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1- OVERVIEW

The HSS (High Speed Stability) test evaluates the effects of vibration, or other rapid environmental or system phenomena, on the stability of the MRI process, or of the hardware used to receive and process MRI signals.

For ***TwinSpeed***, select one of the gradient coils to be used for the tests, and complete it with the same GradMode.

2- HSS PROCEDURE

2-1 Required Tools

Refer to Table 2-1 for required tools. Refer to Table 2-2 for a breakdown of kits based on field strength.

TABLE 2-1
REQUIRED TOOLS

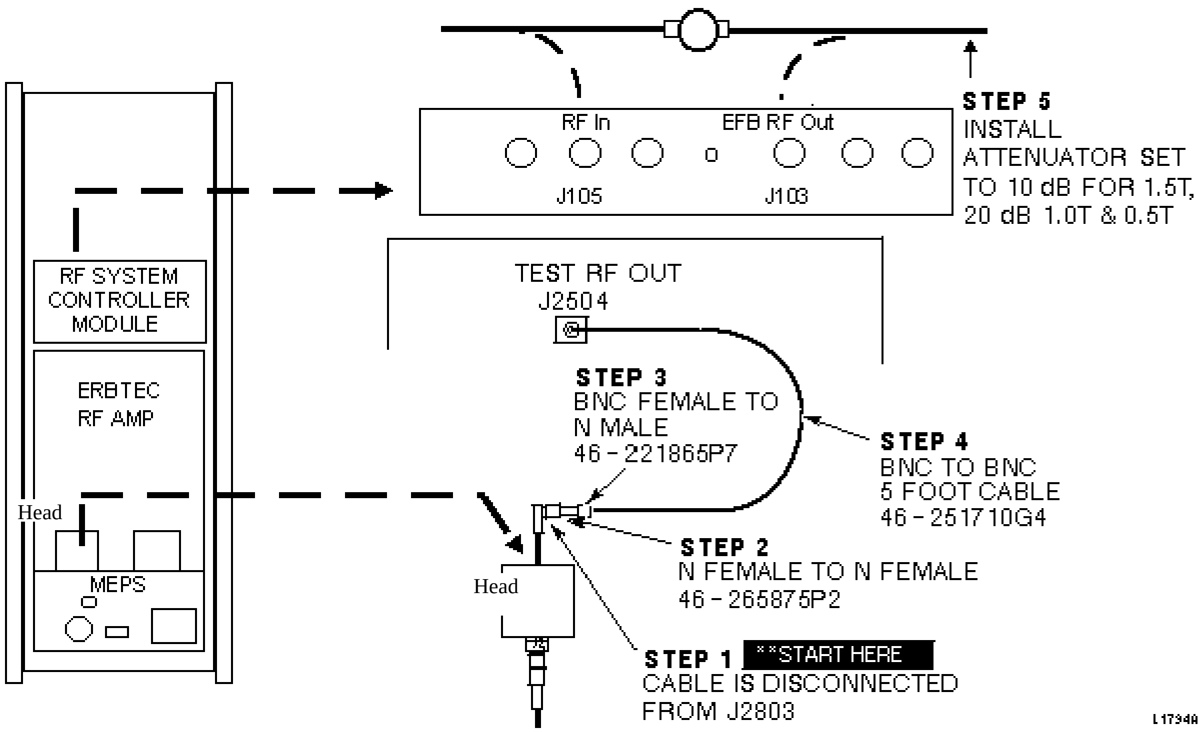
ITEM	DESCRIPTION	PART NUMBER	QUANTITY
1	Universal Small Sample Proton Coil 1.5T, 1.0T	46-320153G1(1.5T) or G4(1.0T)	1
2	Sample Vial, 0.25M NiCl2 (green in color)	46-287780G4	1
3	Sample Vial, 0.5M CuSO4 (deep blue color)	46-287780G3	1
4	Connectors Case parts:	46-301042G1	
	Five Foot 50 Ohm Coaxial Cable with Male BNC Connectors	46-251710G4	1
	BNC "Bullet" Adapter	46-220427P3	1
	BNC Female to N Male Adapter	46-221865P7	1
5	Base Plate	46-320332G1	1
6	Attenuator		1

TABLE 2-2
FIELD STRENGTH AND SST KITS

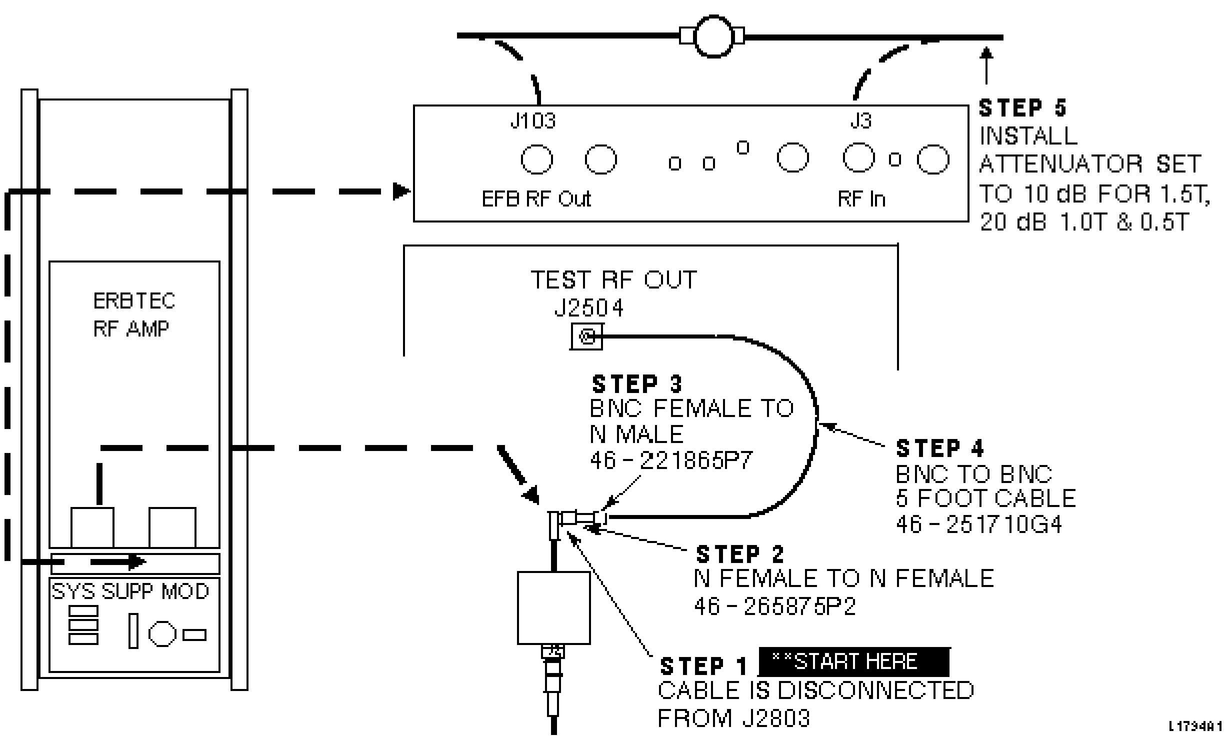
FIELD STRENGTH	UNIVERSAL SST KIT
1.0T	46-320383G6
1.5T	46-320383G8

2-2 RF Amplifier Setup

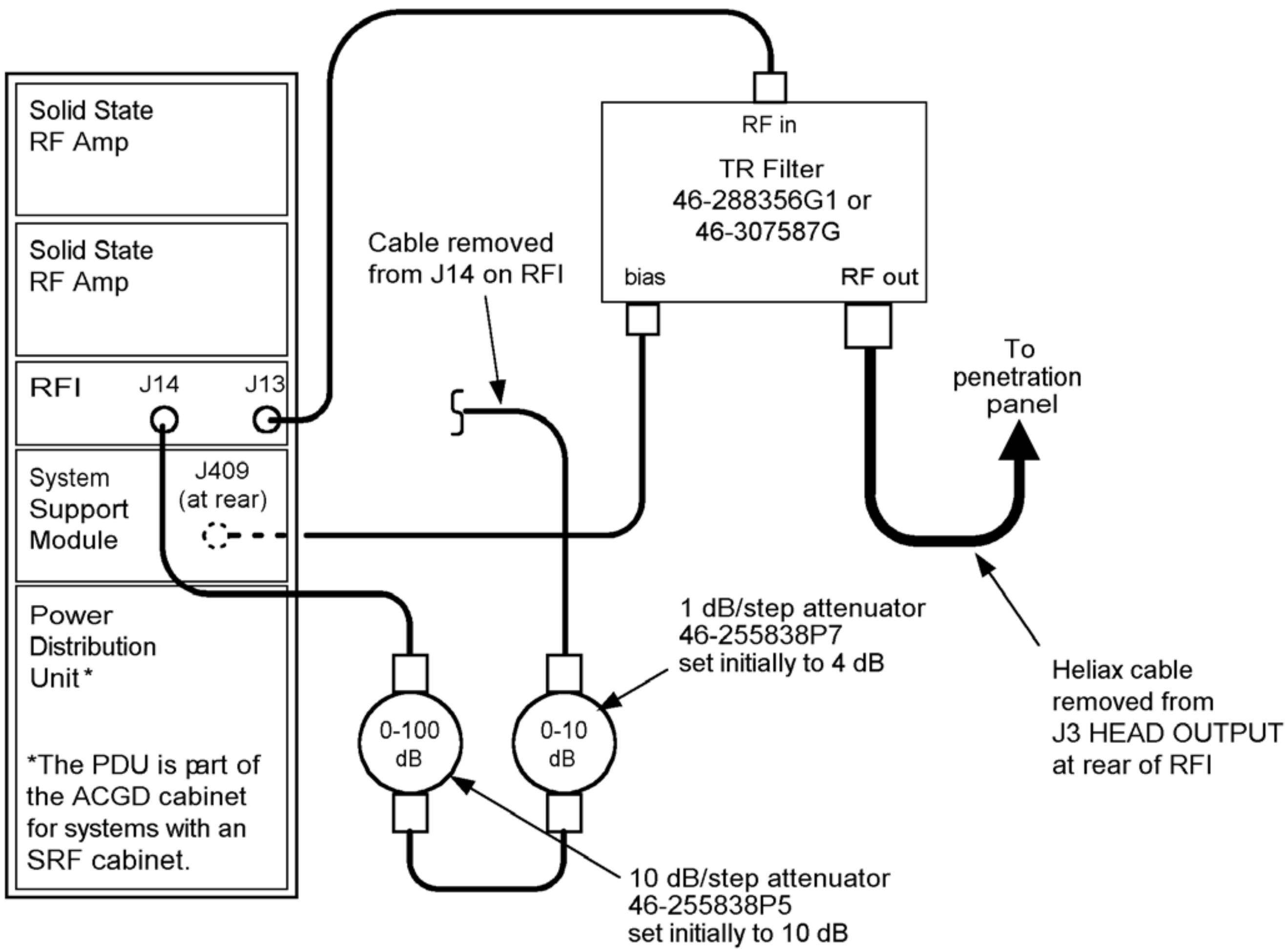
To make test alterations to RF/PEN, RF/PEN II, or RF/PDU cabinets, refer to Illustration 2-1A, 2-1B, or 2-1C. For SRF cabinets, the PDU is located in the ACGD cabinet; refer to Illustration 2-1C. For SRFD2 cabinets, refer to Illustration 2-1D.



RF/PEN CABINET ALTERATIONS
ILLUSTRATION 2-1A

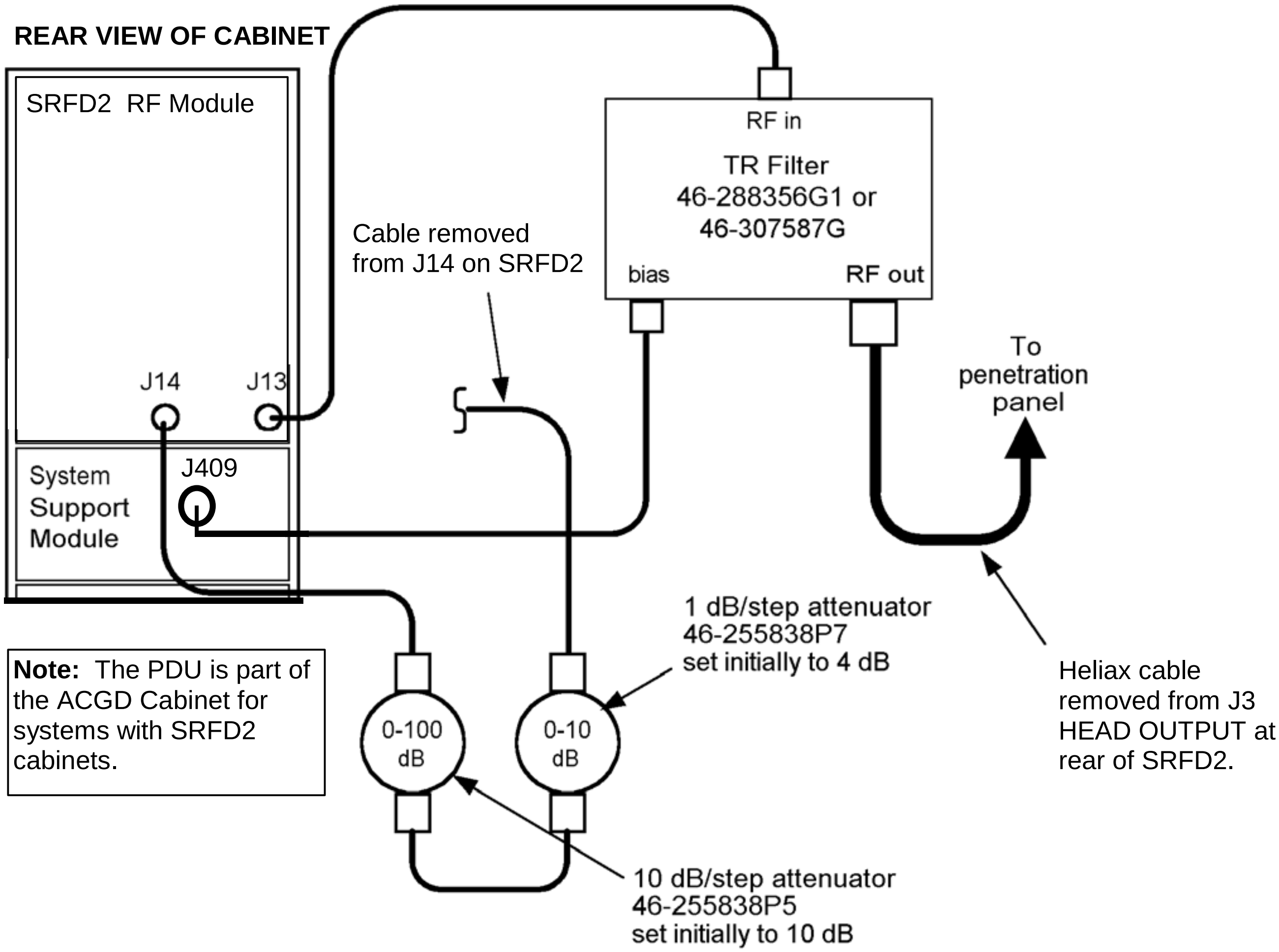


RF/PEN II CABINET ALTERATIONS
ILLUSTRATION 2-1B



NOTE: All RF/PDU connections are at the front of the cabinet unless otherwise noted.
All cables added for the test are BNC-to-BNC coax cables.

RF/PDU OR SRF CABINET ALTERATIONS
ILLUSTRATION 2-1C



NOTE: All SRFD2 connections are at the rear of the cabinet. All cables added for the test are BNC-to-BNC coax cables.

SRFD2 CABINET ALTERATIONS
ILLUSTRATION 2-1D

2-3 Procedure

This section includes both Low- and High-Frequency Bandwidth tests.

Note
Make sure the RF Amplifier is set up per sub-section *2-2*, *RF Amplifier Setup*.

1. Connect the cable from Universal 1.5T or 1.0T SST RF coil to the proper adapter.

   Note
   For 1.5T, use Extremity Coil/Linear Head Coil Adapter or 1.5T Service Tool Interface; for 1.0T, use the Service Tool Interface Adapter.

2. Insert the proper sample vial into the coil.

Note

Use 0.25M NiCl2 (green in color) for low-bandwidth mode (to test for ***vibration*** disturbance); use 0.5M CuSO4 (deep blue color) for high bandwidth mode (to test for ***electrical*** disturbance).

Note

Ensure no solution is trapped in the top section of the vial before inserting the vial into the coil. If solution is trapped in the vial top, correct by flicking the vial with your finger to knock the solution to the bottom of the vial.

WARNING!

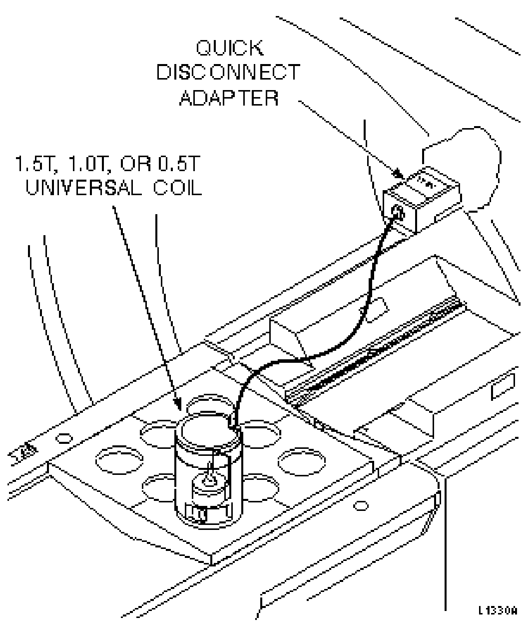
SAMPLE MOTION CAN AFFECT HSS OUTPUT. TO ENSURE THE VIAL FITS SNUGLY INTO THE COIL HOUSING, A PIECE OF TAPE CAN BE WRAPPED COMPLETELY AROUND THE VIAL BEFORE PLACING INTO THE HOLDER.

