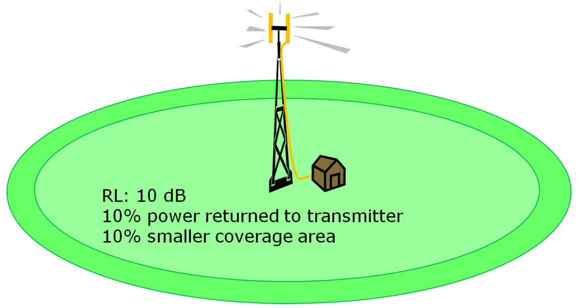
Cable and Antenna Troubleshooting Guide – utilizing Anritsu's Handheld Site Master™, LMR Master™, VNA Master™, Cell Master™, or BTS Master™

Antenna Sweeping
Why Sweep Antennas?
Commissioning Sweeps

Why sweep antennas? 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.



Reduced coverage increases dropped and blocked calls due to weak signal areas and network loading imbalances.

On the data link side, the increased signal distortion caused by a low return loss means that data rates are reduced and capacity suffers.

Finally, poor Return Loss or VSWR can cause transmitter shutdown and even damage, taking out a sector until repaired.

Keeping antenna systems in shape means the system as a whole runs better. Uptime is increased, call drops go down, data rates go up, and both managers and customers are happier.

Commissioning sweeps provide the basis for acceptance of the antenna systems. They also provide a reference trace for use when looking for changes later. For best accuracy, they use a short and a load at the top of the antenna run. They may also be done with an antenna attached.

The same data that is used for Return Loss or VSWR is also used for the Distance to Fault (DTF) calculations and display. Users can change between the two displays at will. This reduces the number of traces that must be archived and tracked by half.

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 trace location. This validation increases the credibility of the measurements and adds value to the work.

Antenna Sweeping (continued)
Maintenance Sweeps
Troubleshooting Sweeps
Common Faults

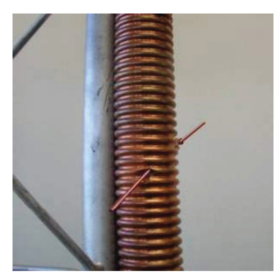
Maintenance sweeps can catch faults early, which will increase network uptime, reduce dropped calls, and allow consistently higher data rates.

Since every cable has a different sweep signature, it can be difficult to judge changes. But a reference trace, from the commissioning sweeps, makes it easy to see changes.

Once a problem is spotted, whether from a VSWR alarm or a maintenance sweep, it's time to troubleshoot the problem.

Troubleshooting sweeps are inherently different from maintenance or commissioning sweeps, since they require a flexible use of the instrument, calibrations, and settings to accurately locate the fault. FlexCal is a BTS Master capability that allows users to change frequency range without a new calibration, which is helpful when troubleshooting.

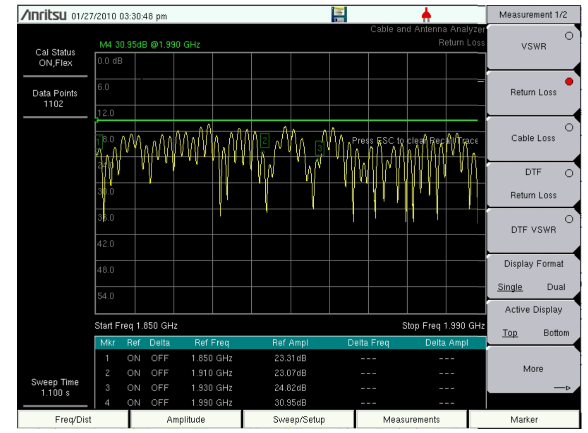
Common faults include connector, cable and antenna faults. When looking for faults, it's important to know that most faults are connector related. This includes loose connectors, corroded connectors, and poorly installed connectors. Most remaining faults are cable related. This includes water in the cable, loose weather wrap, pinched cables, poorly installed ground kits, bullet holes, and even nails in the cable! A small portion of the faults are antenna related.



It is possible to damage GPS antennas by sweeping. Their active components are not intended to take higher power levels so they should be replaced by a load (for Return Loss) or a short (for DTF) before measuring the line.

Measurement accuracy is critical. That's why there are a variety of calibration routines as discussed in other parts of this guide. Improper use of the calibration standards, or use of an antenna sweeper with lower specifications, can lead to inaccurate measurements and unnecessary equipment replacement due to false fails. What is the cost of a false fail?

Return Loss and VSWR
Measuring Reflections
Setting Cable Types
Limit Lines



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.

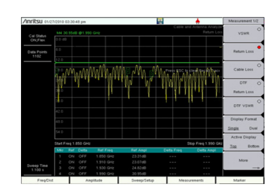
This trace would typically be accepted as good. **Reflections are measured** using either VSWR or Return Loss. These are two different ways to measure the same thing. Return Loss is a logarithmic scale, and Voltage Standing Wave Ratio (VSWR) is a linear scale. Your choice can be made by personal preference, the unit's limit numbers are given in, or by company requirements. Here's the conversion formula:

Return Loss = 20 log |VSWR +1/VSWR-1|

VSWR = $1+10^{-RL/20}/1-10^{-RL/20}$

However the quickest conversion is to just change the instrument units to the preferred settings.

