GE Medical Systems

High Order Shim
Operator Manual

Direction 2326530-100
Revision 0

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Introduction:

Refer to the system Learning and Reference Guide for a complete list of warnings and instructions necessary for safety and regulatory compliance of this product.

The High Order Shim feature allows the user to shim over a region-of-interest (ROI) taking advantage of the High Order Shim (HOS) coils. This feature is likely to improve the local field homogeneity for use in applications such as fat suppression, spectroscopy, spiral scanning and functional imaging.

The High Order Shim process is run as another series in the exam prior to the main clinical series.

High Order AUTOSHIM in an exam

The following sections describe the basic routine for in-vivo high order shimming with a patient, and additional parts with a brief explanation of the options available in each screen. Currently there is a specific order of steps that need to be followed to use the shim process in regards to the shim series capturing any S/I FOV offset that may occur between the localizer series and subsequent clinical series. This process is explained in the next section.

Process:

The only recommended process for using this feature is as follows:

1. Prescribe and run a localizer series as is normally performed.
2. Prescribe and run any other series that you wish to run prior to specific localized shimming or just go right to the shim series.
3. Prescribe and save the clinical series you wish to run following the shim series before pulling in the shim series. Remember to turn off the "Autoshim" option in this series since the High Order Shim will take precedence. Make sure there is a series description for each series used. The High Order Shim series will use the series description as shown in step 6. (Further notes regarding the protocol Autoshim button are found below in the section "Autoshim Button")
4. Choose one out of the four series from the **GE/other/HighOrderAutoshim** protocol. The choice depends on the expected maximum FOV (<**24**cm or <**48**cm) and the Gradient coil (**WB** for WHOLE-BODY or **ZM** for ZOOM) to be used during clinical scanning. (The shim series are further described below in the section "Available Shim Series") Change the patient position parameters and RF coil to match those of the clinical series to be run next. This HOS scan should be run just prior to the actual clinical series, but after having used "Saved Series" for the clinical series. A change in the Gradient coil used and/or cradle location for other series with the same patient will require a rerun of the HOS scan. Refer to notes in Errata.
5. Save the series without changing any of the scan parameters other than those mentioned in the previous step.
6. At this point the shim series should give you the following message with the choices of accept or reject:

"Running High Order Shim calibration for clinical protocol: Saved *series description here*"
Other messages will also appear in the same message pop up window if there is any conflict identified between the clinical series and the shim series such as the GradMode and RF coil used do not match the subsequent series to be scanned. See Figure 1 below for messages that may appear.
If this information matches then select "Accept" and prep for scan, if not then reject and pull in a new shim series and make the appropriate modifications. The system will now ask you to press advance to scan so it can move the table to the new position.

7. Run the shim series, and complete the HOS calibration as described in the section on "the Shimming process" below.
8. Prep and run the previously saved clinical series. No cradle movement should occur at this time. If you did not deselect Autoshim previously, use view/edit to deselect autoshim, Save Series and proceed with the scan.