3. Disable the TNS.

   a. **LX System Cabinet:** Locate the TNS in the rear of the upper part of the System Cabinet and move the switch on the front of the TNS to the down (DISABLE) position.

   b. **EXCITE System Cabinet:** Locate the TNS in the rear of the System Cabinet in the lower-left side. Move the switch on the front of the TNS to the down (DISABLE) position.

4. Position the base plate at the head end of cradle. Place and lock the coil into the base plate in the corner; then connect the adapter to the head carriage (see Illustration 2-2).



COIL PLACEMENT
ILLUSTRATION 2-2

5. At the operator workspace, select the scan icon in the desktop control panel.

6. If necessary, exit out of any previous exams by selecting **[End Exam].**

7. Click on **[New Pt]** and enter the following:

   Patient ID: **geservice**
   Patient Name: **hss**
   Weight (lb.): **111**

8. Set Patient Protocols to **Service**.

9. In the Protocol field:

   - Type **o.1.1** (o=Other, 1=protocol number, 1=series number) and **<Enter>**.

     or

   - Click on "Other" and select protocol **1** and series **1** from the menu; then click on **[Accept]** to load the protocol.

   - For ***TwinSpeed***, select the appropriate gradient from the GradMode field.

Note

You can enter up to 32 characters in the Exam Description field as comments. (The comments are displayed on the Report Header Info screen.) In the Patient Position screen, you can enter up to 29 characters in the Series Description field as comments. (Comments are also displayed on the Report Header Info screen.) Click **Full Info** to access the Exam Description.

10. Landmark at the center of the base plate (not on the coil). At the keypad on the magnet front enclosure, press **LANDMARK** and **ADV TO SCAN** or **MOVE TO SCAN**, depending on the magnet enclosure type.

11. In the Additional Parameters screen, click on **[User CVs]**. The default is BW=0 (45Hz).

    - Use Bandwidth=**0** (45Hz) with 0.25M $NiCl_2$ vial (for vibration noise sources).

    - Use Bandwidth=**1** (250Hz) with 0.5M $CuSO_4$ vial (for electrical noise sources).

    - Press **<Enter>**, then click **[Accept]**.

12. Select **[Save Series]**.

13. Using the *right* mouse button, select **[Research Operations]**, **[Setup Params]**.

    a. Verify or move the slider to make the following settings:

       R1 = **11**
       R2 = **14**
       TG = **50**

b. Verify or enter the following values, pressing **<Enter>** after changing each entry:

Number of Frames: **2 <Enter>**
WINDOW 1
Frame: **1 <Enter>**
Frame: **0 <Enter>**

WINDOW 2
Frame: **1 <Enter>**
Frame: **0 <Enter>**
[Done]

14. Select **[Research Operations]**, **[Display CVs]**, and type in the cv **rfamp_type** and press **<Enter>**.

15. Type in the appropriate CV value for your RF amp type. (The default is tube-type)

CV	**Value**	**Description**
rfamp_type	0	Tube type
rfamp_type	1	Solid State
rfamp_type	2 (not valid for LX or EXCITE)	Vectra (not valid for LX or EXCITE)

Note
You must press the **<Enter>** key and click **[ACCEPT]** for the CV change to take effect.

16. Select **[Research Operations]**, then **[Download]**.

17. Select **[Manual Prescan]**. From the Windows menu on the Manual Prescan window, select **Two Windows**. Set their values as follows:

WINDOW 1
Plot Gain = **1**
Plot Type = **Magnitude**

WINDOW 2
Plot Gain = **1**
Plot Type = **P. Spect.**

Note

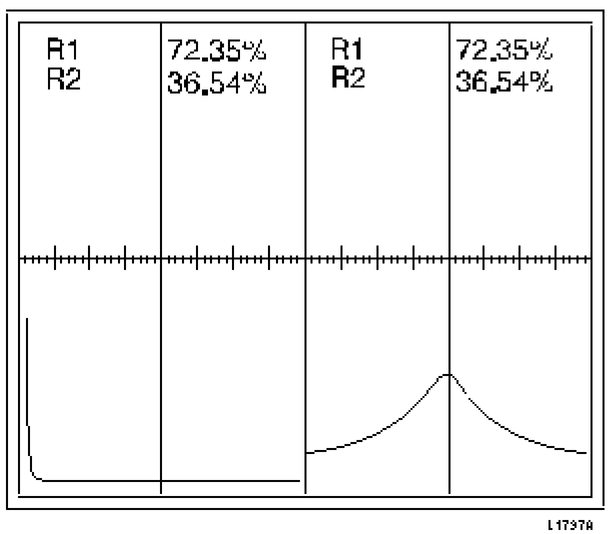
The HSS PSD places the RF amplifier in test mode for prescan and scan. In a system equipped with an Erbtec RF amplifier, the RF signal comes from a solid-state class A amplifier within the Erbtec RF amplifier which is very linear, yielding more accurate RF pulses.

There is up to a ten-second delay before prescan starts to accomplish the mode transition in the RF amplifier. Test mode can be verified on the Erbtec RF amplifier status LEDs as follows: HEAD and BODY LEDs should be off, and OPERATE LED (RF PEN, RF PEN II) should be on. Test mode can be verified on the RFI (RF/PDU or SRFD) by noting that both the HEAD and BODY LEDs are off and the RUN LED is on.

Note

For SRFD2 modules, test mode can be verified by noting that both the Test and Operate LEDs are ON.

18. Verify that the power spectrum looks similar to Illustration 2-3 for the 0.5M $CuSO_4$ vial. For the 0.25M $NiCl_2$ vial, the signal on the left decays slower; the magnitude signal on the right will be narrower.



POWER SPECTRUM - 0.5M $CuSO_4$
ILLUSTRATION 2-3

Note

If there is no signal, make sure the TNS is disabled

19. Adjust DX to center waveform on the power spectrum display (right plot).

20. Select [**Transmit Gain**]. Adjust TG for the maximum value of R1 on the power spectrum display (right plot).

21. Select **[Done]**, then **[Scan]**.

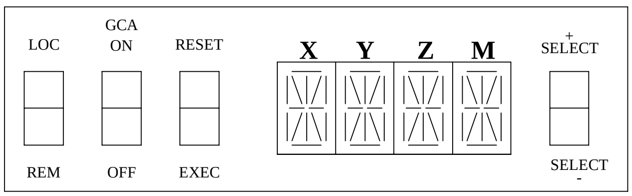
Note

Important! Do not start a new HSS scan until the current HSS analysis is finished or the analysis for the new scan may fail to start (only one set of scan data can be analyzed at a time).

The scan time display counts down to 00:00. The zeroes are displayed for up to fifteen seconds as the HSS PSD gives RF amplifier control back to Signa.

Note

After the initial HSS scan on systems with SGD Base (8280) Gradient Amplifiers, the Gradients are left in stand-by. The second scan cannot be started. The workaround for this problem is to manually reset the gradients to the proper state after each HSS scan. Perform the following on the 8280 Gradient Amplifier's SCA Front Panel Display. See the Illustration below.



1) Set "Loc/Rem" switch to **Loc**

2) Press the "**GCA On**" switch

3) Set "Loc/Rem" switch to **Rem**

After the scan is complete, automatic data analysis begins in a window on the desktop. The analysis provides messages that identify each pass as its data are analyzed. When the analysis is complete, click inside the window, then press **<Enter>** to close the window.

Note

Analysis time takes approximately four seconds per pass.

3- HSS RESULTS

High Speed Stability results can be reported with both graphics and text using the Report Manager tool, which is located in the MR Service Tools desktop on the SGI host computer. Refer to the Report Manager Tool procedure to view the HSS test results.

For ***TwinSpeed***, the results are stored with the suffix _WHOLE or _ZOOM.

3-1 HSS Limits

Table 3-1 lists the frequency limits for fixed point stability for the 45Hz (vibration) bandwidth mode. At present, there are no specs for the 250Hz (electrical) bandwidth mode. Illustration 3-1 shows the allowable instability in the MR frequency, given the limits on the amplitude of the frequency components in a Fourier transform of (x_1,y_1,z_1,t) for the 45Hz bandwidth mode.

TABLE 3-1
FREQUENCY LIMITS FOR FIXED POINT STABILITY (45HZ BW MODE ONLY)

Frequency Deviation Limits For Fixed Point Stability (45Hz BW Mode)	Frequency Dev. (p-p)	Units
Frequency instability (p-p)	0.5 p-p	Hz
Frequency instability, cold head off	0.2 p-p	Hz

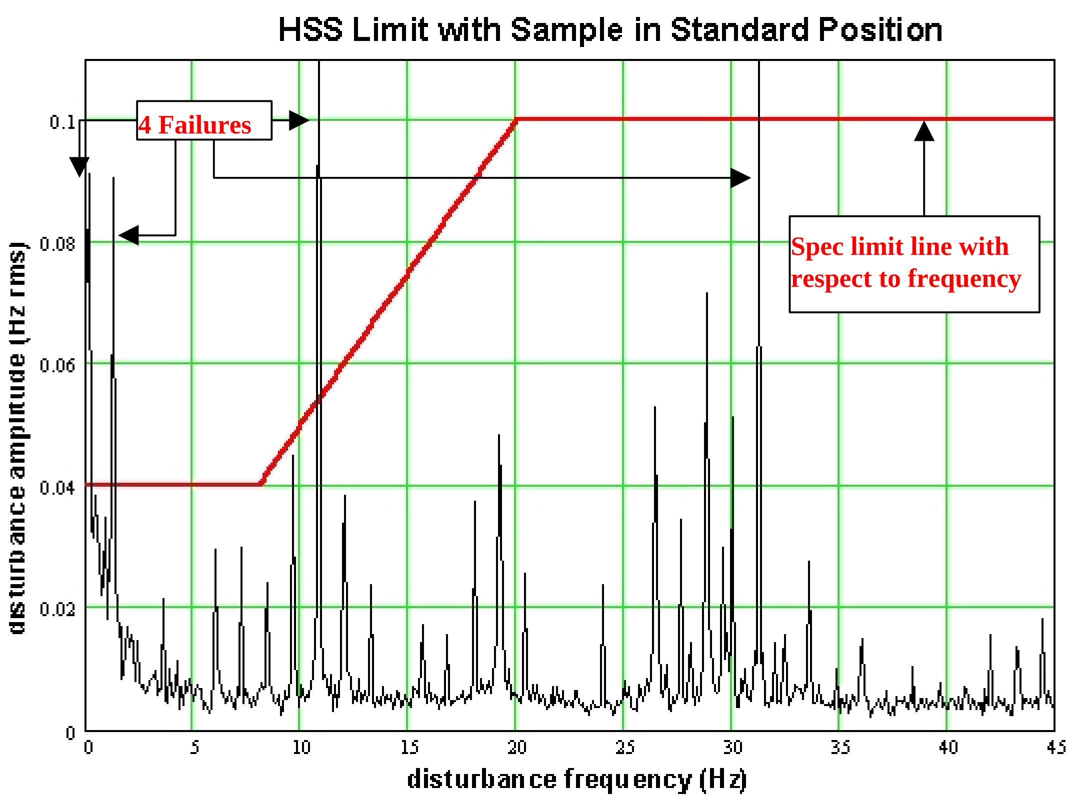
Note

The only difference between the UCERD and UCERD2 is the Exciter Module. All the other hardware is common to both. If the Exciter Module has part number 2221399-6 then the assembly is designated as UCERD2.

HSS Area Measurement Specification: The upper limit is **1.2** for CERD, UCERD2, EXCITE and **1.9** for UCERD.

Note

Illustration 3-1 is to be used for low-frequency (45Hz) bandwidth tests only.



SYSTEM STABILITY WITH RESPECT TO FREQUENCY (45HZ BW MODE ONLY)
ILLUSTRATION 3-1

3-2 Example HSS Report Screens

Scan Header (Refer to Table 3-2 for a description of the items in the scan header):

- `9b983237.HSS/0 Header Info RDF/GRP Revision:   1.0  /44`

- `SITENAME    =`
- `USN         = 000000E12N`
- `MLN         = 9999`
- `SRVCONFIG   = 11/08/99 16:07:45`
- `EXCITER     = 000`
- `RECEIVER    = S0/E0/PE0`
- `XMTRFCOIL   = HEAD`
- `RCVRFCOIL   = HEAD`
- `FREQ        = 63868949 Hz`
- `TIME        = 11/12/99 07:57:00`
- `BASERUN     = 18944`
- `CONFIGCODE  = 004`
- `SOFTREV     = 8.3.9944.C`
- `NUCLIDE     = 000`
- `HEADERCODE  = 0x00000000`
- `GRADMODE    = N/A`
- `RCVCOILGAIN = 2  R1 = 11  R2 = 14  TG =  100`
- `-------  Exam description  -------`

- `NO COMMENT`
- `------- Series description -------`
- `HeadAx,2D,SE`

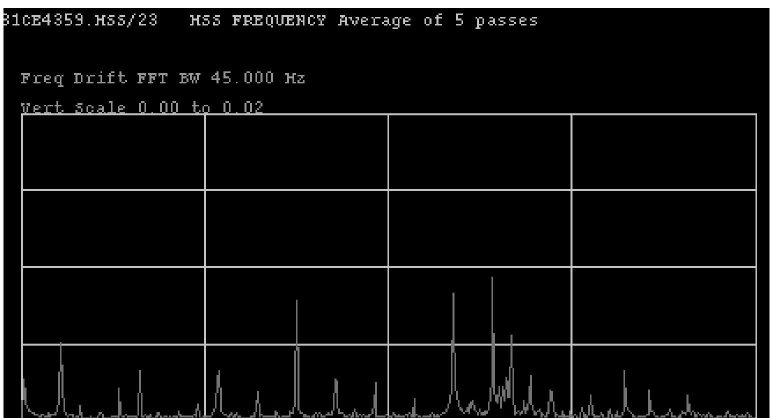
TABLE 3-2
HEADER PARAMETERS DESCRIPTION

Parameter	Legal Values	Source
SITENAME	SITE NAME	RAW HEADER
USN	UNIQUE SYSTEM NUMBER (GECARES ISSUED)	Host.cfg FILE
MLN	MOBILE LOCATION NUMBER (9999 = NON-MOBIL)	Mrconfig.cfg FILE
SRVCONFIG	DATE/TIME MRCONFIG FILE LAST CHANGED	Mrconfig.cfg FILE
EXCITER	(NOT USED)	(NONE)
RECEIVER	STARTING RCVR #, ENDING RCVR #, PORT ENABLE #	SCAN Rx; Mrconfig.cfg FILE
XMTRFCOIL	BODY, HEAD	RAW HEADER
RCVRFCOIL	BODY, HEAD, <SURFACE COIL NAME>	RAW HEADER
FREQ	MAGNET FREQUENCY	RAW HEADER
TIME	YY/MM/DD HH:MM:SS	RAW HEADER
BASERUN	BASE RUN NUMBER OF SCAN	RAW HEADER
CONFIGCODE	(NOT USED)	(NONE)
SOFTREV	SOFTWARE REVISION	“mrswrev” SCRIPT
NUCLIDE	(NOT USED)	(NONE)
HEADERCODE	ERROR # IF PROBLEM CREATING THIS TEST HEADER	CREATED BY TEST ANALYSIS
REVCOILGAIN	CALIBRATION VALUE (TYP. 1-10)	CoilConfig.cfg FILE
R1, R2, TG	1-13, 1-15, 0-200	RAW HEADER
Exam *“Comments”*	UP TO 32 CHARACTERS FROM EXAM DESCRIPTION	IMAGE HEADER
Series “*Comments*”	UP TO 29 CHARACTERS FROM SERIES DESCRIPTION	IMAGE HEADER

Refer to Illustrations 3-2 and 3-3 for a “typical” HSS average plot and data displayed in the Report Manager tool.

```
81CE4359.HSS/23     HSS FREQUENCY STABILITY (AVERAGE)
=========================================================
Average     TR          FFT BW      FFT Peak Threshold
of  5     (msec)         (Hz)      (st dev above mean)
Passes    11.111       45.000             2.000
---------------------------------------------------------
                             FFT Statistics    Grad Amps
                           mean         st dev   in OPR
                           0.001        0.001    None
---------------------------------------------------------
            FFT              FFT          Area
Pk No    Frequency        Amplitude       0.302
 1          2.373           0.005
 2          7.207           0.003
 3         12.041           0.003
 4         16.787           0.008
 5         26.367           0.008
 6         28.828           0.009
 7         29.619           0.003
 8         29.971           0.006
 9         31.113           0.003
10         36.914           0.003
---------------------------------------------------------
```

AVERAGE DATA DISPLAY
ILLUSTRATION 3-2




```
          FFT          FFT         Area
 Pk No  Frequency    Amplitude    0.302
  1     2.373       0.005
  2     7.207       0.003
  3     12.041       0.003
  4     16.787       0.008
  5     26.367       0.008
  6     28.828       0.009
  7     29.619       0.003
  8     29.971       0.006
  9     31.113       0.003
 10     36.914       0.003
```

PLOT DISPLAY FOR AVERAGE HSS
ILLUSTRATION 3-3

4- SYSTEM RESTORATION

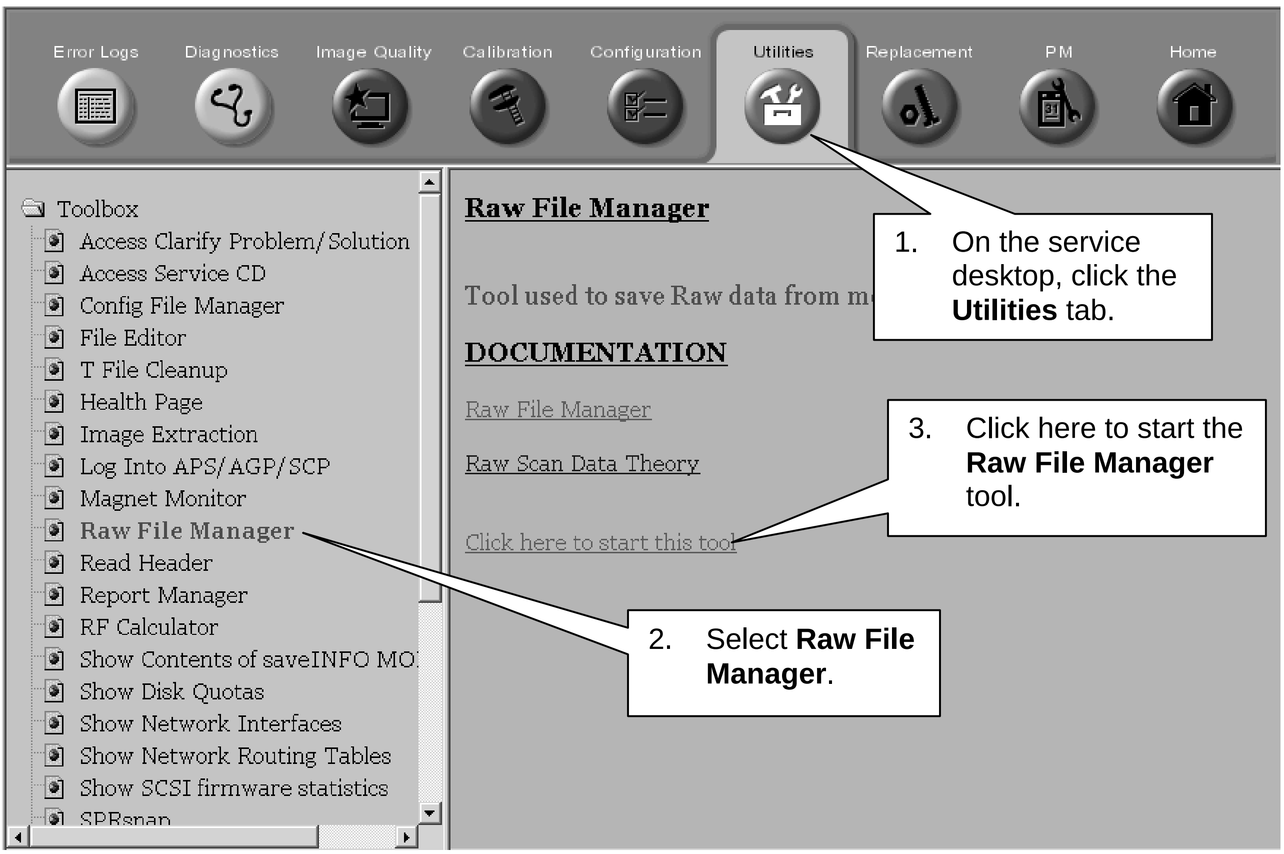
Restore normal Signa functioning as follows:

1. Restore the connections at the back of the RF cabinet (refer to initial setup Illustrations 2-1A (RF/PEN), 2-1B (RF/PEN-II), 2-1C (RF/PDU or SRF), or 2-1D (SRFD2).

