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Description - If the proprietary GE Power Measurement kit is not available, this procedure directs you how to calibrate the dummy load and cables which are used while monitoring / adjusting RF output power with a scope. It will also accommodate the calibration of cable(s) needed if a wattmeter is used as your instrument of choice.

Note

When measuring high frequency (42 or 64 MHZ) on any 100 MHZ scope, there may be an error due to the bandwidth limitations of the scope. (If necessary, read 'Scope Trivia' at the end of this procedure.)

1- OVERVIEW

Test cables long enough to reach the cable or dummy load, plus cables 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 scan is taken and stored in a raw file. "Atten_test" is used to calculate the baseline factor for the 'shorted' test cables. (i.e., there is an expected 'no loss' from the test cables). This scan will be designated a reference scan.

Next, the attenuator and/or cable(s) to be tested are inserted in series with the test cables and another scan is taken. Again, use 'atten_test' to determine the "Magnitude Squared Attenuation Factor". (i.e, how much has the test signal been attenuated?) What is the 'attenuation factor'?

2- TOOLS AND INSTRUMENTS REQUIRED

See Table 2-1

TABLE 2-1
REQUIRED TOOLS AND INSTRUMENTS

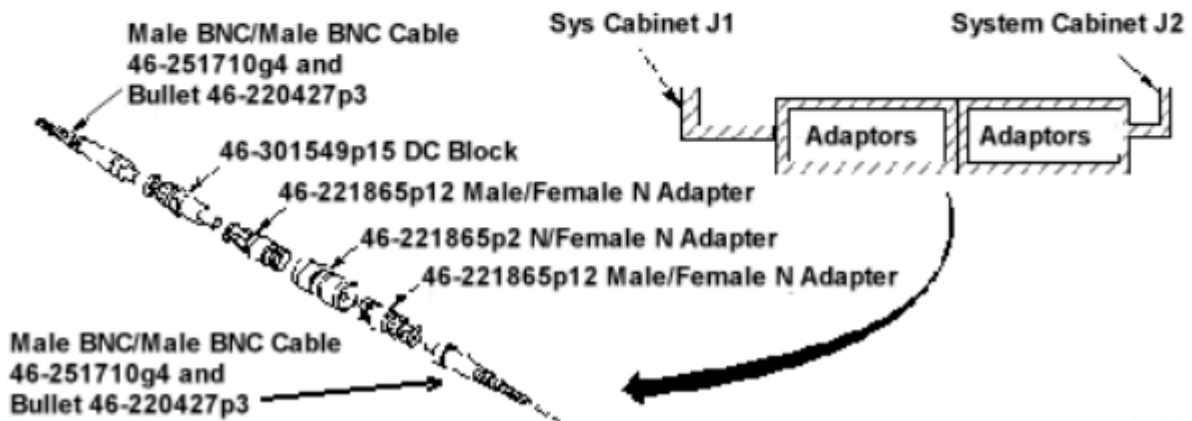
Item	Description	Part Number	Qty.
1	50-ohm dummy load, 200 watt, 30 dB attenuator - Bird Model 8322 (or equivalent).	46-317724P14	1
2	RF Test Cables Kit	46-255816G1	1

3- INITIAL SETUP

1. Remove front cover from system cabinet.
2. Reconfigure test hardware as shown in Illustration 3-1.



Test Cables and Adapters



CONNECTIONS FOR INITIAL AMPLITUDE SCAN
ILLUSTRATION 3-1

Note

It may not be necessary to use all adapters (from RF Cable Kit) required to connect to dummy load or cable, but use as many as is practical.

3. Disconnect the existing cables at the Systems cabinet I/F panel J1 (RF Out) and J2 (Receiver Body Input) and set them aside.
4. Connect the assembled test cables and adapters between J1 (RF Out) and J2 (Receiver Body Input) on the System Cabinet interface.
5. 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 μ sec 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]**.

