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1- GRADCAL TEST

This test checks whether the TLT phantom was properly positioned during the scan and also checks Gradient calibration. The first time the Gradcal test is run, the calculated phantom sphere diameter values for each axis are placed in the TLT data file; there are no specs for these numbers. In addition, a normalization file is created ("tltgradbody" or "tltgradhead"), which is simply a multiplier factor to "normalize" the calculated diameter values to the expected values (270mm for body; 170 mm for head).

For all subsequent TLT scans which run Gradcal test, the new calculated numbers are first normalized (multiplied by the appropriate normalization value) prior to being placed in the TLT data file. Therefore, if Gradient calibration remains the same, the TLT Gradcal values should always be ~270mm for body and ~170mm for head scans. Any deviation (per the data sheet spec) generally indicates a drift in gradient calibration. The tltgradbody and tltgradhead files are automatically deleted if Gradcal (the calibration tool) changes are saved.

2- SHIM TEST

This test is fairly equivalent to the calibration version Quickshim program See Table 1. For complete Quickshim theory, refer to Magnet Shimming Theory.

TABLE 1
SHIM COMPARISONS

PARAMETER	TLT SHIM	CALIBRATION QUICKSHIM
ANALYSIS VOLUME	20 cm	22 cm
TE	9 msec	9 msec
TR	60 msec	25 msec
FOV	40 cm	40 cm
SCAN THICKNESS	15 mm	10 mm
BANDWIDTH	2000 Hz	Typ. 1000 Hz
SCAN PLANES	4	4, 8, or 16

The differences observed between TLT shim results and Quickshim results are due to the different phantoms used and the also the scan differences. As a result, when the system is shimmed below 10Hz stand. dev. for Quickshim, the TLT shim stand. dev. value will generally remain higher (e.g. 10) due mainly to the different phantoms.

3- GRAFIMAGE TEST

This test checks the gradient-induced field transients (eddy currents) by reconstructing phase images from the raw data. The raw data is acquired by applying an eddy current gradient producing pulse (same as for Grafidy) during a gradient echo imaging sequence. To shorten data collection time, a TR = 1 sec. (as opposed to 2 sec. for Grafidy) is used for this test. As a result, long time constant eddy current effects are underestimated by this test. The test, however, does provide computed values corresponding to B0 eddy currents ("B0"), eddy currents ("G1"), and cross-term eddy currents ("G2") for four time constant ranges (up to 100 msec). The cross-term eddy currents in a shielded Gradient Coil system are controlled by alignment of the inner and outer coils.

4- SIGNAL-TO-NOISE (SNR) TEST

This test provides the SNR of the system for each axis selected and plots of SNR values corresponding to a % of the ROI. For each plane selected, a fixed 128 view, 256 sample, single slice, four echo scan is acquired. The "Mean" SNR is the mean value of SNR ("Signal"/"Noise") in all pixels within the ROI for the first echo. For Body, Head and Phased Array scans, the ROI "Area" is ~80% of the cross-sectional area of the TLT sphere at it's center. For Surface Coils, the hottest pixel in the image is found first. The ROI "Area" then, is all pixels that are between the hottest pixel and 25% of the hottest pixel in value.

"Signal" is the pixel intensity (divided by coil Recon Scale and FOV factors) of each pixel within the ROI. "Noise" (no RF modulation; 30% full scale gradients applied) is calculated from the last 64 views of blanked raw data acquired in the the noise scan. Receiver baseline is the average of all samples in the last 64 views of the noise data. This baseline is subtracted from all views (blanked and unblanked) prior to noise calculation. This is done for the I and Q channels separately. "Inoise" ("Qnoise") is the rms value of baseline corrected samples in the I (Q) channel. "Noise" is the average of the Inoise and Qnoise values.

The first 64 noise views are acquired with no RF modulation and no gradients. Using the first 44 unblanked noise views, "Peak Unblank Noise" is the peak value of the baseline corrected magnitude and "Average Unblank Noise" is the average value of the baseline corrected magnitude. Baseline correction means subtraction of the I and Q receiver baseline values prior to calculating the magnitude of each sample.Using the last 20 blanked noise views (views 45 through 64), "Peak Blank Noise" is the peak value of the baseline corrected magnitude and "Average Blank Noise" is the average value of the baseline corrected magnitude.

