TABLE OF CONTENTS

1 – OVERVIEW AND FLOWCHART

This procedure describes how to calibrate the RFI in a 0.7T system. Please see illustration 1-1 on the next page to confirm that the 0.7T GRFD cabinet pictured matches the cabinet to be checked and/or adjusted. The RFI should come from the factory pre-calibrated and, ideally, no initial calibration of the RFI in the field should be needed. The RFI must be checked, however, to confirm that it is calibrated. The 0.7T RFI is calibrated when the body and head maximum RF output power is within specifications. Three methods are available and listed in the order of preference for measuring head and body RF output power:

- **RF Power Measurement Kit** - Easy to use, preferred method of power measurement.
- **Bird wattmeter** - Must account for cable(s) and dummy load loss factor(s) to determine actual power.
- **Oscilloscope** - Must account for cable and dummy load loss to accurately calculate the power from the observed peak voltage. This method works but the measuring process is cumbersome and not as accurate as the other two methods. It is, for this reason, not recommended.

It is *strongly recommended* that the RF Power Measurement Kit be used to obtain an accurate measurement of the RF output power. If it is not possible to obtain an RF Power Measurement Kit then one of the two other methods can be used *provided* that the "Dummy Load and Cables Calibration" procedure in Appendix E has been performed and the exact individual loss values of the dummy load and interconnecting cables are known.

CAUTION

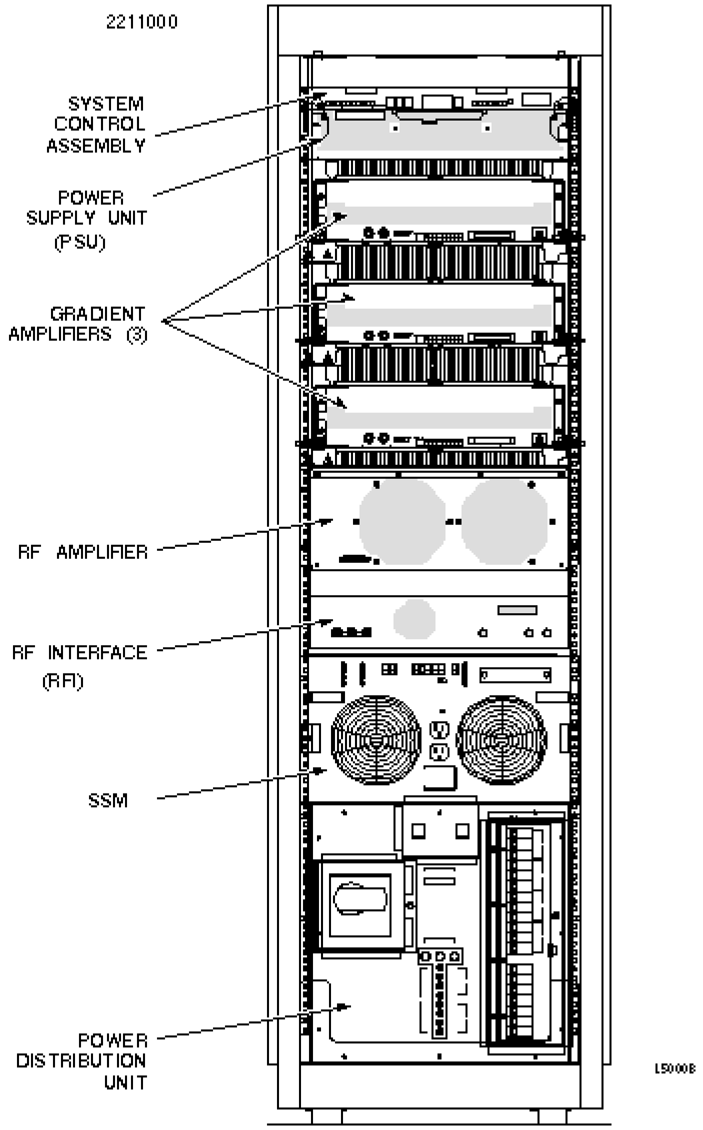
FAILURE TO ACCOUNT FOR THE ACTUAL LOSSES IN THE DUMMY LOAD AND CABLES WHEN NOT USING THE RF POWER MEASUREMENT KIT TO MEASURE RF POWER CAN RESULT IN SIGNIFICANT MEASUREMENT ERRORS.

Calibration is done to prevent faults due to the amplifier gain being improperly set. Adjustments may need to be made if any of the hardware in the RF chain has been replaced (see Appendix B), output levels have decreased with age, or if any of the measurements taken during the check are found not to meet specifications. The head and body RF power levels will be checked in section 2 and, if in specification, no adjustments will be made. Head and body power level adjustments, if needed, are made in section 3. Please see the flowchart in Illustration 1-2. Appendices A - E are referred to in the procedure and provide extra information and directions to assist the user with accomplishing the RF power measurement task. Appendix F provides helpful troubleshooting information in the event that a problem is encountered during the RF power check or calibration.

Note

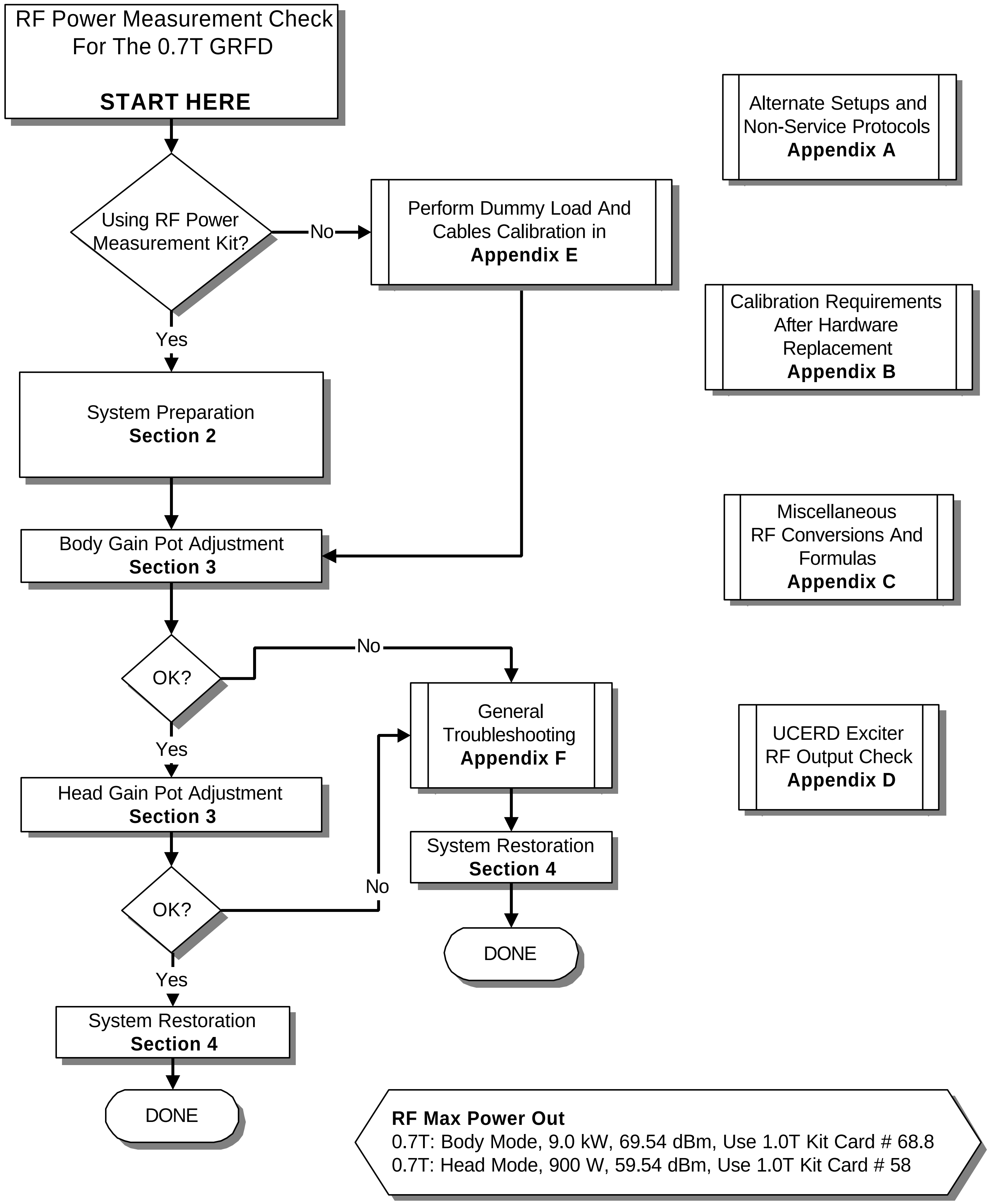
The Body and Head Gain pots are in series with each other. The Body Gain pot is first in the series. The Head Gain pot is factory set so that the head gain is 10 dB less (59.54 dBm) than the body gain (69.54 dBm).

1 – OVERVIEW AND FLOWCHART (CONTINUED)



0.7T (GRFD) POWER CABINET
ILLUSTRATION 1-1

1 – OVERVIEW AND FLOWCHART (CONTINUED)



CALIBRATION FLOWCHART
ILLUSTRATION 1-2

2 – SYSTEM PREPARATION

2-1 RF Power Measurement Kit Re-calculations

The RF Power Measurement Kit is the preferred method of RF power measurement. Skip this section if not using this kit. Users of this kit will use the 1.0T Quick Reference Cards (card **68.8** for body and card **58** for head) to calibrate the 0.7T RF subsystem. It is important to understand, however, that the maximum body and head power levels of the two systems ***are not*** the same. See Table 2-1. Accounting for the higher RF power output by the 0.7T system means that the Scope Power (in dBm) and the Scope Rdg (in Vpp) listed on both the Head and Body card calibration stickers **must** be re-calculated. See Table 2-2 for *example* data that would be seen on the 1.0T Body (card 68.8) and 1.0T Head (card 58) RF Power Measurement Card calibration stickers.

