Antenna Sweeping

**Why Sweep Antennas?**

**Commissioning Sweeps**

- Poor VSWR/Return Loss: Can damage transmitters, reduce the coverage area, and lower data rates. For instance, a return loss of 10 dB means that 10% of the total power is not radiated and (if the transmitter is still running) that the coverage area is 10% smaller than the transmitter power settings might imply.

- Measuring Reflections:
  - **For Base Stations**
    - Maintenance sweeps can catch faults early, which will increase network uptime, reduce instance, a return loss of 10 dB means that 10% of the total power is not radiated and (if the transmitter is still running) that the coverage area is 10% smaller than the transmitter power settings might imply.
  - **For Repeaters**
    - Poor isolation. Failures mean that the sector is prone to excessive inter-modulation distortion, which lowers signal quality. Repeated dropped and blocked calls due to weak signal areas and network loading imbalances.

**Maintenance Sweeps**

- **Common Faults**
  - Corroded connectors, and poorly installed connectors. Most remaining faults are cable related. This includes water in the cable, loose weather strip, pinched cables, poorly installed ground kits, bullet holes, and even nails in the cable. A small portion of the faults are antenna related.

- **Propagation Velocity and Cable Loss**
  - Cable loss is also an important commissioning check. Excessive cable loss reduces the radiated power, but also, can mask return loss issues, creating false good readings later.

- **GPS location reporting allows verification of**
  - The frequency range should be restricted to the antenna’s pass band.

**Troubleshooting Sweeps**

- **Frequency Range**
  - The frequency range should be restricted to the antenna’s pass band.
  - Propagation Velocity and Cable Loss
  - Return Loss, or VSWR if you prefer, can be used as a one-number screening tool. As seen above, the markers for this sweep are set at the edges of the antenna’s pass band. The trace between the markers is better than 15.5 dB, (or a VSWR of 1.40) a common limit for sweeps with an antenna at the far end. This trace would typically be accepted as good. Reflections are measured using either VSWR or Return Loss. These are two different ways to measure the same thing. Return Loss is a logarithmic scale, and Voltage Standing Wave Ratio (VSWR) is a linear scale.

- **Return Loss or VSWR**
  - Limit lines can be created on the Master series sweepers and, when accepted, moved from one instrument to another.

- **Limit Lines**
  - The frequency range for DTF sweeps should be set to stay within the load’s bandwidth. If an antenna is used for the load, any portion of the DTF sweep that goes outside of the pass band is referred, reducing the accuracy of the vertical axis Return Loss or VSWR measurements.

- **DTF is a way to locate faults identified by Return Loss or VSWR measurements.**

- **Tracing**
  - Changes are often more significant than actual values. Even so, typical values with a good setup are:
  - Open or Short: 0 to 5 dB
  - Antenna: Better than 16 dB
  - Connectors: Better than 25 dB

- **Propagation velocity**
  - PV or Vp directly affects distance accuracy. PV must be set to stay within the load’s bandwidth. If an antenna is used for the load, any portion of the DTF sweep that goes outside of the pass band is referred, reducing the accuracy of the vertical axis Return Loss or VSWR measurements.

- **Distance to Fault (DTF)**
  - A wider frequency range improves distance resolution and lowers the maximum measurable distance. However, if an antenna is in place at the other end of the cable, the DTF frequency range should be restricted to the antenna’s pass band.

- **Further information**
  - Return Loss and VSWR testing can be found in the application note “Understanding Cable & Antenna Analysis” at www.Anritsu.com.

- **Further information**
  - On DTF testing can be found in the application note “Distance To Fault” at www.Anritsu.com
Cable and Antenna Troubleshooting Guide – utilizing Anritsu’s Handheld Site Master™, LMR Master™, VNA Master™, Cell Master™, or BTS Master™

**Tower Mounted Amplifiers (TMAs) Tower Testing**

TMAs create a larger receive coverage area. If a TMA has low gain, distortion, is in bypass mode, is improperly installed, or is completely open, a base stations’ receive coverage can be seriously compromised. TMA failure, whether partial or complete, reduces the uplink coverage area which in turn leads to dropped calls. TMA failure can also lead to cell load imbalances and call blocking.

*TMAs can be tested on the tower, which verifies the TMA and the installation as well as saves the time and expense of hiring a tower crew to bring the TMA down.*

**Transmission Line Concepts**

Antenna cables are a type of transmission line, a cable that has a constant impedance throughout its length. Any change in impedance causes a partial radio signal reflection.

Changes in impedance, in turn, are caused by mismatches, or physical changes in the cable, such as:

- Narrow spots, perhaps caused by clamps, sharp bends, cable stretch, or other external pressure.
- Change in the internal insulating material, the dielectric, for instance, when water gets into the cable.
- Connectors, particularly when improperly installed, loose or corroded.
- Physical damage such as bullet holes or nails.