2. Remove all SST Coil hardware (coil, test cables, etc.) from the bore.

3. Enable the TNS by moving the switch on the front of the TNS to the up (ENABLE) position.

4. HSS creates extensive locked raw files that must be removed to restore locked raw file capacity. Follow the steps on the graphic below:



RESTORING LOCKED RAW FILE CAPACITY
ILLUSTRATION 4-1

5. Under the DISK heading, highlight the HSS files, and click on [Delete].

6. Perform at least one head scan to verify proper system operation. For TwinSpeed, repeat for each gradient mode.

5- HSS THEORY

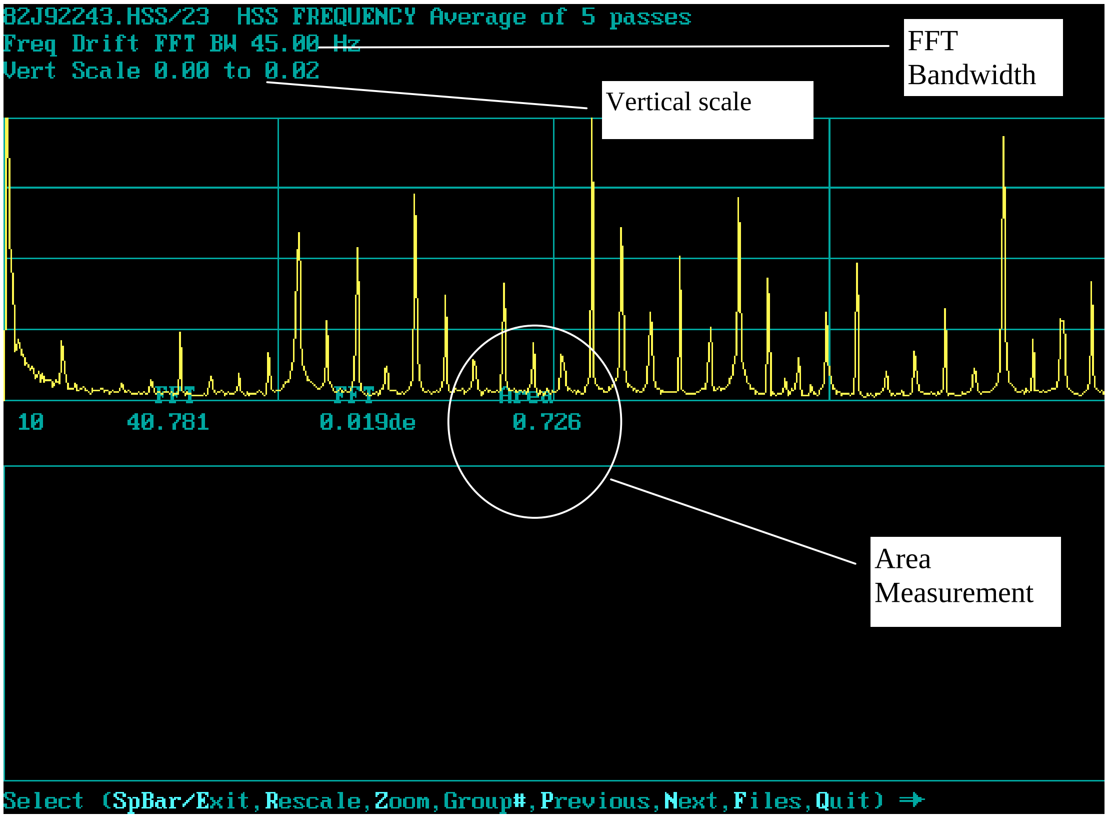
The HSS PSD drives the Signa Exciter with a rectangular RF pulse that is modulated to full scale to create a simple FID, and collects the resultant FID with the Signa receiver. The FID is used to measure the frequency deviation or phase deviation over time. A real FFT is performed on the deviation data to produce a frequency spectrum of any magnetic field disturbance within the selected bandwidth for the test.

The HSS PSD communicates with the LX IPG or EXCITE MGD to take control of the RF and gradient amplifiers from Signa. The gradient amplifiers can contribute noise at 30, 60, 120, and 180 Hz frequencies. The gradient amplifiers are placed in stand-by (via the HSS PSD) to eliminate potential gradient electrical noise from interfering with the vibration-related sources of noise which we are primarily interested in identifying. To identify the rotational frequency (RPM) of equipment such as fans and blowers, multiply the frequency by 60, for example, a peak located at 18 Hz may be caused by something rotating at 1080 RPM.

APPENDIX A - HSS AND VIBRATION TROUBLESHOOTING

This Appendix contains Service Note 60963 - HSS and Vibration Troubleshooting. MR Engineering has prepared an HSS specification for base lining 1.0T and 1.5T Signa sites. The specification puts limits on FFT Area and FFT Amplitudes and is listed in this note. This spec will be extremely useful in reducing installation and warranty costs as well as troubleshooting time. By running HSS at the time of system installation, problems with site vibration can be identified and brought to the customer's attention for correction.

This Appendix is intended to help Field Engineers use HSS for the purpose of making vibration troubleshooting more tangible. Several actual case studies will be investigated to determine the method of isolating vibration disturbances. An example of an HSS output is shown in Illustration A-1.



HSS OUTPUT EXAMPLE WITH AREAS OF INTEREST
ILLUSTRATION A-1

Things to take note of:

- The top line shows filename and "Average of 5 passes", The number of passes is selectable in 'USERCVs' when prescribing the test.
- Note FFT bandwidth. All low frequency vibration troubleshooting will be performed at 45 Hz bandwidth. The bandwidth is selectable in 'USERCVs' when prescribing the test.
- Vertical scale is important to note as rescaling the graph is sometimes helpful for viewing peak references of other HSS passes.

- Area - this is the total area under the spectrum. The upper limit is **1.2** for CERD, UCERD2, EXCITE and **1.9** for UCERD.

Note

The only difference between the UCERD and UCERD2 is the Exciter Module. All the other hardware is common to both. If the Exciter Module has part number 2221399-6 then the assembly is designated as UCERD2.

Example of HSS Output for Average of 5 Passes

```
FR882J92243.HSS/23     HSS FREQUENCY STABILITY (AVERAGE)
=========================================================
Average     TR         FFT BW      FFT Peak Threshold
of  5     (msec)        (Hz)      (st dev above mean)
Passes   11.1110       45.000           2.000
---------------------------------------------------------
                              FFT Statistics    Grad Amps
                            mean        st dev   in OPR
                            0.001        0.003    None
---------------------------------------------------------
           FFT              FFT         Area
Pk No    Frequency        Amplitude       0.726
 1        12.041           0.012
 2        14.414           0.011
 3        16.787           0.015
 4        23.994           0.027
 5        25.225           0.012
 6        27.598           0.010
 7        29.971           0.014
 8        31.201           0.009
 9        34.805           0.010
10        40.781           0.019
---------------------------------------------------------
```

Things to take note of:

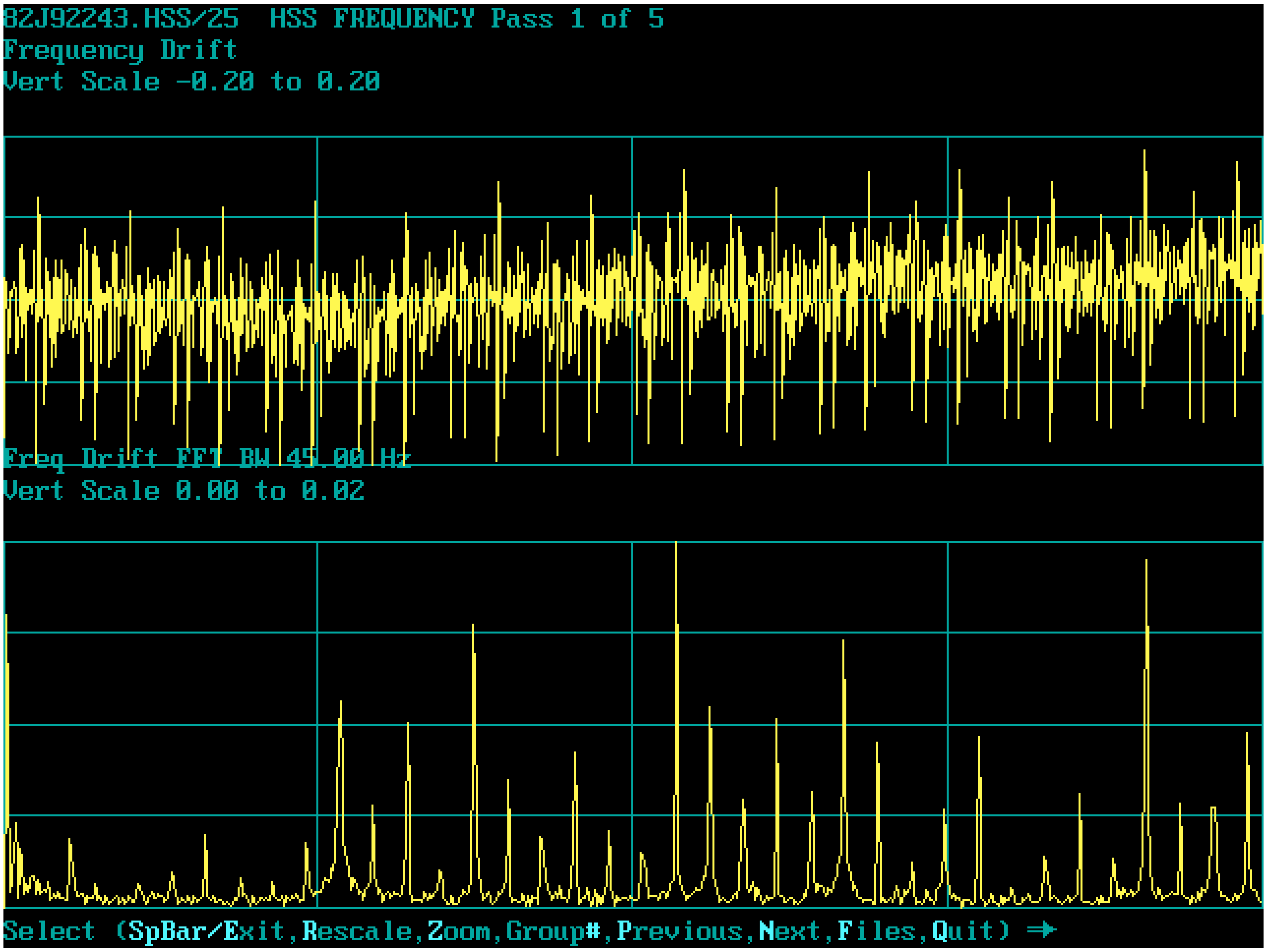
- The top line “Average of 5 passes”, the number of passes is selectable in **USERCVs** when prescribing the test.

- Note the FFT bandwidth. All low frequency vibration troubleshooting will be performed at 45Hz bandwidth. The bandwidth is selectable in ‘USERCVs’ when prescribing the test.

- The top 10 peak distribution. HSS auto-selects the ten highest peaks to report although all peaks are displayed in the graph. Note the frequency and amplitude measurements for top ten.

- Area measurement reported for each pass. The above example averages 5 passes, or an average of 5 area measurements.

Refer to Illustration A-2 for an example of HSS Output for 1 of 5 passes.



EXAMPLE OF HSS OUTPUT FOR 1 OF 5 PASSES
ILLUSTRATION A-2

Things to take note of:

- In the upper plot or plot 1, individual passes display time domain data.
- The lower plot shows FFT Freq amplitude as in the previous display of averages. Divisions are approximately 11.25 Hz.

Example of HSS Output for 1 of 5 Passes

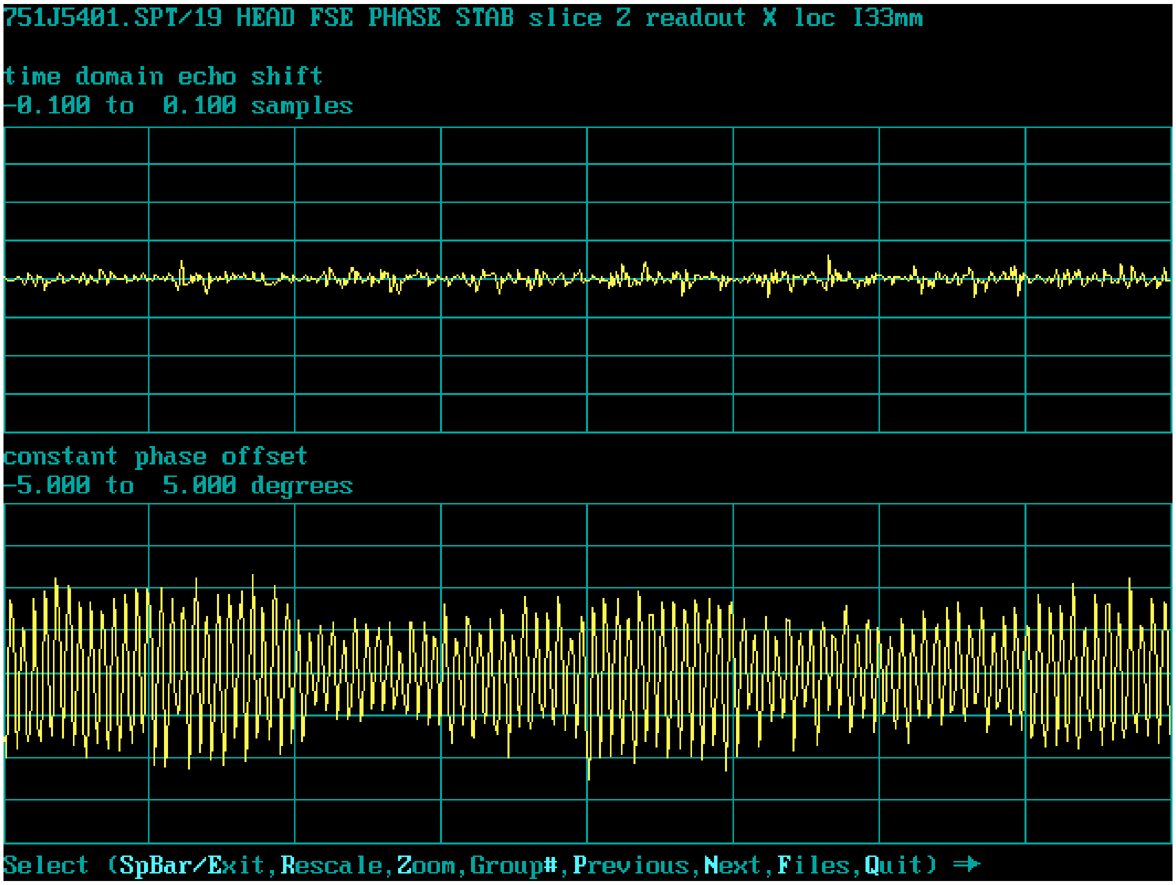
```
FR882J92243.HSS/25  HSS FREQUENCY STABILITY
=========================================================
 Pass       TR         FFT BW      FFT Peak Threshold
 1 of     (msec)        (Hz)      (st dev above mean)
 5       11.1110       45.000           2.000
---------------------------------------------------------
    Frequency Deviation       FFT Statistics    Grad Amps
    p-p          st dev     mean        st dev   in OPR
   0.389          0.059     0.001        0.002    None
---------------------------------------------------------
           FFT              FFT         Area
Pk No    Frequency       Amplitude       0.627
 1         12.041          0.011
 2         14.414          0.010
 3         16.787          0.015
 4         23.994          0.025
 5         25.225          0.011
 6         27.598          0.010
 7         29.971          0.015
 8         34.805          0.009
 9         40.781          0.019
10         44.385          0.010
---------------------------------------------------------
```

<u>Test Case #1:</u>

Details: Customer complaint was poor system performance, ghosted images with FSE, only on certain studies.