TABLE 2-1
RF OUTPUT POWER COMPARISON

RF Output Port	1.0T Max. Power	0.7T Max. Power	Difference
Body	7.58kW (68.80dBm)	9kW (69.54dBm)	0.74dB
Head	750W (58.75dBm)	900W (59.54dBm)	0.79dB

TABLE 2-2
***EXAMPLE 1.0T RF POWER MEASUREMENT KIT CARD CALIBRATION STICKER DATA**

1.0T HEAD CARD # 58 CALIBRATION STICKER DATA	1.0T BODY CARD # 68.8 CALIBRATION STICKER DATA
Card Number 46-317724P32	Card Number 46-317724P33
Nominal: 58.75 dBm Attenuation: -55.43 dB Scope Power: 3.32 dBm Scope Rdg: 0.927 Vpp	Nominal: 68.80 dBm Attenuation: -65.41 dB Scope Power: 3.39 dBm Scope Rdg: 0.934 Vpp

***EXAMPLE VALUES ONLY. DO NOT USE THESE VALUES TO CALCULATE SCOPE POWER.**

1. Use the formulas in Table 2-3 and the Scope Power (in dBm) listed on the 1.0T RF Power Measurement Card Calibration Stickers (cards 68.8 and 58) in the kit to be used to calculate the new Body and Head Scope Power values (in dBm).

TABLE 2-3
SCOPE POWER CALCULATION AND EXAMPLE

Port	Scope Power Calculation (in dBm)	Example:

Body	Scope Power (in dBm) **+** 0.74 dB	3.39 dBm **+** 0.74 dB = **4.13 dBm**
Head	Scope Power (in dBm) **+** 0.79 dB	3.32 dBm **+** 0.79 dB = **4.11 dBm**

2-1 RF Power Measurement Kit Re-calculations (Continued)

2. The Scope Rdg (in Vpp) listed on the Body (card **68.8**) and Head (card **58**) RF Power Measurement Card Calibration Stickers must now be re-calculated. Two Methods are available for doing this:

Method I (recommended and easiest):

Mouse click on the **ToolBelt Icon** and then **[Utilities], [RF Calculator], [Start].** The 1.0T Body Card # 68.8 Calibration Sticker Data from Table 2-2 is used in this example.

(Q)uick RF Calculator
(R)F Calculator

Enter selection: (Q,R) [Q] : **R**

RF Power Calculator

1) Watts to dBm
2) dBm to Watts
3) Scope relative voltage from relative power (Watts)
4) Scope relative voltage from relative power (dBm)
5) Scope relative power from relative voltage (Watts)
6) Scope relative power from relative voltage (dBm)
7) Quit

Enter selection: (1..7) [1] : **4**

****** NOTE: Constant attenuation is assumed! ******

Enter reference power in dBm: (0.0..1000.00) [10.00] : **3.39** ← Scope Power *from card.*
Enter reference Volts peak: (0.0..100.00) [8.00] : **0.437** ← Scope Rdg *from card* divided by 2.
Enter desired power in dBm: (0.0..1000.00) [10.00] : **4.13** ← Table 2-3 Calc. Scope Power.
Peak voltage for desired power is **0.508 Volts** ← Multiply this value by **2** for Vpp = **1.016**

Press ENTER to continue [ ] :

RF Power Calculator

1) Watts to dBm
2) dBm to Watts
3) Scope relative voltage from relative power (Watts)

4) Scope relative voltage from relative power (dBm)
5) Scope relative power from relative voltage (Watts)
6) Scope relative power from relative voltage (dBm)
7) Quit

Enter selection: (1..7) [4] : **7**

2-1 RF Power Measurement Kit Re-calculations (Continued)

Method II (use if RF Calculator software is not available):

Alternatively, the Scope Rdg (in Vpp) could be calculated using the formula below.

$$Vpp = 10^{\left(\frac{dBm}{20}\right)} \textbf{ X } 0.632 \quad \text{or} \quad Vpp = \text{antilog}\left(\frac{dBm}{20}\right) \textbf{ X } 0.632$$

where dBm is the value that was calculated from Table 2-3.

The LX system calculator can be used to determine the Vpp. Move the mouse cursor into the background, right mouse click, select "Calculator" from the menu and enter the values into the calculator exactly as shown:

dBm **[¸]** 20 **[=]** **[INV LOG]** **[*]** 0.632 **[=]** VP-P.

Example: Using 4.13 dBm, the Scope Power calculated from Table 2-3:

4.13 **[¸]** 20 **[=]** (0.2065) **[INV LOG]** (1.609) **[*]** 0.632 **[=]** (**<u>1.016</u>**) VP-P.

3. Record the Scope Rdg (in Vpp) in Table 2-4 for later reference.

TABLE 2-4
NEW BODY AND HEAD SCOPE READINGS (RDG)

Body Scope Rdg	__________Vpp
Head Scope Rdg	__________Vpp

2-2 System Preparation

DANGER!!

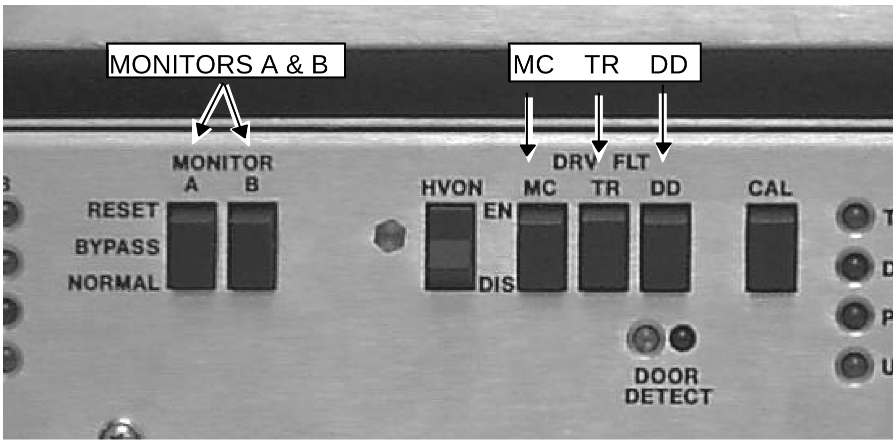
PROPERTY DAMAGE! PREVENT COIL AND ASSOCIATED SWITCH DAMAGE, BY REMOVING ALL PHANTOMS AND HARDWARE (I.E., HEAD COIL, SURFACE COIL...) FROM THE MAGNET BORE.

1. Verify that the system is not scanning and that all coils have been removed from the magnet bore. See the **DANGER** message on this page.

2. Remove the front cabinet cover and open the rear cabinet cover.

2-2 System Preparation (Continued)

3. See Illustration 2-1. On the front of the SSM place the:
   - 2 (two) power MONITOR switches (A and B) to the middle BYPASS position.
   - 3 (three) DRV FLT switches to the bottom DIS (disable faults) position.



SSM FRONT PANEL SWITCHES DISABLED
ILLUSTRATION 2-1

4. **If you are not using the RF Power Measurement Kit** then complete the Dummy Load and Cables Calibration procedure in Appendix E.

3 – BODY AND HEAD MAXIMUM RF OUTPUT POWER CHECKS AND ADJUSTMENTS

This process will test the assumptions that:

- The UCERD exciter is outputting enough power for the system to meet the rated head and body RF output power levels (Appendix D describes how to check the UCERD exciter output.).
- The RFI has been pre-adjusted at the factory and that, ideally, no further adjustments by the FE are necessary.
- The RFI is capable of outputting 9.0 kW.

The UCERD exciter cannot be adjusted. Appendix D describes how to measure and verify that the exciter output is correct. The head and body RF output power levels must be checked and, if not correct, adjusted into specification.

A Calibration Flowchart, Illustration 1-2, has been provided in the Overview, Section 1.

All the test points and pots are accessible from the front of the RFI.

3-1 Tools and Instruments Required

Refer to Table 3-1 for equipment required to measure power with the RF Power Measurement Kit or refer to Appendix A (Alternate Equipment Setup). The RF Power Measurement Kit is the preferred method for RF power measurement.

TABLE 3-1
EQUIPMENT REQUIRED IN ADDITION TO THE RF POWER MEASUREMENT KIT

Item	Description	Part Number
1.	100 MHz Oscilloscope (equivalent or greater)	• 46-183029P61
2.	RF Power Measurement Kit **NOTE:** G1 kit does **not** contain the 30 dB Dummy Load. 50 ohm, 200 Watt, 30dB Attenuator Bird Model 8322 50 ohm, 200 Watt, 30dB Attenuator used in RF PM Kit	• 46-317724G1 or G2 • 46-255837P10 or • 46-317724P14
3.	Mu-metal shield for scope (optional)	• 46-317725G10
4.	Pot Tweaker	• 46-194427P361

3-2 Body Gain Pot Adjustment

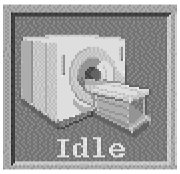
DANGER!!

PROPERTY DAMAGE! PREVENT COIL AND ASSOCIATED SWITCH DAMAGE, BY REMOVING ALL PHANTOMS AND HARDWARE (I.E., HEAD COIL, SURFACE COIL...) FROM THE MAGNET BORE.

1. Verify that the system is not scanning and that all coils have been removed from the magnet bore. See the two **DANGER** messages on this page.

DANGER!!

PERSONAL INJURY! PREVENT POSSIBLE RF BURNS WHEN DISCONNECTING HELIAX CABLES FROM J3 OR J4 ON THE RFI BY VERIFYING THAT THE SYSTEM IS NOT MANUALLY PRESCANNING OR SCANNING. VERIFY THAT THE SCAN DESKTOP ICON DISPLAYS THE "IDLE" MESSAGE.



2. **If using the RF Power Measurement Kit** then refer to the RF Power Measurement Kit laminated card set.

   a. Look in the upper, right corner of each card and find the card labeled **68.8** (1.0T Body Output).

   b. Configure the system as shown in the illustration on the card.

CAUTION

The body RF output connection is no longer to the non-existent EFB unit, as the older RF Power Measurement Kit cards show, but instead to the J4 output on the rear of the RFI. An RF adapter is provided in the RF Power Measurement Kit to connect between the HN J4 body RF output and the RF Power Measurement Kit 40 dB N-connector coupler.

   c. Confirm that the rotary attenuator is set to the correct position indicated on the card.

3. **If using the wattmeter or scope** (NOT the RF Power Measurement Kit) to measure power then refer to Appendix A (Alternate Equipment Setup) for the proper system body configuration.

3-2 Body Gain Pot Adjustment (Continued)

4. Prepare the system to scan in Body mode per Table 3-2 or refer to Appendix A (Non-Proprietary protocol).

TABLE 3-2
SCAN PROTOCOL: BODY MODE

Note: This is the alternate proprietary procedure available for GE use and for sites with a valid Advanced Service Package Limited License.
Refer to Appendix A for the non-proprietary protocol.

