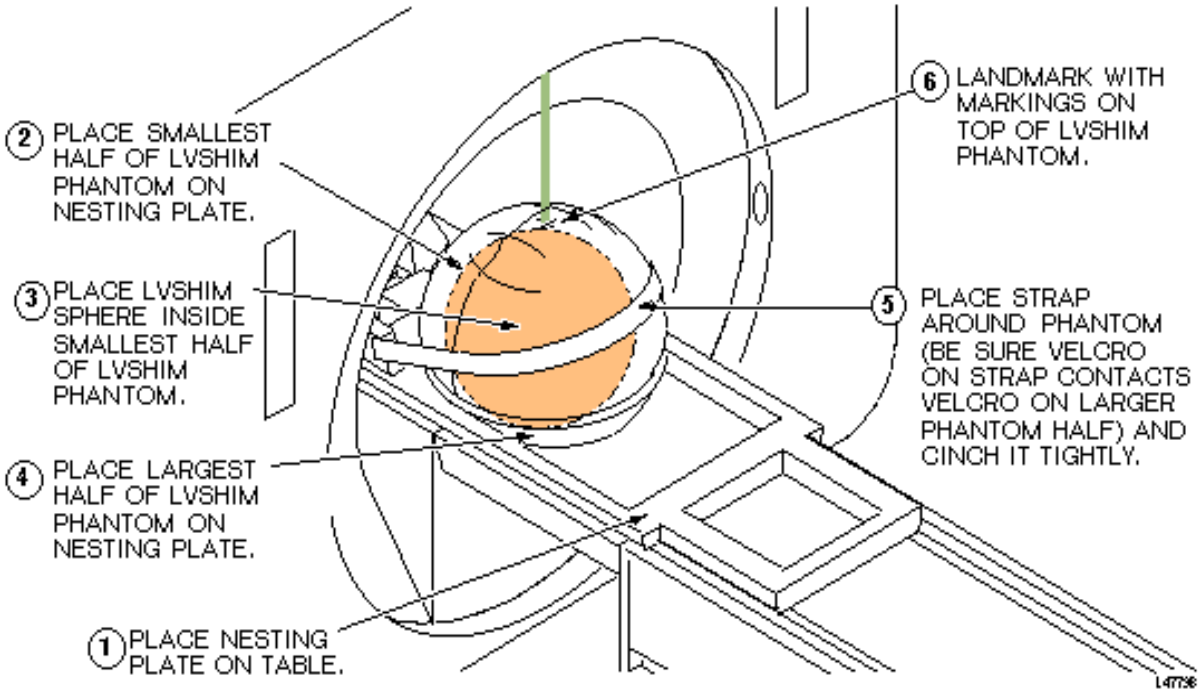
3-3 Phantom Setup

CAUTION

Completely remove the Quad Head Coil from the cradle before performing any body scans. Failure to do this may damage the Head Coil T/R network.

1. Remove the Quad Head Coil from the cradle and remove any other phantoms from the bore.

2. Set up and align the LVshim Phantom per Illustration 3-1.



ALIGNING LVSHIM PHANTOM ON PATIENT TABLE
ILLUSTRATION 3-1

3-4 Rough LVshim Procedure

Overview

Rough LVshim is normally needed at new sites that have never been shimmed before. If your site has previously been shimmed with LVshim, Quickshim, or CSI Shim, you should skip Rough LVshim and begin with Main LVshim. Rough Shim needs a starting point to work. For a new magnet installation, the magnet ATR shim currents are used for Rough LVshim. The ATR shim currents can be used for all magnet types except S-III with Magnishield.

For the LCC Magnet, the cryocooler coldhead must be turned off for 10 minutes before installing the ATR shim currents. This is due to magnetic flux build-up within a superconducting shield around the coldhead sleeve during magnet ramping. Also, the helium vessel pressure must be at 4.0 psi ± 0.3 psi. Failure to scan at the proper pressure will result in erroneous data collection. Refer to Appendix A for methods to increase vessel pressure during shimming.

3-4-1 LVshim Scan

Procedure

1. At the operator workspace, select the scan icon in the desktop control panel and set up LVshim scan as follows:

   a. At the operator workspace, prepare the system for LVshim 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.

   b. **[New Pt]**
      Id: **geservice <Enter>**
      Name: **lvshim**
      Weight (lb.): **300 <Enter>**
      Set Patient Protocols to **Service**
      At the front enclosure, press **LANDMARK,** then **MOVE TO SCAN**.

   c. In the Patient Position Protocol field:
      Type **0.19.2** and press **<Enter>** (o=Other, 19.2 = series) to load the lvshim protocol.
      or
      Select **other** and select protocol **19** and series **2.**
      For **Twin*Speed***, use the default **GradMode** of **WHOLE**.

   d. In Additional Parmeters, click **[User CVs Screen]**.
      In the User Control Variables window, enter the following:
      No. of Scan Planes. **6**
      Bandwidth: **5000**

   e. **[Save Series]**.

Note

For Rough LVshim, enter 5000 for the starting bandwidth. For Main LVshim, start with 1000, then reduce the bandwidth in subsequent iterations. If 1000 for bandwidth is OK and a change to 500 does not work, move the phantom location. Bandwidth for the final iteration of Main LVshim should be 500. For Gradient LVshim, enter 200.

f. **[Prepare to Scan]**.

Note

Perform a manual prescan before every scan. If the manual prescan check is not made, the frequency may not be properly centered or the gain values may be set too high (over ranged), causing the scan data to be invalid.

Note

Perform the DC offset (from the Diagnostics Menu) before **each** LVShim scan.

2. Click **[Manual Prescan]**.

   a. While in the **[Center Freq. Fine (CFH)]** mode, verify that the frequency peak is centered in the display. Center frequency peak as necessary. After locating the best signal, open the **Frequency** menu at the top of Manual Prescan window and select **[Save Frequency]** to save the new center frequency.

   b. Click **[Transmit Gain (TG)],** open the Markers menu at the top of the Manual Prescan and select **[Horizontal Hairline]**. Adjust Transmit Gain for the highest value.

Note

The TG needs to be adjusted correctly after performing Auto Prescan. Auto Prescan sets the TG for this phantom too high which results in the RF being overdriven and will produce NaN (Not a Number) in the LVshim analysis. Typically the TG will maximize at approximately 20 counts less than the Auto Prescan setting when adjusted in Manual Prescan.

   c. Click **[Scan TR (R1/R2)]**. Verify that R_1 and R_2 are not over ranged. Adjust R_1 and R_2 for approximately 50%.

3. Click **[Done]** to exit manual prescan.

4. When finished with manual prescan, click **[Scan]**.

Note

If Auto prescan is used, check TG and make sure TG is between 130 to 160.

5. When the scan is completed, go to Section 3-4-2, *LVshim Analysis*.

Note

The annotation on the LVshim images is not correct and does not change. The scan plane is driven by the LVshim PSD, not through scan prescription. Therefore, the software that is responsible for the image annotation doesn't know about the plane changes and keeps the annotation at the first plane. The images are in the correct plane and orientation; however, the annotation does not reflect this.

3-4-2 LVshim Analysis

Perform the shim analysis in Table 3-1using the following:

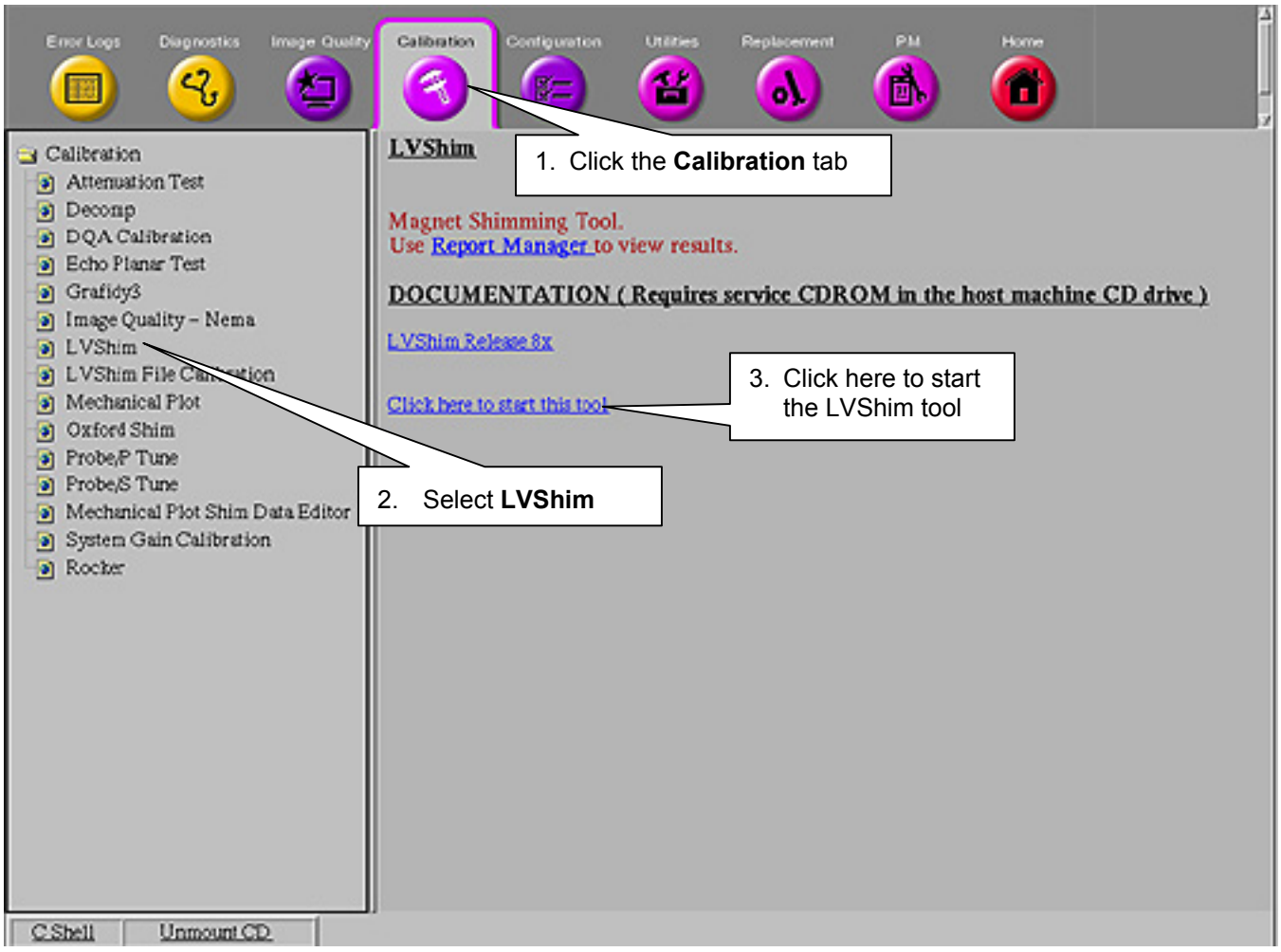
- Change Shim Type to either S/C or resistive (depending on magnet type: S/C for GE magnets; resistive for Oxford magnets).
- For LVshim Scan, choose the calibration file that ends with **_45dsv** for 60cm Body Coil or **_40dsv** for CRM (55cm) Body Coil.
- During LVshim analysis, choose Basic coil set and the calibration file ending with **_22dsv** for GE 18-coil magnets (S-II, S-III, S-IV, S-X, S-XC_1, and Cx 1.5T & 1.0T) and GE 12-coil magnets (S-V and S-XC_2).

If the LVshim analysis shows *NaN* instead of values for the harmonics and delta currents, then the image is not good enough for LVshim. You may be able to "stretch" the image into shape using the gradients (refer to Section 3-8 – *Troubleshooting and Solutions*).

Refer to Section 3-10, *LVshim Data Sheets*, for the appropriate magnet data sheet.

1. At the operator workspace, select the **Tools** icon, then **[Cal/Checks]**, then **[LVShim]**, then **[Start]**.

   9.x, 10.x: To run the LVShim tool from the Service Browser, follow the instructions on Illustration 3-2. below:



STARTING THE LVSHIM TOOL FROM THE SERVICE BROWSER
ILLUSTRATION 3-2

3. For ***TwinSpeed***, highlight **WHOLE** and click **OK**.

TABLE 3-1
LVSHIM ANALYSIS

OUTPUT/PROMPTS	INPUTS/COMMENTS
<<< LVshim Analysis >>> (Magnet Type : GE SIII) 1. Shim Type (Gradient, Sup18 1.5T, TEST):Gradient <-- 2. Image Data (Ex, Se, Im Number) :50007, 3, 1 3. Operation Mode (Service or Research) :Service <-- 4. Display Mag and Phase Diff Images : No 5. Calibration File Name : lv_15t_3gc_22dsv.8645 <-- 6. Existing Current in Each Coil. XGRAD: 0.000 YGRAD: 0.000 ZGRAD: 0.000 <-- 0. Accept (q or s to quit). Enter the Index Number to Change Default (0..6) [0]:	(Example: change to **Sup18 1.5T** Change to **Research** (Example: change cal file to **lv_15t_18sc_45dsv.full** Enter existing S/C currents For this example, the above change were made to the initial LVshim Analysis menu. See menu below for result of these changes.
<<< LVshim Analysis >>> (Magnet Type : GE SIII) 1. Shim Type (Gradient, Sup18 1.5T, TEST): Sup18 1.5T 2. Image Data (Ex, Se, Im Number) : 5007, 3, 1 3. Operation Mode (Service or Research) : Research 4. Display Mag and Phase Diff Images : No 5. Calibration File Name : lv_15t_18sc_45dsv.full 6. Existing Current in Each Coil. AX_1: 4.704 T1_1: 6.433 T2_1: -2.557 AX_2: -0.702 T1_2: 2.892 T2_2: -8.939 AX_3: -6.360 T1_3: -7.267 T2_3: -0.203 AX_4: -6.531 T1_4: 2.926 T2_4: -2.769 AX_5: -0.364 T1_5: -1.048 T2_5: -0.039 AX_6: -9.274 T1_6: 0.485 T2_6: -2.158 0. Accept (q or s to quit). Enter the Index Number to Change Default (0..6) [0]:	Enter **0** when all items in the menu are acceptable. Refer to procedure in Section 4-2 LVshim Analysis Details, for more information about the menu items.
PLANE MIN MAX P-P AVE STD 1. -114 50 164 -40.00 26.51 2. -132 44 176 -39.33 25.31 3. -138 40 178 -39.91 32.48 4. -138 32 190 -50.04 36.14 5. -140 46 186 -48.49 34.68 6. -122 48 170 -48.76 32.53	<--The data analysis is displayed one plane at a time.
If image phase wrap was detected, the following message appears: Excessive phase wrapping. ...Please re-scan at Wider Bandwidth or smaller test diameter	

OUTPUT/PROMPTS	INPUTS/COMMENTS
`Exit LVshim? (Y,N) [N] :.....`	(See below)

1. Select scan icon in desktop control panel to return to scan parameter window.

2. Under **[Research Operations]** *select* **Display CV's**.

3. In Display CV's window enter a new bandwidth for opuser2:
Valid bandwidth entries are: 200, 500, 1000, and 5000.

4. Click ***[Accept]***.

5. Under **[Research Operations]** *select* **Download**.

```
Exam 50007, Series 3, Image 1
6 Planes, Bandwidth = 500 Hz, FOV = 60 cm, DSV = 45 cm
Inhomogeneity = 31.98 Hz. ( 0.504 ppm)


Harmonic Coefficients (Zero to Peak)

Z1:  -8.19      X:  -8.70      Z2X:  -3.44
Z2:   4.55      Y:  36.93      Z2Y:  -0.49
Z3:   3.71     ZX:  -5.56  ZX2_ZY2:   0.64
Z4:   0.08     ZY:   4.76      ZXY:   2.83
Z5:  -2.64  X2_Y2:   2.12       X3:  -3.73
Z6:   5.25     XY:  -2.36       Y3:  -1.83
```

If "NaN" is displayed in the Harmonic Coefficient data, you should check TG value.

It should be between 130-160.

```
Generating LVshim report file
=============================
Please enter two lines of comments (Max 70 characters/line)
Press Return at the end of each line
To leave a comment line empty, press Return
|------------- Max comment length -----------------|
Comment Line 1:.....
```

Enter comments if desired.

```
Comment Line 2:.....
```

Enter comments if desired.

If Yes *was entered for Display Mag and Phase Diff Images, this appears:*

```
The Following Are the Image Display Options.

  1. Image Plane 1
  2. Image Plane 2
  3. Image Plane 3
  4. Image Plane 4
  5. Image Plane 5
  6. Image Plane 6
  0. Continue
Enter Index (0..6) [1] :.....
```

Enter appropriate choice. Refer to procedure in Section 4-2-4, Display Mag and Phase Diff Images, for more information about the image display options. Enter **0** to continue.

