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1 – OVERVIEW

This procedure explains various methods for troubleshooting problems and isolating failures to components contained within the 1.5T RF/PDU and 1.5T SRF Cabinets. Components checked in this document include the 1.5T Analogic AN8102 RF amplifiers, the 1.5T RF Interface Module (RFI), and the various large and small signal RF coaxial cables associated with each. Processes are also provided for checking the UCERD Exciter RF output and the integrity of the RF coaxial cable that provides a transmission path from the UCERD Exciter in the System Cabinet to the RF/PDU or SRF Cabinet. A flowchart is provided in **SECTION 2 – 1.5T ANALOGIC RF AMPLIFIER TROUBLESHOOTING FLOWCHART** that the FE will follow during the course of the troubleshooting process. The FE will begin the troubleshooting process at **START** and then progress through the flowchart until the problem is isolated or diagnosed. The flowchart will, at certain points, refer the reader back to various sections within the document. The FE will perform the troubleshooting processes documented in those sections and then, if the problem is still not isolated or diagnosed, return back to the flowchart at the point where the diversion originally occurred.

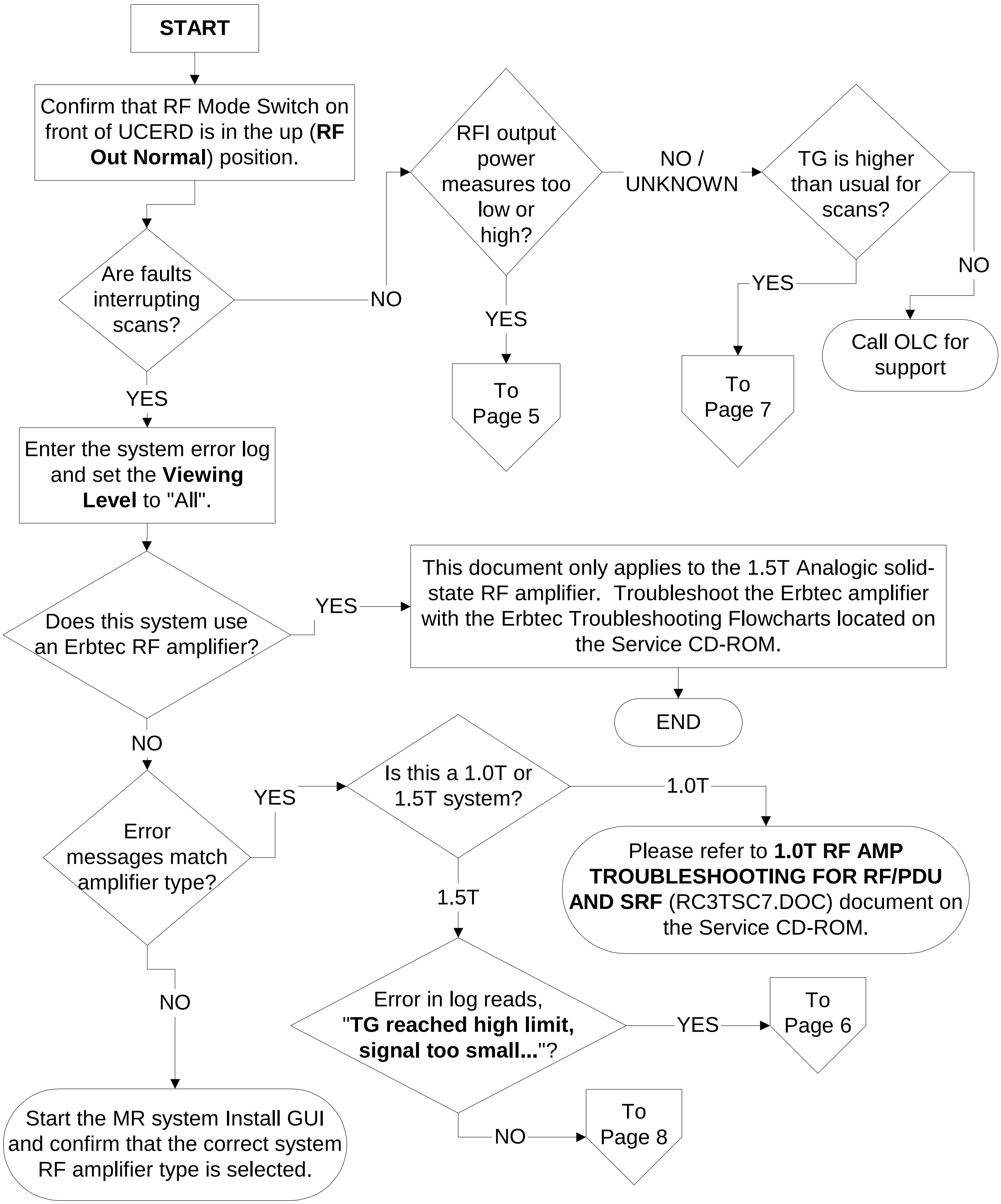
1-1 Required Tools

TABLE 1-1
EQUIPMENT REQUIRED

Item	Description	Part Number
1.	100 MHz Scope (equivalent or greater)	46-183029P61
2.	RF Power Measurement Kit	46-317724G1 or G2
3.	50 ohm, 200 Watt, 30dB Attenuator (dummy load) **NOTE:** Only required with above 46-317724G1 kit.	46-317724P14
4.	RF Test Cables Kit	46-255816G1
5.	Digital Multimeter (DMM)	46-194427P49
6.	TPS RF Service Interface Kit	46-301927G1
7.	Wattmeter Kit (optional)	46# not supplied

2 – 1.5T ANALOGIC RF AMPLIFIER TROUBLESHOOTING FLOWCHART

2-1 Main Body And RF Output Troubleshooting



2-1 Main Body And RF Output Troubleshooting (Continued)

From Page 4

Check scan parameters:
- setup
- scan CVs
- center frequency correct? (Verify **8 digits** beginning 638XXXXX)

All OK? — No → Correct and try calibration again.

Yes ↓

Closely inspect the test equipment and setup:

- Re-inspect the configuration setup and variable attenuator setting.
- Visually inspect RF cables for evidence of damage to outer braid or connectors; any open/ broken? Test cables by swapping.
- Check the condition of the fixed and variable attenuators; may need to swap these out to check.
- Refer to **SECTION 6 - RF POWER MEASUREMENT EQUIPMENT CHECKS** and check the condition of the 200 Watt, 30dB Attenuator (Dummy Load), cables and RF Power Measurement Kit attenuation hardware.
- Use a DMM to measure from the center pin to the shell on both sides of the 50 ohm feedthru connector thats connects to the oscilloscope and confirm that the resistance is approximately 50 ohms +/- 10 ohms.
- Check output of 4dBm RF source (if used) with a 300 MHz scope and confirm output is 1 Volt peak-peak. A less accurate check can also be done with a lesser bandwidth scope as long as the channel scope correction factor is known. The 4dBm RF source is a calibrated reference and should only be adjusted by the metrology laboratory reponsible for calibrating the RF Power Measurement Kit.

↓

Check the condition of the oscilloscope:

- Oscilloscope should have bandwidth of at least 100MHz.
- If an external 50 ohm terminator is connected to the scope channel input then make certain that internally scope channel is set for High Impedance (at lease 1 megaohm) and not 50 ohms.
- Confirm that 20MHz Bandwidth Limit switch on scope is not engaged.
- Confirm that variable voltage adjustment is disabled for channel in use.
- Confirm that scope setup (trigger source, trigger threshold, sweep, volts/div, etc.) is correct.
- Try using other scope channel or another scope.

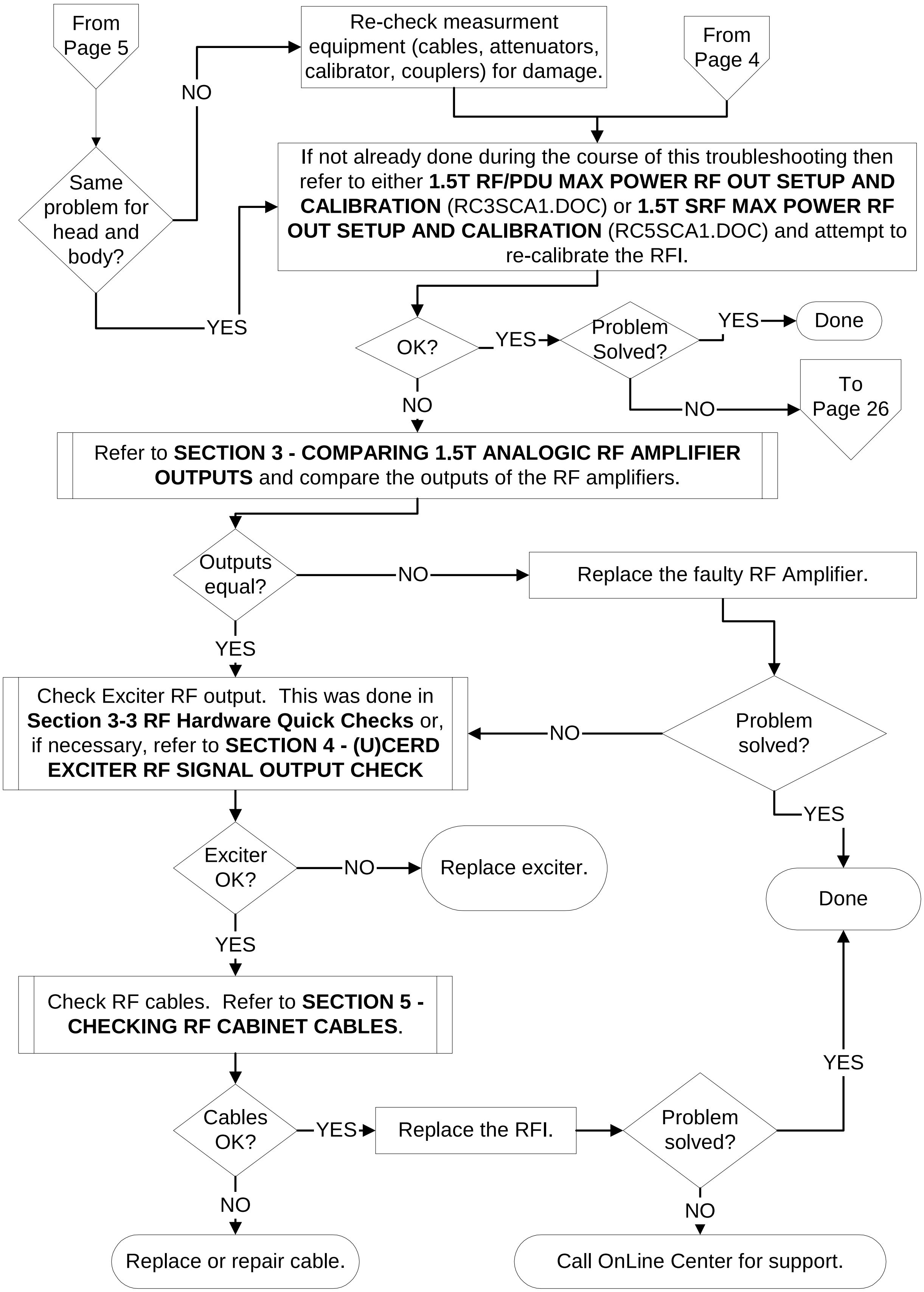
↓

Setup OK? — NO → Correct and try calibration again.

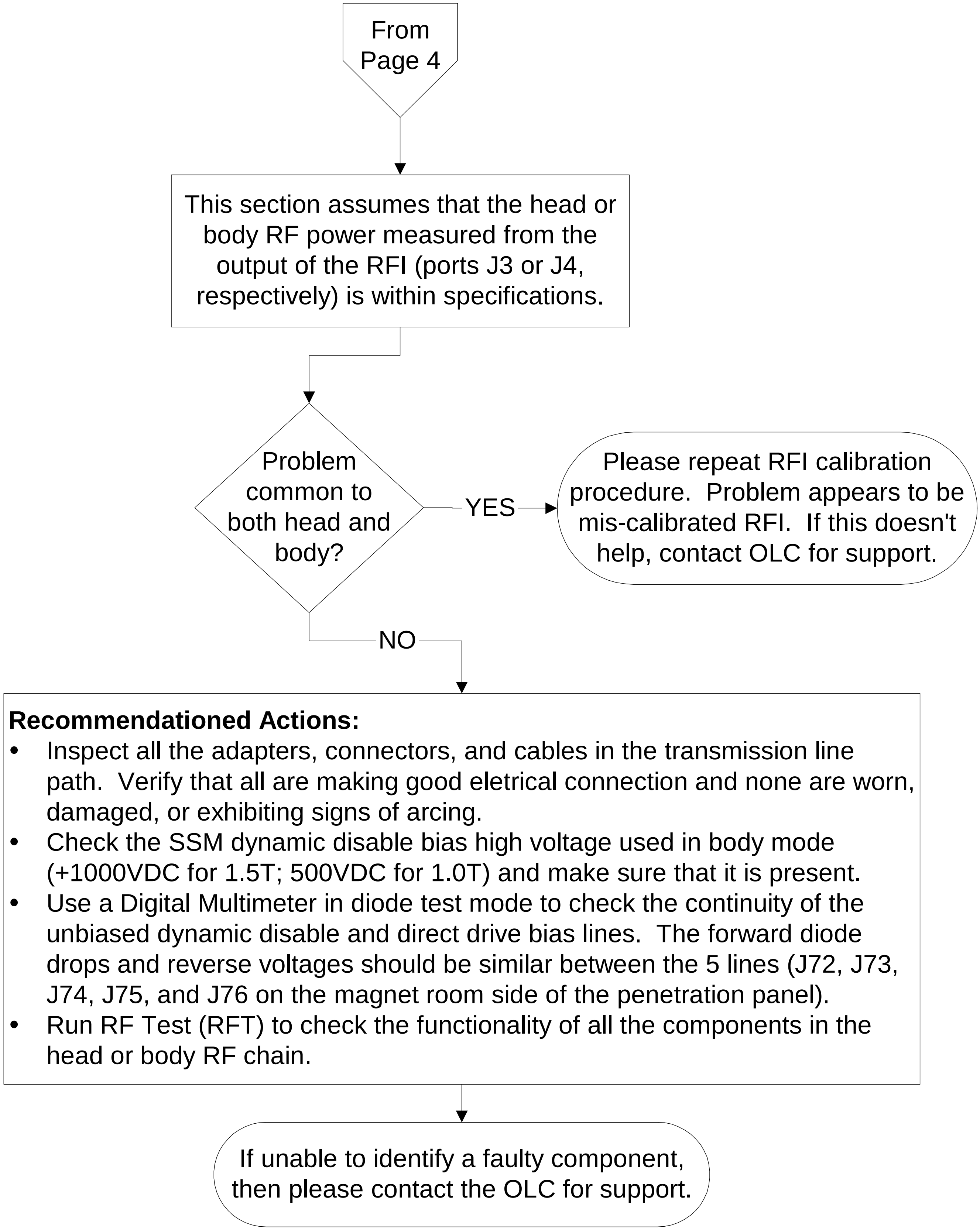
YES ↓

To Page 6

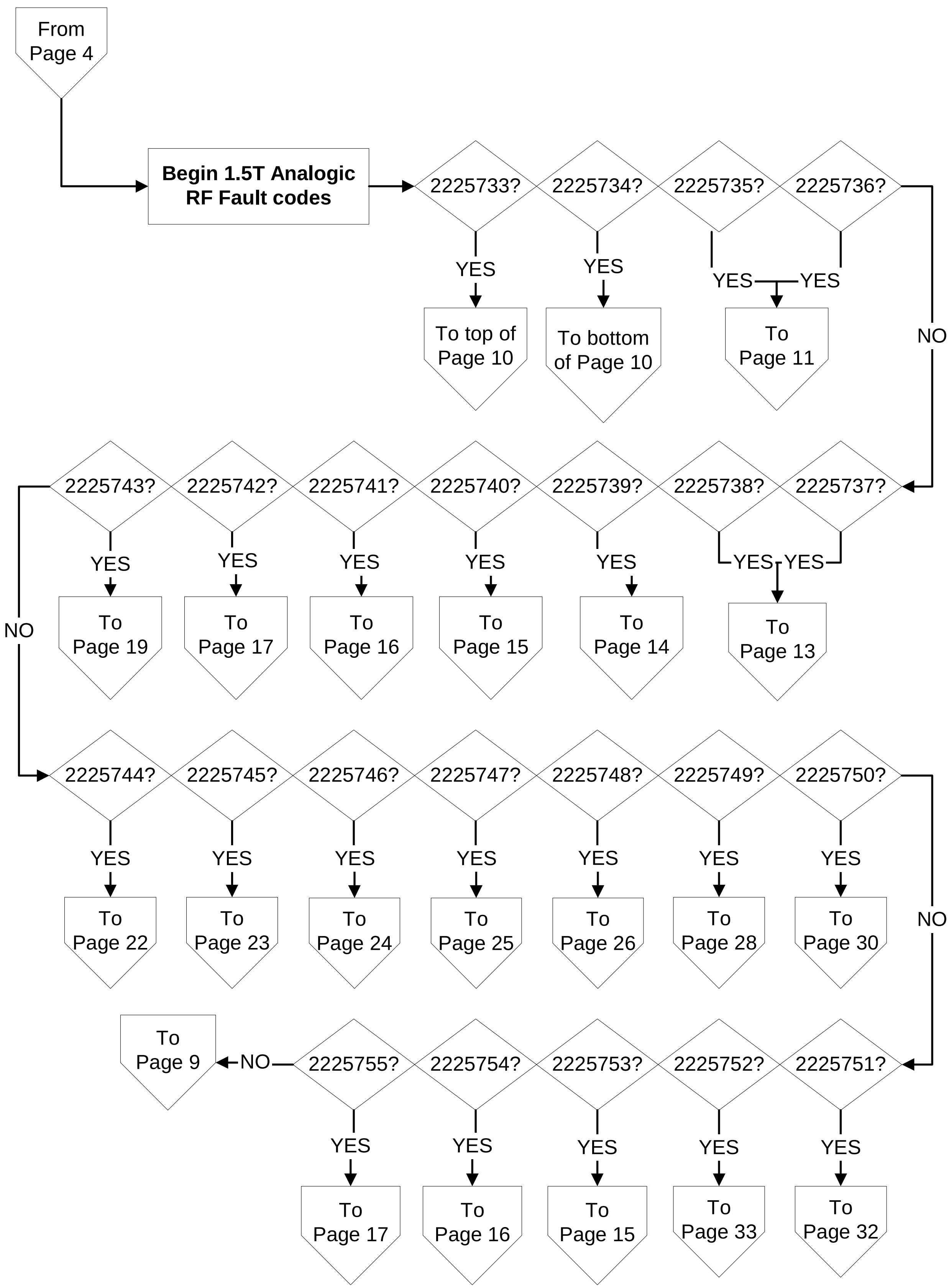
2-1 Main Body And RF Output Troubleshooting (Continued)



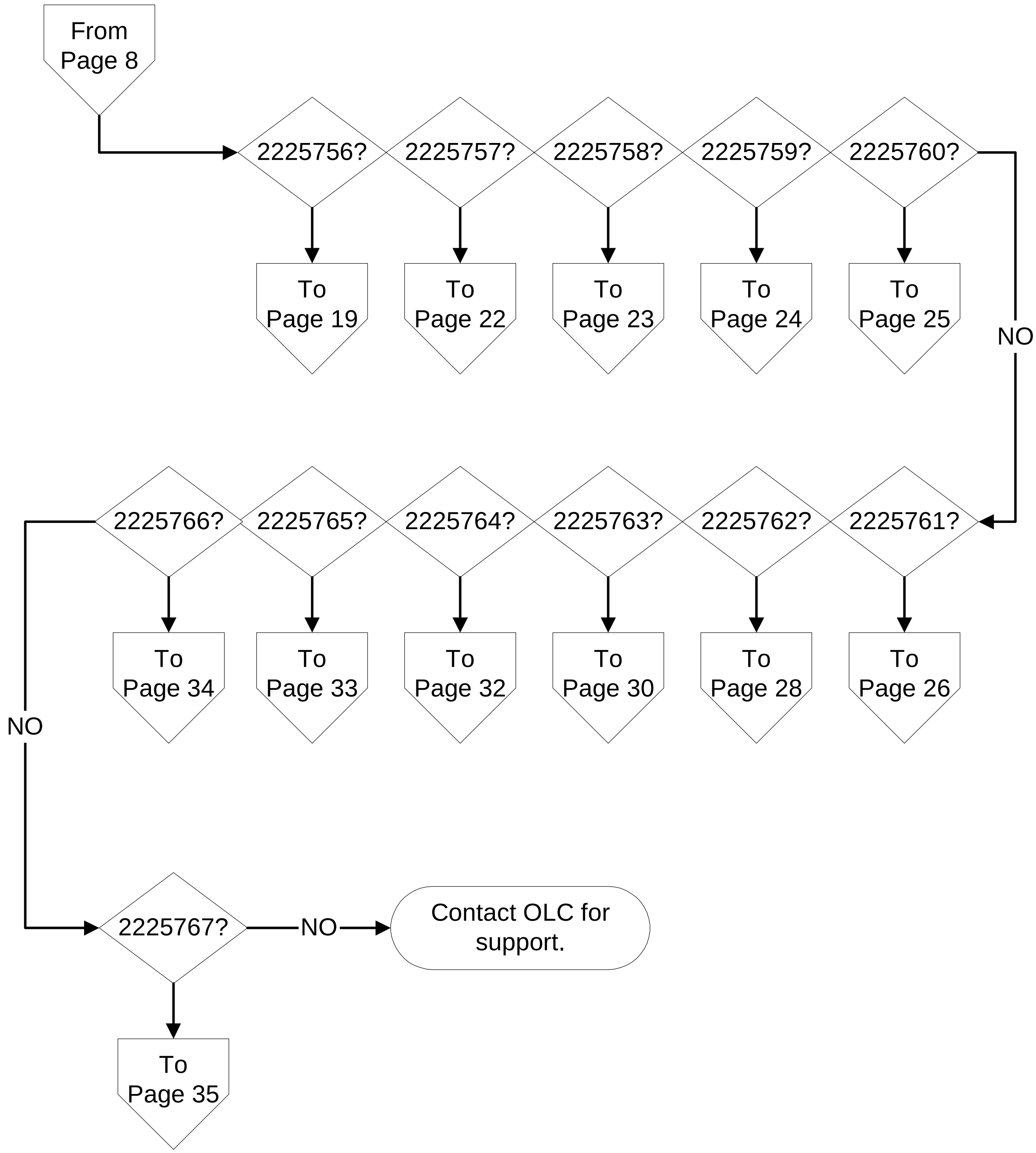
2-1 Main Body And RF Output Troubleshooting (Continued)



2-2 1.5T Analogic RF Amplifier Fault Code Tree



2-2 1.5T Analogic RF Amplifier Fault Codes (Continued)



2-3 RFI Fault Code 2225733

From Page 8

Error Message # 2225733:

RF Interface (RFI) General Overheating Fault. Possible causes: restricted air flow, or defective RFI.

Recommended Actions:

- Check that RFI fan is turning.
- Make sure equipment room is not over-temperature.
- Make sure inside of RF Cabinet is not over-temperature.
- May need to replace RFI.

2-4 RFI Fault Code 2225734

From Page 8

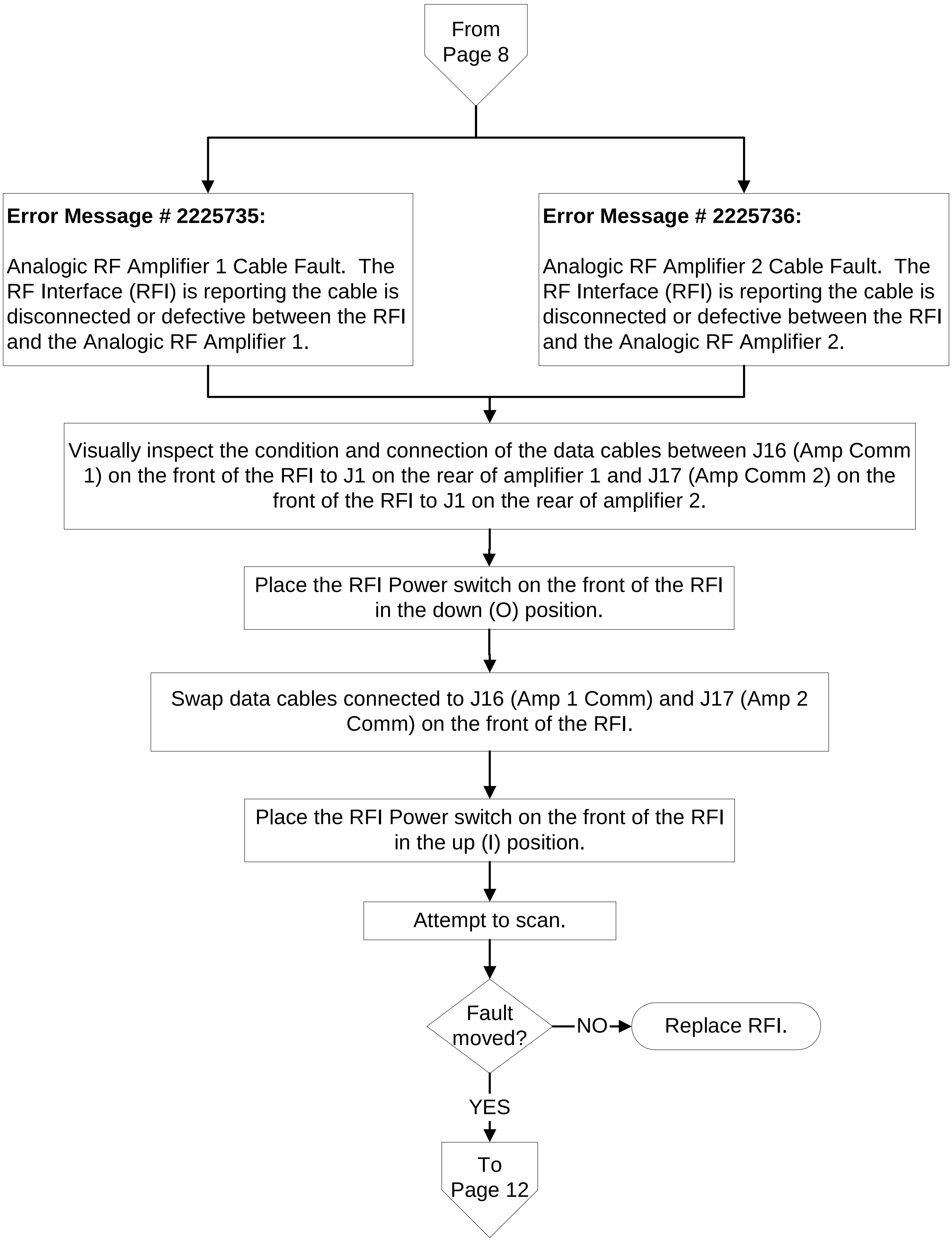
Error Message # 2225734:

RF Interface (RFI) Mismatch Fault. The Dump Resistor in the RFI has overheated. Possible causes: improper calibration, missing or improper cables between RFI and amplifier(s), defective RFI or defective Analogic RF Amplifier(s).

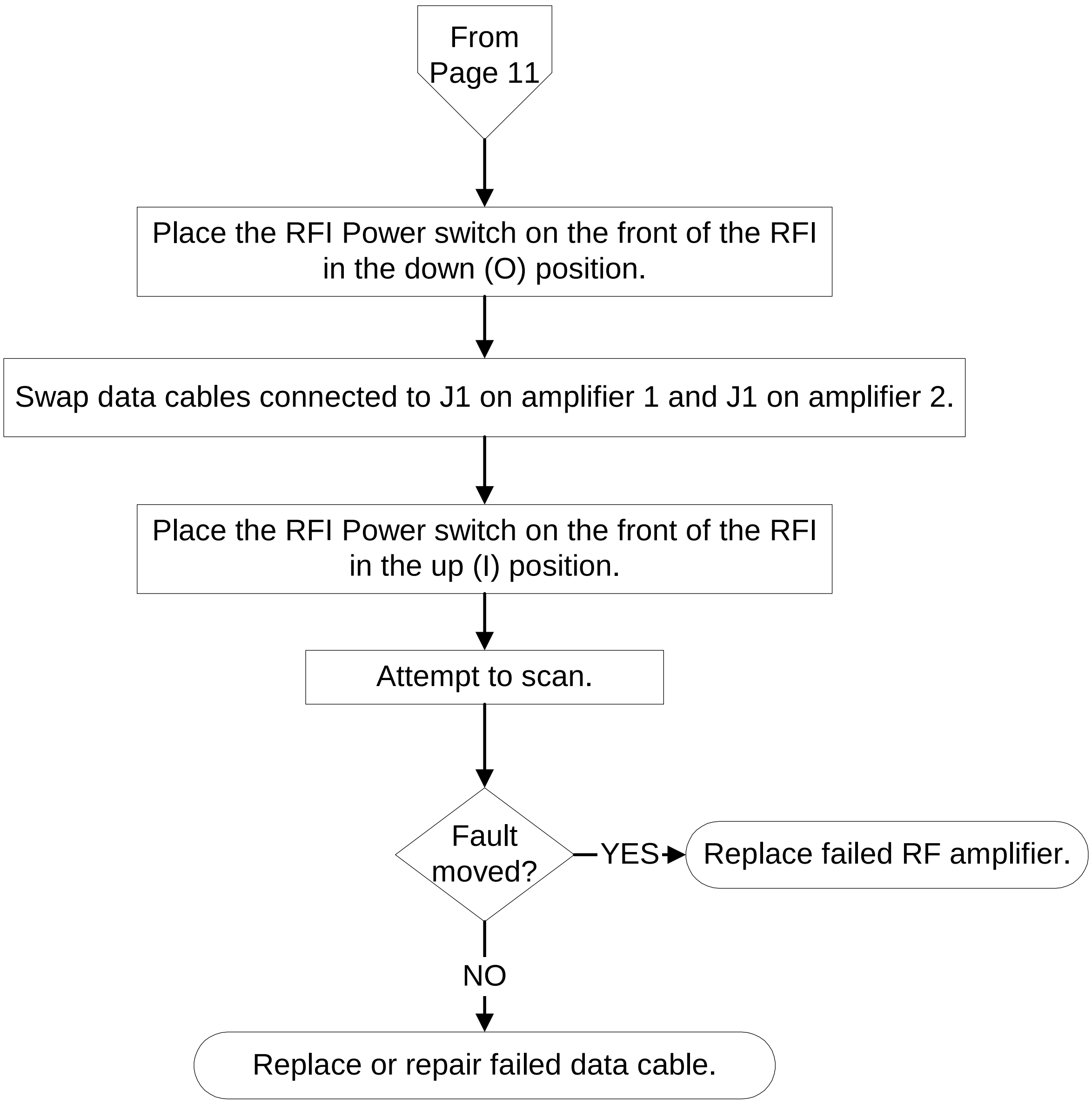
Recommended Actions:

- Calibrate the RFI, if possible.
- Perform actions in **SECTION 3 - COMPARING 1.5T ANALOGIC RF AMPLIFIER OUTPUTS.**
- Perform actions in **SECTION 5 - CHECKING RF CABINET CABLES**.
- As a last resort, replace the RFI.

