MBITR Antenna Systems Sweep Testing Standard: MOP and Acceptance Requirements

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Overview

This document describes the method of procedures for the antenna system sweep testing and acceptance requirements for all MBITR antenna and coax systems – Global Positioning System (GPS), and Base Radio Station (BRS) Systems. It focuses on the use of standard setup and calibration techniques to establish the necessary criteria that determines the validity of the antenna systems being tested.

Recording and saving the data is important for future sweep tests. The ***Antenna Systems Site Submission Forms*** are the documents that should be used to record sweep test results and system configuration data.

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Acronyms and Terms

The following acronyms and terms are used in this document:

DIN	Deutsches Institut für Normung
DTF	Distance-to-Fault
MAU	Mast Amplifier Unit
MHA	Mast-Head Amplifier
TMA	Tower-Mounted Amplifier
TTA	Tower-Top Amplifier

Trademarks

The following trademarks or registered trademarks for products are discussed in this document:

SiteMaster is a registered trademark of Anritsu, Inc.

Note: Printed copies of this information are uncontrolled and could be obsolete.

1. Purpose of the Antenna System Sweep Testing

Today's digital wireless communication systems require a much more rigorous component and system specification as compared to previous analog systems. Consequently, there is a need for high performance testing.

Antenna system sweeps are an invaluable tool that is used to identify cable, connector, transient voltage surge suppressor (TVSS) and antenna problems, or degradations to the complete antenna system: GPS, or BRS paths. A complete antenna system includes the components of the base station site that lie between the base station equipment up to and including the antenna.

On newly installed sites, system sweeps are used to measure the quality of the installation and identify or resolve any issues before a site is allowed to carry public safety traffic.

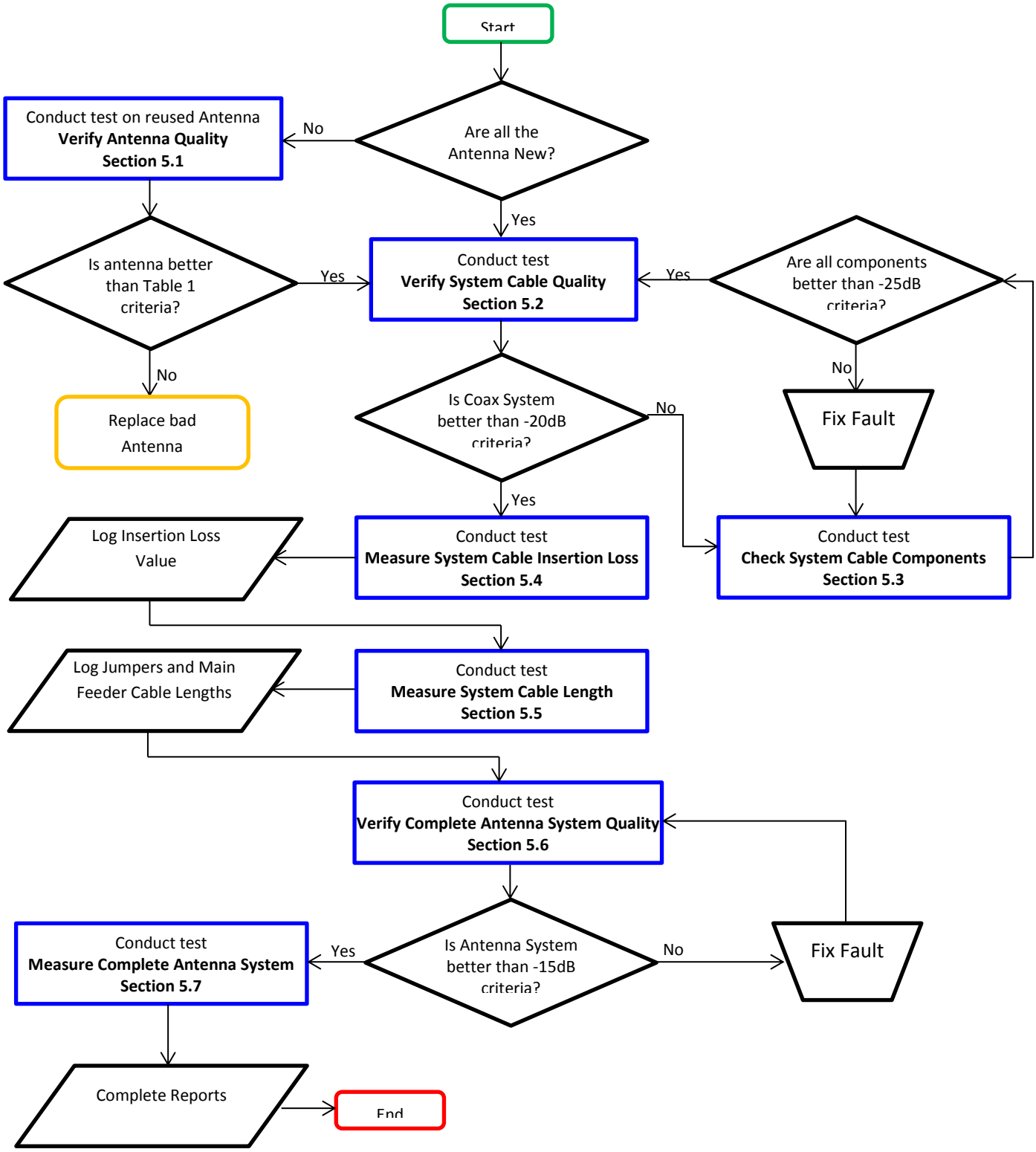
Note: A new antenna is assumed to work correctly from the factory. If there is any concern regarding the antenna functionality, a separate antenna only test is provided.

On existing sites, antenna sweeps are important from a preventive maintenance perspective. Scheduled site antenna system sweeps can help to identify any adverse changes in the antenna system before service is impacted.

2. Antenna System Testing Process

To assist in the understanding of this suite of tests, a high-level process flow is provided. **Figure 1** illustrates the typical steps to qualify and quantify a complete antenna system. A new BRS antenna system configuration will require all five main tests while existing antenna systems and GPS configurations require less as detailed in **Section 3**.