OUTPUT/PROMPTS	INPUTS/COMMENTS

If performing 18-Coil S/C shimming, the following appears:

```
The Following Are the Possible Coil Set Selections.

  1. Full (18 Coils)
  2. Basic (7 Coils)
  3. Standard (14 Coils)
  4. Axial Coils Only
  5. T1 Coils Only
  6. T2 Coils Only
  7. Transversal Coils Only
  8. No Z6

Enter the Index Number (1..8) [1] :.............
```

Select appropriate coil set. Refer to procedure in Section 6-4 for more information

```
    ************************************************************
    * If Magnet Monitoring is installed on your system, please *
    * disable it by setting `CALLOUT HOLDOFF` to the amount of *
    * hours you intend to S/C shim the magnet. Since the       *
    * pressure in the cryostat increases during S/C shimming,  *
    * using the `CALLOUT HOLDOFF` feature prevents Magnet      *
    * Monitoring from sending a high helium pressure alarm due *
    * to S/C shimming.                                         *
    ************************************************************
```

```
Press <Enter> to continue. [ ] :.................
```

<Enter>

```
Shim Current Settings

 Coil  Existing  Delta   New
 AX_1    4.704  -0.017    4.687
 AX_2   -0.702  -0.075   -0.777
 AX_3   -6.360   0.015   -6.344
 AX_4   -6.531  -0.133   -6.663
 AX_5   -0.364  -0.019   -0.384
 AX_6   -9.274  -0.159   -9.433
 T1_1    6.433   0.005    6.438
 T1_2    2.892   0.054    2.946
 T1_3   -7.267   0.012   -7.255
 T1_4    2.926   0.032    2.957
 T1_5   -1.048   0.002   -1.046
 T1_6    0.485   0.020    0.505
 T2_1   -2.557  -0.033   -2.591
 T2_2   -8.939   0.034   -8.905
 T2_3   -0.203  -0.014   -0.217
 T2_4   -2.769   0.007   -2.762
 T2_5   -0.039   0.030   -0.009
 T2_6   -2.158  -0.041   -2.200
```

If performing 18-Coil S/C shimming, you'll see this:

```
Accept or Re-compute New Currents.

  1. Select Another Coil Set.
```

OUTPUT/PROMPTS	INPUTS/COMMENTS
2. Modify the New Currents. 3. Reject the New Currents and Re-scan. 0. Accept and Install the New Currents. Enter the Index Number (0..3) [1] :	Enter appropriate choice.
If you're not performing 18-Coil S/C shimming, this appears: Accept the New Currents? (Y,N) [Y] :	If magnet shim is within the specifications in Table 3-5, enter **n**; if not in spec enter **y** to accept the new currents.
Run LVshim Again? (Y,N) [Y] :	Enter **y** or **n** as appropriate.
If Yes was entered at Run LVshim Again? prompt, this appears: Please Use Bandwidth = 500 Hz For Next Scan. Press <Enter> After Scan Is Completed. [ ] :	Go to Step 3.

3. If a new bandwidth is suggested by the software, perform the following:

   a. Select the scan icon in the desktop control panel to redisplay the scan window.

   b. Under **[Research Operations]**, select **Display CV's**.

   c. In the Display CV's window, enter the new bandwidth value for CV *opuser2*. Click **[Accept].**

   d. Under **[Research Operations]** select **Download**.

Note

The bandwidth of the final iteration of Main LVshim should be 500 Hz. The bandwidth of the final iteration of Gradient Shim should be 200 Hz.

4a. If performing gradient shimming, go to step 5 (the new currents are automatically entered into the gradient amplifiers by the software).

Note

If you get the message "Loading Gradient Current Failed," you will need to enter the new gradient currents manually as follows: Select **[Manual Prescan]**. Enter the new X, Y, and Z values. From the **Files** menu, select **Save Shim File**. Click on **Done** to save the new shim values. Click on **Done** to exit Manual Prescan.

Note

Perform the DC offset (from the Diagnostics menu) before **each** LVShim scan.

4b. For all other types of shimming, enter the new currents at the appropriate shim power supply, then go to step 5. (Refer to Section 6, *Shim Power Supply Details*, for more information about entering new shim currents.)

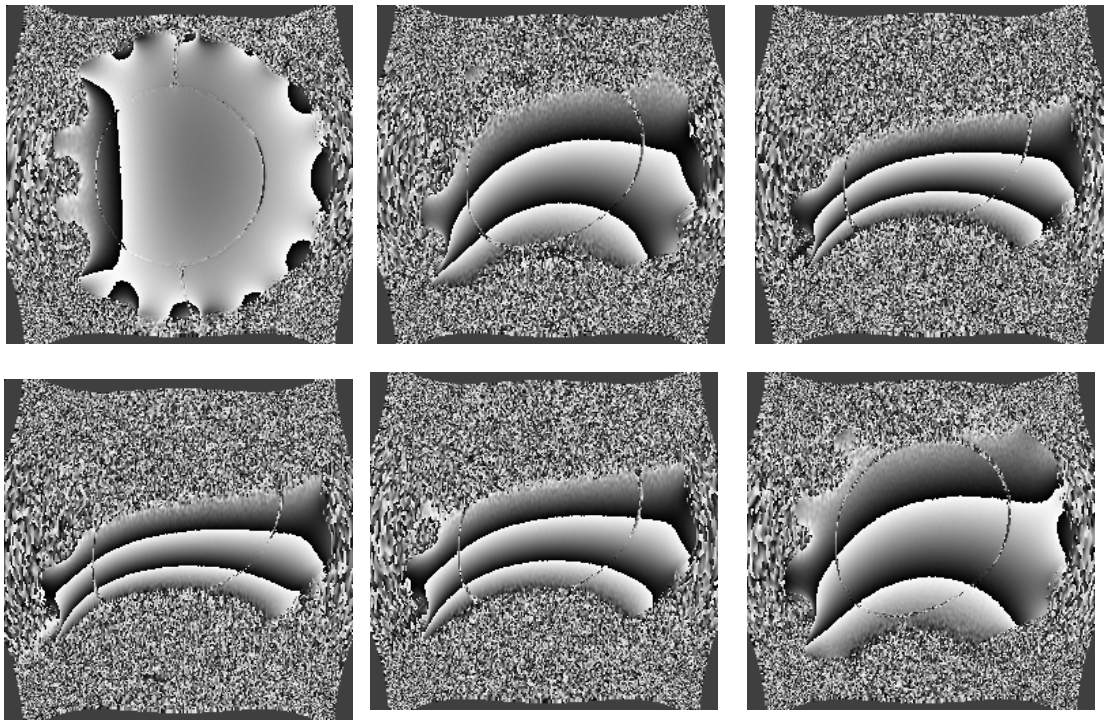
5. Click **[Scan]**.

6. When the scan is completed, repeat the LVshim Analysis procedure.

7. Guidelines for Rough LVshim

- There are no specifications clearly defining when to use or stop using the Rough LVshim procedure. It is purely subjective based on the shape of the phantom image displayed.
- The objective of Rough LVshim is to obtain enough homogeneity in order to start other system calibrations such as isocenter, Grad Cal and Grafidy. It usually only takes 1 to 2 iterations of Rough LVshim to get to this point.
- Check the uniformity of the 12 images (6 phase images and 6 magnitude images). See Illustration 3-2, LVshim Images With Poor Uniformity. If the images look like these and are very distorted or weak, try adjusting the X, Y and Z Gradshim values to improve the uniformity of the image. If this is not effective, go to Section 3-8, Troubleshooting and Solutions. When the center of the images (22 DSV) have good uniformity (see Illustration 3-3, LVshim Images With Good Uniformity), then stop the Rough LVshim process and start the other system calibrations.
- Before taking the scan, verify that the helium vessel pressure in the LCC magnet is 4.0 psi ±0.3 psi.

First LVShim Scan Image (Phase Only)

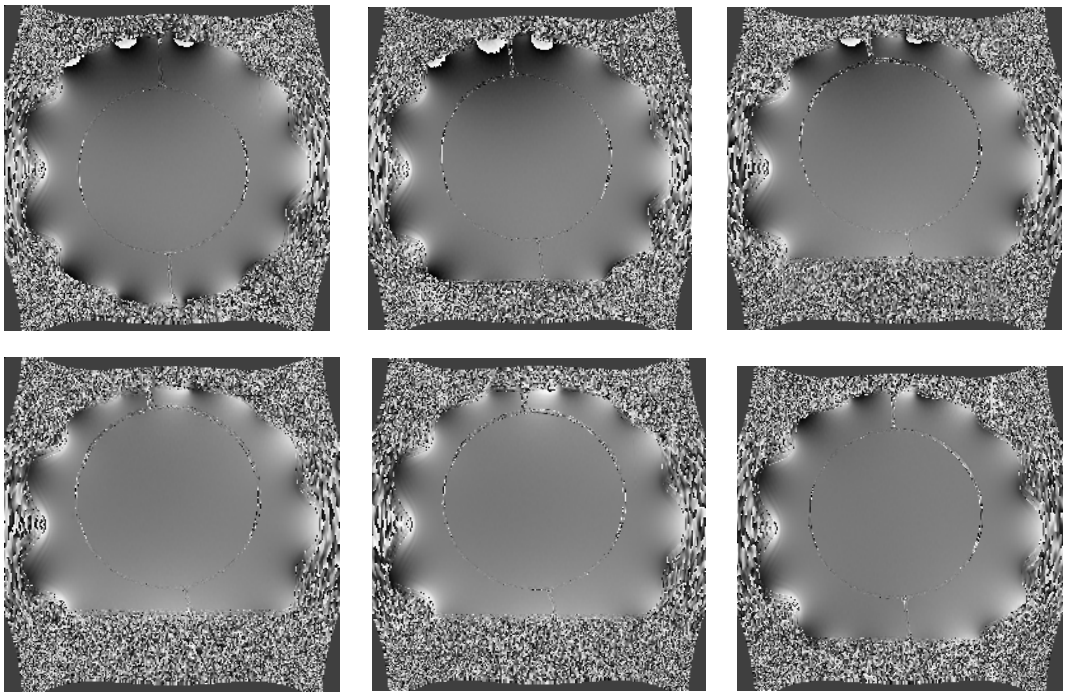


LVSHIM IMAGES WITH POOR UNIFORMITY
ILLUSTRATION 3-3

Note

The overall inhomogeneity number is not accurate when most of the harmonic coefficient numbers are out of spec.

Images After Rough LVShim (Phase Only)



LVSHIM IMAGES WITH GOOD UNIFORMITY
ILLUSTRATION 3-4

3-5 Main LVshim

Overview

Before starting Main LVshim the following system calibrations must be completed:

- Electric isocenter calibration
- Gradient calibration
- Gram Tuning (Grafidy)
- DC Offset checked and adjusted to zero

The goal of Main LVshim is to use S/C or resistive shim coils to achieve the Main LVshim specifications at 45-cm DSV (40-cm DSV for CRM Body Coil). Refer to Section 3-9, *LVshim and Gradient Shim Specifications*.

For the LCC Magnet

- After ramping the magnet, the cryocooler coldhead must be turned off for 10 minutes before installing shim currents. This is due to the magnetic flux buildup within a superconducting shield around the coldhead sleeve during magnet ramping.
- The helium vessel pressure must be at 4.0 psi ± 0.1 psi. Failure to scan at the proper pressure will result in erroneous data collection. Refer to Appendix A for methods to increase vessel pressure during shimming.

Procedure

1. Install the three-piece LVshim phantom on the patient table. Align and landmark the phantom using the procedure in Section 3-3, *Phantom Setup*.

2. Perform LVshim Scan using the following parameters:

   - Make sure that the X, Y, and Z gradients are all set to zero before scanning.
   - Use a bandwidth of 1000 Hz during the first scan acquisition.
   - Use manual prescan to locate and center the best possible signal.
   - Adjust the TG during manual prescan to optimize the signal.
   - Be sure to select the Frequency menu at the top of the Manual Prescan window and select **[Save Frequency]** before scanning.
   - Refer to Section 3-4-1, *LVshim Scan*, for the scan protocol.

3. Perform LVshim Analysis using the following:

   - Change the Shim Type to either S/C or resistive (depending on the magnet type: S/C for GE magnets, resistive for Oxford magnets).
   - Choose the calibration file ending with **_45dsv** (**_40ds**v for CRM Body Coil). For GE 18-coil magnets (S-II, S-III, S-X, S-XC_1, and Cx 1.5T & 1.0T) and GE 12-coil magnets (S-V and S-XC_2).
   - Choose the full coil set coils or full set without Z6 for the initial iterations.
   - Refer to Section 3-4-2, LVshim Analysis, for screen details.

4. After the first iteration, you should be able to choose the Full coil set.

Note

During Main LVshim, you may be prompted to enter currents into the even axial power supplies (Z2, Z4, and Z6) that are above the limit of 20 amps. If this is the case, you should use Z6 to configure out the Z6 coil. This should help you reduce the other even axial harmonics without exceeding the power supply limits. Also, when current is applied to the axial power supplies, the magnet center frequency shift may be significant. You should try to limit the axial power supply currents by configuring out axial coils as they meet the shim specifications. Otherwise, you may need to re-park the magnet if the center frequency is moved outside of the specification. Contact the On-Line Center if you have to use more than 20 amps.

5. Continue to scan and analyze until you achieve the Main LVshim specifications for overall homogeneity and spherical harmonics over the 45-cm DSV (40-cm DSV for CRM Body Coil). Reduce the bandwidth to 500 Hz while you are approaching the specification. The final shim iteration should be at a 500-Hz bandwidth.

Note

Signa Horizon systems with a GRAM may cause stability issues with the LVshim PSD, which may cause some harmonics to diverge (especially X3 and Y3). If you are shimming a system with a GRAM and notice certain harmonics diverging, use the half current shim calibration files to force the convergence of these harmonics.

Note

If you have an S-IV or S-X magnet that was originally passive-shimmed on a C6 volume, and you cannot achieve the Main LVshim specifications, you may need to redo passive shimming on a 45-cm spherical volume. However, if you do not redo passive shimming, your shim quality will be no worse than it was before LVshim (and probably a little better, especially on large FOV images). It will meet the Gradient LVshim specification (to prove it is at least as good as Quickshim), but it may not meet the Main LVshim specifications (especially the harmonic coefficients). You can wait until the passive shim option is available for the LVshim tool or you can perform passive shim on a 45-cm spherical volume using the plotting fixture. Refer to the appropriate magnet service manual (Direction 15345 for S-IV; Direction 15537 for S-X) for the procedure to passive shim with the plotting fixture.

6. When you are finished with Main LVshim, go to the next step, Gradient Shim. There is no need to redo Gram Tuning (Grafidy). The eddy current compensation should not need re-calibration at this point.

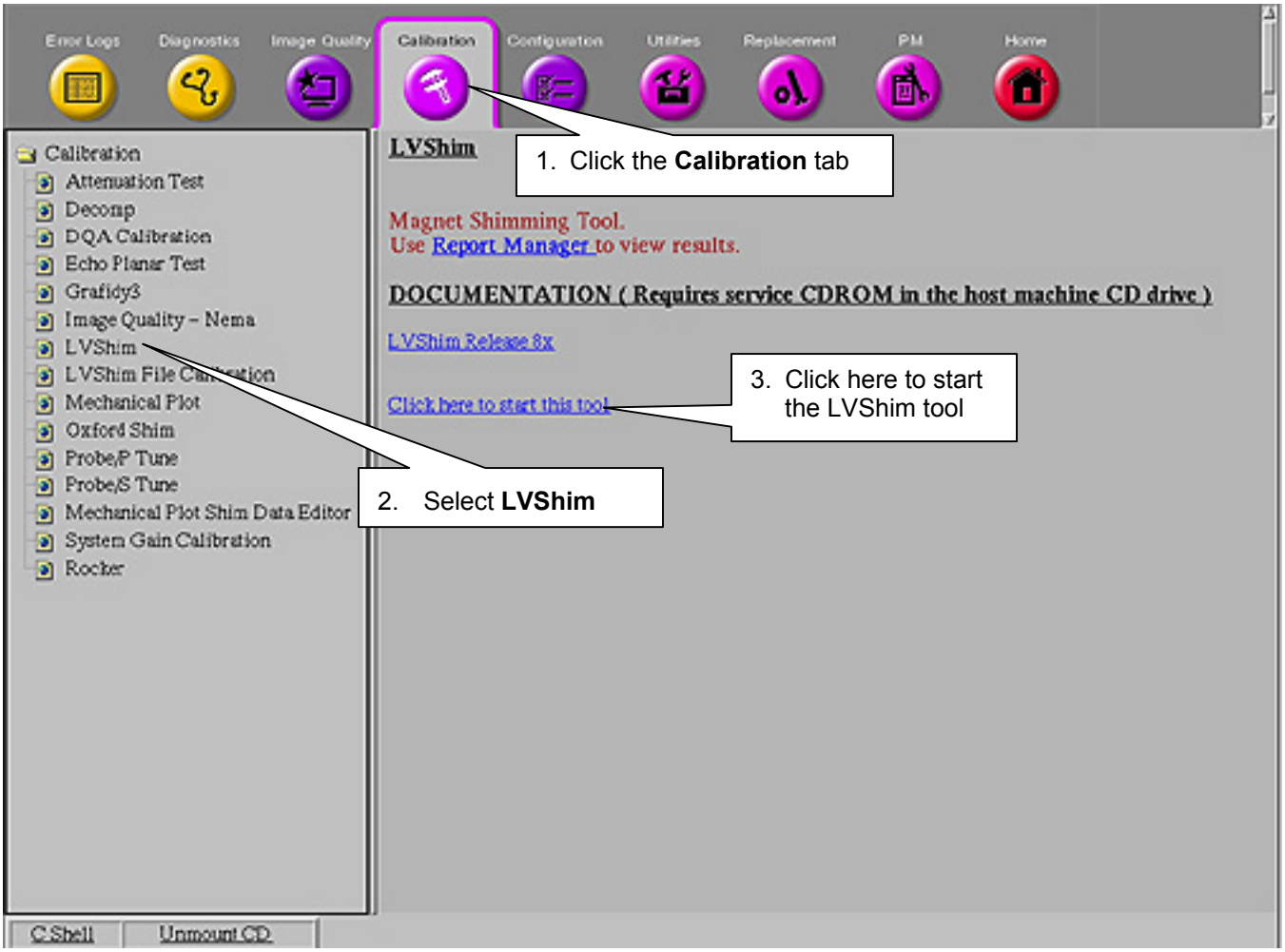
3-6 Passive Shim (S-V and S-XC_2 Magnets Only)

This procedure applies to S-V and S-XC_2 magnets only.

1. Perform a 12-plane, 500 Hz, LVshim scan. For ***TwinSpeed***, use **GradMode=WHOLE**.

2. After the scan is complete, select the Tools icon, **[Cal/Checks]**, then **[LVShim]**, then **[Start]**.

   For 9.x, 10.x: To run the LVShim tool from the Service Browser, follow the instructions on Illustration 3-5. below:



STARTING THE LVSHIM TOOL FROM THE SERVICE BROWSER
ILLUSTRATION 3-5

3. **Twin*Speed***, highlight **WHOLE** and click on **OK**.