2-5 1.5T Analogic RF Amplifier 1 And 2 Fault Codes 2225735 And 2225736



2-5 1.5T Analogic RF Amplifier 1 And 2 Fault Codes 2225735 And 2225736 (Continued)



2-6 1.5T Analogic RF Amplifier 1 And 2 Fault Codes 2225737 And 2225738

From Page 8

Error Message # 2225737:

Power Monitor 1 Fault. RF Transmit power has reached safety limit allowed for scan parameters and patient weight. Check patient weight entered.
amplitude: ###
pulse width: ###
duty cycle: ###

Error Message # 2225738:

Power Monitor 2 Fault. RF Transmit power has reached safety limit allowed for scan parameters and patient weight. Check patient weight entered.
amplitude: ###
pulse width: ###
duty cycle: ###

Recommended Actions:

- Check patient weight value entered by customer for scan and make sure it has not been significantly under-reported.
- Have customer pad patient extremities away from sides of tube so that there is at least 0.5 inches (1.27 cm) distance between patient and side of tube.
- If site has Multi-nuclear Spectroscopy (MNS) Hardware make certain that MNS Cabinet cabling is connected and MNS Cabinet is powered on.
- Check TG from customer scans or SPT and make sure it has not increased from what it is normally due to a system hardware problem. Investigate the cause of any substantial increases in TG.
- If power monitor faults only happen when using head coil then replace white head coil transmit cable (connects to female BNC outlined with blue circle on QD Box) and check Head Coil, Head TR Nework for damage.
- Check Config File Mgr and make certain Start TA, Coil Loss, and Cable Loss values for the coil in use when the fault happens are correct.
- Check RF output power and make sure it is within specifications. Calibrate the RFI if the RF output power is not in specifications.
- Run **proprietary** power monitor functional checks and use the field laptop and the MONS1.EXE software to check that the power monitors (APM Board inside SSM) are in good working order. During the functional check verify that there is not excessive RF leakage from RFI Body Sense ports A and B to Head Sense ports A and B. Replace the RFI if RF leakage is excessive.

2-7 RFI Error Code 2225739

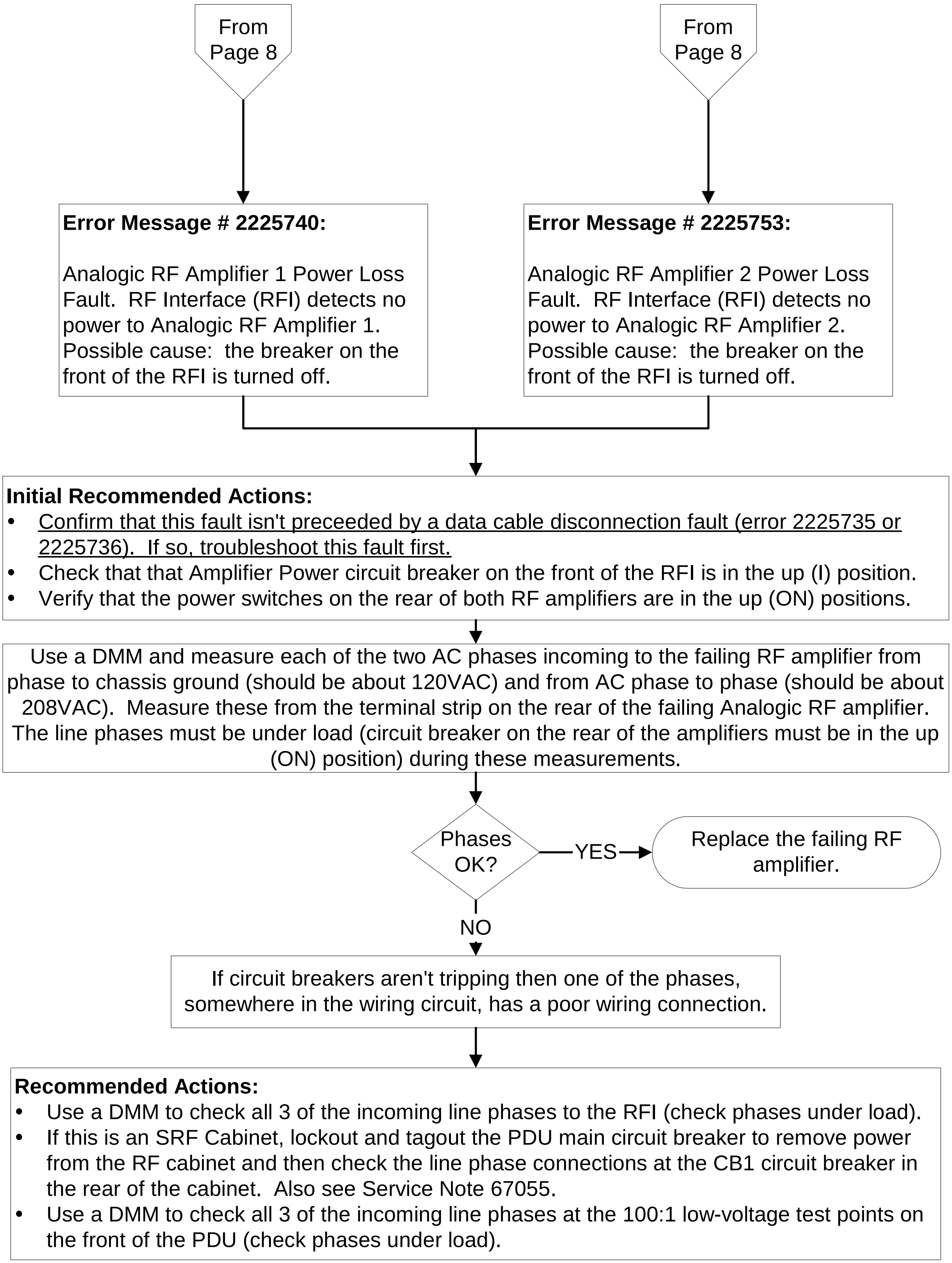
From Page 8

Error Message # 2225739:

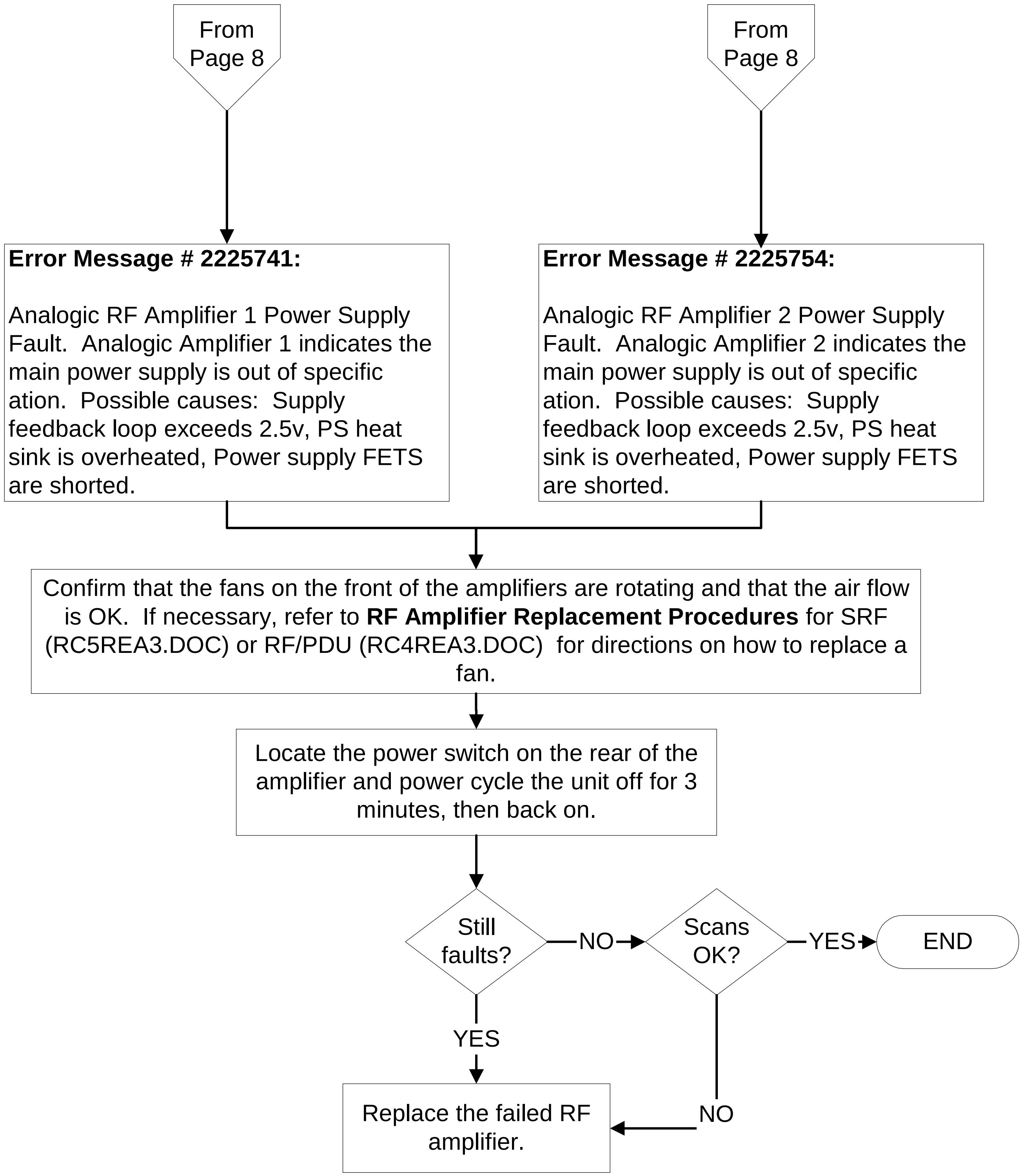
RF Interface (RFI) High Voltage Relay Fault. Possible causes: RF Monitor Cable to System Support Module (SSM) is disconnected or defective. Note: This fault may occur in conjunction with a Power Monitor Fault or when power cycling the SSM.

Recommended Actions:
- This fault normally occurs in conjunction with 2225713 or 2225714. Make sure this fault isn't a by-product of a power monitor fault.
- This fault normally occurs when the SSM is power cycled. Make sure this fault is not a result of a power cycle.
- Check the connection and condition of the cable that interfaces between the J18 General Communications port on the RFI and the J503 port on the SSM.

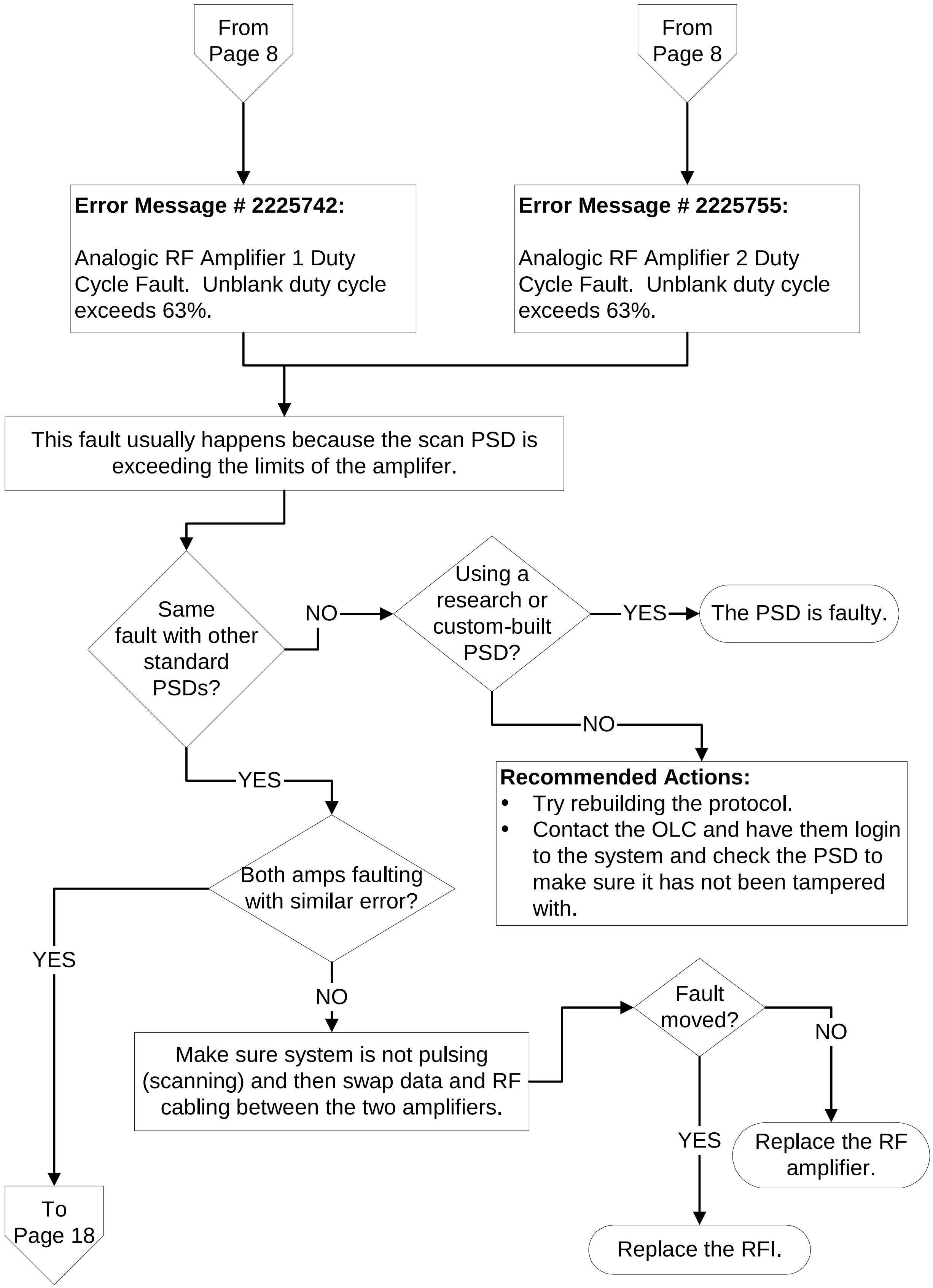
2-8 1.5T Analogic RF Amplifier 1 And 2 Fault Codes 2225740 And 2225753



2-9 1.5T Analogic RF Amplifier 1 And 2 Fault Codes 2225741 And 2225754



2-10 1.5T Analogic RF Amplifier 1 And 2 Fault Codes 2225742 And 2225755



2-10 1.5T Analogic RF Amplifier 1 And 2 Fault Codes 2225742 And 2225755 (Continued)

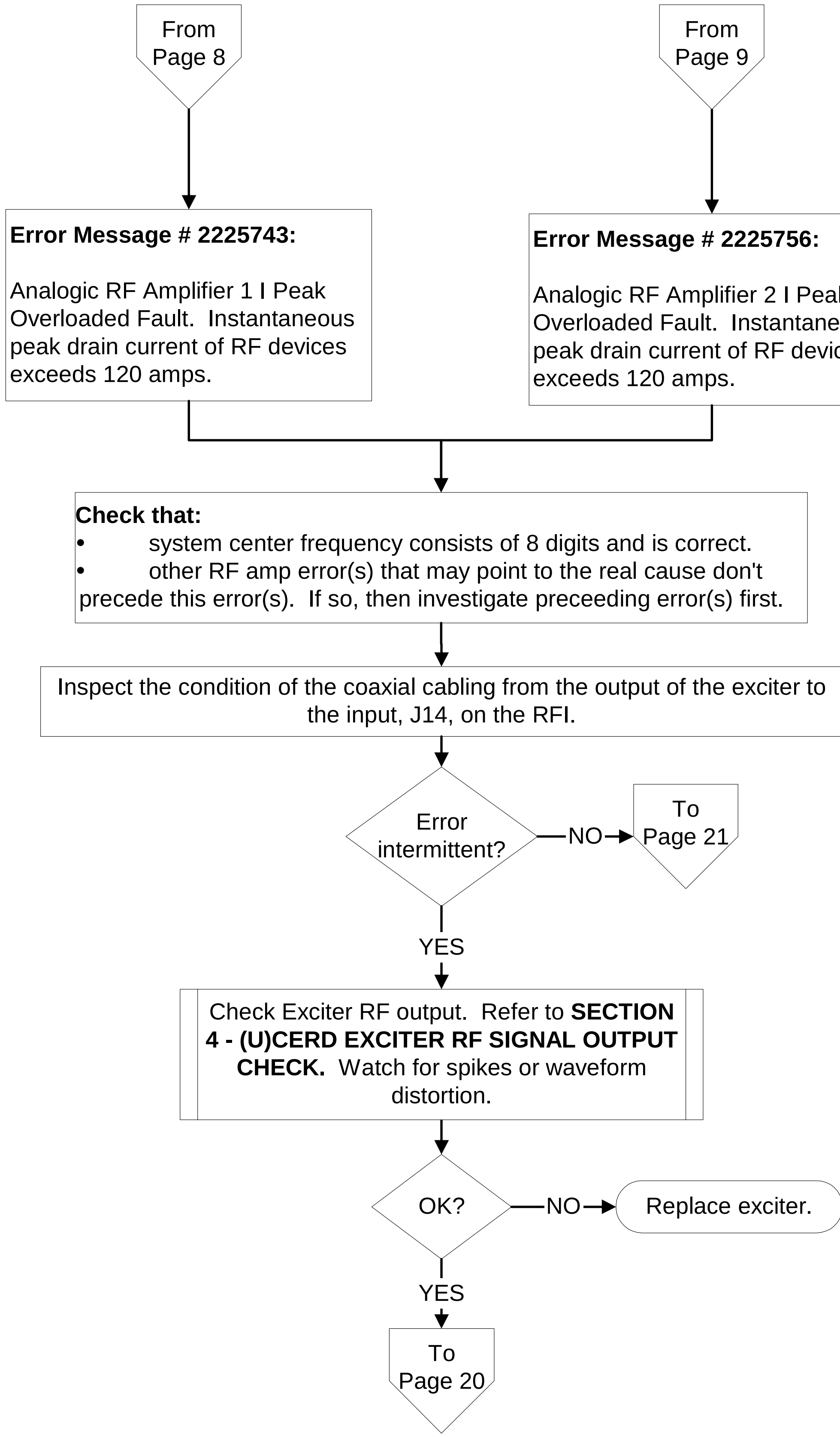
From Page 17

Use an oscilloscope to measure the RF Unblank pulses at the sample ports on the front of the IPG Board in the TPS. Make certain that the pulses look like clean square waves. **THEORY:** Unblank originates in the IPG and is output from J30 on the TYME Board to J5 UNBLK IN on the rear of the SSM where it is split into different Unblank signals for different uses. It is then output to the RFI J18 General Comm. from the SSM J504 PCM. The amplifiers receive the Unblank from the RFI via the Amp Comm cables. During scan the GATE LED on the rear of the amplifiers flash indicating that Unblank is reaching the amplifiers.

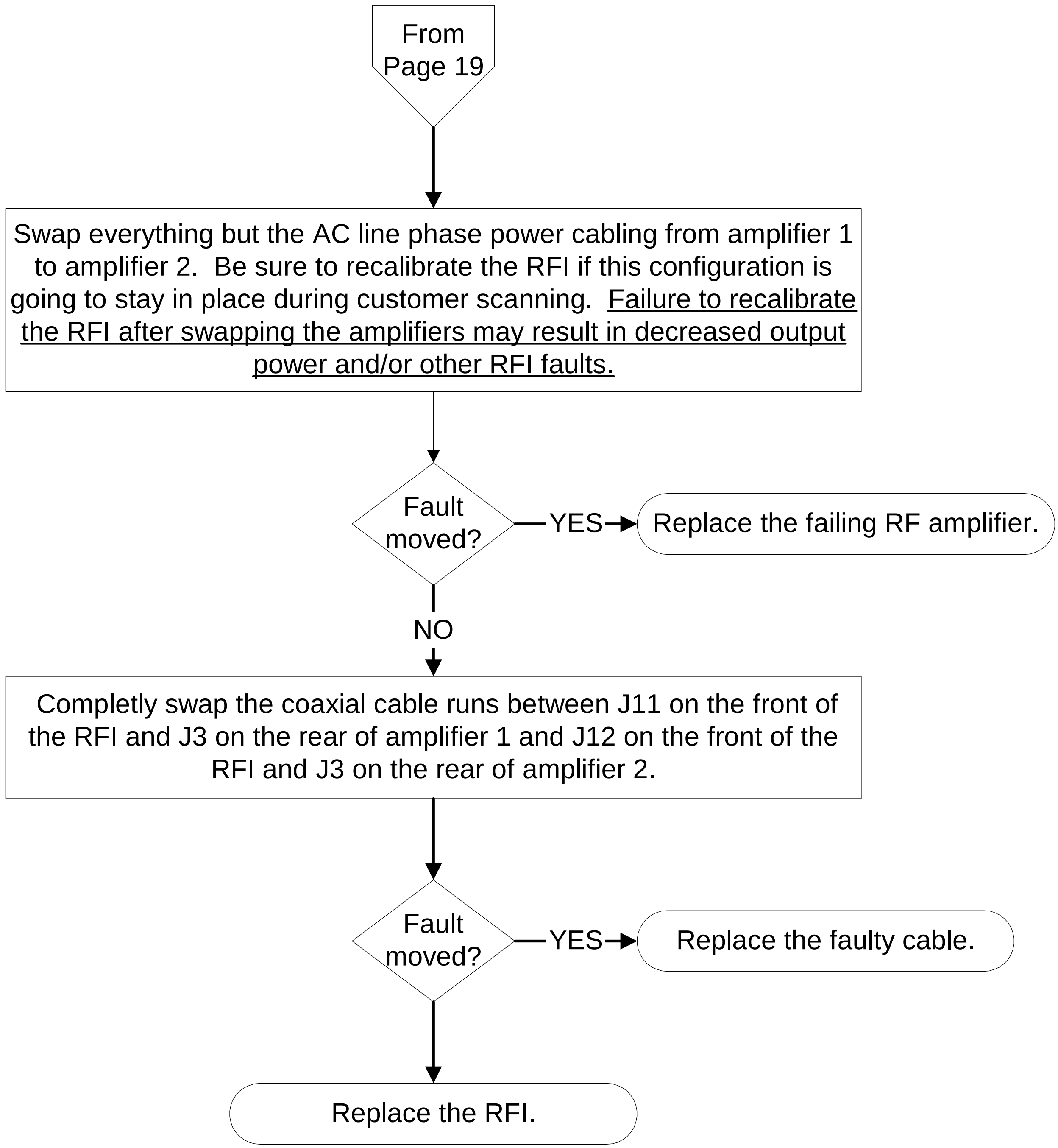
It is very unusual to have reached this point. Unblank is provided by the SSM CPD Board to the RFI for distribution to the RF amplifiers.

Replace the RFI.

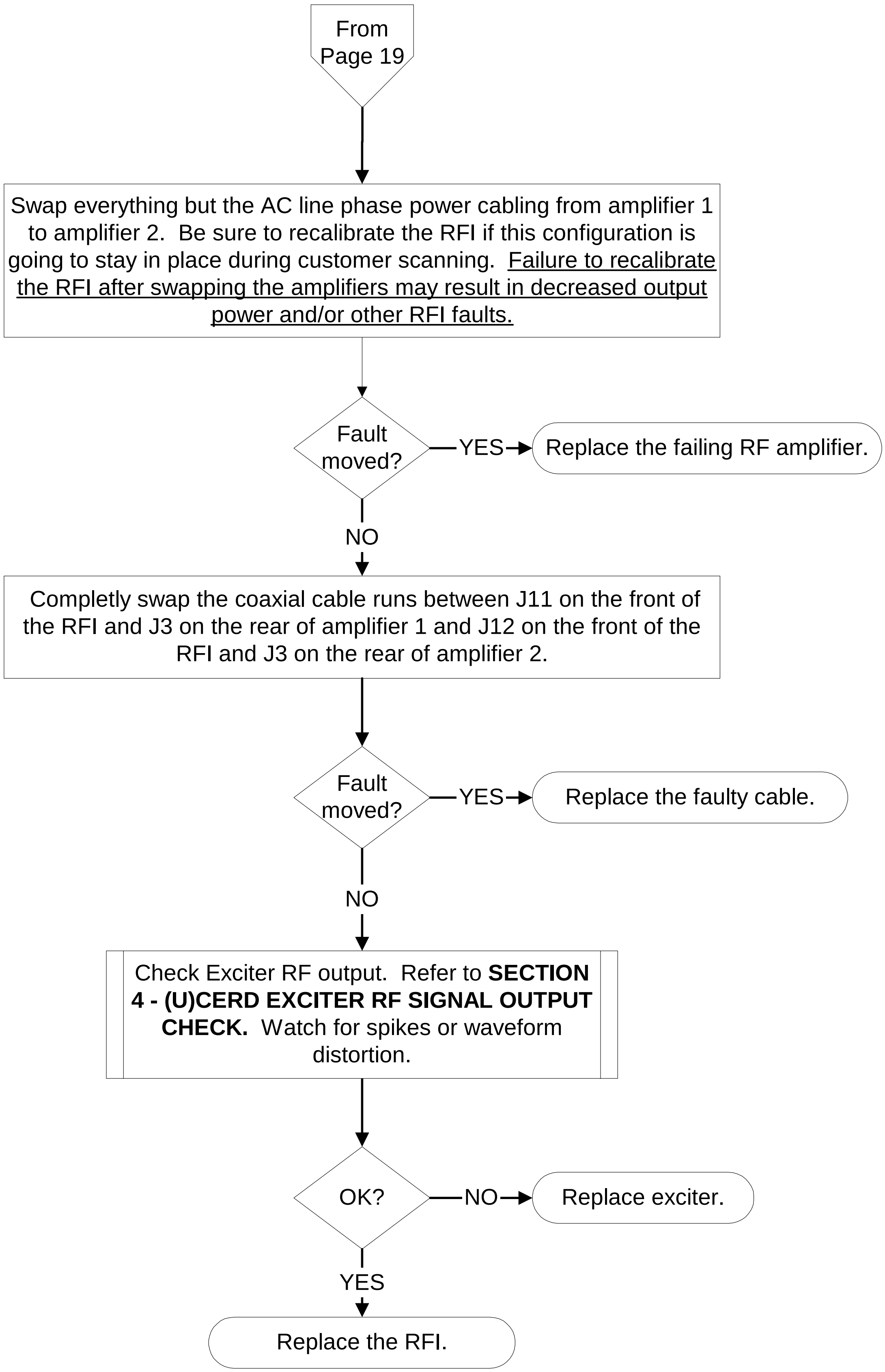
2-11 1.5T Analogic RF Amplifier 1 And 2 Fault Codes 2225743 And 2225756



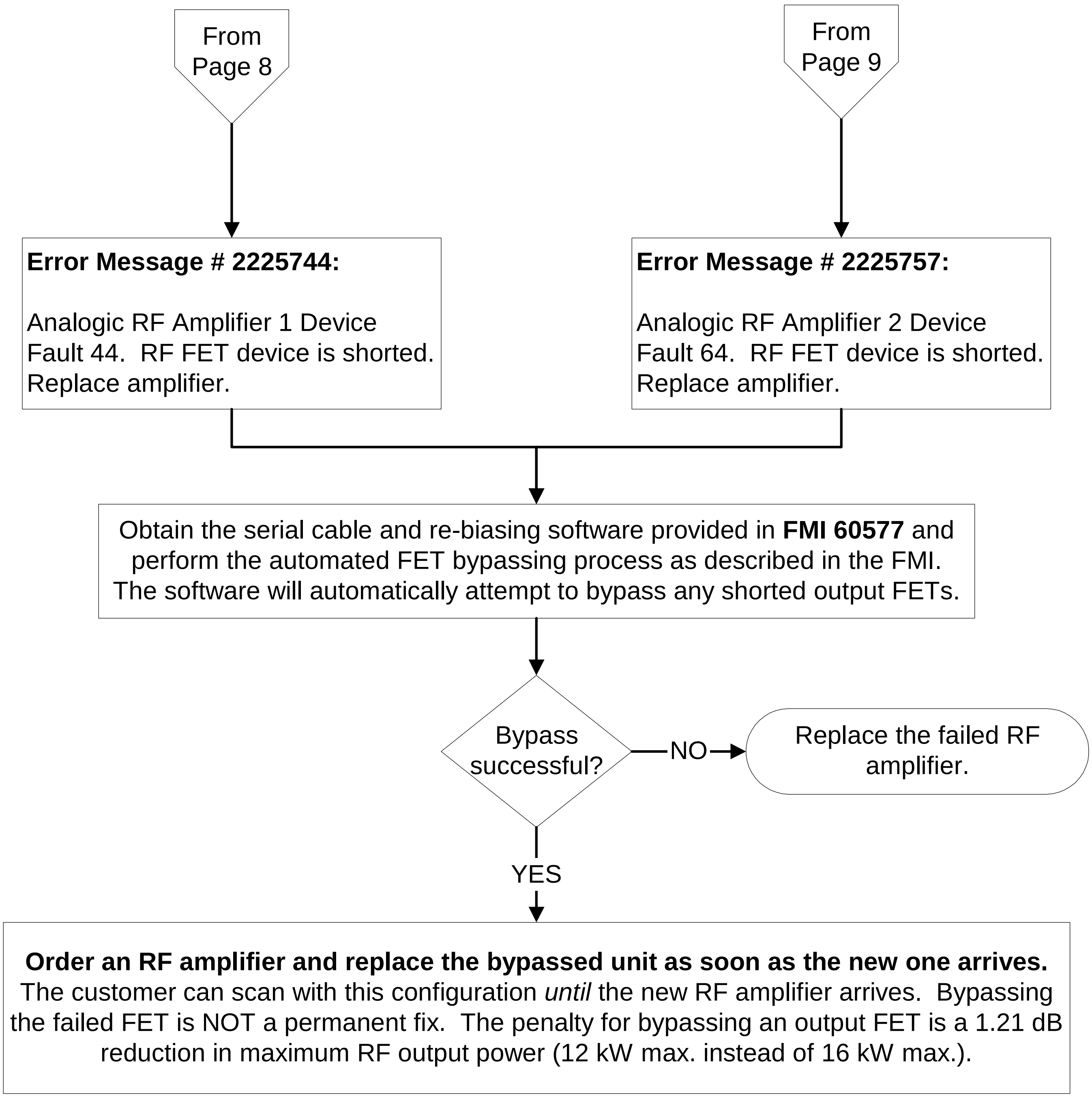
2-11 1.5T Analogic RF Amplifier 1 And 2 Fault Codes 2225743 And 2225756 (Continued)



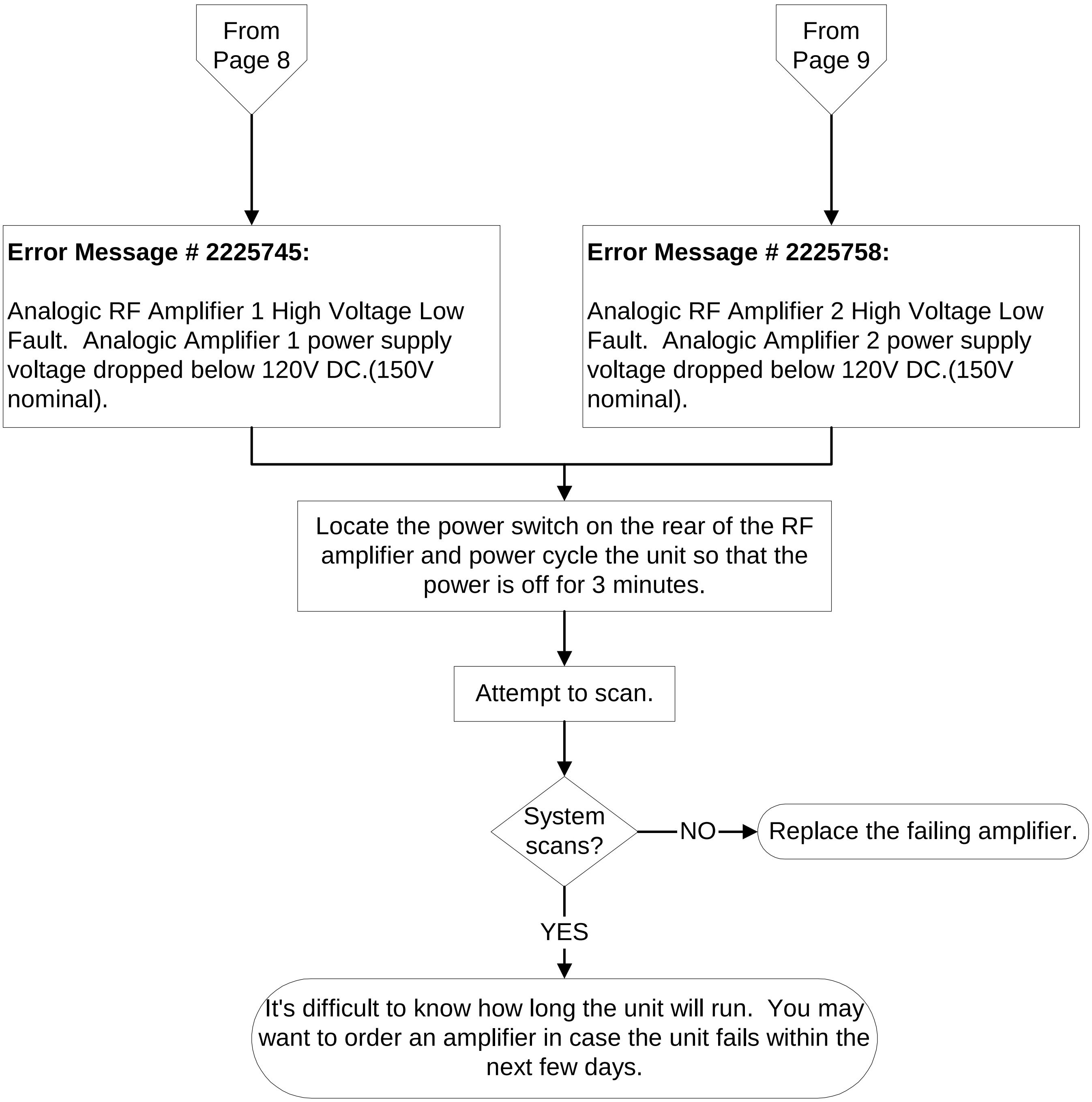
2-11 1.5T Analogic RF Amplifier 1 And 2 Fault Codes 2225743 And 2225756 (Continued)



