TABLE OF CONTENTS

1 – OVERVIEW

This procedure explains various methods for troubleshooting problems and isolating failures to components contained within the SRFD2 Cabinet. Components checked in this document include the 1.5T Analogic AN8103 RF amplifier, and the various large and small signal RF coaxial cables associated with each. Processes are also provided for checking the RF output and the integrity of the RF coaxial cable that provides a transmission path from the Exciter in the System Cabinet to the SRFD2 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

1-2 Hint and Tips When Troubleshooting SRFD2

- The arrangement of the SRFD2 is such that the top RF Deck is the master and the bottom RF deck is the slave. All command, control and status information from Signa is handled by the microprocessor on the master RF deck. The central section of the SRFD2 houses the small signal front end splitter and gain adjustment, and the high power combiner and couplers that interface to the SSM power monitor.

- When the SRFD2 is power cycled, the system message log may show errors such as the SRFD2 Power Supply Fault – this is because the high voltage supply is being shutdown, and the communication board inside the amplifier still has time to report it as a problem before the entire amplifier is off. There is no actual PSU fault in the SRFD2.

- The DCHV red LED on the front panel should be ON when the amplifier is in the STANDBY or OPERATE states. If the amplifier is in the OFF state, the LED will be OFF. Note that the LED is an indicator of the stored charge in the large capacitor banks of the amplifier. It will take some time for the capacitors to discharge and the LED will gradually fade according to the charge level.

- MDS Link errors are indicative of a loss of communication to the SSM, not the amplifier. Loss of communication with the amplifier itself has its own set of error messages. Please see the appropriate section below.

- SRFD2 amplifiers with a status code of 5 (S/N 0320-0809 or later) OR amplifiers that have FMI 60654 installed have the ability to reset the amplifier microprocessor via a TPS reset. A system restart, system boot from cold, or an SSM power cycle will also reset the SRFD2 microprocessor. This was done to make sure the stack in the SRFD2 microprocessor code would be refreshed on a regular basis, just as all the other microprocessors in the system are.

- SRFD2 amplifiers with the communication fixes of the FMI or status code 5 above have the ability to reset themselves if the microprocessor stack should become corrupted. The self-recovery will be indicated by a specific set of messages in the system error log. There should no longer be a need for the customer to have to physically power cycle the SRFD2 to wake it up.

- When reading the status code label on the front panel of the SRFD2, a number that is crossed-out means that the change associated with that status code was implemented in the amplifier. E.g., a crossed-out 5 means that the SRFD2 has a new communication I/F board and 4.14 firmware installed. Also note that it is possible to have status codes that were skipped because of the order of implementation of the changes.

- Power Monitor Faults are generated by the APM in the SSM, but they are reported via fault codes in the RF amps. If the system is experiencing an inordinate number of power monitor faults, the first place to look is the RF Max output power – make sure the SRFD2 has been properly calibrated to 16kWpep for body and 2kWpep for head. If the RF power is OK, use the MONS program or other methods to verify the SSM APM is functioning properly.

- Failures of the RF fuses in the SRFD2 indicate that a failure of a component elsewhere has occurred. The purpose of the fuses is to protect the rest of the RF deck by not allowing the failure to propagate through the system. Replacing a failed fuse will not repair the system – the fuse will fail again because the component failure is still in place. The SRFD2 needs to be returned for proper repair.

- The SRFD2 has the ability to automatically bypass certain RF FET failures and run in a state called OPERATE LOW. Messages logged in the system log will indicate if this has occurred. In this condition the maximum SRFD2 output drops to about 12kWpep, but the system can still be used for scanning with some limitations until the SRFD2 is replaced.

1-3 Common SRFD2 Issues and How to Identify Them

1-3-1 Communication Lockups

Root cause – stack corruption in the master RF deck microprocessor.

Symptoms - "Response Timeout" error messages and other amplifier control errors AND **a true need to power cycle the RF amp to wake it up**. See additional details on the symptoms in the section on *General RF Amplifier Communication and Configuration Errors*.

Solution – Install FMI60654 if the amplifier has not already received the update at the factory. Amplifier status code of "5" crossed out means the update was already done.

Note that updated SRFD2's have not suffered from any true uP lockups. However the "Response Timeout" message or other messages such as "RF Amp not ready" may still appear from time to time in the error log or the system status message area if there is a slight stumble in the communication. Even if the updated SRFD2 were to experience a true uP lockup, the amplifier is now capable of performing self-recovery if needed. See additional details on the symptoms and behavior in the section on *General RF Amplifier Communication and Configuration Errors*.

1-3-2 Loss of Communication Following FMI 60654 Installation

Root cause – Incomplete firmware initialization, mis-aligned pins on interface board connection, IPS (master-slave) ribbon cable in backwards.

Symptoms - "Response Timeout" error messages and/or other amplifier control errors AND power cycling the amp to wake it up does not work. .

Solution – Double check the IPS ribbon cable installation against the directions in the FMI document. Double check the alignment and connections to the Interface board installed during the FMI. Verify the ability to communicate to the microprocessors directly with the laptop and re-initialize the firmware using the manual method in the FMI document, section 4-4.

1-3-3 Vicor DC-DC Converter failures

Root cause – components inside a Vicor DC-DC converter module are failing.

Symptoms - A loss of communication from Signa (if the failure is on the master deck), cable 22 faults (if the failure is on the slave deck), AND no fans on the affected deck. Note that a cable 22 fault alone is very likely a cable problem – see section on fault code 2254202.

Solution – There is no field fix for a Vicor failure. There is however a new Vicor module available. All SRFD2's get updated with new Vicor converters during repair.

1-3-4 VSWR Faults

Root Cause – assuming that the system load and the internal RF connections of the SRFD2 are truly OK, the VSWR faults are likely to be the result of ringing on the VSWR monitoring circuit inside the SRFD2.

Symptoms - The SRFD2 shuts down with VSWR faults (reported in the error log) whenever running at higher TG's (~170 or so) EVEN if running the RF into a good 50 ohm dummy load.

Solution – There is no field fix. There is however a design modification that corrects the problem. All units sent in for repair get updated with this design modification. If the unit has the status code of “6” crossed out, it already has the VSWR monitoring noise fix installed.

1-3-5 Loss of RF Output with No Apparent Failure

Root Cause – A poor ground connection on any of the high power RF interconnects can result in ground noise during scanning. The ground noise interferes with the logic and control circuitry of the SRFD2, causing the UNBLANK signal to drop out inside the SRFD2. The loss of the UNBLANK gate cuts off the RF output power from the amp.

Symptoms - System scans fine, no SRFD2 errors, but may get poor IQ images, or messages re: prescan failures because the signal is too small. Typically this will occur at higher TG levels. Can check by running a manual prescan and increasing the TG as the signal is displayed – the signal will drop out at some TG level. Can also verify this with the dummy load and a scope.

Solution – Check the nuts that attach the grounds of the high power connectors to the chassis of the SRFD2 to make sure they are tight. Check the connectors at both the rear panel of the module and on the sub-panels behind the front plate (you have to remove the front plate to get at them.) A glob of red torque seal indicates the connections were checked and sealed before shipment, but it may be possible that the hardware came loose anyway.

1-3-6 PDU Circuit Breaker Trips on SRFD2 Power Up

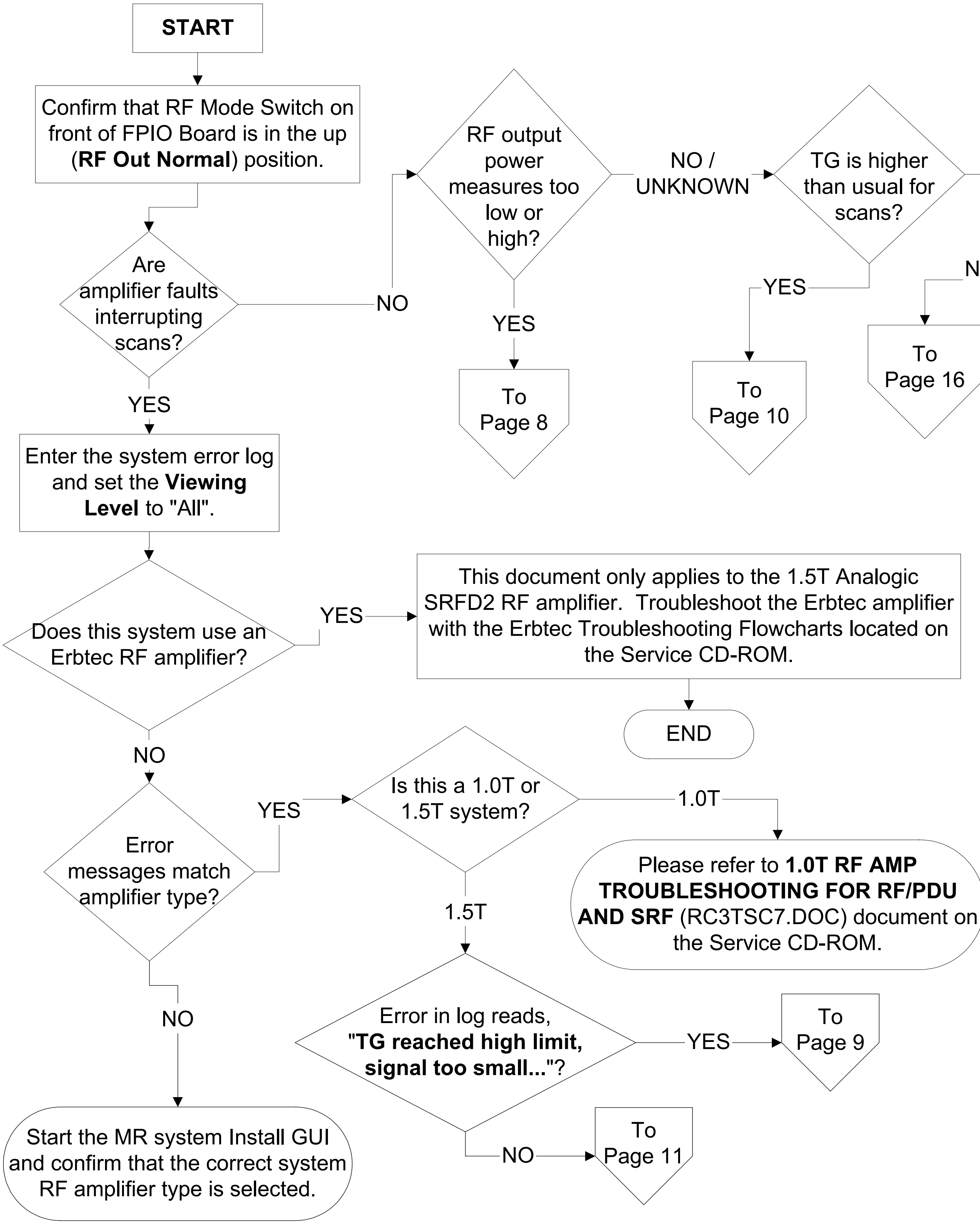
Root Cause – Capacitor(s) across the rectified AC main power input have failed as a result of environmental stress.

Symptoms - System typically works fine for many months, then will suddenly trip the PDU RFI/AMP circuit breaker. Repeated attempts to power up the SRFD2 after resetting the PDU breaker will trip the PDU again. Measurement of the resistance between the L1/L2/L3 connections of the SRFD2 power pigtail may show 1 or more low impedance pathways (these impedances should be theoretically infinite.)

Solution – There is no field solution at this time. The unit needs to be replaced and sent back for repair. This issue has been addressed recently. An amplifier with status code “9” crossed out has the fix for this issue installed.

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 7

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.