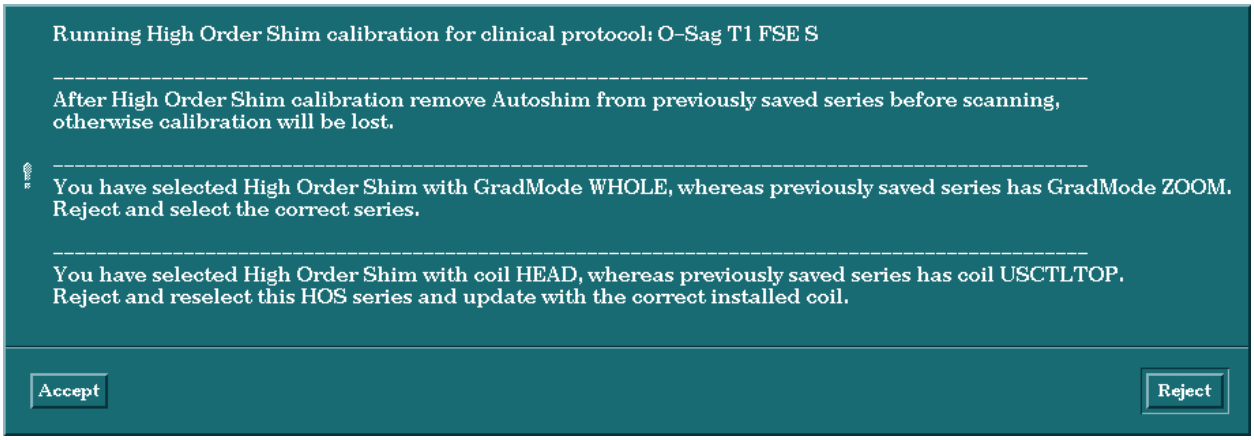


Figure 1: Messages that may appear when saving a shim series

Available shim series:

There are four shim series available defined by FOV and GradMode. The 48cm FOV series is primarily used in the body coil but can also be used for receive only surface coils and for small volume T/R coils that are off-center such as the wrist or knee coils. For use with the volume T/R coils, you may want to update the coil used after selecting the head shim series, to benefit from the increased SNR.

The 24cm FOV series is used primarily for the head coil and can also be used for the knee T/R volume coil if the knee is positioned at isocenter. Anything outside the 24cm region at isocenter must be shimmed with the 48cm series.

To use the 24cm FOV shim series for a coil other than the head coil, select the series matching the GradMode you will use in the next clinical series and then change the patient orientation and coil name to match.

Choose the GradMode to match with that defined in the clinical series just saved. In the event of a mis-match, a message to this effect will be given upon Save Series of the HOS series.

Autoshim Button:

Anytime you enable the "Autoshim" button after running a High Order Shim series, you will see the following message:

"You have set ON the autoshim button after having run the high order shim calibration.
If this remains ON, scanning with this series will reset ALL the shim coils."

This is telling you that all the shims channels will be reset to zero as if you had never run the shim series. Reselecting Autoshim should be done anytime you change locations in the anatomy that are outside the previously shimmed volume or that will cause the table to move due to a new S/I offset. A new shim series should also be performed for any new slices prescribed that will fall outside the previously selected shim ROI even if an S/I table movement is not required. This is due to the fact that ONLY the region inside the ROI used in the last shim series will be shimmed as noted in the section "The Shimming process".

Refer to the Errata section below for other reasons to rerun the High Order Shim (HOS) calibration.

The Shimming process:

After the shim scan and reconstruction finishes, the Shim User Interface will appear as shown in Figure 2 below.

Note: The processing and displaying times of this interface are a function of the HOS series used, and may take many seconds to appear. The 24cm FOV series processing will only take 5-10 seconds whereas the 48cm FOV series will take 30-45 seconds before the shim interface will appear.

The Shim User Interface is where the action of defining a specific region to shim takes place. Only the region inside the ROI used in the shim series will be shimmed, given that the patient has not been moved. Anatomy outside the region selected for shimming may be adversely affected by the shim process and may cause image distortions and artifacts. The High Order Shim process is for improving localized areas of anatomy to correct for affects of the patient in the magnetic field. This process improves further upon the capabilities of the current Autoshim process but only in the area selected by the ROI in the shim user interface. The shim of the regions surrounding the ROI is sacrificed in order to allow the area inside the ROI to be further improved. It is important to insure that the ROI selected will cover the slices desired in the follow on series.

Selecting a region of interest (ROI)