A. **[New Pt]**
   Id: **geservice<ENTER>**
   Name: **rfi cals**
   Weight (Lb.): **300<ENTER>**
   Set Patient Protocols to **Service**.
B. At front enclosure:
   Landmark in the Head area—remove any coils.
   Press **LANDMARK**.
   Press **MOVE TO SCAN**.
C. In the Patient Position Protocol field:
   type **o.41.1<ENTER>**(o=Other, 41.1 =series) to load the body protocol
   OR select **other** and select protocol **41** and select series **1**. This is the apb cal Body protocol.
D. **[Save Series]**.
E. **[Research Operations]**.
   [Setup Params]. Set TG to **50 [Done]**.
F. **[Research Operations]**.
   [Display CVs]. Highlight CV Name and enter the following:
   CV Name: **calmode<ENTER>**, CV Value: **5<ENTER>** (Dual Logamp Waveform).
   CV Name: **ia_rf1<ENTER>**, CV Value: **32766<ENTER>** (sets 90º pulse full scale).
   CV Name: **ia_rf2<ENTER>**, CV Value: **0<ENTER>** (turns off 180º pulse).
   [Accept]
G. **[Research Operations]**
H. **[Download]**

5. Verify Body LED is illuminated on front of RFI Module.

6. **[Manual Prescan] [Scan TR]**. View the Body RF output waveform on the oscilloscope. Increase TG to 170 and then increment the TG in units of 10 to 200.

7. Verify the Unblank LED or Gating LED on the Amplifier pulses on/off indicating that the amplifier is outputting RF energy.

Note

If the LED is not pulsing then check the SSM enable/disable switches and make sure each is configured properly. Check the error log for messages if necessary. If there is no RF waveform visible on the scope screen then verify that the bandwidth limit button on the scope is not enabled, the RF toggle switch on the UCERD is not disabled, and that there is RF input to J14 of the RFI.

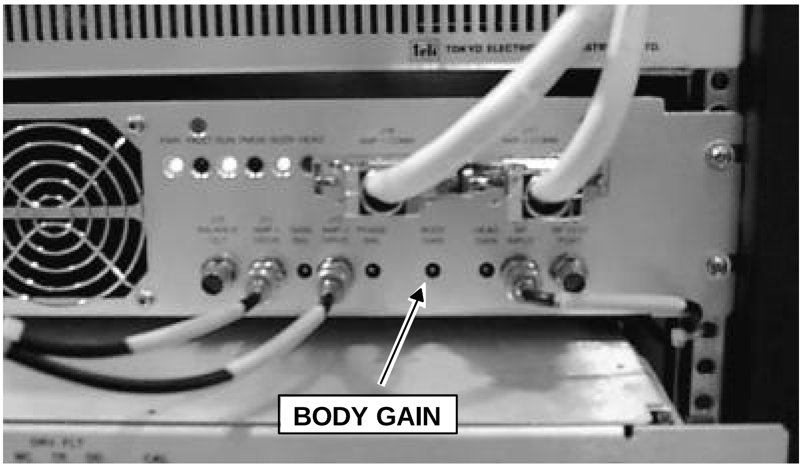
3-2 Body Gain Pot Adjustment (Continued)

Note

If the RF Amplifier trips, slightly minimize the Body Gain pot to reduce the RF Out and then repeat the adjustment again. If the RF amplifier continues to fault then check the cabling to and from the RF amplifier.

Note

The Power Amplifier sampling ports J2A and J2B on the rear of the amplifier must be 50 ohm terminated to generate full output power.



POT LOCATIONS ON RFI MODULE
ILLUSTRATION 3-2

8. **If using the RF Power Measurement Kit** then adjust the Body Gain pot on the front of the RFI so that the RF waveform displayed on the scope meets, but does not exceed, the Body **Scope Rdg** value (in Vpp) recorded earlier in Table 2-4. See Illustration 3-2.

9. **If using the wattmeter procedure** then read the display and calculate the RF output power from the formula below. The dummy load and cable loss factor was determined from the procedure in Appendix E. Adjust the Body Gain pot on the front of the RFI until the RF output calculated from the formula meets, and does not exceed, the 9kW (69.54dBm) specification. See Illustration 3-2.

RF Power Measurement (in watts) Using Wattmeter And Formula:
Wattmeter reading (in watts) **X** dummy load and cable loss factor

3-2 Body Gain Pot Adjustment (Continued)

10. **If using the oscilloscope procedure (NOT the RF Power Measurement Kit) procedure** then read the peak voltage (*Vpeak*) from the scope display and use the formula below to calculate the RF output power. The dummy load and cable loss factors were determined from the procedure in Appendix E. Adjust the Body Gain pot on the front of the RFI until the RF output calculated from the formula meets, and does not exceed, the 9kW (69.54dBm) specification. See Illustration 3-2.

RF Power Measurement (in watts) Using Oscilloscope And Formula:
$\frac{(\text{Vpeak})^2}{100}$ **X** dummy load and cable loss factor

11. Decrease TG to 0 (zero). **[Done] [End Exam].**

12. Verify that the scan desktop icon is displaying the "Idle" message.

3-3 Head Gain Pot Adjustment

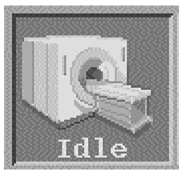
DANGER!!

PROPERTY DAMAGE! PREVENT COIL AND ASSOCIATED SWITCH DAMAGE, BY REMOVING ALL PHANTOMS AND HARDWARE (I.E., HEAD COIL, SURFACE COIL...) FROM THE MAGNET BORE.

1. Verify that the system is not scanning and that all coils have been removed from the magnet bore. See the two **DANGER** messages on this page.

DANGER!!

PERSONAL INJURY! PREVENT POSSIBLE RF BURNS WHEN DISCONNECTING HELIAX CABLES FROM J3 OR J4 ON THE RFI BY VERIFYING THAT THE SYSTEM IS NOT MANUALLY PRESCANNING OR SCANNING. VERIFY THAT THE SCAN DESKTOP ICON DISPLAYS THE "IDLE" MESSAGE.



2. **If using the RF Power Measurement Kit** then refer to the RF Power Measurement Kit laminated card set.

    a. Look in the upper, right corner of each card and find the card labeled **58** (1.0T Head Output).

    b. Configure the system as shown in the illustration on the card.

CAUTION

The head RF output connection is no longer to the non-existent EFB unit, as the reference cards in some of the older kits show, but instead to the J3 output on the rear of the RFI.

3-3 Head Gain Pot Adjustment (Continued)

c. Confirm that the rotary attenuator is set to the correct position indicated on the card.

3. **If using the wattmeter or scope** (NOT the RF Power Measurement Kit) to measure power then refer to Appendix A (Alternate Equipment Setup) for the proper system head configuration.

4. Prepare the system to scan in Head mode per Table 3-3 or refer to Appendix A (Non-Proprietary protocol).

TABLE 3-3
SCAN PROTOCOL: HEAD MODE

Note: This is the alternate proprietary procedure available for GE use and for sites with a valid Advanced Service Package Limited License.
Refer to Appendix A for the non-proprietary protocol.

A. **[New Series]**
At Patient Protocols – select **other**.
B. In the protocol field, type **o.41.2<ENTER>** (o=Other, 41.2 =series) to load the head protocol **OR** select **[o.41] [Series 2] [Accept]**.
C. **[OK]** (if required).
D. **[Save Series]**
E. **[Prepare to Scan]**.
F. **[Research Operations]**.
[Setup Params]. Set TG to **50 [Done]**.
G. **[Research Operations]**.
[Display CVs]. Highlight CV Name and enter the following:
CV name: **calmode<ENTER>**, **5<ENTER>** (Dual Logamp Waveform).
CV name: **ia_rf1<ENTER>**, **32766<ENTER>** (sets 90º pulse full scale).
CV name: **ia_rf2<ENTER>**, **0<ENTER>** (turns off 180º pulse).
[Accept].
H. **[Research Operations]**
I. **[Download]**
J. **[Prepare to Scan]**

5. Verify Head LED is illuminated on front of RFI Module.

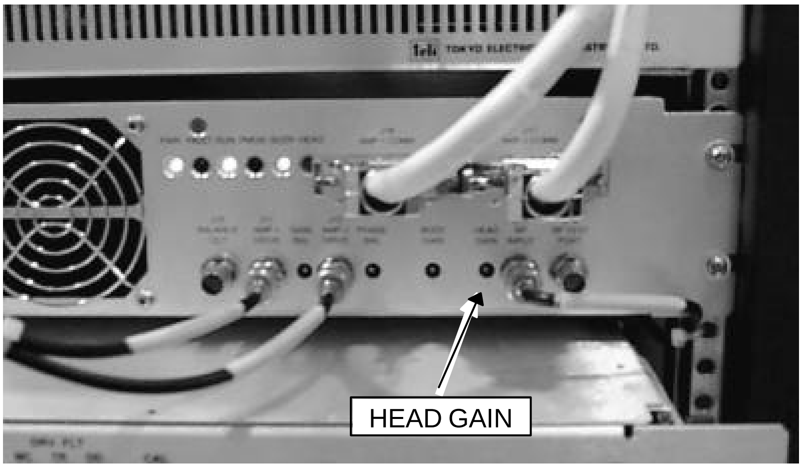
CAUTION

The Head Gain pot is directly affected by changes to the Body Gain pot. Adjust the Head Gain pot ONLY after completing final adjustment of the Body Gain pot.

6. **[Manual Prescan] [Scan TR]**.

7. Verify the Unblank LED's or Gating LED's on the Amplifiers pulse on/off.

3-3 Head Gain Pot Adjustment (Continued)



POT LOCATIONS ON RFI MODULE
ILLUSTRATION 3-4

8. **If using the RF Power Measurement Kit** then adjust the Head Gain pot on the front of the RFI so that the RF waveform displayed on the scope meets, but does not exceed, the Head **Scope Rdg** value (in Vpp) recorded earlier in Table 2-4. See Illustration 3-4.

9. **If using the wattmeter procedure** then read the display and calculate the RF output power from the formula below. The cable loss factor was determined from the procedure in Appendix E. Adjust the Head Gain pot on the front of the RFI until the RF output calculated from the formula meets, and does not exceed, the 900W (59.54dBm) specification. See Illustration 3-4.