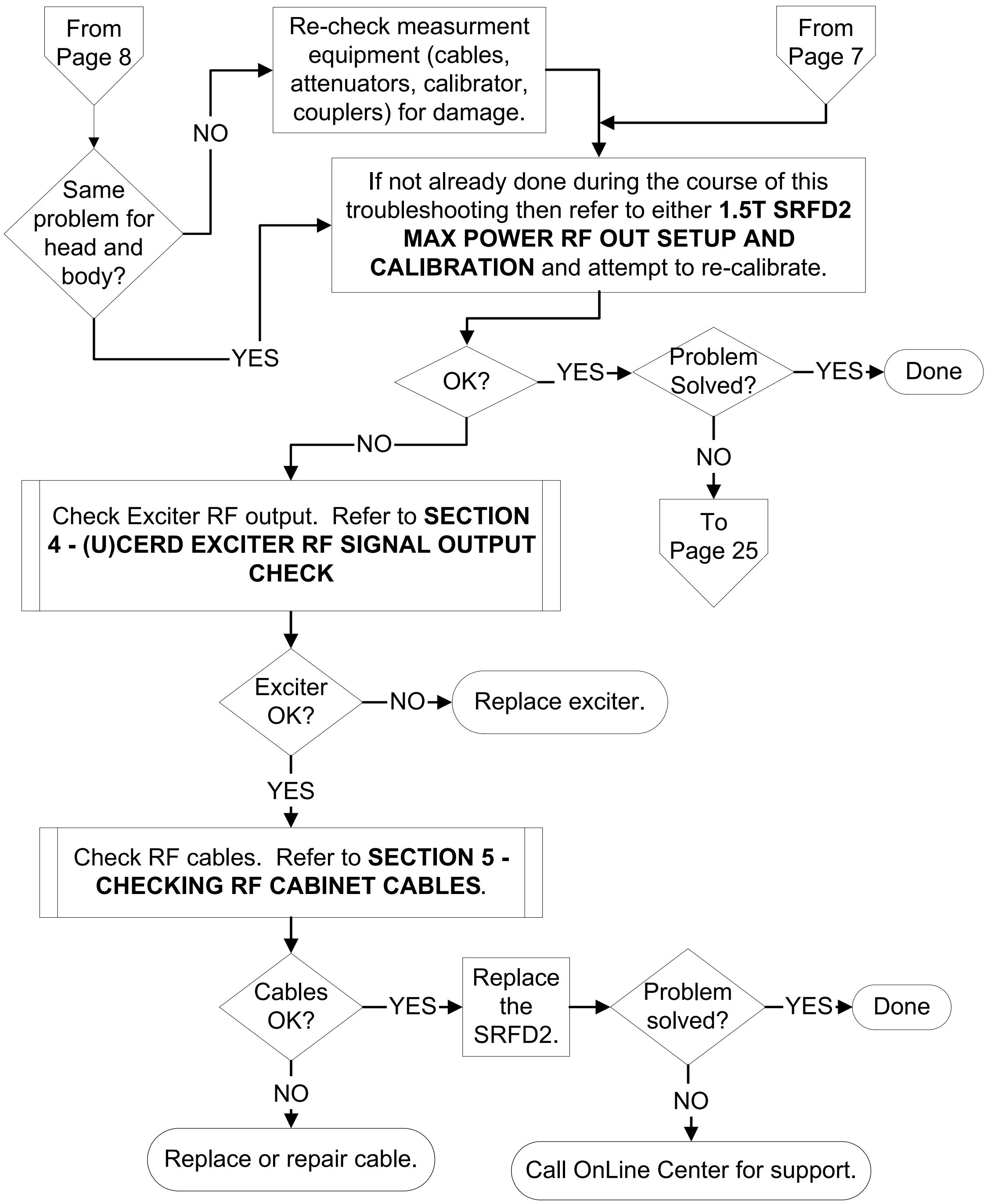
↓

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

YES ↓

To Page 9

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



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

From Page 7

This section assumes that the head or body RF power measured from the output of the SRFD2 (ports J3 or J4, respectively) is within specifications.

Problem common to both head and body?

YES → Please repeat SRFD2 calibration procedure. Problem appears to be mis-calibrated SRFD2. If this doesn't help, contact OLC for support.

NO →

Recommendationed Actions:

- Inspect all the adapters, connectors, and cables in the transmission line path. Verify that all are making good eletrical connection and none are worn, damaged, or exhibiting signs of arcing.
- Check the SSM dynamic disable bias high voltage used in body mode (+1000VDC for 1.5T; 500VDC for 1.0T) and make sure that it is present.
- Use a Digital Multimeter in diode test mode to check the continuity of the unbiased dynamic disable and direct drive bias lines. The forward diode drops and reverse voltages should be similar between the 5 lines (J72, J73, J74, J75, and J76 on the magnet room side of the penetration panel).
- Run RF Test (RFT) to check the functionality of all the components in the head or body RF chain.

If unable to identify a faulty component, then please contact the OLC for support.

2-2 1.5T SRFD2 RF Amplifier Fault Code Steering

This section contains a list of 1.5T SRFD2 RF fault codes. Referring to Table 2-1, locate the appropriate system fault code then go to the indicated page. If the fault code is not listed in Table 2-1, then contact the OLC for support.

TABLE 2-1
1.5T SRFD2 RF AMPLIFIER FAULT CODES

FAULT CODE	GO TO PAGE
2254201	12
2254202	13
2248814, 2248815	14
2254053	15
2254203	16
2254204	17
2254205	18
2254206	19
2254207	20
2254208	21
2254209	22
2254210	23
2254211	24
2254212	25
2254213	27
2225470, 2248759	28
2225471, 2248770	29
2225472, 2248762	29
2225473, 2248761	29
2225474, 2248768	30
2225476, 2248763	30
2225478, 2248764	30
2225480, 2248765	31
2225487, 2248755	31
2225498	31
2225590, 2248850	32
2225703, 2248673	32
2225704, 2248674	32
2225707	33
2254054	34
2254214	35
2254215	36
2254216	37
2248734	38
2248735	39

2-3 1.5T SRFD2 Fault Code 2254201

From Page 11

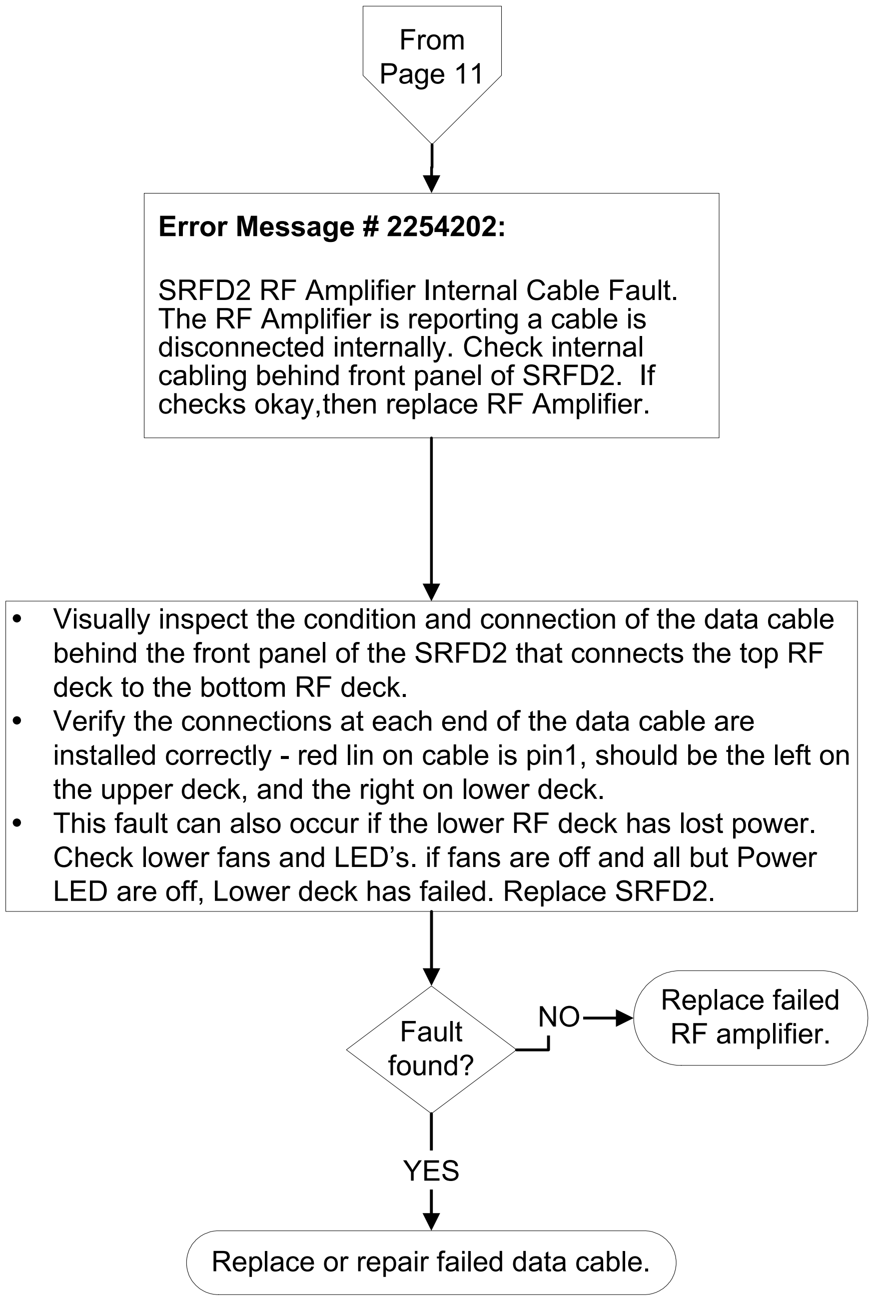
Error Message # 2254201:

SRFD2 General Overheating Fault. RF Amplifier has exceeded maximum internal temperature. Possible causes: Restricted air flow, defective fans, or defective SRFD2 combiner.
Extended Error Message:
The interal heat sendor in the SRFD2 detected fault. Check fan, may be blocked or defective. Possible defective combiner, replace RF Amplifier.

Recommended Actions:

- Check that SRFD2 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 SRFD2 if fan OK and cabinet temperature OK.

2-4 1.5T SRFD2 Fault Code 2254202



2-5 1.5T SRFD2 Fault Codes 2254051 And 2254052

From Page 11

Error Message # 2254051:

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: ###
This could also occur when power cycling SSM.

Error Message # 2254052:

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: ###
This could also occur when power cycling the SSM

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 SRFD2 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 SRFD2 Body Sense ports A and B to Head Sense ports A and B. Replace the SRFD2 if RF leakage is excessive.
- Check the connections to the SRFD2 @J18 and to the SSM @ J503. These faults can occur if connections is broken or if SSM has been power cycled.

2-6 1.5T SRFD2 Fault Code 2254053

From Page 11

Error Message # 2254053**:**

RF Amplifier 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.
Extended Error Message:
High voltage (is really emulated for Erbtec Amp) relay fault will occur with Power Monitor Faults.

Recommended Actions:

- This fault normally occurs in conjunction with 2254051 or 2254052. 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 SRFD2 and the J503 port on the SSM.

2-7 1.5T SRFD2 Fault Code 2254203

From Page 11

Error Message # 2254203:

SRFD2 RF Amplifier Power Loss Fault.
RF Amplifier detects no power to RF decks or high voltage supply.
Possible cause: Defective RF Amplifier.

Replace the failing RF amplifier.

From Page 11

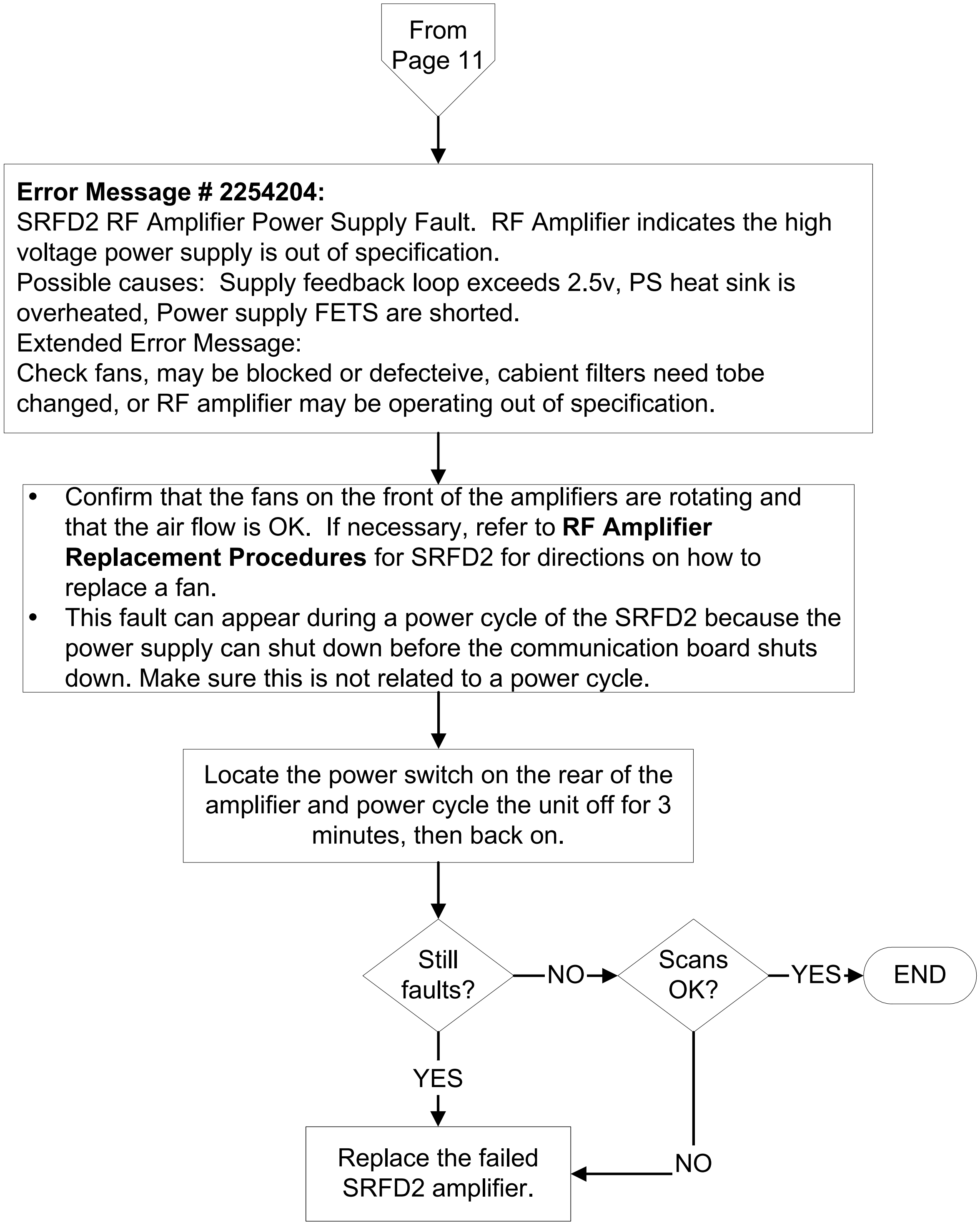
Electromagnetic Interference (EMI) Internal to the Amp can cause the amplifier to stop functioning without reporting and amplifier fault. Remove the front grill cover from the amplifier and check tha tall the nuts securing the RF fittings to the Amp are tight. Replace grilland run RF check again.