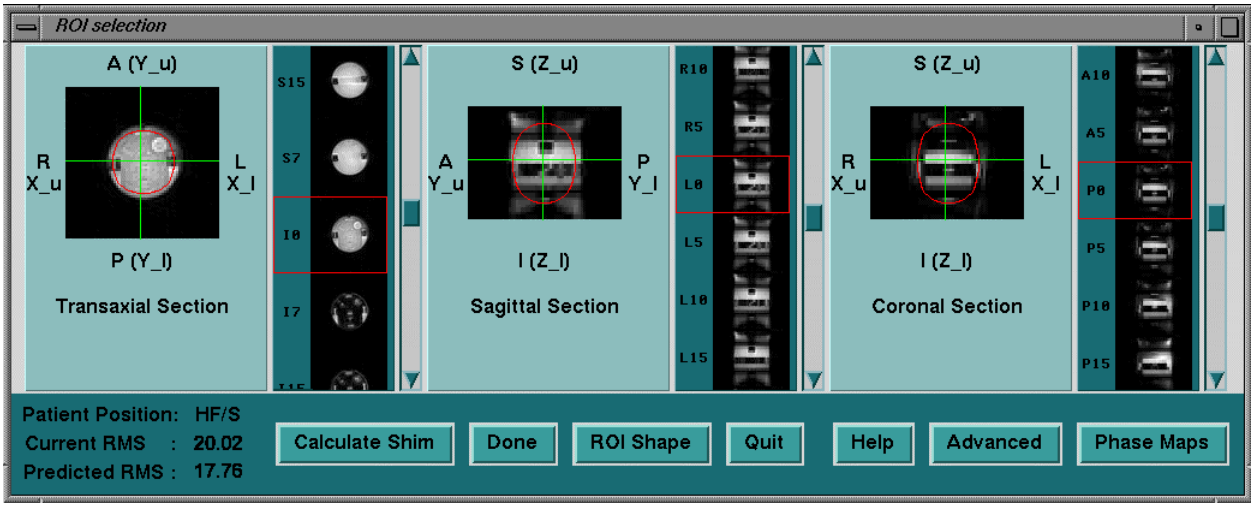


Figure 2: Magnitude Images in the basic screen

For selecting the ROI, the operator can select any slice from the corresponding scrollbar in each direction. The slice may also be selected by using the two green intersection lines on each of the three images (Axial, Sagittal & Coronal). The selected ROI may be either rectangular or elliptical.

The operator may drag and resize the ROI on any image (details in Help). The ROI displayed on the other two images will be updated accordingly.

In the basic screen, the user may select any of the following features, by clicking on the appropriate button:

- **ROI Shape** - to select between rectangular and oval shape.
- **Green lines** - to off-center the intersection between all three displayed images.

- **Calculate Shim** - to run the shim values calculation with the current ROI selection.
- **Done** - to download the calculated values to the Shim supply and exit.
- **Quit** - to exit without download.
- **Help** - has instructions for manipulating the ROI and the green lines, as follows:

*** Change ROI shape by clicking on 'ROI Shape' button , select either "rectangle" or "oval"**
*** To move the ROI, place cursor inside the ROI and drag**
*** To resize the ROI, place cursor outside the ROI and drag**
*** To move the intersecting planes one by one, place cursor on one of the green lines outside the ROI and drag**

- **Phase / Magnitude Maps** - to toggle between displaying phase or magnitude images. The Phase Maps can help identify the location of off-center anatomy such as knees, wrists or shoulders. Small regions will show up as small objects and hard to see in the large FOV shim series. The phase maps can help in locating a suitable ROI around the anatomy.
- **Advanced** - to open the ADVANCED window for additional choices, see below for details.

1. Manipulate the ROI on the images so that it occupies the desired region.
2. Click on **Calculate Shim**. Now the optimum values to improve the magnet homogeneity within the specified ROI volume are calculated. The results are shown as the current and predicted RMS as shown in Figure 2. See "Shim Improvement identification" below for more details including information regarding "What if the shim calculation fails".
3. When the calculation is complete, the Done button will highlight. Any ROI size/position changes and subsequent "Calculate Shim" requests must be done prior to selecting the Done button.
4. Click on **Done**. At this point, the new values for the central frequency and linear shims are transferred to the system, and the five high order shim currents are downloaded to the shim supply channel by channel.
5. Once the download is complete, the High Order Shim interface will close.
6. If required, run the shim scan again by selecting "Scan" to check the shim corrections. Ensure prior to any scanning that the HOS screens have been closed (the HOS screens remain open after download when this action is run from the Advanced screen).
7. When the User Interface comes up again, just select "Calculate Shim" and verify that the current RMS value has improved. See the section "Shim improvement identification" below for details.