RF Power Measurement (in watts) Using Wattmeter And Formula:
Wattmeter reading (in watts) **X** cable loss factor

10. **If using the oscilloscope procedure (NOT the RF Power Measurement Kit) procedure** then read the peak voltage (*Vpeak*) from the scope display and use the formula below to calculate the RF output power. The dummy load and cable loss factor was determined from the procedure in Appendix E. Adjust the Head Gain pot on the front of the RFI until the RF output calculated from the formula meets, and does not exceed, the 900W (59.54dBm) specification. See Illustration 3-4.

RF Power Measurement (in watts) Using Oscilloscope And Formula:
$\frac{(\text{Vpeak})^2}{100}$ **X** dummy load and cable loss factor

11. Decrease TG to 0 (zero). **[Done] [End Exam]**.

12. Verify scan desktop icon is displaying the “Idle” message.

13. Re-connect the Head RF Heliax cable to J3 on the rear of the RFI.

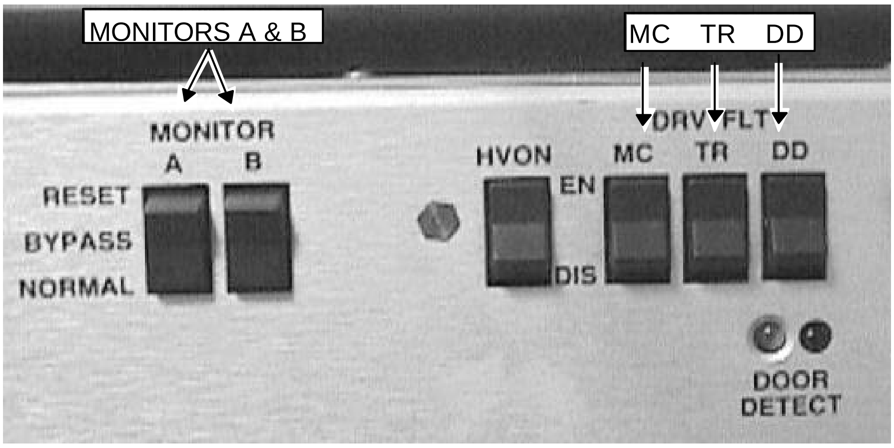
3-3 Head Gain Pot Adjustment (Continued)

14. Proceed to **Section 4 - System Restoration**.

4 – SYSTEM RESTORATION

1. Verify the system is not scanning and the scan desktop icon is displaying the “Idle” message.

2. See Illustration 4-1. On the front panel of the SSM place the:
   - 2 (two) power MONITOR switches (A and B) to the Normal position.
   - 3 (three) DRV FLT switches to the EN (enable faults) position.



SSM FRONT PANEL SWITCHES ENABLED
ILLUSTRATION 4-1

3. Remove all test equipment.

4. Verify that the Head RF Heliax cable to J3 on the rear of the RFI is connected.

5. Verify that the Body RF Heliax cable to J4 on the rear of the RFI is connected.

6. Re-install the front cabinet cover.

7. Close the rear cabinet door/cover.

8. Successfully complete one body scan.

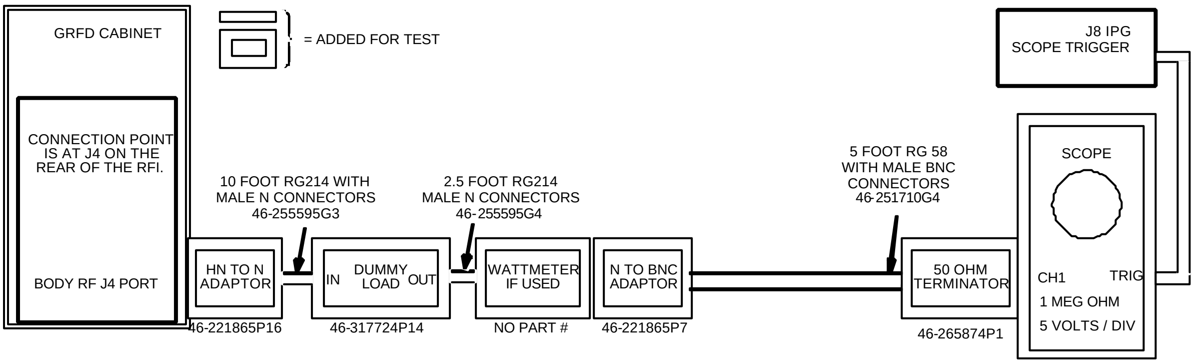
9. Successfully complete one head scan.

APPENDIX A — ALTERNATE EQUIPMENT SETUPS & MANUAL ENTRY PROTOCOLS

Use this section ONLY if the RF Power Measurement Kit is NOT going to be used. This section contains the setup information and protocols necessary to measure the body and head RF output power using either a wattmeter or oscilloscope. See Table A-1 for required equipment.

TABLE A-1
EQUIPMENT REQUIRED IF NOT USING THE RF POWER MEASUREMENT KIT

Item	Description	Part Number
1.	RF Test Cable Kit	46-255816G1
2.	100 MHz Scope (equivalent or greater)	46-183029P61
4.	50 ohm, 200 Watt, 30 dB Attenuator	46-317724P14
5.	Pot Tweaker	46-194427P361
6.	Wattmeter Kit (optional)	46# not supplied



ALTERNATE BODY EQUIPMENT SETUP
ILLUSTRATION A-1

Note

If the wattmeter is not available then bypass it's connection in the circuit using an N-female to N-female connector, 46-265875P2.

MANUAL ENTRY BODY PROTOCOL

PATIENT REGISTER . **[New Pt]**

PATIENT INFORMATION

Patient Id	**geservice**
Patient Name	**body rf**
Weight (Lb)	**300** ¬ *IMPORTANT* **[Landmark]**
Landmark	**[>] [Sternal Notch]**

PATIENT PROTOCOLS **[Patient Position]**

PATIENT POSITION

Patient Position	**[>] [Supine]**
Patient Entry	**[>] [Head First]**
Coil	**[...] [Body] [Accept]**

IMAGING PARAMETERS

Plane	**[>] [Axial]**
Mode	**[>] [2D]**
Pulse Seq	**[...] [Spin Echo] [Accept]**
Imaging Options	none (default)
Psd Name	**cal**
Protocol	no entry

SCAN TIMING

* of Echoes	1 (default)
TE	**[25]**
TR	**[55]**

SCANNING RANGE

FOV	**[24]**
Slice Thickness	**[5]**
Spacing	**0**
Start	**0**
End	**0**
# Slices	1 (default)
L/R Center	0 (default)
P/A Center	0 (default)
Table Delta	0.00 (default)

ACQUISITION TIMING

Freq	**[256]**
Phase	**[128]**
NEX	**[2]**
Freq Dir	**[>] [A/P]**
Auto Center Freq	**[>] [Peak]**
(lowest window)	**[Save Series]**

[Research Operations] [Display CVs]

Modify the following:

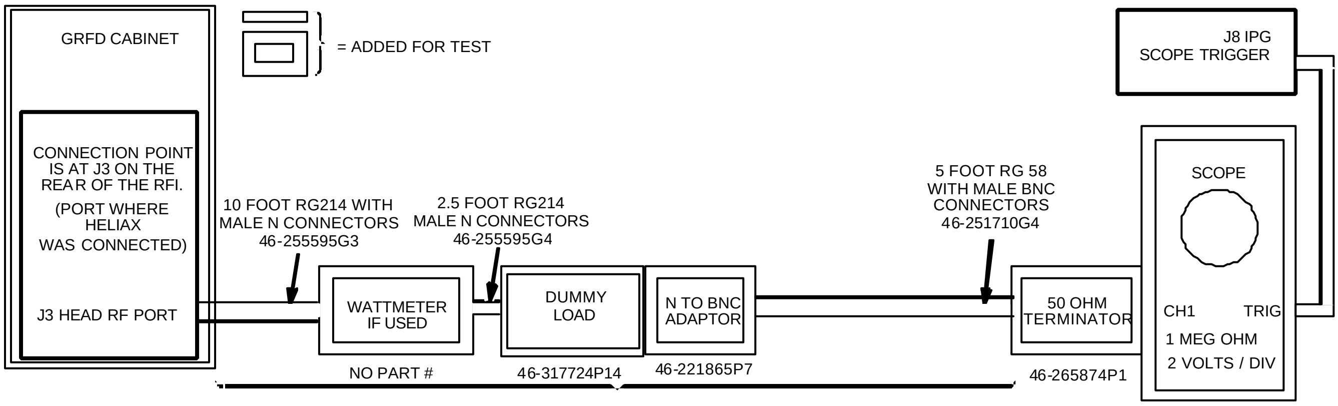
calmode	**5**
ia_rf1	**32766** (90° maximum)
ia_rf2	**0** (180° minimum) **[Accept]**

[Research Operations] [Setup Params]

Set TG **0 [Done]**

[Research Operations] [Download]

[Prepare To Scan]



ALTERNATE HEAD EQUIPMENT SETUP
ILLUSTRATION A-2

Note

If the wattmeter is not available then bypass it's connection in the circuit using an N-female to N-female connector, 46-265875P2.

MANUAL ENTRY HEAD PROTOCOL

<u>PATIENT REGISTER</u> .	**[New Pt]**
<u>PATIENT INFORMATION</u>	
Patient Id	**geservice**
Patient Name	**head rf**
Weight (Lb)	**300** ¬ *IMPORTANT* **[Landmark]**
Landmark	**[>] [Sternal Notch]**
<u>PATIENT PROTOCOLS</u>	**[Patient Position]**
<u>PATIENT POSITION</u>	
Patient Position	**[>] [Supine]**
Patient Entry	**[>] [Head First]**
Coil	**[...] [Head] [Accept]**
<u>IMAGING PARAMETERS</u>	
Plane	**[>] [Axial]**
Mode	**[>] [2D]**
Pulse Seq	**[...] [Spin Echo] [Accept]**
Imaging Options	none (default)
Psd Name	**cal**
Protocol	no entry
<u>SCAN TIMING</u>	
* of Echoes	1 (default)
TE	**[25]**
TR	**[55]**

<u>SCANNING RANGE</u>	
FOV	**[24]**
Slice Thickness	**[5]**
Spacing	**0**
Start	**0**
End	**0**
# Slices	1 (default)
L/R Center	0 (default)
P/A Center	0 (default)
Table Delta	0.00 (default)
<u>ACQUISITION TIMING</u>	
Freq	**[256]**
Phase	**[128]**
NEX	**[2]**
Freq Dir	**[>] [A/P]**
Auto Center Freq	**[>] [Peak]**
(<u>lowest window</u>)	**[Save Series]**

[Research Operations] [Display CVs]

Modify the following:

calmode	**5**
ia_rf1	**32766** (90° maximum)
ia_rf2	**0** (180° minimum) **[Accept]**

[Research Operations] [Setup Params]

Set TG **0 [Done]**

[Research Operations] [Download]

[Prepare To Scan]

APPENDIX B — CALIBRATION REQUIREMENTS AFTER HARDWARE REPLACEMENT

TABLE B-1
RE-CALIBRATION REQUIREMENTS AFTER HARDWARE REPLACEMENT

Hardware Replaced	Required Calibration
1. Exciter Board (UCERD)	1. Entire Procedure
2. RF Power Amplifier Module	2. Body and Head Gain Adj.
3. RFI Module	3. Entire Procedure
4. BNC cable that drives the RF Power Amp.	4. Body and Head Gain Adj.
5. N cable between RF Power Amp. And RFI	5. Body and Head Gain Adj.