OK?

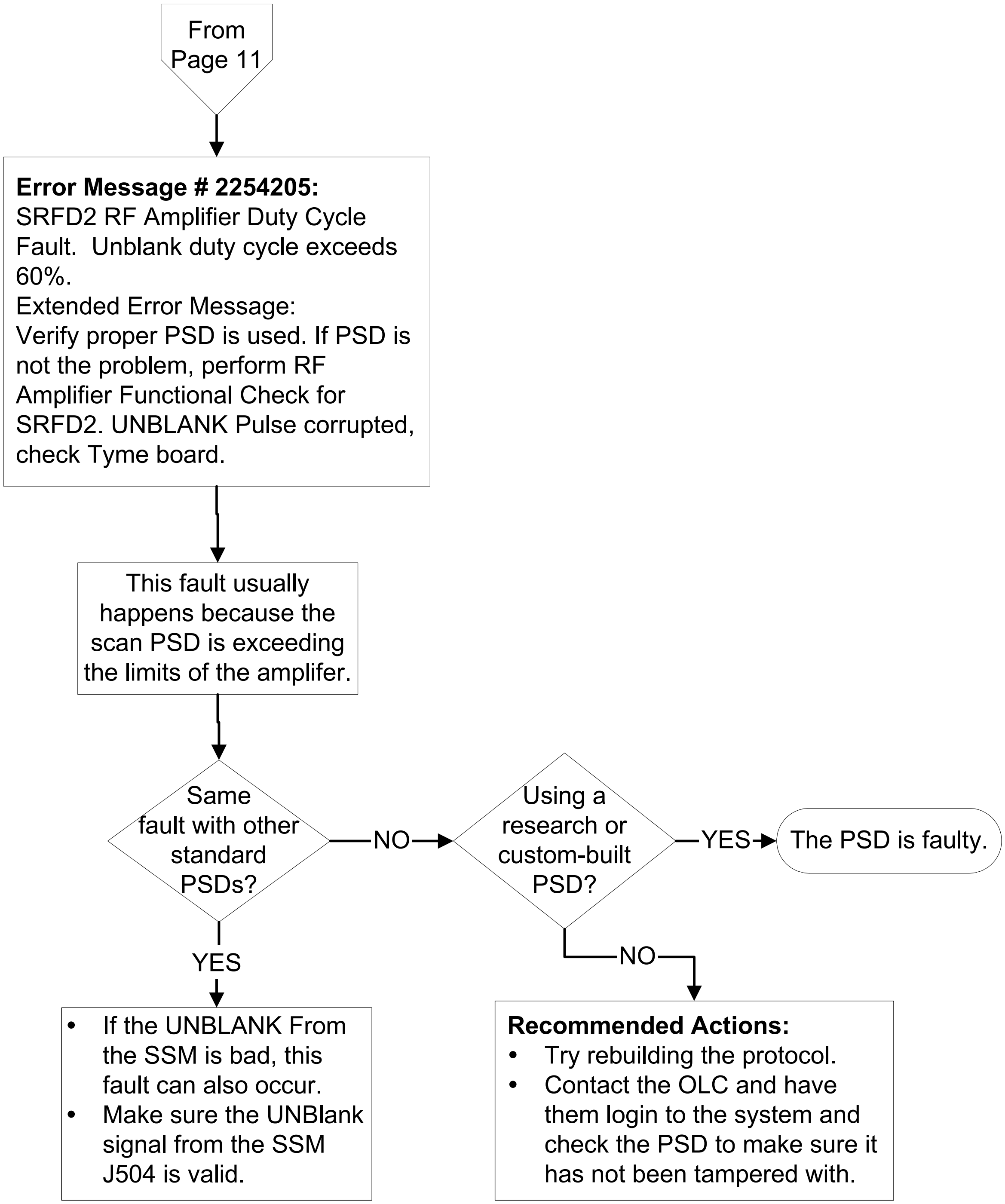
Yes → **DONE**

No → **Call OLC for Support**

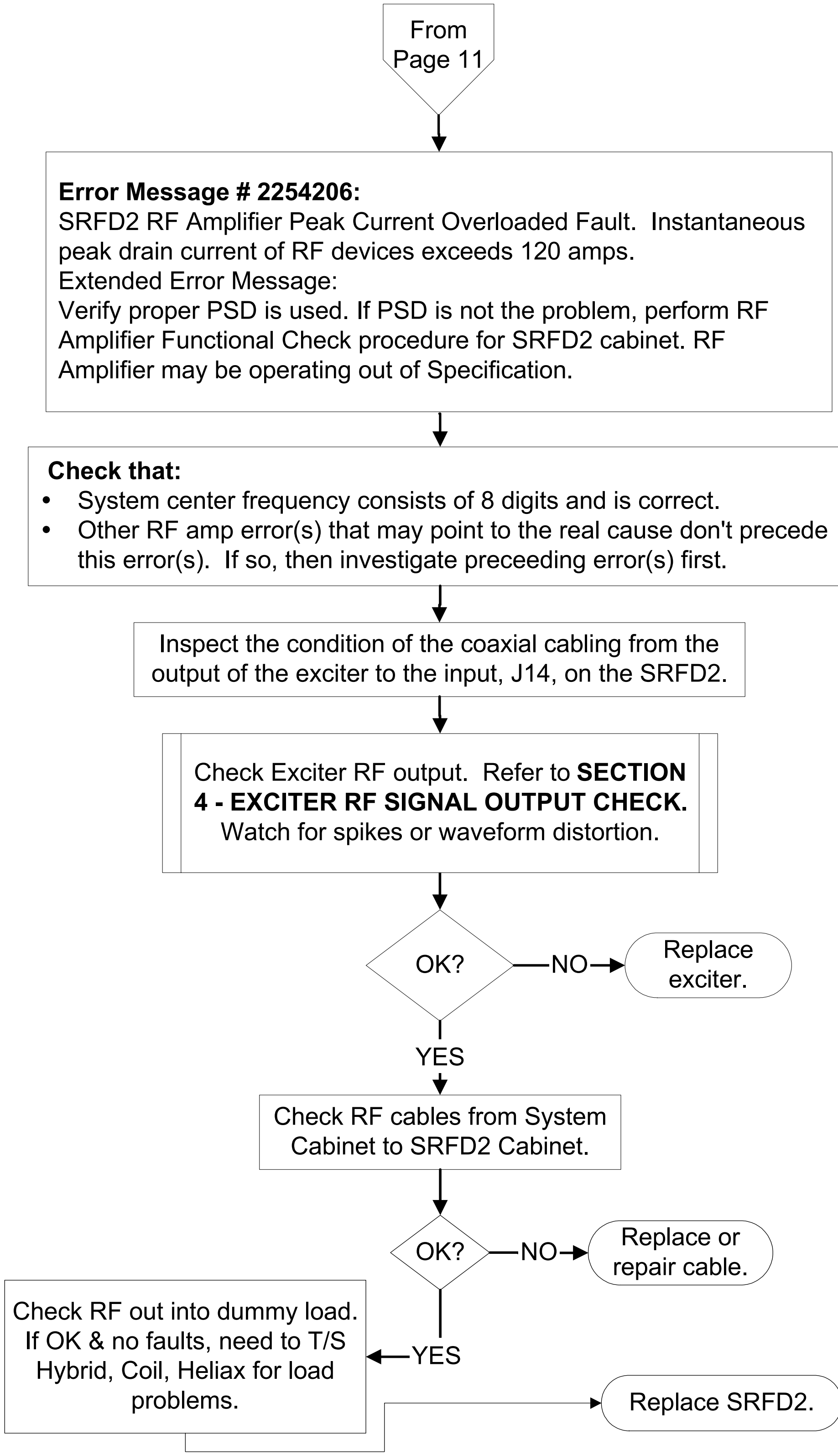
2-8 1.5T SRFD2 Fault Code 2254204



2-9 1.5T SRFD2 Fault Code 2254205



2-10 1.5T SRFD2 Fault Code 2254206



2-11 1.5T SRFD2 Fault Code 2254207

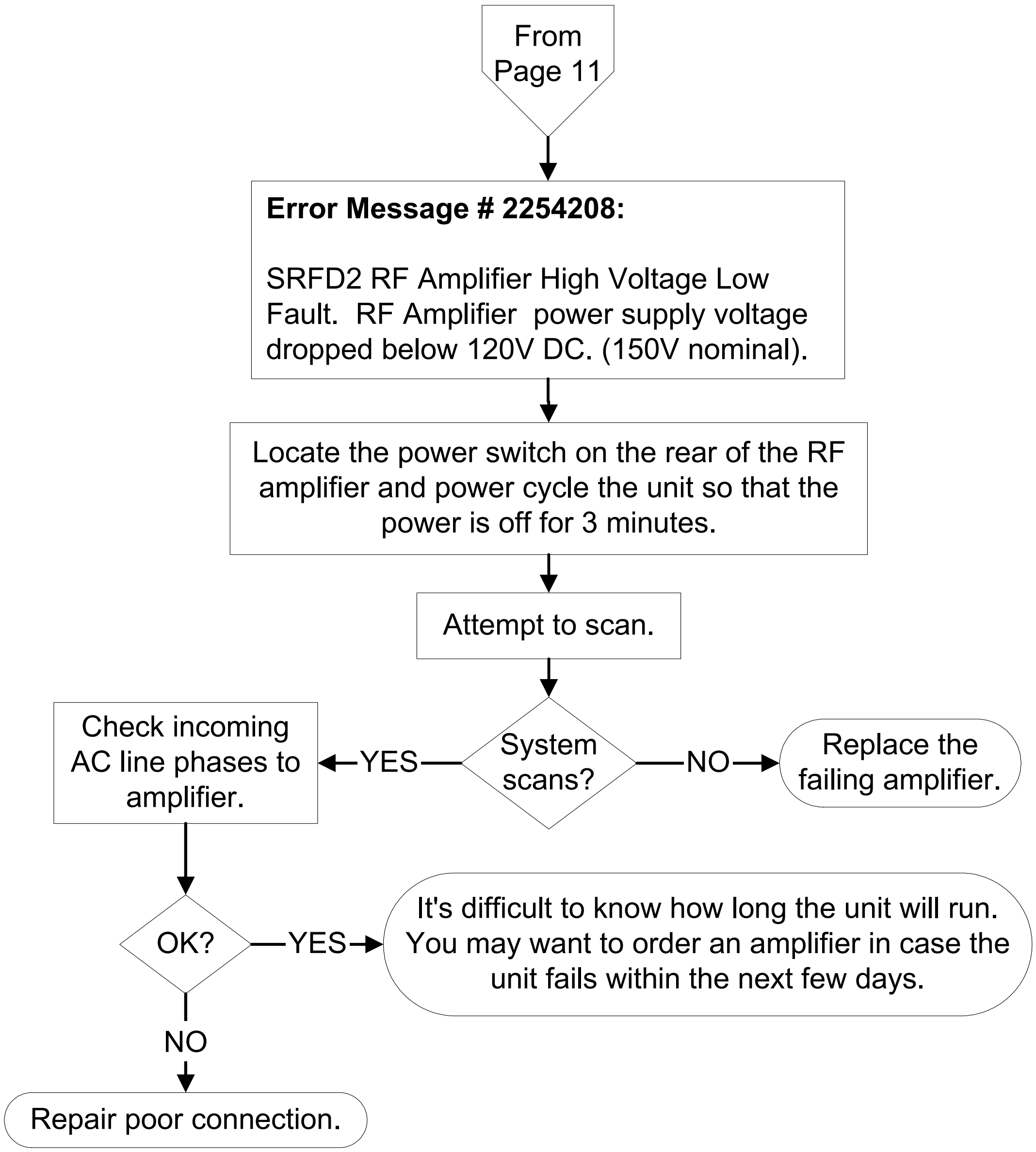
From Page 11

Error Message # 2254207:

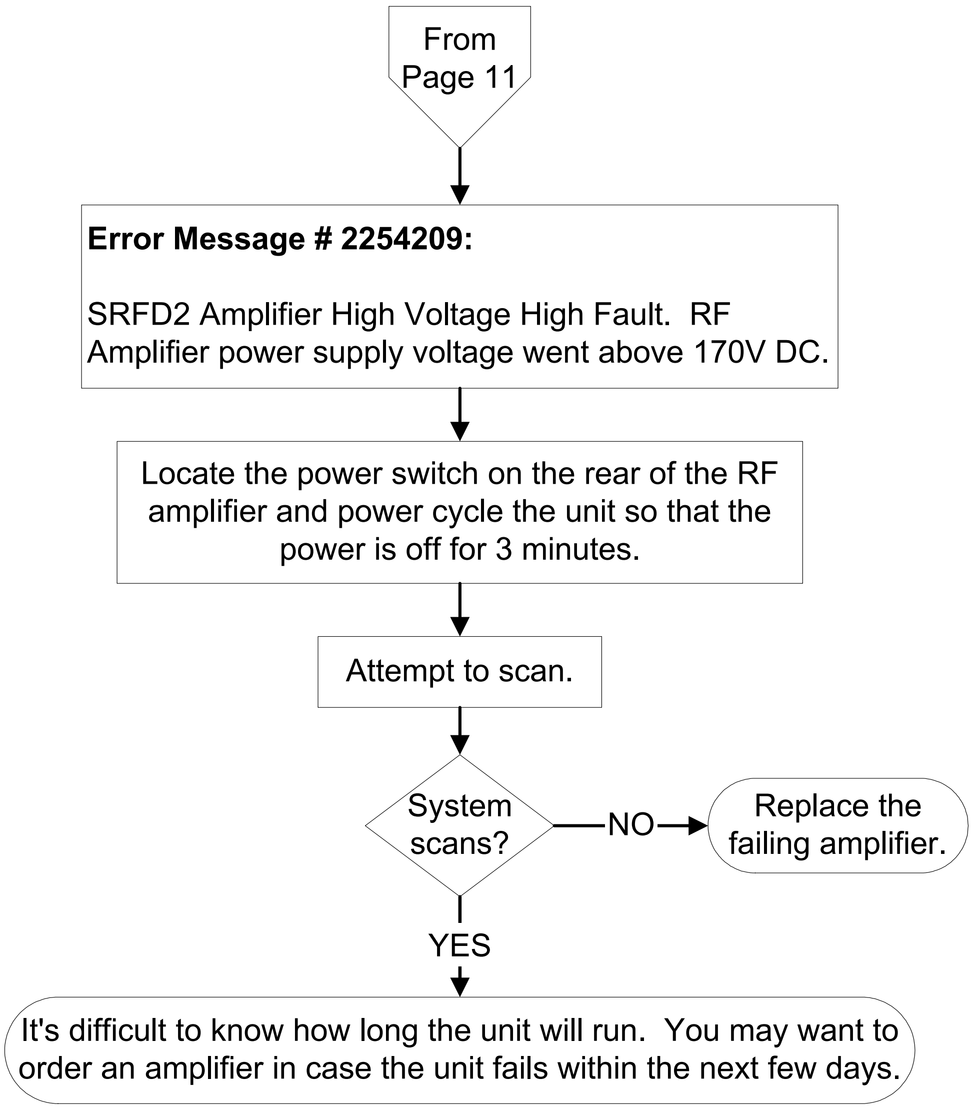
SRFD2 RF Amplifier Device Fault 44. RF FET device is shorted. SRFD2 will attempt to bypass this failure and run in low power mode. Replace Amplifier. Extended Error Message: If Bypass is successful you may continue t scan, but the amplifier must be replaced.

If the bypass is sucessful, message number 2254054 will appear. Order an RF amplifier and replace the bypassed unit as soon as the new one arrives. The customer can scan with this configuration *until* the new RF amplifier arrives. Bypassing the failed FET is NOT a permanent fix. The penalty for bypassing an output FET is a 1.21 dB reduction in maximum RF output power (12 kW max. instead of 16 kW max.). If the FET failure cannot be bypassed, the amp must be replaced immediately. The site will not be able to scan.

2-12 1.5T SRFD2 Fault Code 2254208



2-13 1.5T SRFD2 Fault Code 2254209



2-14 1.5T SRFD2 Fault Code 2254210

From
Page 11

Error Message # 2254210:

SRFD2 RF Amplifier Excessive Input Drive Fault.
RF Amplifier detects input greater than 20dBm.
Possible causes: RF Gain miss-calibration, defective exciter, or defective RF Amplifier.
Extended Error Message:
Check exciter level. If exciter level is within specification, check gain adjustment on SRFD2.
Refer to SRFD2 Functional Check Procedures.

To
Page 25

2-15 1.5T SRFD2 Fault Code 2254211

From Page 11

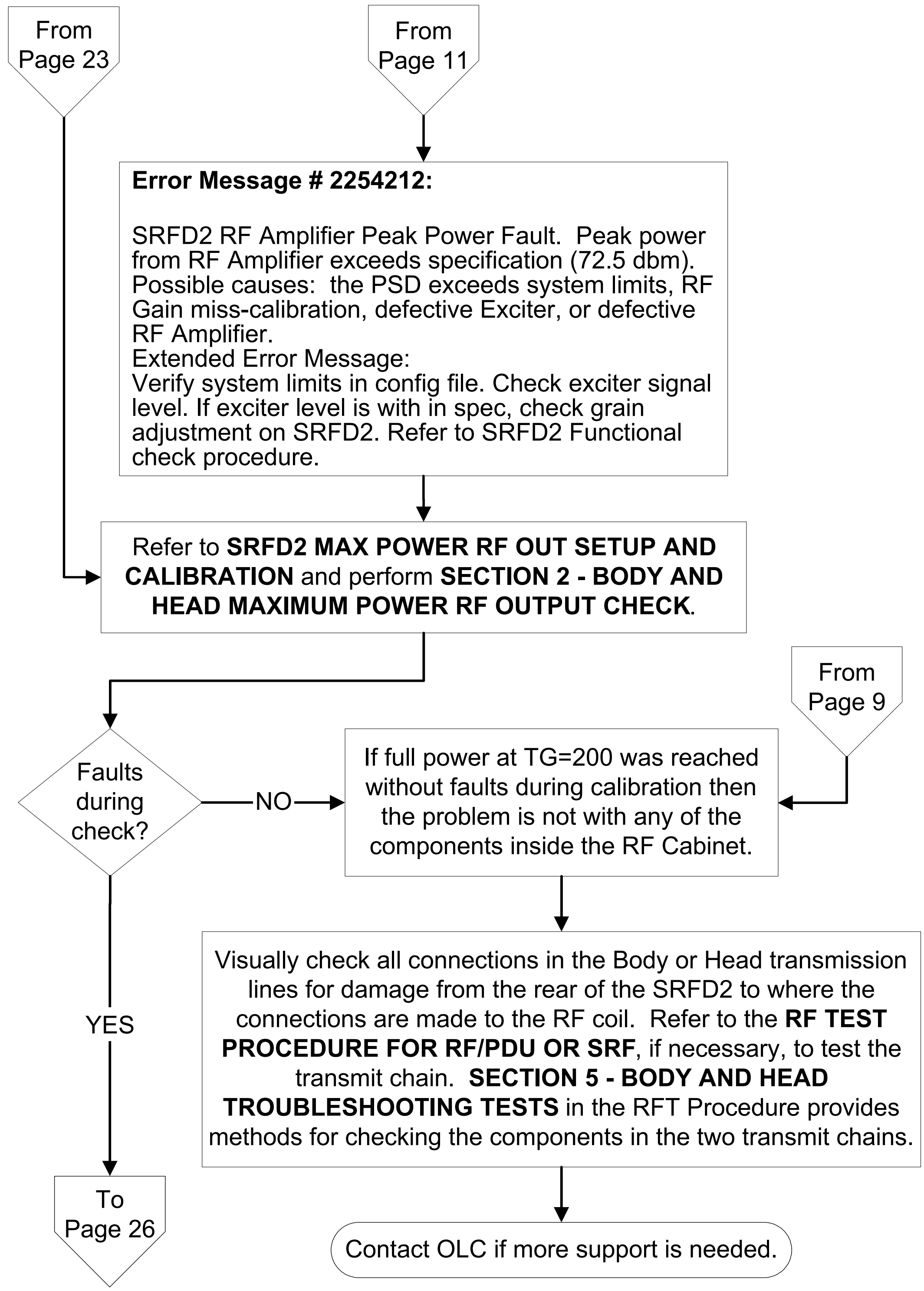
Error Message # 2225747:

SRFD2 RF Deck Overheat Fault. RF Amplifier reports the thermal switch has exceeded 80 degrees C.
Possible causes: restricted air flow, blown fan fuse, defective fan, room environment out of spec, or defective RF Amplifier.

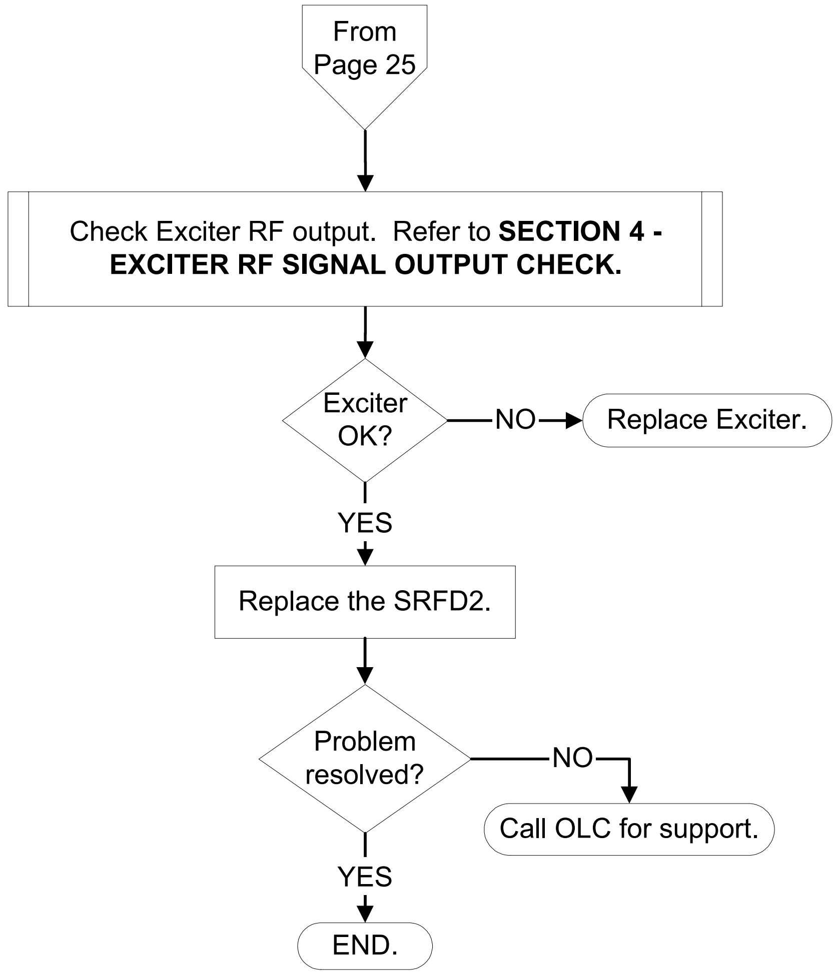
Recommended Actions:

- 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.
- If all else OK then it may be necessary to replace the RF amplifier.