Shim improvement identification:

To identify the improvement in the shim of the ROI selected look at the RMS deviation current and predicted fields in the Shim UIF after positioning the ROI and selecting "Calculate Shim". The current field tells you what the shim is now and the predicted will give you a sense of how much it might improve after Done/Download is run. Any shifting by the patient will make the results shift. Generally if the predicted value is close to the current value(within 1-2Hz) then there will be very little benefit in running another iteration. Generally only one or two iterations should be necessary.

If there seems to be little to no improvement for the very first pass, select the Advanced button to open the Advanced screen and make sure that all shim coils are enabled for use on the right hand side. This will be evident by see that the buttons next to each coil is indented (selected), if not, then select them all and calculate shim again. They will stay enabled until someone manually disables them. See Figure 3 for the Advanced screen and coil buttons.

What happens if the calculate shim fails?

If the shim calculation fails you will see an error message pop up stating: "SVD error: not enough points". This is telling you that the software could not identify enough data points within the ROI that are above a certain pixel intensity threshold to be used in the calculation of the new shim settings.

Possible causes:

- **The image is very dark. i.e. not enough signal.** It may be possible to fix this by exiting the shim interface, running autoprescan again, enter manual prescan and increase the R1 receive gain by 1 or more counts while looking at the Scan TR entry point. May also use the R2 gain if R1 is at maximum. If this does not help, then the anatomy currently being imaged will not be able to be shimmed.
- **The ROI contains too much of the background inside the ROI boundaries**. Check the ROI size and position, shifting and repositioning as necessary. Selecting Calculate shim repeatedly during this process will let you know when the problem is corrected sufficiently to provide shim information.
- **The patient is causing a severe shim distortion.** This may occur for many reasons such as imaging near metal implants that cause RF reflection. Selecting "Phase Maps" from the shim interface can help identify this issue. What you will see if there are severe shim distortions are white and black stripes side by side inside the ROI. The shim option is not able to correct for shim distortions that are this severe.

The Advanced screen

1. To review details of the shim calculation results, save a shim-set of data, recall a previously saved set, manually enter values or remove one or more of the shim channels, click on **Advanced** in the basic screen, as seen in figure 2.
2. The Advanced screen as seen in figure 3 appears.

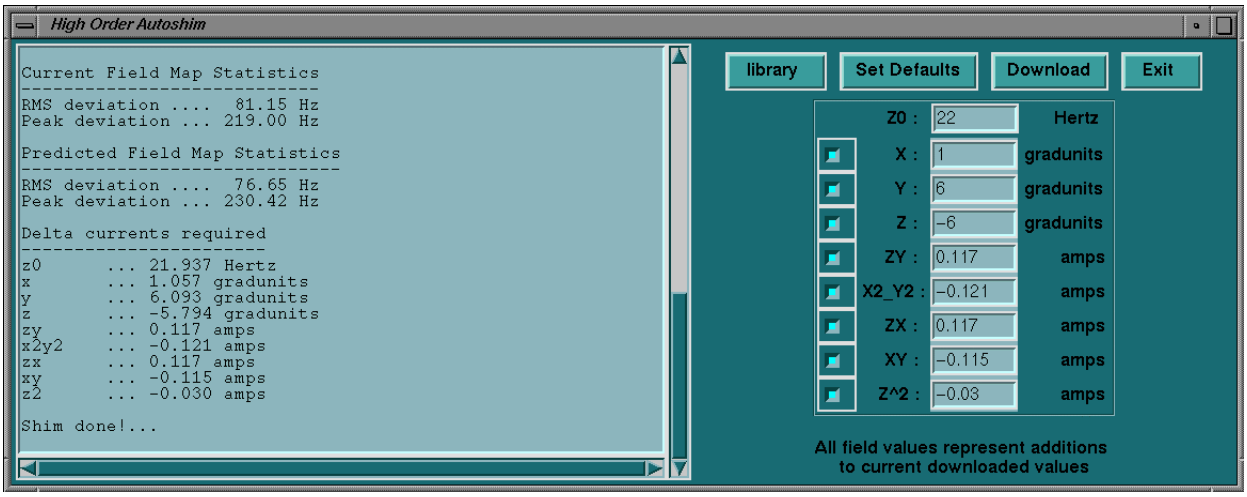


Figure 3: Advanced screen

In the Advanced screen, the user may select any of the following features by clicking on the appropriate button:

- **Log window** – to review a log of the shim calculation and download details. An estimate as to the quality of the improvement after the channels are

updated can be seen by looking at the change in RMS deviation between the Current and Predicted Map statistics.

- **Library –** to open the LIBRARY window, to either save a shim-set or recall a previously saved one. See below for details.
- **Set defaults –** to select a set of predefined shim values, corresponding to resetting the linear shims to the original system LVShim values, and with high order shim channels set to zero.
- **Download** – to load the current set of shim values to the Shim supply.
- **Exit** – to return to the basic screen window.
- **ON/OFF for each shim [**small button alongside each channel, default is **ON]**– to remove a linear and/or high order shim channel from the current shim set, i.e. not to use it for updating the calculation or downloading to the Shim supply. More than one can be removed for this purpose.
- **Field** – difference value to be added to this channel, entered automatically after use of **Calculate Shim**, or manually using this screen.
- **Field range of value** – in table 2-1. These are suggested ranges for each channel based on expected changes in field homogeneity, and are not necessarily typical values.

The numbers in each channel are add-on values to whatever is already in that channel. Hence any positive or negative value within the ranges defined is valid.

Channel	Units	Negative limit	Positive limit
Zo	frequency in Hertz	-500	+500
X	linear shim in gradunits	-20	+20
Y	linear shim in gradunits	-20	+20
Z	linear shim in gradunits	-20	+20
ZY	**high order shim in A**	- 0.500	+ 0.500
$X^2\_Y^2$	**high order shim in A**	- 0.500	+ 0.500
ZX	**high order shim in A**	- 0.500	+ 0.500
XY	**high order shim in A**	- 0.500	+ 0.500
Z^2	**high order shim in A**	- 0.250	+ 0.250

Table 2-1: Suggested range of maximum values for each channel

Typical values are below +/- 0.100A, with less than +/- 0.010A considered negligible.

Features of the Library screen

1. To save a shim-set of data, recall a previously saved set, or manually adjust a previously saved set, click on **Library** in the Advanced screen, as seen in figure 3.
2. The Library screen as seen in figure 4 appears.