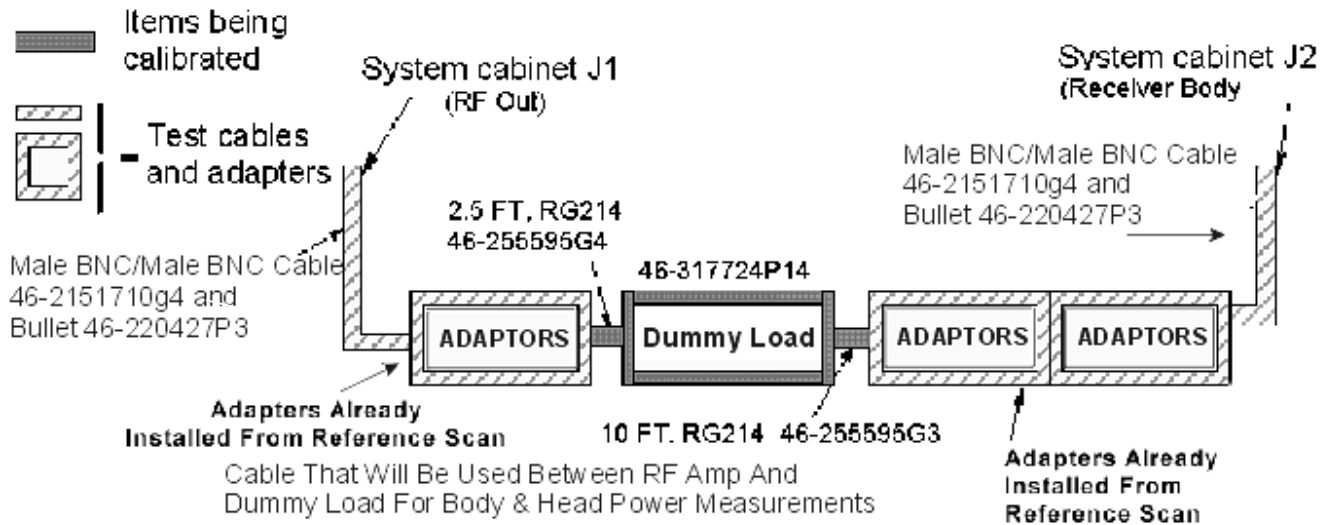
4- DATA COLLECTION

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 appears to be normal. Do not react to this event!)
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 4-1.

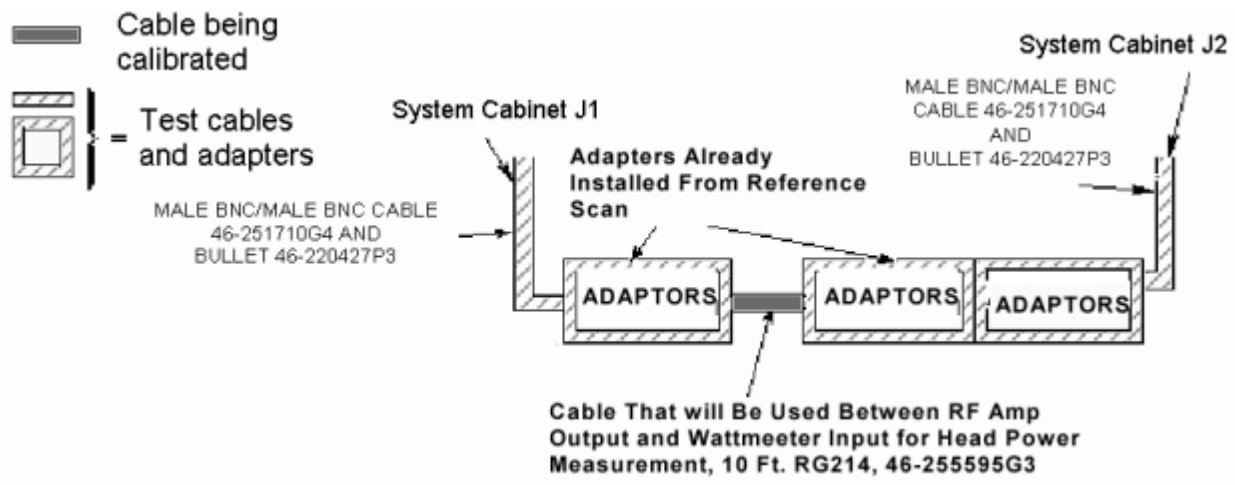
TABLE 4-1
DATA COLLECTION

Output/Prompts	Input/Comments
Last run number used was: XXXX	
Please enter runfile number (XXXX):	<Enter>
Please select Locked / Unlocked file (L,U) (U):.....	<Enter> (working)
<pre> ***** ***** Average Max. magnitude Across All Views = aaaaa Average Max. magnitude Squared = bbbbb Average RMS Across All Views = ccccc ***** </pre>	
Do you want to make this run the reference(Y,N)(N):.....	Y<Enter>