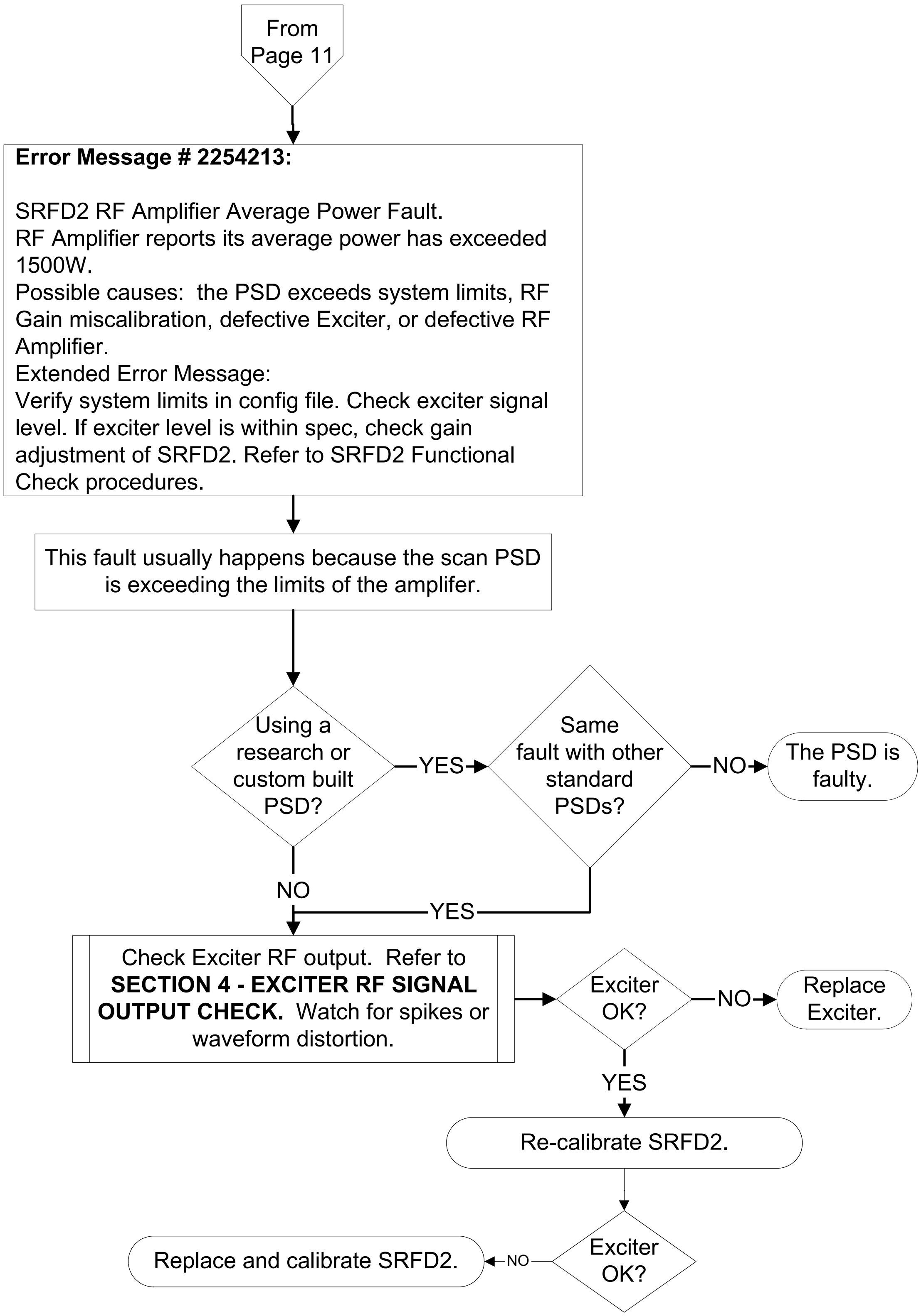
2-16 1.5T SRFD2 Fault Code 2254212



2-16 1.5T SRFD2 Fault Code 2254212 (Continued)



2-17 1.5T SRFD2 Fault Code 2254213



2-18 General RF Amplifier Communication and Configuration Errors

From Page 11

Error Message Number: 2225470 (9.x) or 2248759 (10.x and up)

Software Constant: EM_SPI_MDS_RF_AMP_BICYCL_ERROR
"RF amplifier response timeout.
RF MDS peripheral - RF Amp/RF Interface link failure.
Verify that the RF Amplifier or RF Interface is powered on and that
the RF MDS peripheral is connected to the RF Amplifier or RF Interface."
Logged: Local Host at Operator Viewing Level and in System Status Area at Priority 4

This message indicates that the actual communication between the SSM and the SRFD2 was disrupted. This message will appear if the communication is hard down. It will also appear if there was even a slight mis-timing of one character in the communication data stream.

With the FMI installed, or with an SRFD2 with status code 5, this message no longer indicates that a power cycle would be needed – if the amplifier loses communication, it will reset itself. The message will still appear in the log to indicate that a problem occurred however.

If the response timeout is a hard failure (i.e., it is not cleared automatically or by a TPS reset) check the following:

- The power is on to the RF amp. The front panel LED's should be displaying a status of STANDBY or OPERATE. The fans should be running.
- The communication cables from the SSM are connected/seated properly. Check J18 on the SRFD2, and J501, J503 and J504 on the SSM.
- Perform a TPS reset and watch the front panel of the SRFD2. When the SSM comes back to life (about 1-2 minutes into the TPS reset) it should also reset the SRFD2. The front panel display will flash and then show the SRFD2 going to OFF then back up to STANDBY or OPERATE.
- Power cycle the SSM only – the microprocessor on the CPD board can become corrupted.
- If this is happening just after the implementation of FMI60654, the new firmware may not have properly downloaded or initialized. Re-initialize by following section 4-4 of the FMI 60654. If still not working, make sure the Interface board and the connections to it are seated properly and solid. If needed, perform the firmware download again per the FMI document.

Error Message Number: 2225471 (9.x) or 2248770 (10.x and up)

From Page 11

Software Constant: EM_SPI_RF_MON_AMP_STATE
"RF Amplifier Error.
The RF amplifier is in an invalid, undefined state.
RF amplifier status register read: 0x%02X
Please power cycle the RF Subsystem and Reset TPS."
Logged: Local Host at Service Viewing Level

This message indicates that either the amplifier communication was disrupted, and so it is no longer properly executing commands OR the RFAmpType in the MRConfig file may be wrong.

Error Message Number: 2225472 (9.x) or 2248762 (10.x and up)

Software Constant: EM_SPI_RF_MON_INVAL_MODE
"RF Amplifier Error.
The RF amplifier failed to go into the commanded mode (head or body),
or the RF amplifier changed mode when not commanded to change.
Present Mode: 0x%02X Requested Mode: 0x%02X
Please power cycle the RF Subsystem and Reset TPS."
Logged: Local Host at Service Viewing Level

This message indicates that either the amplifier communication was disrupted, and so it is no longer properly executing commands OR the RFAmpType in the MRConfig file may be wrong.

Error Message Number: 2225473 (9.x) or 2248761 (10.x and up)

Software Constant: EM_SPI_RF_MON_WATCHDOG
"RF Amplifier Error.
The RF amplifier reset watchdog engaged.
This indicates either a microprocessor fault condition exists
or a cold start is in progress."
Logged: Local Host at Service Viewing Level

If the SRFD2 microprocessor locks up, an on-board watchdog will engage and restart the SRFD2 microprocessor. This message gets logged to let the system know that a self-restart was performed. This is the self-recovery mechanism added to the SRFD2 for the uP lockup problems.

From Page 11

Error Message Number: 2225474 (9.x) or 2248768 (10.x and up)

Software Constant: EM_SPI_RF_MON_INVALID_STATE_TRANS
"RF Amplifier Error.
The RF amplifier changed state (powered off, went to standby or operate)
without being commanded.
Previous state: 0x%02X New state: 0x%02X
Please power cycle the RF Subsystem and Reset TPS."
Logged: Local Host at Service Viewing Level

This message indicates that either the amplifier communication was disrupted, and so it is no longer properly executing commands OR the RFAmpType in the MRConfig file may be wrong.

Error Message Number: 2225476 (9.x) or 2248763 (10.x and up)

Software Constant: EM_SPI_RF_MON_FAIL_TO_POW_OFF
"RF Amplifier Error.
RF amplifier failed to power off, in the allotted amount of time,
when commanded to do so.
Please power cycle the RF Subsystem and Reset TPS."
Logged: Local Host at Service Viewing Level

This message indicates that either the amplifier communication was disrupted, and so it is no longer properly executing commands OR the RFAmpType in the MRConfig file may be wrong.

Error Message Number: 2225478 (9.x) or 2248764 (10.x and up)

Software Constant: EM_SPI_RF_MON_FAIL_TO_READY
"RF Amplifier Error.
RF amplifier failed to power on or go to ready when commanded,
or took too long to power on.
Please power cycle the RF Subsystem and Reset TPS."
Logged: Local Host at Service Viewing Level

This message indicates that either the amplifier communication was disrupted, and so it is no longer properly executing commands OR the RFAmpType in the MRConfig file may be wrong.

Error Message Number: 2225480 (9.x) or 2248765 (10.x and up)

From Page 11

Software Constant: EM_SPI_RF_MON_FAIL_TO_OPERATE
"RF Amplifier Error.
RF amplifier failed to go to operate when commanded to do so.
Please power cycle the RF Subsystem and Reset TPS."
Logged: Local Host at Service Viewing Level

This message indicates that either the amplifier communication was disrupted, and so it is no longer properly executing commands OR the RFAmpType in the MRConfig file may be wrong.

Error Message Number: 2225487 (9.x) 2248755 (10.x and up)

Software Constant: EM_SPI_RF_AMP_TYPE_INCORRECT
"RFampType in MRconfig.cfg file does not match RF Amplifier Type
determined by SPI. Please update MRconfig.cfg file with correct RFampType.
Actual RF Amplifier Type: %01d.%01dT %b"
Logged: Local Host at Service Viewing Level

This message indicates that either the MRconfig file is wrong, or the RF amplifier type in the SRFD2 is wrong. If the SRFD2 itself is correct, the "Actual RF Amplifier Type:" will read "1.5T SRFD2." The RFampType in the MRconfig file should be set to "10" to make the error go away.

This mismatch can cause a host of problems related to command and control timing of the SRFD2. It's better to fix it than to let it ride.

Error Message Number: 2225498

Software Constant: EM_SPI_UNKNOWN_STRING
"Unknown Amplifier"
Logged: Local Host at Service Viewing Level

This message means that either the SRFD2 is not responding with the correct RF amplifier type code OR that the software version on the system doesn't recognize the RF amplifier. The host software must be at 9.x with the SRFD2 patch or at a later version to recognize the SRFD2 RFAmpType code.

Error Message Number: 2225590 (9.x) or 2248850 (10.x and up)

From Page 11

Software Constant: EM_SPI_ERB_AMP_ERROR
"RF Amplifier fault %02d."
Logged: Local Host at Service Viewing Level

This error message is used for reporting any SRFD2 microprocessor errors. If the SRFD2 watchdog goes off, the reason for the watchdog event is reported by this error message. The "%2d" field above will report one of the following:

Watchdog Reset Error Condition	Error Code in %2d Field
COP Watchdog failure	80
COP Clock Monitor fail	81
Uimplemented instruction trap	82
Software interrupt	83
Unused Timer channel	84
Unused Pulse accumulator	85
ATD(Analog-to-Digital Converter) interrupt	86
BDLC(Byte Data Link Communications) interrupt	87
RAM broken	88
Not defined State	89
Reserved	90-96

Since the SRFD2 recovers from the uP lockup by itself, the purpose of this error message is only to capture the data and requires no intervention by service.

Error Message Number: 2225703 (9.x) or 2248673 (10.x and up)

Software Constant: EM_SPI_MDS_RCV_ERR_BRK_1
"MDS link failure.
The MDS fiber optic link appears to be broken between the Gradient and the RF cabinets. Check gradient cabinet power, fiber optic connections and signal level of fiber optic link. Run MDS fiber optic link diagnostics."
Logged: Local Host at Operator Viewing Level

MDS link failures are not to be confused with a loss of communication to the RF amp. This message indicates a problem in the fiber optic communication to the SSM.

Error Message Number: 2225704 (9.x) or 2248674 (10.x and up)

From Page 11

Software Constant: EM_SPI_MDS_RCV_ERR_BRK_2
"MDS link failure.
The MDS fiber optic link appears to be broken between the RF and System cabinets. Check RF cabinet power, fiber optic connections and signal level of the fiber optic link between the cabinets. Run MDS fiber optic link diagnostics."
Logged: Local Host at Operator Viewing Level

MDS link failures are not to be confused with a loss of communication to the RF amp. This message indicates a problem in the fiber optic communication to the SSM.

Error Message Number: 2225707

Software Constant: EM_SPI_MDS_SPC_RCV_BAD_ADDRESS
"MDS link failure.
The RF cabinet MDS peripheral board reported a bad address. Replace the RF MDS peripheral board."
Logged: Local Host at Operator Viewing Level

MDS link failures are not to be confused with a loss of communication to the RF amp. This message indicates a problem in the fiber optic communication to the SSM, more specifically that the SSM is not processing addresses properly (the RF MDS peripheral is in the SSM.)