4. Continue as follows:

```
------------------------------------------------------------------------
<<< LVshim Analysis >>>
      (Magnet Type : GE S-V)


1. Shim Type (Gradient, Sup12_1.5T, Passive, TEST)
   :Gradient <----------------------------------  Change to Passive.
2. Image Data (Ex, Se, Im Number) :50007, 3, 1 <-  Verify for correct image.
3. Operation Mode (Service or Research)  :Service
4. Display Mag and Phase Diff Images     : No
5. Sampling Diameter in Centimeters      : 45

0. Accept (q or s to quit).

Enter Index Number to Change Default(0..6) [0]:     For this example, the above
                                                    changes were made to the initial
                                                    LVshim Analysis menu. Enter 0
                                                    when the options are correct.

Harmonic Coefficients (Zero to Peak)
Z1:  -8.19      X:  -8.70      Z2X:  -3.44
Z2:   4.55      Y:  36.93      Z2Y:  -0.49
Z3:   3.71     ZX:  -5.56  ZX2_ZY2:   0.64
Z4:   0.08     ZY:   4.76      ZXY:   2.83
Z5:  -2.64  X2_Y2:  13.64       X3:  -3.73
Z6:   5.25     XY:   0.58       Y3:  -1.83
```

If "NaN" is displayed in the Harmonic Coefficient data, you should re-scan at a lower TG value (10-15 units lower than the value calculated by Auto Prescan).

```
========================================
XY and X2-Y2 Passive Shim for S-V Magnet
========================================
XY Passive Shim Correction:
  Remove drawers:       120/300
  Install XY shims:     0.0 mils at z={3,3.5,4,4.5,21.5,22,22.5,23}
                        on each drawer)

X2-Y2 Passive Shim Correction:
  Remove drawers:       90/270
  Install X2-Y2 shims:  0.5 mils at z={3,3.5,4,4.5,21.5,22,22.5,23}
                        on each drawer)

Generating LVshim report file
=============================
Please enter two lines of comments (Max 70 characters/line)
Press Return at the end of each line
To leave a comment line empty, press Return
|------------- Max comment length -----------------|
Comment Line 1: ..............................  Enter comments if desired.

Comment Line 2: ..............................  Enter comments if desired.

Exit LVshim? (Y,N)  [N] : .....................  Y <Enter>

------------------------------------------------------------------------
```

5. Install passive shims per the LVshim analysis.

6. Re-enter S/C shim currents from last iteration.

7. Perform another LVshim scan, analyze the results, and perform another passive shim iteration if analysis does not meet specifications.

3-7 Gradient LVshim

Overview

The goal of Gradient LVshim is to clean up the shim over a 22-cm DSV using gradients only.

Procedure

1. Perform a phantom setup, unless it was already done during Rough or Main LVshim. Refer to Section 3-3, *Phantom Setup*.

2. Perform LVshim using the following parameters:

    - Use a bandwidth of 200 Hz during scan acquisition.
    - Use manual prescan to locate and center the best possible signal.
    - Adjust the TG during manual prescan to optimize the signal.
    - Be sure to open the **Frequency** menu at the top of Manual Prescan window and select **[Save Frequency]** before scanning.
    - Refer to Section 3-4-1, *LVshim Scan*, for scan protocol.

3. Perform LVshim Analysis using the following:

    - Select **Gradient** as the Shim Type.
    - Choose the calibration file appropriate for the type of gradient coil you have. For all magnets except 0.5T, use the **_22dsv**. file for the epoxy-filled body coil.
    - Refer to Section 3-4-2, *LVshim Analysis*, for screen details.

4. Continue to scan and analyze until the delta currents for all three gradients are <1.000. This should take only a couple of iterations.

5. Check harmonic coefficients of X3 (3,-3), Y3 (3,3), Z3 (3,0), Z2Y (3,1) and Z2X (3,-1). If changing the bandwidth from 500 to 200 Hz dramatically changed these harmonics, then check your Grafidy data at this point. If you have to redo the Grafidy, please check your LVshim results again.
6. Delete the LVshim images when finished shimming in order to maximize image disk space for the customer.

7. For the **Twin*Speed*** system, repeat the calibration for the Zoom coil.

3-8 Troubleshooting and Solutions

3-8-1 Localizer Scan

Overview

The main purpose of the Localizer Scan is to check the landmark and verify that the ROI is in the center of the image.

Tools Required:

- LVshim Phantom Assembly, 2125245
- Nesting Plate Assembly, 2125247

Note

Foreign material (such as staples, metal filings, dirt, etc.) on the LVshim phantom or nesting plate will alter shim harmonics, ensuring that the system will not properly shim. Therefore, before using the phantom and nesting plate, be sure that all foreign material has been cleaned off.

Procedure

1. Refer to Section 3-3, *Phantom Setup*, if the phantom has not been previously set up.

2. At the operator workspace, select the Scan icon in the desktop control panel, if you have not already done so.

3. Click on **[Autoview]**, just below the Autoview image display screen. Your images will be displayed automatically.

3. Set up the Localizer scan as follows:

   a. In Patient Register, click **[New Pt]**.

   b. In Patient Information, enter:

      Patient ID **geservice** and press **<Enter>**

      Patient Name **LVshim** and press **<Enter>**

      Weight (lb.) **300**

      Click **[Landmark]**

      Next to the Landmark box, click **[>]** and select **[Sternal Notch]**.

   c. At the keypad on the front magnet enclosure, press LANDMARK and MOVE TO SCAN to position the landmarked phantom at the center of the magnet bore.

   d. At the operator workspace, prepare the system for LVshim scan using the "Service Protocols" procedure located on the service methods CD-ROM, or, for the alternate proprietary procedure, see below.

Note

Perform the DC offset (From Diagnostics menu) before **each** LVShim scan.

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

In the Protocol field, type **o.19.1** (o = Other, 19 for protocol, 1 = series number).

For ***TwinSpeed***, ensure **GradMode** is set to **WHOLE**. There is no need to repeat this for **ZOOM**.

e. Click **[Save Series]**.

4. Click **[Scan]**.

Note

If you are performing Rough LVshim, you may have to use [Manual Prescan] to find the center frequency. Use [Center Freq Coarse (CFL)] to center on the frequency peak as necessary. Be sure to save the center frequency value before exiting manual prescan. Select the Frequency menu at the top of Manual Prescan window and select **[Save Frequency]**. You should also write down the center frequency value for future reference.

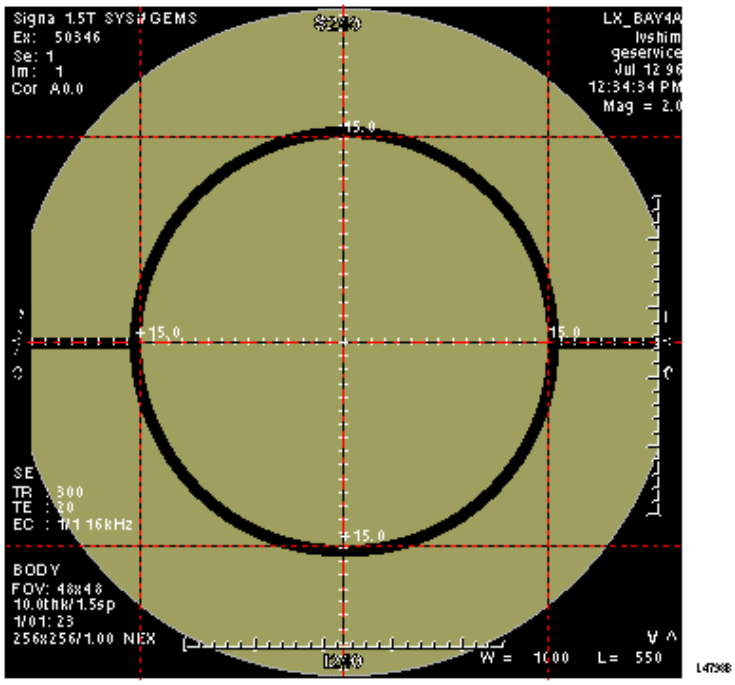
5. When the image is displayed in the Autoview window, select the Display icon in the desktop control panel. To display the image, select the Exam, Series, and Image, and click **[Viewer]**. Do the following to verify that the phantom is centered in the Z direction:

   a. Click **[User Prefs]**.

   b. In the User Preferences pop-up window, find **Grid Prefs** and click **[Customize…]**.

   c. Change Grid Spacing (mm) to 150, click **[OK]**, and then click **[Apply]**.

   d. Select the button with the grid symbol to turn on the grid. See Illustration 3-6, Centering LV Phantom, for an example of an image with the alignment grid on.



CENTERING LVSHIM PHANTOM
ILLUSTRATION 3-6

e. Adjust Window (W) and Level (L) settings until the edges of the phantom image can be clearly seen.

f. Verify that the inner phantom sphere is centered within the 150-mm grid in the S/I direction, as shown in Illustration 3-6. If the phantom is not centered, move the phantom in or out of the bore as necessary (based on the grid markings), then landmark again and re-scan.

3-8-2 Crude Image Procedure

Overview

The Crude Image procedure is usually used when there is no signal or a very weak signal (such as troubleshooting for reversed I and Q cable).

Tools Required

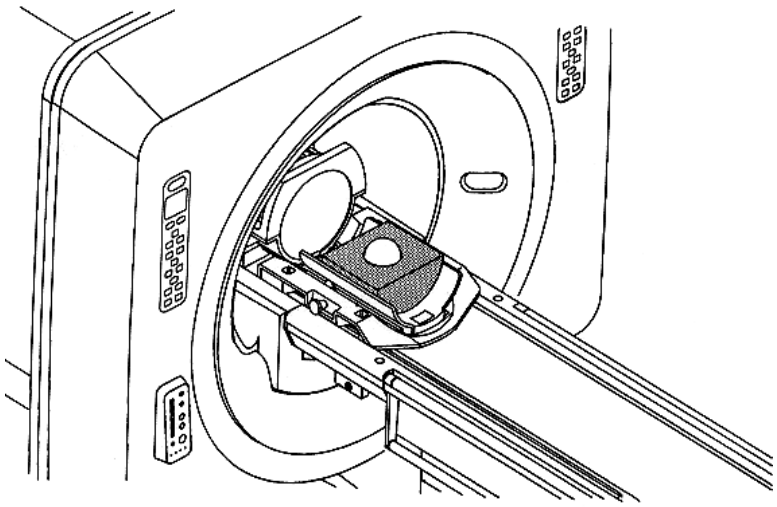
- 100mm Sphere phantom, 46-317586G1
- EPI Foam Positioner, 2138870

Note

Foreign material (such as staples, metal filings, dirt, etc.) on the LVshim phantom or nesting plate will alter shim harmonics, ensuring that the system will not properly shim. Therefore, before using the phantom and nesting plate, be sure that all foreign material has been cleaned off.

Procedure

1. Set up the system to perform a head coil scan. Place the EPI foam phantom holder and 100-mm sphere in the head coil as shown in Illustration 3-7.



EPI PHANTOM POSITIONING IN HEAD COIL
ILLUSTRATION 3-7

2. Landmark on the center of the head coil, adjust the positioner / sphere to axial alignment light, and press the MOVE TO SCAN button.

3. At the operator workspace, select the Scan icon in the desktop control panel, if you have not already done so.

4. Click on **[Autoview]**, just below the Autoview image display screen. Your images will be displayed automatically.

5. Set up the scan as follows:

   a. In Patient Register, click **[New Pt]**.

   b. Enter Patient Information:
   Patient ID **geservice**
   Patient Name **LVshim**
   Weight (lb.) **100**
   Click **[Landmark]**
   Next to the Landmark box, click **[>]** and select **[Nasion]**.

   c. At the keypad on the front magnet enclosure, press LANDMARK and MOVE TO SCAN to position the landmarked phantom at the center of the magnet bore.

d. At the operator work space, prepare the system for LVshim 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.

In the Protocol field, type **o.19.1** (o = Other, 1 = series number).

For ***TwinSpeed***, ensure **GradMode** is set to **WHOLE**. There is no need to repeat this for **ZOOM**.

e. Make the following changes to the protocol:
Patient Position Coil: **HEAD**.
Acquisition Timing Phase: **128**, select **Autoshim**
Scanning Range FOV: **12**

f. Click **[Save Series]**.

6. Click **[Manual Prescan]**. While in the **[Center Freq Fine (CFH)]** mode, verify that the frequency peak is centered in the display. Center the frequency peak as necessary. After locating the best signal, open the **Frequency** menu at the top of Manual Prescan window and select **[Save Frequency]** to save the new center frequency. If a signal cannot be found, measure the center frequency at the center of the bore using a magnetometer probe. Repeat this step and enter probe measurement for center frequency. If a signal still cannot be found then try re-entering the shim currents.

7. Click **[Done]** to exit manual prescan.

8. Click **[Auto Prescan]** to perform Autoshim. When Auto Prescan is complete, click **[Auto Prescan]** again. It is necessary to perform a second Auto Prescan to get accurate center frequency and Gradshim values. Auto Prescan performs a frequency adjustment prior to the Autoshim adjustment and there is interaction between the two processes.

9. Click **[Manual Prescan]**. Verify the Gradshim values and the System Frequency, and verify that the waveform is centered. Then open the **Frequency** menu at the top of Manual Prescan window and select **[Save Frequency]** to save the new center frequency.

10. Click **[Scan]**.

11. When the scan is completed, view the image.

a. If the image resembles the phantom, continue to Section 3-8-3, Axial Currents.

b. If the image does not resemble the phantom, and any additional adjustments made by Autoshim do not affect the image, then perform the mechanical plotting procedure in the appropriate magnet service manual.

3-8-3 Axial Currents

Development of LVshim uncovered some differences in the way certain magnets behave, especially with respect to even axial harmonics (primarily Z4 and Z6). With some magnets (especially the Active Shield types S-IV, S-V, S-X, S-XC_1 and S-XC_2), it is difficult to reduce both the Z4 and Z6 harmonics (they tend to affect each other significantly). The LVshim analysis software may request the entry of currents as high as 20 amps into the Z4 and Z6 coils. The solution to this situation is to run LVshim and use no Z6 coil option. This allows the software to solve for the Z4 harmonic without calculating excessively high currents. This also prevents the Z6 coil from pushing the magnet center frequency outside of the specification. The CX and LCC magnets should use the Z6 coil.

3-8-4 Possible Need to Repark a Magnet

There is a possibility, after shimming a magnet on a new install, that the center frequency of the magnet could fall outside the allowable bandwidth range for the system. Therefore, it will be necessary after shimming to check the magnet center frequency and re-park the magnet. Refer to Table 3-2 for center frequency specifications.

TABLE 3-2
MAGNET FINAL PARKING FREQUENCY SPECIFICATIONS

MAGNET TYPE	MAGNET FIELD STRENGTH GAUSS (FREQUENCY)	BANDWIDTH GAUSS (FREQUENCY)
1.5T	15,000 G (63,864000 MHz)	+/- 7.5 G (+/- 31.932 kHz)
1.0T	10,025 G (42,682440 MHz)	+/- 5.0 G (+/- 21.288 kHz)

If the system cannot meet the LVshim Specifications during Main LVshim, and requires more than 20 amps on the axial shim coils, please contact the On-Line Center for help.

Signa Horizon systems with a GRAM may cause stability issues with the LVshim PSD, which may cause some harmonics to diverge (especially X3 and Y3). If you are shimming a system with a GRAM, and you notice certain harmonics diverging, use the half-current shim calibration files to force the convergence of these harmonics.

3-8-5 Gradient Shim

LVshim can usually shim a magnet starting from magnet ATR currents, eliminating the need for any mechanical plotting; however, there are a few situations that may make this goal somewhat difficult to achieve. Gradient Shim is a very useful tool at this point.

The system must be able to achieve at least some images in the center for LVshim to work. The image can be very distorted and weak, but you must have something to start with. Usually the magnet ATR currents are enough to give you a useable first image. However, the signal may be very weak and hard to find due to different site conditions.

It is very important that you use Manual Prescan to find and center on the best possible signal. You may have to increase the Receive Gains (R_1 and R_2) during manual prescan to find the signal. Also, you should adjust the TG until the signal is maximized. After locating the best signal, be sure to open the **Frequency** menu at the top of Manual Prescan window and select **[Save Frequency]** to save the new center frequency.

If the image is too weak or distorted for LVshim to analyze, you may be able to use the gradients to "stretch" the image into shape. This will take some experimentation, but it may help you avoid mechanical plotting. After the magnet is rough shimmed, the gradients should be set back to zero and their effects translated to shim currents before performing Main Shim.

When the gradients are set back to zero, an equivalent current should be entered into the X, Y, and Z1 shim power supplies before the next iteration. Refer to Table 3-3 for the multiplier to use when converting the gradient units into shim power supply currents. For example, for an S-IV magnet with an epoxy-filled gradient coil, if 280 units of Z gradient were used during rough shimming, the equivalent amount of shim current to enter into the Z-shim power supply would be 1.288 amps (.0046 x 280). As shown in Table 3-3, for all magnets except Oxford, two shim coils (T2-2 and T2-4) must be used to get an effect equivalent to the X gradient, and two shim coils (T1-2 and T1-4) must be used to get an effect equivalent to the Y gradient.

Note

If the gradients were used to "stretch" the image during Rough LVshim, they should be set back to zero before you perform Main LVshim.

TABLE 3-3
GRADIENT TO SHIM COIL EQUIVALENTS

MAGNET TYPE (Note 1)	GRADIENT	SHIM COIL	MULTIPLIER FOR BRM (Note 2)	MULTIPLIER FOR CRM (Note 2)
S-II, S-III, S-IV, S-V, S-X, S-XC_1, S-XC_2, Cx 1.5T, Cx 1.0T	Z	AX1	+0.0042	TBD
	Y	T1-2	+0.0080	
		T1-4	+0.0080	
	X	T2-2	-0.0077	
		T2-4	-0.0077	

Note 1: No equivalents are given for Oxford and S-I Magnets. Rough Shim will not be necessary for Oxford and S-I Magnets, since they have already been previously shimmed.

Note 2: Multiplier value is to convert Gradshim value to shim coil current.

This table requires updating for the TwinSpeed.

