MONOPULSE BEACON TEST SET (MBTS)
SYSTEM CALIBRATION PROCEDURE

March 31, 2003

Document No. 101115, Rev. C

Prepared By:
Freestate Electronics, Inc.
6530 Commerce Court, Suite 300
Warrenton, VA 20187

REVISION NO.	REVISION DESCRIPTION	DATE REVISED
A	Approved Release	1/16/02
B	Incorporate Evaluation Comments	3/19/02
C	Revisions associated with Roll-Call Software	03/31/03

Approved by:
Freestate Electronics, Inc.
Name: Ronald M. Harris
Title: President
Date: April 1, 2003

MBTS SYSTEM CALIBRATION PROCEDURE

TABLE OF CONTENTS

MBTS SYSTEM CALIBRATION PROCEDURE

LIST OF FIGURES

1 MBTS SYSTEM CALIBRATION AND ALIGNMENT

1.1 Introduction

It is recommended that the accuracy of the output signal level of the MBTS be verified yearly. The process to verify the output level accuracy of the MBTS is described below. If calibration of the MBTS is indicated, this process is also described in the following sections. Read and thoroughly understand this information before attempting to recalibrate the MBTS.

The Absolute Output Power Calibration Mode, one of the operational modes of the OCS, automatically creates a new output level calibration file. This file, when loaded into the MBTS, aligns the achieved output signal level of the MBTS with the indicated output level setting over the full dynamic range of signal level control.

In addition to the MBTS and the OCS, the calibration process requires the use of an HP-8902A Measuring Receiver (with an HP 11722A Power Sensor). The OCS controls the entire measurement process, including the HP-8902 and the MBTS, through an IEEE-488 interface.

2 MBTS SYSTEM SETUP

2.1 Required Equipment

The following items are required to perform the processes described in this document.

1) An MBTS Instrument – part of the MBTS System.
2) An OCS PC – part of the MBTS System.
3) An HP-8902A Measuring Receiver with support documentation.
4) An HP-11722A Power Sensor – part of the HP8902.
5) Two GPIB cables – one 25-foot cable is included with the MBTS System.
   A short PCMCIA to IEEE-488 adapter cable is also included with the System.

2.2 Required Documents

1) HP-8902 Users Guide.

2.3 Instrument Connections and Settings

Figure 1, the Absolute Output Power Calibration Setup indicates how the OCS, the MBTS, and the HP-8902 should be configured. Make sure that GPIB bus addresses are as indicated and that bus interconnect cables are attached to each interface port. The 11722A Power Sensor must be connected to the Channel A Sum Output connector, J1, of the MBTS. A Configuration Switch, located on the side of the PCC Module, must also be set to allow changes to MBTS calibration settings. Refer to Section 2.3.1 if either the MBTS GPIB bus address or the Configuration Switch setting must be altered. Adjustment of these settings should be made prior to applying power to the MBTS instrument.