Equipment: 1.5T Signa Horizon Echospeed, S5 magnet, transportable building

Refer to Illustration A-3 for the initial SPT plot.



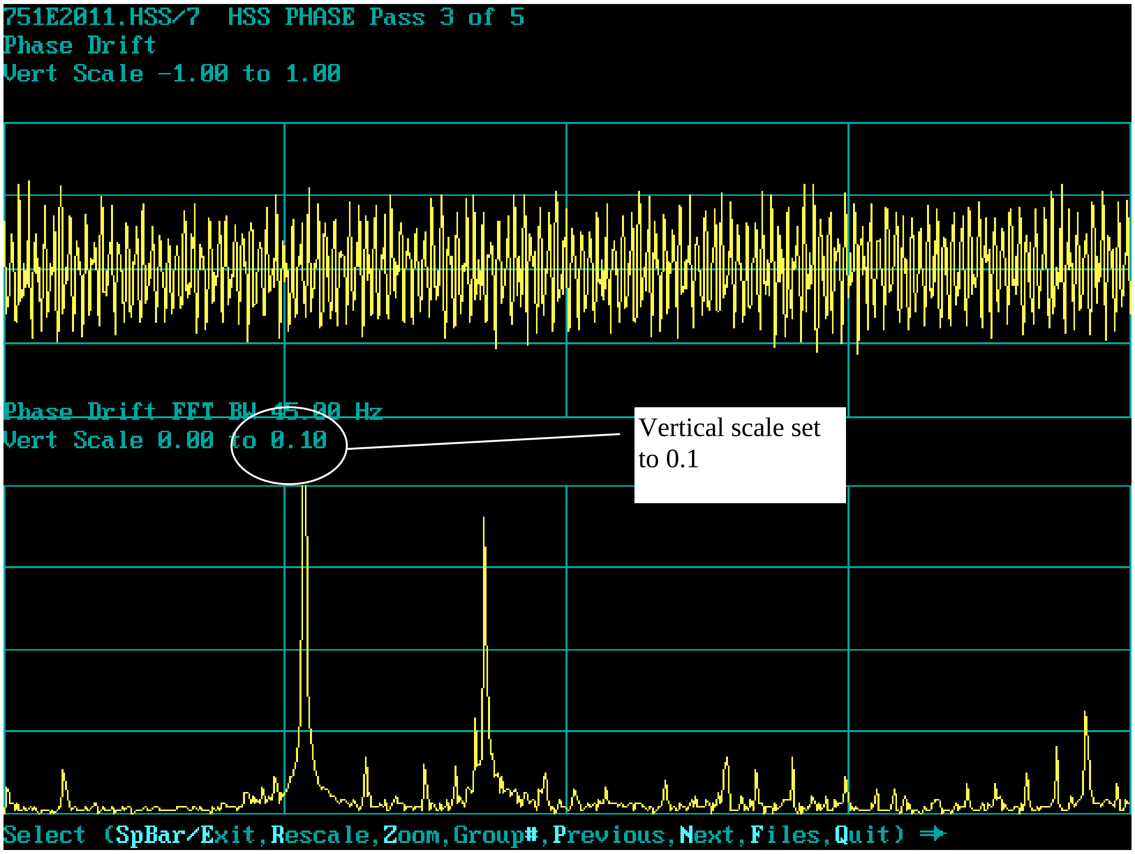
INITIAL SPT FSE PLOT
ILLUSTRATION A-3

SPT shows a plot of constant phase to have envelope oscillation in slice Z readout X scan. This is a typical plot of vibration disturbance. This site had similar oscillation in slice X readout Y scan.

```
751J5401.SPT/19 HEAD FSE PHASE STABILITY slice Z readout X
===============================================================================
location I33mm (with patient position head first supine)
------------------------echo shift (time domain samples)-----------------------
                  -----------------------echo number----------------------
       overall    1       2       3       4       5       6       7       8
p-p     0.028   0.014   0.022   0.016   0.016   0.021   0.028   0.020   0.016
----------------phase drift (constant phase offset in degrees)----------------
                  -----------------------echo number----------------------
       overall    1       2       3       4       5       6       7       8
p-p     6.041   5.258   5.691   3.572   4.770   5.553   4.421   4.160   5.035
-------------------------------------------------------------------------------
```

The overall phase drift is 6.041, which is well above the spec limit of 4.

Refer to Illustration A-4 for the HSS results.



RESULTS OF HSS TEST
ILLUSTRATION A-4

```
FR8751E2011.HSS/7      HSS PHASE STABILITY
=========================================================
 Pass        TR          FFT BW      FFT Peak Threshold
 3 of      (msec)         (Hz)      (st dev above mean)
 5        11.1110       45.000             2.000
---------------------------------------------------------
      Phase Deviation            FFT Statistics    Grad Amps
    p-p            st dev      mean        st dev   in OPR
   1.168            0.242      0.004        0.010    None
---------------------------------------------------------
               FFT              FFT          Area
Pk No       Frequency        Amplitude       2.259
 1           11.953            0.126
 2           18.809            0.029
 3           19.160            0.090
 4           43.154            0.031
 5            0.000            0.000
 6            0.000            0.000
 7            0.000            0.000
 8            0.000            0.000
 9            0.000            0.000
10            0.000            0.000
---------------------------------------------------------
```

Failures

Note
Refer to HSS limit plot in Illustration 3-1 to see that the FFT Amplitude failures exceed the limit.

Note the setting for vertical scale at 0.1 in the graphical data. The area measured for this experiment was 2.259, well above the spec of 1.2. Frequency failures are 11.953Hz and 19.16Hz, with reported amplitudes of 0.126 and 0.090 respectively.

Test Case #1 Summary:

The results of these tests prove this site's susceptibility to ambient vibration. This transportable site was placed on a concrete foundation that was too narrow for its base, which allowed for one complete wall, which ran the length of the building, to cantilever. Also, an adjacent building was placed in contact with the MR structure, allowing vibration to transfer between buildings. This construction error made the building unstable and susceptible to vibrations from multiple sources. As a result, the structure has a tendency to resonate around 12 and 19 Hz. Any disturbance, such as wind, automotive traffic, building traffic, swinging or automated mechanical doors, air conditioning units, coldhead compressor, etc., will cause an increase in FFT amplitude at these frequencies.

Vibration troubleshooting is basically a process of elimination. By removing the suspected sources of vibration one-by-one, such as powering off an AC unit or compressor, and comparing sequential passes of HSS with a baseline, vibration sources can be identified. Conversely, it is sometimes valuable to introduce a vibration source to see if it affects stability.

One method is commonly called the heel-drop test. During data acquisition, stamp your heel to the floor near the magnet. HSS will detect the disturbance. Compare the results to vibration specs for analysis. Try several areas around the magnet and table. Introduce other potential sources of vibration, such as mechanical doors, elevators, HVAC blower motors, etc., to find the main contributors. Suspect activities of nearby areas include loading docks or Emergency Rooms that have heavy traffic. HSS is a sensitive tool and will pick up very small disturbances.

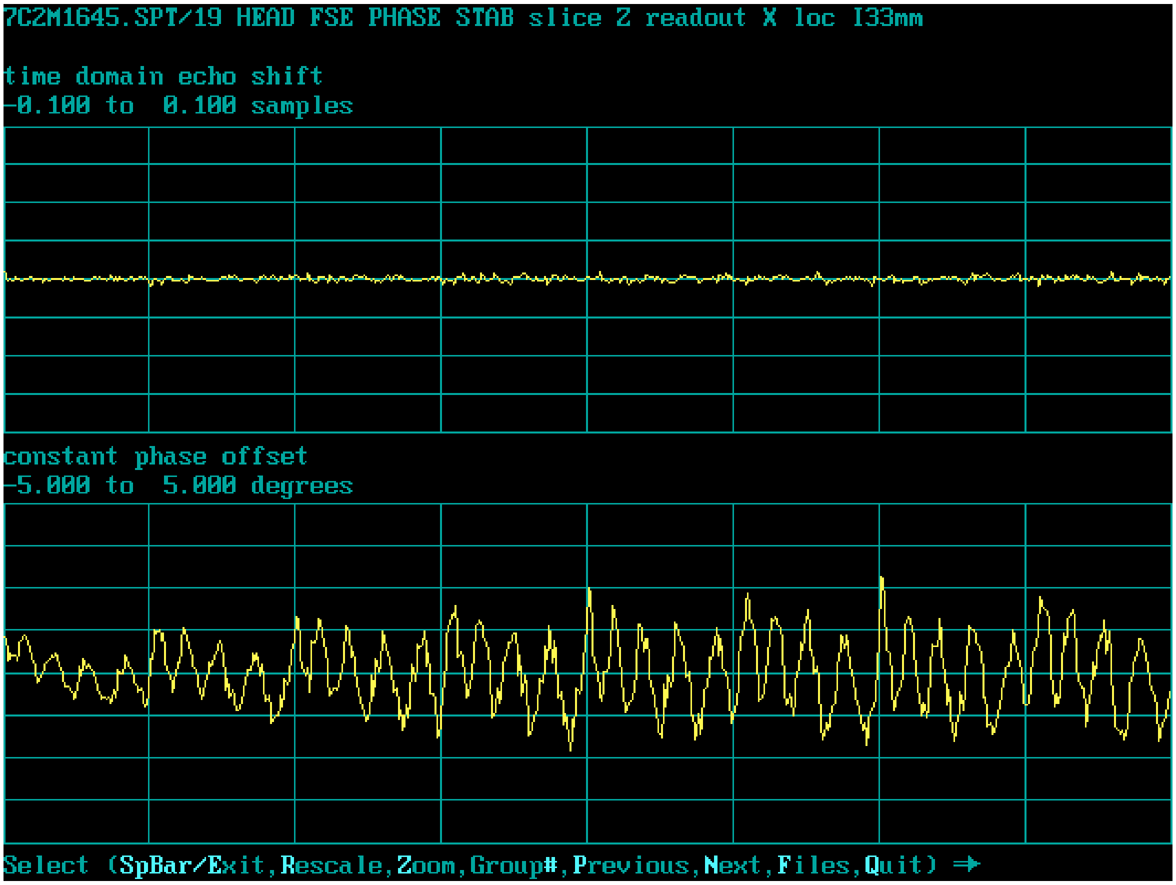
If all else fails, a vibration expert/consultant may need to be contacted to help with the analysis. Before going to outside help, contact the On-Line Center or ZSE to assist with your troubleshooting.

Case Study #2:

Details: Phase smearing affecting image quality

Equipment: 1.5T Signa Hispeed LX with CX magnet

Refer to Illustration A-5 for the initial SPT plots.

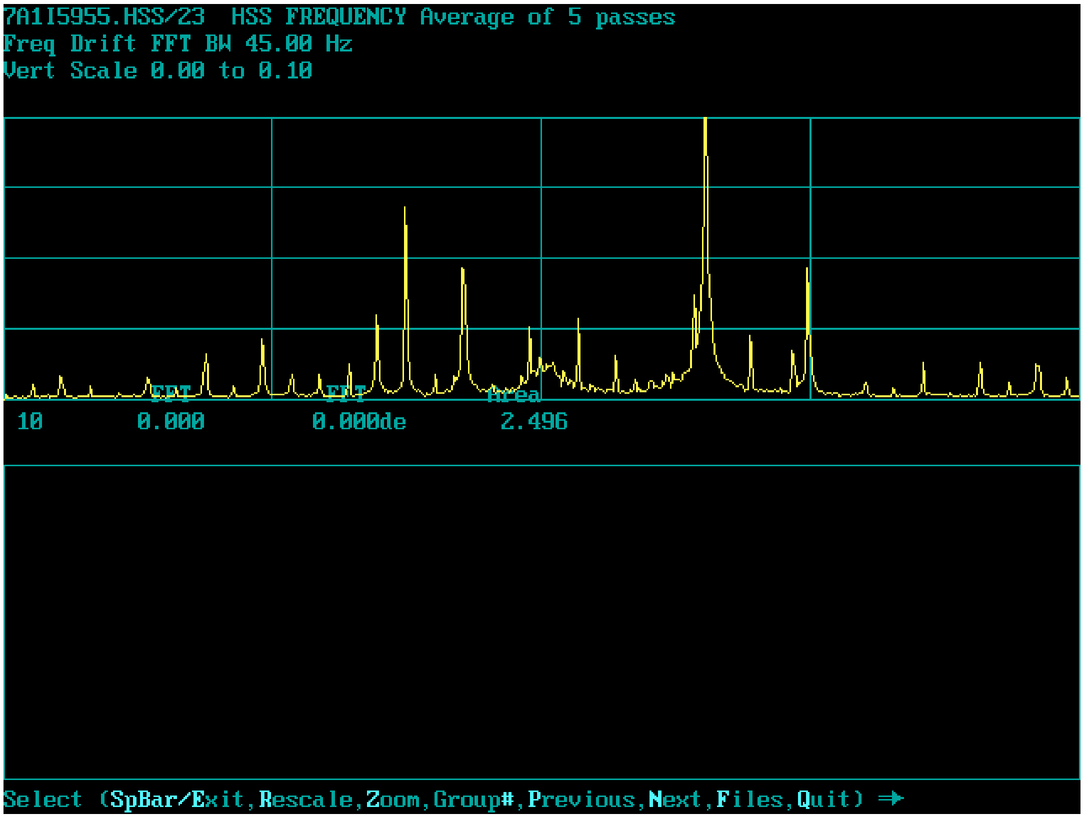


INITIAL SPT FSE PLOT
ILLUSTRATION A-5

This site's SPT Constant Phase Plot showed similar oscillation on all gradients. Phase numbers were from 5 to 7p-p. Turning the coldhead off and repeating the experiment lowered the phase numbers to 3-5p-p. However, oscillations were still present.

```
7C2M1645.SPT/19 HEAD FSE PHASE STABILITY slice Z readout X
================================================================================
location I33mm (with patient position head first supine)
------------------------echo shift (time domain samples)------------------------
                  -----------------------echo number-----------------------
       overall    1       2       3       4       5       6       7       8
p-p     0.010   0.007   0.007   0.006   0.007   0.008   0.009   0.008   0.010
----------------phase drift (constant phase offset in degrees)----------------
                  -----------------------echo number-----------------------
       overall    1       2       3       4       5       6       7       8
p-p     5.134   2.075   2.816   3.537   4.252   4.490   4.481   4.869   4.270
--------------------------------------------------------------------------------
```

Refer to Illustration A-6 for the HSS results with the coldhead on.



HSS OUTPUT WITH COLDHEAD ON
ILLUSTRATION A-6

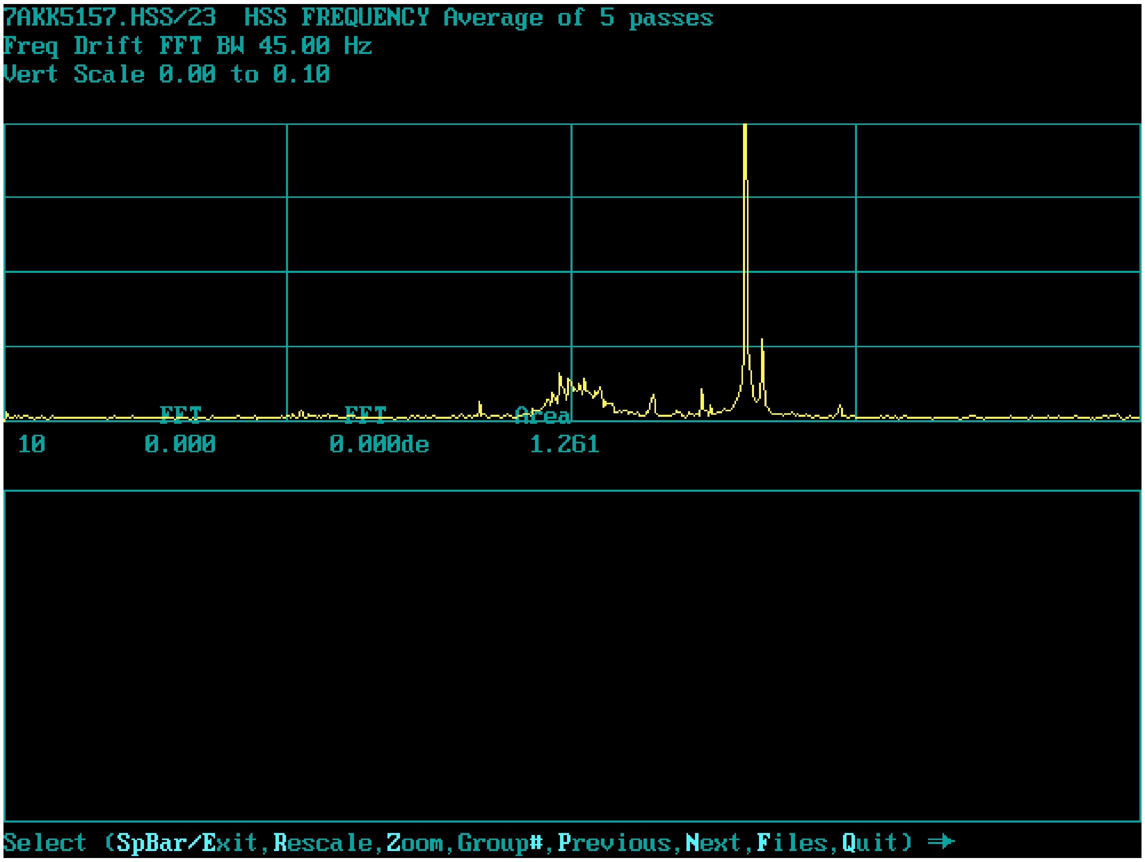
HSS output with coldhead on. Note the vertical scale at 0.1. The coldhead can introduce vibration peaks as shown in the plot. The peaks from the coldhead are not the problem.

```
FR87A1I5955.HSS/23     HSS FREQUENCY STABILITY (AVERAGE)
=========================================================
Average      TR          FFT BW      FFT Peak Threshold
of   5      (msec)        (Hz)      (st dev above mean)
Passes    11.1110        45.000            2.000
---------------------------------------------------------
                               FFT Statistics    Grad Amps
                            mean          st dev    in OPR
                            0.005          0.011     None
---------------------------------------------------------
            FFT                FFT            Area
Pk No     Frequency         Amplitude         2.496
  1         15.557            0.030
  2         16.787            0.068
  3         19.160            0.046
  4         23.994            0.028
  5         28.828            0.037
  6         29.355            0.145
  7         33.574            0.046
  8          0.000            0.000
  9          0.000            0.000
 10          0.000            0.000
---------------------------------------------------------
```

Failures

Note
Refer to HSS limit plot in Illustration 3-1 to see that the FFT Amplitude failure exceeds the limit.