3-8-6 Additional Passive Shimming Required

For S-IV, S-X, S-V, S-XC_1, and S-XC_2 Magnets, if additional passive shimming is required beyond the passive shimming performed in Florence (usually due to site environmental conditions), you will need to perform a passive shim. The need for additional passive shimming at the site is minimized because Florence now shims Active Shield magnets using 45-cm spherical plotting during acceptance testing.

There is a new configuration line in the MR Configuration file for entering the "magnet serial number." The LVshim analysis program now reads this line in the MR Configuration file instead of the "magnet type" entry (i.e. 201, 202, etc.) to determine magnet type and to list your magnet's calibration files for shimming.

The 32-cm files (files names ending with **`32.full`**) are for troubleshooting purposes only. These files may cause some problems during normal shimming, so they should be used only as directed by the Support Center - Magnet Team, or MR Engineering.

When a new Load From Cold (LFC) is performed, there is an option to retain the existing shim calibration files. If the user chooses to retain the old files, some of the new files on the LFC tape may not get loaded onto the system. Therefore, to be certain that all new calibration files are loaded, existing shim calibration files should be renamed before the LFC procedure is performed.

The generic LVshim calibration files work for both forward- and reverse-ramped magnets. The LVshim PSD uses information in the Gradient Configuration File to determine the magnet ramp direction.

3-9 LVshim and Gradient Shim Specifications

See Table 3-4A for LVshim specifications by magnet type with BRM and TRM(WB) Coils.

See Table 3-4B for LVshim specifications by magnet type with CRM and TRM(SG) Coils.

Monitor the overall inhomogeneity change from one iteration to the next. If you are seeing no more than a 1-Hz change between iterations, stop shimming. If you are unable to shim the magnet below the specified overall inhomogeneity, you may need to:

- Check and adjust B_0. Refer to the Eddy Current Compensation procedure for details on measuring and adjusting B_0.
- Check for image artifacts, such as zippers, spike noise, etc.
- Call your Zone Support Engineer or OLC for assistance if the system cannot achieve the magnet shim specifications.

TABLE 3-4A
LVSHIM SPECIFICATIONS – BRM AND TRM(WB)

LVSHIM TYPE	OVERALL HOMOGENEITY		HARMONIC COEFFICIENTS (ZERO TO PEAK)			
	"SHIM TO" GOAL*	CUSTOMER ACCEPTANCE	MAGNET TYPE	HARMONIC NAME	"SHIM TO" GOAL*	CUSTOMER ACCEPTANCE
Main (45-cm DSV 500Hz BW)	<45 Hz	< 80 Hz after Gradshim	**Oxford** (12 coils)	Z5, Z6, Z(X2-Y2), ZXY, X3, Y3	NA**	NA
				Z3, Z4, Z2X, Z2Y	< 100 mA† delta current	NA
				Z2, ZX, ZY, X2-Y2, XY	< ±25 Hz	< ±50 Hz after Gradshim
Main (45-cm DSV 500Hz BW)	<45 Hz	< 80 Hz after Gradshim	**S-I** (14 coils)	Z5, Z6, X3, Y3	NA**	NA
				Z3, Z4, Z2X, Z2Y	< 100 mA† delta current	NA
				Z2, ZX, ZY, X2-Y2, XY	< ±25 Hz	< ±50 Hz after Gradshim
				X, Y, Z1	< ±10 Hz	NA
Main (45-cm DSV 500Hz BW)	<45 Hz	< 80 Hz after Gradshim	**S-II**, **S-III**, **S-IV**, **S-X**, **S-XC_1** (18 coils)	Z6	< ±200 Hz‡	NA
				Z3, Z4, Z5, Z2X, Z2Y, Z(X2-Y2), ZXY, X3, Y3	< 100 mA† delta current	NA
				Z2, ZX, ZY, X2-Y2, XY	< ±25 Hz	< ±50 Hz after Gradshim
				X, Y, Z1	< ±10 Hz	NA
Main (45-cm DSV 500Hz BW)	<45 Hz	< 80 Hz after Gradshim	**S-V, S-XC_2** (12 coils)	X2-Y2, XY, Z(X2-Y2), ZXY, X3, Y3	NA**	NA
				Z6	< ±200 Hz‡	NA
				Z3, Z4, Z5, Z2X, Z2Y	< 100 mA† delta current	NA
				Z2, ZX, ZY	< ±25 Hz	< ±50 Hz after Gradshim
				X, Y, Z1	< ±10 Hz	NA
Gradient (22-cm DSV)	< 6 Hz	< 12 Hz after Gradshim	**All,** except CX & LCC magnets (3 coils)	X, Y Z1	≥ ±1 delta gradient unit	< 200 total gradient units

***** Most magnets should be able to achieve the "Shim To" values shown. All magnets must meet the "Customer Acceptance" values. As long as the magnet meets the Customer Acceptance values, Gradient LVshim should be sufficient to maintain an acceptable shim quality. When the Customer Acceptance values are exceeded, Main LVshim must be performed to re-establish an acceptable shim quality.

****** Oxford, S-I, S-V, and S-XC_2 magnets do not have a full set of 18 shim coils; therefore, the harmonics associated with the "missing" coils do not have LVshim specifications. Passive shimming is required to reduce these harmonics. For S-V and S-XC_2 magnets, if X2-Y2, or XY, are > ±25 Hz, you must perform passive to reduce these to < ±25 Hz.

† Note that this spec is for **< 100 mA** delta current, **NOT < ±100 Hz.** As a rule of thumb, all the power supply delta currents should be below 100 mA.

‡ The specification for the Z6 harmonic can be ignored if it forces the center frequency to move out of specification (i.e., forcing the magnet to be re-parked) or if it forces the current in the Z4 or Z6 power supply to exceed 20 amps.

TABLE 3-4A (Continued)
LVSHIM SPECIFICATIONS – BRM AND TRM(WB)

	OVERALL HOMOGENEITY		**HARMONIC COEFFICIENTS (ZERO TO PEAK)**			
LVSHIM TYPE	**"SHIM TO" GOAL***	**CUSTOMER ACCEPTANCE**	**MAGNET TYPE**	**HARMONIC NAME**	**"SHIM TO" GOAL***	**CUSTOMER ACCEPTANCE**
Main LVshim 45 cm dsv 6 scan Planes 500 Hz BW LVshim 50 cm Diam Phantom	< 33 Hz < 20 units of Gradshim	< 54 Hz after Gradshim	**Cx 1.0T & LCC 1.0T** (18 coils)	1, 0 (Z1) 2, 0 (Z2) 3, 0 (Z3) 4, 0 (Z4) 5, 0 (Z5) 6, 0 (Z6) 8, 0 (Z8) 10, 0 (Z10) 12, 0 (Z12) 1, 1 (Y) 1, -1 (X) 2, 1 (ZY) 2, -1 (ZX) 2, 2 (X2-Y2) 3, 1 (Z2Y) 3, -1 (Z2X) 3, 2 (ZX2-ZY2) 3, -2 (ZXY) 3, 3 (Y3) 3, -3 (Y3)	< 15 Hz < 25 Hz < 25 Hz < 50 Hz < 50 Hz < 50 Hz No spec No spec No spec < 15 Hz < 15 Hz < 25 Hz < 25 Hz < 25 Hz < 25 Hz < 25 Hz < 25 Hz < 25 Hz < 25 Hz < 25 Hz < 25 Hz	see Gradshim < 50 Hz < 50 Hz < 100 Hz < 100 Hz < 100 Hz No spec No spec No spec see Gradshim see Gradshim < 50 Hz < 50 Hz < 50 Hz < 50 Hz < 50 Hz < 50 Hz < 50 Hz < 50 Hz < 50 Hz < 50 Hz
Gradshim 22cm DSV	< 4 Hz	< 6 Hz after Gradshim		XYZ	≤ 1unit	< 200 units
6 scan planes, 200 Hz BW, TLT or LVshim Phantom						
Main LVshim 45 cm dsv 6 scan Planes 500 Hz BW LVshim 50 cm Diam Phantom	< 50 Hz < 20 units of Gradshim	< 80 Hz after Gradshim	**Cx 1.5T & LCC 1.5T** (18 coils)	1, 0 (Z1) 2, 0 (Z2) 3, 0 (Z3) 4, 0 (Z4) 5, 0 (Z5) 6, 0 (Z6) 8, 0 (Z8) 10, 0 (Z10) 12, 0 (Z12) 1, 1 (Y) 1, -1 (X) 2, 1 (ZY) 2, -1 (ZX) 2, 2 (X2-Y2) 3, 1 (Z2Y) 3, -1 (Z2X) 3, 2 (ZX2-ZY2) 3, -2 (ZXY) 3, 3 (Y3) 3, -3 (Y3)	< 10 Hz < 25 Hz < 25 Hz < 50 Hz < 50 Hz < 50 Hz No spec No spec No spec < 10 Hz < 10 Hz < 25 Hz < 25 Hz < 25 Hz < 25 Hz < 25 Hz < 25 Hz < 25 Hz < 25 Hz < 25 Hz < 25 Hz	see Gradshim < 50 Hz < 50 Hz < 100 Hz < 100 Hz < 100 Hz No spec No spec No spec see Gradshim see Gradshim < 50 Hz < 50 Hz < 50 Hz < 50 Hz < 50 Hz < 50 Hz < 50 Hz < 50 Hz < 50 Hz < 50 Hz
Gradshim 22cm DSV	< 4 Hz	< 6 Hz after Gradshim	**All CX & LCC**	XYZ	≤ 1unit	< 200 units
6 scan planes, 200 Hz BW, TLT or LVshim Phantom						

***** Most magnets should be able to achieve the "Shim To" values shown. All magnets must meet the "Customer Acceptance" values. As long as the magnet meets the Customer Acceptance values, Gradient LVshim should be sufficient to maintain an acceptable shim quality. When the Customer Acceptance values are exceeded, Main LVshim must be performed to re-establish an acceptable shim quality.

TABLE 3-4B
LVSHIM SPECIFICATIONS – CRM AND TRM(SG)

	OVERALL HOMOGENEITY		**HARMONIC COEFFICIENTS (ZERO TO PEAK)**			
LVSHIM TYPE	**"SHIM TO" GOAL***	**CUSTOMER ACCEPTANCE**	**MAGNET TYPE**	**HARMONIC NAME**	**"SHIM TO" GOAL***	**CUSTOMER ACCEPTANCE**
Main (45-cm DSV 500Hz BW)			**Oxford** (12 coils)	Z5, Z6, Z(X2-Y2), ZXY, X3, Y3 Z3, Z4, Z2X, Z2Y Z2, ZX, ZY, X2-Y2, XY	Magnet not compatible at present.	
Main (40-cm DSV 500Hz BW)	<36 Hz	< 64 Hz after Gradshim	**S-I** (14 coils)	Z5, Z6, X3, Y3 Z3, Z4, Z2X, Z2Y Z2, ZX, ZY, X2-Y2, XY X, Y, Z1	NA** < 100 mA† delta current < ±18 Hz < ±10 Hz	NA NA < ±36 Hz after Gradshim NA
Main (40-cm DSV 500Hz BW)	<36 Hz	< 64 Hz after Gradshim	**S-II**, **S-III**, **S-IV** (18 coils)	Z6 Z3, Z4, Z5, Z2X, Z2Y, Z(X2-Y2), ZXY, X3, Y3 Z2, ZX, ZY, X2-Y2, XY X, Y, Z1	< ±160 Hz‡ < 100 mA† delta current < ±18 Hz < ±10 Hz	NA NA < ±36 Hz after Gradshim NA
Main (40-cm DSV 500Hz BW)	<40 Hz	< 64 Hz after Gradshim	**S-V** (12 coils)	X2-Y2, XY, Z(X2-Y2), ZXY, X3, Y3 Z6 Z3, Z4, Z5, Z2X, Z2Y Z2, ZX, ZY X, Y, Z1	NA** < ±160 Hz‡ < 100 mA† delta current < ±18 Hz < ±10 Hz	NA NA NA < ±36 Hz after Gradshim NA
Gradshim (22-cm DSV)	< 6 Hz	< 12 Hz after Gradshim	**All** except CX & LCC magnets (3 coils)	X, Y Z1	≥ ±1 delta gradient unit	< 200 total gradient units

***** Most magnets should be able to achieve the "Shim To" values shown. All magnets must meet the "Customer Acceptance" values. As long as the magnet meets the Customer Acceptance values, Gradient LVshim should be sufficient to maintain an acceptable shim quality. When the Customer Acceptance values are exceeded, Main LVshim must be performed to re-establish an acceptable shim quality.

** Oxford, S-I, S-V, and S-XC_2 magnets do not have a full set of 18 shim coils; therefore, the harmonics associated with the "missing" coils do not have LVshim specifications. Passive shimming is required to reduce these harmonics. For S-V and S-XC_2 magnets, if X2-Y2, or XY, are > ±25 Hz, you must perform passive to reduce these to < ±25 Hz.

† Note that this spec is for **< 100 mA** delta current, **NOT < ±100 Hz.** As a rule of thumb, all the power supply delta currents should be below 100 mA.

‡ The specification for the Z6 harmonic can be ignored if it forces the center frequency to move out of specification (i.e., forcing the magnet to be re-parked) or if it forces the current in the Z4 or Z6 power supply to exceed 20 amps.

TABLE 3-4B (Continued)
LVSHIM SPECIFICATIONS – CRM AND TRM(SG)

	OVERALL HOMOGENEITY		HARMONIC COEFFICIENTS (ZERO TO PEAK)			
LVSHIM TYPE	**"SHIM TO" GOAL***	**CUSTOMER ACCEPTANCE**	**MAGNET TYPE**	**HARMONIC NAME**	**"SHIM TO" GOAL***	**CUSTOMER ACCEPTANCE**
Main LVshim 40 cm dsv 6 scan Planes 500 Hz BW LVshim 50 cm Diam Phantom	< 40 Hz < 20 units of Gradshim	< 64 Hz after Gradshim	**Cx 1.5T, LCC 1.5T** (18 coils)	1, 0 (Z1) 2, 0 (Z2) 3, 0 (Z3) 4, 0 (Z4) 5, 0 (Z5) 6, 0 (Z6) 8, 0 (Z8) 10, 0 (Z10) 12, 0 (Z12) 1, 1 (Y) 1, -1 (X) 2, 1 (ZY) 2, -1 (ZX) 2, 2 (X2-Y2) 3, 1 (Z2Y) 3, -1 (Z2X) 3, 2 (ZX2-ZY2) 3, -2 (ZXY) 3, 3 (Y3) 3, -3 (Y3)	< 10 Hz < 25 Hz < 25 Hz < 50 Hz < 50 Hz < 50 Hz No spec No spec No spec < 10 Hz < 10 Hz < 25 Hz < 25 Hz < 25 Hz < 25 Hz < 25 Hz < 25 Hz < 25 Hz < 25 Hz < 25 Hz < 25 Hz	see Gradshim < 50 Hz < 50 Hz < 100 Hz < 100 Hz < 100 Hz No spec No spec No spec see Gradshim see Gradshim < 50 Hz < 50 Hz < 50 Hz < 50 Hz < 50 Hz < 50 Hz < 50 Hz < 50 Hz < 50 Hz < 50 Hz
Gradshim 22cm DSV	< 4 Hz	< 6 Hz after Gradshim		XYZ	≤ 1unit	< 200 units
6 scan planes, 200 Hz BW, TLT or LVshim Phantom						

* Most magnets should be able to achieve the “Shim To” values shown. All magnets must meet the “Customer Acceptance” values. As long as the magnet meets the Customer Acceptance values, Gradient LVshim should be sufficient to maintain an acceptable shim quality. When the Customer Acceptance values are exceeded, Main LVshim must be performed to re-establish an acceptable shim quality.

3-10 LVshim Data Sheets

Record the data from the LVshim Analysis in appropriate Data Sheet located in appendix B:

- Supercon (GE S-I)
- Supercon (GE S-II, S-III, S-IV, S-V, S-X, S-XC)
- Gradient/Resistive (GE S-I, S-II, S-III)
- Resistive (Oxford 12-coil)
- Resistive (Oxford 18-coil)

- Gradient (All)
- Supercon (GE LCC)

4- LVSHIM SOFTWARE

The LVshim software consists of three elements:

- The **LVshim PSD**: Defines the pulse sequence data base (PSD) used to acquire the LVshim scan data.
- **LVshim Calibration File Generator**: Generates LVshim calibration files.
- **LVshim Analysis Tool**: Analyzes the scan data acquired by the LVshim PSD and computes the magnetic field inhomogeneity and new shim current settings.

4-1 LVshim Calibration Files

Overview

LVshim calibration files contain coil characterization data used by the LVshim analysis tool to calculate the new currents needed to correct for magnetic field inhomogeneity. Generic shim calibration files are supplied with the system software for all gradient coils and for GE S/C shim coils.

4-1-1 Magnet Serial Number

The magnet serial number is used by LVshim to determine the appropriate set of calibration files to display during the shimming process. The magnet serial number must be correctly entered in the MR Configuration file. (The Magnet Type field is no longer used by system software tools.) Table 4-1 shows the value for each magnet type.

TABLE 4-1
MAGNET SERIAL VALUES

MAGNET TYPE	VALUE	MAGNET TYPE	VALUE
Oxford	**4**xxxx **(Note 1)**	Cx 1.0T	**P**xxxx
S-I	**67**xxx	Cx 1.5T	**N**xxxx
S-II	**C**xxxx	LCC 1.0T	**Q**xxxx
S-III	**D**xxxx	LCC 1.5T	**R**xxxx
S-IV	**G**xxxx		
S-V	**J**xxxx		
S-X	**X**xxxx		
S-Xc_1	**K**xxxx		
S-Xc_2	**L**xxxx		
Note 1: Use o12 as a prefix to the magnet serial number for Oxfords with a 12-coil resistive shim and use o18 as a prefix for Oxfords with a 17-coil resistive shim (Ex: o1240366).			

4-1-2 Calibration File Type

The software displays only the Calibration File Types appropriate for the type of magnet being shimmed. Table 4-2 shows the Cal File Types for each type of magnet.