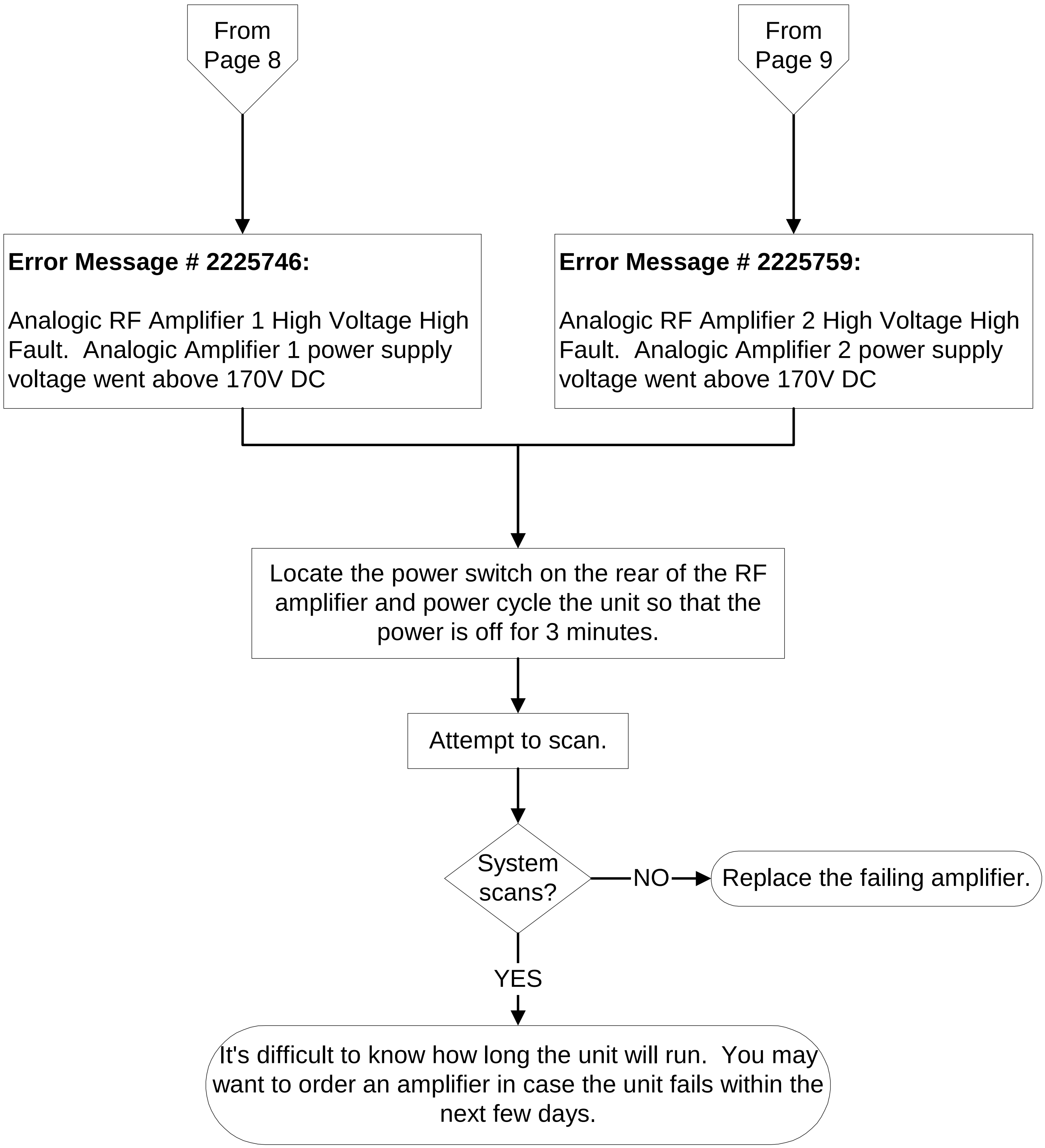
2-12 1.5T Analogic RF Amplifier 1 And 2 Fault Codes 2225744 And 2225757



2-13 1.5T Analogic RF Amplifier 1 And 2 Fault Codes 2225745 And 2225758



2-14 1.5T Analogic RF Amplifier 1 And 2 Fault Codes 2225746 And 2225759



2-15 1.5T Analogic RF Amplifier 1 And 2 Fault Codes 2225747 And 2225760

From Page 8

Error Message # 2225747:

Analogic RF Amplifier 1 Overheat Fault. Analogic Amplifier 1 reports the thermal switch has exceeded 80 degrees C. Possible causes: restricted air flow, blown fan fuse, defective fan, room environment out of specification or defective RF Amplifier 1.

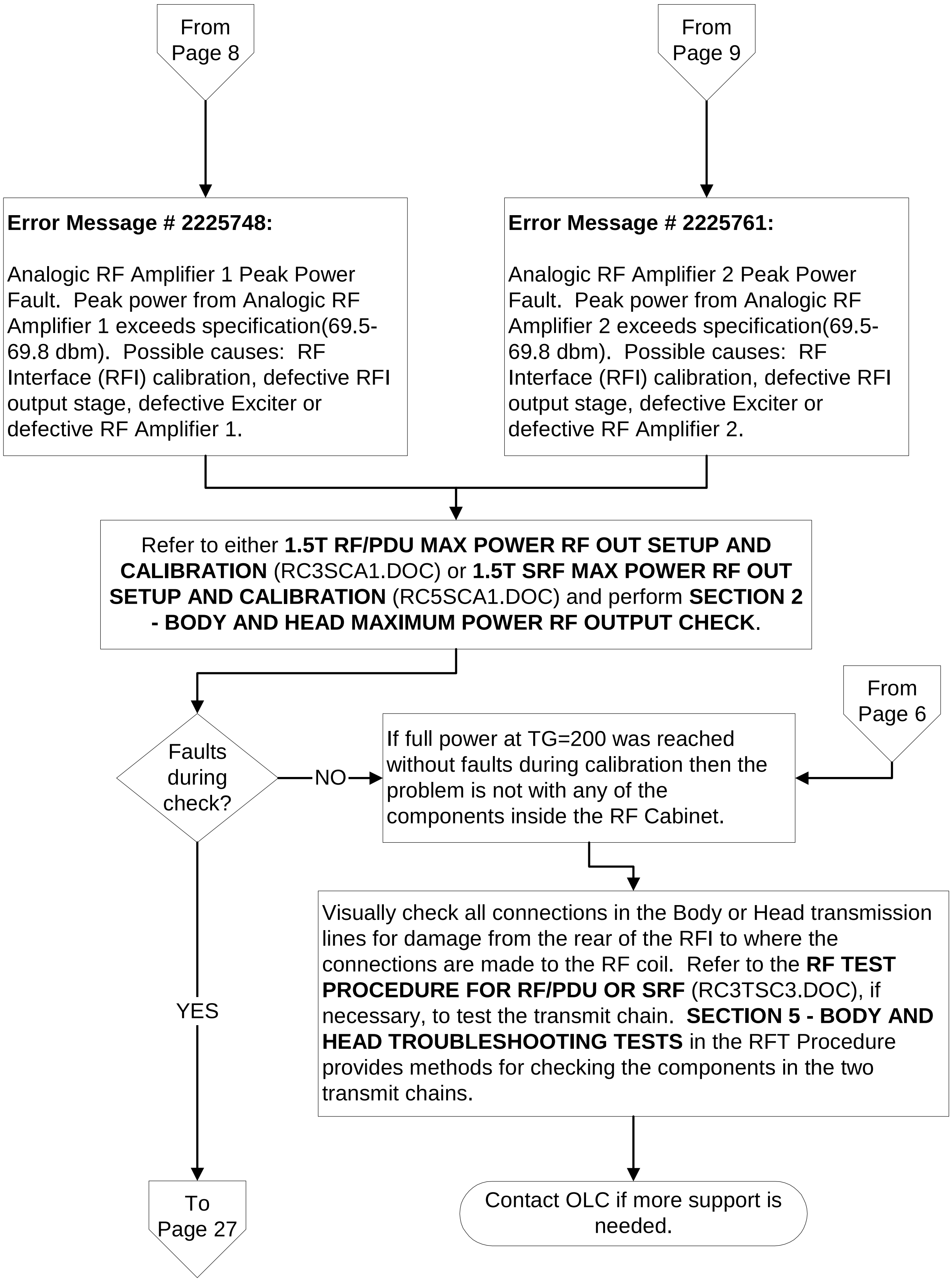
From Page 9

Error Message # 2225760:

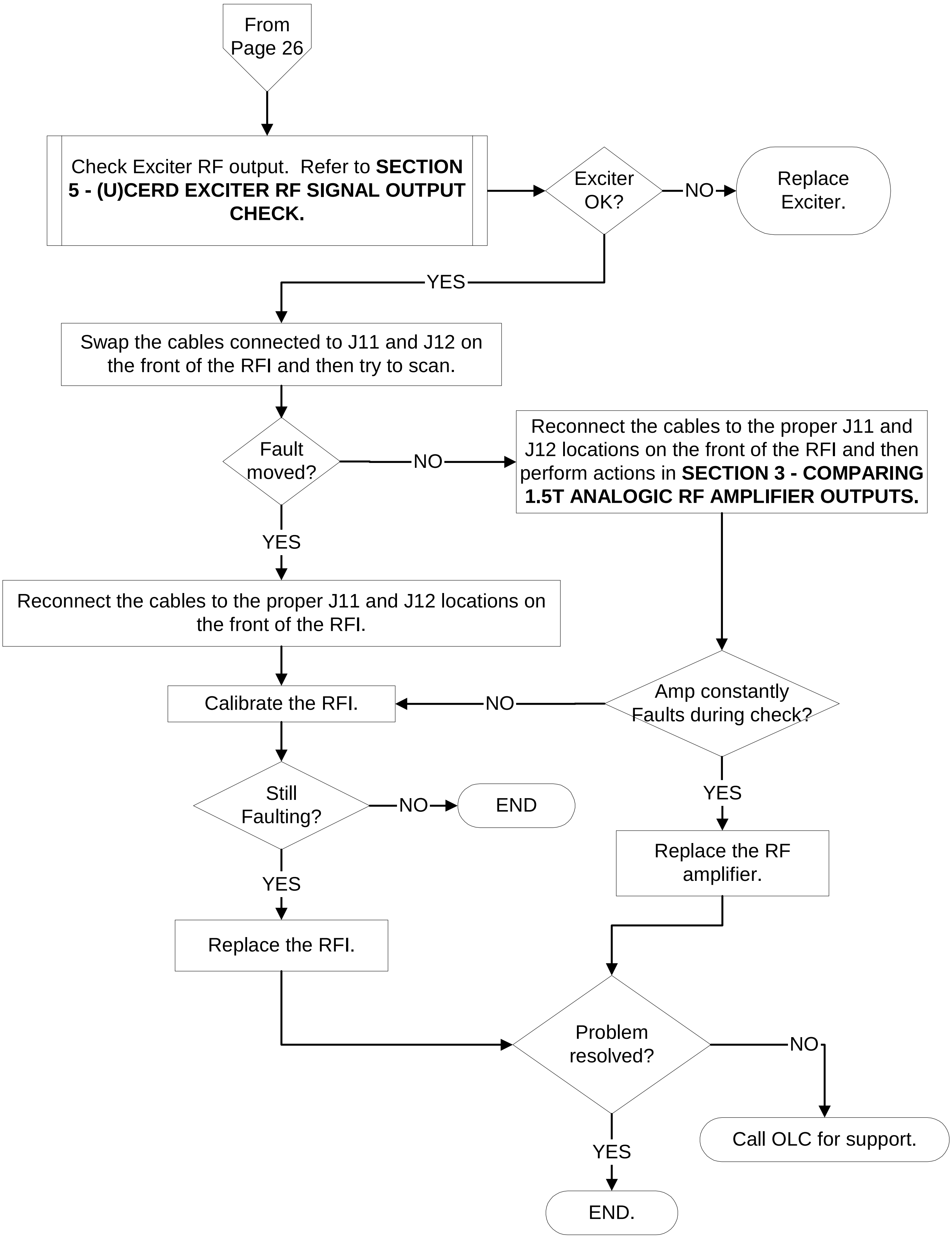
Analogic RF Amplifier 2 Overheat Fault. Analogic Amplifier 2 reports the thermal switch has exceeded 80 degrees C. Possible causes: restricted air flow, blown fan fuse, defective fan, room environment out of specification or defective RF Amplifier 2.

Recommended Actions:
- Confirm that the room temperature is within specification.
- Check for blockage (lint, hair or paper) on front and rear fan vents.
- Confirm that the amplifier fans rotate. If no rotation or poor rotation then it may be necessary to replace the failed fan or amplifier. The fans can be replaced in the field. If necessary, refer to **RF Amplifier Replacement Procedures** for SRF (RC5REA3.DOC) or RF/PDU (RC4REA3.DOC) for directions on how to replace a fan.
- If all else OK then it may be necessary to replace the RF amplifier.

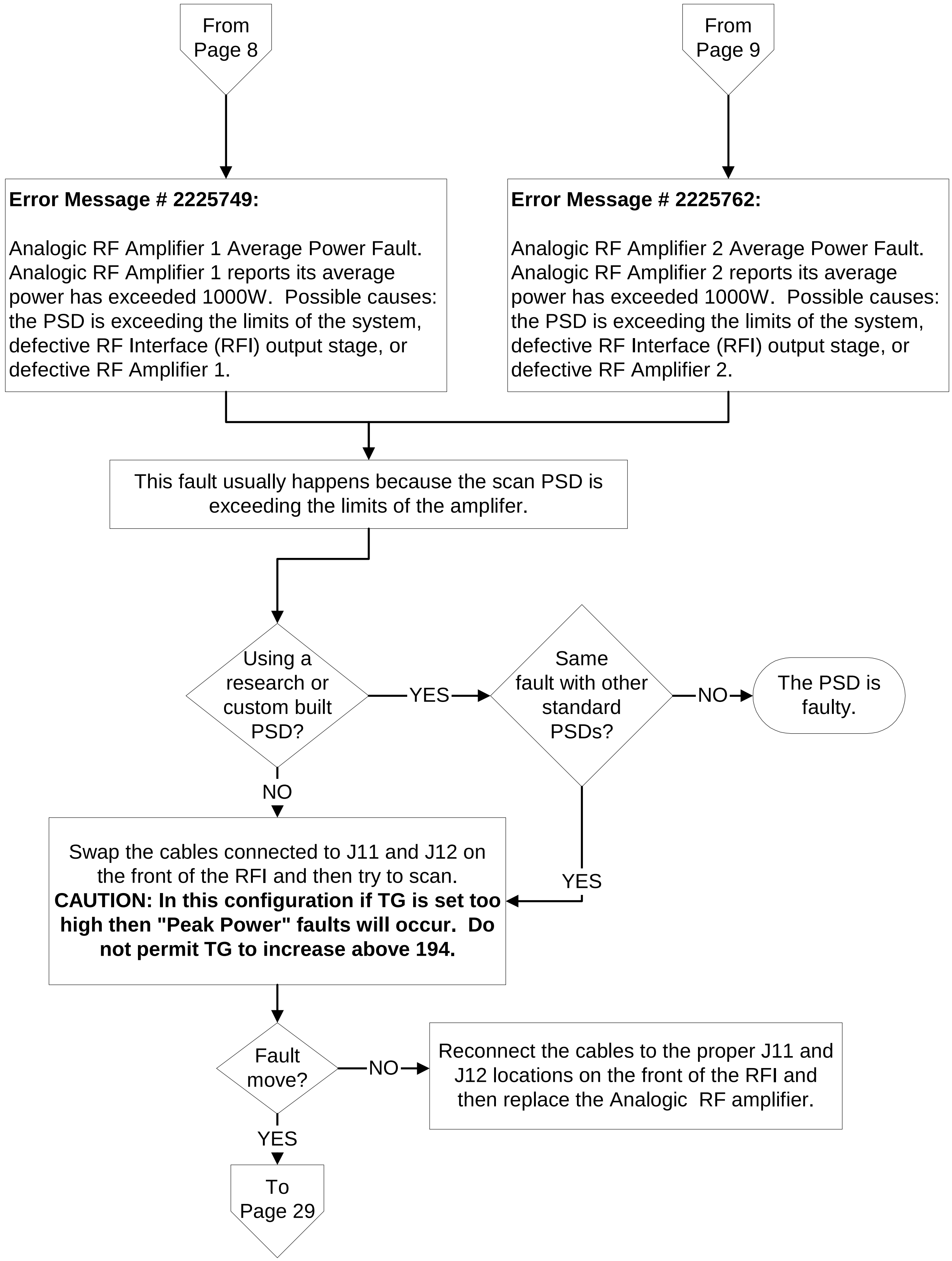
2-16 1.5T Analogic RF Amplifier 1 And 2 Fault Codes 2225748 And 2225761



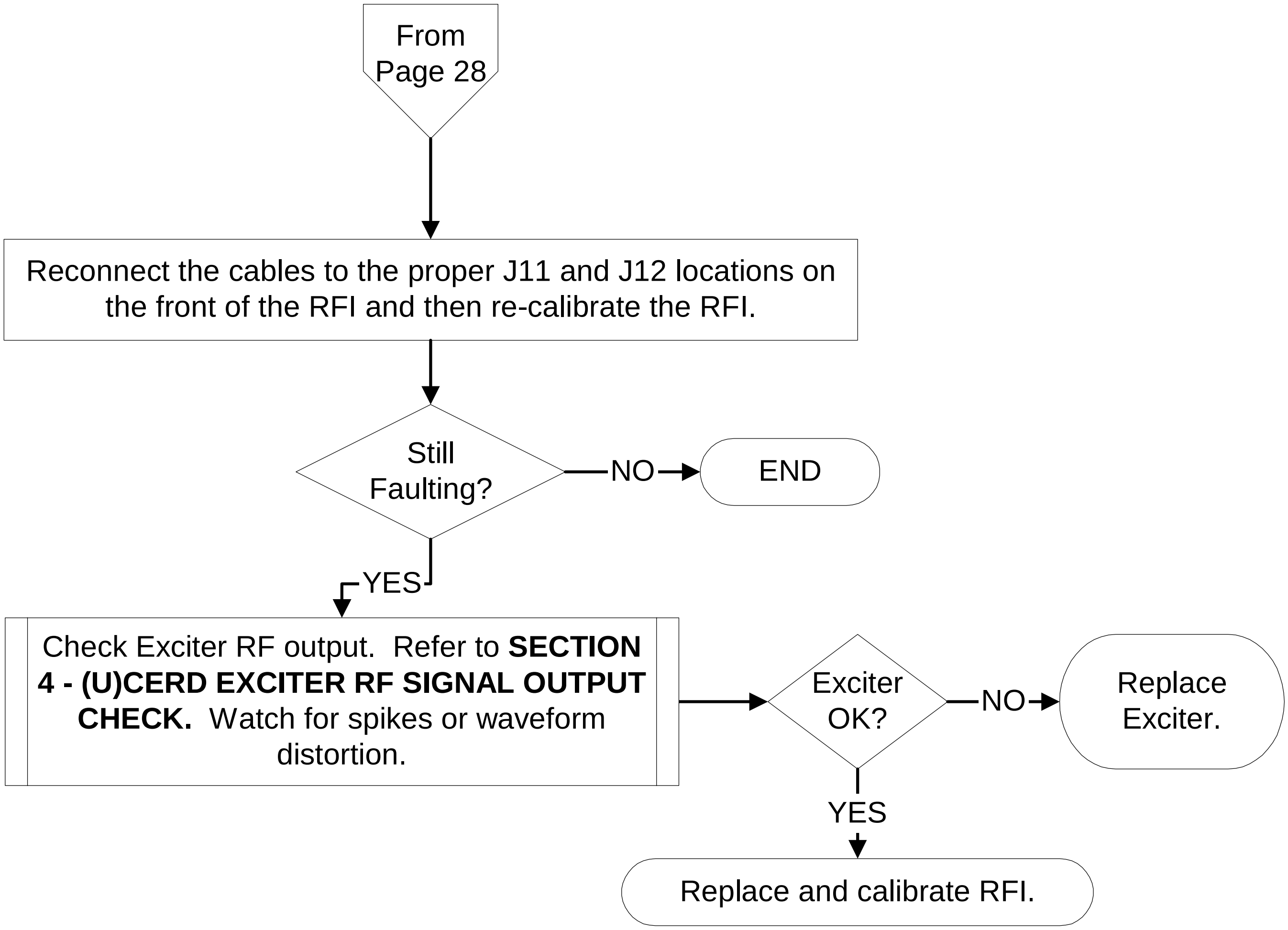
2-16 1.5T Analogic RF Amplifier 1 And 2 Fault Codes 2225748 And 2225761 (Continued)



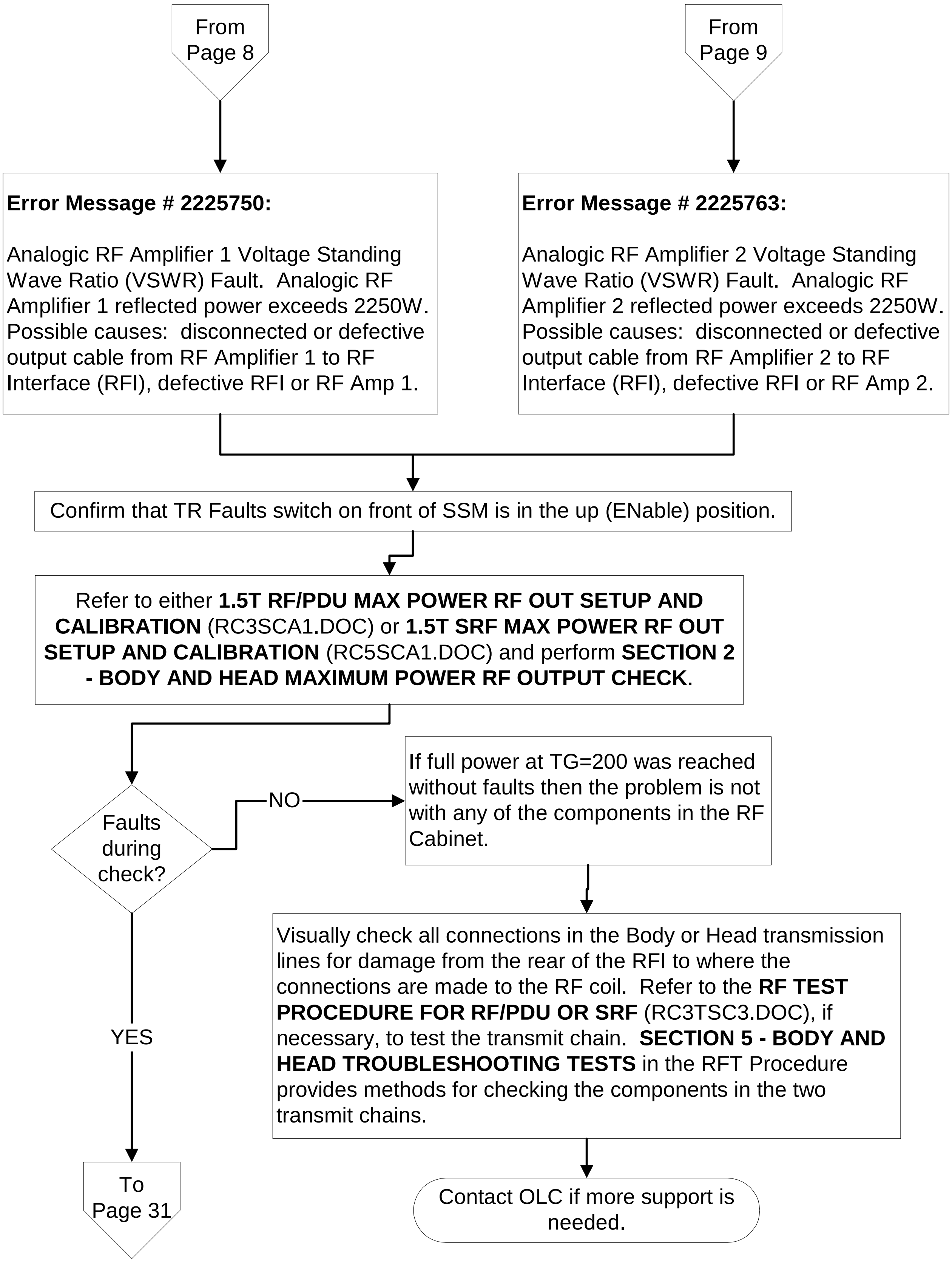
2-17 1.5T Analogic RF Amplifier 1 And 2 Fault Codes 2225749 And 2225762



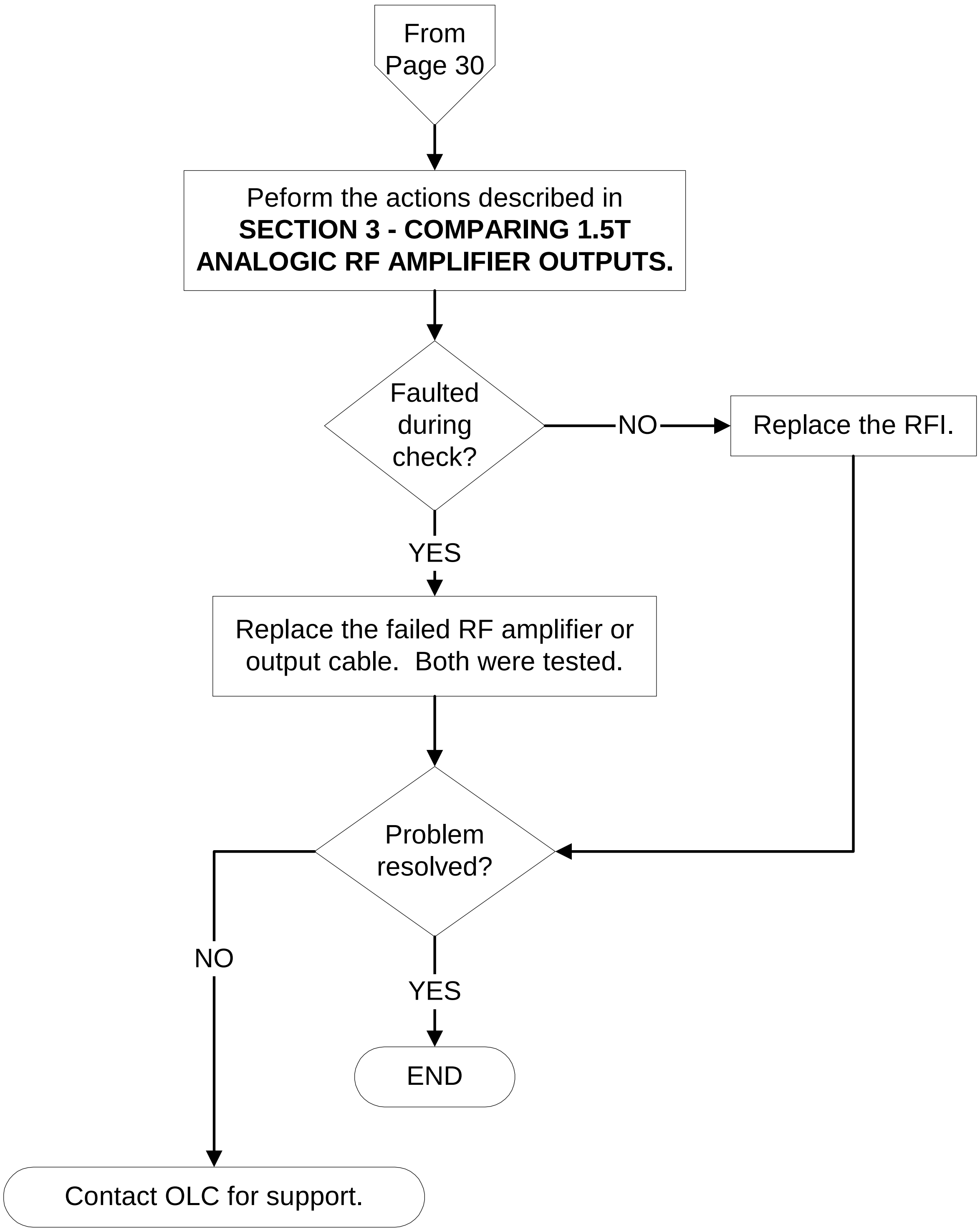
2-17 1.5T Analogic RF Amplifier 1 And 2 Fault Codes 2225749 And 2225762 (Continued)



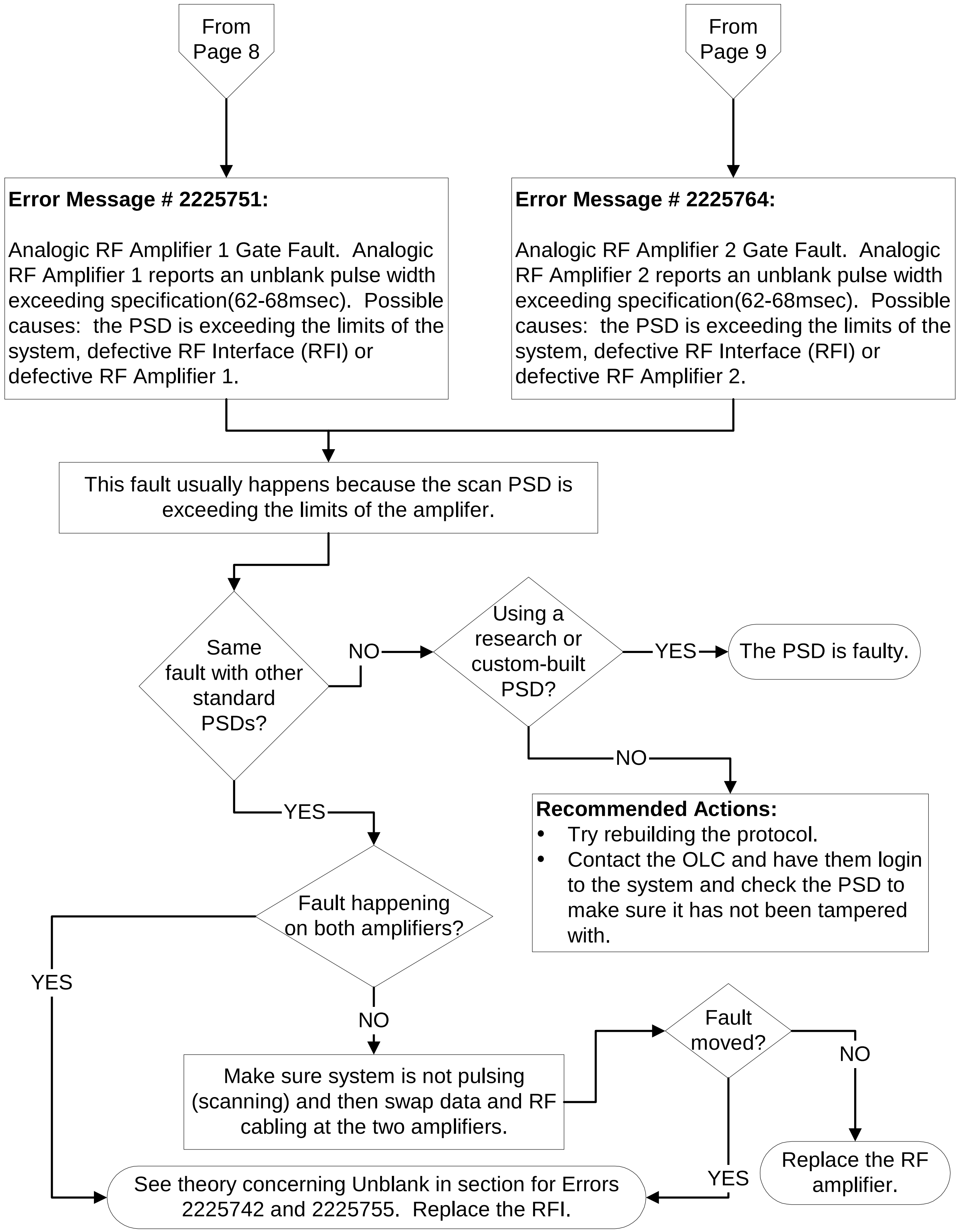
2-18 1.5T Analogic RF Amplifier 1 And 2 Fault Codes 2225750 And 2225763