APPENDIX C — MISCELLANIOUS RF CONVERSIONS

The formulas in this Appendix are provided to assist the more experienced FE with troubleshooting. The RF conversions below are presented in two different formats. The first format is the actual mathematical formula. The second format assumes that you are entering the data into the LX system calculator (access the LX system calculator by moving the mouse cursor into the background, right mouse click, and then select "Calculator" from the Root menu) exactly as you read it from the page. Be aware that there is also an RF Power Calculator available on the LX system under the **Toolbelt icon**, **[Utilities]**, **[RF Calculator], [Start]**. Watts to dBm, dBm to Watts, relative volts to relative power, and relative power to relative volts conversions can be done with the RF Power Calculator tool.

VP-P to dBm Calculation:

$$\text{dBm} = 20 \log\left(\frac{Vpp}{0.632}\right)$$

VP-P **[¸]** 0.632 **[=]** **[LOG]** **[*]** 20 **[=]** dBm.

dBm to VP-P Calculation:

$$\text{Vpp} = 10^{\left(\frac{dBm}{20}\right)} \times 0.632 \quad \text{or} \quad \text{Vpp} = \text{antilog}\left(\frac{dBm}{20}\right) \times 0.632$$

dBm **[¸]** 20 **[=]** **[INV LOG]** **[*]** 0.632 **[=]** VP-P.

Example: Using 3.65 dBm, the Scope Power reading obtained from Table 2-3, and the LX system calculator to determine the equivalent Vpp:

3.65 **[¸]** 20 **[=]** (0.1825) **[INV LOG]** (1.5222991) **[*]** 0.632 **[=]** (0.9620931) VP-P.

dBm to Watts Calculation:

$$\text{Watts} = 10^{\left(\frac{dBm}{10}\right)} \times 0.001 \quad \text{or} \quad \text{Watts} = \text{antilog}\left(\frac{dBm}{10}\right) \times 0.001$$

dBm **[¸]** 10 **[=]** **[INV LOG]** **[=]** **[*]** 0.001 **[=]** Total Watts.

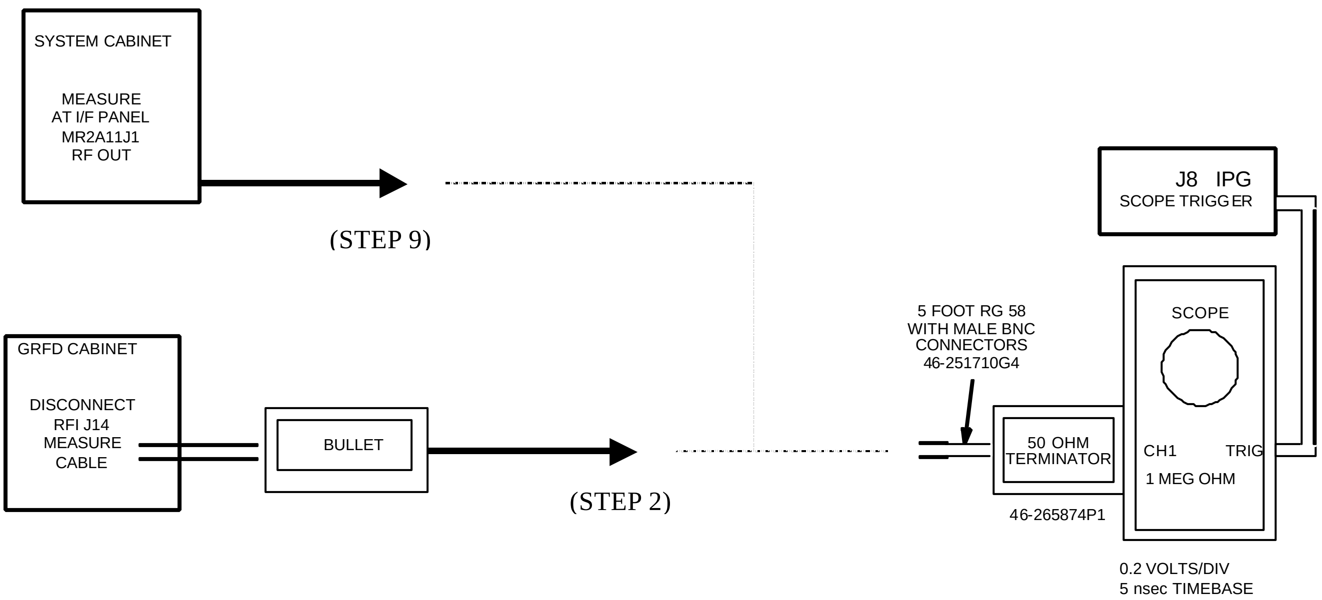
APPENDIX D — UCERD EXCITER RF SIGNAL OUTPUT

A minimum RF signal level from the UCERD is required or else it will be impossible to meet the specified 9 kW (69.54 dBm) body and 900 W (59.54 dBm) head RF power output levels. Use this section to verify that the exciter is outputting at least the minimum amount of power required to the RFI. See Table D-1 for needed tools and test equipment.

TABLE D-1
ITEMS NEEDED TO CHECK (U)CERD RF SIGNAL OUTPUT

Item	Description	Part Number
1.	RF Test Cable Kit	46-255816G1
2.	Cannon to BNC Test Cable (included in item 3 below)	46-301549P6
3.	TPS RF Connector/Adapter and Cable Test Kit (optional)	46-301927G1
4.	RF Power Measurement Kit (recommended)	46-317724G1 or G2
5.	100 MHz Scope (equivalent or greater)	46-183029P61

1. Connect the oscilloscope to the system hardware as per Illustration D1 -1. Confirm that the oscilloscope is properly configured, that the channel 1 vertical Volts/div variable control is fully CCW, and that the bandwidth limit button on the oscilloscope is not selected.



RF SIGNAL MEASUREMENTS USING A 100 MHZ OSCILLOSCOPE
ILLUSTRATION D1-1

2. Ensure that channel 1 is terminated with a 50 ohm feed-through terminator. Disconnect the cable going to J14 on the front of the RFI and connect it to the input of the 50 ohm terminator connected to channel 1 on the scope. A short (less than 5 ft.) length of coax and a BNC bullet can be connected to the cable removed from J14 to route the signal to the scope.

3. Prepare the system to scan using the proprietary protocol listed in Table 3-2.

APPENDIX D — UCERD EXCITER RF SIGNAL OUTPUT (CONTINUED)

4. **[Manual Prescan] [Scan TR].** Increase TG to 200.

5. Read the peak to peak voltage (Vpp) from the scope face and confirm that it meets the specification listed in Table D-1. A voltage level exceeding the upper limit is generally not a cause for concern.

6. Decrease TG to 0 (zero). **[Done].**

7. Replace the cable removed from J14 on the front of the RFI.

8. If the signal meets the specification then low signal from the exciter circuit is not the problem. Discontinue this procedure. Otherwise, continue on with step 9.

TABLE D-1
J14 RFI RF SIGNAL REQUIREMENT

DESCRIPTION	SPECIFICATION
0.7T RF In RFI — J14	$\geq$ 0.597 VPP (-0.50 dBm minimum)

9. Disconnect the cable going to J1 on the rear of the System Cabinet and connect to J1 a known good coax test cable 5 ft. in length. Route the other end of the test cable to the input of the 50 ohm feed-through terminator connected to channel 1 on the scope.

10. Prepare the system to scan using the proprietary protocol listed in Table 3-2.

11. **[Manual Prescan] [Scan TR].** Increase TG to 200.

12. Read the peak to peak voltage (Vpp) from the scope face and confirm that it meets the specification for the "MR2A11J1 System Cabinet I/F" listed in Table D-2. A voltage level exceeding the upper limit is generally not a cause for concern.

TABLE D-2
CERD / UCERD BOARD RF SIGNAL REQUIREMENT

DESCRIPTION	SPECIFICATION AT FRONT OF ISE CHASSIS RF OUT	SPECIFICATION AT MR2A11J1 SYSTEM CABINET I/F PANEL
0.7T RF In MR2A11J1	0.893 to 1.12 VPP (3.0 dBm to 5.0 dBm)	0.843 to 1.12 VPP (2.5 dBm to 5.0 dBm)

APPENDIX D — UCERD EXCITER RF SIGNAL OUTPUT (CONTINUED)

13. Decrease TG to 0 (zero). **[Done].**

14. Reconnect the cable removed from J1 on the rear of the System Cabinet.

15. If the signal meets the specification then check the cable run between J14 on the RFI and J1 on the rear of the system cabinet. Otherwise, continue with step 16.

16. Insert the cannon to BNC test cable from the TPS RF Connector/Adapter and Cable Test Kit into the topmost female plug inside the J109 connector on the UCERD, marked EXC RF OUT.

17. Connect the BNC end of the test cable to the 50 ohm feed-through connector on scope channel 1.

18. **[Manual Prescan] [Scan TR].** Increase TG to 200.

19. Read the peak to peak voltage (Vpp) from the scope face and confirm that it meets the specification for the "ISE Chassis RF Out" listed in Table D-2. A voltage level exceeding the upper limit is generally not a cause for concern.

20. Read the peak to peak voltage (Vpp) from the scope face and confirm that it meets the specification for the "ISE Chassis RF Out" listed in Table D-2. A voltage level exceeding the upper limit is generally not a cause for concern.