Figure 1: Antenna System Test Suite Process



3. Antenna System Test Scenarios

The purpose is to provide guidance required when performing sweep tests for New, Existing, or GPS Antenna Systems.

3.1 New Antenna System

Perform sweep test **Section 5.2** and **Section 5.4** through **Section 5.7** at the appropriate frequency band, **Table 2** or **Table 3**. Complete BRS Antenna System Site Submission Form.

The results of sweep tests shall be provided to MBITR, or MBITR's authorized representative, as part of the site turnover documentation in accordance with **Section 6**.

3.2 Existing Antenna System

Refer to **Appendix C** - **Section 9**. Complete BRS Antenna System Site Submission Form.

The results of sweep tests shall be provided to MBITR, or MBITR's authorized representative, as part of the site turnover documentation in accordance with **Section 6**.

3.3 GPS Antenna System

Perform sweep test **Section 5.2** and **Section 5.4** and **Section 5.5** at the appropriate GPS frequency range, **Table 4**. Complete GPS Antenna System Site Submission Form.

The results of sweep tests shall be provided to MBITR, or MBITR's authorized representative, as part of the site turnover documentation in accordance with **Section 6**.

4. Tools and Equipment

There are several manufacturers for spectrum and network analyzers. MBIT Radio will not disqualify any manufacturer nor sweep testing results that are completed using equipment other than what is outlined in the standard document. Currently, this document recommends the use of either the S331/332 D/E/L/P, S361/362 E, S820 D/E SiteMaster models manufactured by Anritsu, Inc.

Other equipment required to complete the sweep tests:

- Precision $^{7}/_{16}$ DIN 50Ω Open/Short/Load
- One $^{7}/_{16}$ DIN (or N) male-to-female adaptor
- One $^{7}/_{16}$ DIN female-to-female adaptor
- Two-way radio for communication between the testing technicians located at the top of the antenna support structure and at the testing point
- 10' long, ½" diameter coax jumper with one $^{7}/_{16}$ DIN male connector located at each end of the jumper. This is only required if the bottom jumper is not already installed into the antenna feedline system.
- Connector torque wrench

Test equipment shall be allowed to stabilize in test environment prior to calibration for a minimum of thirty minutes, and shall be recalibrated at a minimum of every two hours and after change in environment to ensure accuracy.

NOTE: ENSURE ALL CALIBRATION EQUIPMENT IS CLEAN AND VOID OF ANY DEBRIS OR ANY OBVIOUS SIGNS OF MECHANICAL DAMAGE OR DEFECTS.

CAUTION: IT IS REQUIRED THAT ALL SITEMASTER AND LOAD EQUIPMENT BE CERTIFIED AND VERIFIED BY AN AUTHORIZED CALIBRATION FACILITY ON AN ANNUAL BASIS. IF REQUESTED, PROOF OF CALIBRATION SHALL SUBMITTED TO MBITR OR MBITR's DESIGNATED REPRESENTATIVE.

5. Antenna System Test Cases

5.1 Return Loss of Antenna: Verify Antenna Quality

This step is strongly recommended for all antennae, but only required to verify the quality of a reused antenna that is being installed. By testing all antennae before mounting onto the antenna support structure eliminates any possibility of rework and cost that may occur due to a faulty antenna.

1. Configure the SiteMaster for **RETURN** LOSS by either recalling the saved Return Loss Setup for the frequency band of interest or performing the steps outlined in **Section 8.1**.
2. Set **LIMIT LINE** based upon the antenna type, **Table 1**.

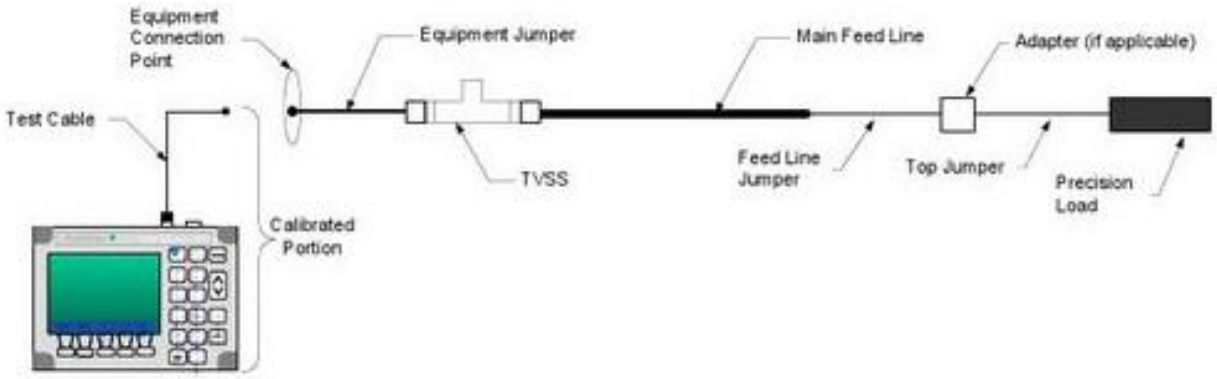
Table 1: Antennae – Loss Value Limit

Antenna Type	Return Loss	Frequency Range
Omni	-14dB	744 MHz – 877 MHz
Panel	-16.5dB	744 MHz – 877 MHz

3. Verify **CAL ON** is displayed at the top left of display.
4. For Panels, ensure that antenna is elevated at least 3' above the ground, away from any metallic objects and in a face-up position. For optimal results when positioning Omnis, place antenna in a vertical orientation clear of any obstacles.
5. Locate the peaks across the entire manufacturers band (between M1 and M2 receive, M3 and M4 transmit) and verify that the sweep in these bands are below the return loss value limit line defined in **Table 1**.
6. Verify all antennae are acceptable prior to installation.

5.2 Return Loss - 50Ω Load: Verify System Cable Quality

Figure 2: Test Cable System Quality



Note: If the equipment jumper is not already installed, configure a 10 ft jumper and connect it to the input of the TVSS unit.

The Main Feedline System is defined as the Equipment jumper (less and diplexers or duplexers), TVSS device, Main Feed Line, Feed Line Jumper, TMA Bypass Adaptor (if applicable), and Top Jumper.