TABLE 4-2
CALIBRATION FILE TYPES

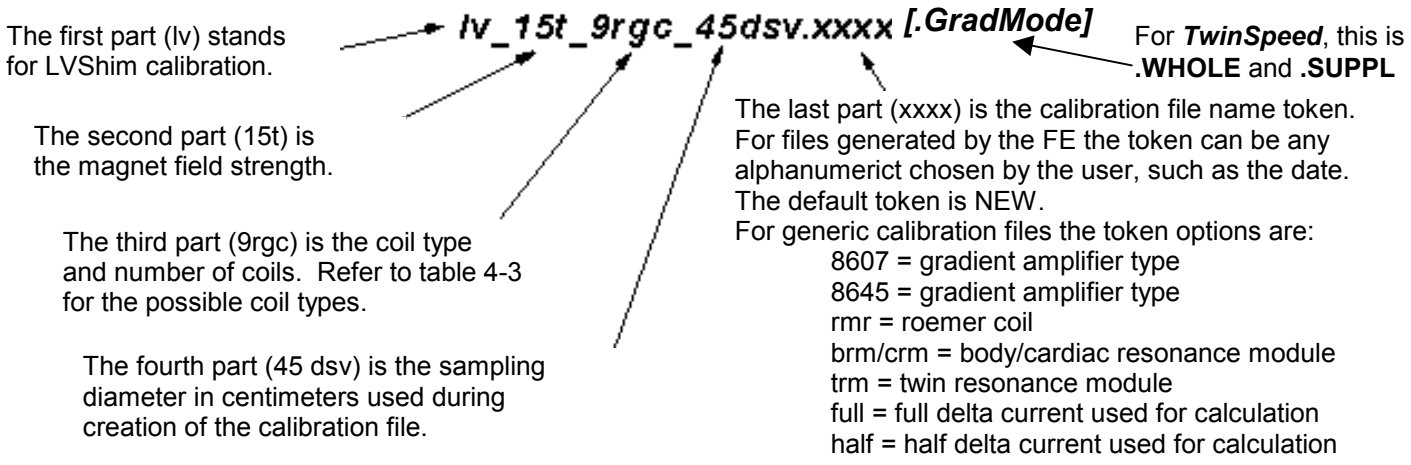
MAGNET TYPE	CAL FILE TYPE							
	GRADIENT	RESISTIVE	RES & GRAD*	S/C16 1.5T	S/C12 1.0T	S/C12 1.5T	S/C18 1.0T	S/C18 1.5T
Oxford 13	X	X						
Oxford 18	X	X						
S-I	X		X	X				
S-II	X		X					X
S-III	X		X					X
S-IV	X	X**						X
S-V	X					X		
Cx, LCC 1.5T	X							X
S-X	X						X	
S-XC_1	X						X	
S-XC_2	X				X			
Cx, LCC 1.0T	X						X	

***** The Res&Grad shim type always displays for S-I magnets, but displays for S-II/S-III magnets only when the Spectroscopy RF Amplifier variable is set to *yes* in the MR Configuration file.

****** The resistive shim option for GE S-IV magnets (Catalog No. M1040CH) consists of three coils: Z2, ZX, and ZY. The resistive shim power supply assembly contains six power supplies (Z2, Z3, ZX, ZY, X2-Y2, and XY), but only Z2, ZX, and ZY are used. However, the software does not support this three coil matrix at this time.

4-1-3 Calibration File Name

Illustration 4-1 is an example of a shim calibration file, with the name components explained. Refer to Table 4-3 for a list of the available coils.



BREAKDOWN OF A SHIM CALIBRATION FILE NAME
ILLUSTRATION 4-1

TABLE 4-3
COIL TYPES

COIL	DESCRIPTION
3gc	Gradient (all magnets)
9rgc **(Note 1)**	Gradient/Resistive (S-I, S-II, and S-III)
6rc	Resistive (S-I, S-II, and S-III)
12rc	Resistive (Oxford)
17rc	Resistive (Oxford)
12sc	12-coil Supercon (S-V, S-XC_2)
14sc	14-coil Supercon (S-1)
18sc	18-coil Supercon (S-II, S-III, S-IV, S-X, S-XC_1, Cx 1.5T, Cx 1.0T, LCC 1.5T, LCC 1.0T)
Note 1: The resistive shim option for GE S-IV magnets (Catalog No. M1040CH) consists of three coils: Z2, ZX, and ZY. The resistive shim power supply assembly contains six power supplies (Z2, Z3, ZX, ZY, X2-Y2, and XY), but only Z2, ZX, and ZY are used. However, the software does not support this three-coil matrix at this time.	

The S/C shim calibration files are divided into magnet/coil type and then by four file types: *22dsv.full*, *32dsv.full*, *40dsv.full, 45dsv.full*, *40dsv.half*, and *45dsv.half*. The number signifies the diameter of the spherical volume. The *22dsv.full* files are used during Rough and Gradient LVshim. The *40dsv.full* (for CRM Body Coil) and *45dsv.full* files are used during Main LVshim.

The *40dsv.half* and *45dsv.half* files are half-current files used in cases where the full file is "overshooting" the target value. The *32dsv.full* files are for troubleshooting purposes only. Table 4-4 lists the generic calibration files supplied with the system.

TABLE 4-4
GENERIC GRADIENT AND S/C SHIM CALIBRATION FILES

FILE TYPE	MAGNET TYPE	SHIM CALIBRATION FILE NAMES
3-Coil Gradient	All	lv_10t_3gc_22dsv.rmr lv_15t_3gc_22dsv.rmr lv_10t_3gc_22dsv.brm lv_15t_3gc_22dsv.brm lv_15t_3gc_22dsv.crm lv_15t_3gc_22dsv.trm.WHOLE * lv_15t_3gc_22dsv.trm.ZOOM *
14-Coil Superconductive	GE S-I	lv_15t_14sc_22dsv.full lv_15t_14sc_32dsv.full lv_15t_14sc_40dsv.full lv_15t_14sc_45dsv.full lv_15t_14sc_40dsv.half lv_15t_14sc_45dsv.half
18-Coil Superconductive	GE S-II, S-III, S-IV, Cx 1.5T, LCC 1.5T	lv_15t_18sc_22dsv.full lv_15t_18sc_32dsv.full lv_15t_18sc_40dsv.full lv_15t_18sc_45dsv.full lv_15t_18sc_40dsv.half lv_15t_18sc_45dsv.half
	GE S-X, S-XC_1, Cx 1.0T, LCC 1.0T	lv_10t_18sc_22dsv.full lv_10t_18sc_32dsv.full lv_10t_18sc_45dsv.full lv_10t_18sc_45dsv.half
12-Coil Superconductive	GE S-V	lv_15t_12sc_22dsv.full lv_15t_12sc_32dsv.full lv_15t_12sc_40dsv.full lv_15t_12sc_45dsv.full lv_15t_12sc_40dsv.half lv_15t_12sc_45dsv.half
12-Coil Superconductive	S-XC_2	lv_10t_12sc_22dsv.full lv_10t_12sc_32dsv.full lv_10t_12sc_45dsv.full lv_10t_12sc_45dsv.half

* only for Twin*Speed*.

4-2 LVshim Analysis Tool Details

This section provides detailed information about the items in the LVshim Analysis menu. When selected, some of the items toggle to another value (available choices are shown in parentheses), some toggle between Yes and No, and some prompt for additional input.

4-2-1 Shim Type

The software displays only the shim types that are associated with the magnet being shimmed. Table 4-5 shows the shim types for each magnet. When Test is selected as the Shim Type, new shim currents are not calculated during LVshim analysis.

TABLE 4-5
TYPES OF SHIMS AVAILABLE

MAGNET TYPE	SHIM TYPE LABELS			
Oxford 12	Gradient	Oxf-12		Test
Oxford 18	Gradient	Oxf-18		Test
S-I	Gradient	Res&Grad*	Sup14_1.5T	Test
S-II	Gradient	Res&Grad*	Sup18_1.5T	Test
S-III	Gradient	Res&Grad*	Sup18_1.5T	Test
S-IV**	Gradient	Sup18_1.5T		Test
S-V	Gradient	Sup12_1.5T	Passive	Test
Cx, LCC 1.5	Gradient	Sup18_1.5T		Test
S-X	Gradient	Sup18_1.0T		Test
S-XC_1	Gradient	Sup18_1.0T		Test
S-XC_2	Gradient	Sup12_1.0T	Passive	Test
Cx, LCC 1.0	Gradient	Sup18_1.0T		Test

* The Res&Grad shim type always displays for S-I magnets, but displays for S-II/S-III magnets only when the Spectroscopy RF Amplifier variable is set to yes in the MR Configuration file.

** The resistive shim option for GE S-IV magnets (Catalog No. M1040CH) consists of three coils: Z2, ZX, and ZY. The resistive shim power supply assembly contains six power supplies (Z2, Z3, ZX, ZY, X2-Y2, and XY), but only Z2, ZX, and ZY are used. However, the software does not support this three coil matrix at this time.

4-2-2 Image Data

Image Data refers to the exam, series, and image number of the image data set to be processed. If an LVshim scan has just been performed, the program automatically picks up the last exam, last series, and first image number of the last set of images scanned, and makes it the default choice. If the last scan was not an LVshim scan, Image Data is shown as <<none selected>>.

Select this menu item when the image data displayed by the software are incorrect. When Image Data is selected, the software prompts for the correct exam, series, and image numbers. If you do not know the exam, series, or image number of the image data to be processed, enter 0 (zero) when prompted for a number; this provides a list of the existing exams, series, or images.

For the **Twin*Speed***, take care to select the series corresponding to the same GradMode highlighted upon entering the LVshim Analysis Tool.

4-2-3 Operation Mode

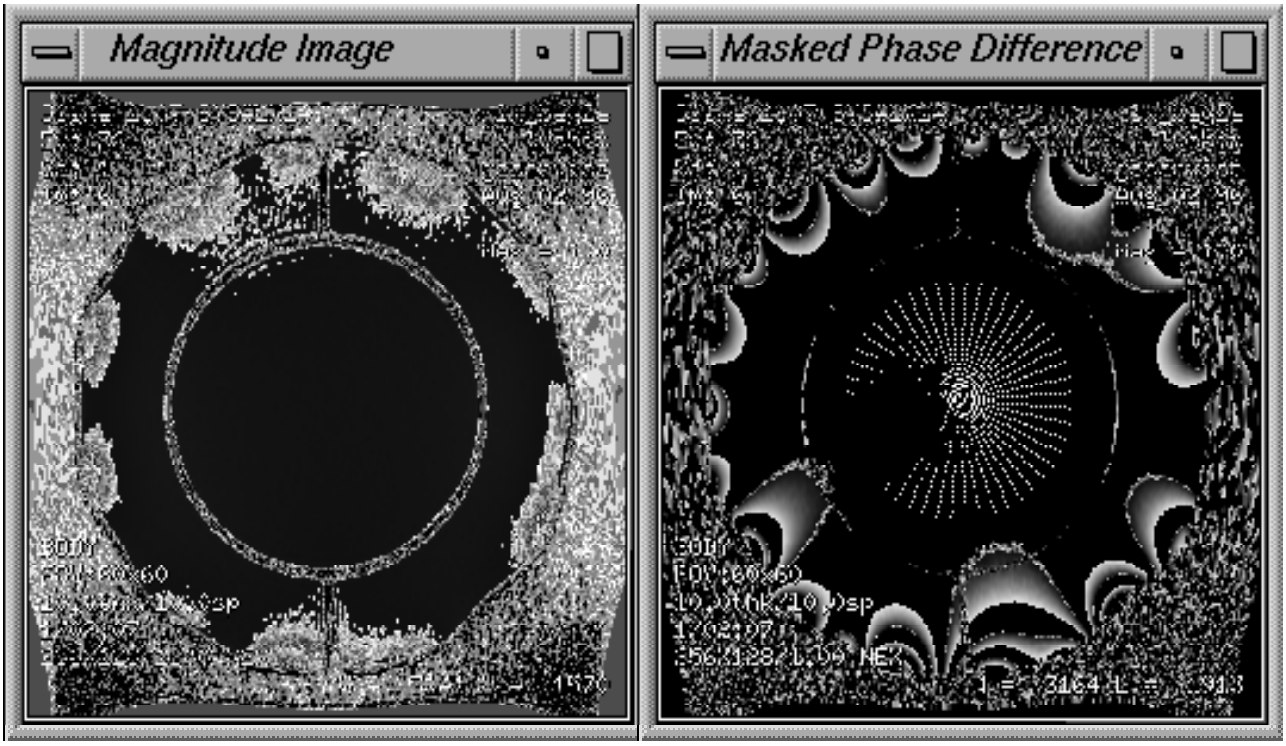
There are two operation mode options: Service and Research. Table 4-6 describes them.

TABLE 4-6
OPERATION MODE OPTIONS

OPTION	DESCRIPTION
Service	This mode should be used for Rough and Main Lvshim and Gradient shimming for all magnet types. This mode also includes all the LVshim features needed to build a shim calibration file.
Research	This mode should be used for Rough and Main LVshim troubleshooting only. While in the Research mode, the user can configure out selected coils during shimming.

4-2-4 Display Mag and Phase Diff Images

This option allows the display of the magnitude image and masked phase difference image each in a separate window after the image data is processed. Both windows are updated when an alternate scan plane is selected. The magnitude image and the masked phase difference image are displayed as shown in Illustration 4-2. These windows will initially appear in the upper right corner of the screen, then relocate as necessary for viewing of LVshim analysis window.



MAGNITUDE IMAGE & MASKED PHASE DIFFERENCE IMAGE
ILLUSTRATION 4-2

4-2-5 Calibration File Name Token

The calibration file name token is used to help distinguish similar calibration file names from each other. The token is attached at the end of the calibration file name. Refer to Section 4-1-3, *Calibration File Name*, for more information about the calibration file name.

5- LVSHIM CALIBRATION FILE GENERATION DETAILS

Overview

LVshim calibration files contain coil characterization data used by the LVshim analysis tool to calculate the new currents needed to correct for magnetic field inhomogeneity. Generic shim calibration files are supplied with the system software for all gradient coils and for GE S/C shim coils. Shim calibration files must be created at the site for Oxford and GE resistive shim coils.

The generic gradient and S/C shim calibration files should work well at all sites, so it should not be necessary to create them. Creating a S/C shim calibration file is time-consuming and prone to errors. The procedures for creating a gradient or S/C shim calibration file on-site have not been supplied. Before creating a gradient or S/C shim calibration file at a site, contact your MAC Team Leader, or the OLC Magnet Support Group for assistance.

Note

If the resistive shim coil assembly is replaced, or is moved within the magnet bore, then a new cal file may need to be created. Also, changes to system software may require the creation of a new cal file.

5-1 Creating a Shim Calibration File

Note

Creating a resistive shim calibration file can take two to four hours, and can be error-prone. Be sure there is adequate time to perform the task, and be careful during coil characterization to enter the correct perturbation currents.

Overview

The procedure in this section describes the creation of a 45-cm DSV Oxford Resistive Shim calibration file. The process of creating a GE Resistive Shim calibration file is similar. If you cannot collect image data to build a 45-cm DSV calibration file (due to phase wrap issues), then build a 32-cm DSV calibration file instead. Shim the magnet using the 32-cm DSV calibration file, but check the shim on a 45-cm DSV. You should be able to meet the 45-cm DSV shim specifications with the 32-cm DSV calibration file. If you cannot meet the 45-cm DSV shim specification, contact your local Zone Engineer or Support Center - Magnet Support Team for assistance.

A shim calibration file can be created in either of two ways:

- Collect coil characterization scan data for all the coils in a coil set, then run the shim calibration processing on all the data to create the calibration matrix.
- Collect coil characterization scan data for one coil in a coil set, then run the shim calibration processing on the data for that coil. This process is repeated until all the coils in the set have been characterized; then the calibration matrix is created.

5-2 Three Generation Options

There are three generation options: Create, Resume, and Modify. Table 5-1 shows all options.

TABLE 5-1
CAL FILE GENERATION OPTIONS

OPTION	CAL FILE TYPE
CREATE	When this option is used, a new calibration file is created for the image data being analyzed. The new file contains the calibration file name token specified in menu item 4.
RESUME	This option allows the user to resume a previously started shim calibration process. The software automatically displays the calibration file name token and sampling diameter of the latest partial shim file associated with the selected cal file type.
MODIFY	This option allows the modification of the data in an existing shim calibration file. The data is modified one coil at a time by re-scanning and reprocessing the baseline and perturbed states for a coil. The process is repeated for each coil to be re-characterized. The software automatically displays the calibration file name and sampling diameter of the latest shim file associated with the selected cal file type. To get a list of other shim calibration files associated with the selected cal file type, enter **4** at the Modify menu.

5-3 Suggested Perturb Currents and Series Descriptions

Perturbation Current

The Perturbation Current is the amount that the coil was perturbed during the collection of the selected image data set. If the perturbation value is set to *0* (zero), the selected image data set is treated as the baseline scan for the named coil.

This section contains the suggested perturb currents and series descriptions to be used during shim calibration file generation. The information in Table 5-2 applies to 9-coil gradient/resistive magnets. Table 5-3 applies to 12-coil resistive magnets.

TABLE 5-2
NINE-COIL GRADIENT/RESISTIVE (GE S-I, S-II, S-III)

COIL NAME	SCAN INFORMATION		
	SCAN TYPE	SUGGESTED PERTURB CURRENT	SERIES DESCRIPTION (SEE NOTE)
GRAD_X	Baseline	–	XGRAD baseline
	Perturbation	50	XGRAD 50
GRAD_Y	Baseline	–	YGRAD baseline
	Perturbation	50	YGRAD 50
GRAD_Z	Baseline	–	ZGRAD baseline
	Perturbation	50	ZGRAD 50
Z2	Baseline	–	Z2 baseline
	Perturbation	2.0	Z2 2.0
Z3	Baseline	–	Z3 baseline
	Perturbation	1.0	Z3 1.0
ZX	Baseline	–	ZX baseline
	Perturbation	1.0	ZX 1.0
ZY	Baseline	–	ZY baseline
	Perturbation	1.0	ZY 1.0
X2-Y2	Baseline	–	X2-Y2 baseline
	Perturbation	5.0	X2-Y2 5.0
XY	Baseline	–	XY baseline
	Perturbation	5.0	XY 5.0

Note: 0 (zero) can be used in place of baseline for baseline scans. For example, XGRAD baseline is the same as XGRAD 0.

