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.
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)

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:

\[
\text{Insertion Loss} = \frac{M1 \text{ dB} + M2 \text{ dB}}{2} = \frac{3.23 + 3.95}{2} = 3.59 \text{ dB}
\]
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.
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.

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:

\[
\text{Insertion Loss} = \frac{M1 \, \text{dB} + M2 \, \text{dB}}{2}
\]

\[
= \frac{6.47 + 7.89}{2}
\]

\[= 3.59 \, \text{dB}
\]

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.
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 test 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:

<table>
<thead>
<tr>
<th>Cable Type</th>
<th>Cable Attenuation (dB/ft)</th>
<th>Cable Length</th>
<th>Insertion Loss (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bottom Jumper</td>
<td>LDF4-50A</td>
<td>0.0204</td>
<td>X 20</td>
</tr>
<tr>
<td>Main Cable</td>
<td>LDF5-50A</td>
<td>0.0115</td>
<td>X 200</td>
</tr>
<tr>
<td>Top Jumper</td>
<td>LDF4-50A</td>
<td>0.0204</td>
<td>X 10</td>
</tr>
</tbody>
</table>

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.

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 excessively long or highly lossy cables. When the cable insertion loss is greater than 20 dB, it will be hard to measure.