We recommend using an ohm meter to verify the lines are correct.

1. Configure the SiteMaster for **RETURN** LOSS by either recalling the saved Return Loss Setup for the frequency band of interest or performing the steps outlined in **Section 8.1**.

Note: Every effort should be used to limit the use of adapters, however, if it is unavoidable, adapters should be high quality, and where possible, included in the calibration so that when calibration is completed, the calibration point will connect directly to the device under test.

If an adapter is required for calibration, THE ADAPTER CAN NEVER BE REMOVED FROM THE EQUIPMENT UNLESS A NEW CALIBRATION IS PERFORMED.

2. Verify **CAL ON** is displayed at the top left of the display.
3. Perform RETURN LOSS with a 50Ω LOAD.
4. Set the **LIMIT** to **-20 dB** across the entire display range.
5. Place the **50Ω LOAD** (same one used for calibration) at the end of the **ANTENNA TOP JUMPER** (if Tower Mast Amplifier/Tower Top Amplifier [TMA/TTA] is installed, by-pass TMA/TTA with $^{7}/_{16}$ DIN female-to-female adaptor and measure **RETURN LOSS**.

6. If the value is above the **-20 dB** limit line anywhere across the sweep range, use the **DISTANCE-TO-FAULT**, **Section 5.3** as a troubleshooting aid to identify the questionable component and repair or replace as necessary. Re-measure **RETURN LOSS** and verify the reading is below the **-20 dB** limit line anywhere across the sweep range.
7. Using M2 marker on the touch screen and place on peak.
8. SAVE THE DISPLAY to memory and record PEAK value on *Antenna Feedline System Site Submission Form*.

5.3 DTF – 50 ohm LOAD - Check Cable System Components

The distance to fault test results shall be used to determine the component within the system where the fault exists.

1. Configure the SiteMaster for **DTF - RETURN LOSS** by either recalling the saved **DTF SETUP** for the frequency band of interest or performing the step outlined in **Section 8.2**.
2. Verify user calibration is valid and is displayed on the top of the display.
3. On the main DTF screen, verify:
    a. **CABLE** type is correct (predominant cable type installed).
    b. End Distance is at least **20%** longer than the maximum line length to test.
    c. **Method**/**RESOLUTION** is set to Normal (**1024 points**).
    d. Select **CALIBRATION VALID** from display and press **ENTER**.
4. Set the **LIMIT** to **–25 dB** across the entire display range.
5. If the value is above **–25 dB** limit line anywhere across the sweep range, identify the questionable component and repair or replace as necessary.

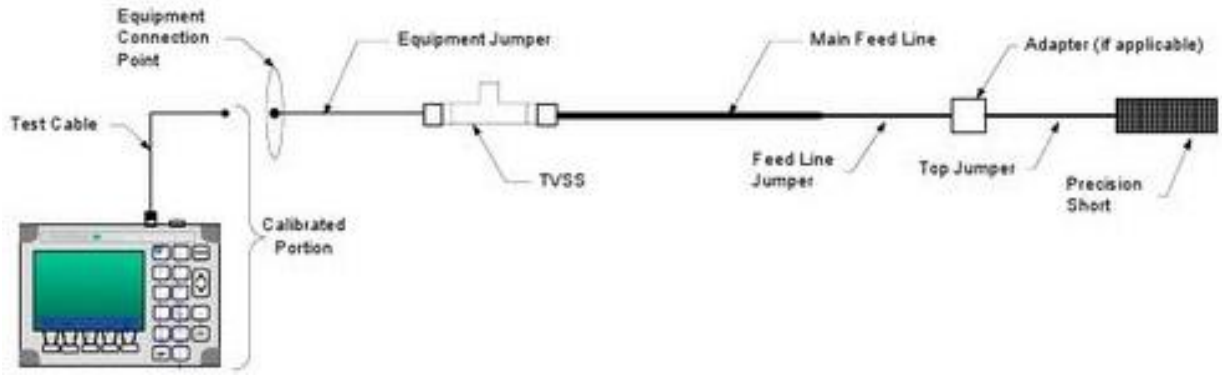
A visual inspection of connector fit and for installation damage is likely to reveal the problem. The following criteria shall be used as a guideline to determine the site requirements:

- **If bottom-side jumper, connector or TVSS are the source of the fault, they shall be replaced.**
- **If top-side jumper, connector, or antenna is the source of the fault, and the pre-sweep test was no worse than the pass/fail limit, proceed with the work and notify MBIT Radio or MBIT Radio's authorized representative that the antenna system does not meet the requirements. Tower top work may be required to correct the fault at the direction of MBIT Radio.**
- **If main coaxial cable is the source of the fault, notify MBIT Radio or MBIT Radio's authorized representative of the fault. The main coaxial cable may be replaced, with MBIT Radio approval.**

6. Save the display to memory.

5.4 Return Loss - SHORT: Measure Cable System Insertion Loss

Figure 3: Measure Cable System Insertion Loss



Note: If the equipment jumper is not already installed, configure a 10 ft jumper and connect it to the input of the TVSS unit.

The Main Feedline System is defined as the Equipment jumper (less and diplexers or duplexers), TVSS device, Main Feed Line, Feed Line Jumper, TMA Bypass Adaptor (if applicable), and Top Jumper.