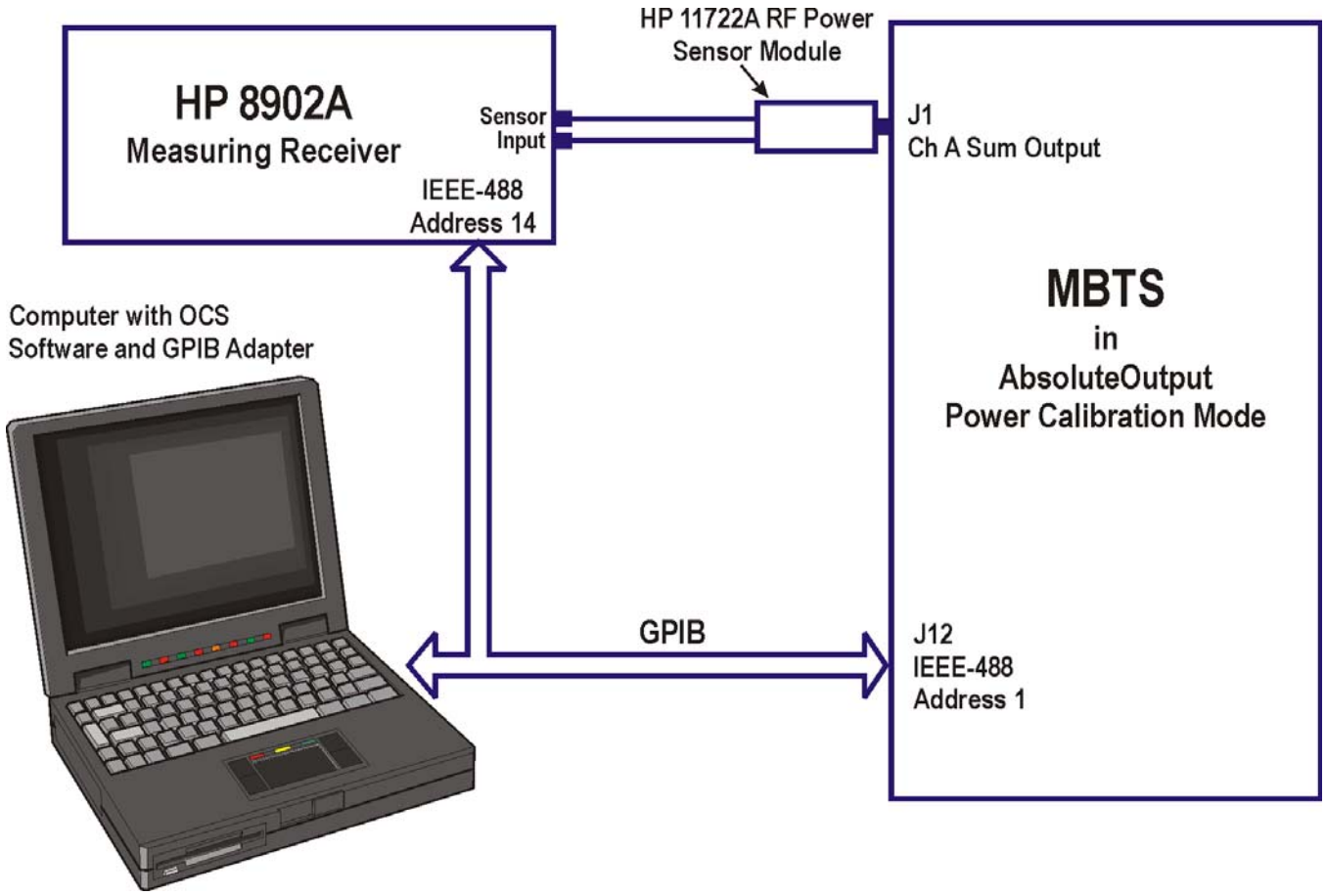


Figure 1. Absolute Output Power Calibration Test Setup

2.3.1 MBTS Configuration Settings

During the calibration process, measurement and control signals are communicated between the OCS, the MBTS, and the HP-8902 over an IEEE-488 interface. The required bus addresses for these are: for the OCS, the system controller, address 0; for the MBTS, address 1; and for the HP-8902, address 14. An 8-position Configuration Switch located on the side of the PCC Module sets the GPIB address of the MBTS.