2-19 1.5T SRFD2 Fault Code 2254054

From Page 11

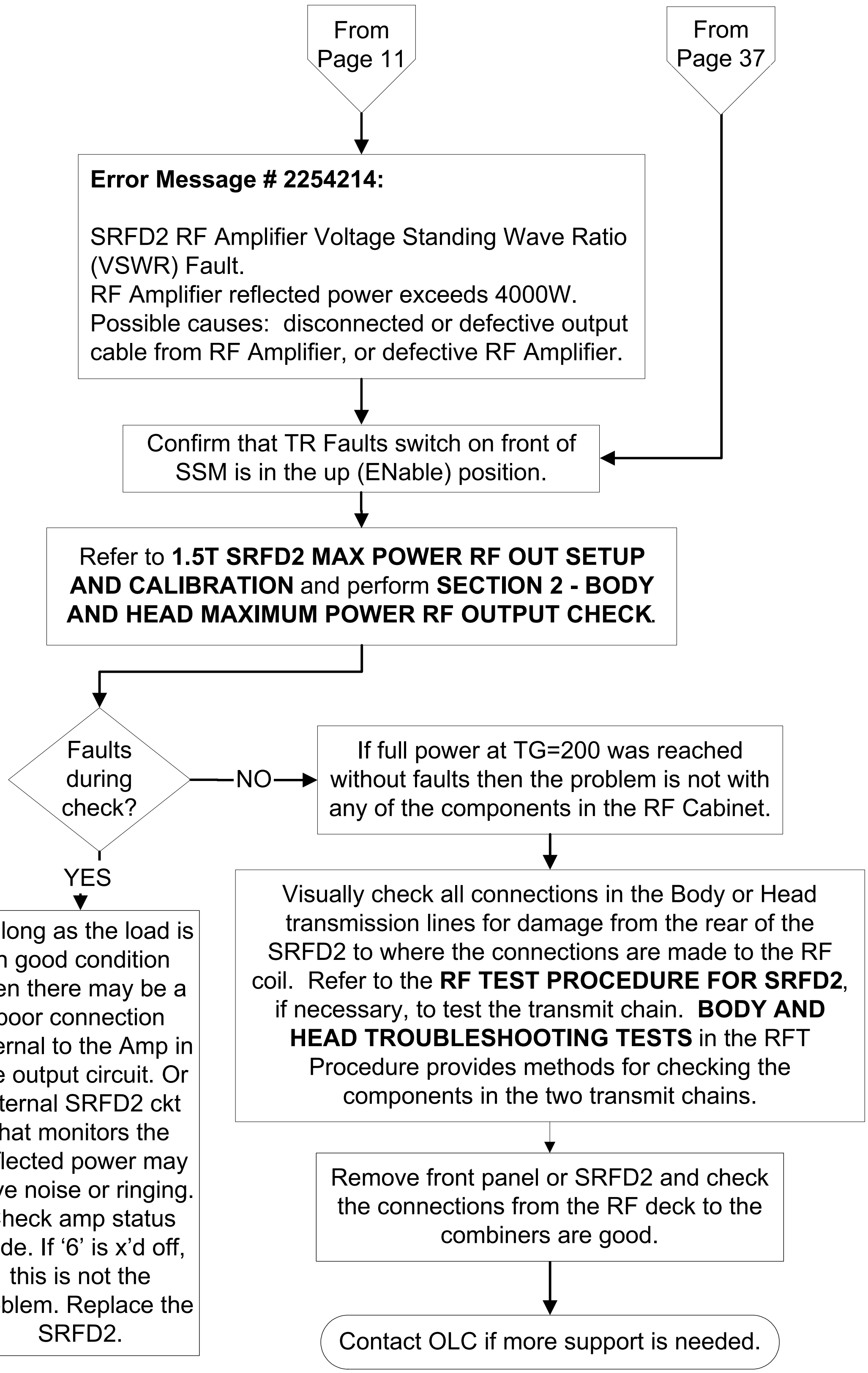
Error Message Number: 2254054
Software Constant: EM_RF_LOW_POWER_STATUS
"RF Amplifier in low power state*; avoid SE, MEMP, FSE scans.\b*
RF Amplifier has successfully bypassed a fault. IQ may be compromised.
Please run prescan again. Scanning can then continue at reduced output levels.
Scanning may be limited. Contact FE."
Extended Error Message:
"Scanning with SE, MEMP, FSE PSD's may be limited, especially with large patients."
Logged: Local Host at Operator Viewing Level and in System Status Area at Priority 4

The SRFD2 has the ability to bypass some types of RF FET failures in the event that one should occur. If this message appears in the log, check to make sure that it was preceded by Error Message Number 2254207, which indicates a true RF FET failure. The FET failure may have occurred at some point prior to the user first noticing this message about the low power state, and the FET failure message will log only once.

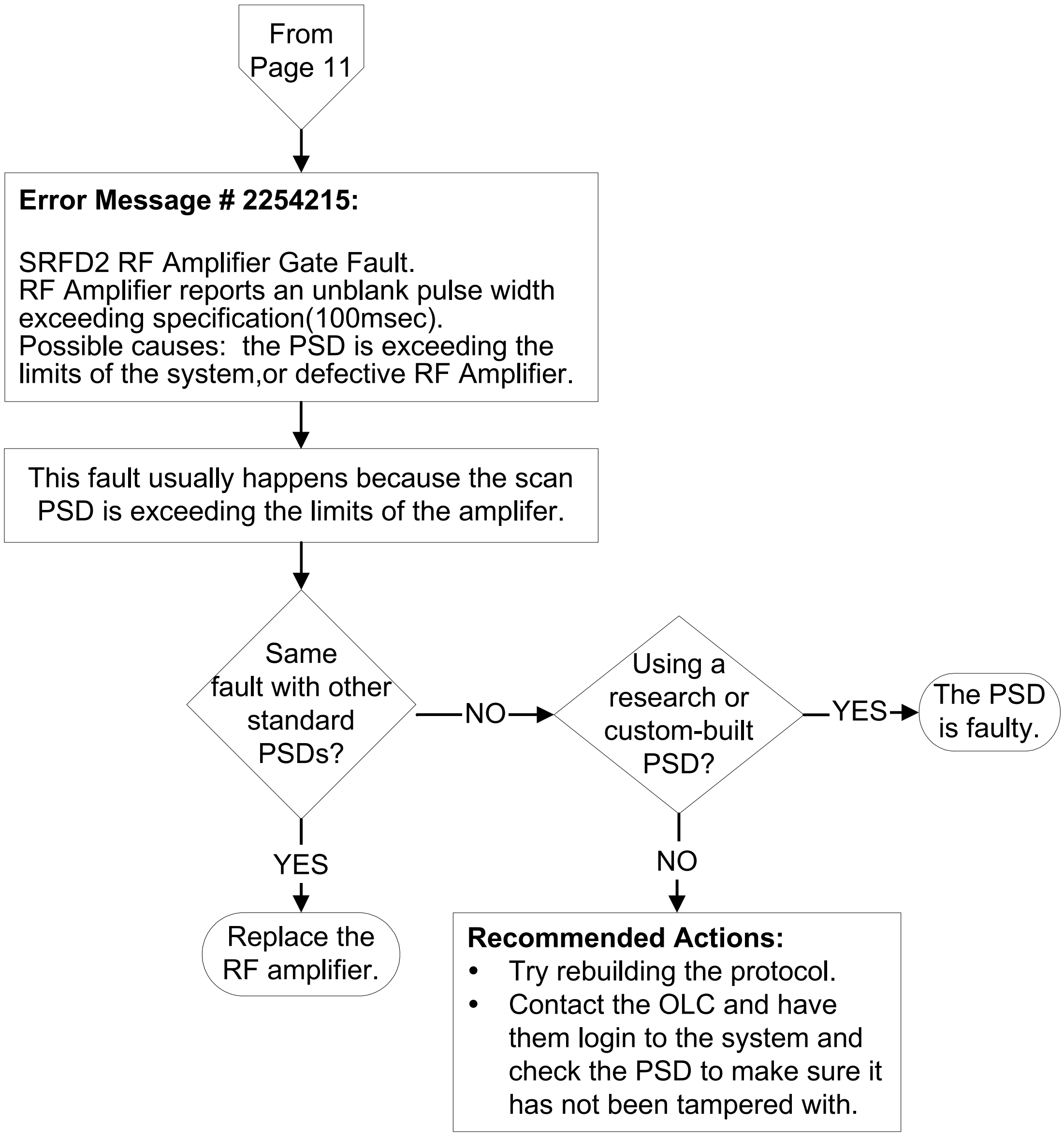
This error message will appear every time a TPS reset is performed as a reminder to the operator that scanning is limited until the amplifier is replaced.

The ultimate solution is that the SRFD2 must be replaced. The low power state allows the site to continue scanning at reduced output until a replacement is installed.

2-20 1.5T SRFD2 Fault Code 2254214

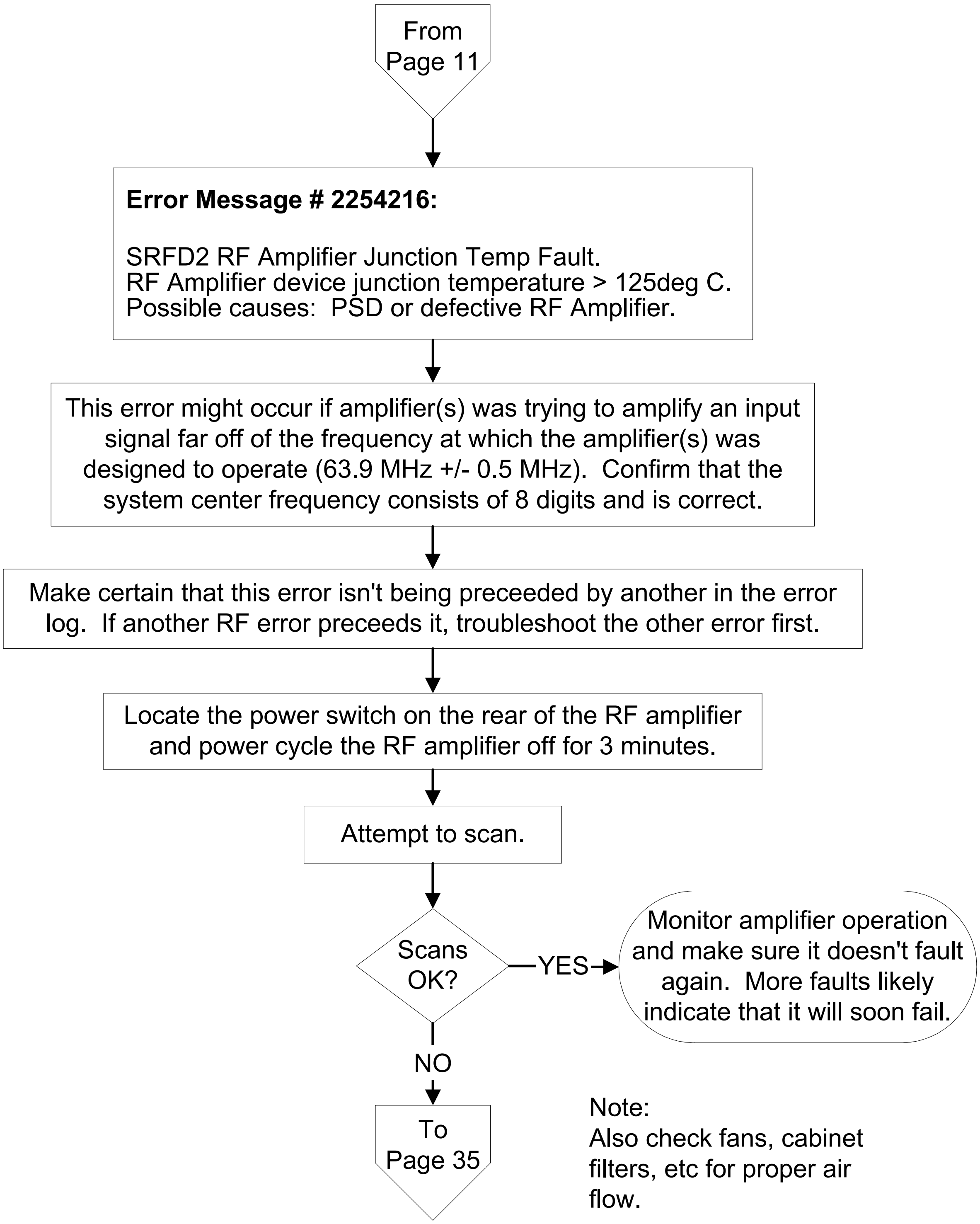


2-21 1.5T SRFD2 Fault Code 2254215



Note:
This error can also occur if the UNBLANK pulse from the SSM is faulty, e.g. Wrong polarity, or not pulsing at all.