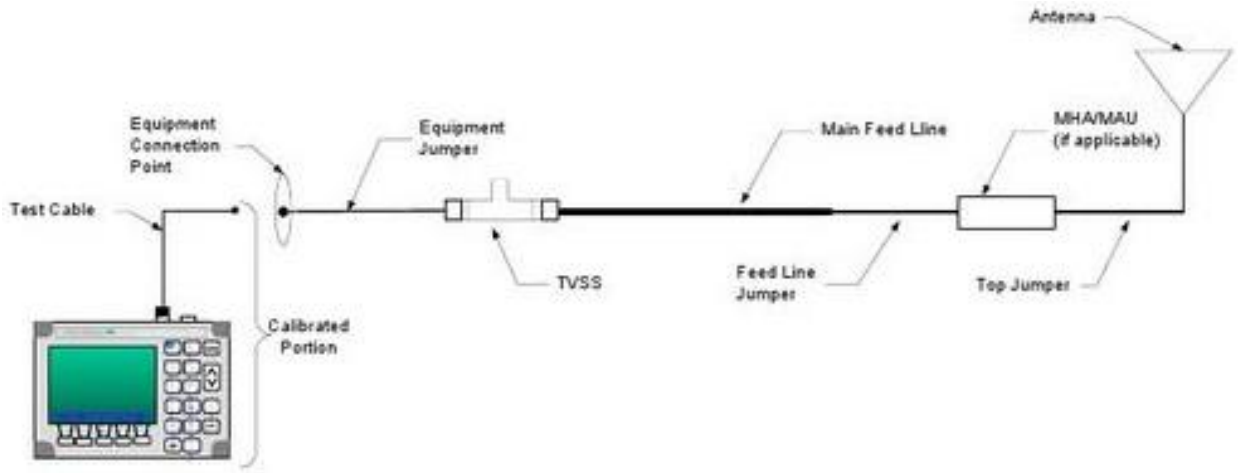
1. Configure the SiteMaster for **CABLE LOSS/RETURN LOSS** by either recalling the saved Return Loss setup for the frequency band of interest or performed the step by step process outlined in the **Section 8.1**.
2. Verify user calibration is valid (**CAL ON**) and is displayed on the top of the display.
3. Place the **SHORT** (same one used for calibration) at the end of the **ANTENNA TOP JUMPER** (if TMA/TTA is installed, by-pass TMA/TTA with $^{7}/_{16}$ DIN female-to-female adaptor) and measure **CABLE LOSS/RETURN LOSS**.
4. Select **AUTO SCALE** to optimize display.
5. Using the Marker function, place **M1** to **PEAK** and **M2** to **VALLEY**.
6. Determine cable loss by adding M1+ M2 markers and dividing by four:
   (M1+M2)/4 = one-way cable insertion loss)
7. Record value in **SITE SUBMISSION FORM**.
8. Save the display to memory.

5.5 DTF – SHORT - Measure System Cable Length

1. Configure SiteMaster for **DTF - RETURN LOSS** by either recalling the saved **DTF SETUP** for the frequency band of interest or performed the step by step process outlined in **Section 8.2**.
2. Verify user calibration is valid and is displayed on the top of the display.
3. On the main DTF screen, verify:
    a. **CABLE** type is correct (predominant cable type installed).
    b. End Distance is at least **20%** longer than the maximum line length to test.
    c. **Method/RESOLUTION** is set to Normal (**1024 points**).
4. Measure & record cable lengths by placing **M1** marker to peak and recording cable length into the ***Antenna System Site Submission Form***. Should be at or near zero dB and is the length for the entire cable line as measured.
5. Save the display to memory.

5.6 Return Loss – Verify Complete Antenna System

Figure 4: Verify Complete Antenna System



Note: If the equipment jumper is not already installed, configure a 10 ft jumper and connect it to the input of the TVSS unit.

The Main Feedline System is defined as the Equipment jumper (less and diplexers or duplexers), TVSS device, Main Feed Line, Feed Line Jumper, TMA Bypass Adaptor (if applicable), and Top Jumper.

1. Connect the **Antenna** to the **Top** jumper. (if a **TMA/TTA** exists, connect **Main Feed Line** jumper to the **TMA/TTA** input and **Top** jumper to the **TMA/TTA** output, **Figure 4**, measure **RETURN LOSS**.
2. Set **LIMIT LINE** to **-13 dB** (-15.5 dB for panel) across entire display.
3. Verify user calibration is valid and is displayed on the top of the display.
4. Using the Marker function, (confirm freq)
   - Place M1 @ 809 MHz for bottom Rx
   - Place M2 @ 813 MHz for top Rx
   - Place M3 @ 854 MHz for bottom Tx
   - Place M4 @ 858 MHz for top Tx
5. With only a Duplexer in-line, verify between Transmit markers (**M3** and **M4**) and Receive markers (**M1** and **M2**) that the displays are below the **-13 dB** (-15.5 dB for panel) **LIMIT LINE**.
6. With a **TMA/TTA** in line, set **TMA/TTA** at bypass mode. Verify between Transmit markers (**M3** and **M4**) and Receive markers (**M1** and **M2**) that the displays are below the **-13 dB** (-15.5 dB for panel) **LIMIT LINE**.
7. If the **TMA/TTA** bypass mode is not available. Only verify between Transmit markers (**M3** and **M4**) that the display is below the **-13 dB** (-15.5 dB for panel) **LIMIT LINE**.
8. Without a **TMA/TTA** or Duplexer in line, verify between markers across the entire band (Transmit and Receive combined) that the display is below the **-13 dB** (-15.5 dB for panel) **LIMIT LINE**.
9. Save the display to memory.

5.7 DTF – Measure Complete Antenna System

This test is used to identify any problems that may cause high loss in the system loss test. These tests provide a baseline for the loss associated with connectors and components in the transmission line. In the future, if the site performance has degraded, comparison of DTF-System plots can identify the problem.

1. Configure SiteMaster for **DTF - RETURN LOSS** by either recalling the saved **DTF SETUP** for the frequency band of interest or performed the step by step process outlined in **Section 8.2**.
2. Verify user calibration is valid and is displayed on the top of the display.
3. On the main **DTF** screen, verify:

a. **CABLE** type is correct (predominant cable type installed).

b. End Distance is at least **20%** longer than the maximum line length to test.

c. **Method/RESOLUTION** is set to Normal (**1024 points**).

4. Display **DISTANCE-TO-FAULT** for the entire antenna feedline system. This sweep will be used in the future as a baseline to track any changes in the cable system and to increase the ability to identify potential problems early and correctly.
5. Save the display to memory.

5.8 Verify Quality of Additional Jumpers

Using the sane tests outlined in x, verify the quality of additional jumpers or provide copies of manufacturing test data.

For LMR-240 cables used on Harris BRS ports use an N (m) to TNC (f) adapter and SMA (f) load.