The histogram shows the number of pixels at each of 64 different SNR values. The Report data summary is:

- Noise* = average of Inoise & Qnoise
- Inoise* = I channel rms noise.
- Qnoise* = Q channel rms noise.

*No RF modulation; 30% max. gradient

- Pk UB** (Peak UnBlank noise) = peak value of the unblank generated signal.

- Av UB** (Ave. UnBlank noise) = average value of the unblank generated signal.

- Pk Bl** (Peak Blank noise) = peak value of the blank generated signal.
- Av Bl** (Average Blank Noise) = average value of the blank generated signal.

**No RF modulation; no gradients.

- Area = for head and body scans, the area (number of pixels) within the phantom periphery. For surface coil scans, the area (number of pixels) within the ROI.
- Signal = mean value of the ROI pixel intensity - 1024.
- Mean SNR = mean Signal/Noise value for all pixels within the ROI.
- SNR St Dev = standard deviation of SNR for all pixels within the ROI.
- Max, mean and sample standard deviation of the SNR histograms.

5- T2 TEST

This test provides the T2 of the system for each axis selected and plots of T2 values corresponding to a % of the ROI. For each plane selected, a fixed 128 view, 256 sample, single slice, four echo scan is acquired. For each pixel within the ROI, the 1024 offset (if present) is removed. Next an exponential curve fit is performed across the four echoes to determine T2 for that pixel. The "Mean" T2 is the mean value of T2 in all pixels within the ROI. For Body/Head scans, the ROI "Area" is ~80% of the cross-sectional area of the TLT sphere at it's center. (This test is not run for Surface Coil or Phased Array scans.)

Report data file summary:

- T2 Mean = mean T2 value for all pixels within the ROI.
- T2 St Dev = standard deviation of T2 for all pixels within the ROI.
- Max, mean, and sample standard deviation of the T2 histograms.

6- TR MAP TEST

This test provides a quantitative method for 3D mapping of the transmit field B1 and the receive field for different transmit/receive combinations. R1, R2 is held constant for this test. Since software cannot change TG for each scan, the RF amplitude is directly scaled for this test. The test assumes that the phantom was nominally peaked to 90° by Auto Prescan. The RF amplitude is then scaled for each of seven 256x128 scans so that 7 equally spaced flip angles result over a + 60° range.

The resulting data from the seven scans (three under flipped, one at 90°, the last three over flipped) is used to determine a "Flip Angle Range Summary" (i.e. what % of the sphere pixels peaked in various flip angle ranges). The test provides histogram plots of "Flip Angle" map (% of pixels in the ROI vs flip angle), "Receive" map (% of pixels in the ROI vs pixel intensity (using the transmit inhomogeneity corrected brightness of each voxel)), and a "Difference" map (% of pixels in the ROI vs pixel intensity resulting from subtracting the 90° image from the "Receive" map image).

Report data file summary:

- Flip Angle Range Summary = what % of the sphere pixels peaked in various flip angle ranges.
- Flip Angle Map = mean, standard deviation, and P-P values of flip angle in all pixels within the ROI.
- Receive Map = mean, standard deviation, and P-P values of pixel intensity for all pixels within the ROI using the transmit inhomogeneity corrected brightness of each voxel.
- Difference Map = mean, standard deviation, and P-P values of pixel intensity for all pixels within the ROI after subtracting the 90° image from the "Receive" map image).

TR Map Profile

TLT creates TR Map Profiles for Head and Body coils whenever TR Map test is selected. TR Map Profile is a pixel profile of the flip and Receive images created by the TR Map portion of the TLT scan. The profiles are done on four planes across TR Map images at 45 degree rotation starting at 0 degrees (see Illustration L1425a). Nine regions of interest are extracted and the mean of the ROI is calculated and reported.