7. Next you will be adding in the dummy load and cables you want to calibrate. Remove only the center male N to male N adapter from the test cables and set it aside. This is assuming that the dummy load you are using has N female connectors at it's input and output. If it should use an N connector at the input and a BNC at the output, an additional adapter will be needed in order to connect it to the test cables.
8. Connect your test cables to opposite ends of either:
 - Illustration 4-1 - Dummy load + cables
 - Illustration 4-2 - Amp to wattmeter cable



CONNECTIONS FOR DUMMY LOAD + CABLES SCAN
ILLUSTRATION 4-1



AMP TO WATTMETER CABLE SCAN
ILLUSTRATION 4-2

9. Reselect the scanning icon again to activate the scanning screen.
10. Select **[Scan]**.
11. When the scan is completed, re-select the tools icon again to activate the atten analysis section again. You will have to toggle between both icons depending how many passes you have to do.

5- ANALYSIS

See Table 5-1.

**TABLE 5-1
ANALYSIS**

Output/Prompts	Input/Comments
Do you want to compute Gain or Attenuation Ratio(G,A)[G]:.	(<i>Important:</i> Wait till the scan is completed, then) A<Enter>
Last run number used was: XXXX Please enter runfile number [XXXX]:.....	<Enter>
Please select Locked / Unlocked file (L,U) [U]:.....	<Enter> (Working)
***** *****	
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	<====Record in Table 5-2.
RMS Attenuation Factor = zzzzz	

1. Record "Magnitude Squared Attenuation Factor" value as either Dummy Load + Cables Atten Factor, or Amp To Wattmeter Atten Factor in Table 5-2.

**TABLE 5-2
ATTENUATION FACTORS**

MODE	CALIBRATED HARDWARE	PART NUMBER(S)	VALUE	NOMINAL VALUES
BODY	DUMMY LOAD + CABLES ATTEN FACTOR	46-255595G3 46-317724P14 46-255595G4		1000 TO 1200
HEAD	AMP TO WATTMETER ATTEN FACTOR	46-255595G3		1.0 TO 1.2

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

6- CALCULATION OF CALIBRATION FACTOR

Peak voltage, not peak-to-peak, can be converted to power using the following formula. See Table 6-1 for Theoretical RF Power Calculation and Table 6-2 for an actual example.



THE SCOPE CORRECTION FACTOR MUST BE KNOWN FOR THE FORMULAS SHOWN IN TABLES 6-1 AND 6-2. IF IT IS NOT KNOWN, DO NOT USE THIS METHOD. GROSSLY INACCURATE MEASUREMENTS AND POSSIBLE SYSTEM DAMAGE WILL RESULT.

TABLE 6-1
FORMULA FOR THEORETICAL RF POWER CALCULATION
NO SCOPE LOSS!

$$\frac{\left(\frac{\text{Peak Voltage}}{\text{Scope Correction Factor}} \right)^2}{(2 \times Z)} \times (\text{Dummy Load and Cable Factor}) = (\text{Watts})$$

Note: Z = 50

Example

$$\frac{\left(\frac{40}{1.00} \right)^2}{(2 \times 50)} \times (1000) = \frac{(1600)}{(100)} \times (1000) = 16000 \text{ Watts}$$

TABLE 6-2
FORMULA WITH ACTUAL RF POWER CALCULATION

NOTE 10% SCOPE LOSS ILLUSTRATED HERE
(This is about as close to 16000 watts as one is going to get!).

$$\frac{\left(\frac{\text{Peak Voltage}}{\text{Scope Correction Factor}} \right)^2}{(2 \times Z)} \times (\text{Dummy Load And Cable Factor}) = \text{Power (Watts)}$$

Note: Z = 50

$$\frac{\left(\frac{35.5}{0.90} \right)^2}{(2 \times 50)} \times (1028) = \frac{(1555.8)}{(100)} \times (1028) = 15,994 \text{ Watts}$$

7- SYSTEM RESTORATION

1. Reconnect original cables to the System Cabinet I/F J1 and J2.
2. Replace cover on System Cabinet.
3. Perform one satisfactory head or body scan.

8- WATTMETER TRIVIA

Why are measurements between a oscilloscope and a Bird Wattmeter found to be different? Repeated GEMS Education Center lab groups that performed the Dummy Load and Cables attenuation process correctly, and obtained an accurate attenuation value, were able to accurately measure RF power as well as with a 400 MHZ scope! Remember, for wattmeter measurements however, the meter reading must be multiplied by the atten factor. Leaving this little factor out is the reason why the above 'note' was made. In body mode the wattmeter is placed after the dummy load. Its atten value must be used to calculate the correct RF value. If it is NOT used, then it should be expected there will be an error of 10% or more!