5.9 Miscellaneous RF Equipment Verification

1. The **TMA/TTA** should be verified at Depot level prior to distribution to the field. For **TMA/TTA** testing, please refer to [1] and [3].
2. Using the same tests outlined in **Section 5.2**, verify all miscellaneous RF equipment (jumpers, diplexers, duplexers, filters, etc.), at minimum, meet the manufacturer's specifications. These tests need to be performed prior to installation into the antenna feedline system. Copies of these tests should be included when submitting final sweep test results.

6. Reporting and Deliverables

- The appropriate completed Antenna System Site Submission Form(s) shall be e-mailed to the MBIT Radio Manager or MBIT Radio's designated representative, within 24 hours of completion of the tests.
- Each antenna path shall have at least 5 graphs (except GPS systems):
  1. Return Loss – 50 ohm LOAD, **Section 5.2**
  2. Return Loss – SHORT (insertion loss), **Section 5.4**
  3. Distance-to-Fault – SHORT (cable length), **Section 5.5**
  4. Return Loss – Complete Antenna System, **Section 5.6**
  5. Distance-to-Fault – Complete Antenna System, **Section 5.7**
- Three (3) hard copies (printouts) of tests performed for all MBIT Radio antennae, miscellaneous RF equipment, and pre-manufactured jumpers located at the site. Two (2) sets shall be provided to the MBIT Radio Manager or MBIT Radio's designated representative and one (1) set shall remain safely at the site.
- One (1) soft copy (electronic copy) of the tests performed for all MBIT Radio antennae located at the site shall be provided to the MBIT Radio Manager or MBIT Radio's designated representative.
- Filename format should follow this guideline: <Radio Tower Site Name>.a0x (.dat)
- Where the "Radio Tower Site Name" is the naming convention that is provided by MBIT Radio.
- A completed Site Submission Form Set. All fields must be completed. Any missing data must be explained in the Notes section.

6.1 Waivers or Variances

If the pre-sweep test results indicate a single peak that is not higher than the highest component peak, a waiver should be considered for the antenna system. If a waiver is granted, the occurrence shall be documented.

If multiple peaks are present during the testing, a waiver should not be considered. Notify MBIT Radio or MBIT Radio's authorized representative.

Appendix A – Sample Site Turn-over Package

The purpose of Appendix A is to provide an example of the format and layout of completed sweeps in the **Site Turn-over Package**. Each antenna system tested will have a set of sweeps as defined in **Section 6**.