Refer to Illustration A-7 for the HSS results with the coldhead off.

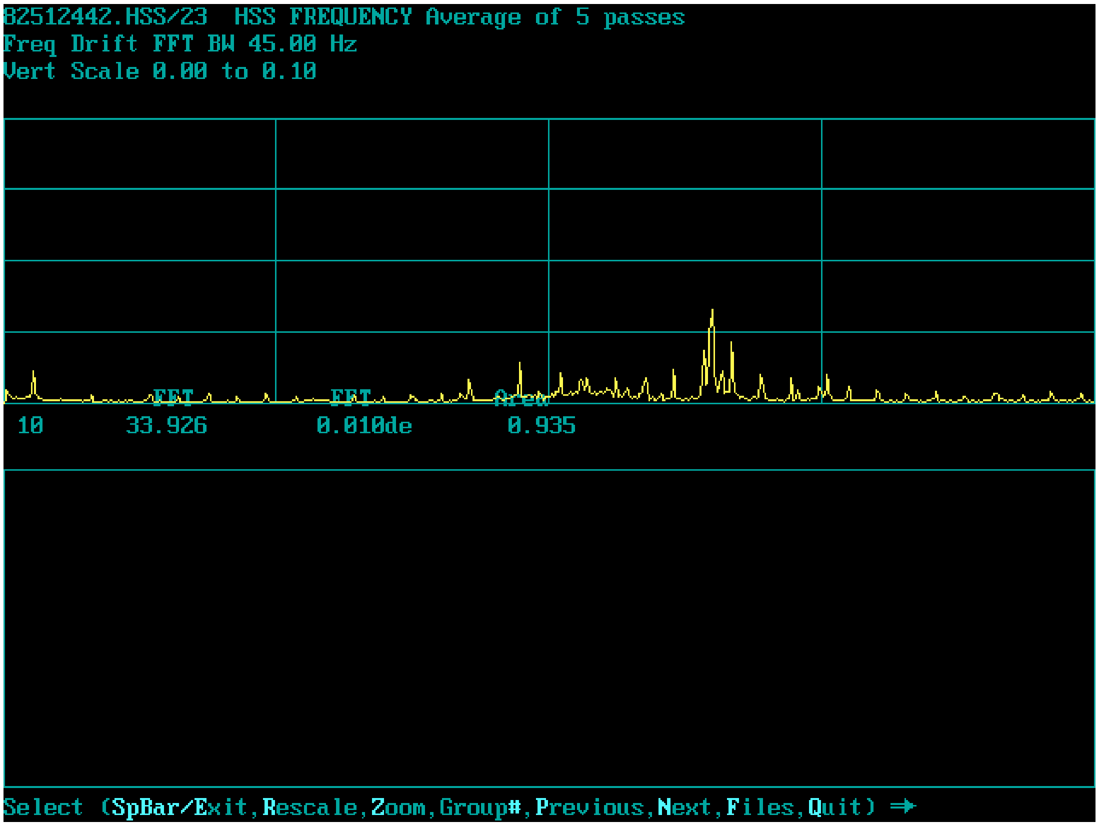


HSS REPEATED WITH COLDHEAD OFF
ILLUSTRATION A-7

HSS repeated with the coldhead off. Problem peak identified at 29 Hz.

```
FR87AKK5157.HSS/23      HSS FREQUENCY STABILITY (AVERAGE)
=========================================================
Average      TR          FFT BW      FFT Peak Threshold
of   5      (msec)        (Hz)      (st dev above mean)
Passes    11.1110       45.000             2.000
---------------------------------------------------------
                                FFT Statistics     Grad Amps
                            mean            st dev    in OPR
                            0.002            0.008     None
---------------------------------------------------------
            FFT               FFT            Area
Pk No     Frequency         Amplitude         1.261
 1         29.355            0.169
 2         29.971            0.027
 3          0.000            0.000
 4          0.000            0.000
 5          0.000            0.000
 6          0.000            0.000
 7          0.000            0.000
 8          0.000            0.000
 9          0.000            0.000
10          0.000            0.000
```

Refer to Illustration A-8 for HSS results after the magnet was re-anchored to the floor.



HSS RESULTS AFTER RE-ANCHOR
ILLUSTRATION A-8

Note that the re-anchoring damped the coldhead peaks.

```
FR882512442.HSS/23     HSS FREQUENCY STABILITY (AVERAGE)
=========================================================
Average      TR          FFT BW      FFT Peak Threshold
of   5     (msec)         (Hz)      (st dev above mean)
Passes    11.1110        45.000            2.000
---------------------------------------------------------
                               FFT Statistics    Grad Amps
                             mean          st dev   in OPR
                             0.002          0.003    None
---------------------------------------------------------
               FFT              FFT          Area
Pk No       Frequency        Amplitude        0.935
 1             1.230           0.011
 2            21.270           0.014
 3            22.939           0.010
 4            27.598           0.011
 5            28.828           0.019
 6            29.180           0.033
 7            29.619           0.011
 8            29.971           0.021
 9            31.201           0.010
10            33.926           0.010
---------------------------------------------------------
```

Test Case #2 Summary:

This 1.5T CX magnet was installed incorrectly. The problem was that the chemical/epoxy anchors used by the contractor didn't have sufficient holding strength. As a result, the anchors loosened when clamping down the magnet. The magnet needed to be moved and a new anchoring system installed. Dir 2120460 Signa Horizon Pre-Installation Section 7-7 requires a magnet clamping force of 12000 +/- 1000 lbs. It's the responsibility of the contractor to provide an anchoring system that meets this requirement. The methods may be different depending on the flooring material. The contractor is required to test the anchoring system before the magnet is installed to verify the clamping force. For more information on magnet mounting and installation, see the following references:

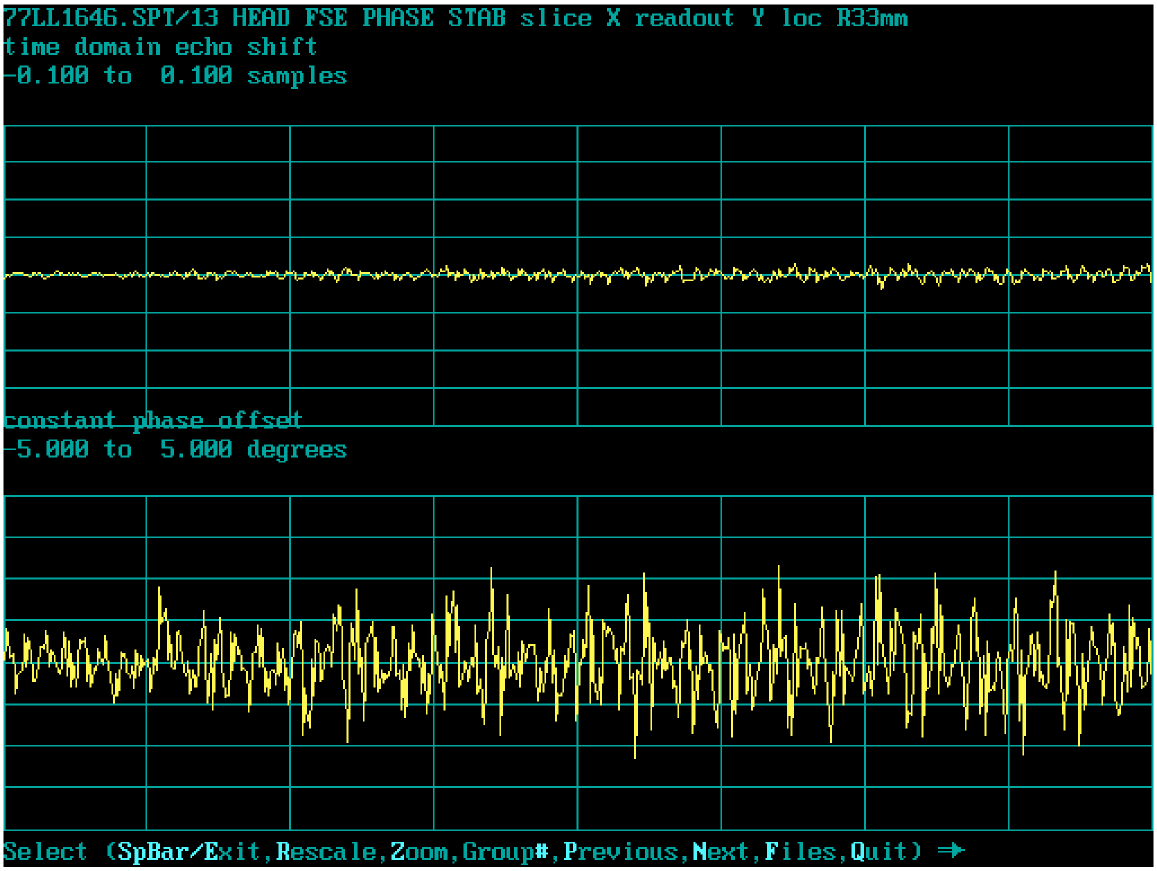
- DIR 2168178 GE 1.5T & 1.0T Cx Active Shield Magnet Delivery and Installation, Sect. 6, Magnet Leveling, Foot Shimming, and Bolting Down
- DIR 2120460 Signa Horizon Pre-Installation
    - Sect. 2-9-1 Magnet Loading Considerations
    - Sect. 2-9-2 Anchoring and Seismic Considerations
    - Sect. 7-7 Anchor Hardware Requirements for MR Equipment Inside RF Shielded Rooms
    - Sect. 4-15 Vibration
    - Appendix A MR Site Vibration Test Guidelines

Test Case #3:

Details: Customer complains of intermittent body coil ghosting and overall system unreliability. Problem occurs several times daily, varying in severity. Images are occasionally undiagnostic.

Equipment: 1.5T Signa Horizon (SR17), S3 magnet fixed, 5.5 software

Refer to Illustration A-9 for initial SPT FSE plots.



INITIAL SPT - FSE PLOT
ILLUSTRATION A-9

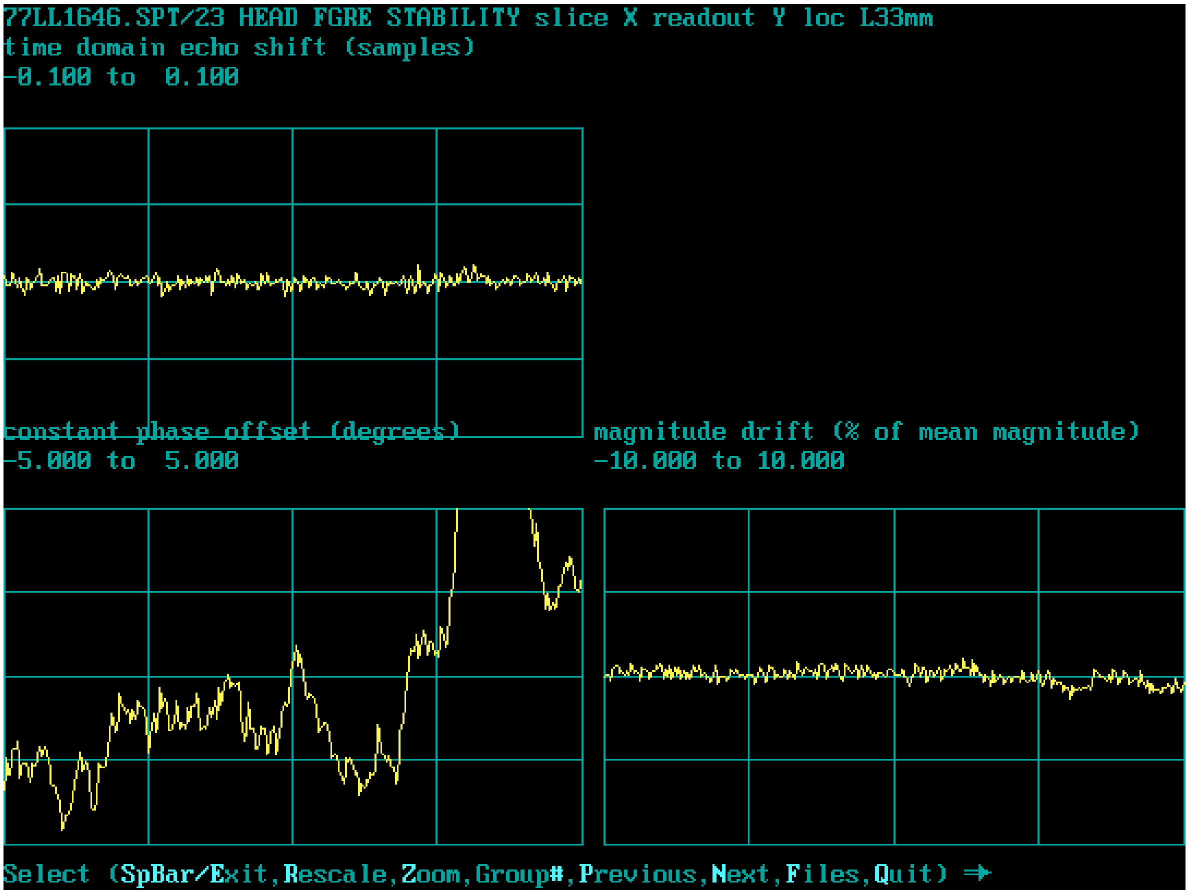
SPT FSE Constant phase plot shows hash that resembles oscillation on all axes. Constant phase is at 5.77.

```
FR877LL1646.SPT/13 HEAD FSE PHASE STABILITY slice X readout Y
===============================================================================
location R33mm (with patient position head first supine)
------------------------echo shift (time domain samples)-----------------------
                  -----------------------echo number-----------------------
       overall    1       2       3       4       5       6       7       8
p-p     0.017   0.005                   0.011   0.013   0.012   0.017   0.014

---------------phase drift (constant phase offset in degrees)----------------
                  -----------------------echo number-----------------------
       overall    1       2       3       4       5       6       7       8
p-p     5.769   2.203   3.689   4.603   4.967   5.505   5.272   4.897   5.457
-------------------------------------------------------------------------------
```

Marginal Failure above 4 p-p

Refer to Illustration A-10 for the initial SPT FGRE plots.

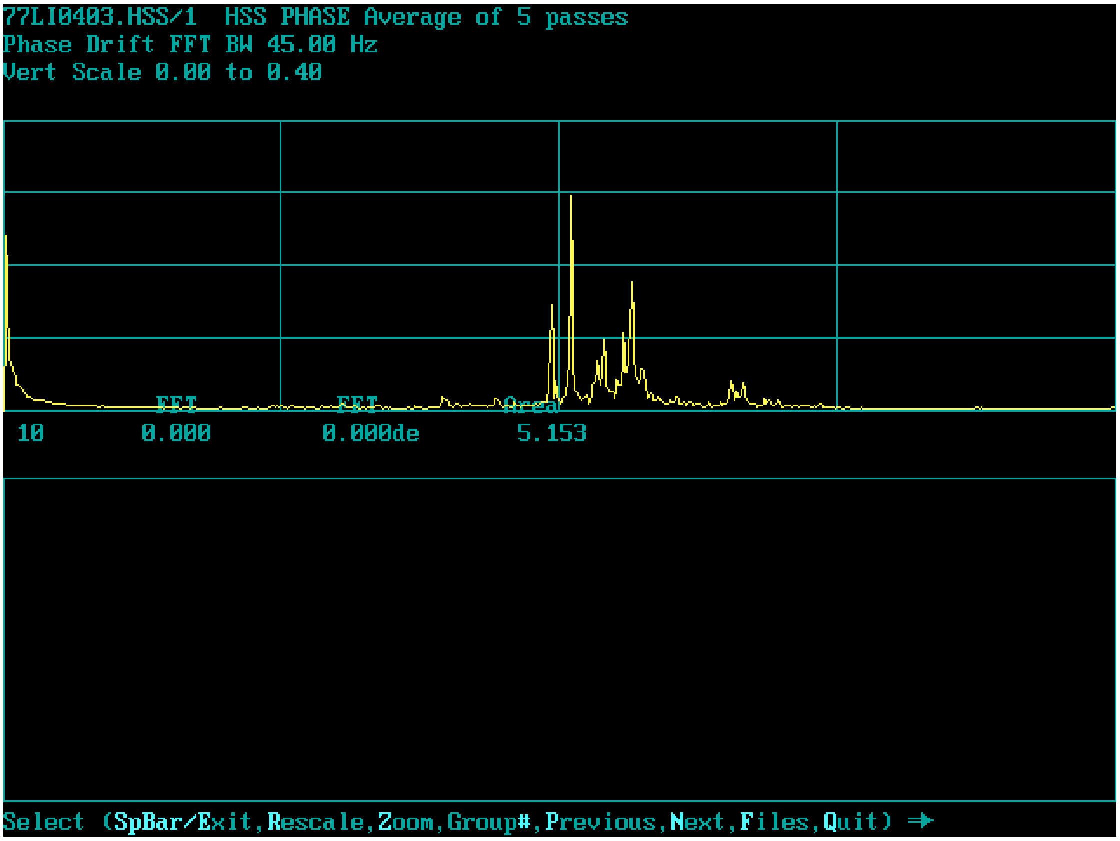


INITIAL SPT - FGRE PLOT
ILLUSTRATION A-10

SPT FGRE Constant Phase plot shows erratic phase drift that varies from 6 to 26 degrees with successive SPT passes.

```
FR877LL1646.SPT/23 HEAD FGRE STABILITY slice X readout Y
===============================================================================
location L33mm (with patient position head first supine)
-------------------------------------------------------------------------------
                          plot data
                      minus linear ramp        linear ramp only
                             p-p                     p-p
echo shift                  0.021                   0.001
(time domain samples)
phase drift                13.481                   8.287
(constant phase offset in degrees)
magnitude drift             2.380                   0.765
(% of mean magnitude)
-------------------------------------------------------------------------------
R1 = 6    R2 = 15   TG = 55   Freq = 63872833
-------------------------------------------------------------------------------
TNS                 Connected          Overflow          Counts This Axis
                      no                 n/a                   n/a
-------------------------------------------------------------------------------
```

Refer to Illustration A-11 for the HSS results.