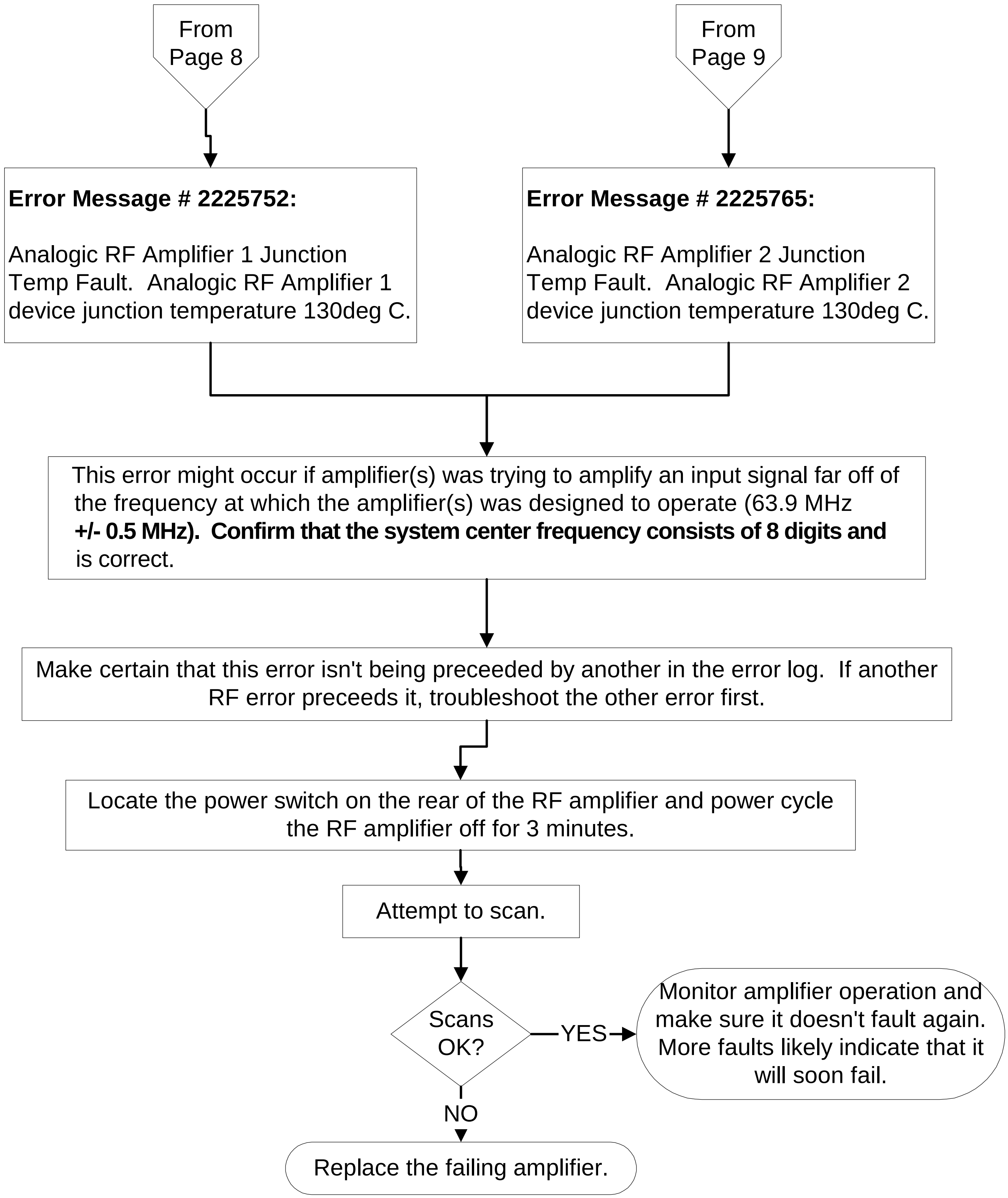
2-18 1.5T Analogic RF Amplifier 1 And 2 Fault Codes 2225750 And 2225763 (Continued)



2-19 1.5T Analogic RF Amplifier 1 And 2 Fault Codes 2225751 And 2225764



2-20 1.5T Analogic RF Amplifier 1 And 2 Fault Codes 2225752 And 2225765



2-21 RF Power Monitor Fault Code 2225766

From Page 9

Error Message # 2225766:

Possible power monitor hardware failure: power sensed with monitor blanked, DC rail to power monitor, or +15V sense failed.

Recommended Actions:

- Refer to the **LAPTOP CONFIG AND TROUBLESHOOTING SOFTWARE** document (RC3TSC5.DOC) on the 8.X Service Methods CD-ROM and check the status of the SSM power supplies using the MONS1.EXE software.
- If MONS1.EXE software not available, then refer to Table 4-1 in **COMMUNICATIONS PIN DRIVER (CPD) SETUP & CALIBRATION** document (RC3SCA2.DOC) and configure the SSM to provide a Monitor Fault Summary as shown in the table.
- Check for loose cabling to the High Voltage Board, APM Board, and CPD Board inside the SSM.
- Depending on what faults are seen with either of the above 2 methods, may need to replace either the High Voltage Board, CPD Board, or APM Board.

2-22 RF Power Monitor Fault Code 2225767

From Page 9

Error Message # 2225767:

Power Monitor Tripped with undermined cause.

This indicates that electronic noise likely within the SSM is causing undetermined trips.

Recommended Actions:

- Replace the APM Board first.
- Replace the CPD Board second.
- If the problem persists, then please contact the OLC for support.

3 – COMPARING 1.5T ANALOGIC RF AMPLIFIER OUTPUTS

Two processes are provided for determining the condition the RF amplifiers. The first is described in **Section 3-3 RF Hardware Quick Checks**. As the name implies, this process provides simple and quick methods for checking the RF hardware for gross failures. It should help the FE isolate and diagnose 90% of all RF hardware problems. It may not be suitable for isolating some RFI or some subtle RF amplifier problems. These types of problems will require the FE to refer either to **Section 3-4 RF Amplifier Comparison Process Using the RF Power Measurement Kit** or **Section 3-5 RF Amplifier Comparison Process Using a Wattmeter or Oscilloscope**. It is easier to perform these checks using the RF Power Measurement Kit and so **Section 3-4 RF Amplifier Comparison Process Using the RF Power Measurement Kit** is recommended. The latter two procedures involve bypassing the RFI and connecting the UCERD Exciter signal directly to the RF amplifier under test. The RF output power from the RF amplifier is then measured using the RF Power Measurement Kit, or an oscilloscope (100MHz or greater) and dummy load, or a wattmeter and dummy load. Reconfiguring the hardware in this fashion simplifies the hardware chain and allows each RF amplifier to be individually tested.

3-1 Tools and Instruments Required

Refer to Table 3-1 for equipment required to measure power with the RF Power Measurement Kit. The RF Power Measurement Kit is the preferred method of RF power measurement.

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

Item	Description	Part Number
1.	100 MHz Scope (equivalent or greater)	46-183029P61
2.	RF Power Measurement Kit	46-317724G1 or G2
3.	50 ohm, 200 Watt, 30dB Attenuator (dummy load) **NOTE:** Only required with above 46-317724G1 kit.	46-317724P14
4.	RF Test Cables Kit	46-255816G1
5.	Digital Multimeter (DMM)	46-194427P49
6.	TPS RF Service Interface Kit	46-301927G1
7.	Wattmeter Kit (optional)	46# not supplied

3-2 Initial Setup

DANGER!!

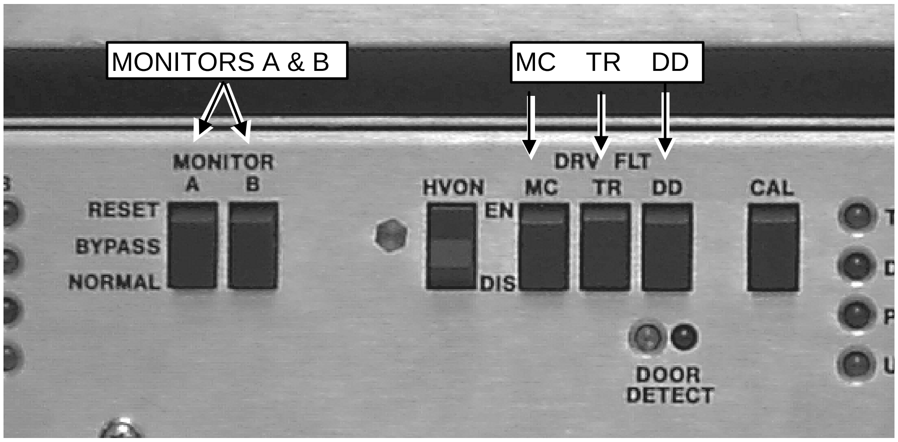
PROPERTY DAMAGE! PREVENT COIL AND ASSOCIATED SWITCH DAMAGE, BY REMOVING ALL PHANTOMS AND HARDWARE (I.E., HEAD COIL, SURFACE COIL...) FROM THE MAGNET BORE.

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

2. Remove the front and rear covers from the RF Cabinet.

3. See Illustration 3-1. 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 3-1

3-3 RF Hardware Quick Checks

This quick section should help the FE identify and isolate most problems inside the RF/PDU or SRF Cabinet. The instructions for hardware setup and waveform evaluation are included in each of the illustrations. More difficult problems may be beyond the scope of this quick check and may require more detailed troubleshooting processes. In these cases the FE can refer to either **Section 3-4 RF Amplifier Comparison Process Using the RF Power Measurement Kit** or, if a RF Power Measurement Kit is not available, **Section 3-5 RF Amplifier Comparison Process Using a Wattmeter or Oscilloscope**.

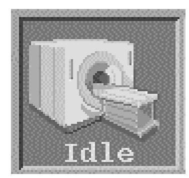
Note

The assumption is made, at this point, that the FE was directed to this section from the flowchart. In this case the FE has already viewed the RF output from the **J4 BODY OUTPUT** on the RFI using the procedure in either **1.5T RF/PDU MAX POWER RF OUT SETUP AND CALIBRATION (RC3SCA1.DOC)** or **1.5T SRF MAX POWER RF OUT SETUP AND CALIBRATION (RC5SCA1.DOC)**.

1. Verify that the system is not scanning.

DANGER!!

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

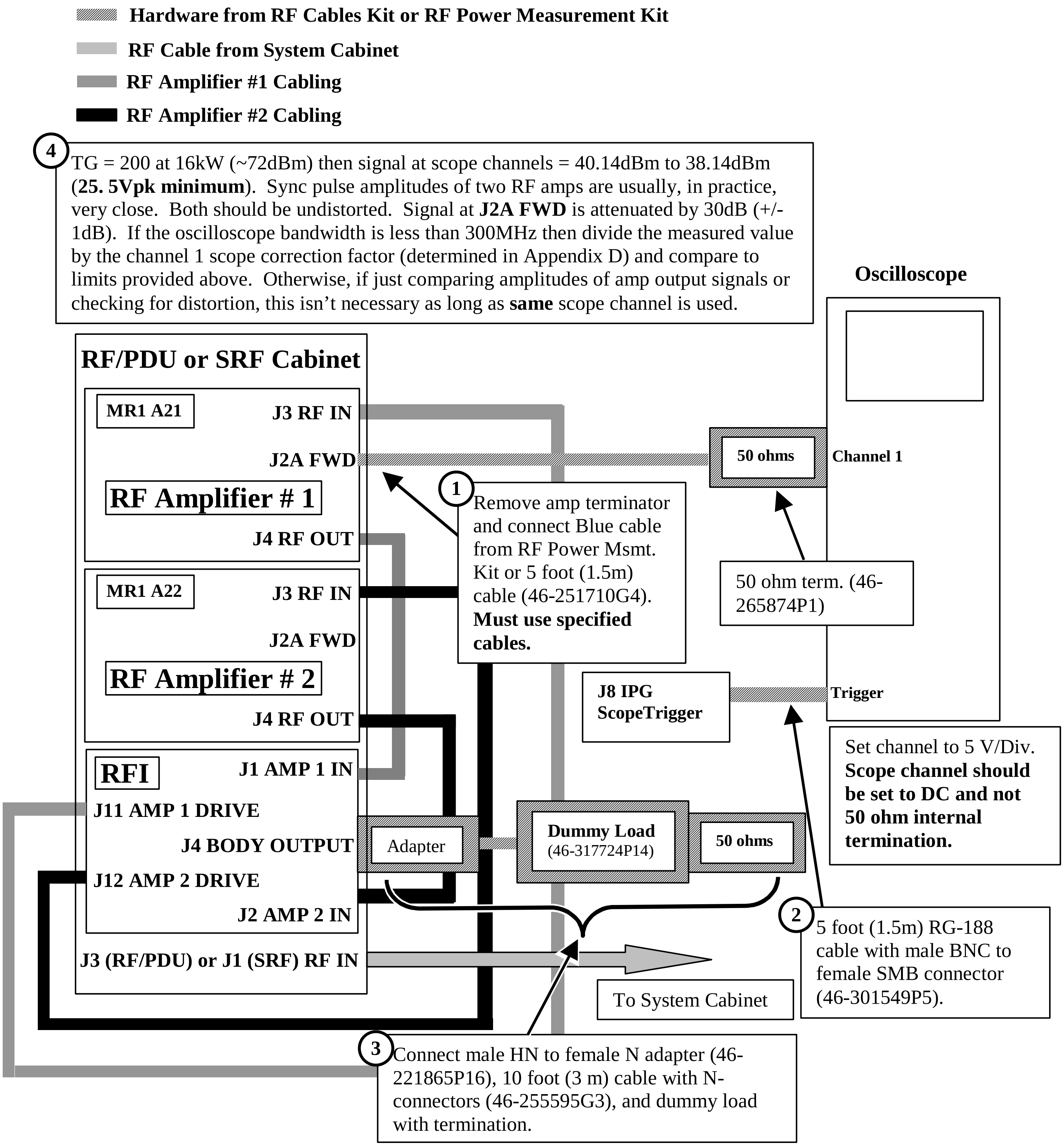


2. Confirm that the SSM power monitors and driver faults have already been bypassed as shown in **Section 3-2 Initial Setup**.

3. If an RF Power Measurement Kit is not available and the oscilloscope being used to take measurements has a bandwidth of less than 300MHz then make certain that the scope correction factor(s) has been determined for the input channel(s) to be used. The process for doing this is described in **APPENDIX D — CHARACTERIZATION FOR SCOPES WITH < 300 MHZ BANDWIDTH**.

3-3 RF Hardware Quick Checks (Continued)

4. Refer to Illustration 3-2 and configure the system in order shown to sample the RF output power directly from RF amplifier # 1 (upper-most RF amplifier in cabinet). Use the scan protocol provided in the next step.



SAMPLING OF RF AMPLIFIER #1 RF OUTPUT POWER
ILLUSTRATION 3-2

3-3 RF Hardware Quick Checks (Continued)

5. Prepare the system to scan in Body mode per Table 3-2 or refer to **APPENDIX A — ALTERNATE NON-SERVICE PROTOCOLS** (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 — ALTERNATE NON-SERVICE PROTOCOLS** for the non-proprietary protocol.

A. **[New Pt]**
   Id: **geservice<ENTER>**
   Name: **rf tests**
   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**.
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).

NOTE
Skip the next two steps if the system has Release 9.X, CNV4, or equivalent software. The software will set the ia_rf1 and ia_rf2 CV values automatically once the calmode CV Value is set equal to 5.

   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]**.

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

7. **[Manual Prescan] [Scan TR]**. View the RF output waveform on the oscilloscope.

CAUTION

If the problem is low and distorted RF output then verify NOW that the system center frequency is correct. Count the number if digits and confirm also that the center frequency consists of 8 digits. Center frequency is displayed without a decimal point and it is easy to omit a digit!

3-3 RF Hardware Quick Checks (Continued)

Note

If the amplifier faults with peak power errors during the following measurements before or when the TG reaches 200 then decrease the TG by 5 and select Start Scan key on the top of the keyboard. Next, increase the TG to the point just before where the amplifier was previously faulting.

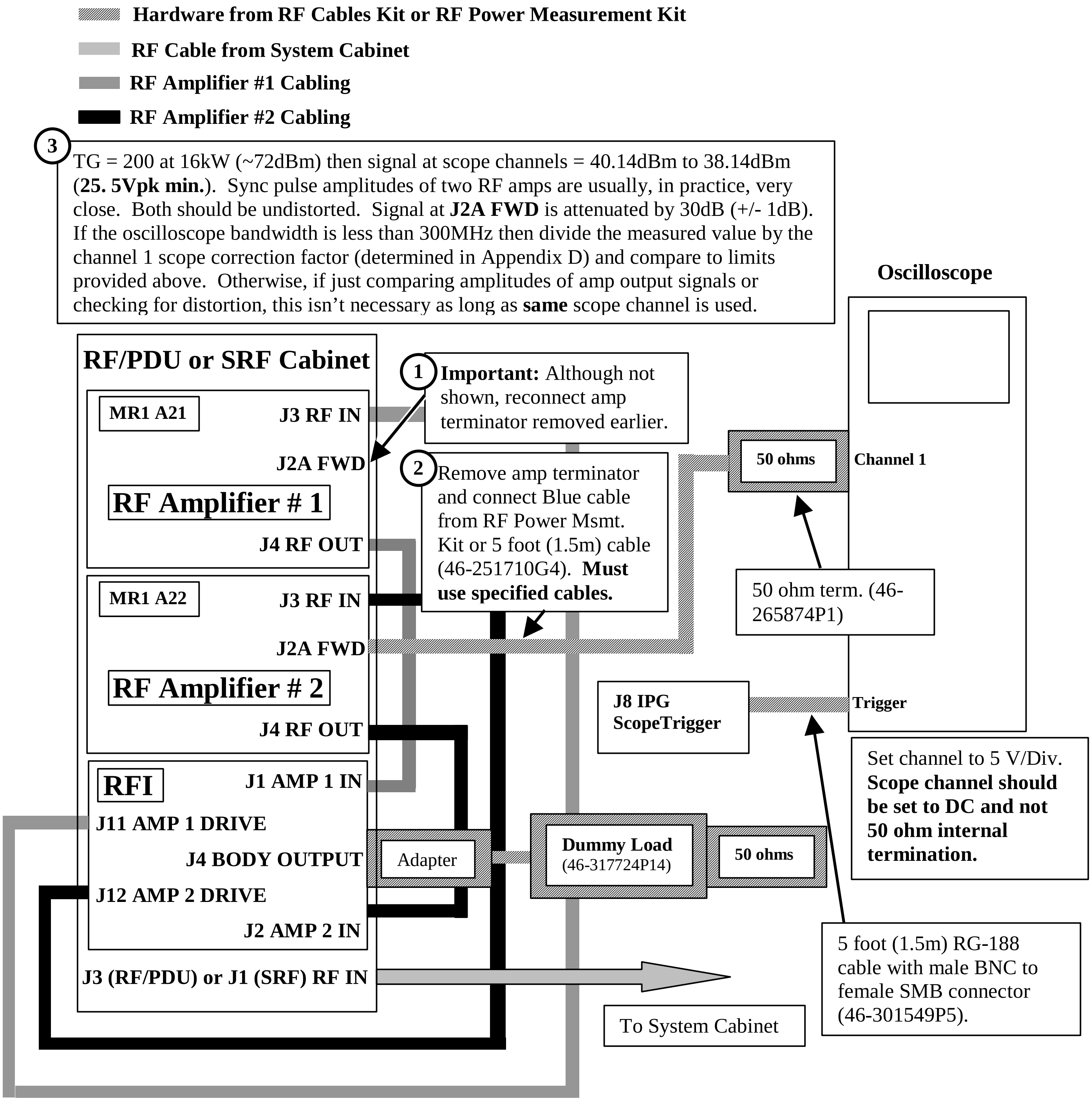
8. Slowly increase TG as high as it will go without faulting.

9. Measure the amplitude of the waveform on the oscilloscope face. Compare the result to the limits given in step 4 of Illustration 3-2.

10. Decrease TG to 0 (zero) and select **[Done]**.

3-3 RF Hardware Quick Checks (Continued)

11. Refer to Illustration 3-3 and configure the system in order shown to sample the RF output power directly from RF amplifier # 2 (bottom-most RF amplifier in cabinet).



SAMPLING OF RF AMPLIFIER #2 RF OUTPUT POWER
ILLUSTRATION 3-3

12. **[Manual Prescan] [Scan TR]**. View the RF output waveform on the oscilloscope.

3-3 RF Hardware Quick Checks (Continued)

Note

If the amplifier faults with peak power errors during the following measurements before or when the TG reaches 200 then decrease the TG by 5 and select Start Scan key on the top of the keyboard. Next, increase the TG to the point just before where the amplifier was previously faulting.

13. Slowly increase TG as high as it will go without faulting.

14. Measure the amplitude of the waveform on the oscilloscope face. Compare the result to the limits given in step 3 of Illustration 3-3.

15. Decrease TG to 0 (zero) and select **[Done]**.

16. If an RF Power Measurement Kit is available then calibrate the oscilloscope by referring to the RF Power Measurement Kit laminated card set.

    a. Look in the upper right corner of each card and find the card labeled **CAL**.

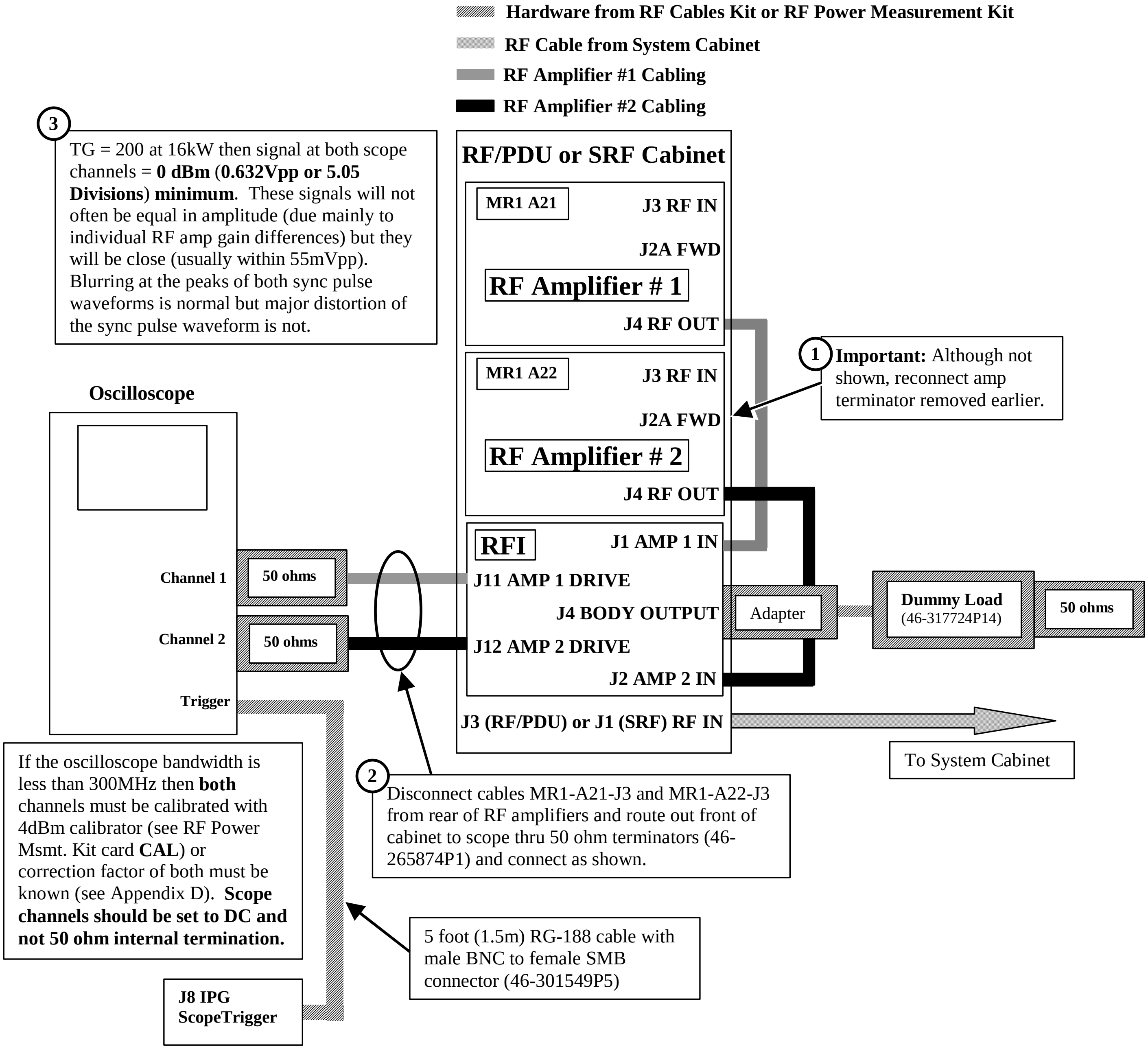
    b. Configure the scope as in the illustration on the card.

    c. Follow the directions on the card to calibrate the scope using the 4 dBm calibrator.

17. If not using the RF Power Measurement Kit but utilizing an oscilloscope of less than 300MHz bandwidth to take measurements, make certain that the scope correction factor(s) has been determined for the input channel(s) to be used. The process for doing this is described in **APPENDIX D — CHARACTERIZATION FOR SCOPES WITH < 300 MHZ BANDWIDTH**.

3-3 RF Hardware Quick Checks (Continued)

18. Refer to Illustration 3-4 and configure the system in order shown to sample the RF output power directly from the RF Interface Module (RFI).



SAMPLING RF OUTPUTS FROM RFI
ILLUSTRATION 3-4

19. **[Manual Prescan] [Scan TR]**. View the RF output waveform on the oscilloscope.

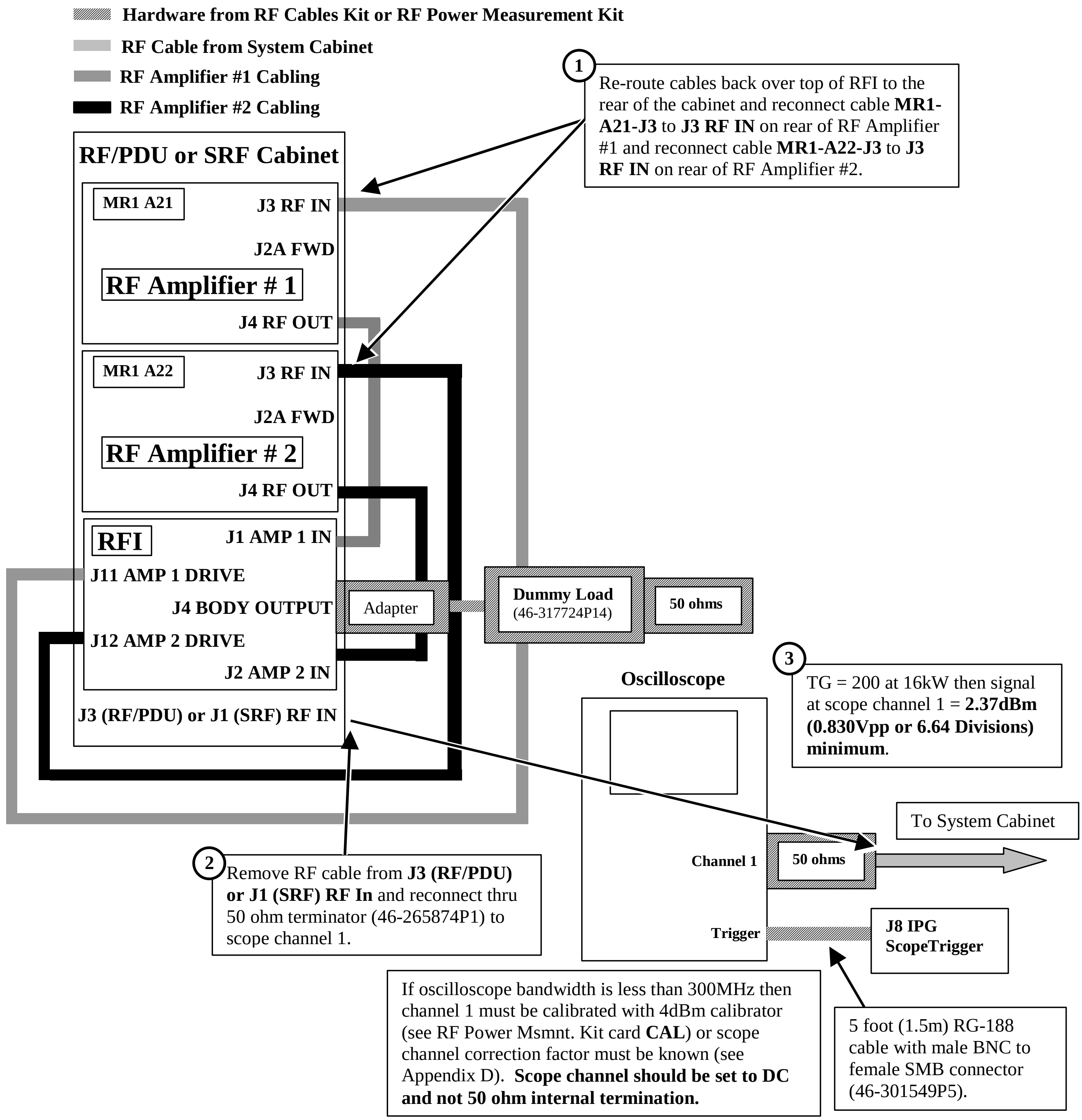
20. Increase TG to 200.

21. Measure the amplitude of the waveform on the oscilloscope face. Compare the result to the limits given in step 3 of Illustration 3-4.

3-3 RF Hardware Quick Checks (Continued)

22. Decrease TG to 0 (zero) and select **[Done]**.

23. Refer to Illustration 3-5 and configure the system in order shown to sample the RF output power at the RF/PDU or SRF Cabinet RF Input.



SAMPLING RF INPUT TO CABINET
ILLUSTRATION 3-5

3-3 RF Hardware Quick Checks (Continued)

24. **[Manual Prescan] [Scan TR]**. View the RF output waveform on the oscilloscope.

25. Increase TG to 200.

26. Measure the amplitude of the waveform on the oscilloscope face. Compare the result to the limits given in step 3 of Illustration 3-5.