2-22 1.5T SRFD2 Fault Code 2254216



2-23 RF Power Monitor Fault Code 2248734

From Page 11

↓

Error Message # 2248734:

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** procedure on the 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** procedure 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.

2-24 RF Power Monitor Fault Code 2248735

From Page 11

Error Message # 2248735:

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 – RRF EXCITER RF SIGNAL OUTPUT CHECK

A minimum RF signal level from the RRF Exciter 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 3-2 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 RRF Exciter is in specification or not. The second method is described in **Section 3-3 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 RRF Exciter and determine whether it is in specification or not.

3-1 Tools Required

TABLE 3-1
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

3-2 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.

3-2 Exciter RF Output Check Using The RF Power Measurement Kit (Continued)

4. 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 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]**.

IMPORTANT
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 center frequency consists of 8 digits. Center frequency is displayed without a decimal point and it is easy to omit a digit!

5. Disconnect the cable going to J14 on the rear of the SRFD2.

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.

3-2 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 rear of the SRFD2.

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 SRFD2).

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 SRFD2).

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 SRFD2) 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 SRFD2).

21. Reconnect the cable removed earlier to the RF IN connector on the inside of the RF Cabinet I/F panel (J1 for SRFD2).

3-2 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 ≥ 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 SRFD2) for poor connections or damage.

28. Remove connector from J8 on the front of the Mux Board on the rear of the RRF Chassis.

29. Insert the SMB to BNC test cable from the TPS RF Connector/Adapter and Cable Test Kit into Master Exciter Out J8 on the Mux Board.

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 ≥ 35.7 **minor divisions**.

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

34. Remove the test cable and reconnect the previously removed cable.

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 6 - SYSTEM RESTORATION**.

3-3 Exciter RF Output Measurement Using an Oscilloscope

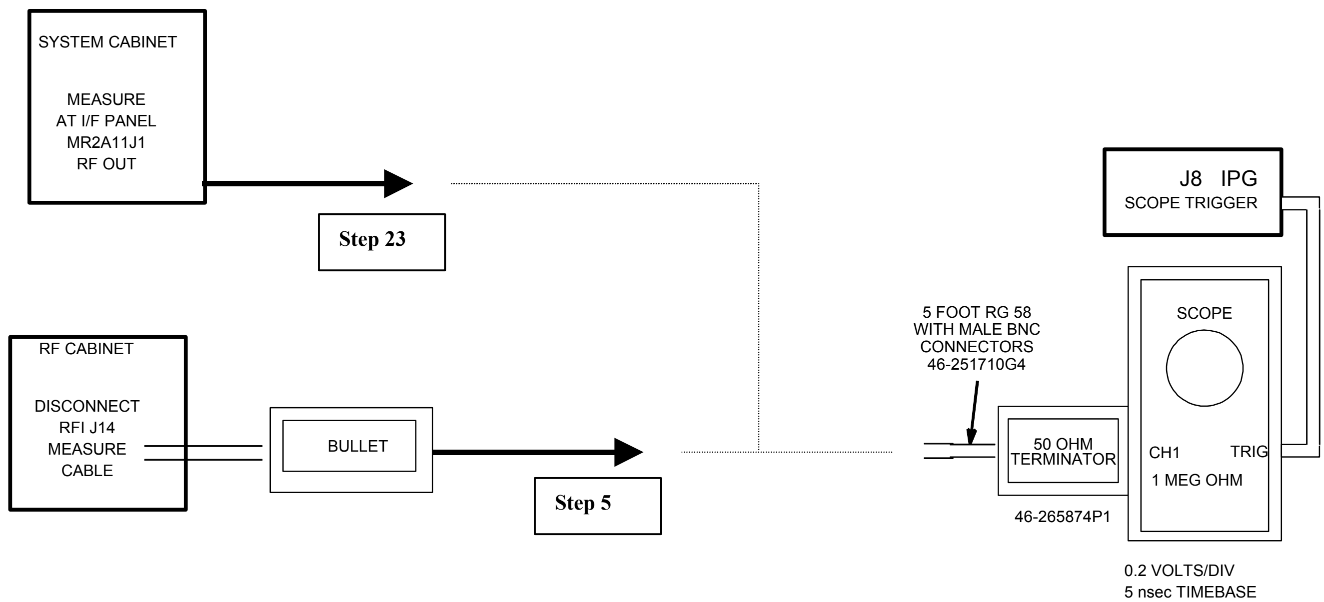
Note

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:

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

3-3 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 rear of the SRFD2.

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.

3-3 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).

3-3 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).

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

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

10. Reconnect the cable removed from J14 on the rear of the SRFD2.

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 SRFD2).

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 SRFD2).

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).

$$\frac{\text{Measured Vpeak to peak}}{\text{Correction factor}}$$ **= 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 rear of the SRFD2 appears bad. Repair or replace this cable.

3-3 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 SRF2).

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 SRF2).

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 J8 Master Exciter Out on the front of the Mux Board.

27. Insert the SMB to BNC test cable from the TPS RF Connector/Adapter and Cable Test Kit into J8 Master Exciter Out on the Mux Board.

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

3-3 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).

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

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

32. Remove the SMB to BNC test cable from J8 on the Mux Board and replace the previously removed cable.

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 6 - SYSTEM RESTORATION**.

4 – CHECKING RF CABINET CABLES

This section will check the condition of the low-power RF coaxial cables in the SRFD2 Cabinet. 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. Obtain a Digital Voltmeter (DVM) and set it so that a 50 ohm load can be accurately measured.

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

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

TABLE 4-1
MEASURED RESISTANCE OF 50 OHM TERMINATOR

Resistance	_________ ohms

4. Return to the rear of the SRFD2 Cabinet and remove the cable connected to **J14 RF INPUT** on the rear of the SRFD2.

5. 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.

6. Reconnect the cable removed from **J14 RF INPUT** on the rear of the SRFD2.

NOTE

The electrical continuity of this cable was already checked in **SECTION 3 - RRF EXCITER RF SIGNAL OUTPUT CHECK** and will not be checked again.

7. From the rear of the SRFD2 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 (for SRFD2).

8. Proceed to **SECTION 6 - SYSTEM RESTORATION**.

5 – 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.

5-1 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** 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).

5-2 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 not 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.

5-3 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.

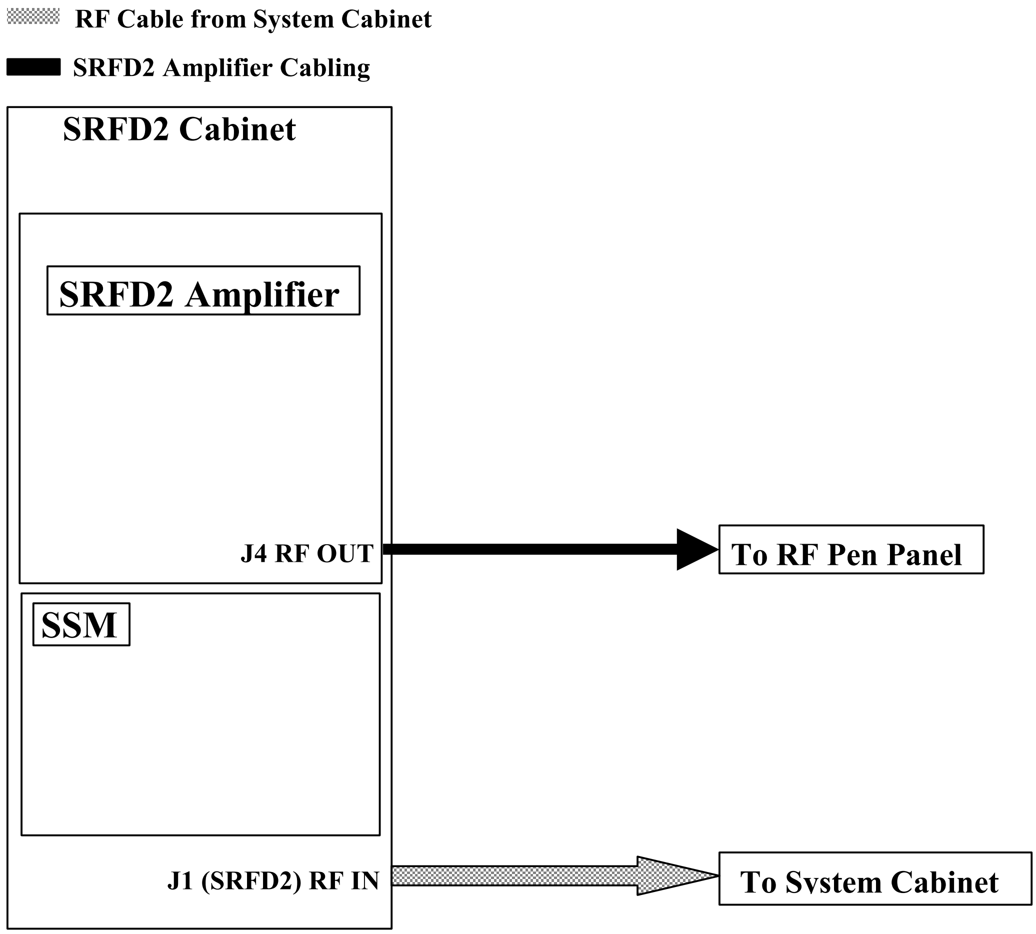
2. RF Power Measurement Kits that are suspected to contain faulty components should be returned to a professional, certified metrology lab for repair and/or calibration.

5-4 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

6 – SYSTEM RESTORATION

1. Verify that the system is not scanning.
2. Refer to Illustration 7-1 and reconfigure the system back to a normal configuration.



NORMAL SYSTEM CONFIGURATION
ILLUSTRATION 7-1

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

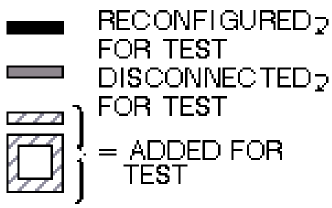
3. Bypass the body TNS (MR2 A24 A1 A1) from the circuit by disconnecting the small coax cables MR2 A24 A1 J12 (signal output) and MR2 A24 A1 A1 J2 (signal input) from the TNS and connecting both together using a female-BNC to female-BNC adapter (also known as a bullet adapter 46-220427P3).

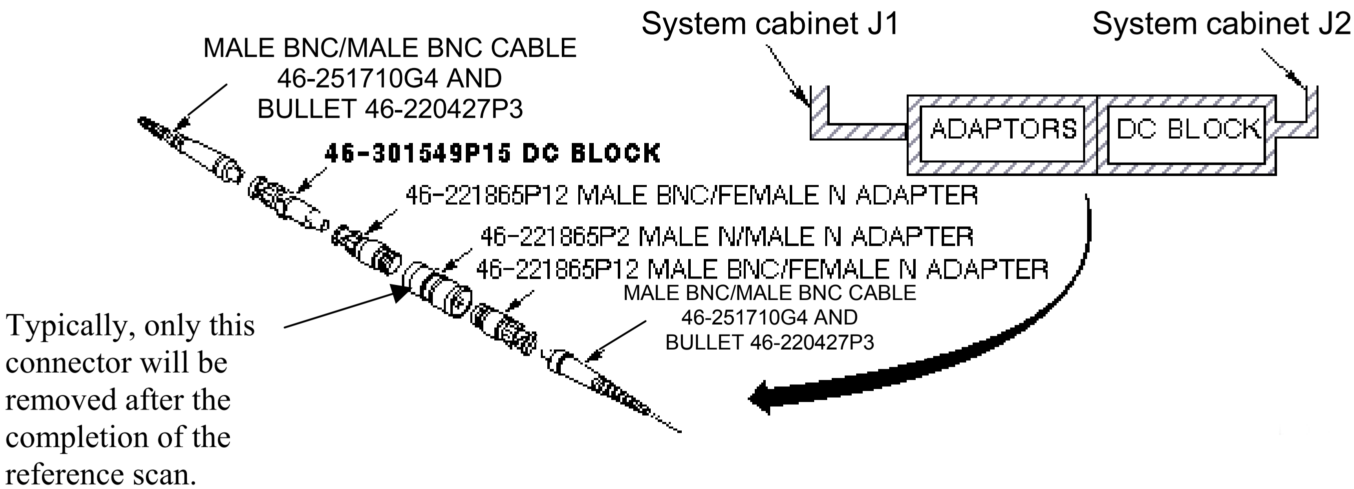
Note

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.