HSS RESULTS
ILLUSTRATION A-11

HSS shows disturbances of 22.1, 23, 24, 24.2, 25, 25.4 Hz with an area measurement of 5.153. Note vertical scale set to 0.4.

```
FR877LI0403.HSS/1      HSS PHASE STABILITY (AVERAGE)
=========================================================
Average        TR           FFT BW      FFT Peak Threshold
of   5       (msec)          (Hz)      (st dev above mean)
Passes      11.1110        45.000            2.000
---------------------------------------------------------
                             FFT Statistics     Grad Amps
                           mean         st dev    in OPR
                           0.010         0.024     None
---------------------------------------------------------
             FFT              FFT          Area
Pk  No     Frequency        Amplitude      5.153
 1          22.148           0.145
 2          22.939           0.295
 3          23.994           0.069
 4          24.258           0.098
 5          25.049           0.106
 6          25.400           0.175
 7           0.000           0.000
 8           0.000           0.000
 9           0.000           0.000
10           0.000           0.000
```

Failures

Note
Refer to HSS limit plot in Illustration 3-1 to see that the FFT Amplitude failures exceed the limit.

Test Case #3 Summary:

By using SPT results in combination with HSS, several huge blower assemblies located in a HVAC utility room three floors above the MRI suite were found to be introducing vibration and intermittently affecting system performance. Building maintenance people were called in to assist with isolating the source. By powering off one blower unit at a time, main contributors were isolated. In this case, several instances were spring isolation devices supporting the duct work that were being mechanically bypassed with support cables, allowing vibration to be transferred to the building structure. Also, the isolation supports for the fan units were found to be inadequate and too soft, allowing vibrations to be transferred to the surrounding structures.

The magnet mounting bolts were also found to be loose. By tightening the bolts, SPT FSE constant phase dropped to within spec. Correcting the problems with the fan units cleared up the HSS peaks, however, SPT FGRE constant phase behavior was still erratic. The phase drift was due to Electro-Magnetic Interference (EMI) from a nearby subway terminal. This was identified by using a flux gate sensor. The magnet was installed within 30 feet of a main power feed that connected a main train station to a local substation. Current passing though the cable produced enough magnetic interference to affect the MRI performance.

APPENDIX B - TROUBLESHOOTING PHASE GHOSTING ON CX MAGNET

Checklist for Proper Hardware Setup

Motorshield

- Check for clearance between the motorshield and the coldhead motor. The motorshield should not touch the coldhead during operation.
- Check for clearance between motorshield and coldhead power connector. The motorshield should not touch the power connector during operation.

Gas Lines

- Make sure the gas lines are secured to the bottom of the motorshield with the safety strap.
- Make sure the gas lines are not sagging and pulling down on the coldhead. Route gas lines to relieve tension on the lines.
- Check for the installation of foam insulation on gas lines.

Inertia Mass Assembly

- Check for proper centering (left/right/up/down and skew) of the brass plate assembly with respect to the coldhead. For example, if the coldhead is not level and slightly skewed downward, then the mass weight assembly must be tilted to match the skew.
- Check for gaps between the brass plates. Plates should be clamped tight leaving no gaps. Check the three threaded rods for the installation of a nut on the backside of brass plate. Early units had rods with less thread, not allowing the installation of the back nut.
- Check the tension in the three threaded rods. Tension on the three rods should be equal. This can be checked by feeling the vibration on each rod during coldhead operation.
- Check for clearance (about 1/8 inch) around the Inertia Mass support frame. The support frame should not touch the enclosure frame or magnet cryostat during coldhead operation.
- For fixed sites, make sure the support frame is tightly clamped to the pipe near the floor and is not resting on the floor.

Bellows Flange

- Check for clearance around the shipping stud as it passes through the hole in the bellows flange during coldhead operation. There should be at least a 1/16 inch gap between the stud and the flange hole. For fixed sites, if the stud is touching the flange, remove the stud. For mobiles, the stud and nut must remain, as they are required for transportation.
- Check for clearance between the bellows flange and the jam nuts during coldhead operation. There should be about a 1/8-inch gap between the nut and the flange. If there is no clearance with the nuts behind the flange, then remove one of the three nuts.
- Check for any distortion in the bellows assembly. There should be equal spacing between and around each convolution. There's nothing to adjust here, just note the condition of the bellows.

BRM / Bridge / Rear Pedestal

- Remove the end bells and check the radial support brackets located at 2 and 10 o'clock on both ends of the BRM assembly. There should be no rubber pads on the phenolic blocks. The torque adjustments of the support brackets should be done by hand-tightening the two bolts. Then use a wrench to turn the bolt head two more flats.
- Check the bridge and make sure it is resting firmly on and parallel to the RF tube as it passes through the bore.
- Check the rear pedestal and make sure the jack screws are contacting the floor and providing proper vertical support.

Magnet Feet / Dock Motor Assembly

- Check for loose anchor hardware for the magnet feet and the dock motor assembly.
- Check the magnet feet for loose or missing shims. The magnet feet must have maximum contact with the floor.

Magnet Room Floor

- Check the floor construction. Note the material used and the number of layers. Soft floors may contribute to phase ghost problems.

Patient Table

- Check for the proper patient table height. Make sure the table does not vibrate during the scan.

APPENDIX C - ANALYZING HSS (HIGH SPEED STABILITY RESULTS

Refer to Service Note 67031 for help analyzing HSS results. This service note can be found on the 2160623-1 Service CD under Troubleshooting, off the main index page.

APPENDIX D - OPENSPEED HSS TROUBLESHOOTING

Note

The troubleshooting information for Open*Speed* has been kept in this standard Signa HSS procedure for a short time at the request of the field (it will be removed in a future update). Refer to *OpenSpeed High Speed Stability (HSS)* (SYSTSC4A.DOC) for the complete Open*Speed* procedure.

Running HSS on the 0.7T system at installation will be extremely useful in reducing installation and warranty costs as well as troubleshooting time for vibration (image ghosting). Problems with site vibration can be identified and corrected.

Note

The Open*Speed* magnet is a new class of magnet. What you may know about the cylindrical magnets may not always apply. Procedures are strikingly similar in all cases. They are not EXACTLY the same, however. Read all procedures carefully before proceeding to troubleshooting or calibrating the Open*Speed* system. The Open*Speed* magnet design is highly susceptible to vibration. The placement of the downposts and extremely small changes in distance between the pole faces can cause ghosting and general poor image quality.

Note

It is recommended that you also refer to Service Note 67031 Analyzing HSS (High Speed Stability) Results, and the High Field, High Speed Stability (HSS) procedure used for troubleshooting 1.0T and 1.5T Signa sites.

D-1 HSS Required During Initial Installation of Open*Speed* System

As of April 1, 2001, High Speed Stability (HSS) must be performed on ALL Open*Speed* systems during the Install phase of the system. The recommended time to run this test is immediately after ECMT (Eddy Current Compensation). The result file should be sent to MR Service Engineering. Attach the file to an e-mail message and direct that e-mail to:

mrservice2@med.ge.com

1. The file should always be analyzed using Report Manager "on-site" as a functional check of the Open*Speed* system to benchmark the site stability related to environmental vibration and troubleshoot known vibration sources. You must also send your files to the e-mail address above for additional MR Engineering analysis and assistance.

2. During the few weeks directly following customer turnover, you may want to run HSS periodically, characterizing the systems operation related to its environment.

D-2 Using HSS as Part of Normal Troubleshooting of Open*Speed*

If vibration has suddenly become an issue, check the suite's environment for recent construction or addition of A/C, air handlers, elevators, changes in the traffic patterns of roads or parking areas near the magnet-anything that could cause the ground to shake. Take note of these, and plan your HSS data collection accordingly.

D-3 Typical Graphical Plots for Open*Speed* System

The following graphical plots are examples of passing and failing HSS data taken from Open*Speed* systems.

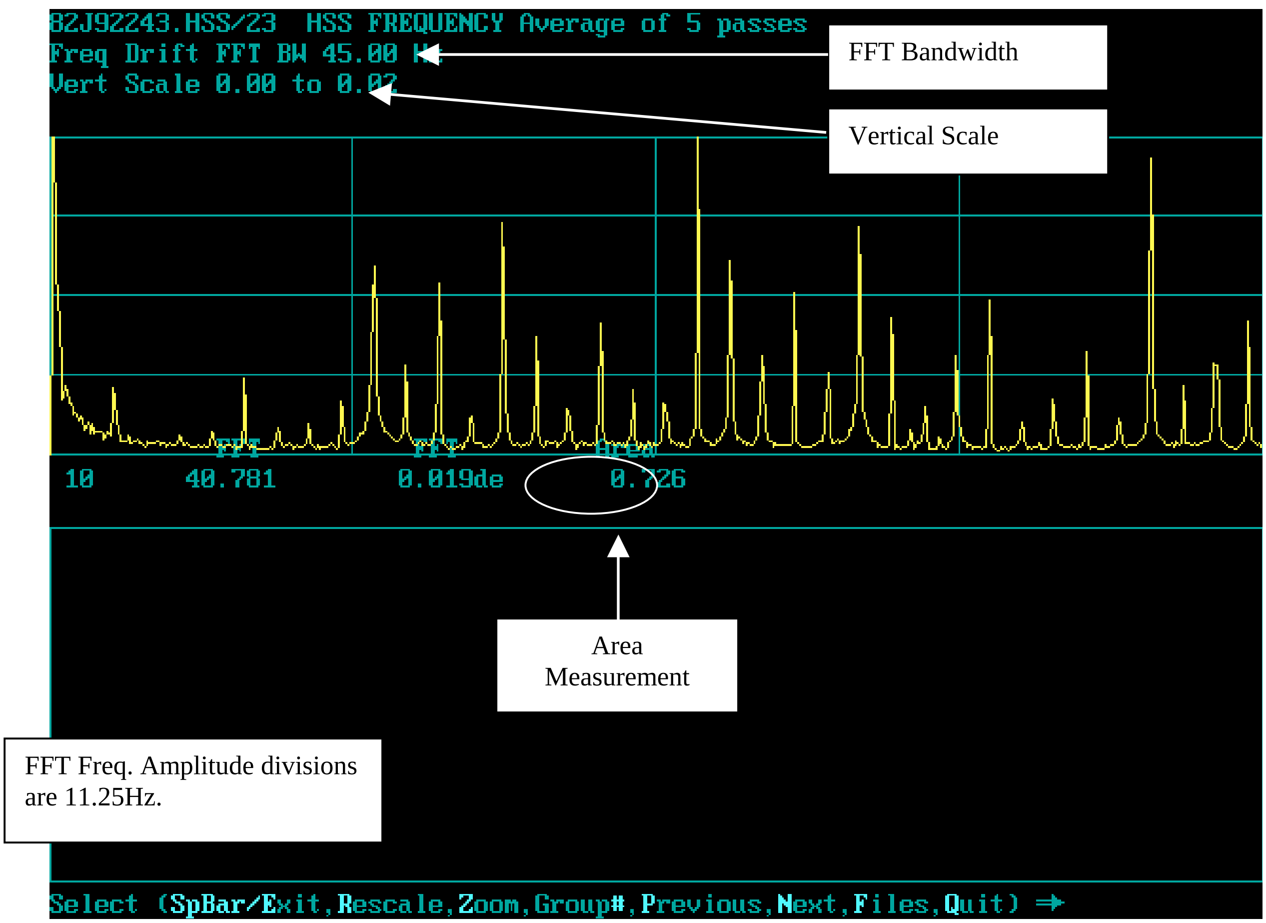
Note

Do not turn over a site to a customer if the HSS procedure indicates the site is failing. Troubleshoot the system for vibration problems. Notify MR Service Engineering to aid in this process.

D-4 Interpreting HSS Graphs and Data Collected Using Report Manager.

HSS must pass any one of the following three specifications. If any of the other tests fail, an HSS failure can result.

- The volume of frequency disturbances registered as the area beneath the frequency spectrum displayed. (Total FFT Area; Spec = 2.0)
- The Total Peak to Peak of all frequencies. (FFT Freq. amplitude P-P; Spec = 1.0)
- The amplitude of any one frequency that provides a constant frequency spike.



HSS OUTPUT EXAMPLE WITH AREAS OF INTEREST
ILLUSTRATION D-1

Things to take note of:

- The top line shows the filename and "Average of 5 passes." The number of passes is selectable in **USERCVs** when prescribing the test.
- Note the FFT bandwidth. All low-frequency vibration troubleshooting will be performed at 45Hz bandwidth. The bandwidth is selectable in **USERCVs** when prescribing the test.
- Vertical scale is important to note as rescaling the graph is sometimes convenient for viewing peak references of other HSS passes.
- Area - this is the total area under the spectrum. The upper spec limit for this is 2.0.
- The menu bar at the bottom. See PC Report or Report Manager Help for details.

Example of HSS Output for Average of 5 Passes

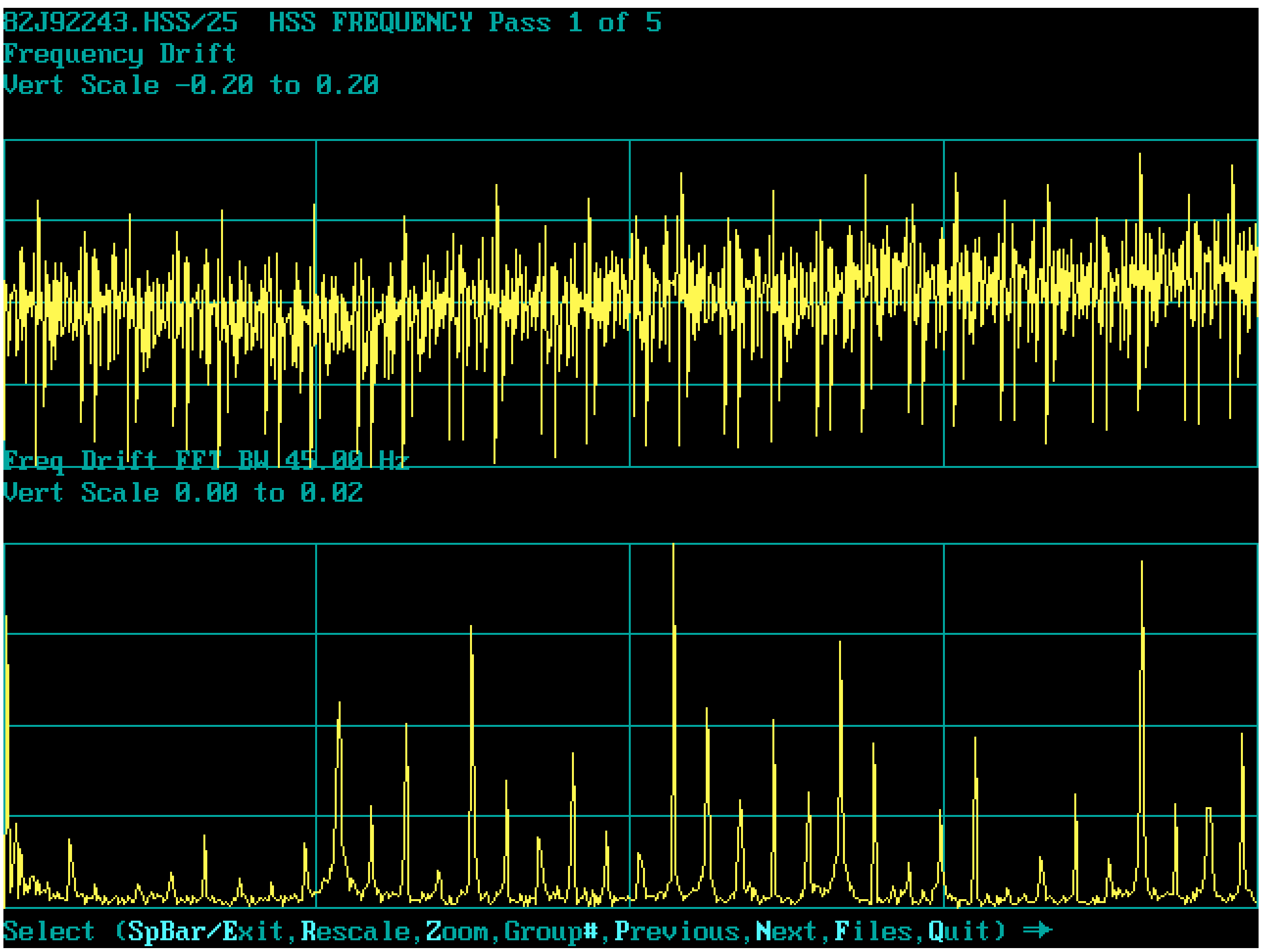
```
FR882J92243.HSS/23     HSS FREQUENCY STABILITY (AVERAGE)
============================================================
Average     TR        FFT BW      FFT Peak Threshold
of  5     (msec)           (Hz)      (st dev above mean)
Passes   11.1110      45.000          2.000
----------------------------------------------------------
 FFT Statistics    Grad Amps
 mean        st dev   in OPR
 0.001       0.003    None
----------------------------------------------------------
           FFT          FFT          Area
Pk No    Frequency  Amplitude       0.726
 1        12.041          0.012
 2        14.414          0.011
 3        16.787          0.015
 4        23.994          0.027
 5        25.225          0.012
 6        27.598          0.010
 7        29.971          0.014
 8        31.201          0.009
 9        34.805          0.010
10        40.781          0.019
----------------------------------------------------------

Select (Help,Group#,SpBar/PlOt,Previous,Next,Files,Quit) -┼
```

Things to take note of:

- The top line "Average of 5 passes." The number of passes is selectable in **USERCVs** when prescribing the test.
- Note the FFT bandwidth. All low-frequency vibration troubleshooting will be performed at 45Hz bandwidth. The bandwidth is selectable in **USERCVs** when prescribing the test.
- Top 10 peak distribution. HSS auto-selects the ten highest peaks to report although all peaks are displayed in the graph. Note the frequency and amplitude measurements for the top ten.
- The area measurement reported for each pass. The above example averages 5 passes, or average of 5 area measurements.