27. Decrease TG to 0 (zero) and select **[Done]**.

28. If the problem was located and solved then refer to **SECTION 7 - SYSTEM RESTORATION**.

29. If this process did not help identify the failed component but the problem is still thought to reside in the RF/PDU or SRF Cabinet then more detailed checks will need to be made.

    a. If an RF Power Measurement Kit is available then refer to **Section 3-4 RF Amplifier Comparison Process Using the RF Power Measurement Kit**.

    b. If an RF Power Measurement Kit is not available then refer to **Section 3-5 RF Amplifier Comparison Process Using a Wattmeter or Oscilloscope.**

3-4 RF Amplifier Comparison Process Using the RF Power Measurement Kit

3-4-1 Calculating New Level

The expected output level printed on the bottom of the RF Power Measurement Kit Card **72** must be re-calculated since only a little more than half of the power from one amplifier is going to be measured. This is necessary due to the non-linear relationship between power and voltage and the fact that power is measured, when using the RF Power Measurement Kit, in divisions. It is important, for these reasons, to note that one-half of the rated output power (output when TG = 200) is NOT equivalent to one-half the value in divisions printed on card **72**.

1. Refer to the RF Power Measurement Kit reference card **72** (1.5T Body RF Output).

2. Locate the calibration sticker data affixed to the card and record the Scope Reading (**Scope Rdg**) value in divisions printed on the sticker in Table 3-3. See Illustration 3-6 for an example of what the calibration sticker looks like.

CAUTION

The data listed in the example will be different from what is printed on the calibration sticker affixed to the card in your kit. Do not use the data listed in the example.

1.5T BODY CARD # 72 CALIBRATION STICKER DATA
Card Number 46-317724PXX
Nominal: 72.00 dBm Attenuation: -68.41 dB Scope Power: 3.59 dBm **Scope Rdg:** 7.64 divisions

EXAMPLE CALIBRATION STICKER
ILLUSTRATION 3-6

3. Use the laptop calculator, a hand calculator, or access the LX system calculator by right mouse-clicking in the background and then selecting Calculator from the Root menu. Multiply the Scope Reading value (**Scope Rdg**) recorded in Table 3-3 by 0.732 and record the result in the Final Result column in the table. See the example in Table 3-3.

TABLE 3-3
SCOPE READING RE-CALCULATION

	Scope Reading	**Multiply by 0.732**	**Final Result**
	________divs	________divs ∗ 0.732 =	________divisions
Example ONLY	7.64 divisions	7.64 ∗ 0.732 =	<u>5.59 divisions</u>

3-4-1 Calculating New Level (Continued)

4. The Final Result value calculated in Table 3-3 is equivalent to 8.5kW (69.3 dBm) or a little more than one-half of the total rated RF output power from both amplifiers. A properly functioning RF amplifier receiving the correct amount of RF input power (at least 0 dBm) from the System Cabinet Exciter should be able to reach 8.5kW (69.3 dBm) with the TG set close to or at 200. Use this calculated Final Result value in place of that printed on the sticker on card **72** when checking the output power from **one** RF amplifier.

3-4-2 Measuring And Comparing RF Amplifier Power Output

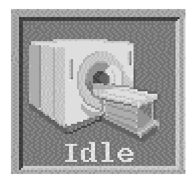
DANGER!!

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 J4 ON THE REAR OF THE RF AMPLIFIER BY VERIFYING THAT THE SYSTEM IS NOT MANUALLY PRESCANNING OR SCANNING. VERIFY THAT THE SCAN DESKTOP ICON DISPLAYS THE "IDLE" MESSAGE.



2. Confirm that the SSM power monitors and driver faults have already been bypassed as shown in **Section 3-2 Initial Setup**.

Note

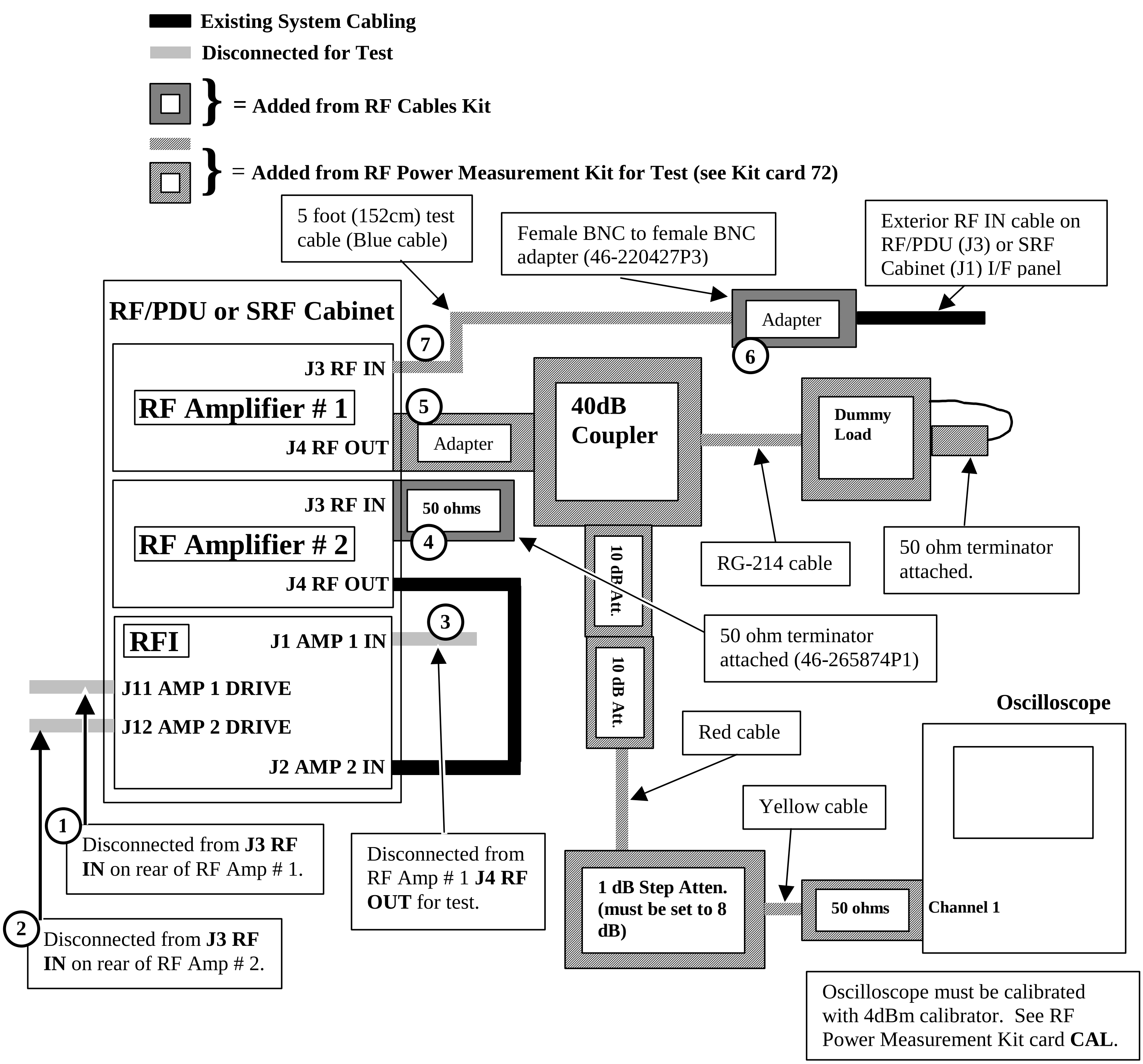
The 1.5T Analogic RF amplifiers are mounted vertically in the cabinet so that one is over the other. The top amplifier is, by convention, designated as amplifier # 1 while the amplifier below it is designated as amplifier # 2. Swapping all the cables from one amplifier to the other effectively swaps amplifier designations.

3. Calibrate the oscilloscope by referring to the RF Power Measurement Kit laminated card set.
   a. Look in the upper right corner of each card and find the card labeled **CAL**.
   b. Configure the scope as in the illustration on the card.
   c. Follow the directions on the card to calibrate the scope using the 4 dBm calibrator.
4. Refer to the RF Power Measurement Kit laminated card **72** and configure the hardware.
   a. Look in the upper, right corner of each card and find the card labeled **72** (1.5T Body Output).

3-4-2 Measuring And Comparing RF Amplifier Power Output (Continued)

b. Configure the RF Power Measurement Kit hardware as shown in the illustration on card **72,** but do not connect the hardware to RF Cabinet hardware. This will be done in the next step.

5. Refer to Illustration 3-7 and configure the system in order shown to measure the RF output power from RF amplifier # 1 (uppermost RF amplifier in cabinet).



CONNECTION DIAGRAM FOR MEASURING RF OUTPUT FROM RF AMPLIFIER # 1
ILLUSTRATION 3-7

3-4-2 Measuring And Comparing RF Amplifier Power Output (Continued)

6. Prepare the system to scan in Body mode per Table 3-4 or refer to **APPENDIX A — ALTERNATE NON-SERVICE PROTOCOLS** (Non-Proprietary protocol).

TABLE 3-4
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 — ALTERNATE NON-SERVICE PROTOCOLS** 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**.

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).

NOTE

Skip the next two steps if the system has Release 9.X, CNV4, or equivalent software. The software will set the ia_rf1 and ia_rf2 CV values automatically once the calmode CV Value is set equal to 5.

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]**.

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

8. **[Manual Prescan] [Scan TR]**. View the RF output waveform on the oscilloscope.

CAUTION

If the problem is low and distorted RF output then verify <u>NOW</u> that the system center frequency is correct. Count the number if digits and confirm also that the center frequency consists of 8 digits. Center frequency is displayed without a decimal point and it is easy to omit a digit!

3-4-2 Measuring And Comparing RF Amplifier Power Output (Continued)

Note

If the amplifier faults with peak power errors during the following measurements before or when the TG reaches 200 then decrease the TG by 5 and select **Start Scan** key on the top of the keyboard. Next, increase the TG to the point just before where the amplifier was previously faulting.

9. Slowly increase TG until either the amplitude of the RF waveform matches the final result value recorded in Table 3-2 or the TG reaches 200.

10. Confirm that the RF waveform viewed from the oscilloscope is not distorted or unstable.

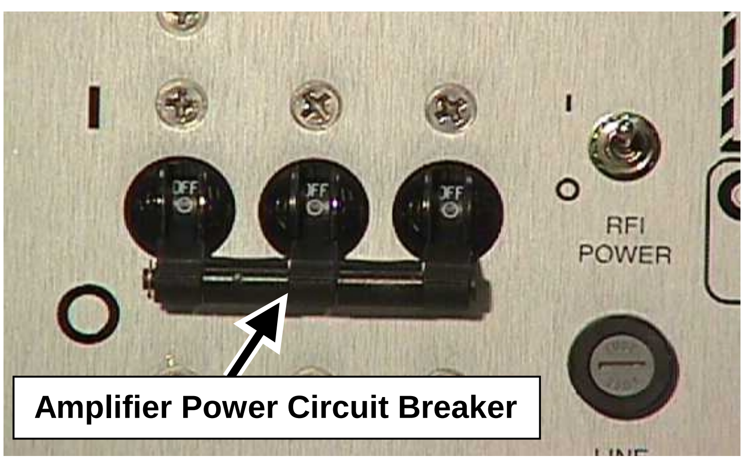
11. Record the TG and the RF output value measured from RF amplifier # 1 in Table 3-5. An RF amplifier in good working condition can, at the minimum, achieve at least 8.5kW (69.3 dBm) or the Final Result value, expressed in divisions, recorded earlier in Table 3-3.

TABLE 3-5
RF AMPLIFIERS POWER OUTPUT

Row	Port or Cable	TG	RF Output Power (in divisions)
1	**RF Amplifier # 1 J4 RF OUT**	_______	_____________
2	**RF Amplifier # 1 Output Cable**	**N/A**	_____________
3	**RF Amplifier # 2 J4 RF OUT**	_______	_____________
4	**RF Amplifier # 2 Output Cable**	**N/A**	_____________

12. Decrease TG to 0 (zero) and select **[Done]**.

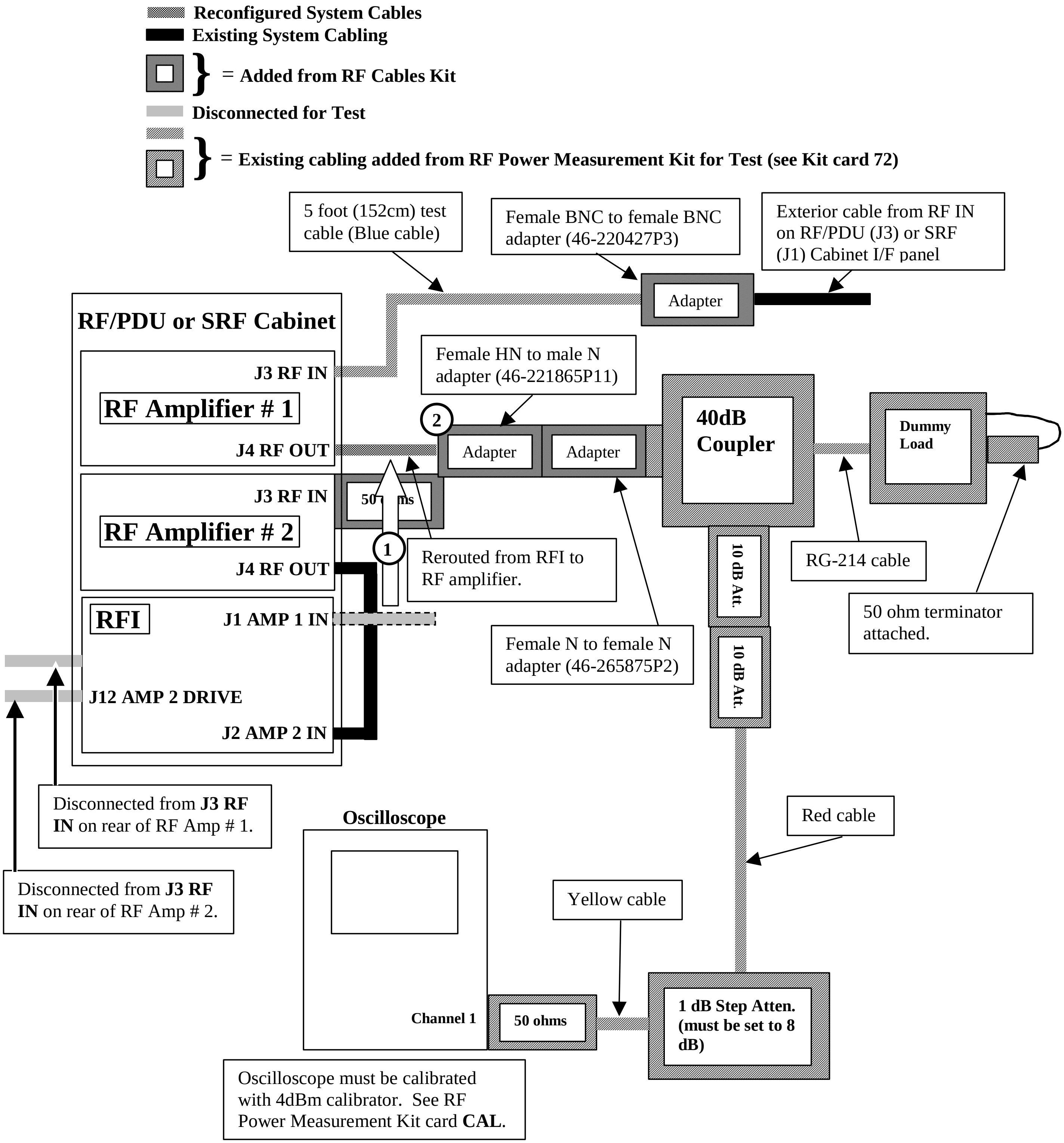
13. Locate the **AMPLIFIER POWER** circuit breaker on the front of the RFI and place this in the down (OFF) position. See Illustration 3-8.



RF AMPLIFIER POWER CIRCUIT BREAKER IN DOWN (OFF) POSITION
ILLUSTRATION 3-8

3-4-2 Measuring And Comparing RF Amplifier Power Output (Continued)

14. Refer to Illustration 3-9 and configure the system in order shown to check the functionality of the J4 RF OUT cable connected to RF amplifier # 1.



CONNECTION DIAGRAM FOR MEASURING RF POWER THROUGH RF OUTPUT CABLE ON AMPLIFIER # 1
ILLUSTRATION 3-9

3-4-2 Measuring And Comparing RF Amplifier Power Output (Continued)

15. Place the **AMPLIFIER POWER** circuit breaker on the front of the RFI in the up (ON) position.

Note

In the next step the system may report that the "RF amplifier is not ready" and not prescan. This is normal after cycling power to the RF amplifiers. Reselect **[Manual Prescan] [Scan TR]** and the system should begin prescanning.

16. **[Manual Prescan] [Scan TR]**. View the RF output waveform on the oscilloscope.

Note

If the amplifier faults with peak power errors during the following measurements before or when the TG reaches 200 then decrease the TG by 5 and select **Start Scan** key on the top of the keyboard. Next, increase the TG to the point just before where the amplifier was previously faulting.

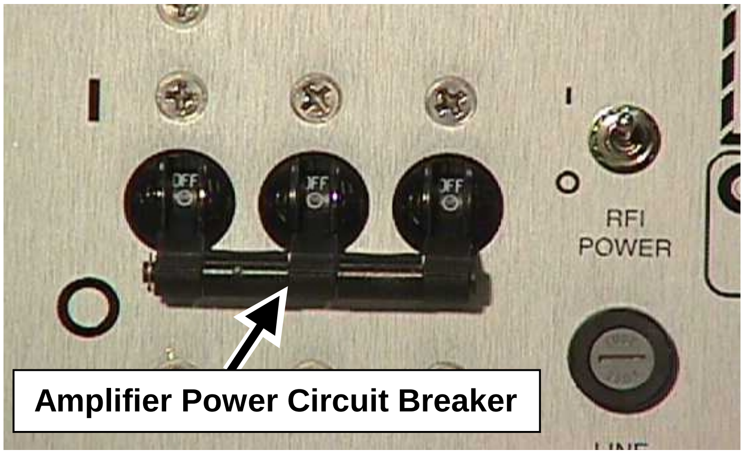
17. Slowly increase TG to the TG value recorded for RF amplifier #1 in the first row of Table 3-4.

18. Confirm that the RF waveform viewed from the oscilloscope is not distorted or unstable.

19. Record the RF output value measured through the RF output cable from RF amplifier # 1 in the second row of Table 3-5.

20. Decrease TG to 0 (zero) and select **[Done]**.

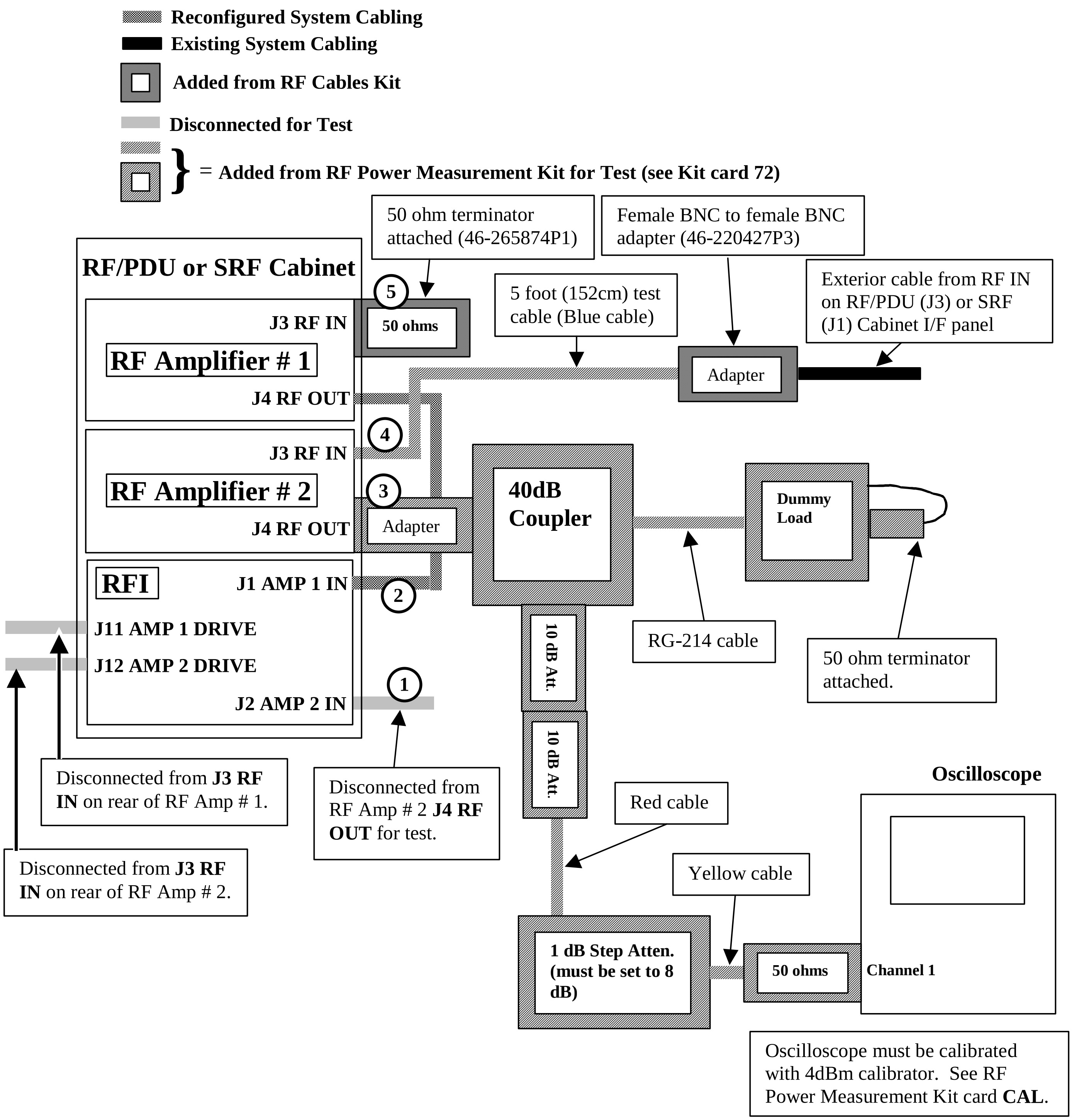
21. Locate the **AMPLIFIER POWER** circuit breaker on the front of the RFI and place this in the down (OFF) position. See Illustration 3-8.



RF AMPLIFIER POWER CIRCUIT BREAKER IN DOWN (OFF) POSITION
ILLUSTRATION 3-8

3-4-2 Measuring And Comparing RF Amplifier Power Output (Continued)

22. Refer to Illustration 3-9 and configure the system in order shown to measure the RF output power from RF amplifier # 2 (RF amplifier #2 is below RF amplifier #1 in cabinet).



CONNECTION DIAGRAM FOR MEASURING RF OUTPUT FROM RF AMPLIFIER # 2
ILLUSTRATION 3-9

3-4-2 Measuring And Comparing RF Amplifier Power Output (Continued)

23. Place the **AMPLIFIER POWER** circuit breaker on the front of the RFI in the up (ON) position.

Note

In the next step the system may report that the "RF amplifier is not ready" and not prescan. This is normal after cycling power to the RF amplifiers. Reselect **[Manual Prescan] [Scan TR]** and the system should begin prescanning.

24. **[Manual Prescan] [Scan TR]**. View the RF output waveform on the oscilloscope.

Note

If the amplifier faults with peak power errors during the following measurements before or when the TG reaches 200 then decrease the TG by 5 and select **Start Scan** key on the top of the keyboard. Next, increase the TG to the point just before where the amplifier was previously faulting.

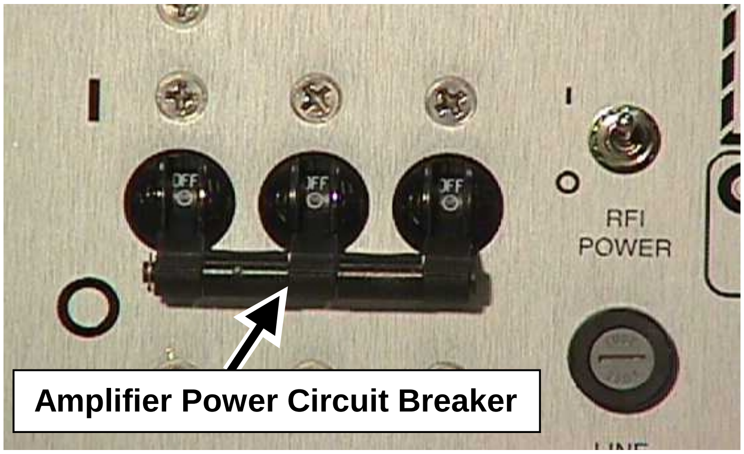
25. Slowly increase TG until either the amplitude of the RF waveform matches the final result value recorded in Table 3-3 or the TG reaches 200.

26. Confirm that the RF waveform viewed from the oscilloscope is not distorted or unstable.

27. Record the TG and the RF output value measured from RF amplifier # 2 in the third row of Table 3-5. An RF amplifier in good working condition can, at the minimum, achieve at least 8.5kW (69.3 dBm) or the Final Result value, expressed in divisions, recorded earlier in Table 3-3.

28. Decrease TG to 0 (zero) and select **[Done]**.

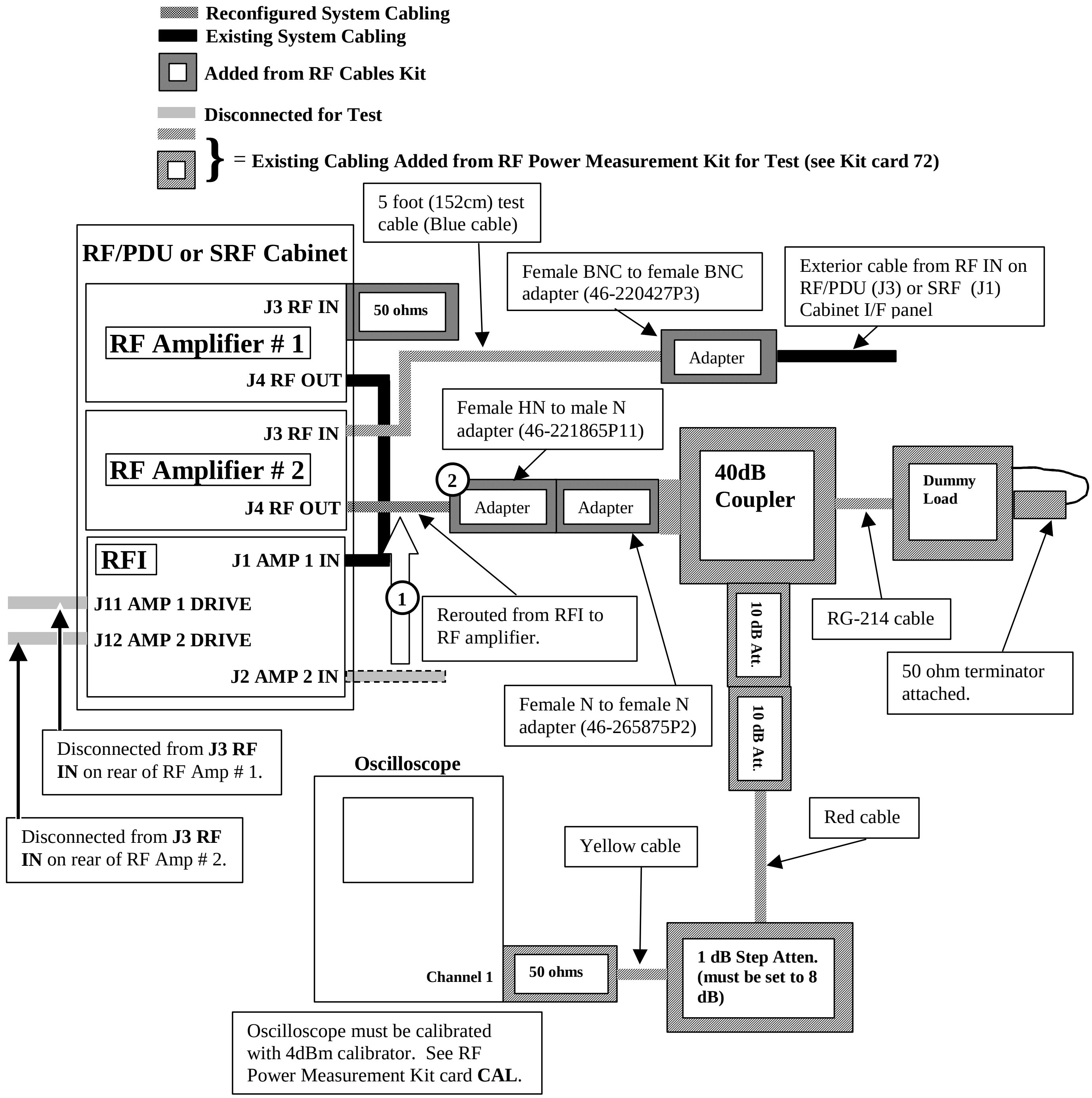
29. Locate the **AMPLIFIER POWER** circuit breaker on the front of the RFI and place this in the down (OFF) position. See Illustration 3-10.



RF AMPLIFIER POWER CIRCUIT BREAKER IN DOWN (OFF) POSITION
ILLUSTRATION 3-10

3-4-2 Measuring And Comparing RF Amplifier Power Output (Continued)

30. Refer to Illustration 3-11 and configure the system in order shown to check the functionality of the J4 RF OUT cable connected to RF amplifier # 2.



CONNECTION DIAGRAM FOR MEASURING RF POWER THROUGH RF OUTPUT CABLE ON AMPLIFIER # 2
ILLUSTRATION 3-11

31. Place the **AMPLIFIER POWER** circuit breaker on the front of the RFI in the up (ON) position.

3-4-2 Measuring And Comparing RF Amplifier Power Output (Continued)

Note

In the next step the system may report that the “RF amplifier is not ready” and not prescan. This is normal after cycling power to the RF amplifiers. Reselect **[Manual Prescan] [Scan TR]** and the system should begin prescanning.

32. **[Manual Prescan] [Scan TR]**. View the RF output waveform on the oscilloscope.

Note

If the amplifier faults with peak power errors during the following measurements before or when the TG reaches 200 then decrease the TG by 5 and select **Start Scan** key on the top of the keyboard. Next, increase the TG to the point just before where the amplifier was previously faulting.

33. Slowly increase TG to the TG value recorded for RF amplifier #2 in the third row of Table 3-5.
34. Confirm that the RF waveform viewed from the oscilloscope is not distorted or unstable.
35. Record the RF output value measured through the RF output cable from RF amplifier # 2 in the last row of Table 3-5.
36. Decrease TG to 0 (zero) and select **[Done] [End Exam].**
37. Compare the RF power output values recorded in Table 3-5.

CAUTION

Recalibrate the RF subsystem if any cables are replaced.

c. If the difference in RF output power between the 2 amplifiers (see first and third rows of Table 3-5) is less than 0.2 divisions (1 minor division) or less than 1 kW then both amplifiers are operating normally. Low, but equal, RF power output from both amplifiers indicates that the RF input signal power from the System Cabinet Exciter is low. This will be checked next in the flowchart.

d. If the waveform seen on the output of both amplifiers is distorted but looks the same on both then it is highly likely that both amplifiers are operating normally but that the RF input signal from the System Cabinet Exciter is distorted. This will be checked next in the flowchart.

e. If the difference between the 2 amplifiers is more than 0.2 divisions (1 minor division) or 1 kW or the RF output waveform from one of the RF amplifiers is distorted then it will be necessary to replace the RF amplifier with the low or distorted RF output.

3-4-2 Measuring And Comparing RF Amplifier Power Output (Continued)

f. The RF output power measured from J4 RF OUT on the RF amplifier should be equal to what was measured through the RF Output cable connected to J4 RF OUT on the same RF amplifier (compare the value in row 1 to that recorded in row 2 and compare the value recorded in row 3 to that recorded in row 4). Replace any faulty cables.

38. Proceed to **SECTION 7 - SYSTEM RESTORATION**.

3-5 RF Amplifier Comparison Process Using a Wattmeter or Oscilloscope

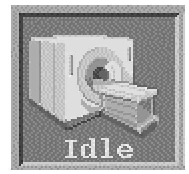
DANGER!!