TABLE 5-3
TWELVE-COIL RESISTIVE (OXFORD)

COIL NAME	SCAN INFORMATION		
	SCAN TYPE	SUGGESTED PERTURB CURRENT	SERIES DESCRIPTION (NOTE 1)
Z1	Baseline	–	Z1 baseline
	Perturbation	0.1	Z1 0.1
Z2	Baseline	–	Z2 baseline
	Perturbation	0.5	Z2 0.5
Z3	Baseline	–	Z3 baseline
	Perturbation	2.0	Z3 2.0
Z4	Baseline	–	Z4 baseline
	Perturbation	2.0	Z4 2.0
X	Baseline	–	X baseline
	Perturbation	0.1	X 0.1
Y	Baseline	–	Y baseline
	Perturbation	0.1	Y 0.1
ZX	Baseline	–	ZX baseline
	Perturbation	1.0	ZX 0.1
ZY	Baseline	–	ZY baseline
	Perturbation	1.0	ZY 1.0
XY	Baseline	–	XY baseline
	Perturbation	1.0	XY 1.0
X2-Y2	Baseline	–	X2-Y2 baseline
	Perturbation	1.0	X2-Y2 1.0
Z2X	Baseline	–	Z2X baseline
	Perturbation	2.0	Z2X 2.0
Z2Y	Baseline	–	Z2Y baseline
	Perturbation	2.0	Z2Y 2.0

Note 1: 0 (zero) can be used in place of baseline for baseline scans. For example, Z1 baseline is the same as Z1 0.

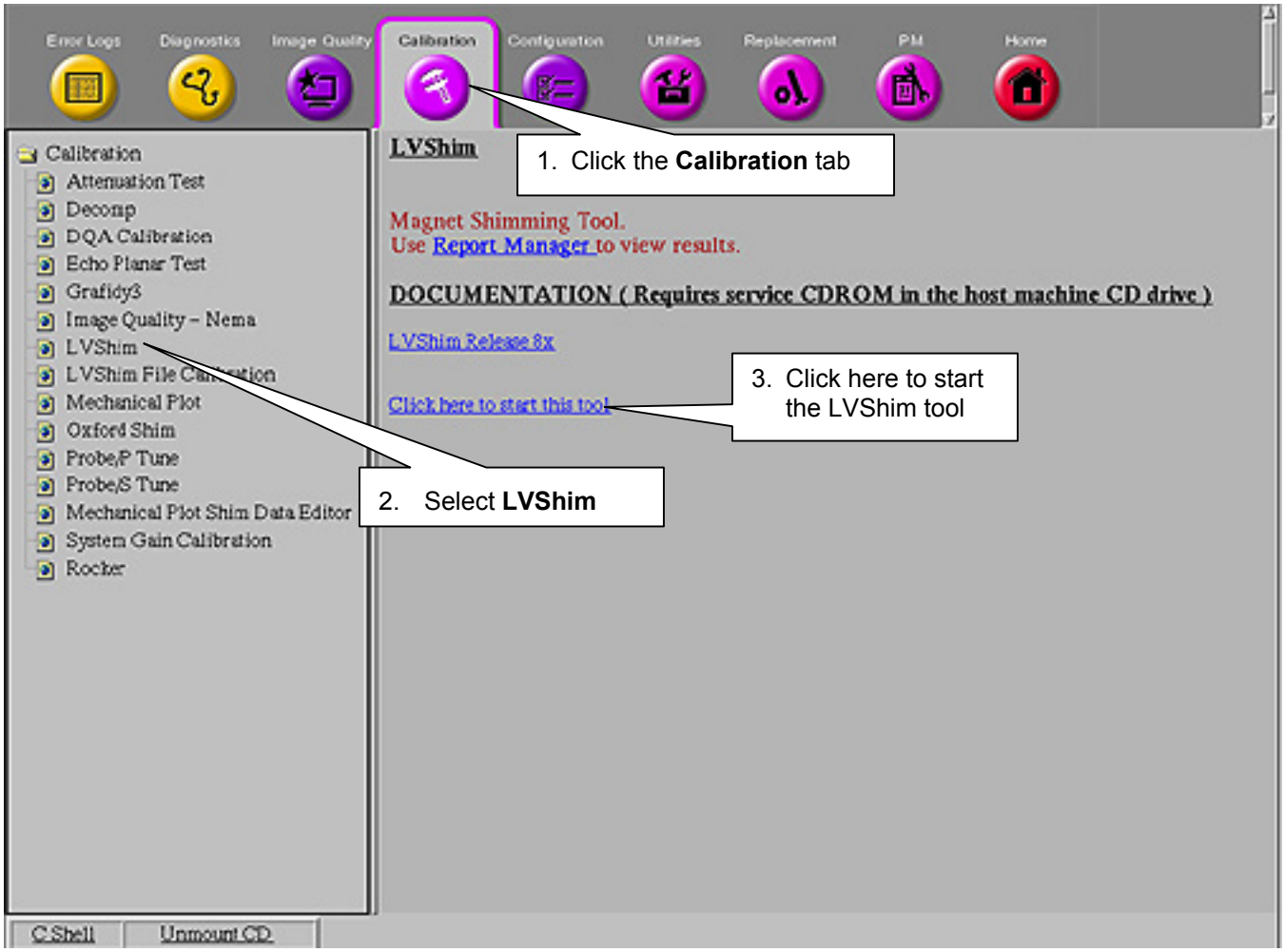
5-4 Enter Baseline Currents

Before starting data collection, enter the baseline currents for the coil set into the system. These are the final mechanical shim currents, or the currents used to get the best shim to date.

1. At the operator workspace, select the tools icon in the desktop control panel.

2. After the scan is complete, select the **Tools** icon, **[Cal/Checks]**, then **[LVShim]**, then **[Start]**.

   9.x, 10.x: To run the LVShim tool from the Service Browser, follow the instructions on Illustration 5-1, below:



STARTING THE LVSHIM TOOL FROM THE SERVICE BROWSER
ILLUSTRATION 5-1

3. For ***TwinSpeed***, highlight the **GradMode**, then click on **[OK]**. Continue as shown in Table 5-4.

TABLE 5-4
ENTERING BASELINE CURRENTS

OUTPUT/PROMPTS	INPUTS/COMMENTS
<<< LVshim Analysis >>> (Magnet Type : Oxford (12 coil)) 1. Shim Type (Gradient, Oxf-12,TEST): Gradient 2. Image Data (Ex, Se, Im Number) : <None Selected> 3. Operation Mode (Service or Research): Service 4. Display Mag and Phase Diff Images : No 5. Calibration File Name : lv_15t_3gc_22dsv.8645 6. Existing Current in Each Coil. XGRAD: 0.000 YGRAD: 0.000 ZGRAD: 0.000 Accept (q or s to quit). Enter the Index Number to Change Default (0..6)[0]: ...	**1<Enter>** To change Shim Type to Resistive.
<<< LVshim Analysis >>> (Magnet Type : Oxford (12 coil)) 1. Shim Type (Gradient, Oxf-12,TEST): Oxf-12 2. Image Data (Ex, Se, Im Number) : <None Selected> 3. Operation Mode (Service or Research): Service 4. Display Mag and Phase Diff Images : No 5. Calibration File Name : lv_15t_12rc_45dsv.tag* 6. Existing Current in Each Coil. Z1: 0.000 X: 0.000 XY: 0.000 Z2: 0.000 Y: 0.000 X2-Y2: 0.000 Z3: 0.000 ZX: 0.000 Z2X: 0.000 Z4: 0.000 ZY: 0.000 Z2Y: 0.000 0. Accept (q or s to quit). Enter the Index Number to Change Default (0..6)[0]: ...	**6<Enter>**
Coil 1 [Z1] (-20.00..20.00) [0.0]:	Enter baseline current for Coil 1 (Z1)
<----------	Enter baseline currents for Coils 2–11
Coil 12 [Z2Y] (-10.00..10.00) [0.0]:	Enter baseline current for Coil 12 (Z2Y)
<<< LVshim Analysis >>> (Magnet Type : Oxford (12 coil)) 1. Shim Type (Gradient, Oxf-12,TEST): Oxf-12 2. Image Data (Ex, Se, Im Number) : <None Selected> 3. Operation Mode (Service or Research): Service 4. Display Mag and Phase Diff Images : No 5. Calibration File Name : lv_15t_12rc_45dsv.tag* 6. Existing Current in Each Coil. Z1: 0.853 X: -3.407 XY: 0.310 Z2: -1.716 Y: -1.292 X2-Y2: 0.280 Z3: 1.489 ZX: 0.557 Z2X: -1.042 Z4: 4.112 ZY: 0.387 Z2Y: 0.641 0. Accept (q or s to quit).	*Make sure the correct currents are displayed, then:*
Enter the Index Number to Change Default (0..6)[0]: ...	**q <Enter>** (To quit.)
Exit LVshim? (Y,N) [N] :	**y <Enter>** (Exit LVshim.)
Press any key to quit -->	Press any key

5-5 Get Hard Copy of Perturbation Currents (Optional)

If a printer is available, and you wish to get a hard copy of the perturbation currents:

1. At the operator workspace, select the **Tools** icon in the desktop control panel.

2. In the Service Desktop Manager, select **[Cal/Checks], [LVshim Calib]** and click **[Start]**.

   For 9.x, 10.x: To run the LVShim tool from the Service Browser, follow the instructions in step 2 of Section 5-4, *Enter Baseline Currents*.

3. For **Twin*Speed***, highlight the **GradMode** and click on **[OK]**. Continue as shown in Table 5-5.

TABLE 5-5
GETTING HARD COPY OF PERTURBATION CURRENTS (OPTIONAL)

OUTPUT/PROMPTS	INPUTS/COMMENTS
<<< LVshim Calibration File Generation >>> (Magnet Type : Oxford (12 coil)) 1. Cal File Type (Gradient, Oxf-12) : Gradient 2. Generation (Create, Resume or Modify): Create 3. Operation Mode (Service or Research) : Service 4. Calibration File Name Token : NEW 5. Sampling Diameter in Centimeters : 45 6. Display Phase Diff Images : No 7. Display Calibration Matrix : Yes 8. Control Gradient Shim Coil Current : Yes 0. Accept (q or s to quit). Enter the index number to change default (0..9) [0]: ..	**1 <Enter>** to change Cal File Type to Resistive
<<< LVshim Calibration File Generation >>> (Magnet Type : Oxford (12 coil)) 1. Cal File Type (Gradient, Oxf-12) : Oxf-12 2. Generation (Create, Resume or Modify): Create 3. Operation Mode (Service or Research) : Service 4. Calibration File Name Token : NEW 5. Sampling Diameter in Centimeters : 45 6. Display Phase Diff Images : No 7. Display Calibration Matrix : Yes 8. Show Suggested Perturb Current : Yes 9. Suggested Perturb Current. Z1: 0.1 X: 0.1 XY: 1.0 Z2: 0.5 Y: 0.1 X2-Y2: 1.0 Z3: 2.0 ZX: 1.0 Z2X: 2.0 Z4: 2.0 ZY: 1.0 Z2Y: 2.0 0. Accept (q or s to quit). Enter the index number to change default (0..10)[0]: ..	**<Enter>**
Displaying Suggested Perturb Current	

5-6 Data Collection

5-6-1 Control Gradient Shim Coil Currents

Note

Option availability I is available only when the Cal File Type is "Gradient."

When this option is set to *yes*, the gradient shim coil perturb currents are automatically set by the software. When the option is set to *no*, the gradient shim coil perturb currents must be manually set.

To manually set the gradient shim coil currents:

1. At the operator workspace, select **[Manual Prescan]**.

2. Set *x*, *y*, and *z* to the desired values, then select **[Files]**, then **[Save Shim File]**. Select **[Done]** to save the file.

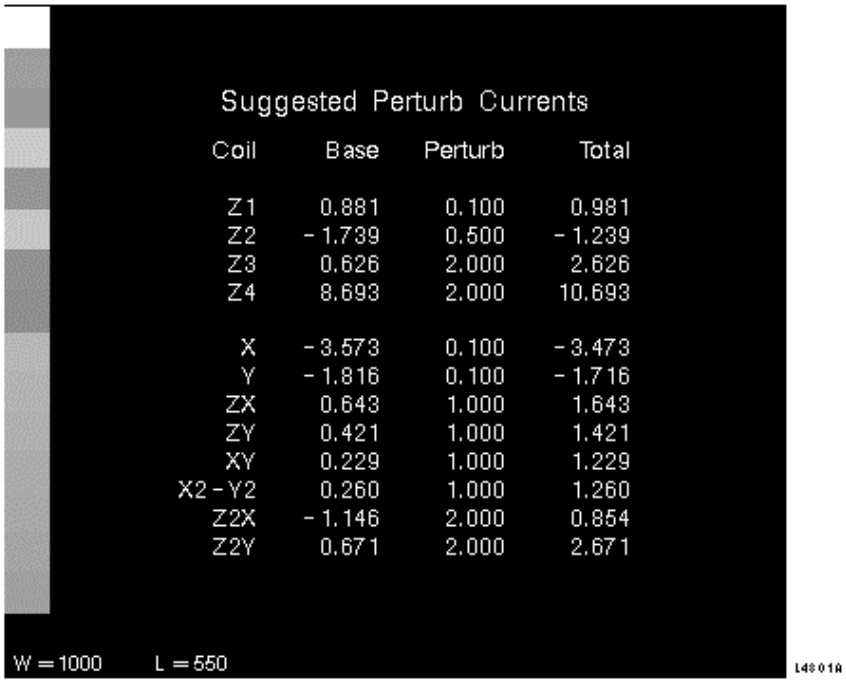
3. Select **[Done]** to exit Manual Prescan.

5-6-2 Suggested Perturb Current

Note

Option availability II is available only when the Cal File Type is not "Gradient."

When this option is set to *yes*, the suggested perturb currents for the coil set being calibrated are displayed, allowing you to get a hard copy of the currents. This option allows you to change the perturb currents to be used for the coil set being calibrated. When selected, the software prompts for the new currents, one at a time. Illustration 5-2A shows a typical suggested perturb currents display (shown in Genesis format; the Lx display is different).



SUGGESTED PERTURB CURRENTS (OXFORD RESISTIVE SHIM COIL)
ILLUSTRATION 5-2A

5-6-3 Storage

There are two types of storage: Accumulate and Replace. **Accumulate** is used when you wish to average multiple scans for a given coil type/perturbation (such as taking three Z1 baseline scans to average the data). **Replace** is used when you wish to throw out the old data and replace them with data from a different scan. If you choose Replace mode, all previous data collected for the coil are lost.

5-6-4 Processing in Silent Mode

This option allows you to perform all the scans necessary for creating a calibration file, and then to use the calibration software to process all the image data at one time with very little user intervention. The software uses the series description to automatically determine the coil name and the perturb current used for each image data set. If the program is unable to determine the coil name or perturb current, the silent mode is automatically turned off, and the user is asked to provide the missing information.

5-6-5 Data Collection

Procedure

1. Perform Section 3-3 *Phantom Setup*, if you haven't already done so.

2. At the operator workspace, select the Scan icon in the desktop control panel and set up LVshim scan as follows:

   a. In RX Manager, click **[New Series]**.

b. At the operator workspace, prepare the system for LVshim 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.

In the Protocol field, type **o.19.2** (o = Other, 2 = series number). For ***TwinSpeed***, select the **GradMode** followed by **Whole Body**.

Note

The Series Description naming convention is very important when shim calibration processing is performed on all the coil data at the same time. The Series Description name consists of the coil name and perturbation current. If you are processing only one coil at a time, the Series Description can be left blank.

c. In Additional Parameters, click **[User CVs Screen]**.

d. In the User Control Variables window enter the following:

No. of Scan Planes: **6**

Bandwidth: **2000**

e. Click **[Accept]** and then **[Save Series]**.

f. In RX Manager, click **[Prepare to Scan]**.

3. Click **[Manual Prescan]**. While in the **[Center Freq Coarse (CFC)]** mode, verify the frequency peak is centered in the display. Adjust the center frequency peak as necessary. After locating the best signal, open the **[Frequency]** menu at the top of Manual Prescan window and select **[Save Frequency]** to save the new center frequency.

4. Click **[Scan TR (R1/R2)]**. Verify that R_1 and R_2 are not over ranged. Adjust R_1 and R_2 for approximately 50%.

5. Click **[Done]** to exit manual prescan.

6. Click **[Scan**].

Note

A Resistive Shim Calibration file can be created by using one baseline scan and one perturbation scan for each coil in a coil set. However, if time allows, three scans should be taken for each baseline and perturbation to insure accuracy of the calibration matrix (by averaging the data).

7. If more than one scan is desired, when the first scan is finished, press **[Scan]** again to collect a second set of scan data. Then, when the second scan is finished, press **[Scan]** again to collect a third set of scan data.

8. When the baseline scan(s) is finished, in RX Manager, copy and paste the present series, then select **[View Edit]**. Change the Series Description to **Z1 0.1**, then click **[Save Series]**, followed by **[Prepare to Scan]**. Perturb the Z1 coil baseline current by 0.1 amps as described in Section 5-6-1, then repeat steps 3 through 8 to collect the Z1 perturbation scan(s). After the Z1 perturbation scan(s) have been collected, set the Z1 coil current back to its baseline value.

9a. To collect scan data for **all of the coils in a coil set** before processing, follow these steps:

   a. In RX Manager, copy and paste the present series, then select **[View Edit]**.
   b. Change the Series Description to **Z2 baseline**, then click **[Save Series]**, followed by **[Prepare to Scan]**.
   c. Perform steps 3 through 9 to collect baseline and perturbation scans for the Z2 coil (use **Z2 0.5** as the Series Description name for the Z2 perturbation scans).
   d. Repeat steps **a** through **c** for the remaining coils in the coil set.
   e. When scan data for all coils have been collected, perform Shim Calibration Processing (Silent Mode = Yes).