Figure #: Return Loss with 50Ω Load – Example Sweep

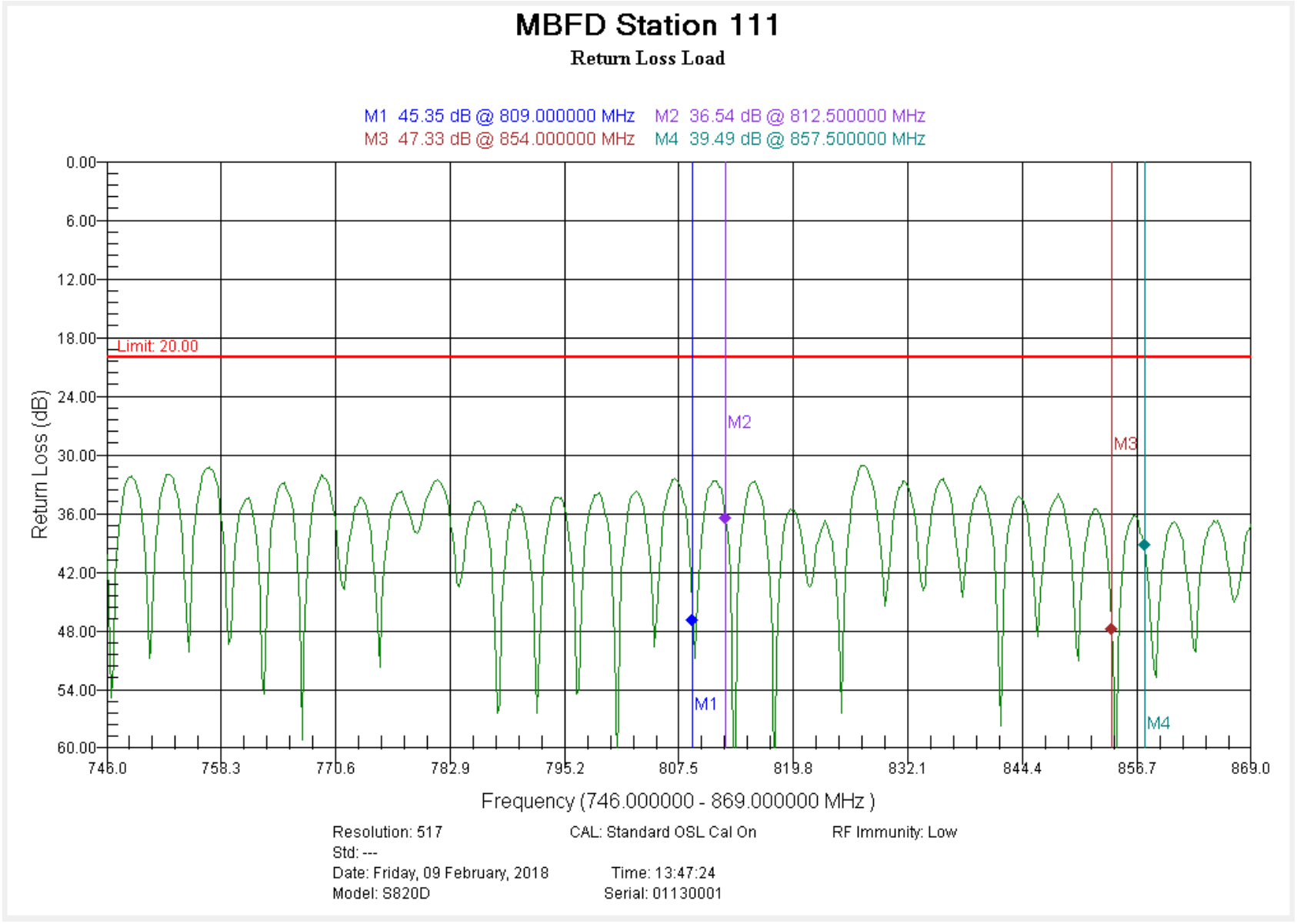


Figure #: Return Loss with Short – Example Sweep

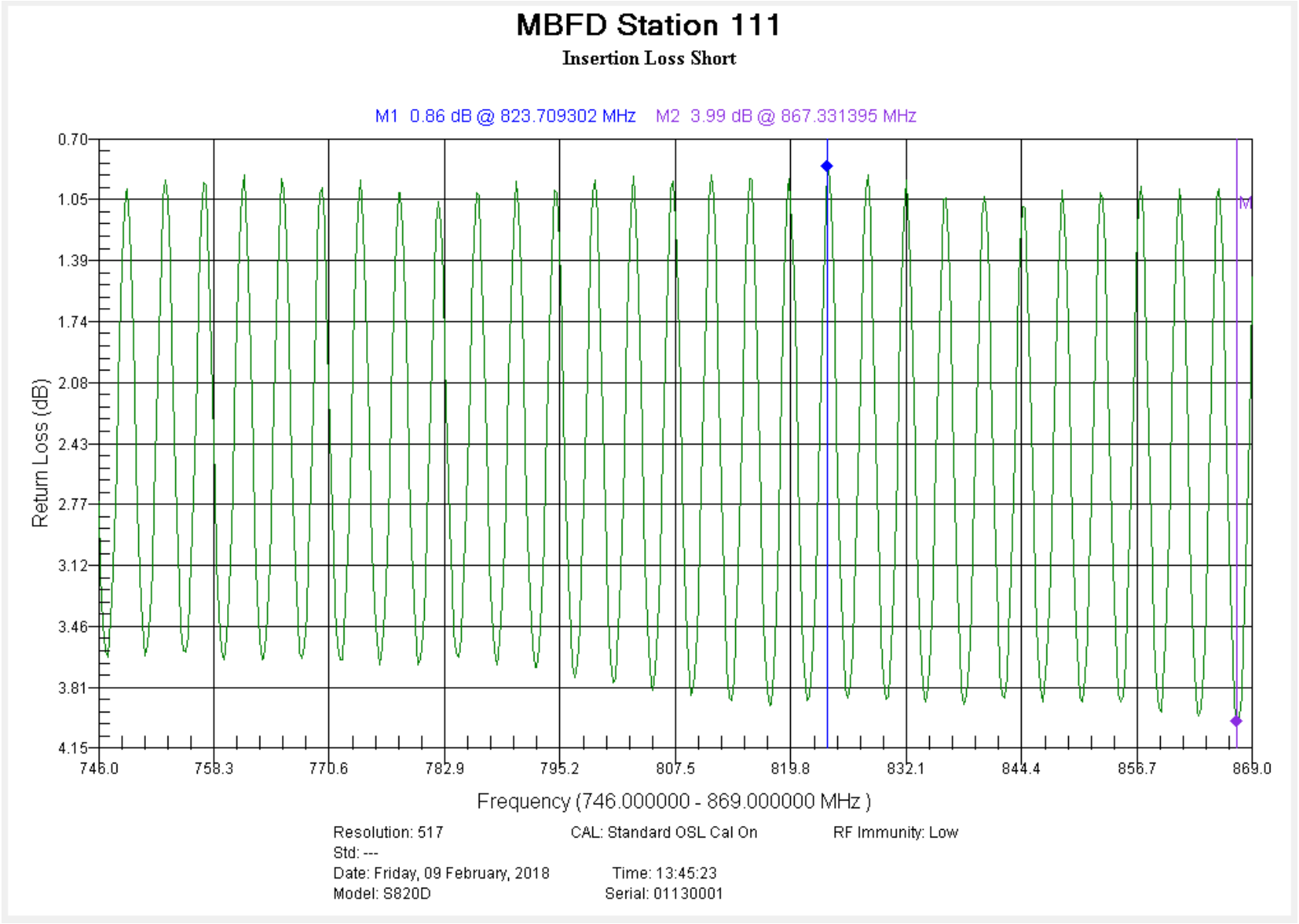