21. Decrease TG to 0 (zero). **[Done].**

22. Remove the cannon to BNC test cable from the topmost plug of J109 on the UCERD and replace the connector that was previously removed from J109.

23. Only consider replacing the exciter if the output is below the specification **AND** the body RF output power cannot be adjusted to meet the 9 kW specification.

APPENDIX E — DUMMY LOAD AND CABLES CALIBRATION

Description - This procedure provides directions for determining the true loss attributable to the dummy load and cables used in the power measurement circuit. This procedure assumes that the power is being measured with either a wattmeter or an oscilloscope with a bandwidth of 100 MHz or greater. It is necessary to know and account for the actual loss these components contribute in order to accurately measure RF power. As long as the scope has a bandwidth of ≥ 100 MHz the loss at 0.7T frequencies is negligible and not considered. This procedure is not needed if using the RF Power Measurement Kit. The RF Power Measurement Kit has already been calibrated so that this loss is known and accounted for.

CAUTION

DO NOT TAKE POWER MEASUREMENTS WITH AN OSCILLOSCOPE HAVING A BANDWIDTH LESS THAN 100 MHz. SIGNIFICANT MEASUREMENT ERROR CAN RESULT.

E1- Overview

Test cables long enough to reach the cables, connectors, and dummy load to be tested are connected between the Exciter RF Output (System Cabinet J1) and Receiver Body Input (System Cabinet J2). Receiver gains (R1 & R2) and transmit gain (TG) are set for near full scale reading on the power spectrum during prescan calibration. A reference scan is taken and stored in a raw file. The Attenuation Test Tool is used to calculate the baseline factor from the reference scan for the test cables (i.e., there is some loss from the test cables).

The dummy load and cable(s) are next inserted in series with the test cables and another scan is taken. Again, the Attenuation Test Tool is used to determine the “Magnitude Squared Attenuation Factor” (i.e, how much has the test signal been attenuated?). These attenuation factors are used in the RF power calibration process to accurately calculate the RF power level.

Note

If any problems are encountered during the following procedure, always start over at the beginning and re-do the reference scan. Then you may add, as directed in this procedure, any type of attenuation hardware you might have reason to test.

E2- Tools and Instruments Required

See Table E2-1

TABLE E2-1
REQUIRED TOOLS AND INSTRUMENTS

Item	Description	Part Number	Qty.
1	50-ohm dummy load, 200 watt, 30 dB attenuator - Bird Model 8322 (or equivalent).	46-317724P14	1
2	RF Test Cables Kit	46-255816G1	1

E3- Initial Setup

1. Open the System Cabinet back door and locate the TNS module inside the upper left of the cabinet. This unit has an LCD display, Reset Button, and Disable/Enable toggle switch on the front.

2. Locate the body TNS on the TNS module. This is one of the two shiny metal TNS boxes affixed to the main TNS module assembly that is mounted farthest from the rear of the cabinet. Multicoil systems have an additional piggyback board affixed with 3 extra TNS boxes that mounts over the top of the main TNS module assembly.

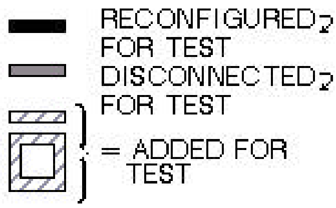
3. Bypass the body TNS (A24 A1 A1) from the circuit by disconnecting the small coax cables A24 A1 A1 J12 (signal output) and A24 A1 A1 J2 (signal input) from the TNS and connecting both together using a female-BNC to female-BNC adapter (also known as a bullet adapter 46-220427P3).

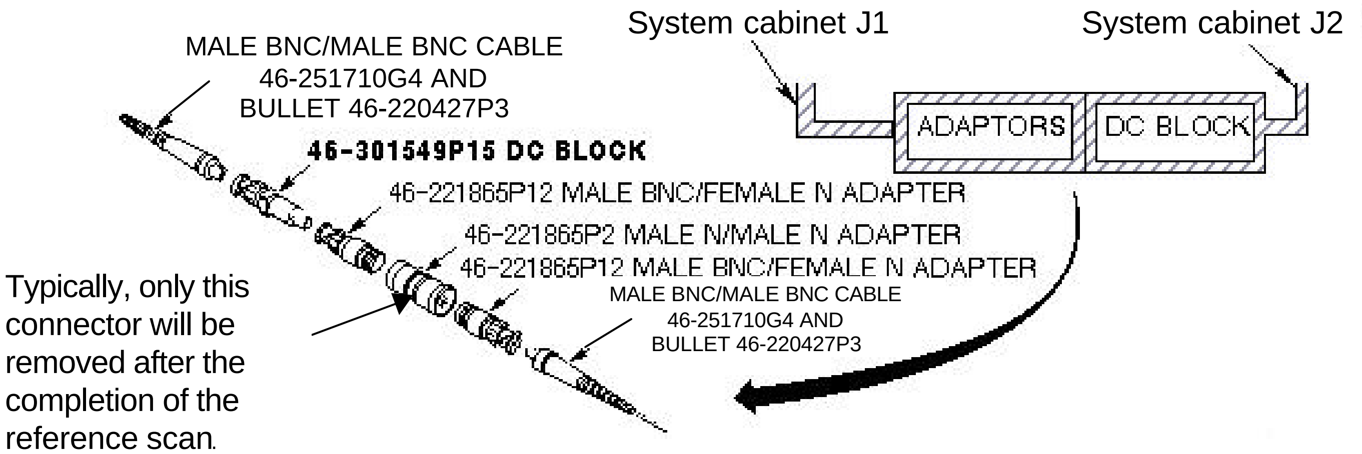
Note

Failure to bypass the body TNS out of the circuit may result no signal being received by the system. Merely disabling the TNS by moving the Enable/Disable toggle switch down to the Disable position instead of bypassing it out of the circuit may work, however, the TNS processor can override the switch.

E3- Initial Setup (Continued)

4. Reconfigure test hardware as shown in Illustration E3-1.





CONNECTIONS FOR INITIAL AMPLITUDE SCAN
ILLUSTRATION E3-1

Note

Adapters not shown in Illustration E3-1 can be added, if necessary, from the RF Cables Kit. Usage of the inline DC Block as shown in Illustration E3-1 is mandatory.

5. Disconnect the existing cables at the Systems cabinet I/F panel J1 (RF Out) and J2 (Receiver Body Input) and set them aside.

6. Connect the assembled test cables and adapters between J1 (RF Out) and J2 (Receiver Body Input) on the System Cabinet interface.

E3- Initial Setup (Continued)

7. At the operator work space, prepare the system for a Dummy Load scan using the procedure, see below.

   a. Click on **[New Pt]**
      Id: **geservice**
      Name: **dummy load**
      Weight (Lb): **111**
      Set Patient Protocols to **Service**.
   b. In the Protocol field, type **o.18.1** (o=Other, 1=series number) to load the protocol.
   c. Set a landmark if necessary, then **Save Series**.
   d. With the right mouse key, select **[Research Operations]**, then select **[Display CVs]**.
      Set value of CV **calmode** to **2** (trapezoid pulse).
      (Caution here. Make sure the previous CV has been cleared before entering the next one. Look at the screen!)
      Set value of CV **p2_ramp** to **1** (1 µsec ramp time).
      Set value of CV **t2** to **50000** (50 msec tr).
      Set value of CV **pismode** to **1** (exc service).
      Set value of CV **pmode** to **1** (data collection).
      Set value of CV **daqm** to **1** (data in window).
   e. Select **[Accept]**
   f. Again, **[Research Operations]**, **[Download]**
   g. **[Manual Prescan]**.

E4- Data Collection

1. When in **[Manual Prescan]**, set **R1** to **7**, and **R2** to **14.**

2. Adjust transmit gain (**TG**) to achieve an R1 <u>or</u> R2 (on IP display) of approximately 98%, <u>without going over</u>.

3. Select **[Done]**.

4. Select **[Scan]** (Ignore the message: MR signal too large, reduce receiver gain.) (Note: on the LX systems, the scan time starts at 13 seconds, counts down to 7 seconds, then ends. This is normal.)

5. From the MR Tools desktop, select **[Cals/checks]** and then **[Attenuation Test]**.

6. Use **[Atten Test]** tool selection to analyze data, as shown in Table E4-1.

TABLE E4-1
DATA COLLECTION

<table>
<tr><th>Output/Prompts</th><th>Input/Comments</th></tr>
<tr><td>Last run number used was: XXXX</td><td></td></tr>
<tr><td>Please enter runfile number (XXXX): ....</td><td><Enter></td></tr>
<tr><td>Please select Locked / Unlocked file (L,U) (U):..........</td><td><Enter>
(working)</td></tr>
<tr><td>|***|
***</td><td></td></tr>
<tr><td>Average Max. magnitude Across All Views = aaaaa
Average Max. magnitude Squared = bbbbb
Average RMS Across All Views = ccccc
***</td><td></td></tr>
<tr><td>Do you want to make this run the reference(Y,N)(N):......</td><td>Y<Enter></td></tr>
<tr><td>STOP! Do not answer the next question at this point.
Continue with step 7 below.</td><td></td></tr>
</table>