In head mode, the wattmeter is placed before the dummy load. In this case only the 'cable' factor is used to correct the wattmeter reading. The 'cable' factor is the other atten test you did for the 10 foot cable only. Typically that value is between 1.0 to 1.2. Doesn't sound like much???? Take your calculator out for a moment. Take 2,000 watts (displayed reading) and multiply by an atten factor of 1.0 ; the results are obvious, 2,000 watts. Now take the same displayed 2,000 and multiply it by an atten factor of 1.2 = 2,400 watts! Hopefully this example will show the importance of the attenuation values. You just calculated a 20% error if you were wrong because you didn't do atten test on the 10 foot cable!

9- SCOPE TRIVIA

A basic 'rule of thumb' in the scope industry is that 'to accurately measure a high frequency signal, the bandwidth of the scope should be at least 5X the frequency being measured'. That means that for a 64 MHZ signal the scope bandwidth would have to be at least 320 MHZ. Along the same line, a 42 MHZ signal would require a bandwidth of at least 210 MHZ. This is why the 400 MHZ scope was chosen several years ago for MR use. Knowing this should alert you as to what might have to be done in order to get correct scope readings from whatever scope you carry today. Who knows what bandwidth scope you'll be working with tomorrow? Will it be of sufficient bandwidth to give accurate measurements? What can you do if it is not covered by the rule of thumb? Read on!

Experimentation with multiple scopes have shown that an error is typically somewhere between 0 and 16%. That's right, some 100 MHZ scopes have no loss! Others may have as much as 15 or 16%. Additionally, it has been found that it is not necessarily the whole scope that has this loss, but the individual channels typically exhibit differences. In other words, channel one might have a 3% loss when channel two could lose 15%. There is no fixed number for all 100 MHZ scopes!

How do you get around these losses? Well, there are two ways. First you could compare a RF waveform on your scope, side by side, with a 400 MHZ scope. Use the same cables etc. and just move the cables from scope to scope. You can then calculate the loss for each channel of the 100 MHZ scope vs. the 400 MHZ scope. Keep the scope intensity low for best accuracy. If and when possible, determine the losses for a 1.5T and 1.0T system. That's for 64 and 42 MHZ. Point of note: there are various losses at 42 MHZ as well as with 64 MHZ. And, typically they differ! Your scope may have a 0 to 15% rolloff at 64 MHZ and 0 to 12% at 42 MHZ. All scopes differ!

Secondly, the next time you have your scope calibrated, just attach a tag asking for the % loss of signal at 42 and 64 MHZ for each channel. You should also state that you want this to be done at the 5 and 2 volts/div setting. This will cover both body and head measurements. At two different re-calibration vendors we use, there are no extra charges incurred for this request.

As mentioned above, the 100 MHZ scope has been shown to be as accurate as a 400 MHZ scopes if the scope rolloff factor is known. Additionally, each channel has it's own unique loss factor.

The biggest error found in GEMS Education Center labs when measuring RF power has proven to be the FE using "typical" dummy load and cables attenuation factors. Basically there are no "typical" factors! All loads and cables are somewhat different. Several may appear to be close in value, but in most cases they are different. If you use a "typical" atten factor in your calculations, then "typically" you will be in error.

Through experimentation at the GEMS Education Center, it has been determined that if you know the attenuation factor for a particular dummy load and cables, those values hold over several years. They do NOT tend to change. This means that if you could do atten test on a dummy load and cables, and keep them as a kit, you don't have to recalibrate them every time you use them. Wow! And possibly a little cheaper than the Power Measurement kit.

If you must, or intend to use a scope to measure body RF power, use atten test on the dummy load and cables.

Knowing the correct attenuation values and the correct scope rolloff values will provide you with measurements as accurate as a 400 MHz scope and / or the GE Power Measurements kit.

REVISION HISTORY

REV	DATE	AUTHOR	PRIMARY REASONS FOR CHANGE
0	July 22, 1998	M. Whitlow	Initial Conversion from Toolbook to Word.
1	Nov 12, 1998	M. Keber	Removed obsolete 8.1 information; misc. style guide cleanup.
2	July 19, 1999	L Anderson	Education Center modified for teaching clarity.
3	Feb 9, 1999	Hawthorne	Reformatted Education Center copy. Remade images used in document for clarity.