APPLICATION NOTE

Anritsu

Insertion Loss Measurement Methods

SITE MASTER™

Introduction

Transmission feed line system performance plays an important role in wireless network coverage. Insertion loss measurement is one of the critical measurements used to analyze transmission feed line installation and performance quality. This application note explains how Site Master is used to measure cable insertion loss with different test methods and how to predict the maximum allowable cable insertion loss through manual calculations.

In wireless communication systems, the transmit and receive antennas are connected to the radio through coaxial cable and/or waveguide transmission lines (Figure 1).

Insertion loss measures the energy absorbed by the transmission line in the direction of the signal path in dB/meter or dB/feet. Transmission line losses are dependent on cable type, operating frequency and the length of the cable run. Insertion loss of a cable varies with frequency; the higher the frequency, the greater the loss.

Insertion loss measurements help troubleshoot the network by verifying the cable installation and cable performance. High insertion loss in the feedline or jumpers can contribute to poor system performance and loss of coverage. Measuring insertion loss using Site Master assures accurate and repeatable measurements.

Verify Cable Insertion Loss From Ground Level

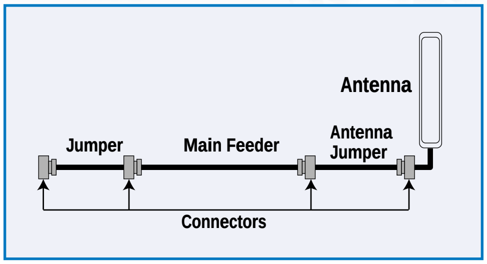

Figure 1. Typical transmission line system

Measurement Methods

During network deployment, maintenance, and trouble shooting phases, insertion loss can be measured by disconnecting the antenna and connecting an enclosed short at the end of the transmission line. If a Tower Mounted Amplifier (TMA) is used in the transmission feed line system, it is best to remove the TMA and antenna from the system configuration to perform an insertion loss measurement. It is best to always disconnect the cable at the same location so the measured data can be compared to the historical data for accuracy and repeatability.

Using Site Master, cable insertion loss can be measured in CABLE LOSS or RETURN LOSS mode. In Cable Loss mode, Site Master automatically considers the signal traveling in both directions thus making the measurement easier for the user in the field.

The following section explains the procedure to measure insertion loss in cable loss mode and return loss mode. The measurement setup and equipment required is the same for both modes.

SiteMaster

Measuring Insertion Loss Using CABLE LOSS MODE

Required Equipment

- ***Site Master Model S11xx, S33xx, or S251x***
- ***Precision Open/Short, Anritsu 22N50 or Precision Open/Short/Load, Anritsu OSLN50LF***
- ***Precision Load, Anritsu SM/PL***
- ***Test Port Extension Cable, Anritsu 15NNF50-1.5C***
- ***Optional 510-90 Adapter, DC to 7.5 GHz, 50 Ω, 7/16(f)-N(m)***

Insertion Loss Measurement Setup

The insertion loss measurement set up for a typical transmission feed line system is shown in Figure 2. Remove the antenna and connect an enclosed precision "short" at the end of the transmission line.

If a Tower Mounted Amplifier (TMA) is in the transmission feed line system, remove the TMA and antenna and connect an enclosed short at the end of the transmission line. Insertion loss measurement for a transmission feed line system with a tower mounted amplifier is shown in Figure 3.

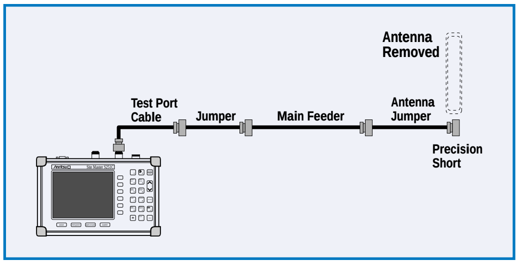

Figure 2. An insertion loss measurement setup after antenna is removed.

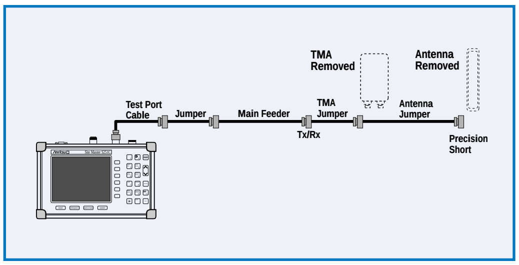

Figure 3. Insertion loss measurement setup when TMA is in line.

Procedure

Step 1. Power On the Site Master and press the **MODE** key.

Step 2. Select **FREQ-CABLE LOSS** using the Up/Down arrow key and press **ENTER**.

Step 3. Set the start and stop frequencies **F1** and **F2**. As an example, F1=750 MHz and F2=850 MHz for a typical cellular frequency band.

Step 4. Connect the phase stable test port extension cable to the RF port.

Step 5. Calibrate the Site Master at the end of the phase stable test port extension cable. (See the section entitled "Calibrating Site Master with the Phase Stable Test Port Extension Cable" for details.)