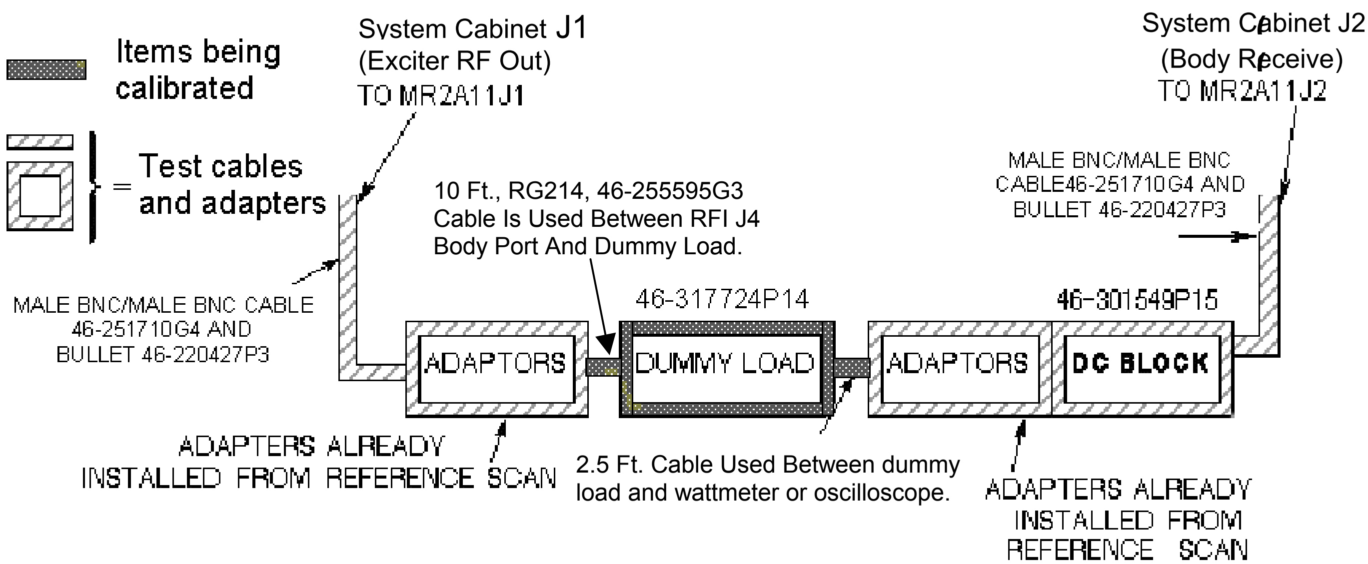
C-4 Data Collection (Continued)

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

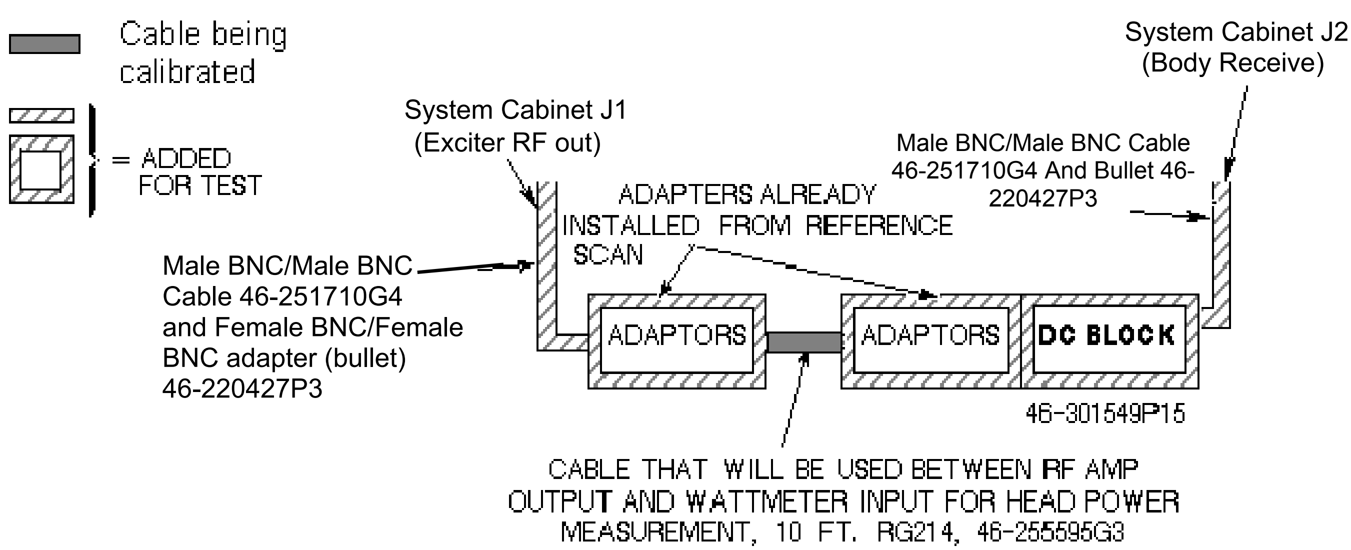
- Illustration C-2 – Dummy Load and Cables
- Illustration C-3 – Amplifier to Wattmeter Cable
- Illustration C-4 – 40dB or 30dB Coupler, Cables, and 1dB Step Attenuator
- Illustration C-5 – 10dB Fixed Attenuators

Note

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

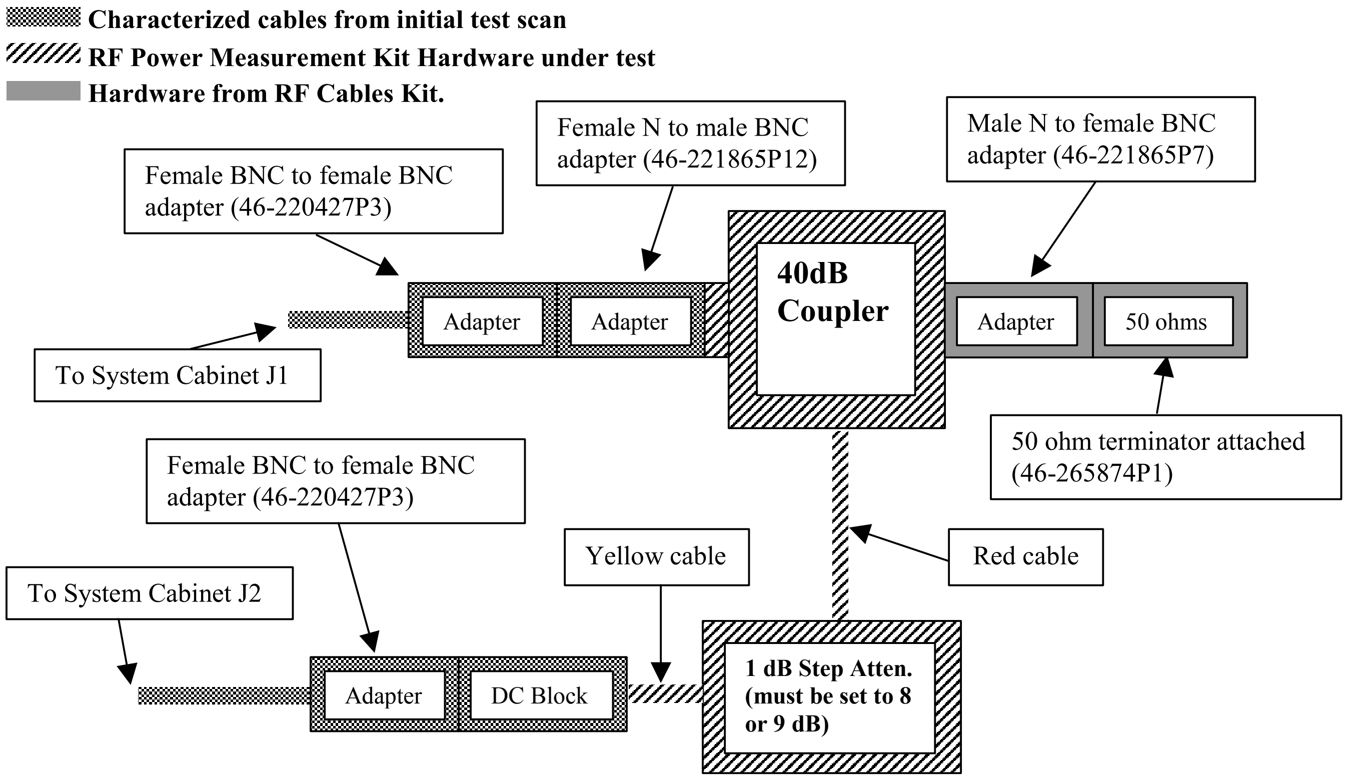


CONNECTIONS FOR DUMMY LOAD + CABLES SCAN
ILLUSTRATION C-2

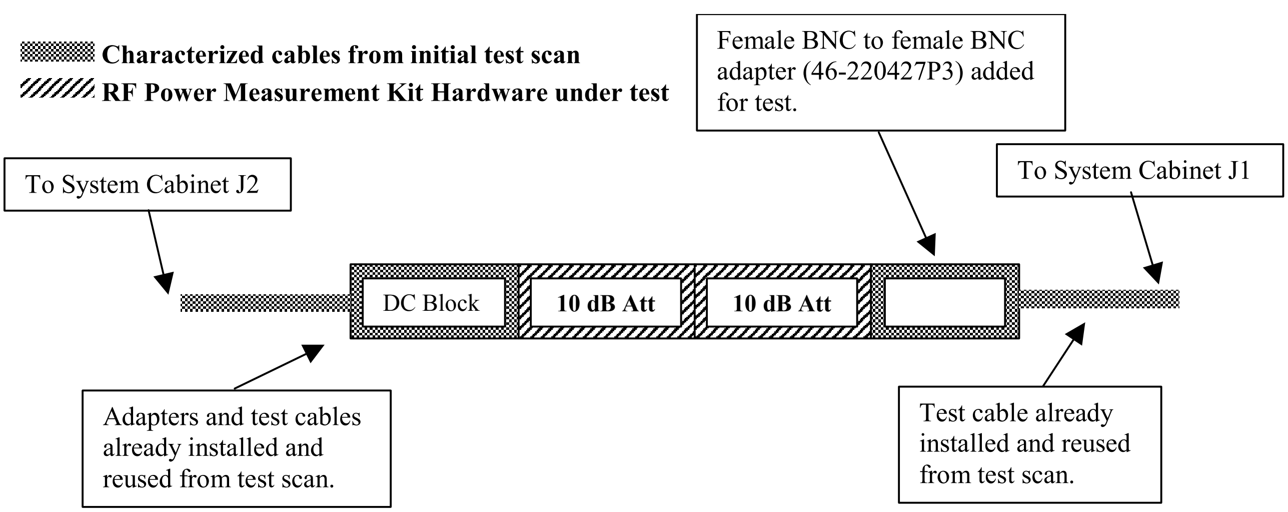


AMP TO WATTMETER CABLE SCAN
ILLUSTRATION C-3

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	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.

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

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

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

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

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

TABLE C-5
RF POWER CALCULATION <u>WITH NO LOSS</u>

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

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

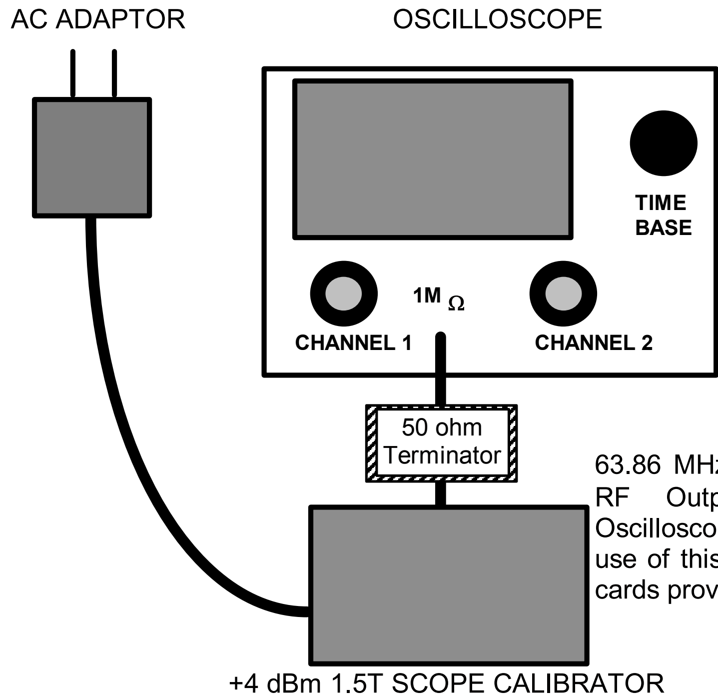
. As long as the same cables are used the loss can also be determined for each cable.

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
A	Oct. 23, 2003	D. Thome	Preliminary version
0	Dec 12, 2003	Hawthorne	Initial Release, final updates from D. Thome.