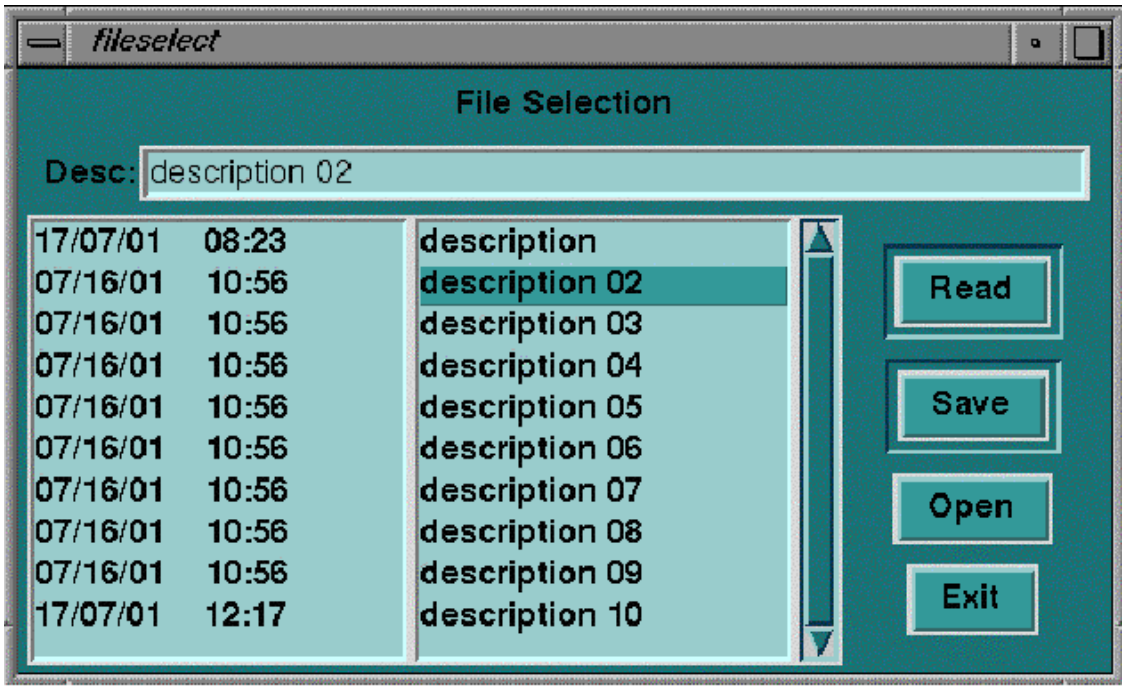


Figure 4: Library screen

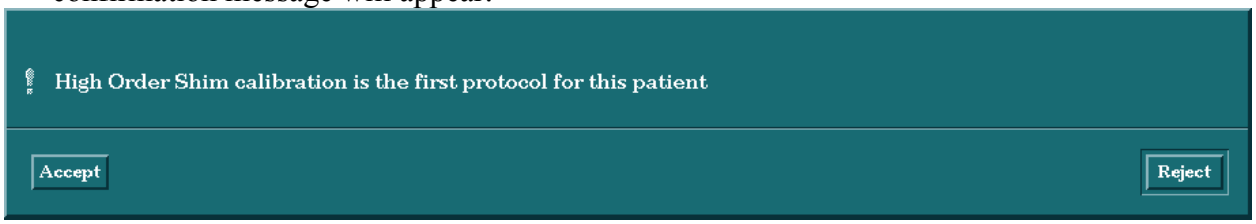
In the Library screen, the user may select any of the following features by clicking on the appropriate button:

- **Desc** - to give the new file a description, which will appear in the list in place of the current ***description*** line. The first line is reserved for the default linear shim values.
- **Read** - to read the current set of shim values from the Shim supply and linear shims, and present the difference between these and the highlighted set in the Library in the Advanced screen.
- **Save** - to save the currently displayed set of shim values to the selected description file.
- **Open** - to open an editor with a previously saved set of shim values, which are afterwards read in as the difference between these values and the currently downloaded set.
- **Exit** - to return to the Advanced screen.

APPENDIX A:

Notes:

- The shim series will take up an Exam series number but will not place any images in the database. When looking at the browser listing, it will be evident as a missing series. A series may also be missing from an Exam if the series was purposely deleted.
- Use as large an ROI as practical for the anatomy to be shimmed. The larger the area, the better the chance of improving the overall shim. Effectiveness becomes reduced for smaller ROI's due to limited data points for the software to distinguish between shim coils for corrections.
- If you choose to run a shim series as the first series in an exam the following confirmation message will appear:



This message may also appear for the very first shim series after the System software has been started even if the shim series is not the first series. This is a known issue and is currently being investigated.

- There will be a 6 second delay in the start of Autoprescan for any series that has changed the GradMode or has AutoShim selected due to the shim feature making sure the High Order Shim coils are reset to zero current.

Don't:

- Don't change any parameter in the shim series other than coil name discussed elsewhere.
- Don't use the GRx box to change slice locations in the shim series.
- Don't use the download button in the Advanced UIF screen more than once per scan. The "Calculate Shim" button can be used as many times as necessary while changing ROI positioning/shape, but only download once.
- Don't Copy/paste any shim series. Always pull in a new copy from the **GE/other** saved protocol HighOrderAutoshim.

Recommended occasions when HOS calibration should be rerun:

- Change in GradMode
- Change in table position
- Change in region to be High Order Shimmed
- When results are not as expected, such as the RMS current value being higher than the last shim iteration during the same shim series.

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