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 J4 ON THE REAR OF THE RF AMPLIFIER BY VERIFYING THAT THE SYSTEM IS NOT MANUALLY PRESCANNING OR SCANNING. VERIFY THAT THE SCAN DESKTOP ICON DISPLAYS THE “IDLE” MESSAGE.



2. Confirm that the SSM power monitors and driver faults have already been bypassed as shown in **Section 3-2 Initial Setup**.

3. Complete the procedure in **APPENDIX C — DUMMY LOAD AND CABLES CALIBRATION**.

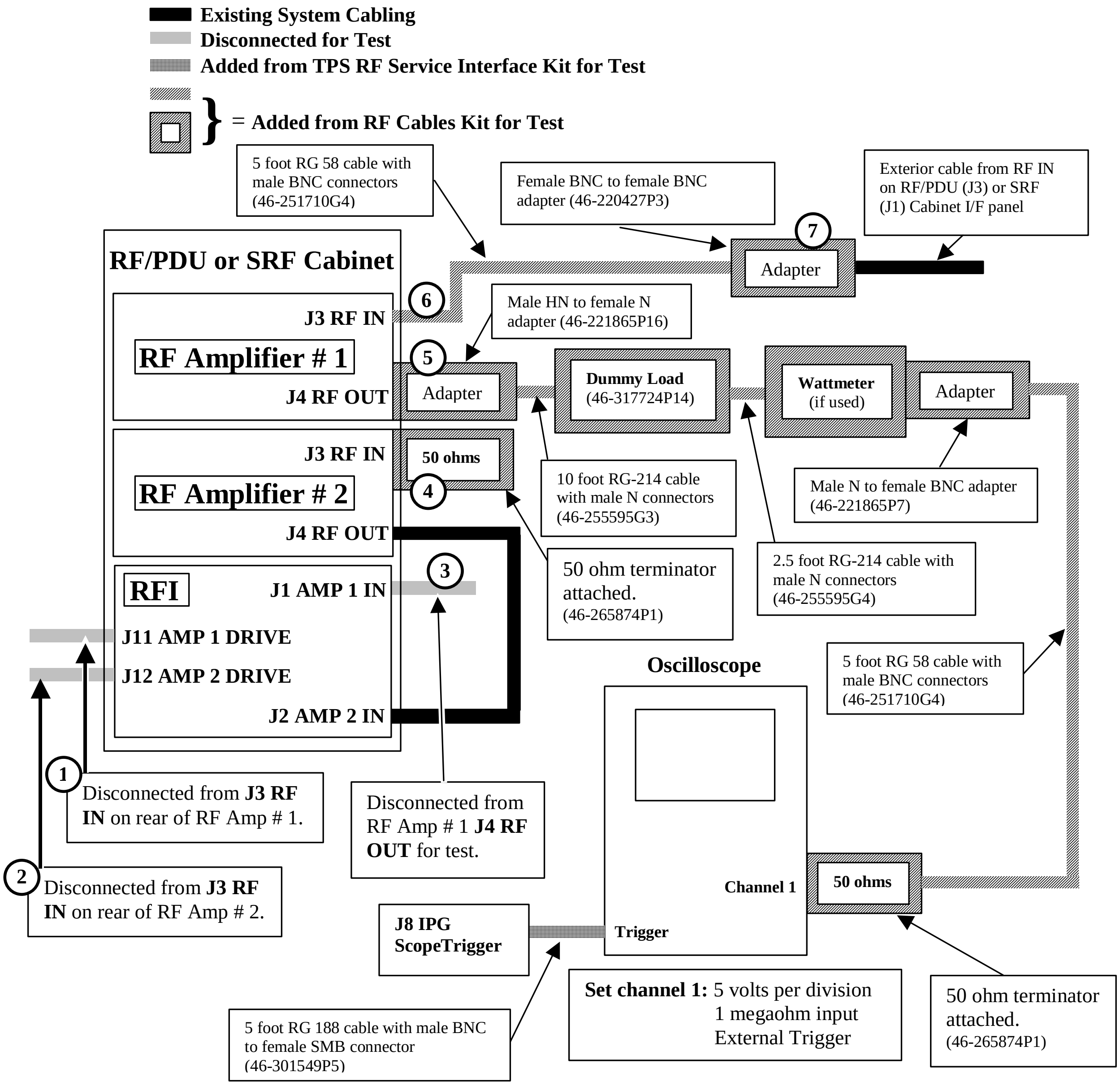
4. If using an oscilloscope to measure the RF output power instead of a wattmeter then make certain that the scope correction factor has been determined for the input channel to be used as described in **APPENDIX D — CHARACTERIZATION FOR SCOPES WITH < 300 MHZ BANDWIDTH**.

Note

The 1.5T Analogic RF amplifiers are mounted vertically in the cabinet so that one is over the other. The top amplifier is, by convention, designated as amplifier # 1 while the amplifier below it is designated as amplifier # 2. Swapping all the cables from one amplifier to the other effectively swaps amplifier designations.

3-5 RF Amplifier Comparison Process Using a Wattmeter or Oscilloscope (Continued)

4. Configure the system as shown in Illustration 3-12.



CONNECTION DIAGRAM FOR MEASURING RF OUTPUT FROM RF AMPLIFIER # 1
ILLUSTRATION 3-12

3-5 RF Amplifier Comparison Process Using a Wattmeter or Oscilloscope (Continued)

5. Prepare the system to scan in Body mode per Table 3-6 or refer to **APPENDIX A — ALTERNATE NON-SERVICE PROTOCOLS** (Non-Proprietary protocol).

TABLE 3-6
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 — ALTERNATE NON-SERVICE PROTOCOLS** 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**.

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).

NOTE

Skip the next two steps if the system has Release 9.X, CNV4, or equivalent software. The software will set the ia_rf1 and ia_rf2 CV values automatically once the calmode CV Value is set equal to 5.

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]**.

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

7. **[Manual Prescan] [Scan TR]**. View the RF output waveform on the oscilloscope.

CAUTION

If the problem is low and distorted RF output then verify <u>NOW</u> that the system center frequency is correct. Count the number if digits and confirm also that the center frequency consists of 8 digits. Center frequency is displayed without a decimal point and it is easy to omit a digit!

3-5 RF Amplifier Comparison Process Using a Wattmeter or Oscilloscope (Continued)

Note

If the amplifier faults with peak power errors during the following measurements before or when the TG reaches 200 then decrease the TG by 5 and select **Start Scan** key on the top of the keyboard. Next, increase the TG to the point just before where the amplifier was previously faulting.

8. **If using the wattmeter procedure** then increase the TG to 170. Read the wattmeter 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 C — DUMMY LOAD AND CABLES CALIBRATION**. Slowly increment the TG until either the RF output power level reaches 8.5kW (69.3 dBm) or the TG reaches 200.

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

9. **If using the oscilloscope procedure (NOT the RF Power Measurement Kit)** then increase the TG to 170. Read the peak voltage (Vpeak) from the scope display and use the formula below or the Power Calculator Tool (located at E:\rf\power\pwrcalc.htm on the Service Methods CD-ROM) to calculate the RF amplifier # 1 output power. The dummy load and cable loss factors were determined from the procedure in **APPENDIX C — DUMMY LOAD AND CABLES CALIBRATION**. The scope correction factor was determined in **APPENDIX D — CHARACTERIZATION FOR SCOPES WITH < 300 MHZ BANDWIDTH**. Slowly increment the TG until either the RF output power level reaches 8.5kW (69.3 dBm) or the TG reaches 200.

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

10. Confirm that the RF waveform viewed from the oscilloscope is not distorted or unstable.

3-5 RF Amplifier Comparison Process Using a Wattmeter or Oscilloscope (Continued)

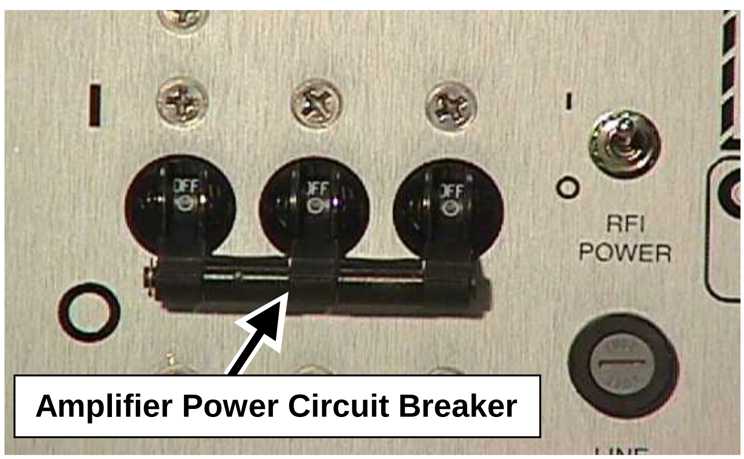
11. Record the RF output value measured from RF amplifier # 1 in Table 3-7. An RF amplifier in good working condition can, at the minimum, achieve at least 8.5kW (69.3 dBm).

TABLE 3-7
RF AMPLIFIERS POWER OUTPUT

Row	Port or Cable	TG	RF Output Power (in Watts)
1	RF Amplifier # 1 J4 RF OUT	______	____________
2	RF Amplifier # 1 Output Cable	N/A	____________
3	RF Amplifier # 2 J4 RF OUT	______	____________
4	RF Amplifier # 2 Output Cable	N/A	____________

12. Decrease TG to 0 (zero) and select **[Done]**.

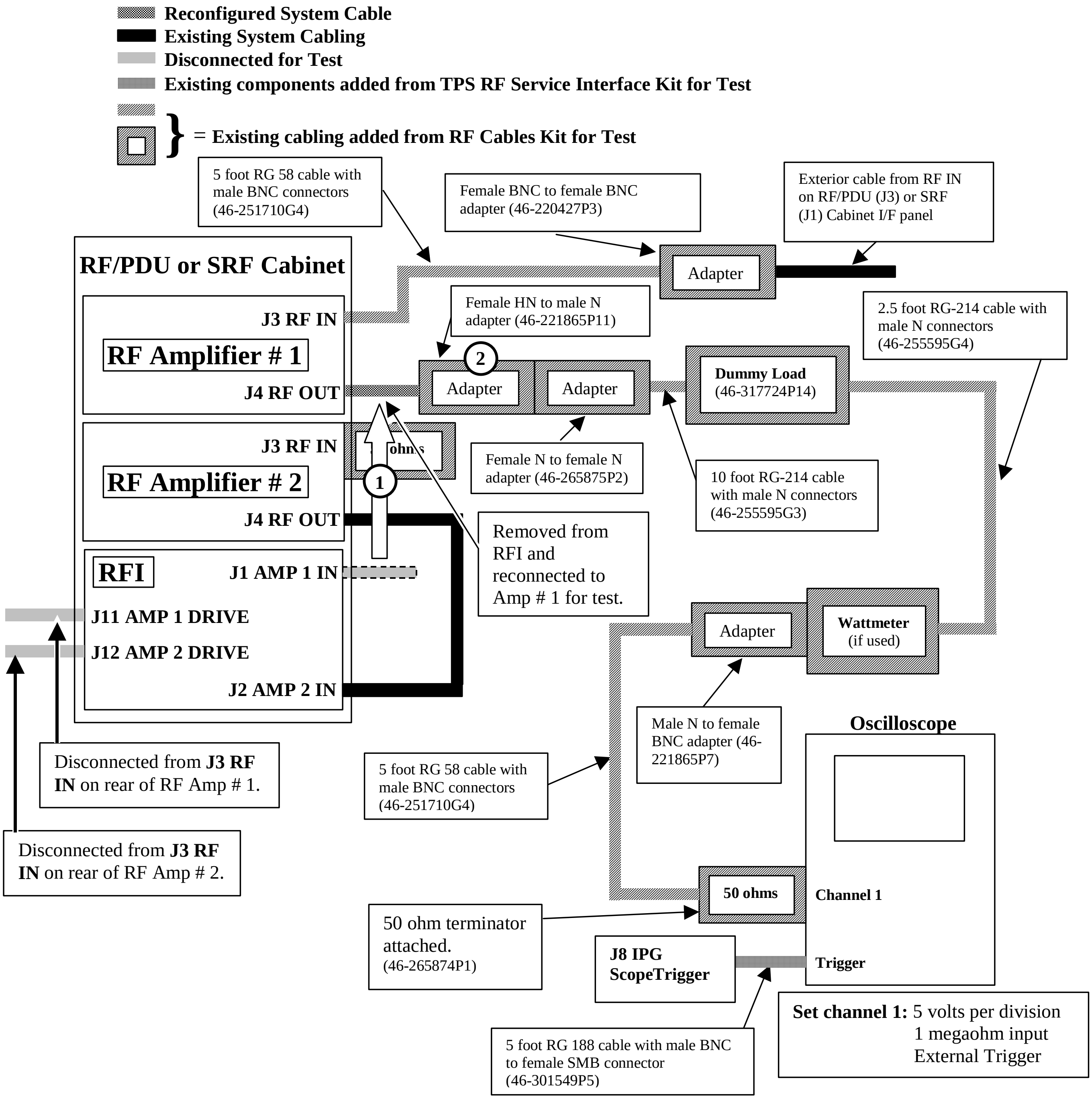
13. Locate the **AMPLIFIER POWER** circuit breaker on the front of the RFI and place this in the down (OFF) position. See Illustration 3-13.



RF AMPLIFIER POWER CIRCUIT BREAKER IN DOWN (OFF) POSITION
ILLUSTRATION 3-13

3-5 RF Amplifier Comparison Process Using a Wattmeter or Oscilloscope (Continued)

14. Refer to Illustration 3-14 and configure the system in order shown to check the functionality of the J4 RF OUT cable connected to RF amplifier # 1.



CONNECTION DIAGRAM FOR MEASURING RF POWER THROUGH RF OUTPUT CABLE ON AMPLIFIER # 1
ILLUSTRATION 3-14

3-5 RF Amplifier Comparison Process Using a Wattmeter or Oscilloscope (Continued)

15. Place the **AMPLIFIER POWER** circuit breaker on the front of the RFI in the up (ON) position.

Note

In the next step the system may report that the "RF amplifier is not ready" and not prescan. This is normal after cycling power to the RF amplifiers. Reselect **[Manual Prescan] [Scan TR]** and the system should begin prescanning.

16. **[Manual Prescan] [Scan TR]**. View the RF output waveform on the oscilloscope.

Note

If the amplifier faults with peak power errors during the following measurements before or when the TG reaches 200 then decrease the TG by 5 and select **Start Scan** key on the top of the keyboard. Next, increase the TG to the point just before where the amplifier was previously faulting.

17. **If using the wattmeter procedure** then increase the TG to the TG value recorded for RF amplifier #1 in the first row of Table 3-7. Read the wattmeter 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 C — DUMMY LOAD AND CABLES CALIBRATION**.

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

18. **If using the oscilloscope procedure (NOT the RF Power Measurement Kit)** then increase the TG to the TG value recorded for RF amplifier #1 in the first row of Table 3-7. Read the peak voltage (Vpeak) from the scope display and use the formula below or the Power Calculator Tool (located at E:\rf\power\pwrcalc.htm on the Service Methods CD-ROM) to calculate the RF amplifier # 1 output power. The dummy load and cable loss factors were determined from the procedure in **APPENDIX C — DUMMY LOAD AND CABLES CALIBRATION**. The scope correction factor was determined in **APPENDIX D — CHARACTERIZATION FOR SCOPES WITH < 300 MHZ BANDWIDTH**.

RF Power Measurment (in watts) Using Oscilloscope And Formula:

$$\frac{\left(\frac{\text{Vpeak}}{\text{scope correction factor}}\right)^2}{100} \;\mathbf{X}\; \text{dummy load and cable loss factor}$$

19. Confirm that the RF waveform viewed from the oscilloscope is not distorted or unstable.

20. Record the RF output value measured from RF amplifier # 1 in Table 3-7. An RF amplifier in good working condition can, at the minimum, achieve at least 8.5kW (69.3 dBm).

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

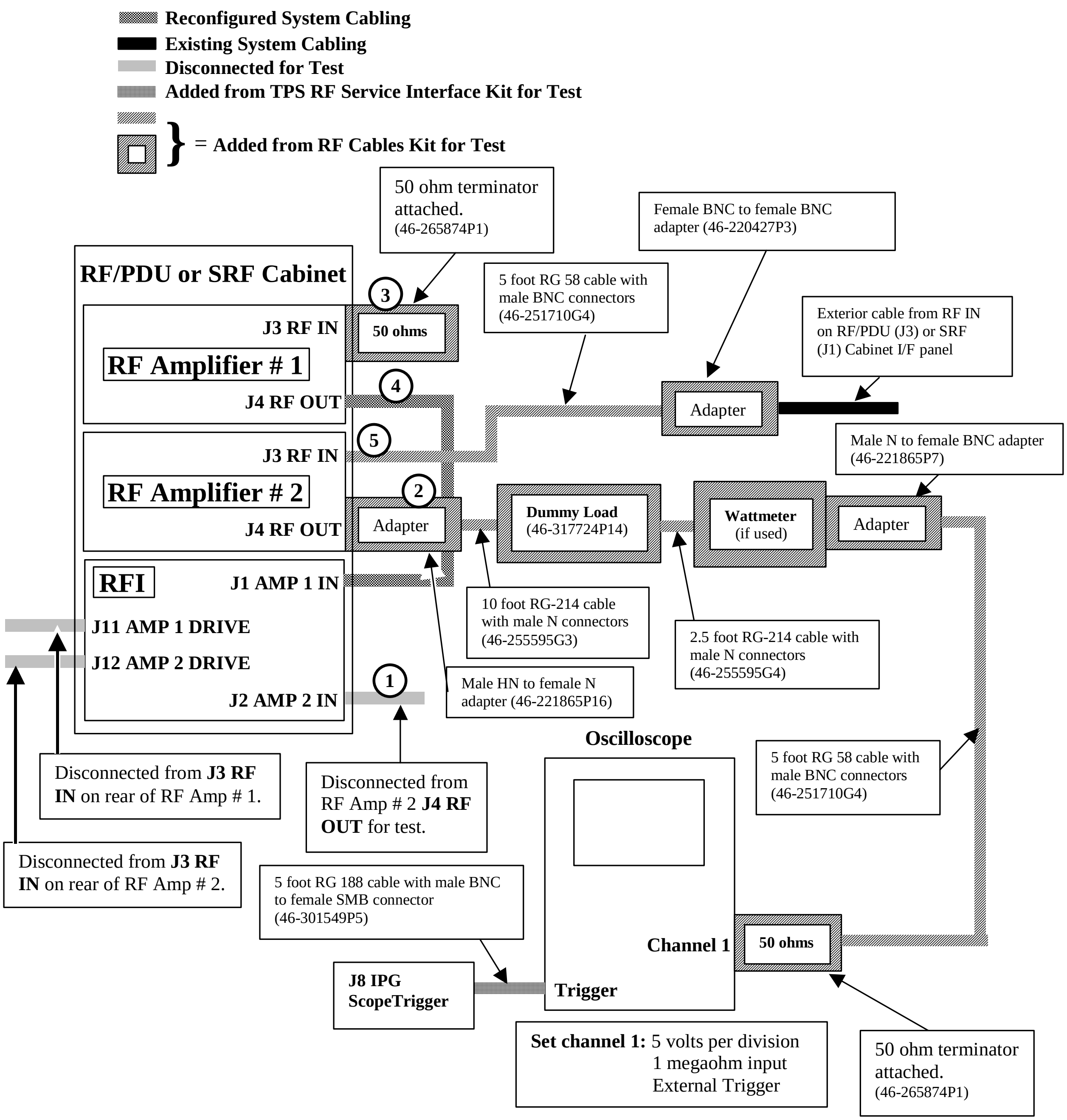
3-5 RF Amplifier Comparison Process Using a Wattmeter or Oscilloscope (Continued)

22. Locate the **AMPLIFIER POWER** circuit breaker on the front of the RFI and place this in the down (OFF) position.

23. Refer to Illustration 3-15 and configure the system in order shown to measure the RF output power from RF amplifier # 2 (RF amplifier #2 is below RF amplifier #1 in cabinet).

NOTE

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



CONNECTION DIAGRAM FOR MEASURING RF OUTPUT FROM RF AMPLIFIER # 2
ILLUSTRATION 3-15

3-5 RF Amplifier Comparison Process Using a Wattmeter or Oscilloscope (Continued)

24. Place the **AMPLIFIER POWER** circuit breaker on the front of the RFI in the up (ON) position.

Note

In the next step the system may report that the "RF amplifier is not ready" and not prescan. This is normal after cycling power to the RF amplifiers. Reselect **[Manual Prescan] [Scan TR]** and the system should begin prescanning.

25. **[Manual Prescan] [Scan TR]**. View the RF output waveform on the oscilloscope.

Note

If the amplifier faults with peak power errors during the following measurements before or when the TG reaches 200 then decrease the TG by 5 and select **Start Scan** key on the top of the keyboard. Next, increase the TG to the point just before where the amplifier was previously faulting.

26. **If using the wattmeter procedure** then increase the TG to 170. Read the wattmeter 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 C — DUMMY LOAD AND CABLES CALIBRATION**. Slowly increment the TG until either the RF output power level reaches 8.5kW (69.3 dBm) or the TG reaches 200.

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

27. **If using the oscilloscope procedure (NOT the RF Power Measurement Kit)** then increase the TG to 170. Read the peak voltage (Vpeak) from the scope display and use the formula below or the Power Calculator Tool (located at E:\rf\power\pwrcalc.htm on the Service Methods CD-ROM) to calculate the RF amplifier # 2 output power. The dummy load and cable loss factors were determined from the procedure in **APPENDIX C — DUMMY LOAD AND CABLES CALIBRATION**. The scope correction factor was determined in **APPENDIX D — CHARACTERIZATION FOR SCOPES WITH < 300 MHZ BANDWIDTH**. Slowly increment the TG until either the RF output power level reaches 8.5kW (69.3 dBm) or the TG reaches 200.

RF Power Measurment (in watts) Using Oscilloscope And Formula:
$\dfrac{\left(\dfrac{\text{Vpeak}}{\text{scope correction factor}}\right)^2}{100}$ **X** dummy load and cable loss factor

28. Confirm that the RF waveform viewed from the oscilloscope is not distorted or unstable.

29. Record the TG and RF output value measured from RF amplifier # 2 in the third row of Table 3-7. An RF amplifier in good working condition can, at the minimum, achieve at least 8.5kW (69.3 dBm).

3-5 RF Amplifier Comparison Process Using a Wattmeter or Oscilloscope (Continued)

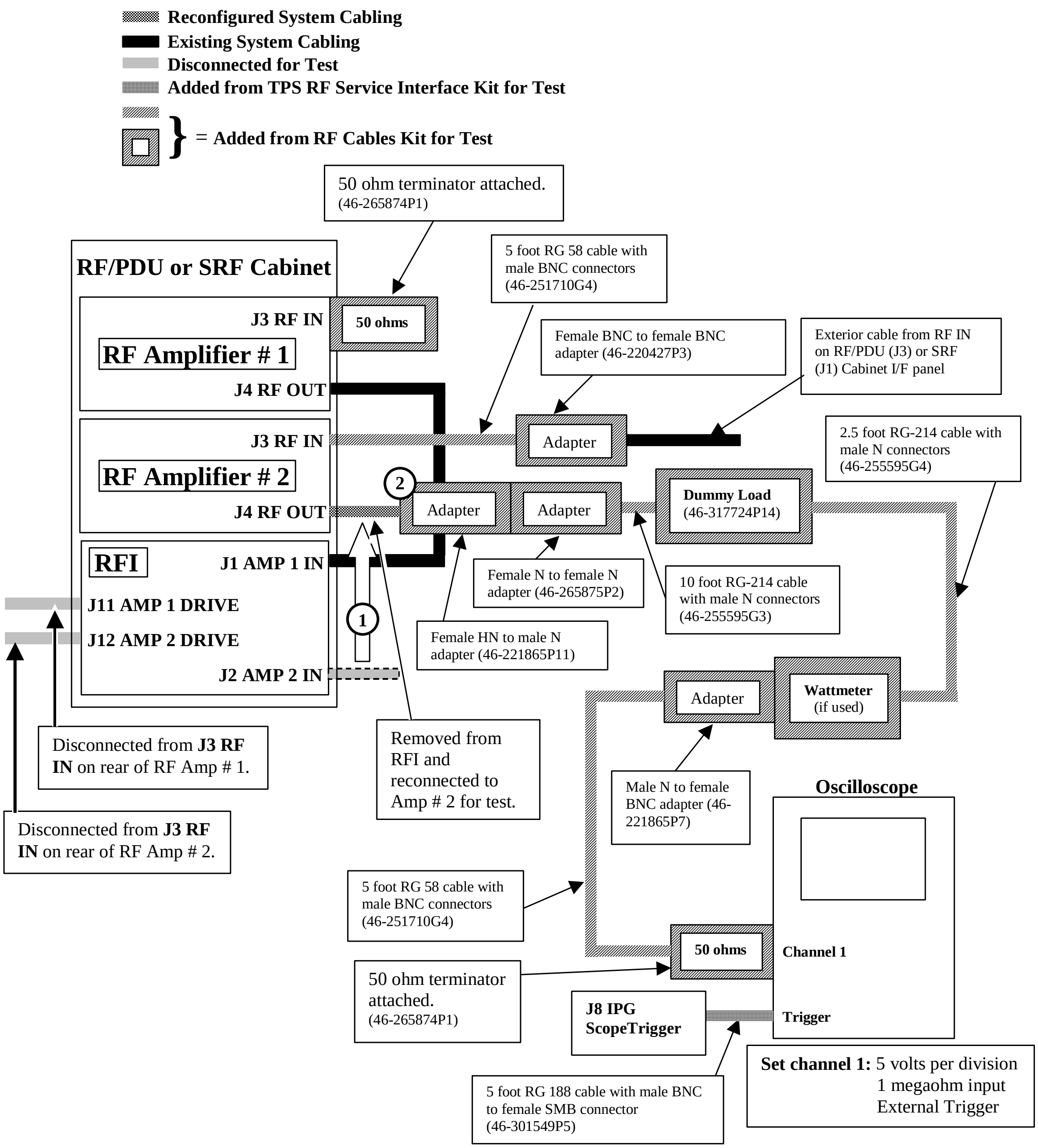
30. Decrease TG to 0 (zero) and select **[Done]**.

31. Locate the **AMPLIFIER POWER** circuit breaker on the front of the RFI and place this in the down (OFF) position.

32. Refer to Illustration 3-16 and configure the system in order shown to check the functionality of the J4 RF OUT cable connected to RF amplifier # 2.

NOTE

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



CONNECTION DIAGRAM FOR MEASURING RF POWER THROUGH RF OUTPUT CABLE ON AMPLIFIER # 2
ILLUSTRATION 3-16

3-5 RF Amplifier Comparison Process Using a Wattmeter or Oscilloscope (Continued)

33. Place the **AMPLIFIER POWER** circuit breaker on the front of the RFI in the up (ON) position.

Note

In the next step the system may report that the "RF amplifier is not ready" and not prescan. This is normal after cycling power to the RF amplifiers. Reselect **[Manual Prescan] [Scan TR]** and the system should begin prescanning.

34. **[Manual Prescan] [Scan TR]**. View the RF output waveform on the oscilloscope.

Note

If the amplifier faults with peak power errors during the following measurements before or when the TG reaches 200 then decrease the TG by 5 and select **Start Scan** key on the top of the keyboard. Next, increase the TG to the point just before where the amplifier was previously faulting.

35. **If using the wattmeter procedure** then increase the TG to the TG value recorded for RF amplifier #2 in the third row of Table 3-7. Read the wattmeter 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 C — DUMMY LOAD AND CABLES CALIBRATION**.

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

36. **If using the oscilloscope procedure (NOT the RF Power Measurement Kit)** then increase the TG to the TG value recorded for RF amplifier #2 in the third row of Table 3-7. Read the peak voltage (Vpeak) from the scope display and use the formula below or the Power Calculator Tool (located at E:\rf\power\pwrcalc.htm on the Service Methods CD-ROM) to calculate the RF amplifier # 1 output power. The dummy load and cable loss factors were determined from the procedure in **APPENDIX C — DUMMY LOAD AND CABLES CALIBRATION**. The scope correction factor was determined in **APPENDIX D — CHARACTERIZATION FOR SCOPES WITH < 300 MHZ BANDWIDTH**.

RF Power Measurment (in watts) Using Oscilloscope And Formula:
$\dfrac{\left(\dfrac{\text{Vpeak}}{\text{scope correction factor}}\right)^2}{100}$ **X** dummy load and cable loss factor

37. Confirm that the RF waveform viewed from the oscilloscope is not distorted or unstable.

38. Record the RF output value measured from RF amplifier # 2 in the fourth row of Table 3-7. An RF amplifier in good working condition can, at the minimum, achieve at least 8.5kW (69.3 dBm).

39. Decrease TG to 0 (zero) and select **[Done] [End Exam]**.

3-5 RF Amplifier Comparison Process Using a Wattmeter or Oscilloscope (Continued)

40. Compare the RF power output values recorded in Table 3-7.

CAUTION

Recalibrate the RF subsystem if any cables are replaced.

a. If the difference in RF output power between the 2 amplifiers (see first and third rows of Table 3-7) is less than 1 kW then both amplifiers are operating normally. Low, but equal, RF power output from both amplifiers indicates that the RF input signal power from the System Cabinet Exciter is low. This will be checked next in the flowchart.

b. If the waveform seen on the output of both amplifiers is distorted but looks the same on both then it is highly likely that both amplifiers are operating normally but that the RF input signal from the System Cabinet Exciter is distorted. This will be checked next in the flowchart.

c. If the difference between the 2 amplifiers is 1kW or more or the RF output waveform from one of the RF amplifiers is distorted then it will be necessary to replace the RF amplifier with the low or distorted RF output.

d. The RF output power measured from J4 RF OUT on the RF amplifier should be equal to what was measured through the RF Output cable connected to J4 RF OUT on the same RF amplifier (compare the value in row 1 to that recorded in row 2 and compare the value recorded in row 3 to that recorded in row 4). Replace any faulty cables.

41. Proceed to **SECTION 7 - SYSTEM RESTORATION**.

4 - (U)CERD EXCITER RF SIGNAL OUTPUT CHECK

A minimum RF signal level from the (U)CERD is required or else it will be impossible to meet the specified 16kW body and 2kW 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. Two methods are documented for doing this. The first, and easiest, method is described in **Section 4-2 Exciter RF Output Check Using The RF Power Measurement Kit.** This method involves using the RF Power Measurement Kit to measure and determine whether the RF signal from the (U)CERD exciter is in specification or not. The second method is described in **Section 4-3 Exciter RF Output Measurement Using an Oscilloscope.** This method involves using a properly characterized 100 MHz or greater bandwidth oscilloscope to measure the RF signal from the (U)CERD exciter and determine whether it is in specification or not.

4-1 Tools Required

TABLE 4-1
ITEMS NEEDED TO CHECK RF SIGNAL OUTPUT FROM (U)CERD

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

4-2 Exciter RF Output Check Using The RF Power Measurement Kit

More accurate measurements are made by using the RF Power Measurement Kit and a 100 MHz oscilloscope. The kit will compensate for any amplitude error due to the bandwidth limitation associated with using a 100 MHz scope. The 1.5T Scope Calibrator provides a 63.86 MHz sine wave at 1.00 VPP (4dBm).

1. Verify that the Bandwidth Limit button is <u>not</u> selected on the oscilloscope.

2. Verify the oscilloscope channel 1 is set to 1 Mega ohm input termination.

3. **If you are using the RF Power Measurement Kit** then calibrate the scope by referring to the RF Power Measurement Kit laminated card set.

Note
Only use an oscilloscope of 100 MHz bandwidth or greater.

   a. Look in the upper right corner of each card and find the card labeled **CAL**.

   b. Configure the scope as in the illustration on the card.

   c. Follow the directions on the card to calibrate the scope using the 4 dBm calibrator.

4-2 Exciter RF Output Check Using The RF Power Measurement Kit (Continued)

4. Prepare the system to scan in Body mode per Table 4-2 or refer to **APPENDIX A — ALTERNATE NON-SERVICE PROTOCOLS** (Non-Proprietary protocol).