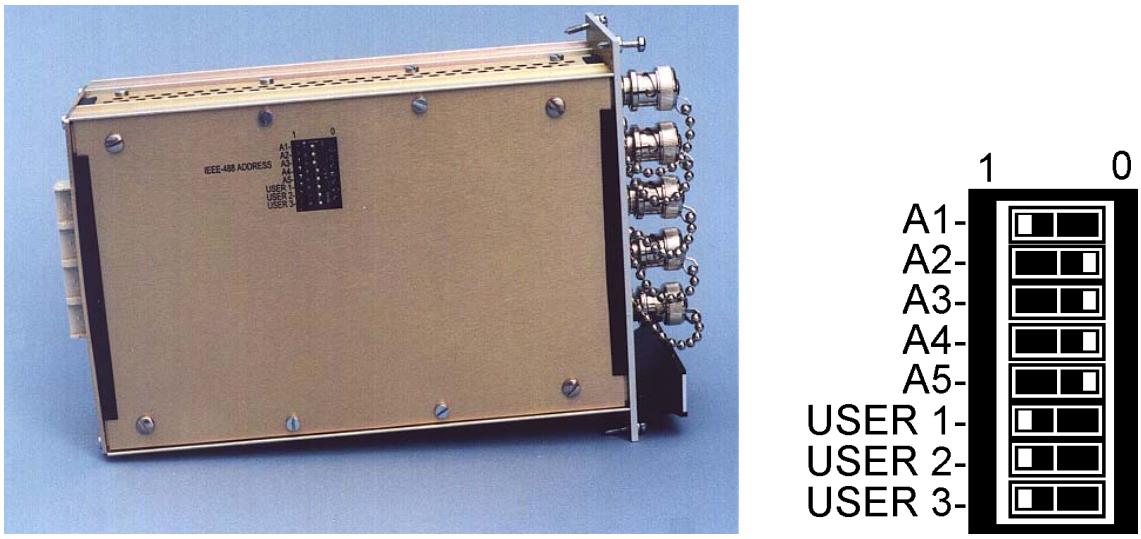


Figure 2. PCC Module Side View Showing Setup Switches and Detail

IEEE-488 ADDRESS SWITCH. Switch A1 denotes the Least Significant Bit (LSB), and A5 denotes the Most Significant Bit (MSB) of the GPIB address switch. Bit weighting is 1, 2, 4, 8, and 16 respectively for switch controls A1 through A5. The MBTS is delivered with a default address of 1 (see above).

CONFIGURATION SWITCH. User 1 enables or disables overwriting of factory calibration settings. The User 1 switch should be placed in the 0 setting for the MBTS to accept new calibration information. The User 2 and User 3 switches are for factory use only.

NOTE

MBTS calibration factors cannot be changed unless the Configuration Switch on the side of the PCC Module is set to allow this operation. This condition is indicated by a red "Write Protected" display in the top-center of the OCS Cal settings/Antenna Patterns Mode window.

2.4 MBTS Initialization and Warm Up

Use the following checklist when starting the MBTS system:

1. **Record** the serial number of the MBTS instrument on the calibration certificate. The calibration certificate is found at the end of this document.
2. Record the serial number and calibration status of the HP-8902 Measuring Receiver and Power Sensor Module.

   If the HP-8902 or Power Sensor are not marked with a current calibration label do not proceed with this process. These must be calibrated to NIST traceable standards.

3. Verify that the OCS laptop computer is connected to the MBTS through the GPIB (IEEE-488) control port. The IEEE-488 adapter plugs into the laptop computer's PCMCIA slot.
4. Verify that the MBTS and the laptop computer are properly connected to a 110/220 VAC, 50/60 Hz power source.
5. Apply power to the MBTS. The Phase Locked Loop (PLL) indicators should illuminate GREEN on the Built In Test Module, the Reply Generator Module, the IDR Module, and the Reference Source Module. Upon completion of all Built-In-Test (BIT) diagnostic tests the PROC LED on the PCC Module front panel will flash on (green) and off once every second. In a quiet environment, the chassis fan should be heard running.
6. Apply power to the OCS computer.
7. After Windows is fully loaded, activate the OCS software by double clicking on the "OCS" icon.
8. The OCS will automatically verify the GPIB connection to the MBTS and will load default operational parameters. *Disable the Antenna Alarm in response to the displayed error indication*. By default, the OCS places the MBTS into the AZ operating mode. When the AZ mode control turns green the OCS virtual instrument panel is active and ready for operator input.
9. Use the OCS to enable Output Channel A of the MBTS.
10. Apply power to the HP-8902. Allow the HP-8902 and the MBTS to warm up for a period of at least one hour.

    For best results the MBTS and the HP-8902 should be allowed to warm up for at least one hour.

11. Calibrate the HP-8902.

    The HP-8902 Tuned Receiver section must be calibrated prior to beginning the output level measurement or calibration processes.

    Refer to the HP-8902 User's Manual for information on this topic.

12. Temperature Calibrate the MBTS.
    a. Click on the CALIBRATE control located on the OCS front panel.
13. Proceed with the MBTS Output Level Verification process.

3 MBTS OUTPUT LEVEL VERIFICATION

The output level accuracy of the MBTS should be within ±0.5 dB of the power level setting indicated on the front panel of the OCS. This can be verified by running the *Target Level Measurement Exe* program located in the C:\OCS folder. This program uses the HP-8902 to measure the output level of the MBTS at each output level setting. The equipment setup is as described above.