Step 6. Disconnect the antenna and connect an enclosed precision "short" at the end of the transmission line.

Step 7. Connect the other end of the transmission line to the phase stable cable of the Site Master. A trace will be displayed on the screen when the Site Master is in continuous sweep mode.

Step 8. Press the **AMPLITUDE** key and set the TOP and BOTTOM values of the display. In Figure 4, the TOP is set to 2 dB, and the BOTTOM is set to 5 dB.

Step 9. Press the **MARKER** key.

Step 10. Set **M1** to **MARKER TO PEAK**.

Step 11. Set **M2** to **MARKER TO VALLEY**.

Step 12. Calculate the insertion loss by averaging M1 (MARKER TO PEAK) and M2 (MARKER TO VALLEY) values as follows:

$$\text{Insertion Loss} = \frac{(\text{M1 dB} + \text{M2 dB})}{2} = \frac{3.23 + 3.95}{2} = 3.59 \text{ dB}$$

Step 13. Press **SAVE DISPLAY** and name the trace using the soft keys and press **ENTER**. Saving the display is recommended for historical documentation. Saved traces can be used in the future to compare, check or verify changes in the transmission feedline performance.

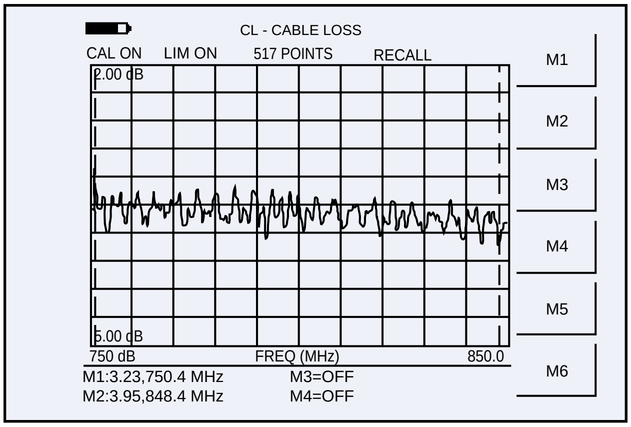

Figure 4. Typical Insertion Loss Display in Cable Loss Mode.

In Cable Loss mode, the Site Master automatically considers the signal path in both directions when calculating the cable insertion loss. As such, Cable Loss mode is recommended when making cable insertion loss measurements.

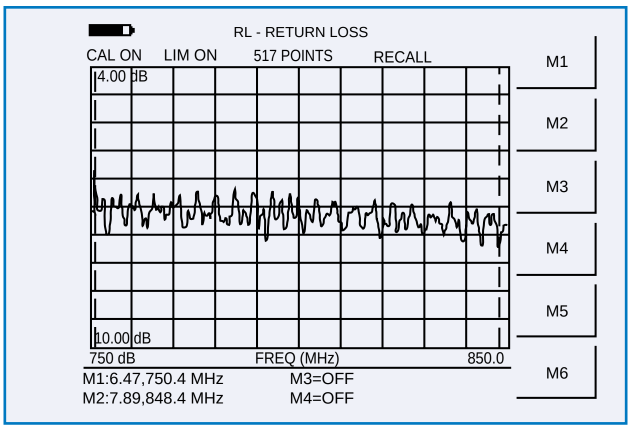

Figure 5. Typical Insertion Loss Display in Return Loss Mode

Measuring Insertion Loss using RETURN LOSS MODE

Step 1. Power on the Site Master and press the **MODE** key.

Step 2. Select the **FREQ-RETURN LOSS** using the Up/Down arrow key and press **ENTER**.

Step 3. Set the start and stop frequencies **F1** and **F2**. As an example, F1=750 MHz and F2=850 MHz for a typical cellular frequency band.

Step 4. Connect the phase stable test port extension cable to the RF port.

Step 5. Calibrate the Site Master at the end of the phase stable test port extension cable. (See the section entitled "Calibrating Site Master with the Phase Stable Test Port Extension Cable" for details.)

Step 6. Disconnect the antenna and connect an enclosed precision "short" at the end of the transmission line.

Step 7. Connect the other end of the transmission line to the phase stable cable of the Site Master. A trace will be displayed on the screen when the Site Master is in continuous sweep mode.

Step 8. Press the **AMPLITUDE** key and set the TOP and BOTTOM values of the display. In Figure 5, the TOP is set to 4 dB, and the BOTTOM is set to 10 dB.

Step 9. Press the **MARKER** key.

Step 10. Set **M1** to **MARKER TO PEAK**.

Step 11. Set **M2** to **MARKER TO VALLEY**.

Step 12. Calculate the insertion loss by averaging M1 (MARKER TO PEAK) and M2 (MARKER TO VALLEY) values and dividing by two as follows:

$$\text{Insertion Loss} = \frac{\frac{\text{M1 dB} + \text{M2 dB}}{2}}{2}$$

$$= \frac{\frac{6.47 + 7.89}{2}}{2}$$

$$= 3.59 \text{ dB}$$

Step 13. Press **SAVE DISPLAY** and name the trace using the soft keys and press **ENTER**.