Refer to Illustration D-2 for an example of HSS Output for 1 of 5 passes.



EXAMPLE OF HSS OUTPUT FOR 1 OF 5 PASSES
ILLUSTRATION D-2

Things to take note of:

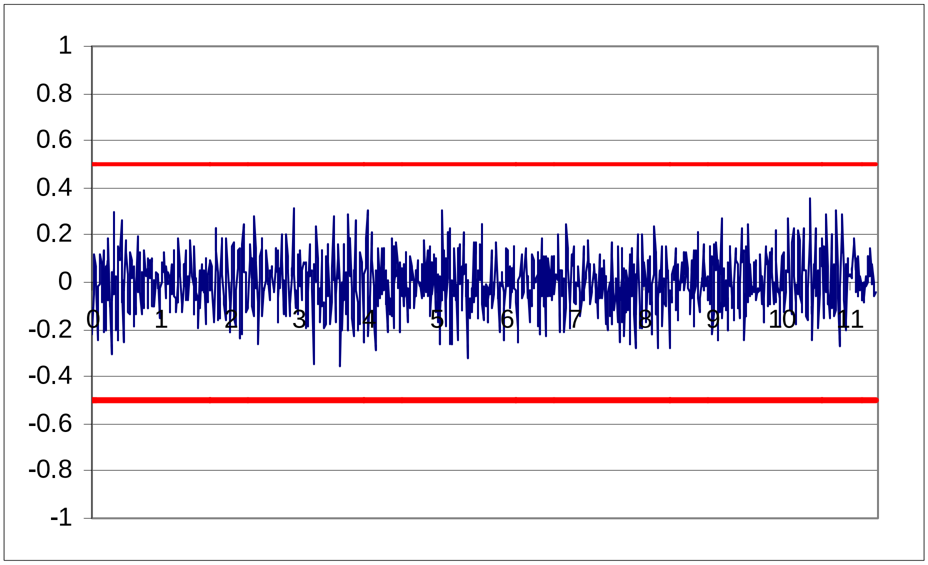
- In the upper plot or plot 1, individual passes display time domain data.
- The lower plot shows FFT Freq amplitude as in the previous display of averages. Divisions are approximately 11.25 Hz.

D-5 Example #1- Typical (Normal) HFO Single Stage (Lower) Coldhead Running

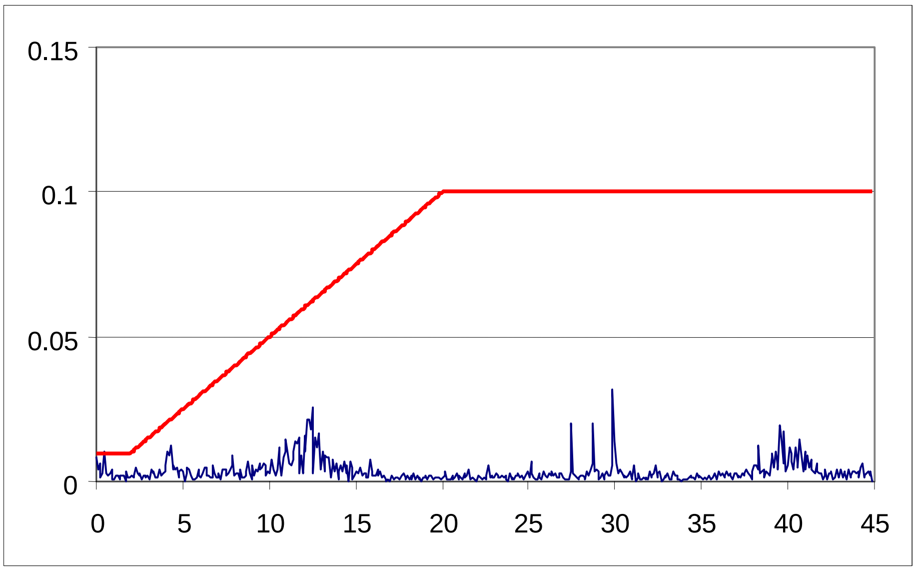
p-p spec 1.0 0.711 area spec 2.0 1.796 ← Pass

↖ Pass

1	12.041	0.016
2	12.217	0.021
3	12.480	0.025
4	12.656	0.015
5	12.832	0.017
6	27.510	0.020
7	28.740	0.020
8	29.883	0.031
9	39.551	0.019
10	39.814	0.017



Typical HSS result for an Open*Speed* system.

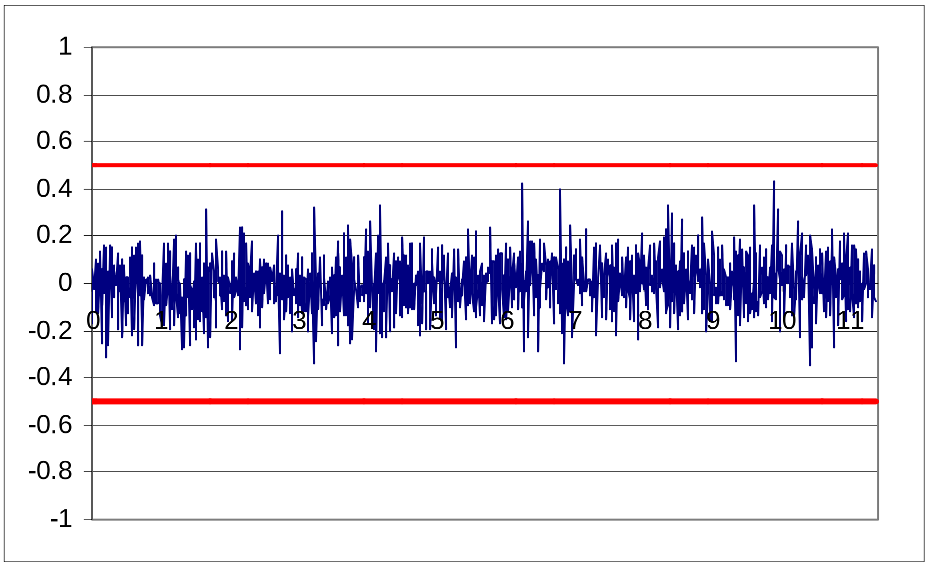


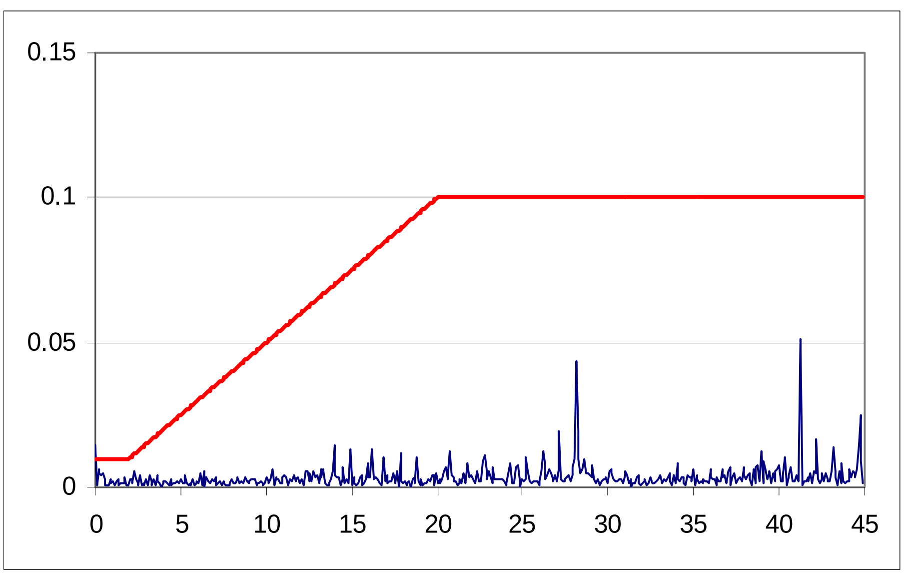
TYPICAL HFO HSS GRAPH
ILLUSTRATION D-3

D-6 Example #2- HFO Single Stage (Lower) Coldhead Running

p-p Spec 1.0 0.782 (Pass) area spec 2.0 1.133 (Pass)

1	13.975	0.015
2	14.941	0.013
3	16.172	0.013
4	20.742	0.013
5	27.158	0.019
6	28.125	0.043
7	41.221	0.051
8	42.188	0.016
9	43.154	0.014
10	44.736	0.025





DESIREABLE HFO HSS GRAPH
ILLUSTRATION D-4

This example shows a highly desirable test result for all OpenSpeed systems.

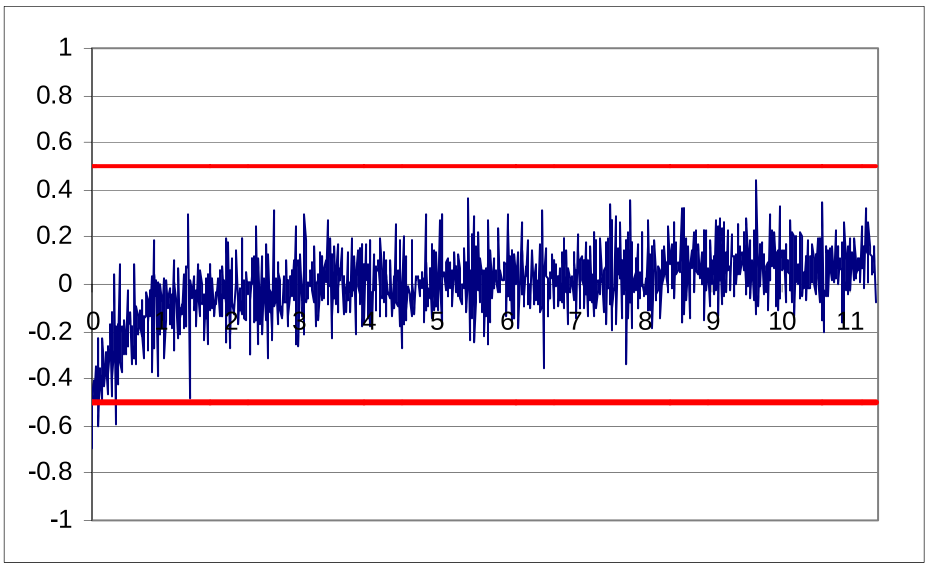
Fine tuning the lower coldhead mount and achieving adjustment to the bellows within its spec contributes greatly to the final result.

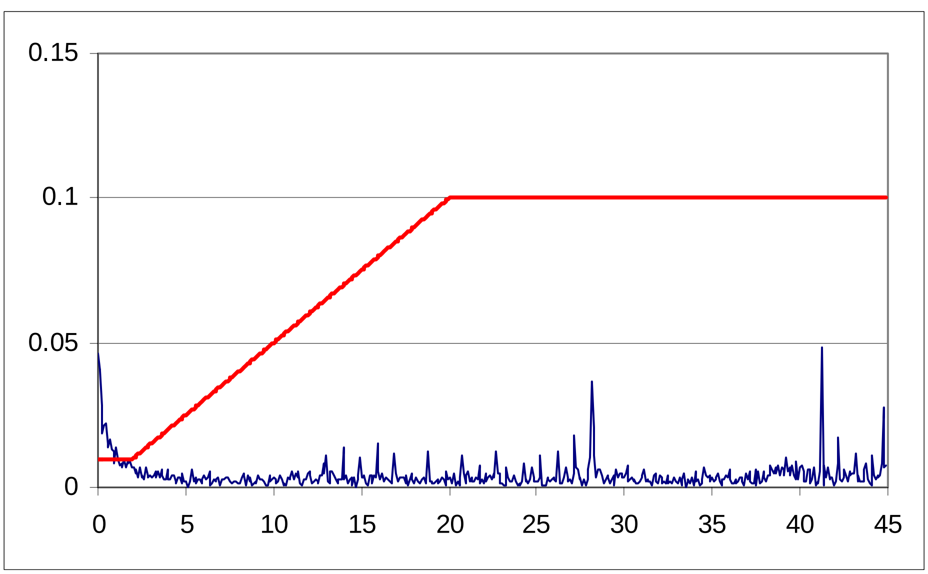
D-7 Example #3- UCERD Affect In First Pass Of HSS Data Collection

p-p Spec 1.0 1.140 area spec 2.0 2.196 ← Failed

Failed

1	0.439	0.022
2	0.703	0.017
3	15.908	0.015
4	27.158	0.018
5	28.125	0.037
6	41.221	0.048
7	42.188	0.017
8	44.736	0.028
9	0.000	0.000
10	0000	0.000





This data has recorded a phenomenon caused by the UCERD. It is under investigation (Apr. 19, 2001).

Solution:
Re-run HSS and re-evaluate.

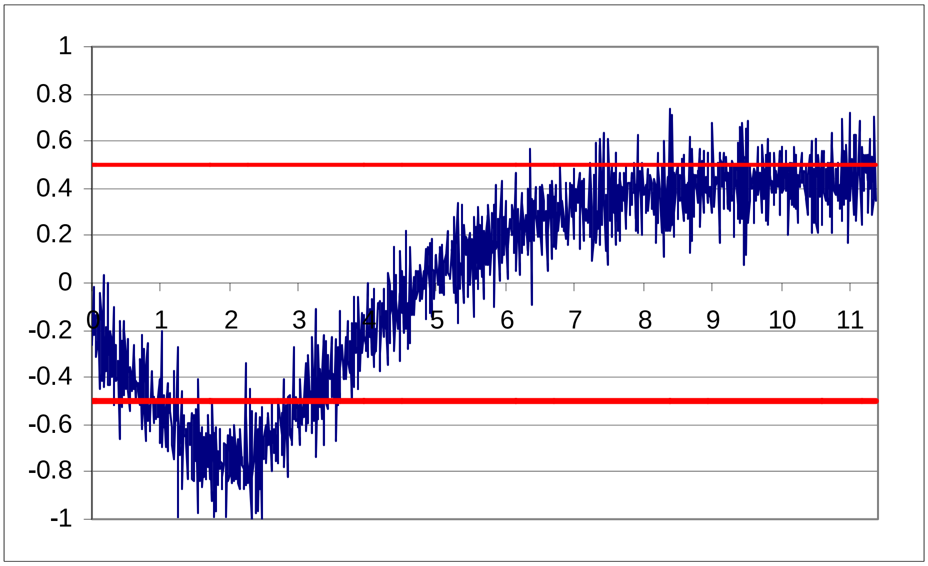
UCERD PHENOMENA
ILLUSTRATION D-5

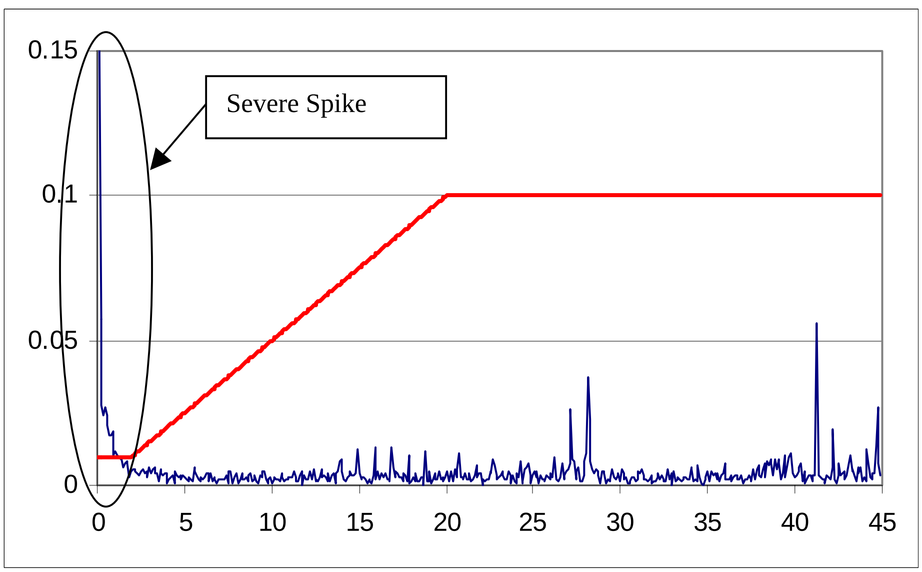
D-8 Example #4- Moving Metal As Seen In HSS Data

p-p Spec 1.0 1.735 area spec 2.0 2.756 ← Fail

Failed

1	41.221	0.056
2	0.000	0.000
3	0.000	0.000
4	0.000	0.000
5	0.000	0.000
6	0.000	0.000
7	0.000	0.000
8	0.000	0.000
9	0.000	0.000
10	0.000	0.000





This example shows a major change in the main magnetic field.

Metal objects close to the magnet will cause this.