Test results are placed in the *Target level Measurements.txt* file in the C:\Test folder. This file is formatted so that the measurement results can be easily reviewed and analyzed. ***Verify the results of this measurement process before recalibrating the MBTS instrument.***

For best results the MBTS and the HP-8902 should be calibrated after a warm up period of at least one hour.

1. Exit the OCS control window.
2. Use Windows Explorer to locate the *Target Level Measurement.Exe* file in the C:\OCS folder.
3. Double click on the *Target Level Measurement.Exe* file to begin program execution.
4. The automated level measurement process will proceed for approximately one half hour.
5. After the measurement process ends, exit the Target Level Measurement window and then print the *Target Level Measurements.txt* file located in the C:\Test folder.
6. Review the *Target Level Measurements.txt* document. For each possible MBTS power level setting the measured output power level is indicated. The measured output level should be within ±0.5 dB of the indicated power level setting. Test results may be easily imported into an Excel spreadsheet and graphed. This can greatly simplify the verification process.
7. Indicate on the calibration certificate whether the output level of the MBTS deviates beyond test limits.
8. If no performance deviations are noted, do not proceed with recalibrating the MBTS. Initial and date the calibration certificate. Attach the plots generated above to the calibration certificate.
9. If MBTS performance deviates from test limits, proceed with the calibration process described in the next section.

4 MBTS OUTPUT LEVEL CALIBRATION

The Absolute Output Power Calibration Mode, one of the operational modes of the OCS, is used to automatically create a new output level calibration file. This file, when loaded into the MBTS, aligns the achieved output signal level of the MBTS with the indicated output level setting over the full dynamic range of signal level control.

At each MBTS output level setting, the OCS adjusts attenuator circuits within the MBTS, and through the use of a measurement feedback loop, determines the best attenuator control value for the signal level setting. Because the output level control circuits of the MBTS have a resolution 0.25 dB, an overall accuracy of much less than the required 0.5 dB is usually achieved.

NOTE

To insure accurate results, the MBTS and Measuring Receiver must warm up for a minimum of 60 minutes prior to performing this calibration.

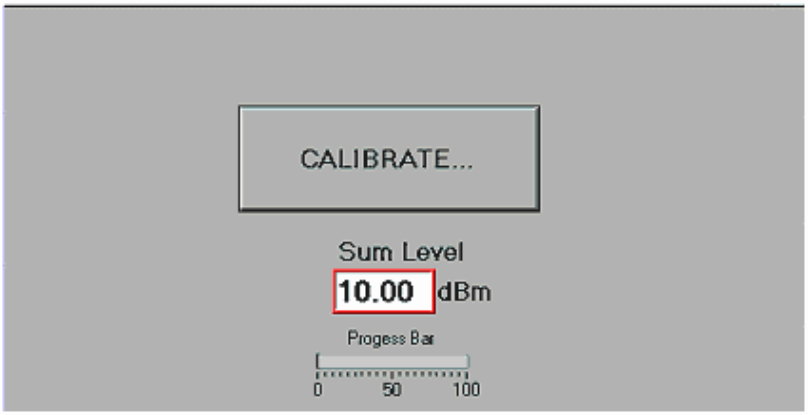
4.1 Absolute Output Power Calibration Mode Setup

1. Equipment setup is as described above.
2. Activate the OCS software by double clicking on the "OCS" icon.
3. The OCS will automatically verify the GPIB connection to the MBTS and will load default operational parameters. *Disable the Antenna Alarm in response to the displayed error indication*. By default, the OCS places the MBTS into the AZ operating mode. When the AZ mode control turns green the OCS virtual instrument panel is active and ready for operator input.
4. Change to the Absolute Output Power Calibration Mode by clicking on the Absolute Output Power Calibration Mode control in the OCS Mode Select Panel.