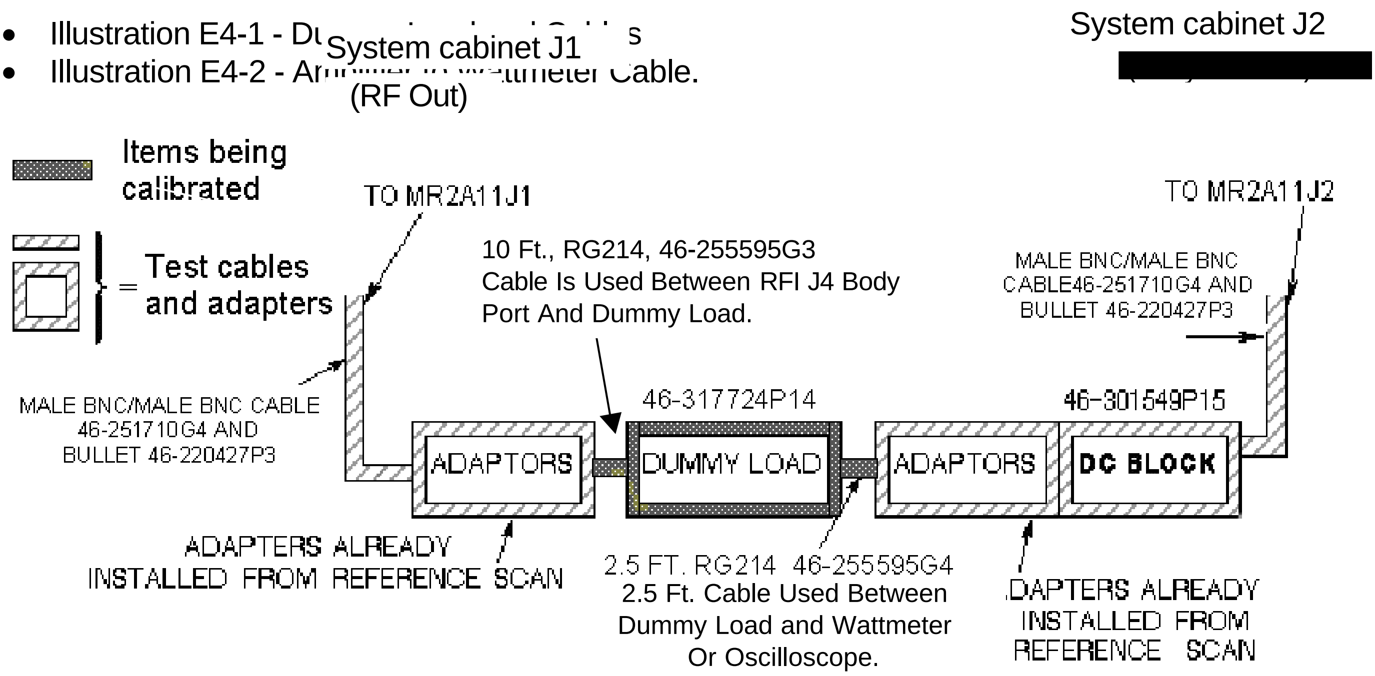
7. The next step will involve removing only the center male N to male N adapter from the test cables, setting it aside, and adding in the dummy load and cables that need to be characterized.

Note

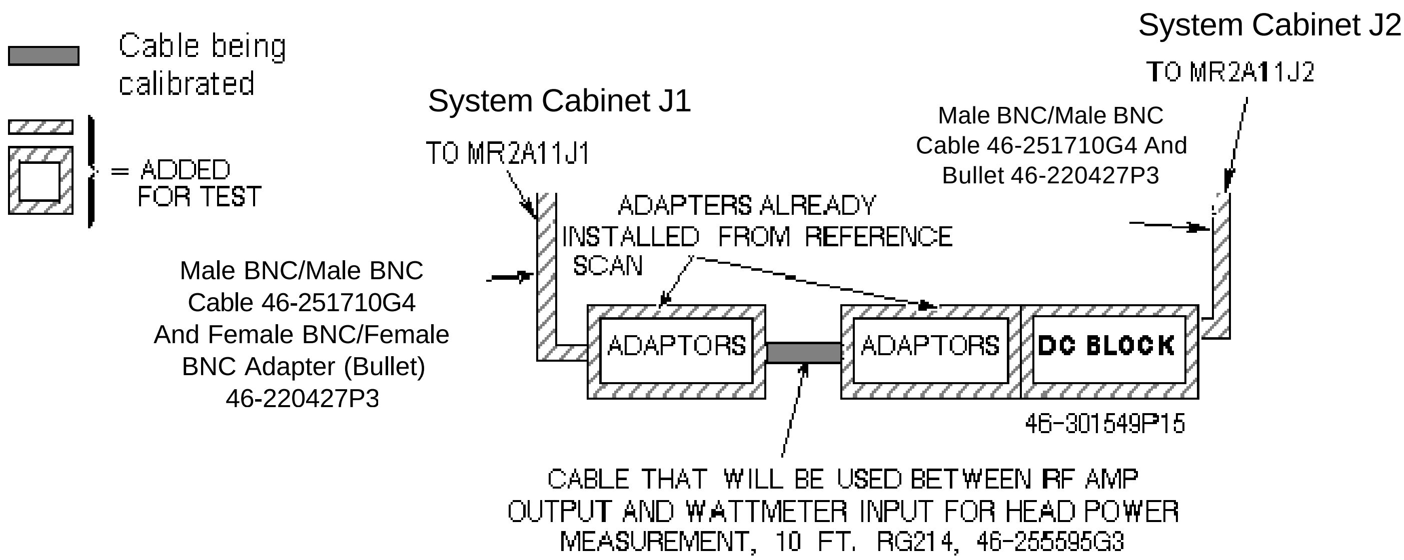
This assumes that the item to be characterized has N female connectors at it's input and output. If it has an N connector at the input and a BNC at the output or BNC connectors at both the input and output then an additional adapter(s) will be needed in order to connect it to the test cables. Adding in one or two uncharacterized adapters should not appreciably change the baseline attenuation factor. In this case, if the wattmeter is not being used, the 2.5 ft. cable (RG214, 46-255595G4) can be eliminated from the circuit. It is not needed.

E4- Data Collection (Continued)

8. Connect your test cables to the opposite ends of either:
   - Illustration E4-1 - Du[illegible]s
   - Illustration E4-2 - Am[illegible]attmeter Cable.



CONNECTIONS FOR DUMMY LOAD + CABLES SCAN
ILLUSTRATION E4-1



AMP TO WATTMETER CABLE SCAN
ILLUSTRATION E4-2

Note

"Bullet" RF connector referred to in illustrations E4-1 and E4-2 is a female BNC/female BNC adapter, 46-220427P3.

9. Select the scanning icon again to activate the scanning screen.

E4- Data Collection (Continued)

10. Select **[Scan]**.

11. When the scan is completed, re-select the tools icon again and begin the Analysis in section E5. It will be necessary to toggle between the **Scan** and **Toolbelt** icons if multiple passes are done.

E5- Analysis

See Table E5-1.

TABLE E5-1
ANALYSIS

<table>
<tr><th>Output/Prompts</th><th>Input/Comments</th></tr>
<tr><td>Do you want to compute Gain or Attenuation
Ratio(G,A)[G]:</td><td>A<Enter> <i><u>IMPORTANT:</u></i>
<i>Answer after the scan is done.</i></td></tr>
<tr><td>Last run number used was: XXXX
Please enter runfile number
[XXXX]:.......................</td><td><Enter></td></tr>
<tr><td>Please select Locked / Unlocked file (L,U)
[U]:...........</td><td><Enter> (Working)</td></tr>
<tr><td>|*************************************|
****
Average Max. Magnitude Across All Views = aaaaa
Average Max. Magnitude Squared = bbbbb
Average RMS Across All Views = ccccc
Magnitude Attenuation Factor = xxxxx
Magnitude Squared Attenuation Factor = yyyyy</td><td><======Record in “Value” column in Table E5-2.</td></tr>
<tr><td>RMS Attenuation Factor = zzzzz

**</td><td></td></tr>
<tr><td></td><td></td></tr>
</table>

1. Record the “Magnitude Squared Attenuation Factor” number and record it in the appropriate Value box in Table E5-2.

TABLE E5-2
ATTENUATION FACTORS

MODE	CALIBRATED HARDWARE	PART NUMBER(S)	VALUE	NOMINAL VALUES
BODY OR HEAD	**DUMMY LOAD + CABLES ATTEN FACTOR**	**46-255595G3 46-317724P14 46-255595G4**		**1000 TO 1200**

HEAD	AMP TO WATTMETER ATTEN FACTOR	46-255595G3		1.0 TO 1.2

E5- Analysis (Continued)

2. Repeat Data Collection and Analysis for Amp To Wattmeter Cable. See Illustration 4-2. Reselect the same runfile for the reference scan.

E6- Calculation of RF power

Peak voltage should be used in the calculation in order to get an accurate result. It can be converted to power using the following formula as long as certain factors are known and accounted for. The *actual* total loss attributed to anything that connects the measuring device to the source must be known. This includes the accumulated loss associated with the dummy load and interconnecting cables. Table E6-1 shows the calculation of power if all the attenuating devices in the measurement circuit exhibited perfect loss; that is, the devices added no more or less loss than what they were designed to provide. Table E6-2 shows the same calculation of power but accounts for the measurement-circuit loss values in deriving the true power. Note that the loss has a significant impact on the calculated power.

$$\frac{\left(\frac{\text{Vpeak}}{\text{scope correction factor}}\right)^2}{2\text{ X Z}} \mathbf{X} \text{ dummy load and cables attenuation} = \text{RF Power}$$

where “X” and “**X**” in the above formula signifies multiplication

Assume Z = 50 Ω, Vpeak = 30.0, scope correction factor = 1.00 (negligible loss at 0.7T frequency when using scope of ≥ 100 MHz bandwidth), dummy load and cables atten. = 1000 (dummy load and cables are all ideal)

$$\frac{\left(\frac{30.0Vp}{1.00}\right)^2}{100} \mathbf{X}\ 1000 = 9000 \text{ Watts} = 9 \text{ kW}$$

This result assumes a ***theoretically*** ***perfect*** situation in which there is no loss. These situations, in common practice, rarely exist!

TABLE E6-1
RF POWER CALCULATION WITH NO LOSS

E6- Calculation of RF power (Continued)

Now, consider the "real life" type situation in Table E6-2 in which the loss is considered:

$$\frac{\left(\frac{\text{Vpeak}}{\text{scope correction factor}}\right)^2}{2 \text{ X } Z} \textbf{ X } \text{dummy load and cables attenuation} = \text{RF Power}$$

where “X” and “**X**” in the above formula signifies multiplication

Assume Z = 50 Ω **,** Vpeak = 29.5, scope correction factor = **1.00** (negligible loss at 0.7T frequency when using scope with a bandwidth ≥ 100 MHz), dummy load and cables atten. = 1028

$$\frac{\left(\frac{29.5Vp}{1.00}\right)^2}{100} \textbf{ X } 1028 = 8946 \text{ Watts (Approximately equal to 9kW.)}$$

Accounting for the loss resulted in an accurate answer. 8946 Watts is as close as we can hope to get to 9000 Watts without using the RF Power Measurement Kit. Note that if none of the loss had been accounted for the error could have been **243 Watts or 2.7%.** As a result, the observer would attempt to adjust the RF power above the 9000 Watt limit.