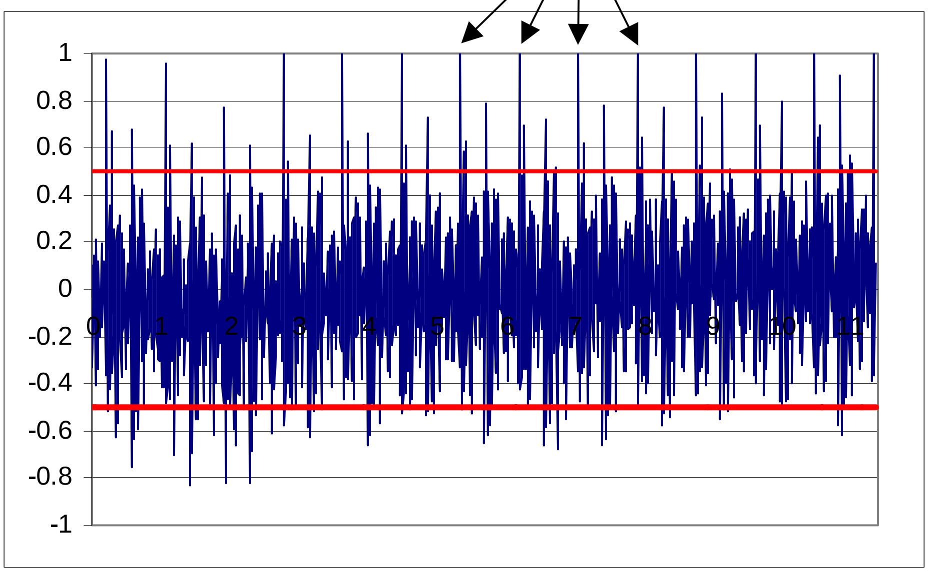
MOVING METAL IN GRAPH
ILLUSTRATION D-6

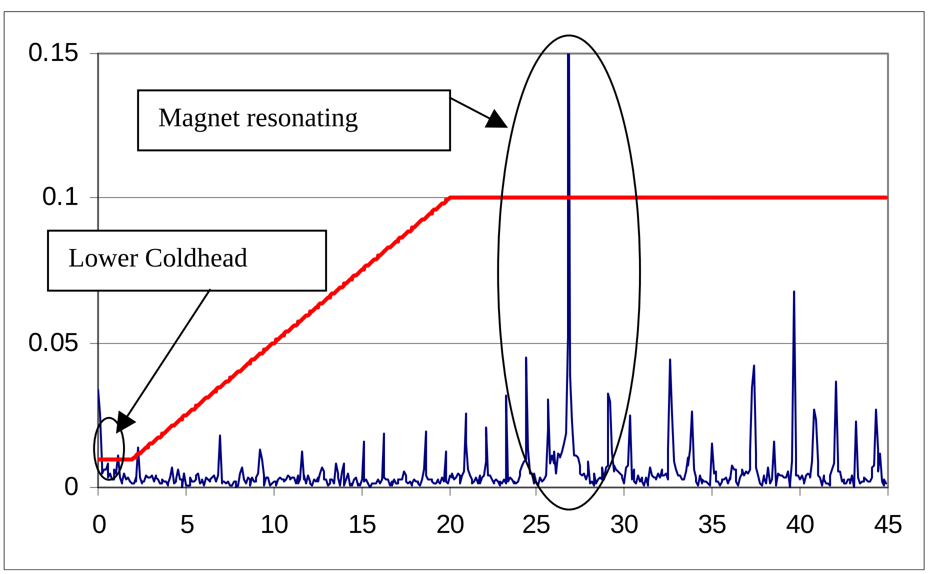
D-9 Example #5- Incorrect Single Stage (Lower) Coldhead Installation

p-p Spec 1.0 1.956 area spec 2.0 2.972 ← Fail

1	24.434	0.045	Failed
2	26.807	0.256	
3	29.092	0.033	
4	32.607	0.044	
5	37.354	0.042	
6	39.639	0.068	
7	42.012	0.037	
8	0.000	0.000	
9	0.000	0.000	
10	0.000	0.000	

Notice regularity of spikes. This is the coldhead transmitting vibration through the bellows assembly. Characteristic of shipping bolts that have not been withdrawn.





SINGLE STAGE COLDHEAD NOT INSTALLED/ADJUSTED PROPERLY
ILLUSTRATION D-7

This problem is caused by the single stage (lower) coldhead inducing vibration into the magnet.

It can be avoided by correctly following the procedure to mount and adjust this coldhead at install.
(Refer to the Magnet Installation manual Section 6-3 for this setup and adjustment.)

It is important to work with the Install contractor very early in the install to insure this coldhead gets mounted correctly and has been adjusted properly BEFORE ramp up.

Lower coldhead can be seen at about 1.2Hz.

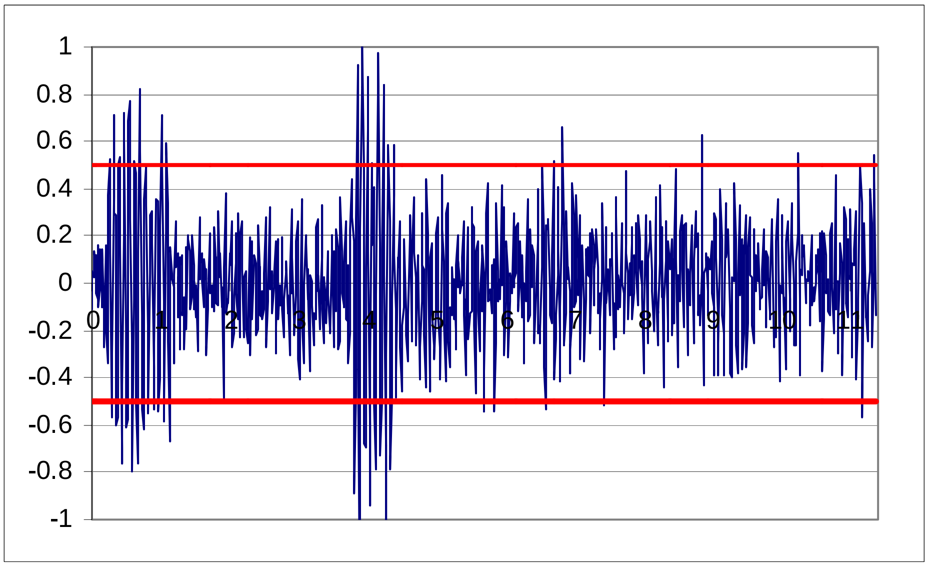
Magnet can be seen around 12-14 Hz with magnet poles flexing at 25 to 40Hz.

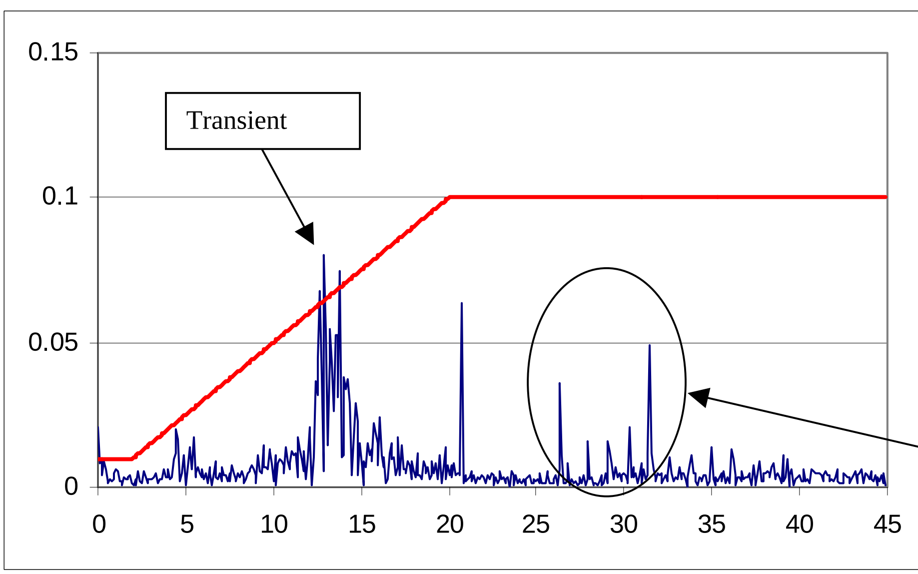
D-10 Example #6- Transient Event Seen In HSS Data

p-p Spec 1.0 2.450 area spec 2.0 3.107 ← Fail

1	12.393	0.037	Failed
2	12.656	0.067	
3	12.920	0.080	
4	13.271	0.055	
5	13.623	0.053	
6	13.799	0.075	
7	14.062	0.038	
8	14.238	0.038	
9	20.742	0.064	
10	31.465	0.049	

External vibrations, which caused the upper magnet section and lower magnet section poles to flex. This generated "Transient" Frequency spikes.





Magnet "ringing" due to pole face flexing, caused by induced vibration.

Many things can cause transients.

Vibration generators:

- Coldheads.
- Lower coldhead not turning off during scan
- Slamming a door
- Chillers
- Cradle Movement
- Nearby vehicular movement across a rough road
- Construction activities near magnet
- Movement of the steel shield surrounding the magnet room
- Minor earthquakes

Refer to Section 8 for magnet vibration characteristics unique to Open Magnet design.

TRANSIENT IN GRAPH
ILLUSTRATION D-8

D-11 Open*Speed* / HSS Theory

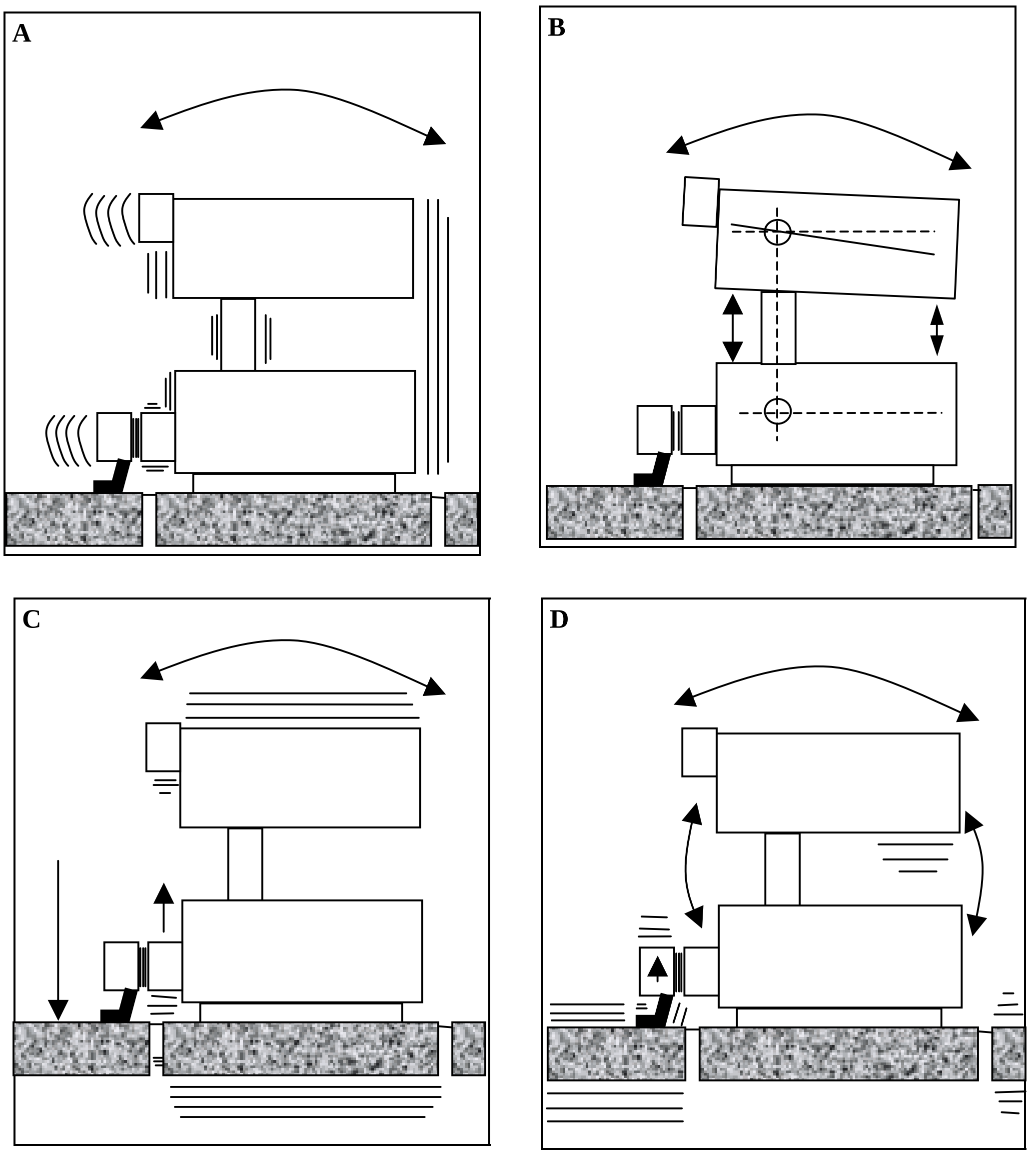
The HSS PSD drives the Signa Exciter with a rectangular RF pulse that is modulated to full scale to create a simple FID, and collects the resultant FID with the Signa receiver. The FID is used to measure the frequency deviation or phase deviation over time. A real FFT is performed on the deviation data to produce a frequency spectrum of any magnetic field disturbance within the selected bandwidth for the test.

The HSS PSD communicates with the IPG to take control of the RF and gradient amplifiers from Signa. The gradient amplifiers can contribute noise at 30, 60, 120, and 180 Hz frequencies. The gradient amplifiers are placed in Standby (via the HSS PSD) to eliminate potential gradient electrical noise from interfering with the vibration-related sources of noise which we are primarily interested in identifying. To identify the rotational frequency (RPM) of equipment such as fans and blowers, multiply the frequency by 60; for example, a peak located at 18 Hz may be caused by something rotating at 1080 RPM.

D-11-1 Theory of Magnet Behavior - Vibration Induced Stability Problems

The unique shape of the Open Magnet design provides inherent stability concerns for the Open*Speed* system. It is extremely important that the Open*Speed* system remain vibration-free.

When induced by a vibration, the magnet rolls from side to side, back and forth, or a combination of these movements. Due to the placement of the downposts, the top portion of the magnet dips or flexes towards the front. Like a clamshell, the opening changes geometry. This action causes the pole faces to shift slightly at the front of the magnet, which causes the magnetic field between the poles to change slightly. This translates to ghosting in images, which will show up in the HSS graphs. Frequency, amplitude, and duration are all factors related to High Speed Stability. The illustrations below show the movements and critical components that are involved in reducing susceptibility.



Side to side, front to back, and all combinations of these translate to pole flexing.

Drawing A: Vibration induced by Single Stage (lower) coldhead incorrectly installed.

Drawing B: "Clamshelling": All vibrations produce clamshelling effect.

Drawing C: Vibration induced into magnet from movement of ground under pad.

Drawing D: Vibration induced by movement of ground under Single Stage (lower) coldhead.

VIBRATION SOURCES
ILLUSTRATION D-9

REVISION HISTORY

REV	DATE	AUTHOR	PRIMARY REASONS FOR CHANGE
0	Jul 17, 1996	M. Keber	Initial release
1	May 16, 1997	JNJ	Updated to Lx format
2	Jun 10, 1997	WEK/G. Murphy	protocols to 8.1 Fixed "Note - Prescan Test Mode Delay"
3	Oct 7, 1997	K L-P	Changes per SPR MRIge42154
4	Feb 25, 1998	FFF	Removed Steps 6-8, Sec 2-4 per MRIge 43732
5	Mar 6, 1998	K. L-P	Updated procedure for Lx
6	April 9, 1998	FFF	Added RF cabinet alteration illustrations
7	June 17, 1998	FFF	Changes based on bay validation: pp. 3, 6,9,11-13
8	June 24, 1998	M. Keber	Cleanup of Illustration and Table numbering; removed obsolete illustrations and information.
9	Sept 3, 1998	M. Keber	Removed obsolete Release 8.1 scan protocol.
10	Sept 14, 1998	K. L-P	Incorporated Service note 60963 in Appendices
11	Aug 31, 1999	J. Wolak	Removed obsolete 8.1 protocol reference.
12	Oct 18, 1999	J. Wolak	Updated from validation on Release 8.3
13	Nov 12, 1999	M. Keber	Updated example header screen, Table 3-2, and cleaned Appendix A screen outputs so they are more readable and the callouts line up right.
14	Feb. 8, 2000	R. Kaufman	Added rf-amp cv change, updated graphs, added UCERD area spec
15	Feb. 18, 2000	G. Boerner	Changes to landmarking per SPR MRIge56065 and rearranged layout of section 2 for clarity.
16	June 21, 2000	M. Jones	Updated RF/PDU cabinet alteration diagrams, added Vectra reference to RF amp type, added "<ENTER> key and ACCEPT" to CV change, modified step 16 note. Other minor changes for clarity.
17	Oct. 20, 2000	M. Jones	Simplified Illustration 2-1C, "RF/PDU Cabinet Alterations"; added PDU note for SRF systems to Section 2-2.
18	Feb. 12, 2001	M. Jones	Deleted attenuator reference from Sec 2-4, step 20. Corrected illustration numbers in Section 3. Minor corrections throughout.
19	May 16, 2001	D. Hofstetter	Added OpenSpeed Appendix E per field request.
20	July 27, 2001	M. Keber	Updated Sec 3-1 to clarify p-p spec limits apply only to 45Hz (vibration) bandwidth mode per MRIge60046; also added UCERD area spec. Updated Appendix C with Sec 3-1 changes. Removed "non-proprietary" steps (procedure is proprietary). Corrected spacing problems for txtpar and step "styles". Changed Appendix E subsections and illustrations to correct "E-" numbering (from 1- numbering).
21	Aug. 13, 2001	J. Wolak	Merged in changes from Haifa (A. Nevelsky, rev 20) document to cover TwinSpeed configuration.
22	Oct. 30, 2001	D. Thome'	Modified document to accommodate MGD Chassis.
23	Dec. 4, 2001	D. Thome'	Removed references to MGD Chassis.
24	Mar 13, 2002	Hawthorne	Minor updates to spelling and word usage through out.
25	July 25, 2002	K. Keshena	Updated procedure with Illustration 2-1D which includes SRFD2 cabinet.
26	Oct. 24, 2002	C. MacDonald	Added Illustration 4-1 with updated interface. Minor syntax and style changes.
27	Feb. 07, 2003	D. Thome'	Updated 1.5T Universal SST Kit part number in Table 2-2 to 46-320383G8.
28	Apr. 28, 2003	D. Thome'	Updated area spec for UCERD2 and EXCITE. Corrected errors.
29	March, 28, 2006	E. Nelson	Updated step 20 to include select Transmit Gain Button