Figure #: Distance-to-Fault with Short – Example Sweep

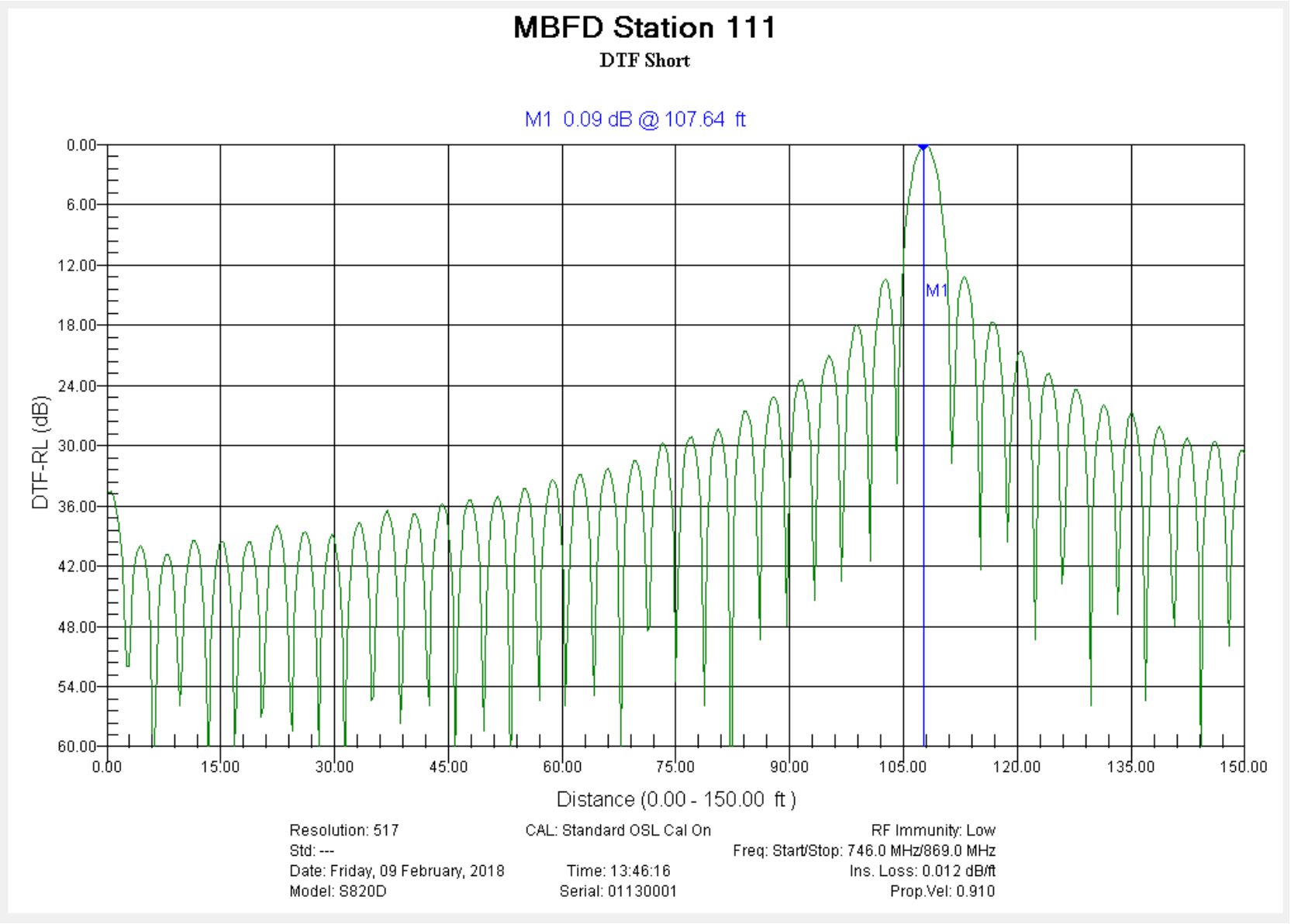


Figure #: Return Loss with Antenna Only – Example Sweep

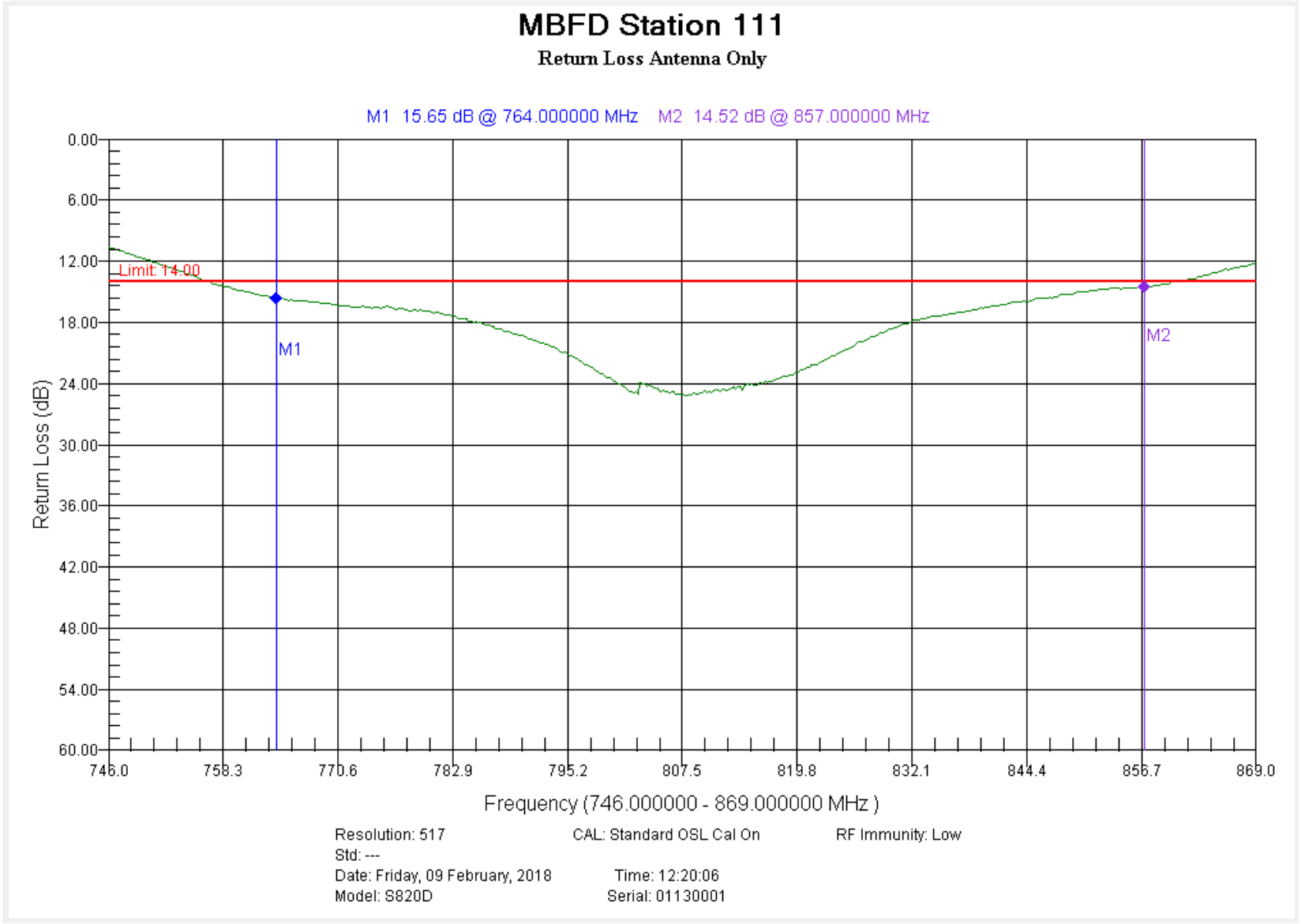
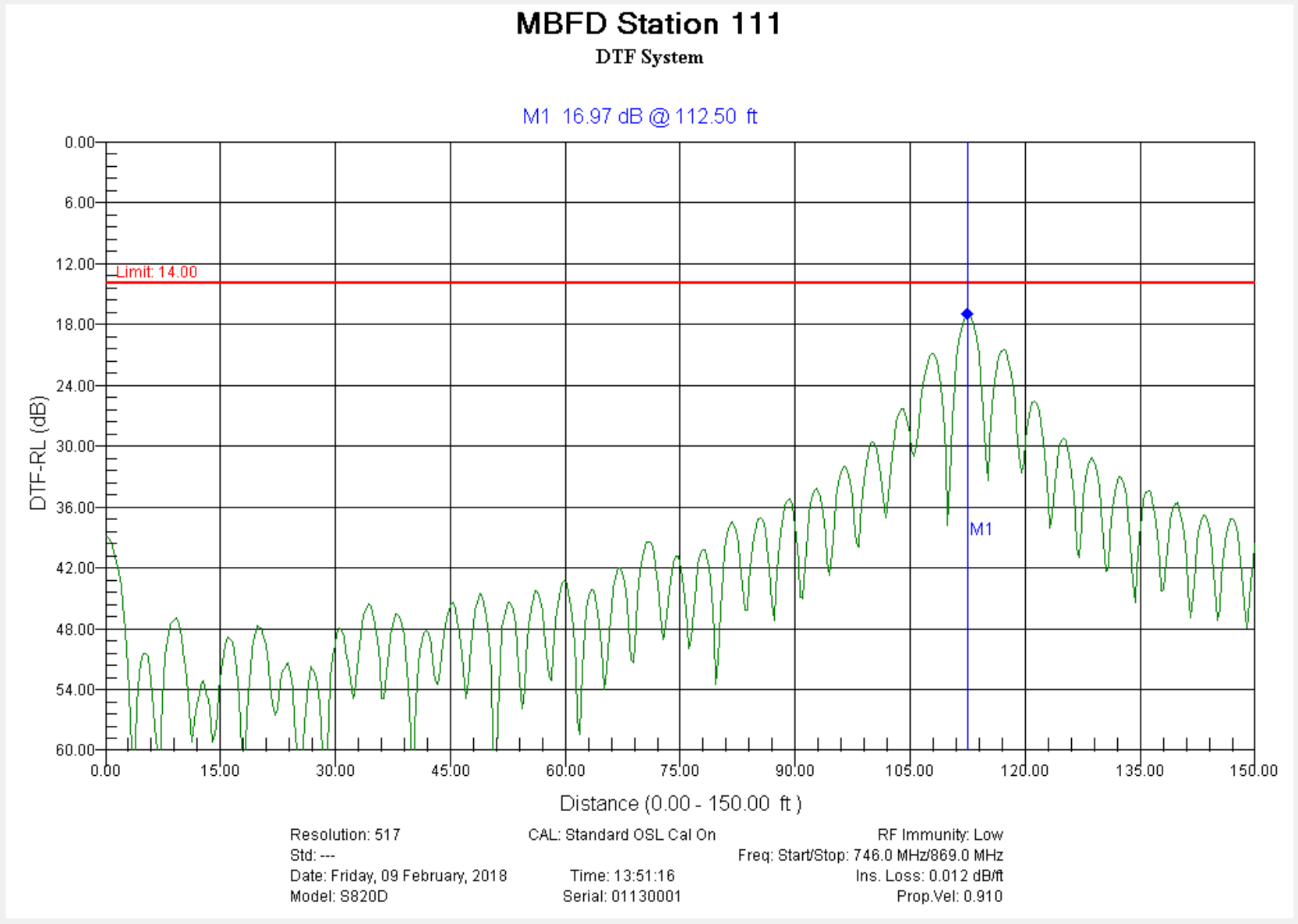