Calibrating Site Master with the Phase Stable Test Port Extension Cable

The phase stable test port extension cable is used as an extension cable to the test port of the Site Master, and ensures accurate and repeatable measurements. The phase stable cable can be moved and bent while making a measurement without causing errors in the measurement. When poor quality cables are used as an extension test port cable, large error will be introduced in the measurements when the cable is moved.

For accurate results, Site Master should be calibrated at the ambient temperature before making any measurements. The Site Master must be re-calibrated whenever the setup frequency changes, the temperature exceeds the calibration temperature window or when the test port extension cable is removed or replaced.

Connect the phase stable test port extension cable to the Site Master RF Port. The Site Master with phase stable cable combination can be calibrated manually using Open, Short and Load (OSL) precision components (Figure 6), or by using the InstaCal® module. Manual calibration is explained here. For the InstaCal procedure, refer to the Site Master user guide.

Note: *The InstaCal module is not compatible with the Site Master S251C Model.*

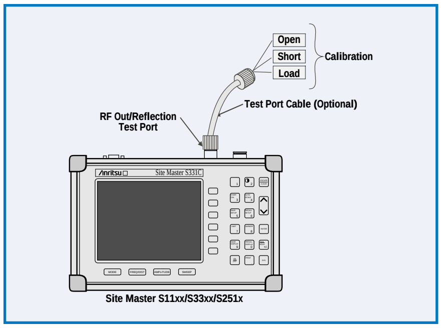

Figure. Calibrating at the end of the Phase Stable Test Port Extension Cable.

Note: *For Cable Loss-One Port measurements, Site Master S251C requires only one port calibration.*

Note: *If the phase stable cable is removed from the test port, the calibration is not valid.*

Manual Calibration Procedure

Step 1. Power on the Site Master.

Step 2. Select the appropriate frequency range.

Step 3. Connect the phase stable test port extension cable to the RF port.

Step 4. Press the **START CAL** key. The message "Connect Open to RF OUT port or connect InstaCal module and press **ENTER**" will appear in the display.

Step 5. Connect the OPEN precision calibration component to the end of the test port extension cable. Press the **ENTER** Key.

Step 6. The message "Measuring OPEN" will appear, and after the measurement "Connect SHORT to RF OUT" will appear.

Step 7. Remove the “open” and connect the “short” precision calibration component to the test port extension cable. Press the **ENTER** key.

Step 8. The message "Measuring SHORT" will appear, and after the measurement "Connect TERMINATION to RF OUT" will appear.

Step 9. Remove the “short” and connect the “precision termination” at the end of the test port extension cable. Press the **ENTER** key.

Step 10. The message "Measuring TERMINATION" will appear. After the measurement, the “CAL OFF” message will change to "CAL ON" on the upper left-hand corner of the display.

Step 11. Remove the precision termination from the text port extension cable.

Calculating Transmission Line Insertion Loss

Cables have different insertion losses at different frequencies. For example LDF4-40A attenuation at 1 GHz is 0.022 dB/ft (0.073 dB/m) and at 2 GHz it is 0.0325 dB/ft (0.107 dB/m). As the frequency increases or the length of the cable run increases, the amount of cable insertion loss increases.

To verify cable insertion loss measurements are reasonable, the expected insertion loss can be calculated manually using the following procedure:

- Calculate the estimated worst loss of each component in the transmission line system.
- Add all the component’s estimated worst losses together to calculate total insertion loss in the transmission line system.

For example:

	Cable Type	Cable Attenuation (dB/ft)		Cable Length		Insertion Loss (dB)
Bottom Jumper	LDF4-50A	0.0204	X	20	=	0.408
Main Cable	LDF5-50A	0.0115	X	200	=	2.30
Top Jumper	LDF4-50A	0.0204	X	10	=	0.204

Number of Connector Pairs		Loss per Pair in dB		Total Connector Loss (dB)
4	X	0.28	=	1.12

Insertion loss of the transmission system = Bottom Jumper Loss + Main Cable Loss + Top Jumper Loss + Connector Losses
= 0.408 + 2.3 +0.204 +1.12
= 4.03 dB

Compare the measured insertion loss to the calculated insertion loss to verify transmission line performance. The measured cable insertion loss should be lower than the calculated cable insertion loss.

Summary

The preferred method to measure Cable Insertion Loss using Site Master is Cable Loss mode. Cable loss mode automatically considers the signal traveling in both directions and thus makes it easier to measure the cable insertion loss in the field. Measured Insertion Loss should always be compared to the calculated loss to verify accuracy thus assuring transmission line performance. The calculated insertion loss is usually a “worst case scenario”.

Cable insertion loss may be difficult to measure on excessivly long or highly lossy cables. When the cable insertion loss is greater than 20 dB, it will be hard to measure.

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