TABLE 4-2
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 — ALTERNATE NON-SERVICE PROTOCOLS** for the non-proprietary protocol.

A. **[New Pt]**
   Id: **geservice<ENTER>**
   Name: **rf test**
   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**.
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).

NOTE
Skip the next two steps if the system has Release 9.X, CNV4, or equivalent software. The software will set the ia_rf1 and ia_rf2 CV values automatically once the calmode CV Value is set equal to 5.

   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. Disconnect the cable going to J14 on the front of the RFI.

6. Connect the cable through a female-BNC to female-BNC adapter to a known good length of 5 foot (152 cm) coax cable.

7. Connect the other end of the coax cable to the 50 ohm terminator connected to channel 1 on the scope.

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

4-2 Exciter RF Output Check Using The RF Power Measurement Kit (Continued)

Note

Understand that each of the 8 divisions on the scope face is composed of 5 minor divisions. Since 8 X 5 = 40 total minor divisions, count the number of individual minor divisions that the RF waveform spans. Since the input signal is small, minor divisions are used in place of divisions so that a more accurate scope measurement can be made. This is discussed in detail in Appendix B.

9. Confirm that the output through the test cable from the J14 cable is $\geq$ 25.28 **minor divisions**.

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

11. Reconnect the cable removed from J14 on the front of the RFI.

12. If the measured voltage meets the specification then the exciter is working properly and there is no need to continue with this procedure. Otherwise, continue with the next step.

13. Open the rear door of the RF Cabinet and from the inside of the cabinet disconnect the cable connecting to the female BNC feed-thru RF IN connector on the inside of the RF Cabinet I/F panel (J1 for SRF or J3 for RF/PDU).

14. Remove the female BNC to female BNC adapter from the 5 foot (152 cm) test cable and connect the test cable to the female BNC feed-thru RF IN connector on the inside of the RF Cabinet I/F panel (J1 for SRF or J3 for RF/PDU).

15. Connect the other end of the 5 foot (152 cm) test cable to channel 1 on the scope.

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

17. Confirm that the output through the test cable from the J3 RF IN connector is $\geq$ 25.28 **minor divisions**.

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

CAUTION

Recalibrate the RF subsystem if any cables are replaced.

19. If the measured voltage now meets the specification then the cable that interconnects RF IN on the inside of the RF Cabinet I/F panel (J1 for SRF or J3 for RF/PDU) to J14 on the front of the RFI appears bad. Repair or replace this cable.

20. Remove the test cable from the female BNC RF IN connector on the inside of the RF Cabinet I/F panel (J1 for SRF or J3 for RF/PDU).

21. Reconnect the cable removed earlier to the RF IN connector on the inside of the RF Cabinet I/F panel (J1 for SRF or J3 for RF/PDU).

4-2 Exciter RF Output Check Using The RF Power Measurement Kit (Continued)

22. Disconnect the cable going to J1 on the rear of the System Cabinet and connect to J1 a known good coax test cable 5 foot (152 cm) 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.

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

24. Read the peak to peak size of the waveform in divisions and then confirm that it is $\geq$ 35.7 **minor divisions**.

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

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

CAUTION

Recalibrate the RF subsystem if any cables are replaced.

27. If the measured voltage meets the specification then check the female BNC to female BNC adapter on the RF Cabinet I/F panel for damage. Also check the cable interconnecting J1 on the System Cabinet to RF In on the exterior of the RF Cabinet (J1 for SRF or J3 for RF/PDU) for poor connections or damage.

28. Remove connector from J109 on the bottom, front of the CERD.

29. 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 CERD, marked EXC RF OUT.

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

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

32. Read the peak to peak size of the waveform in divisions and then confirm that it is $\geq$ 35.7 **minor divisions**.

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

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

35. Only consider replacing the exciter if the output is below the specification **AND** the body RF output power cannot be adjusted to meet the 16 kW specification. Otherwise, check the System Cabinet RF cabling and connectors.

36. Proceed to **SECTION 7 - SYSTEM RESTORATION**.

4-3 Exciter RF Output Measurement Using an Oscilloscope

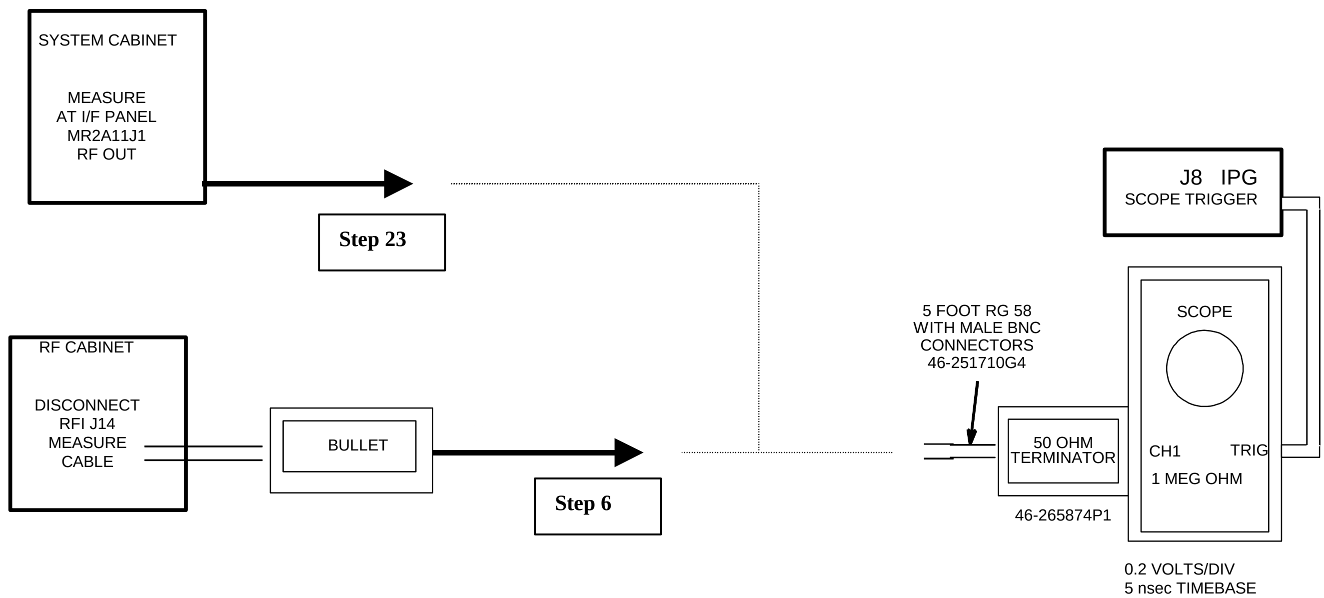
Note

Please read the following if you do not have an RF Power Measurement Kit and you are going to attempt to measure the exciter output directly with a 100 MHz oscilloscope. Be aware that, due to oscilloscope bandwidth limitations, an exciter RF voltage reading at 63.86 MHz taken directly from a 50 ohm terminated 100 MHz oscilloscope input channel can be as much as 16% less than the actual exciter RF output voltage level. This error is accounted for, and is not a problem, when using the oscilloscope in conjunction with the RF Power Measurement Kit. Reading *reasonably* accurate 63.86 MHz voltage levels directly from a 100 MHz oscilloscope *without* using the RF Power Measurement Kit requires one to know the correction factor of the scope channel being used. This is so that the approximate true RF voltage level can be calculated. The FE can request that the 63.86 MHz correction factor for each channel be determined and reported by the metrology lab the next time the oscilloscope is returned for calibration or, if the FE has access to the 4dBm (1 Vpp) oscilloscope calibrator tool used in the RF Power Measurement Kit, he can determine this correction factor himself. See **APPENDIX D — CHARACTERIZATION FOR SCOPES WITH < 300 MHZ BANDWIDTH** for more information concerning the derivation of the correction factor. Divide the Vpp value read from the oscilloscope by the correction factor to determine the approximate true RF voltage level value. The simple formula is as follows:

$$\frac{\text{Measured Vpeak to peak}}{\text{Correction factor}} = \textbf{Approximate True RF Voltage Value}$$

4-3 Exciter RF Output Measurement Using an Oscilloscope (Continued)

1. Connect the oscilloscope to the system hardware as per Illustration 4-1. 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 ≥ 300 MHZ OR CHARACTERIZED 100 MHZ SCOPE
ILLUSTRATION 4-1

2. Ensure that channel 1 is terminated with a known good (measure with a DMM before using) 50 ohm feed-through terminator.

3. Disconnect the cable going to J14 on the front of the RFI.

4. Connect the cable through a female-BNC to female-BNC adapter to a known good length of 5 foot (152 cm) coax cable.

5. Connect the other end of the coax cable to the 50 ohm terminator connected to channel 1 on the scope.

4-3 Exciter RF Output Measurement Using an Oscilloscope (Continued)

6. Prepare the system to scan in Body mode per Table 4-3 or refer to **APPENDIX A — ALTERNATE NON-SERVICE PROTOCOLS** (Non-Proprietary protocol).

TABLE 4-3
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 — ALTERNATE NON-SERVICE PROTOCOLS** 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**.
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).

NOTE

Skip the next two steps if the system has Release 9.X, CNV4, or equivalent software. The software will set the ia_rf1 and ia_rf2 CV values automatically once the calmode CV Value is set equal to 5.

 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]**.

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

8. Measure the amplitude of the waveform on the scope.

   a. If using a scope with a bandwidth of 300 MHz or greater then read the peak to peak voltage from the scope face and confirm that it is $\geq$ 0.815 Vpp (2.21dBm).

4-3 Exciter RF Output Measurement Using an Oscilloscope (Continued)

b. If using a < 300 MHz scope read the peak to peak voltage from the scope face and then, *using the correction factor for the scope channel in use*, calculate the approximate true RF voltage value by using the formula below. Confirm that the approximate true RF voltage value is $\geq$ 0.815 Vpp (2.21 dBm).

$$\frac{\text{Measured Vpeak to peak}}{\text{Correction factor}} = \textbf{Approximate True RF Voltage Value}$$

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

10. Reconnect the cable removed from J14 on the front of the RFI.

11. If the measured voltage meets the specification then the exciter is working properly and there is no need to continue with this procedure. Otherwise, continue with the next step.

12. Open the rear door of the RF Cabinet and from the inside of the cabinet disconnect the cable connecting to the female BNC RF IN feed-thru connector on the inside of the RF Cabinet I/F panel (J1 for SRF or J3 for RF/PDU).

13. Remove the female BNC to female BNC adapter from the 5 foot (152 cm) test cable and connect the test cable to the female BNC RF IN feed-thru connector on the inside of the RF Cabinet I/F panel (J1 for SRF or J3 for RF/PDU).

14. Connect the other end of the 5 foot (152 cm) test cable to channel 1 on the scope.

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

16. Measure the amplitude of the waveform on the scope.

a. If using a scope with a bandwidth of 300 MHz or greater then read the peak to peak voltage from the scope face and confirm that it is $\geq$ 0.815 Vpp (2.21 dBm).

b. If using a < 300 MHz scope read the peak to peak voltage from the scope face and then, *using the correction factor for the scope channel in use*, calculate the approximate true RF voltage value by using the formula below. Confirm that the approximate true RF voltage value is $\geq$ 0.815 Vpp (2.21 dBm).

$$\frac{\text{Measured Vpeak to peak}}{\text{Correction factor}} = \textbf{Approximate True RF Voltage Value}$$

CAUTION

Recalibrate the RF subsystem if any cables are replaced.

17. If the measured voltage now meets the specification then the cable that interconnects J3 RF IN on the inside of the RF Cabinet I/F panel and J14 on the front of the RFI appears bad. Repair or replace this cable.

4-3 Exciter RF Output Measurement Using an Oscilloscope (Continued)

18. Remove the test cable from the female BNC RF IN feed-thru connector on the inside of the RF Cabinet I/F panel (J1 for SRF or J3 for RF/PDU).

19. Reconnect the cable removed earlier to the BNC RF IN feed-thru connector on the inside of the RF Cabinet I/F panel (J1 for SRF or J3 for RF/PDU).

20. Disconnect the cable going to J1 on the rear of the System Cabinet and connect to J1 a known good coax test cable 5 foot (152 cm) 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.

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

22. Measure the amplitude of the waveform on the scope.

    a. If using a 300 MHz bandwidth or greater scope then read the peak to peak voltage from the scope face and confirm that it is 0.893 to 1.12 Vpp (3.0 dBm to 5.0 dBm). A voltage level exceeding the 1.12 Vpp (5.0 dBm) typical upper limit is generally not a cause for concern.

    b. If using a < 300 MHz bandwidth scope read the peak to peak voltage from the scope face and then, *using the correction factor for the scope channel in use*, calculate the approximate true RF voltage value by using the formula in step 6 and confirm that the approximate true RF voltage value is $\geq$ 0.893 Vpp (3.0 dBm).

$$\frac{\text{Measured Vpeak to peak}}{\text{Correction factor}} = \textbf{Approximate True RF Voltage Value}$$

CAUTION

Recalibrate the RF subsystem if any cables are replaced.

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

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

25. Check for poor connections in the cabling or connectors between the System Cabinet and RF Cabinet if the voltage measured at J1 on the rear of the System Cabinet meets specification.

26. Remove connector from J109 on the bottom, front of the CERD.

27. 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 CERD, marked EXC RF OUT.

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

4-3 Exciter RF Output Measurement Using an Oscilloscope (Continued)

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

30. Measure the amplitude of the waveform on the scope.

    a. If using a 300 MHz bandwidth or greater scope then read the peak to peak voltage from the scope face and confirm that it is 0.893 to 1.12 Vpp (3.0 dBm to 5.0 dBm). A voltage level exceeding the 1.12 Vpp (5.0 dBm) typical upper limit is generally not a cause for concern.

    b. If using a < 300 MHz bandwidth scope read the peak to peak voltage from the scope face and then, *using the correction factor for the scope channel in use*, calculate the approximate true RF voltage value by using the formula in step 6 and confirm that the approximate true RF voltage value is $\geq$ 0.893 Vpp (3.0 dBm).

$$\frac{\text{Measured Vpeak to peak}}{\text{Correction factor}} = \textbf{Approximate True RF Voltage Value}$$

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

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

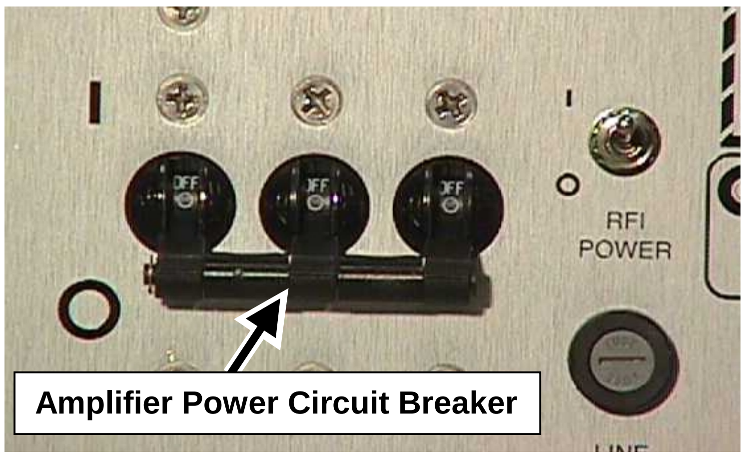
33. Only consider replacing the exciter if the output is below the specification **AND** the body RF output power cannot be adjusted to meet the 16 kW specification. Otherwise, check the System Cabinet RF cabling and connectors.

34. Proceed to **SECTION 7 - SYSTEM RESTORATION**.

5 - CHECKING RF CABINET CABLES

This section will check the condition of the low-power RF coaxial cables in the RF/PDU or SRF Cabinet. The high-power RF output cables were checked in **Section 3-4-2 Measuring And Comparing RF Amplifier Power Output** or **Section 3-5 RF Amplifier Comparison Process Using a Wattmeter or Oscilloscope**. Most cable problems result from poorly attached or damaged connectors. Unless the cable was damaged in some type of accident, it is very unusual for failures to occur anywhere else along the length of the cable.

1. Locate the **AMPLIFIER POWER** circuit breaker on the front of the RFI and place this in the down (OFF) position. See Illustration 5-1.



RF AMPLIFIER POWER CIRCUIT BREAKER IN DOWN (OFF) POSITION
ILLUSTRATION 5-1

2. Obtain a Digital Voltmeter (DVM) and set it so that a 50 ohm load can be accurately measured.

3. Obtain a 50 ohm terminator (46-265874P1) from an RF cables kit or the RF Power Measurement Kit.

4. Measure the female BNC end of the 50 ohm terminator with the DVM and record the result in Table 5-1.

TABLE 5-1
MEASURED RESISTANCE OF 50 OHM TERMINATOR

Resistance	________ ohms

5. Remove the cable connected to **J11 AMP 1 DRIVE** on the front of the RFI.

6. Visually inspect the BNC connector on the cable for evidence of damage.

   a. Check for poor cable crimps and confirm that the interface between the connector and cable isn't loose or worn.

   b. Confirm that the BNC center pins on both cables are not loose or broken and that neither are recessed too far into the connector.

5 - CHECKING RF CABINET CABLES (CONTINUED)

c. Replace or repair any damaged cables.

CAUTION

Recalibrate the RF subsystem if any cables are replaced.

7. Set the cable aside.

8. From the rear of the RF/PDU or SRF Cabinet remove the cable connected to the female BNC connector on the rear of RF amplifier # 1 labeled **J3 RF Input**.

9. Repeat step 6 and inspect the cable connector.

10. Connect the female BNC end (the end where the measurement was earlier taken) of the 50 ohm terminator to this end of the cable.

11. At the front of the RF/PDU or SRF Cabinet measure the resistance between the BNC connector shell and center pin of this cable.

Note

It may be helpful to gently flex the cable during the resistance measurements so that an intermittent poor connection, if present in the cable, can be seen.

a. A satisfactory result is one where the resistance measured does not differ from what was recorded in Table 5-1.

b. From the rear of the RF/PDU or SRF Cabinet remove the terminator and, from the front of the RF/PDU or SRF Cabinet, place it on the other end of the same cable where the first measurement was earlier made.

c. Measure the resistance on the opposite end of the same cable from the rear of the RF/PDU or SRF Cabinet.

d. A satisfactory result is one where the resistance measured does not differ from what was recorded in Table 5-1.

e. If the cable measurements were good in both directions then the cable is in good working order.

CAUTION

Recalibrate the RF subsystem if any cables are replaced.

12. Replace or repair any cables found faulty.

13. Reconnect the cable removed from **J11 AMP 1 DRIVE** on the front of the RFI.

14. From the rear of the RF/PDU or SRF Cabinet remove the terminator from the other end of the cable and reconnect the cable to **J3 RF Input** on RF amplifier # 1.

5 - CHECKING RF CABINET CABLES (CONTINUED)

15. Remove the cable from **J3 RF Input** on the rear of RF amplifier # 2.
16. Repeat step 6 and inspect the cable connector.
17. Connect the 50 ohm terminator to the end of this cable and then set it aside.
18. Return to the front of the RF/PDU or SRF Cabinet and remove the cable connected to **J12 AMP 2 DRIVE** on the front of the RFI.
19. Repeat step 6 and inspect the cable connector.
20. Repeat steps 11 – 12 and check the electrical continuity of the cable.
21. Reconnect the cable removed from **J12 AMP 2 DRIVE** on the front of the RFI.
22. From the rear of the RF/PDU or SRF Cabinet remove the terminator from the other end of the cable and reconnect the cable to **J3 RF Input** on RF amplifier # 2.
23. From the rear of the RF/PDU or SRF Cabinet remove the cable from the male BNC feed-thru connector cabinet interface at RF IN (J3 for RF/PDU or J1 for SRF).
24. Repeat step 6 and inspect the cable connector.
25. Connect the 50 ohm terminator to the end of this cable and then set it aside.
26. Return to the front of the RF/PDU or SRF Cabinet and remove the cable connected to **J14 RF INPUT** on the front of the RFI.
27. Repeat step 6 and inspect the cable connector.
28. Reconnect the cable removed from **J14 RF INPUT** on the front of the RFI.

NOTE

The electrical continuity of this cable was already checked in **SECTION 4 - (U)CERD EXCITER RF SIGNAL OUTPUT CHECK** and will not be checked again.

29. From the rear of the RF/PDU or SRF Cabinet remove the terminator from the other end of the cable and reconnect the cable to RF IN on the rear of the cabinet interface (J3 for RF/PDU or J1 for SRF).
30. Proceed to **SECTION 7 - SYSTEM RESTORATION**.

6 – RF POWER MEASUREMENT EQUIPMENT CHECKS

Faulty RF power measuring equipment can cause inaccurate RF power measurement results, RF waveforms that are torn or otherwise distorted, and RF amplifier faults. This section will provide guidelines for testing and determining the condition of various types of hardware recommended for measuring RF output power.

6-1 Testing the 200 Watt, 30dB Attenuator Load

1. Remove any cables connected to the 200 Watt, 30dB attenuator (large black or grey unit with metal fins; also sometimes called a “dummy load”).

2. Use a Digital Multimeter (DMM) to measure the center-pin to center-pin and center-pin to shell resistance of the 30dB attenuator.

    a. Approximately 95 ohms should be seen on the DMM when measuring from the center-pin of one side of the 200 Watt, 30dB attenuator to the center-pin of the other.

    b. Approximately 50 ohms should be seen on the DMM when measuring from center-pin to shell on either side of the 200 Watt, 30dB attenuator.

3. If values markedly different than what is described above are measured then the attenuator has failed.

    a. **If this is the black, 30dB attenuator with the large fins included in the RF Power Measurement Kit (GE Part # 46-317724P14)** try removing the top cover to the unit and then checking the electrical solder connections between the center-pins of the RF connectors and the internal load. If the connections cannot be re-soldered or extensive burn or other damage is found then it will be necessary to replace the unit.

    b. **If this is the older, gray, rectangular 30dB attenuator with the metal handle (Bird Corp. model # 8322)** this unit can be repaired in the field. Refer to the **BIRD DUMMY LOAD/ATTENUATOR REPAIR (RC1REA7.DOC)** document located under the RF/PEN – 1 section on the 8.X Service Methods CD-ROM for detailed instructions and parts lists needed for repairing this unit in the field. It may be necessary to obtain parts for repair directly from the Bird Corporation.

4. The attenuation value of the 30dB attenuator can be verified by referring to **APPENDIX C — DUMMY LOAD AND CABLES CALIBRATION** and re-measuring this value. Refer to the RF Kit Calibration Verification portion of the Power Calculator Tool (located at E:\rf\power\pwrcalc.htm on the Service Methods CD-ROM) to convert the Magnitude Squared Attenuation Factor derived in Appendix C to decibels (dB).

6-2 Checking and Testing the Oscilloscope

1. Check the following:

   a. If using a 100MHz oscilloscope without the RF Power Measurement Kit to measure power, confirm that all scope measurements are corrected using the correction factor measured for the oscilloscope channel in use. Ignoring the correction factor can result in severe measurement error.

   b. Confirm that the 20MHz Bandwidth Limit Switch is disengaged.

   c. Scope channel being used for RF measurements is terminated with either a known good external 50 ohm feed-thru terminator connected to the channel input connector or scope channel selection switch is set so that channel is internally terminated with 50 ohms. **Both internal and external 50 ohm termination must <u>not</u> be used at the same time.**

   d. The UNCAL or VAR Knob (usually located in the center of the Volts/Div. Knob) is in the fully-clockwise, detent position (off).

   e. Scope trigger source is set to the channel in use or to a known good external source.

   f. Channel in use is set for a DC measurement and correct Volts/Div setting is selected.

2. Try the other oscilloscope channel, if necessary.

6-3 Checking the RF Power Measurement Kit Coupling and Attenuation Hardware

The total attenuation of the RF Power Measurement Kit hardware can be measured using the procedure in **APPENDIX C — DUMMY LOAD AND CABLES CALIBRATION AND VERIFICATION.** The results can then be compared to the specifications shown in the process and the attenuation value printed on the laminated calibration card **72** for body RF power measurement located in the RF Power Measurement Kit.

1. Refer to **APPENDIX C — DUMMY LOAD AND CABLES CALIBRATION AND VERIFICATION** and measure the RF Power Measurement Kit hardware as shown in the procedure.

2. RF Power Measurement Kits that are suspected to contain faulty components should be returned to a professional, certified metrology lab for repair and/or calibration.

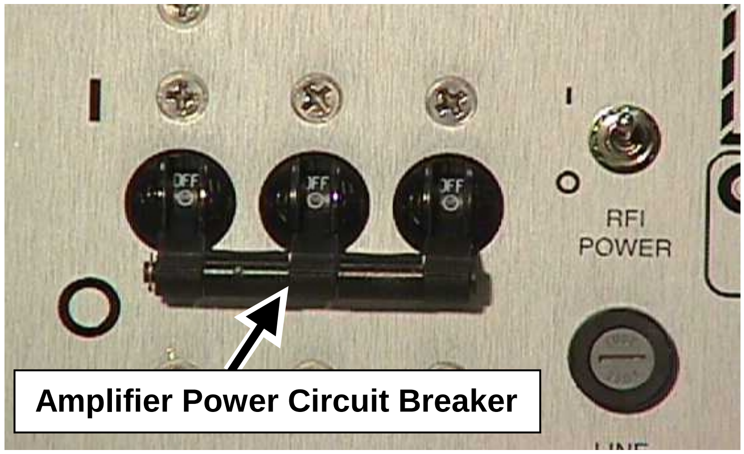
6-4 Checking the Integrity of the RF Coaxial Cables and Connectors

The cables supplied with the RF Power Measurement Kit have been manufactured to close tolerances and each was measured during the kit calibration process. Uncalibrated cables should not be substituted into this kit. When measuring RF power with the RF Power Measurement Kit use only the cables referenced on the laminated cards. Visually inspect cables and connectors for obvious signs of wear and damage that may introduce measurement error. Use a digital multimeter to verify the continuity of the cable connections

7 - SYSTEM RESTORATION

1. Verify that the system is not scanning.

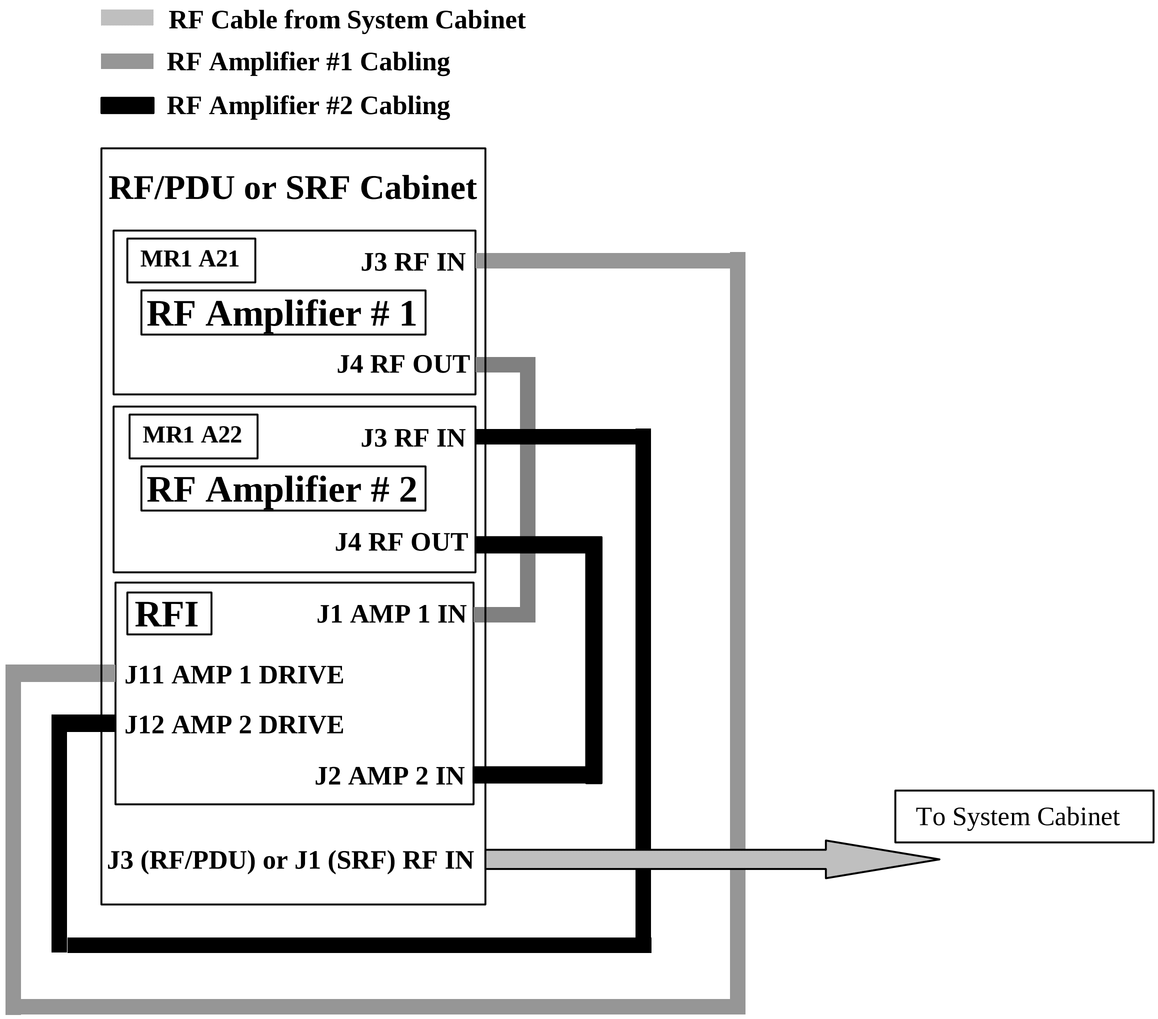
2. Locate the **AMPLIFIER POWER** circuit breaker on the front of the RFI and place this in the down (OFF) position. See Illustration 7-1.



RF AMPLIFIER POWER CIRCUIT BREAKER IN DOWN (OFF) POSITION
ILLUSTRATION 7-1

7 - SYSTEM RESTORATION (CONTINUED)

3. Refer to Illustration 7-2 and reconfigure the system back to a normal configuration.

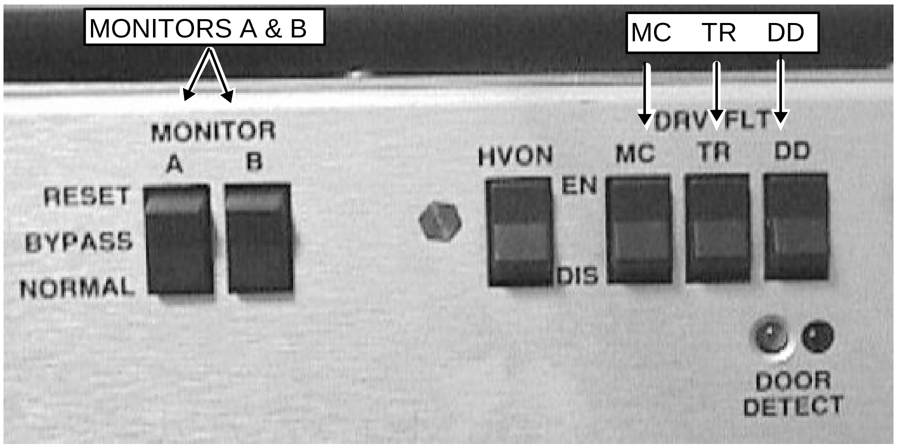


NORMAL SYSTEM CONFIGURATION
ILLUSTRATION 7-2

4. Place the **AMPLIFIER POWER** circuit breaker on the front of the RFI in the up (ON) position.

7 - SYSTEM RESTORATION (CONTINUED)

5. Refer to Illustration 7-3. At the front of the SSM place the:
   - 2 (two) power MONITOR switches (A and B) to the bottom NORMAL position.
   - 3 (three) DRV FLT switches to the top EN (enable faults) position.



FRONT PANEL SWITCHES ENABLED
ILLUSTRATION 7-3

6. If the problem was found and resolved then perform one head and one body scan to confirm system functionality.

CAUTION

The system may report that the "RF amplifier is not ready" and not prescan. This is normal after cycling power to the RF amplifiers. Restart the scan or prescan and the system should this time complete the prescan normally.