Figure #: Distance-to-Fault System – Example Sweep



Appendix B - Typical Cable Loss Reference

Table 3: Andrew – Typical Cable Loss Values

Cable Size	Model	attenuation @ 900 MHz [dB/100 ft]	attenuation @ 2 GHz [dB/100 ft]
1/4"	LDF1-50	3.911	6.097
1/2"	LDF2-50	3.313	5.172
3/8"	LDF4-50A	2.089	3.251
3/8"	FSJ4-50	3.38	5.37
7/8"	AVA5-50	1.08	1.68
7/8"	LDF5-50A	1.18	1.86
7/8"	VXL5-50	1.28	2.01
1 1/4"	LDF6-50	0.801	1.29
1 1/4"	VXL6-50	0.914	1.47
1 5/8"	AVA7-50	0.643	1.02
1 5/8"	LDF7-50A	0.694	1.131
1 5/8"	VXL7-50	0.694	1.13
2 1/4"	LDF12-50	0.601	0.994

Table 4: RFS – Typical Cable Loss Values

Cable Size	Model	attenuation @ 900 MHz [dB/100 ft]	attenuation @ 2 GHz [dB/100 ft]
1/4”	LCF14-50	4.01	6.16
1/4"	SCF14-50	5.61	8.69
1/2"	LCF12-50	2.07	3.20
1/2”	SCF12-50	3.22	5.01
3/8"	LCF38-50	3.27	5.01
3/8"	SCF38-50	4.06	6.27
7/8"	LCF78-50P	1.09	1.68
7/8"	LCF78-50	1.13	1.77
7/8"	UCF78-50	1.20	1.88
1 1/4"	LCFS114-50P	0.819	1.30
1 1/4"	LCFS114-50	0.843	1.35
1 1/4"	UCF114-50P	0.868	1.37
1 1/4"	UCF114-50	0.901	1.44
1 5/8"	LCF158-50	0.684	1.11
1 5/8"	LCF158-50P	0.645	1.02
2 1/4"	LCF214-50	0.603	0.99

Table 5: Eupen – Typical Cable Loss Values

Cable Size	Model	attenuation @ 894 MHz [dB/100 ft]	attenuation @ 2 GHz [dB/100 ft]
1/4”	EC1-50	4.12	6.39
1/4"	EC1-50HF	5.33	8.20
1/2"	EC4-50	2.09	3.25
1/2”	EC4-50HF	3.10	4.90
3/8"	EC2-50	2.98	4.60
7/8"	EC5-50	1.10	1.71
1 1/4"	EC6-50	0.798	1.26
1 5/8"	EC7-50	0.652	1.03