9b. To collect and process scan data for **each coil, one at a time**:

   a. Perform Shim Calibration Processing on the Z1 coil scans (baseline and perturbation) (Silent Mode = No).
   b. When the processing is done, in RX Manager, copy and paste the present series, then select **[View Edit]**. Change the Series Description to **Z2 baseline**, then click **[Save Series]**, followed by **[Prepare to Scan]**.
   c. Perform steps 3 through 9 to collect baseline and perturbation scans for the Z2 coil.
   d. Repeat steps **a** through **c** for the remaining coils in the coil set.

5-6-6 Existing Current in Each Coil

Existing current values are displayed for all the coils in the coil set being shimmed. This option allows you to change the existing values. When the gradient current values are changed, the new values are automatically sent to the gradient amplifiers by the software.

5-7 Shim Calibration Processing

1. In Service Desktop Manager, select **[Cal/Checks], [LVshim Calib]** and click **[Start]**.

   For 9x., 10.x: In the Service Browser, select the **Calibration** tab, then in the menu options on the left side of the browser, click **LVShim**. On the right side, click the link **Click here to start this tool**.

2. For ***TwinSpeed***, highlight the **GradMode** and click on **OK**. Continue as shown in Table 5-6.

TABLE 5-6
SHIM CALIBRATION PROCESSING

OUTPUT/PROMPTS	INPUTS/COMMENTS
<<< LVshim Calibration File Generation >>> (Magnet Type : Oxford (12 coil)) 1. Cal File Type (Gradient, Oxf-12) : Gradient 2. Generation (Create, Resume or Modify): Create 3. Operation Mode (Service or Research) : Service 4. Calibration File Name Token : NEW 5. Sampling Diameter in Centimeters : 45 6. Display Phase Diff Images : No 7. Display Calibration Matrix : Yes 8. Control Gradient Shim Coil Current : Yes 0. Accept (q or s to quit). Enter the index number to change default (0..9) [0] :	**1 <Enter>** to change Cal File Type to Oxf-12
<<< LVshim Calibration File Generation >>> (Magnet Type : Oxford (12 coil)) 1. Cal File Type (Gradient, Oxf-12) : Oxf-12 : *(Additional menu selections displayed)* 9. Suggested Perturb Current. Z1: 0.1 X: 0.1 XY: 1.0 Z2: 0.5 Y: 0.1 X2-Y2: 1.0 Z3: 2.0 ZX: 1.0 Z2X: 2.0 Z4: 2.0 ZY: 1.0 Z2Y: 2.0 0. Accept (q or s to quit). Enter the index number to change default (0..10) [0]:	**0 <Enter>** when all menu items are acceptable.
<<< Characterizing Shimming Coils >>> Z1: X: XY: Z2: Y: X2-Y2: Z3: ZX: Z2X: Z4: ZY: Z2Y: Common Baseline: Pending 1. Image Data (Ex, Se, Im Number) : 50008, 1, 1 (Series Description: Z1 baseline) 2. Storage (Accumulate or Replace): Accumulate 3. Display Phase Diff Images : No 4. Processing in Silent Mode : No 5. Coil Name (To be Characterized): <None Selected> 0. Accept (q or s to Return). Enter the Index Number to Change Default (0..6) [0]: ...	**5 <Enter>** (To select coil to be characterized.)

TABLE 5-6 (Continued)
SHIM CALIBRATION PROCESSING

OUTPUT/PROMPTS	INPUTS/COMMENTS
1. Z1 0.100 [Z1] 2. Z2 0.500 [Z2] 3. Z3 2.000 [Z3] 4. Z4 2.000 [Z4] 5. X 0.100 [X] 6. Y 0.100 [Y] 7. ZX 1.000 [ZX] 8. ZY 1.000 [ZY] 9. XY 1.000 [XY] 10. X2-Y2 1.000 [X2_Y2] 11. Z2X 2.000 [Z2X] 12. Z2Y 2.000 [Z2Y] 0. Common Baseline. Enter the Index Number (0..12) [6] :	**1 <Enter>** to select Z1 coil
<<< Characterizing Shimming Coils >>> Z1: X: XY: Z2: Y: X2-Y2: Z3: ZX: Z2X: Z4: ZY: Z2Y: Common Baseline: Pending 1. Image Data (Ex, Se, Im Number):50008, 1, 1 <------- (Series Description: Z1 baseline) 2. Storage (Accumulate or Replace): Accumulate 3. Display Phase Diff Images : No 4. Processing in Silent Mode : No <-------------- 5. Coil Name (To be Characterized): Z1 6.Perturbation Current : 0.100 <--------------- 0. Accept (q or s to Return). Enter the Index Number to Change Default (0..7)[0]: ..	Be sure this is the correct (Series Description: Z1 baseline) image data set for the Z1 baseline scan **0 <Enter>** to change Perturbation Current to Baseline **0 <Enter>** when all of the menu items are acceptable.
If Silent Mode was set to Yes, the following is displayed: Processing ... plane 1 of 6. <------------- Processing ... done. 6 of 6 *When all the coils have been characterized, the following is displayed (if Yes was entered for Display Calibration Matrix):* Displaying Calibration Matrix Cal File Generation Complete. Run Again? (Y,N)[N]: ...	Image data are processed (planes 1 - 6) Enter **y** or **n** as appropriate

TABLE 5-6 (Continued)
SHIM CALIBRATION PROCESSING

OUTPUT/PROMPTS	INPUTS/COMMENTS
If Silent Mode was set to No*, the following is displayed:*	
`Processing plane 1 of 6 <----------`	Image data is processed (planes 1 - 6).
`Processing ... done. 6 of 6`	
If image phase wrap is detected, the following message appears:	
`Excessive phase wrapping.`	
`...Please re-scan at Wider Bandwidth or smaller test diameter`	
`Exit Cal File Generator? (Y,N) [N]: .....`	Select **[Research Operations]** and **[Modify CVs]**. Type **opuser2** and enter a higher bandwidth. Valid bandwidth entries are: 200, 500, 1000, and 5000. Select **[Research Operations] [Download]**, and restart the calibration file process using the higher bandwidth.
If Yes was entered for Display Phase Diff Images, the following appears:	

`The Following Are the Image Display Options.`
`1. Image Plane 1`
`2. Image Plane 2`
`3. Image Plane 3`
`4. Image Plane 4`
`5. Image Plane 5`
`6. Image Plane 6`
`7. Image With Sampling Pixels.`
`8. Save Phase Difference Image Into Database.`
`0. Return`	

`Enter Index (0..8) [1] : .....`	Enter appropriate choice for more option information, or **0 <Enter>** to continue.
`Coil Name (To be Characterized) : Z1 <----------` `Perturbation Current : 0.100`	When processing is done, the next image data set is displayed and processed. Each image data set is displayed and processed until all have been processed. If all the data sets have been processed, but not all the coils have not been characterized, the Characterizing Shimming Coils screen is displayed.
`More Coils to Process (Y,N) [Y] : .....`	**y <Enter>** to process the Z1 perturbation scan (or a second Z1 baseline scan).

TABLE 5-6 (Continued)
SHIM CALIBRATION PROCESSING

OUTPUT/PROMPTS	INPUTS/COMMENTS
If Yes was entered at More Coils to Process prompt, the following appears:	

`<<< Characterizing Shimming Coils >>>`
 	
`Z1: (B 1, C 0)  X:  XY:  <--------`
`Z2:  Y:  X2-Y2:`
`Z3:  ZX:  Z2X:`
`Z4:  ZY:  Z2Y:`
 	
`Common Baseline: Pending`
	The software automatically shows the current status of the coil characterization process. In this example, *B 1* means that one baseline scan has been performed, and *C 0* means that zero perturbation scans have been performed.

`1. Image Data (Ex, Se, Im Number): 50008, 2, 1 <-----`
`(Series Description: Z1 0.100)`
`2. Storage (Accumulate or Replace): Accumulate`
`3. Display Phase Diff Images : No`
`4. Processing in Silent Mode : No`
	The software automatically increments to the next image data set. If there are no more LVshim images, it displays `<None Selected>`. Be sure that these are the correct data before accepting.

`5. Coil Name (To be Characterized): Z1 <----`
`6. Perturbation Current : 0.100 <-------`
 	
`0. Accept (q or s to Return).`
	The software automatically increments to the next logical coil name and perturbation current. Be sure this information is correct before accepting.

`Enter the Index Number to Change Default (0..7)[0]: ..`	**0 <Enter>** when all menu items are acceptable.
`Processing plane 1 of 6 <----------`	Image data are processed (planes 1 - 6).
`Processing ... done. 6 of 6`	
`More Coils to Process (Y,N) [Y] : ..........`	Repeat scanning and processing until all coils in the coil set have been characterized, then **n <Enter>** to continue.
When No *is entered at the More Coils to Process prompt, this happens:*	
If some coils have not been characterized, the following appears:	

`Coil Characterization Is Incomplete.`
`Not Enough Data To Create Calibration Matrix`
`Build Partial Matrix? (Y,N) [Y] : ..........`
	Since not all of the coils have been characterized, the software may not able to create a calibration file. Generally, you should enter **n** at this prompt.

If No *is entered at Build Partial Matrix prompt, the following appears:*	
`Process Will Be Saved and Can Be Resumed Later.` `Exit Cal File Generator? (Y,N) [N] : ..........`	Enter **y** or **n** as appropriate. The processed calibration data are saved. The calibration generation process can be resumed later by selecting Resume for menu item 2 (Generation).

TABLE 5-6 (Continued)
SHIM CALIBRATION PROCESSING

OUTPUT/PROMPTS	INPUTS/COMMENTS
If Yes *is entered at Build Partial Matrix prompt, this may appear:*	

`Coil Characterization Is Incomplete.`
`Matrix Is Not Invertable.`
`Process Will Be Saved and Can Be Resumed Later.`
`Exit Cal File Generator? (Y,N) [N]: .....`
	Enter **y** or **n** as appropriate. The software was not able to generate a calibration matrix because some of the coils have not been characterized. The processed calibration data are saved. The calibration generation process can be resumed later by selecting Resume for menu item 2 (Generation).

If all the coils have been characterized, the following appears	
(if Yes *was entered for Display Calibration Matrix):*	

`Displaying Calibration Matrix`
`Displaying Calibration Matrix`
`Please Get the Hardcopy if Desired.`
`Press <Enter> to Continue. [ ] : .....`
	The Calibration Matrix is displayed. See Section 6-9 for details. If a hard copy of the matrix is desired, print it now. Then, press Enter to continue.

`Cal File Generation Complete. Run Again? (Y,N) [N]: ..`	Enter **y** or **n** as appropriate.

Note

Signa 1.0T Mobiles may have a Z2 Resistive Shim Coil installed on the Passive Shim Drum. Make sure that the Z2 Resistive Shim Power Supply (mounted on the operator workspace table) is powered **off** when performing this procedure.

5-8 Sampling Diameter in Centimeters

The sampling diameter is the size of the diameter spherical volume (DSV) to be used during processing. Only data within this specified volume are processed. This value is editable during creation of the shim calibration file, but is fixed during normal shimming.

5-9 Details of Characterizing Shimming Coils

This section provides detailed information about the items in the Characterizing Shimming Coils menu. When selected, some of the items toggle to another value (available choices are shown in parentheses), some toggle between Yes and No, and some prompt for additional input.

5-9-1 Coil Characterization Status

The coil characterization status is located in the area under the menu title line. It consists of the following information for each of the coils in the coil set:

- Coil name
- Number of Baseline scans for the coil (designated with a *B*)
- Number of Perturbation scans for the coil (designated with a *C*)

The following is an example of the coil characterization status for a typical coil (with three baseline scans and three perturbation scans):

AX_1: (B 3, C 3)

The coil characterization status area also shows whether a common baseline has been processed for the coil set. A *common baseline* is a baseline scan used during characterization of all the coils in a coil set. A common baseline is not necessary if a new baseline scan is performed before each coil perturbation.

5-9-2 Coil Name

This is the name of the coil to be characterized by the selected image data set. If the selected image data set is being used as the baseline scan for all the coils, use the name *common baseline*.

6- SHIM POWER SUPPLY DETAILS

6-1 GE Gradient/Resistive Shim (S-I, S-II, and S-III Magnets)

The GE resistive shim coil set does not provide correction for *x*, *y*, or *z* harmonic errors, but the gradient coil does. Therefore, the resistive shim coil and gradient coil assemblies are characterized at the same time, creating a 9-coil calibration file. This file allows the magnet to be shimmed by both the gradient and resistive shim coils at the same time (one process rather than two).

6-1-1 Gradient Amplifiers

To set the gradient shim coil currents:

1. At the operator workspace in the Scanning Parameters window, click **[Manual Prescan]**.

2. In the Manual Prescan window under Gradient Shimming, set *x*, *y*, and *z* to the desired values, then click **[Done]** to exit Manual Prescan.

6-1-2 Resistive Shim Power Supply

To set the resistive shim coil currents:

1. At the resistive shim power supply, set the appropriate shim channel(s) to the desired current value.

Note

After setting shim channel(s) at resistive shim power supply, wait a few minutes to allow the power supply and magnetic field to stabilize before scanning.

6-2 Oxford Resistive Shim (Oxford Magnet)

CAUTION

Inaccurate data possibility. The Z0/T channel on Oxford air-cooled shim supplies (Model 2141) must always be set to *0.00 amps/hr*. This channel was designed to increase or decrease the main magnetic field (Z_0) by a fixed rate per hour. Center frequency will continually drift, making shimming virtually impossible, if this channel is not set to *0.00 amps/hr*.

1. Set the appropriate resistive shim channel(s) to the desired current values. The Z0/T channel should always be set to 0.00 amps/hr.

2. After setting the shim channel(s) at the resistive shim power supply, wait a few minutes to allow the power supply and magnetic field to stabilize before scanning.

6-3 GE 14-Coil Superconductive (S-I Magnet)

S/C shimming of S-I magnets requires some hardware setup at the magnet. Refer to *Direction 15001, GE 1.5T Magnet And Cryogens Subsystem*, Section 2-10, Power Connections (Ramping/Shimming), for installing the following:

- Cable Support Fixture
- Shim Lead Extension into Cryoplug
- S/C Shim Power Supply Cable Connections

For systems with the resistive shim coil option, the Resistive Shim Power Supply must be turned off during the S/C LVshim procedure.

CAUTION

Equipment damage possibility. Do not attempt to perform this procedure if the helium level in the magnet is below 50%. A quench may occur, possibly causing damage to the magnet.

Be sure that the vent bypass cap is removed from the shim lead extension vent line to properly cool this lead. Failure to do so will damage the Shim Lead Extension Assembly.

<u>Always</u> enter the axial currents last during the shimming procedure. This allows for proper lead cooling.

<u>Always</u> match the currents in the axial coils with the power supplies before turning on the axial switch heater. These coils couple closely with the main field, and a main field quench may occur if large amounts of axial currents are suddenly dumped.

On the rear of the Phase II Power Supply, verify that the main heater switch is in the *down* position. This prevents the Main Switch Heater from being energized in case the MAIN HEATER BUTTON on the front control panel is accidentally pushed, causing the magnet to QUENCH. The Main Heater Button on the front panel of the power supply should be checked to ensure that it is in the IN position before turning on the power supply. Remember: the IN position is OFF, and the OUT position is ON.

Note

Do not pulse the gradients while trying to stabilize currents in the S/C shim coils.

1. Enter new shim current settings into the S/C Shim Power Supply. For detailed instructions, refer to *Direction 15001, GE 1.5T Magnet And Cryogens Subsystem*, Section 2-12-5, Adjusting S/C Shim Coil Power Supply Currents.

Note

LVshim does not compute correction currents for the Axial 5 and Axial 6 S/C shim coils on S-I magnets. The Axial 5 and Axial 6 coil currents, determined during the mechanical plotting procedure, must be entered for each shim iteration during the S/C LVshim procedure. The Axial 5 and Axial 6 S/C shim coils correspond to power supplies PS-8 and PS-11, respectively.

Note

Wait about 5 minutes after the new currents have been applied to the S/C coils to allow the switch heaters to cool before dialing the power supplies to zero in preparation for the next LVshim scan.

6-4 GE 12-Coil or 18-Coil Superconductive Magnets

6-4-1 Coil Set Selection

There are nine coil set choices available during S/C LVshim when the Research operation mode is used:

- Full
- Standard
- Basic
- Axial Coils Only
- T1 Coils Only
- T2 Coils Only
- Transversal Coils Only
- No Z6
- Selected Coils

The spherical harmonics affected by the Full, Standard, Basic, No Z6, Axial Coils Only, and Transversal Coils Only sets are shown in Table 6-1 for S-II, S-III, S-IV, S-X, and S-XC_1 or Table 6-2 for S-V and S-XC_2. The Selected Coil sets allows you to select any combination of coils.

TABLE 6-1
SPHERICAL HARMONICS AFFECTED BY VARIOUS SHIM COIL SETS

AFFECTED	COIL SET (FOR 18 S/C COIL MAGNETS)				
SPHERICAL HARMONICS	FULL (18-COIL)	STANDARD (14-COIL)	BASIC (7-COIL)	AXIAL (6-COIL)	TRANSVERSAL (12-COIL)
Z1	X	X	X	X	
Z2	X	X	X	X	
Z3	X	X	X	X	
Z4	X	X		X	
Z5	X			X	
Z6	X			X	
X	X	X	X		X
Y	X	X	X		X
ZX	X	X	X		X
ZY	X	X	X		X
X2-Y2	X	X			X
XY	X	X			X
Z2X	X	X			X
Z2Y	X	X			X
Z(X2-Y2)	X	X			X
ZXY	X	X			X
X3	X				X
Y3	X				X

TABLE 6-2
SPHERICAL HARMONICS AFFECTED BY VARIOUS SHIM COIL SETS

AFFECTED	COIL SET (FOR 12 S/C COIL MAGNETS)				
SPHERICAL HARMONICS	**FULL (12-COIL)**	**STANDARD (10-COIL)**	**BASIC (7-COIL)**	**AXIAL (6-COIL)**	**TRANSVERSAL (6-COIL)**
Z1	X	X	X	X	
Z2	X	X	X	X	
Z3	X	X	X	X	
Z4	X	X		X	
Z5	X			X	
Z6	X			X	
X	X	X	X		X
Y	X	X	X		X
ZX	X	X	X		X
ZY	X	X	X		X
X2-Y2*					
XY*					
Z2X	X	X			X
Z2Y	X	X			X
Z(X2-Y2)*					
ZXY*					
X3*					
Y3*					

* S-V and S-X_C2 magnets do not have coils to compensate for the following 6 harmonics:

- X2-Y2
- XY
- Z(X2-Y2)
- ZXY
- X3
- Y3

Passive shim is required to correct for these 6 harmonics.