7. If the root cause of the problem has not yet been determined then return to the flowchart and continue with the troubleshooting process.

APPENDIX A — ALTERNATE NON-SERVICE PROTOCOLS

Use this section if the RF Power Measurement Kit is NOT going to be used. This section contains the protocols necessary to measure body RF output power using either a wattmeter or oscilloscope.

NOTE

If the system is operating with Release 9.X, CNV4 software, or its equivalent then it is no longer necessary to modify the ia_rf1 and ia_rf2 CV values. These will be set automatically when the calmode CV value is set equal to 5.

NON-SERVICE 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: (if 9.X, CNV4, or equivalent only modify **calmode**)

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

[Research Operations] [Setup Params]

Set TG **50 [Done]**

[Research Operations] [Download]

[Prepare to Scan]

APPENDIX B — SOFTWARE AND FORMULAE FOR MISCELLANIOUS RF CONVERSIONS

Software are described and formulae are presented in this section that will allow the FE to perform various conversions and calculations.

B-1 RF Conversion Software

B-1-1 RF Power Calculator

The first tool, the RF Power Calculator, is a UNIX-based application 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.

B-1-2 Power Calculator Tool

The second tool, the Power Calculator, is an HTML document that is available from the 8.X Service Methods CD-ROM. This tool will run from either the laptop PC or MR host computer. The tool can manually be started from the laptop PC by selecting **Start, Run,** and then entering the following file pathname in the "Open" entry box: E:\rf\power\pwrcalc.htm. Next, select **OK**. The tool is divided into 3 sections. The first section allows one to calculate RF power from measured peak voltage when using a 100 MHz oscilloscope and a properly characterized RF cables kit and dummy load. The second section provides Vpp to dBm, Vp to dBm, dBm to Watts, dBm to Vpp, and dBm to Vp conversion capability. The third section provides short instructions and a means for comparing the attenuation in dB reported on each RF Power Measurement Kit Card with the measured Magnitude Squared Attenuation Factor reported by the Attenuation Test tool that is described in **APPENDIX C – DUMMY LOAD AND CABLES CALIBRATION.**

B-2 RF Conversion Formulae

These are provided to assist the experienced FE with RF power measurement and 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 exactly as you read it (Access the LX system calculator by right mouse clicking in the background and then selecting the calculator from the Root menu.).

VP-P to dBm Calculation:

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

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

APPENDIX B — SOFTWARE AND FORMULAE FOR MISCELLANIOUS RF CONVERSIONS (CONTINUED)

dBm to VP-P Calculation:

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

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

Example: Using 3.65 dBm, the Scope Power reading listed on a particular Kit card, 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:

Watts = $10^{\left(\frac{dBm}{10}\right)}$ **X** 0.001 or Watts = antilog $\left(\frac{dBm}{10}\right)$ **X** 0.001

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

APPENDIX C — DUMMY LOAD AND CABLES CALIBRATION AND VERIFICATION

Description - This procedure provides directions for determining the true loss attributable to the dummy load and cables used when measuring the RF output power with a wattmeter or oscilloscope of 100 MHz bandwidth or greater. It also provides directions for verifying that the attenuation value reported on laminated kit card **72** in the RF Power Measurement Kit is correct. It is critical to know and account for the actual loss contributed by attenuation components in order to accurately measure RF power. Card **72** utilizes most of the attenuation hardware in the kit to measure body RF power. Measuring and verifying the attenuation of the components used in this test is a good gauge of the overall performance of the kit. **Please understand that it is normally not necessary to use this process to measure the attenuation of the components in the RF Power Measurement Kit.** The advantage of using the RF Power Measurement Kit to measure RF power is that the attenuation components have already been calibrated/characterized in a professional, certified metrology lab and the measured attention is printed on each of the laminated cards. So, unless one suspects that the attenuation value of one or more of these components may have changed, it is not necessary or desirable to perform the calibration/characterization procedure on the components of the RF Power Measurement Kit. Kits with components that have significantly varied in attenuation since the last calibration should be returned to a professional, certified metrology lab for repair and/or re-calibration.

Note

This tool will accurately measure attenuation values up to 50dB. The combined attenuation of the dummy load and cables is well below this value. The accuracy of the tool begins to diminish when measuring attenuation values over 50dB.

C-1 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/or cable(s) to be tested 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?). This attenuation factor is 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.

C-2 Tools and Instruments Required

See Table C-1

TABLE C-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
3	TPS RF Service Interface Kit	46-301927G1	1

C-3 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.

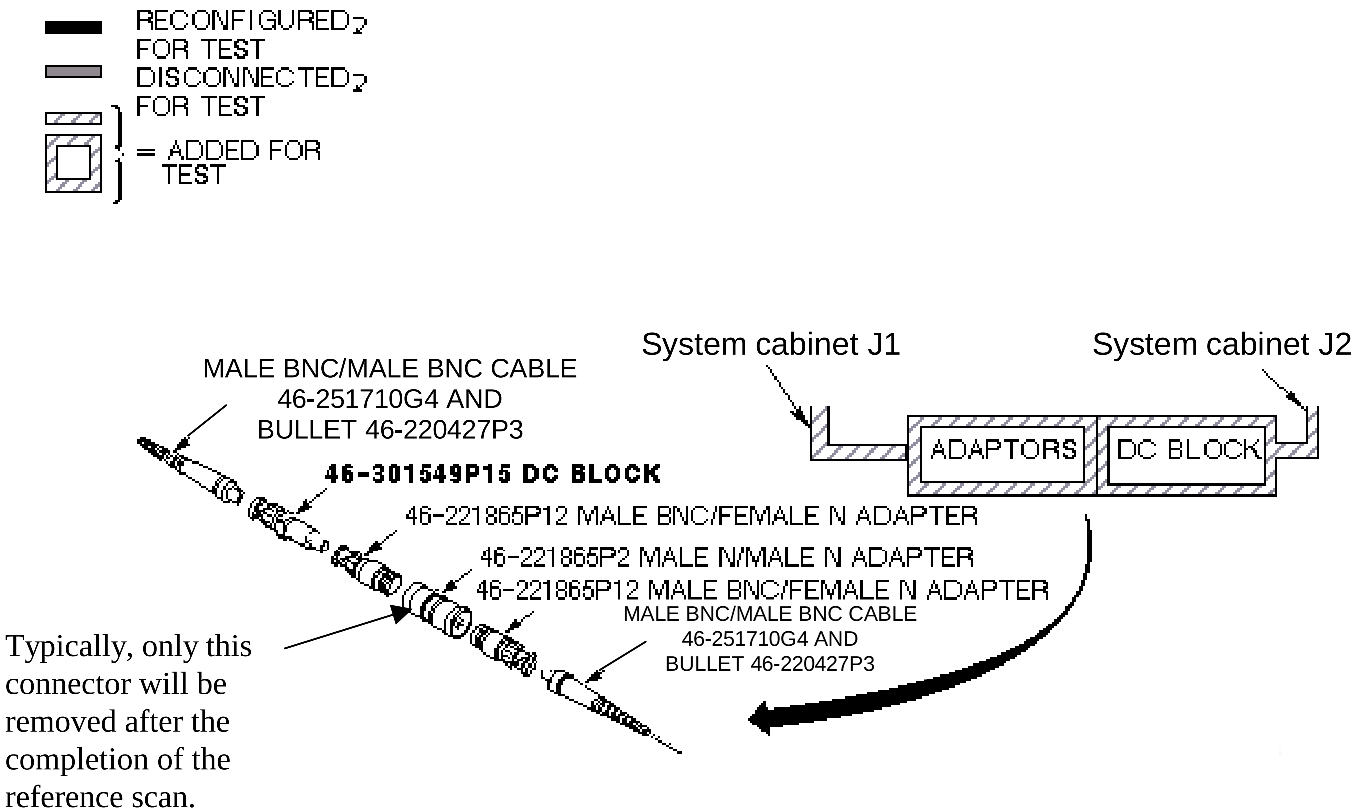
3. Bypass the body TNS (MR2 A24 A1 A1) from the circuit by disconnecting the small coax cables MR2 A24 A1 J12 (signal output) and MR2 A24 A1 A1 J2 (signal input) from the TNS and connecting both together using a female-BNC to female-BNC adapter (also known as a bullet adapter 46-220427P3).

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.

C-3 Initial Setup (Continued)

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



CONNECTIONS FOR INITIAL AMPLITUDE SCAN
ILLUSTRATION C-1

Note

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

C-3 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]** and then select **[Research Operations]**, then select **[Download]** then select **[Manual Prescan**.

C-4 Data Collection

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

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

3. Select **[Done]**.

4. Select **[Scan]** (Ignore the message: `MR signal too large, reduce receiver gain.`) (Note: on the LX systems tested, the scan time starts at 13 seconds, counts down to 7 seconds, then ends. This is normal and is not cause for alarm.)

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 C-2.

TABLE C-2
DATA COLLECTION

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

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 attenuation devices 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.

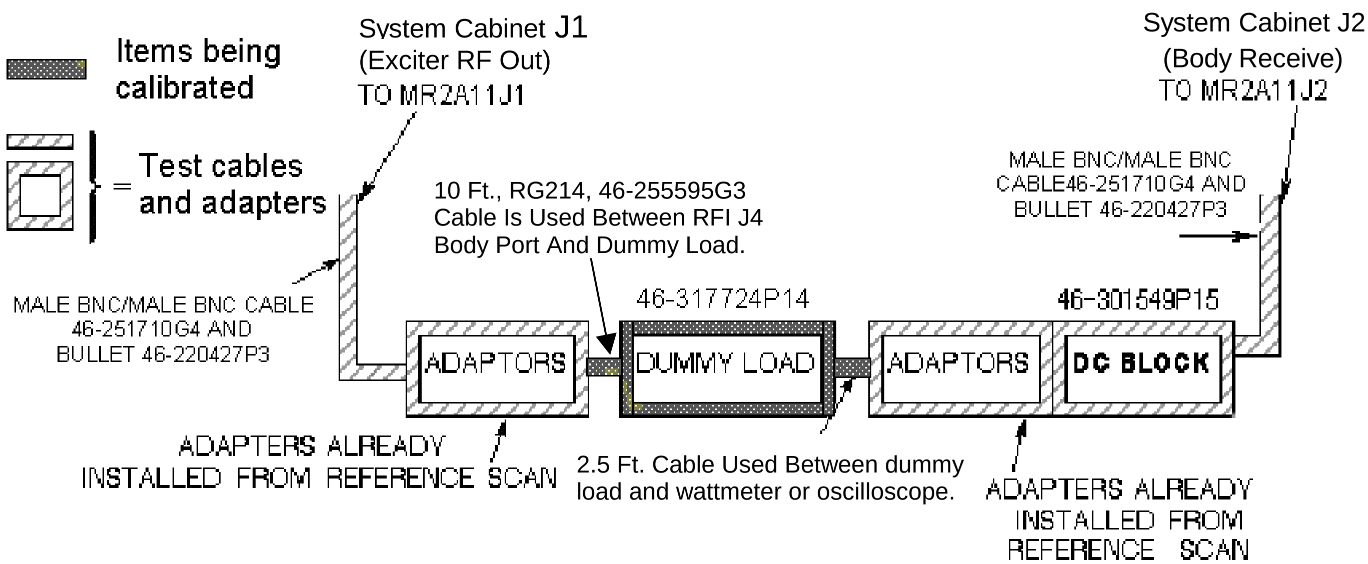
C-4 Data Collection (Continued)

8. Connect your test cables to the opposite ends of either:

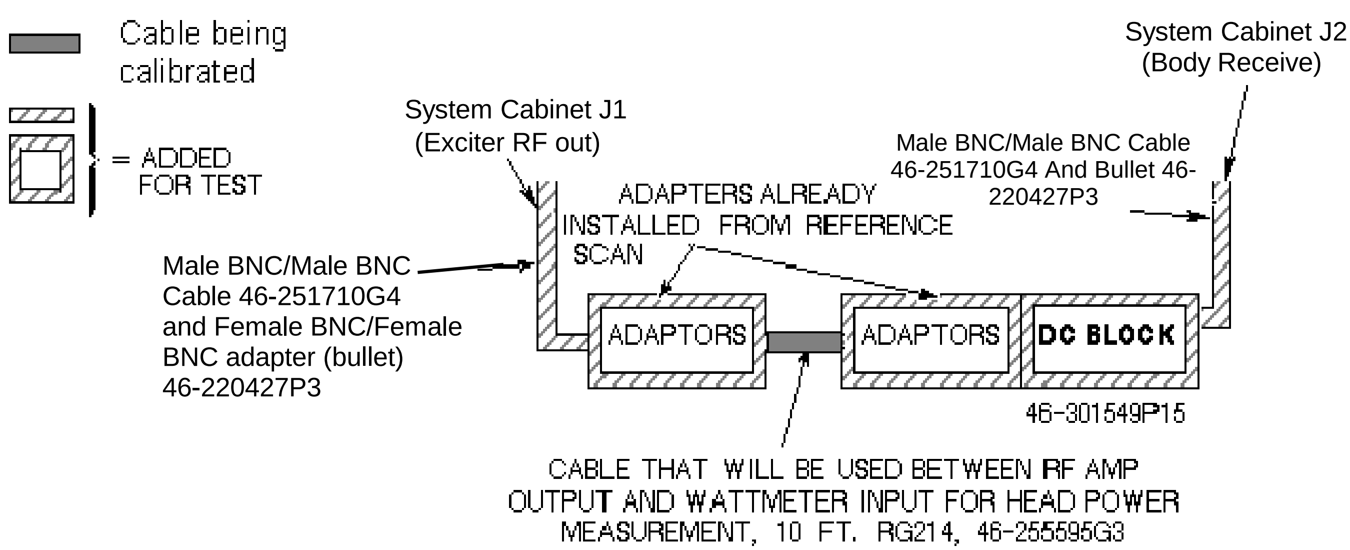
- Illustration C-2 – Dummy Load and Cables
- Illustration C-3 – Amplifier to Wattmeter Cable
- Illustration C-4 – 40dB or 30dB Coupler, Cables, and 1dB Step Attenuator
- Illustration C-5 – 10dB Fixed Attenuators

Note

"Bullet" RF connector referred to in illustrations C-2 and C-3 is a female BNC/female BNC adapter, 46-220427P3.

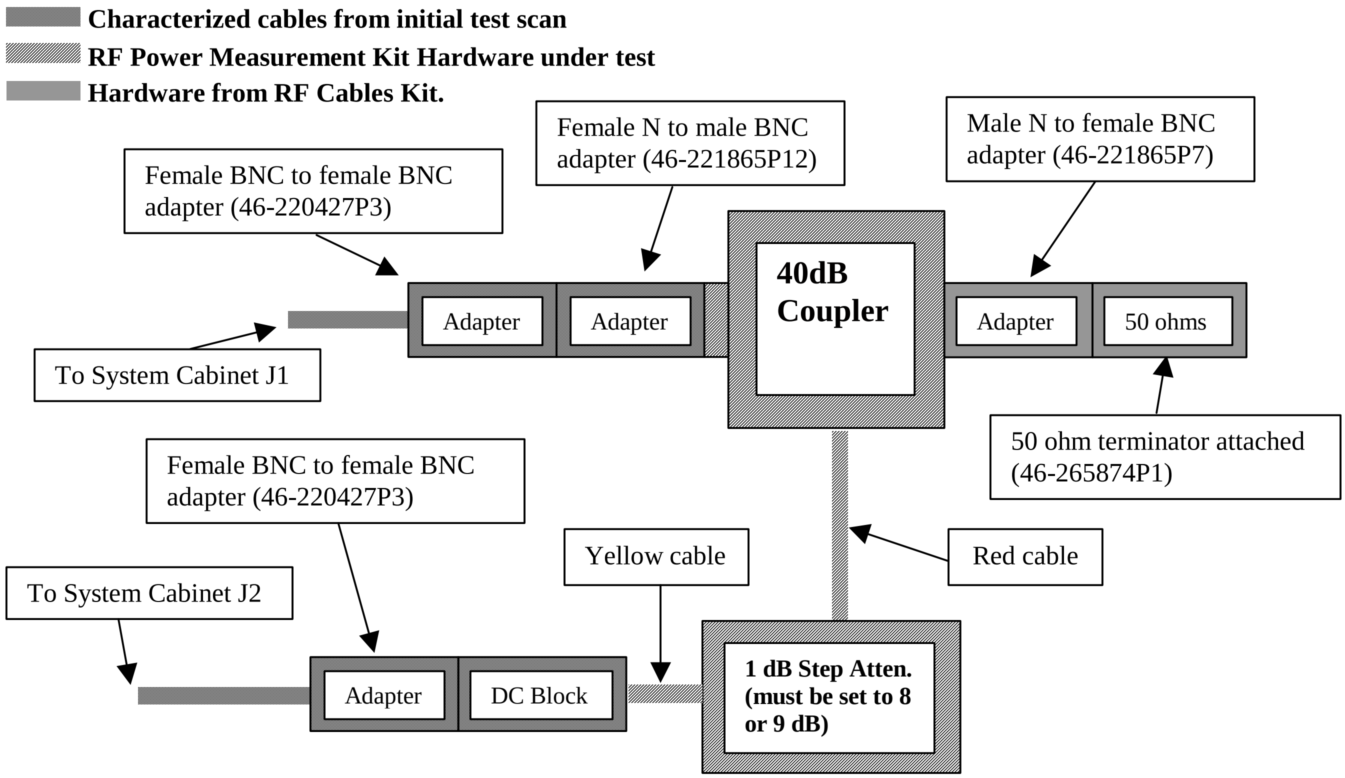


CONNECTIONS FOR DUMMY LOAD + CABLES SCAN
ILLUSTRATION C-2

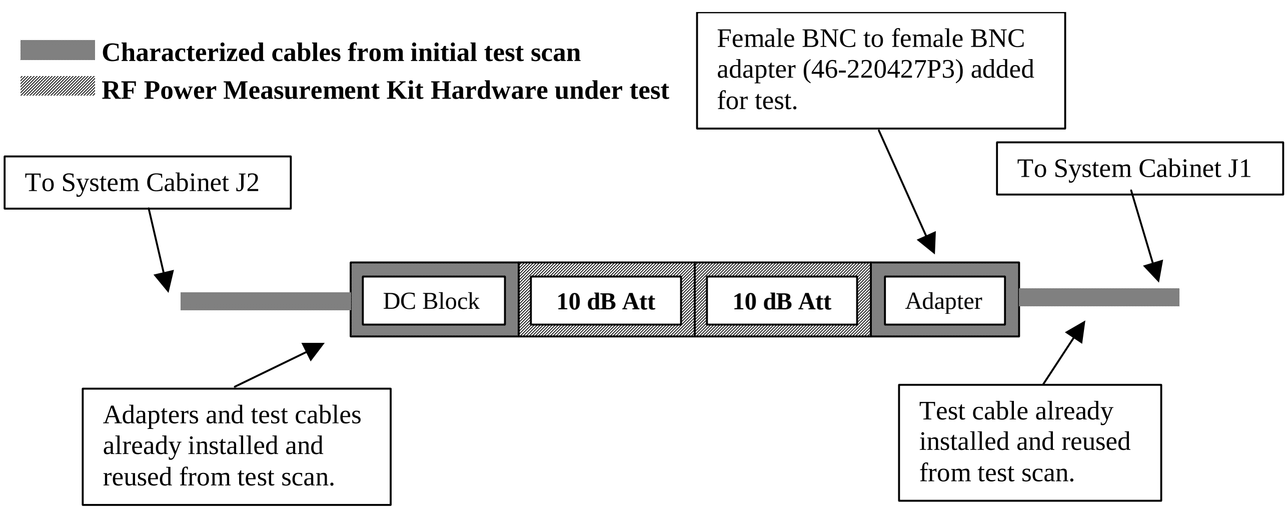


AMP TO WATTMETER CABLE SCAN
ILLUSTRATION C-3

C-4 Data Collection (Continued)



CONNECTIONS FOR MEASURING 40DB COUPLER, CABLES, AND 1DB STEP ATTENUATOR
ILLUSTRATION C-4



CONNECTIONS FOR MEASURING 10DB FIXED ATTENUATORS
ILLUSTRATION C-5

Note

Substituting one or two adapters into the test circuits shown in Illustrations C-4 and C-5 that were not there during the initial baseline scan will not greatly affect the measurement results. Substituting in long cables that were not there during the initial baseline scan, however, will likely have a significant affect on the measurement results and should not be done.

C-4 Data Collection (Continued)

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

10. Select **[Scan]**.

11. When the scan is completed, re-select the tools icon again and begin the Analysis in section C-5. It will be necessary to toggle between the Scan and Toolbelt icons if multiple passes are done.

C-5 Analysis

See Table C-3.

TABLE C-3
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> 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>If system has ISE chassis then select U<Enter>; otherwise select L<Enter>.</td></tr>
<tr><td>|*************************************|
**</td><td>(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 C-4.</td></tr>
<tr><td>RMS Attenuation Factor = zzzzz

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

C-5 Analysis (Continued)

1. Record the "Magnitude Squared Attenuation Factor" number and record it in the appropriate Value box in Table C-4.

TABLE C-4
ATTENUATION FACTORS

ROW	MODE	CALIBRATED HARDWARE	PART NUMBER(S)	VALUE	NOMINAL VALUES
1	**BODY OR HEAD**	**DUMMY LOAD + CABLES ATTEN FACTOR**	**46-255595G3 46-317724P14 46-255595G4**		**931 TO 1172**
2	**HEAD**	**AMP TO WATTMETER ATTEN FACTOR**	**46-255595G3**		**1.03 TO 1.04**
3	**BODY OR HEAD** (RF Power Measurement Kit Verification ONLY)	**40dB COUPLER + 1dB STEP ATTENUATOR (set to 8dB) + RED CABLE + YELLOW CABLE**	**46-317724P5 46-317724P8 46-317724P10 46-317724P11**		**56234 TO 81283**
4	**BODY OR HEAD** (RF Power Measurement Kit Verification ONLY)	**RED 10dB FIXED ATTENUATOR + YELLOW 10dB FIXED ATTENUATOR**	**46-317724P6 46-317724P7**		**87.1 TO 114.8**
5	**HEAD ONLY** (RF Power Measurement Kit Verification ONLY)	**40dB COUPLER + 1dB STEP ATTENUATOR (set to 9dB) + RED CABLE + YELLOW CABLE**	**46-317724P8**		**71038 TO 102660**
6	**ERBTEC / ETO TEST ONLY** (RF Power Measurement Kit Verification ONLY)	**30dB COUPLER**	**46-317724P4**		**891 TO 1122**

2. If the purpose of this exercise was to characterize the dummy load and cables for use in RF power measurement then the characterization is now complete. Proceed to **Section C-7 System Restoration**.

Note

Section C-6 is informational and explains why it is important to exercise care when measuring RF power. This section does not contain any extra processes or steps. It is not necessary to continue to this section.

3. Confirm that the measured values in Rows 3 – 6 are within the range of the Nominal values provided in the same row.

C-5 Analysis (Continued)

4. If the purpose of this exercise was to verify the integrity of RF Power Measurement Kit components then use the RF Calibration Kit Verification section in the Power Calculator Tool (located at E:\rf\power\pwrcalc.htm on the 8.X Service Methods CD-ROM) to convert the Magnitude Squared Attenuation Factor recorded in the **VALUE** column in Table C-4 to decibels (dB) or refer to **Appendix B-2 RF Conversion Formulae** to do this manually using the LX system calculator. Record the values (in dB) in Table C-5.

TABLE C-5
SUM OF BODY OR HEAD VALUES EXPRESSED IN DECIBELS

BODY OR HEAD (ROW 3)	BODY OR HEAD (ROW 4)	SUM (Body attenuation)
__________dB	__________dB	ROW 3 value (dB) + ROW 4 value (dB) = _________dB

5. Compare the SUM value in Table C-5 to the Attenuation value (for this comparison, ignore the negative sign) printed on the sticker affixed to RF Power Measurement Kit Card **72**. The two values should be similar. See Illustration C-6 below.

1.5T BODY CARD # 72 CALIBRATION STICKER DATA
Card Number 46-317724P32
Nominal: 72 dBm **Attenuation:** -68.32 dB Scope Power: 3.68 dBm Scope Rdg: 7.72 div

SAMPLE CALIBRATION STICKER
ILLUSTRATION C-6

6. The verification is now complete. If problems are found with any of the components in the RF Power Measurement Kit then please return the kit to a facility certified for this type of repair and calibration. Proceed to **Section C-7 System Restoration**.

Note

Section C-6 is informational and explains why it is important to exercise care when measuring RF power. This section does not contain any extra processes or steps. It is not necessary to continue to this section.

C-6 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 scope correction factor MUST be known. So must the *actual* total loss attributed to anything that connects the measuring device to the source. This often includes the accumulated loss associated with the dummy load and any interconnecting cables. Table C-5 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 C-6 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.

WARNING!

THE SCOPE CORRECTION FACTOR MUST BE KNOWN FOR THE FORMULAE SHOWN IN TABLES C-5 AND C-6. IF IT IS NOT KNOWN, DO NOT USE THIS METHOD. GROSSLY INACCURATE MEASUREMENTS AND POSSIBLE SYSTEM DAMAGE WILL RESULT.

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

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

Assume Z = 50 Ω, Vpeak = 40.0, scope correction factor = 1.00 (no loss), dummy load and cables atten. = 1000, (dummy load and cables are all ideal)

$$\frac{\left(\frac{40.0Vp}{1.00}\right)^2}{100} \textbf{ X } 1000 = 16000 \text{ Watts} = 16 \text{ kW}$$

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

TABLE C-5
RF POWER CALCULATION WITH NO LOSS

C-6 Calculation of RF power (Continued)

Now, consider the "real life" type situation in Table C-6 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 = 34.61, scope correction factor = 0.88, dummy load and cables atten. = 1028

$$\frac{\left(\frac{34.61Vp}{0.88}\right)^2}{100} \textbf{ X } 1028 = 15901 \text{ Watts (very close to 16kW.)}$$

Accounting for the loss resulted in an accurate answer. 15899 Watts is as close as we can hope to get to 16000 Watts without using the RF Power Measurement Kit. Note that if none of the loss had been accounted for the error could have been **3587 Watts or 22.6%.** As a result, the observer would attempt to adjust the RF power far above the 16000 Watt limit!

TABLE C-6
RF POWER CALCULATION WITH LOSS CONSIDERED

C-7 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 MR2 A24 A1 J12 and MR2 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 if necessary or possible.
4. Return to the appropriate procedure.

APPENDIX D — CHARACTERIZATION FOR SCOPES WITH < 300 MHZ BANDWIDTH

WARNING!

THIS PROCEDURE REQUIRES THAT THE SCOPE IN USE HAS A BANDWIDTH OF AT LEAST 100 MHZ. DO NOT ATTEMPT TO PERFORM RF POWER MEASUREMENTS WITH AN OSCILLOSCOPE THAT HAS A BANDWIDTH LESS THAN 100 MHZ. SIGNIFICANT MEASUREMENT ERRORS CAN RESULT.

The scope correction factor for the scope channel in use must be known for oscilloscopes with a bandwidth < 300 MHz. One may assume that the correction factor is 1 (unity) for oscilloscopes with a bandwidth ≥ 300 MHz. Do not assume a correction factor for an input channel and do not assume that all the scope input channels have the same correction factor. Each channel must be characterized separately. There are three ways that this can be done.

D-1 Scope Channel Characterization Done During Calibration

One way that the scope channel characterization can be accomplished is to request this information from the metrology lab the next time the scope is sent back for calibration. Attach a tag in a conspicuous location on the scope before it is sent back for calibration requesting this information. Ask that the percent of signal loss at 63.86 MHz (1.5T) and 42 MHz (1.0T) be measured at the 5 volt/div and 2 volt/div settings (for body and head measurements, respectively) for both scope channels and that this information be included with the returned scope. The metrology lab can usually do this upon request and without charge during the calibration process.

D-2 Scope Channel Characterization Done By Comparison

A 400 MHz scope exhibits negligible measurement error at 63.86 MHz or 42 MHz. If a 400 MHz scope is available then it can be compared side-by-side on site with a scope of < 300 MHz bandwidth. Be sure the scope inputs have a 1Mohm impedance and then are terminated with a 50 ohm feed-through adapter before making the measurements. Be sure to characterize all the inputs that are to be used. The signal loss at 63.86 MHz (1.5T) and 42 MHz (1.0T) for each channel at the 5 volt/div and 2 volt/div settings can be determined from the ratio of signal measured on the 100 MHz scope to that seen on the 400 MHz scope

$$\frac{\text{100 MHz scope measured Vpp signal}}{\text{400 MHz scope measured Vpp signal}} = \text{scope correction factor}$$

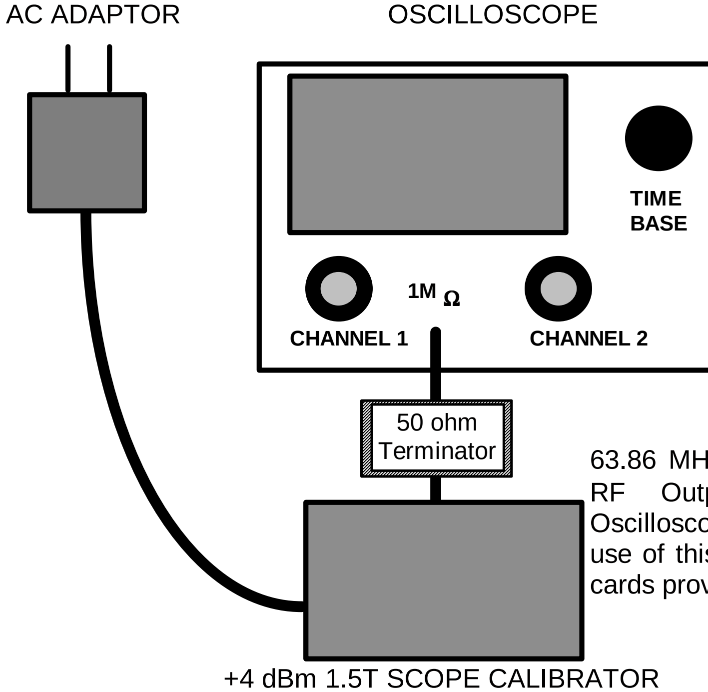
. As long as the same cables are used the loss can also be determined for each cable.

D-3 Scope Characterization Using the RF Power Measurement Kit Signal Reference

The RF Power Measurement Kit contains a 63.86 MHz, 4dBm (1 Vpp) calibrated signal reference that can be used to characterize the scope input channels. Be aware that these values are accurate only for 1.5T systems.

D-3 Scope Characterization Using the RF Power Measurement Kit Signal Reference (Continued)

1. Connect the calibrated reference to the scope as in Illustration D3-1 below.



Note
63.86 MHz oscillator with 4dBm/1.00 VP-P RF Output into 50 Ω termination. Oscilloscopes less than 300 MHz require the use of this 1.5T Scope Calibrator. All 1.5T cards provide Scope Readings in Divisions.

1.5T SCOPE CALIBRATOR CONNECTIONS
ILLUSTRATION D3-1

2. Set the scope amplitude for the channel to be checked to 0.2 volts/div.
3. Set the sweep rate to 5 nsec.
4. Confirm that the channel input impedance is set for 1Mohm and not 50 ohms.
5. Confirm that the scope bandwidth limit switch is not enabled.
6. Confirm that the "Uncal" knob is not rotated and the channel is not uncalibrated.
7. Carefully measure the peak to peak voltage from the calibrated source. The measured value should be 1 Vpp or less.
8. Calculate the correction factor (it should be less than 1):

$$\frac{\text{Vpp measured}}{1\,\text{Vpp}} = \text{correction factor}$$

9. Repeat this process and derive the correction factor for the other scope input channel(s).
10. Note these correction factors for each channel on a piece of tape affixed to the scope for later reference.

REVISION HISTORY

REV	DATE	AUTHOR	PRIMARY REASONS FOR CHANGE
1	April 10, 2002	D. Thome	Initial Release