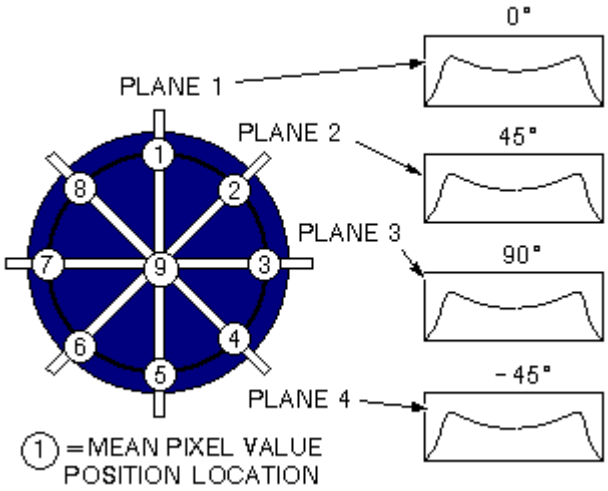

ILLUSTRATION L1425A
TR MAP PROFILES (PLANES, DATA POINTS)

7- STABILITY TEST

This test checks signal stability on each selected axis with the corresponding gradient applied. A normal 4mm CSMEMP slice selection gradient is applied on each selected axis for 256 views (two 256 x 128 acquisitions). Though four echoes are used, only data from the third echo is actually acquired. Each axis is then analyzed for "Echo Position" (i.e. echo peak location), peak signal magnitude, frequency, and phase stability.

The test provides plots of "Magnitude Drift" (%), "Frequency Drift" (Hz), and "Phase Drift" (Hz). The Report data file summary is:

- Echo Position - The temporal location of the sample with greatest magnitude is determined for each view. "Echo Position" (delay) is the mean location of these peak samples across all views.

- Magnitude (signal amplitude) Drift - The magnitude of the complex data pair for each sample across all views is normalized to the the average magnitude of that sample across all views. The P-P and RMS data is then derived from the average of 5 samples centered about the "Echo Position".

- Frequency Drift - The frequency is determined for each view by fitting phase as a function of sample number to a straight line. The slope of this line is the frequency for the view.

- Phase Drift - "Echo Position" is used for the starting phase delay. The phase drift is determined for each view by fitting phase as a function of sample number to a straight line. The extrapolated phase value at sample zero is the phase drift.

8- TLT HARDWARE

The TLT head and body phantoms are spheres that fit the head and body loader. These spheres are filled with a solution of NiCl in water having a T1 of ~125 msec and a T2 of ~100 msec. A universal positioner and a 100 mm sphere are used for surface coils.

9- TEST SELECTIONS

Top Level Test consists of a set of tests which can be run individually or together as a group. The normal (recommended) test mode is to run all tests for all available axes. The complete test mode provides a thorough analysis of major subsystem operation and system performance trending. Selective tests can also be run. This mode of operation is useful when troubleshooting an individual test failure.

The "TLT User CV Page" screen has a CV called "ASC Analysis". For sites with appropriate dial-out hardware (InSite modem), TLT will automatically dial out for ASC analysis if either ASC analysis CV is set to 1, or all tests are selected, or tltc.psd (customer version) is used. The ASC phone number used comes from the Service Config File (defaults to GEMS-AM ASC phone #).

Note

Important! When TLT is run by an authorized customer, the special customer version PSD (tltc.psd) should be used. Direction 15199, Signa InSite Customer Documentation is available to customer authorized to run TLT.

10- TEST OUTPUTS

Data results from TLT (both graphs and numerical summaries) are stored in the /usr/g/service/data directory. The analysis results are viewed by selecting **[Report]** from the Utility MR Tools Menu. Data is not encrypted, since the TLT analysis tool will not run unless an appropriate security key is installed in the Operator Console.

Image reconstruction is performed on all TLT raw files. Some tests require only magnitude images (e.g. SNR), others only phase images (e.g. Grafimage) and some neither (e.g. Stability). However, both magnitude and phase reconstruction are performed while scanning since this concurrent scan/reconstruction feature helps to reduce the TLT analysis time. All reconstructed images are retained. The SNR images (intended for customer viewing) are annotated with mean SNR and mean T2 values in the text page of the image (press "text/image" button in the keypad).

REVISION HISTORY

REV	DATE	AUTHOR	PRIMARY REASONS FOR CHANGE
0	Aug 19, 1998	R. Hawthorne	Initial conversion to Word
1	Oct 14, 1999	M. Keber	Added correct proprietary heading to document.