6-4-2 Setting Shim Power Supply Currents

Procedure

CAUTION

Equipment damage possibility. Do not attempt to perform this procedure if the helium level in the magnet is below operating level specified in the appropriate magnet manual. Low helium level may result in a quench, causing possible damage to the magnet.

Be sure that the vent bypass cap is removed from the shim lead extension vent line to properly cool this lead. Failure to do so will damage the Shim Lead Extension Assembly.

Always enter the axial currents last during the shimming procedure. This allows for proper lead cooling.

Always match the currents in the axial coils with the power supplies before turning on the axial switch heater. These coils couple closely with the main field and a main field quench may occur if large amounts of axial currents are suddenly dumped.

Note

Do not pulse the gradients while trying to stabilize currents in the S/C shim coils.

Note

Normally, the switch heater would stay turned on for approximately 5 minutes to allow the shim coils currents to stabilize. For S-V and S-XC_2 magnets, the shim coil inductance is higher, thereby requiring more time for the shim coils currents to stabilize. Typically 15 to 25 minutes is required for S-V and S-XC_2 magnets to stabilize.

1. For systems with the Resistive Shim Coil option, the resistive shim power supply must be turned off during the S/C LVshim procedure.

2. Enter the new shim current settings into the S/C shim power supply per one of the following procedures:

   For GE S-II and S-III unshielded magnets, refer to *Direction 15120, GE 1.5T Magnet And Cryogens Subsystem*, Setup & Calibration tab, Section 9-5, Adjusting S/C Shim Coil Power Supply Currents For Magnet Shimming.

   For GE S-III shielded magnets, refer to *Direction 15174, GE 1.5T Magnet And Cryogens Subsystem With Add-On Shield*, Setup & Calibration tab, Section 9-5, Adjusting S/C Shim Coil Power Supply Currents For Magnet Shimming.

For GE S-IV magnets, refer to *Direction 15345, GE 1.5T SIV Magnet & Cryogens Subsystem*, Set Up & Calibration tab, Section 11-4-3, Adjusting S/C Shim Coil Power Supply Currents For Active Shimming.

For GE S-V magnets, refer to *Direction 2141548, GE 1.5T SV Active Shield Magnet & Cryogens Subsystem*, Setup & Calibration tab, Section 11-4, Adjusting S/C Shim Coil Power Supply Currents For Active Shimming.

For GE S-X magnets, refer to *Direction 15537, GE 1.0T Magnet & Cryogens Subsystem*, Setup & Calibration tab, Section 10-4-3, Adjusting S/C Shim Coil Power Supply Currents For Active Shimming.

For GE S-XC_1 magnets, refer to *Direction 2145123, GE 1.0T SXC-Phase 1 Magnet & Cryogens Subsystem*, Setup & Calibration tab, Section 10-4-3, Adjusting S/C Shim Coil Power Supply Currents For Active Shimming.

For GE S-XC_2 magnets, refer to *Direction 2145089, GE 1.0T SXC-Phase 2 Magnet & Cryogens Subsystem*, Setup & Calibration tab, Section 10-4-3, Adjusting S/C Shim Coil Power Supply Currents For Active Shimming.

For GE Cx magnets, refer to *Direction 2159496, GE 1.5T & 1.0T Cx Active Shield Magnet & Cryogens Subsystem*, Setup & Calibration tab, Section 13-4, Input Shim Currents.

For GE LCC magnets, refer to *Direction 2192624, GE 1.5T & 1.0T LCC Active Shield Magnet & Cryogens Subsystem*, Setup & Calibration tab, Section 13-4, Input Shim Currents.

Note

Wait about 5 minutes after the new currents have been applied to the S/C coils to allow the switch heaters to cool before dialing the power supplies to zero in preparation for the next LVshim scan.

Note

For all magnet systems, remove the cables from the S/C shim power supply and close the RF door before performing the LVshim scan, otherwise RF noise from external sources could cause imaging artifacts that will affect the LVshim results.

7- SHIMCONFIG DETAILS

7-1 Overview

The ShimConfig.cfg file is located in **/usr/g/w/config** and contains the following information for each coil:

- harmonic naming order
- current calculation; on or off
- existing coil current value
- pertubation current value
- maximum power supply current
- power supply or gradient coil name
- harmonic name.

The vi editor is used to edit this file.

7-2 Coil Removal

1. At the operator workspace, select the Tools icon in the desktop control panel.

2. In Service Desktop Manager click **[Cal/Checks]** and click **[CShell...]**. Refer to Table 7-1.

   For 9.x., 10.x: In the Service Browser, select the **Calibration** tab, then in the menu options on the left side of the browser, click **LVShim**. On the right side, click the link **Click here to start this tool**.

TABLE 7-1
COIL REMOVAL

OUTPUT/PROMPTS	INPUTS/COMMENTS
{unix prompt}	**cd /usr/g/w/config<Enter>**
{unix prompt}	Verify the file exists **ls -al Shim*.*<Enter>** ShimConfig.cfg is part of Load From Cold software.
If ShimConfig exists, the following is displayed: -rw-rw-rw- 1 sdcbin informix 7973 Sep20 18:25 ShimConfig.cfg	
{unix prompt}	**vi ShimConfig.cfg** to edit the file. 1. Move cursor to appropriate coil set. 2. Position on the line of the power supply to be turned off. 3. Move cursor to 2nd column of line and change the 1 to 0. 4. Exit vi saving changes. The power supply with 0 in the 2nd column has been eliminated from the coil matrix.

APPENDIX A - LCC VESSEL PRESSURE CONTROL

An LVshim scan should only be performed when the LCC magnet is at its normal operating pressure of 4.0 psi (± 0.3 psi for rough shim and ± 0.1 for Main LVshim). Large pressure changes within the helium vessel will result in large variations in shim homogeneity and harmonic error.

Here are some methods for adjusting the vessel pressure.

After Ramping An LCC Magnet And Shim Lead Is Already Engaged

Note

This method will only be useful after ramping when there are no shim currents in the shim coils.

The most rapid method to restore operating pressure at the completion of magnet ramping is to use the shim switch heaters. Make all electrical connections for shimming, then turn on all three shim switch heaters (Axial, T_1 and T_2). This method should restore about 2.0 psi of pressure per hour. Monitor the pressure in the magnet continually during this process to ensure that pressure does not exceed acceptable limits and cause venting of helium through the 5 psi relief valve. When the normal operating pressure is reached, begin the process of entering the ATR currents into the shim coil.

In Between Shim Iterations

For low starting pressure:

Close the shim lead vent valve and wait for the pressure to build up. The combination of the seated shim lead and the activation of the pressure controller should result in a pressure gain of 0.5 psi every 30 minutes.

Note

Turning off the shield cooler to try to build pressure faster is not recommended as this adds heat to the first stage shield. The shield will continue to radiate heat to the helium vessel until the cryocooler is able to cool it back down to its normal temperature. This action may result in venting of helium gas to maintain pressure within the operating limits.

For high starting pressure:

Open the shim lead vent valve and allow the lead to vent until the pressure drops to below 4.1 psi.

In Between Shim Sessions

The magnet's helium vessel pressure should have been operating at 4.0 psi. The shim lead will be pre-cooled before insertion and engaging into the sav-con connector. Monitor the pressure during this process. Follow the same steps as listed in the method *In Between Shim Iterations* for raising or lowering the helium vessel pressure.

APPENDIX B - SHIM DATA SHEETS

Based on magnet type, choose the proper data sheet on the following pages.

Superconductive Shim Data (GE S-1 Magnets)

R1___ R2___ TG___ SYSTEM FREQ _____	**SITE** _____ **DATE** _____						
	ITERATION #1	**ITERATION #2**	**ITERATION #3**	**ITERATION #4**	**ITERATION #5**	**ITERATION #6**	**ITERATION #7**
POWER SUPPLY	**INITIAL CURRENTS**	**NEW CURRENTS**					
PS 1							
PS 2							
PS 3							
PS 4							
PS 5							
PS 6							
PS 7							
PS 8							
PS 9							
PS 10							
PS 11							
PS 12							
PS 13							
PS 14							
PS 15							
PS 16							
CENTER FREQUENCY							
BANDWIDTH							
SYSTEM FREQUENCY							
BASIC/STD/FULL							
INHOMOGENEITY STD DEV (HZ)							

HARMONIC COEFFICIENT	HARMONIC ERROR (HZ. PEAK)						
Z or Z1							
Z2							
Z3							
Z4							
Z5							
Z6							
X							
Y							
ZX							
ZY							
X2-Y2							
XY							
Z2X							
Z2Y							
Z(X2-Y2)							
ZXY							
X3							
Y3							

Superconductive Shim Data (GE S-II, S-III, S-IV, S-V, S-X, S-XC)

R1___ R2___ TG___ SYSTEM FREQ _____	**SITE** _____ **DATE** _____						
	ITERATION #1	**ITERATION #2**	**ITERATION #3**	**ITERATION #4**	**ITERATION #5**	**ITERATION #6**	**ITERATION #7**
POWER SUPPLY	**INITIAL CURRENTS**	**NEW CURRENTS**					
AX 1							
AX 2							
AX 3							
AX 4							
AX 5							
AX 6							
T1-1							
T1-2							
T1-3							
T1-4							
T1-5							
T1-6							
T2-1							
T2-2							
T2-3							
T2-4							
T2-5							
T2-6							
CENTER FREQUENCY							
BANDWIDTH							
SYSTEM FREQUENCY							
BASIC / STD / FULL							

INHOMOGEINEITY STD DEV (HZ)							
HARMONIC COEFFICIENT	**HARMONIC ERROR (HZ. PEAK)**						
Z or Z1							
Z2							
Z3							
Z4							
Z5							
Z6							
X							
Y							
ZX							
ZY							
X2-Y2							
XY							
Z2X							
Z2Y							
Z(X2-Y2)							
ZXY							
X3							
Y3							

Superconductive Shim Data for CX and LCC Magnets

R1___ R2___ TG___ SYSTEM FREQ _____	**SITE** _____ **DATE** _____						
	ITERATION #1	**ITERATION #2**	**ITERATION #3**	**ITERATION #4**	**ITERATION #5**	**ITERATION #6**	**ITERATION #7**
POWER SUPPLY	**INITIAL CURRENTS**	**NEW CURRENTS**					
AX 1							
AX 2							
AX 3							
AX 4							
AX 5							
AX 6							
T1-1							
T1-2							
T1-3							
T1-4							
T1-5							
T1-6							
T2-1							
T2-2							
T2-3							
T2-4							
T2-5							
T2-6							
VESSEL PRESSURE AT TIME OF SCAN							
CENTER FREQUENCY							
BANDWIDTH							
SYSTEM FREQUENCY							

FREQUENCY							
BASIC / STD / FULL							
INHOMOGEINEITY STD DEV (HZ)							
HARMONIC COEFFICIENT	**HARMONIC ERROR (HZ. PEAK)**						
1,0(Z or Z1)							
2,0(Z2)							
3,0(Z3)							
4,0(Z4)							
5,0(Z5)							
6,0(Z6)							
8,0(Z8)							
10,0(Z10)							
12,0(Z12)							
1,1(Y)							
1,-1(X)							
2,1(ZY)							
2,-1(ZX)							
2,2(X2-Y2)							
2,-2(XY)							
3,1(Z2Y)							
3,-1(Z2X)							
3,2(ZX2-ZY2)							
3,-2(ZXY)							
3,3(Y3)							
3,-3(X3)							

Gradient Shim Data (All GE and Oxford Magnets)

R1__R2__TG_____	**SITE** _____ **DATE** _____ ***TwinSpeed*** **WHOLE / ZOOM**						
SYSTEM FREQUENCY _____	**ITERATION #1**	**ITERATION #2**	**ITERATION #3**	**ITERATION #4**	**ITERATION #5**	**ITERATION #6**	**ITERATION #7**
GRADIENT AMP	**INITIAL VALUES**	**NEW VALUES**					
GRAD X							
GRAD Y							
GRAD Z							
EXAM /SERIES /IMAGE							
BANDWIDTH							
INHOMOGENEITY STD. DEV. (HZ)							
HARMONIC COEFICIENT	**HARMONIC ERROR (HZ. PEAK)**						
Z or Z1							
Z2							
Z3							
Z4							
Z5							
Z6							
X							

Y							
ZX							
ZY							
X2-Y2							
XY							
Z2X							
Z2Y							
Z(X2-Y2)							
ZXY							
X3							
Y3							

Gradient/Resistive Shim Data (GE S-I, S-II, and S-III Magnets)

R1__R2__TG_____	**SITE** _____ **DATE** _____						
SYSTEM FREQUENCY _____	**ITERATION #1**	**ITERATION #2**	**ITERATION #3**	**ITERATION #4**	**ITERATION #5**	**ITERATION #6**	**ITERATION #7**
POWER SUPPLY	**INITIAL CURRENTS**	**NEW CURRENTS**					
GRAD X							
GRAD Y							
GRAD Z							
Z2							
Z3							
ZX							
ZY							
X2-Y2							
XY							
CENTER FREQUENCY							
BANDWIDTH							
INHOMOGENEITY STD. DEV. (HZ)							
HARMONIC COEFICIENT	**HARMONIC ERROR (HZ. PEAK)**						

Z or Z1							
Z2							
Z3							
Z4							
Z5							
Z6							
X							
Y							
ZX							
ZY							
X2-Y2							
XY							
Z2X							
Z2Y							
Z(X2-Y2)							
ZXY							
X3							
Y3							

Resistive Shim Data (Oxford Magnets)

R1__R2__TG_____	**SITE** _____ **DATE** _____							
SYSTEM FREQUENCY _____	**ITERATION #1**	**ITERATION #2**	**ITERATION #3**	**ITERATION #4**	**ITERATION #5**	**ITERATION #6**	**ITERATION #7**	
POWER SUPPLY	**INITIAL CURRENTS**	**NEW CURRENTS**						
Z1								
Z2								
Z3								
Z4								
X								
Y								
ZX								
ZY								
XY								
X2-Y2								
Z2X								
Z2Y								
CENTER FREQUENCY								
BANDWIDTH								
INHOMOGENEITY STD. DEV. (HZ)								
HARMONIC COEFICIENT	**HARMONIC ERROR (HZ. PEAK)**							
Z or Z1								
Z2								

Z3								
Z4								
Z5								
Z6								
X								
Y								
ZX								
ZY								
X2-Y2								
XY								
Z2X								
Z2Y								
Z(X2-Y2)								
ZXY								
X3								
Y3								

Resistive LVshim Data (Oxford 18 Coil Magnets)

R1___ R2___ TG___ SYSTEM FREQ _____	**SITE** _____ **DATE** _____						
	ITERATION #1	**ITERATION #2**	**ITERATION #3**	**ITERATION #4**	**ITERATION #5**	**ITERATION #6**	**ITERATION #7**
POWER SUPPLY	**INITIAL CURRENTS**	**NEW CURRENTS**					
AX 1							
AX 2							
AX 3							
AX 4							
AX 5							
AX 6							
T1-1							
T1-2							
T1-3							
T1-4							
T1-5							
T1-6							
T2-1							
T2-2							
T2-3							
T2-4							
T2-5							
T2-6							
CENTER FREQUENCY							
BANDWIDTH							
BASIC / STD / FULL							

INHOMOGENEITY STD DEV (HZ)							
HARMONIC COEFFICIENT	**HARMONIC ERROR (HZ. PEAK)**						
Z or Z1							
Z2							
Z3							
Z4							
Z5							
Z6							
X							
Y							
ZX							
ZY							
X2-Y2							
XY							
Z2X							
Z2Y							
Z(X2-Y2)							
ZXY							
X3							
Y3							

REVISION HISTORY

REV	DATE	AUTHOR	PRIMARY REASONS FOR CHANGE
0	Mar 24, 1998	L. Loehrer	Converted Toolbook document (Syssca8a.tbk) to MS Word 7.0.
0+	July 1, 1998	Keber P. Senski	Updated to include CRM Body Coil, LCC magnet, and general format cleanup.
1	Dec 1, 1998	P. Kargard	Included data sheets and added few minor changes.
2	Oct 18, 1999	J. Wolak	Changes based on Doug Reichley's validation on Release 8.3. Eliminated references to 8.1 and 8.2.
3	Sep 6, 2000	J.Gerber	Updated to include TwinSpeed
4	July 16, 2001	J.Gerber	Updated for TwinSpeed scanner for 9.0 release.
5	Aug. 8, 2001	J. Wolak	Wolak merged in the M. Jones changes from Milwaukee's published rev 3 version which included: Swapped steps 1d and 1e in paragraph 3-4-1. Moved helium pressure note from page 9 to page 4. Also edited the procedure to state LVshim only needed on Whole Body coil, no need to repeat for Zoom coil.
6	Sept 17, 2001	Kargard	Changed verbage on the tables concerning gradshim values.
7	Dec 3, 2001	Kargard	Added statement to include Zoom gradshim calibration.
8	May 8, 2002	D. Thome	Changed title to include 9.X and 10.X.
9	Jan. 28, 2003	C. MacDonald	Edits per Don Thomé, added LV Shim access from CSD, minor formatting changes.