TABLE E6-2
RF POWER CALCULATION WITH LOSS CONSIDERED

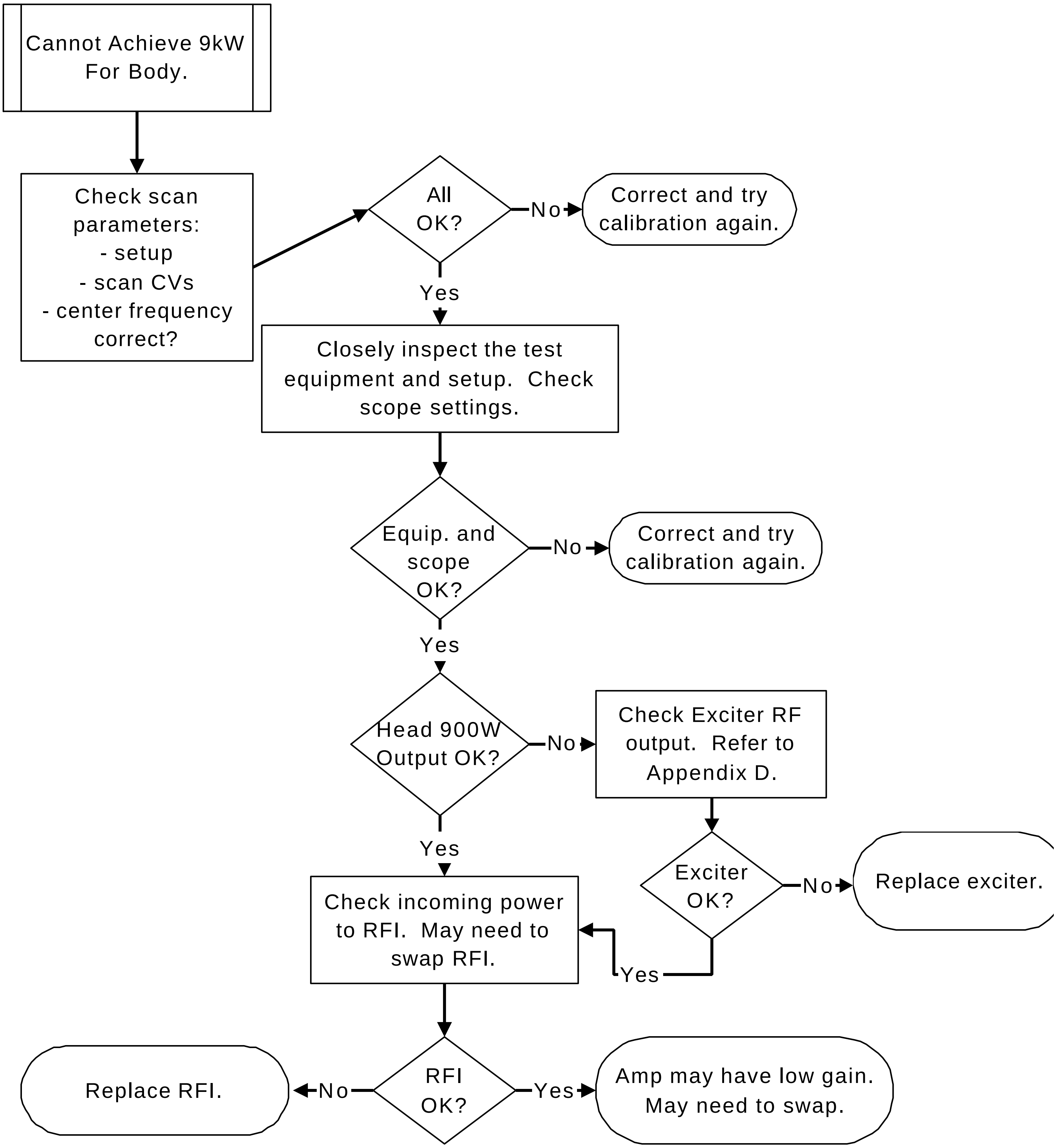
E7- System Restoration

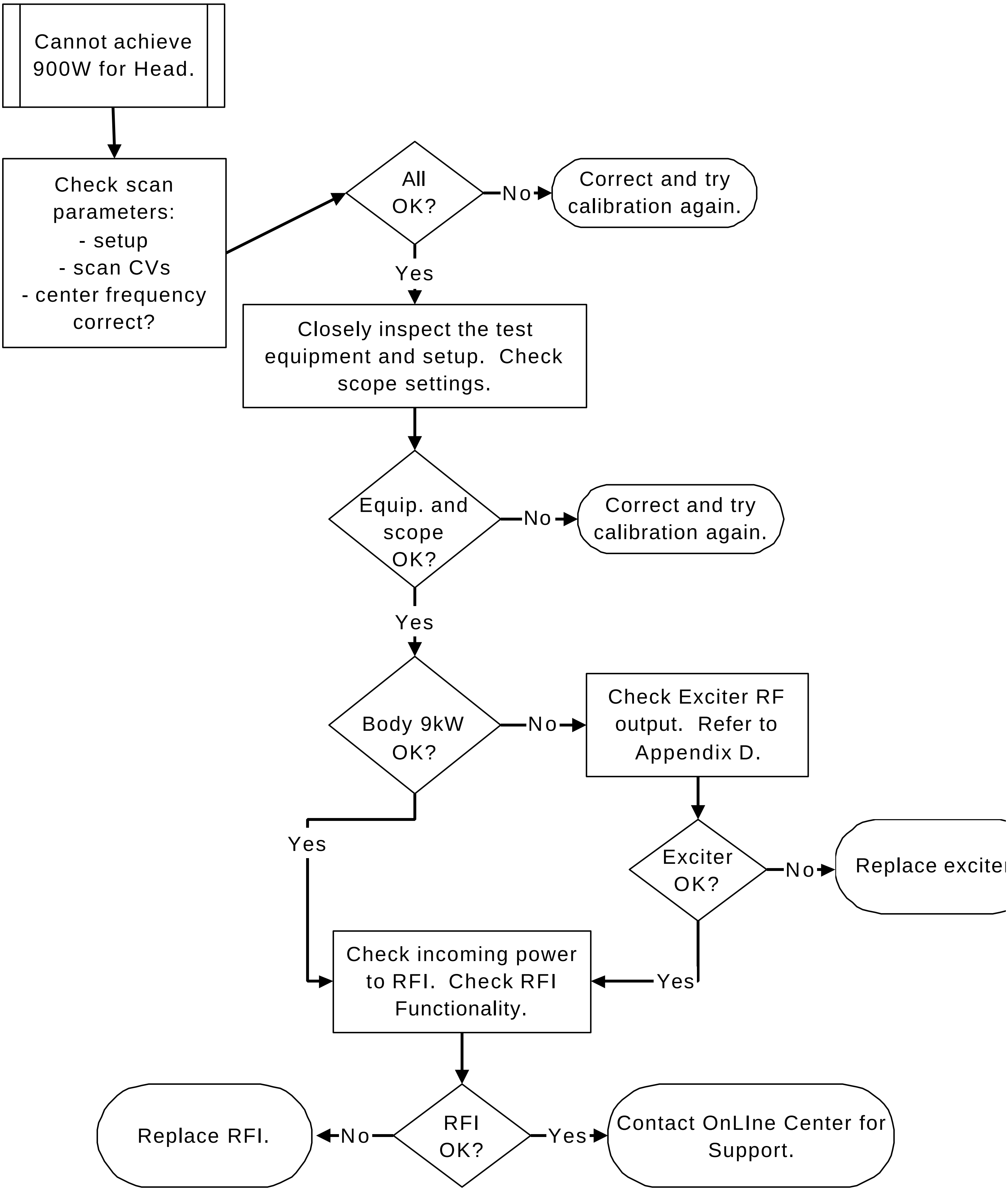
1. Reconnect original cables to the System Cabinet I/F J1 and J2.
2. Remove the female-BNC to female-BNC (bullet) adapter joining A24 A1 A1 J12 and A24 A1 A1 J2 and reconnect these to the body TNS. J2 (signal input) will connect to the top of the TNS and J12 (signal output) will connect to the bottom.
3. Perform one satisfactory head or body scan.

APPENDIX F — GENERAL TROUBLESHOOTING

RF Amplifier Faults During Calibration

- Reduce gain pot, try calibration adjustment again.
- Check cabling between amplifier and RFI.
- Check coil selection from scan setup screen.
- Check that desired scan prescription is active.
- Check cabling to RFI J3 Head or J4 Body.
- If this is a new installation does system center frequency match magnet field strength?
- Make sure that the amplifier has enough gain and is able to source 9.0 kW.


Cannot Achieve 9kW For Body.
Check scan parameters:
- setup
- scan CVs
- center frequency correct?
All OK?
No
Correct and try calibration again.
Yes
Closely inspect the test equipment and setup. Check scope settings.
Equip. and scope OK?
No
Correct and try calibration again.
Yes
Head 900W Output OK?
No
Check Exciter RF output. Refer to Appendix D.
Exciter OK?
No
Replace exciter.
Yes
Yes
Check incoming power to RFI. May need to swap RFI.
RFI OK?
No
Replace RFI.
Yes
Amp may have low gain. May need to swap.


Cannot achieve 900W for Head.
Check scan parameters:
- setup
- scan CVs
- center frequency correct?
All OK?
No
Correct and try calibration again.
Yes
Closely inspect the test equipment and setup. Check scope settings.
Equip. and scope OK?
No
Correct and try calibration again.
Yes
Body 9kW OK?
No
Check Exciter RF output. Refer to Appendix D.
Exciter OK?
No
Replace exciter
Yes
Yes
Check incoming power to RFI. Check RFI Functionality.
RFI OK?
No
Replace RFI.
Yes
Contact OnLIne Center for Support.

REVISION HISTORY

REV	DATE	AUTHOR	PRIMARY REASONS FOR CHANGE
A	August 18, 1999	Resa Lambert	Preliminary version.
B	October 28, 1999	Resa Lambert	Added GRFD Cabinet Illustration 1-1.
C	November 12, 1999	Resa Lambert	Changed J14 RF In spec to –0.50 dBm.
D	November 29, 1999	Resa Lambert	Changed Illustration 1-1. Clarified dBm calculations.
E	December 6, 1999	Resa Lambert	Initial Release.
0	October 18, 2000	Don Thome'	Added Appendices, RF calculation procedures.
1	December 26, 2000	Don Thome’	Added information to t-shooting flowcharts. Changed format.