The term Voltage Standing Wave Ratio (VSWR) comes from how radio waves are distributed along a transmission line. When reflections are present, a combination of the forward (incident) and reflected wave produce a standing wave that forces the RF voltage to vary with distance. The ratio between the high and low voltage where the transmission line is the Voltage Standing Wave Ratio. The log version of VSWR is called Return Loss.

**Calibration and Accuracy**

Antenna and cable sweepers need to be calibrated to correct for the very small reflections that will otherwise lower the accuracy of the measurement. The accuracy of the instrument depends on the accuracy of the Open, Short, and Load (OSL) used for calibration.

A poor load, cable, or connectors can reduce the calibration accuracy enough to mask problems with the base station’s antenna and cable run.

It is important to use a phase stable cable when a jumper is needed. While standard cables can be used for jumpers, and even can be calibrated to very good numbers, a standard cable’s reflections can change when it is moved or bent. This can change the noise floor by 20 dB or more. A phase stable jumper cable will remain calibrated when flexed.

**Caring for Precision Cables and Connectors**

Precision cables and connectors are sensitive to mishandling. It only takes one mishandled attachment and detachment to lower the accuracy of a precision connector. Mishandling can destroy the accuracy of an OSL calibration standard.

The key is to avoid twisting the body of the connector, making sure that the center pin (gold coated in the picture) does not rotate when attaching the precision connector. This prevents the formation of circular rubbing marks on the center pin that destroy the accuracy of the connector.

Precision cables have a minimum bend radius. If the cable is bent too tightly, or pinched, the center conductor moves closer to the shielding, changing the impedance and causing a reflection. At this point, the abused cable is no longer a precision cable.

**Which Calibration to Use?**

- **Open, Short, and Load (OSL)**
- **InstaCal, FlexCal**
- **Open, Short, Load, Isolation, Through (OSLIT)**

OSL is the most accurate calibration for one port tests such as Return Loss, VSWR, and DTF. An OSL calibration requires the use of three precision standards, and is as accurate as the standards.

This calibration can be done either at the instrument test port, or at the end of a phase stable cable, in which case it compensates for the length of the cable. This is useful when measuring DTF. One side effect of the high accuracy OSL calibration is that it is dependent on the frequency span of the antenna tester. If the start and stop frequency is changed, the OSL cal will need to be redone.

InstaCal can be used with the Site Master and Cell Master. It allows a quicker OSL style calibration with a slight loss of accuracy. It changes the open, short, and load electronically, making calibration faster.

FlexCal can be used for troubleshooting tasks at a slight cost in accuracy. FlexCal uses the OSL calibration, but does the calibration over the full range of the sweeper. This allows users the flexibility to change the sweep start and stop frequencies as needed to better resolve a fault without stopping to recalibrate the instrument.

**OSLIT** is used for the two port tests. Two port tests, as mentioned elsewhere, use a signal source, a device under test, and a measurement of the output of that device. After running an OSLIT, it is possible to test TMAs, amplifiers, filters, antenna isolation, and many other active and passive RF devices.

Further information on two port testing can be found in the application note “Tower Mounted Amplifiers, Diagnostics and Isolation Measurements” at www.anritsu.com.

**Line Sweep Tools (LST)**

**Trace Processing**

**File Transfer Limit Lines**

Line Sweep Tools is a PC based program that makes life easier for people testing cables and antennas. It helps with collecting traces, verifying traces, and generating reports in an industry accepted manner. It also helps ensure common pass/fail standards across the organization.

**File processing tools in LST include:**

- **Marker presets** – a quick way to make sure markers are set to the same place on each trace.
- **File renaming** – A quick way to rename trace file names, titles, and subtitles.
- **A database** – a way to collect groups of traces, say, from one base station, into one file for ease of forwarding.
- **Ways to compare traces by overlaying to quickly spot changes.** With this capability, trace analysis becomes much simpler.

In addition, LST’s output files can be viewed in the legacy Handheld Software Tools (HHST) software, ensuring compatibility between users of either software tool.

**File transfer** between the Master series instruments and a PC allows trace validation, report generation, and archiving. Transfer can happen several ways. Perhaps the simplest is to test, save the trace to either a USB memory stick or a Compact Flash RAM. Data can also be moved over an USB or Ethernet cable.

**Limit lines**, either single limits, or multi-point limits, can be created by LST, as well as the Master series cable and antenna testers.

This is a powerful way to ensure that common pass/fail standards are used by everyone involved in testing antennas and antenna cables.

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