4.2 Absolute Output Power Calibration File Generation

1. The Absolute Output Power Calibration Mode OCS control panel appears as shown in Figure 3.

Figure 3. Absolute Output Power Calibration Screen



2. Click on the Calibrate control to start the measurement and calibration file generation process. If old calibration files exist, rename and save the old files in an appropriate folder or location on the OCS computer for archival purposes prior to starting the calibration process. Each old file should be renamed to include the serial number of the MBTS unit, as well as the date and time of the old file, within the new filename.
3. For each MBTS output power level setting between +10.0 dBm and -85.0 dBm a best-fit attenuation setting is determined. These attenuator settings are recorded on the OCS hard drive. As the process advances the Sum Level indicator changes from +10 dBm to –85 dBm, and the progress bar fills in. The measurement process requires about 30 minutes. It is complete when the -85 dBm level is reached.
4. Two calibration files are created in the C:\OCS folder, *Raw Levels.txt* and *Power Info.txt*. The *Raw Levels* file is in the proper format for uploading into the MBTS using the process explained in the next section. The Power Info.txt file is formatted so that the calibration results can be easily reviewed and analyzed.
5. Using WordPad, or any other text editor, ***review the contents of the Power Info.txt file.*** Three columns of data are presented. The third column of numbers should smoothly progress from a value of about 0 to about 500 as power level settings (second column) transition from +10 dBm to -85 dBm (except the values between 256 and 384, which are not allowed). The HP-8902 can generate erroneous readings if its tuned receiver is out of alignment.
6. If the *Power Info.txt* file does not appear correct rerun the calibration routine. Otherwise, proceed with the next section.

4.3 Load Absolute Output Power Calibration File

When selected, the OCS Cal Settings/Antenna Patterns Mode displays a window that includes tools for uploading new calibration data and User Defined antenna pattern files into the MBTS. The Cal Settings / Antenna Patterns Data window also displays all of the calibration factors currently in use by the MBTS.

1. Change to the Cal Settings/Antenna Patterns Mode by clicking on the Cal Settings/Antenna Patterns Mode control in the OCS Mode Select Panel.
2. Click on the UPLOAD CAL TARGET TABLE control to start the upload process.
3. Find and select the Raw Levels.txt file located in the C:\OCS folder. The file transfer is completed in less than one second.
4. Use the VIEW CURRENT SETTING control to update the calibration settings displayed on the OCS.
5. Verify that the new MBTS CALTGTTABLE settings reflect the information contained in the *Power Info.txt* file.

4.4 Verify MBTS Output Power Levels

Always verify calibration results before using the MBTS instrument.

1. Once the Raw Levels.txt file is loaded into the MBTS, verify the output level accuracy of the MBTS using the process outlined in Section 3, above.
2. Record the completion of the calibration process.
3. Copy, rename, and save the *Raw Levels.txt* and *Power Info.txt* files in a secure folder or location for archival purposes. Be sure to include the serial number of the calibrated MBTS, as well as the date and time of each file, within the new filename.
4. Turn off the OCS, the MBTS, and the HP-8902.
5. Reset the MBTS Configuration Switch, User 1 to position 1. Refer to Section 2.3.1, above.
6. Reconnect the MBTS and the OCS to the radar system.

MBTS OUTPUT LEVEL CALIBRATION CERTIFICATE

MBTS SERIAL NUMBER:_____ HP8902 SERIAL NUMBER:_____ HP8902 CAL DUE DATE:_____

	(CIRCLE ONE)	
SECTION 3 MBTS OUTPUT LEVEL VERIFICATION		
SECTION 3.7 OUTPUT OF MBTS REQUIRES CALIBRATION:	YES	NO
SECTION 3.8 TARGET LEVEL MEASUREMENTS.TXT PLOT ATTACHED:	YES	NO
SECTION 4 MBTS OUTPUT LEVEL CALIBRATION		
SECTION 4.2.5 POWER INFO.TXT FILE OK:	YES	NO
SECTION 4.3.5 CALTGTTABLE SETTINGS MATCH POWER INFO.TXT FILE:	YES	NO
SECTION 4.4.1 OUTPUT LEVEL ACCURACY OF MBTS OK:	YES	NO
SECTION 4.4.2 CALIBRATION PROCESS COMPLETE:	YES	NO
SECTION 4.4.3 RAW LEVELS.TXT AND POWER INFO.TXT FILES ARCHIVED:	YES	NO
MBTS CONFIGURATION USER 1 SWITCH RESET TO POSITION 1:	YES	NO
MBTS RECONNECTED TO RADAR SYSTEM:	YES	NO

COMMENTS OR ISSUES:

INITIALS OF TECHNICIAN: _____ DATE OF CALIBRATION: _____