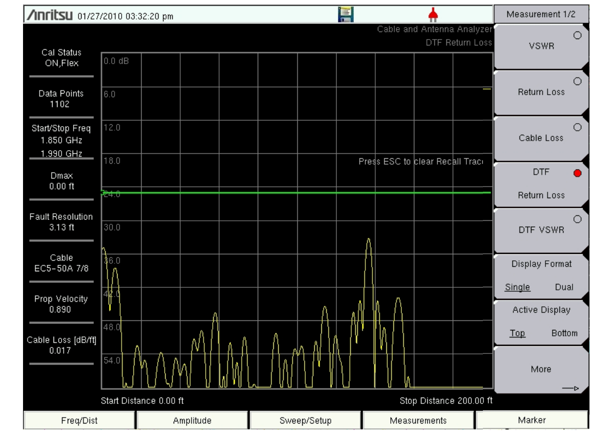
Limit lines can be created on the Master series sweepers and, when, accepted, moved from one instrument to another using a USB stick or Compact Flash Memory. This makes looking for faults straightforward and helps ensure consistency.



Return loss, with an antenna on the far end, should be between 15 to 25 dB. For a line with a load on the far end, the value should be between 30 and 40 dB.

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

Distance to Fault (DTF)
Comparing Traces
Propagation Velocity and Cable Loss
Frequency Range



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

Trace comparisons are often used for diagnostics because small changes in cables will have large effects on the DTF trace. Because of this, it is accepted practice to take reference sweeps of each cable at commissioning time for later comparison. 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 V_p) directly affects distance accuracy. PV must be set either manually or by entering a cable type.

Cable Loss also needs to be set accurately, either manually, or by selecting a cable type. False cable loss values can mask Return Loss or VSWR problems.

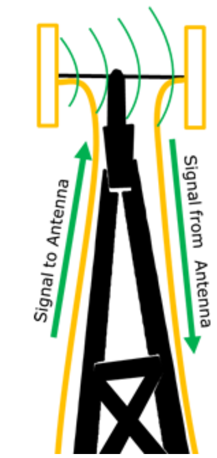
The frequency range for DTF sweeps should be set to stay within the load's bandwidth. If an antenna is used for the load, any portion of the DTF sweep that goes outside of the pass band is mostly reflected, reducing the accuracy of the vertical axis Return Loss or VSWR measurements.

A wider frequency range improves distance resolution and lowers the maximum measureable 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 on DTF testing can be found in the application note "Distance To Fault" at www.Anritsu.com

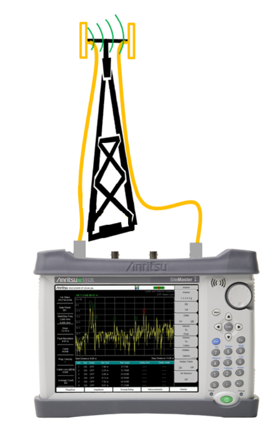
Antenna Isolation
For Base Stations
For Repeaters
Setup

Poor **base station** antenna isolation allows RF signals from one base station antenna to leak to another. If the leak is strong enough, BTS signal quality can be compromised causing dropped and blocked calls. This sort of problem can affect more than just the radios with poor isolation. Failures mean that the sector is prone to excessive inter-modulation distortion, which lowers signal quality, increases dropped calls, and can cause interference with other radio services.



Base station antenna isolation limits, when dealing with cellular systems typically should be lower than the -50 to -60 dBm range, although different situations require different limit numbers.

Repeaters with insufficient isolation between the two antennas are prone to oscillations, creating interference that can seriously harm communications over a wide area.



Repeaters are tested in much the same manner as base stations; however they require better isolation numbers. Consult your repeater installation instructions for specific guidelines.

The **setup** for antenna isolation tests uses the BTS Master, Cell Master, or Site Master's Two Port Insertion Loss capability. After a two port calibration (An OSLIT cal), the signal source is connected to one antenna while the sense terminal is connected to the other. The amount of power lost during the transmission is the antenna isolation.

Further information on isolation testing can be found in the application note "Tower Mounted Amplifiers, Diagnostics and Isolation Measurements" and "Practical Tips on Transmission Measurements" at www.Anritsu.com.

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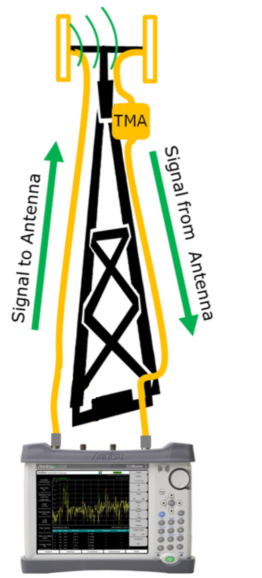
Tower Mounted Amplifiers (TMAs)

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 saving the time and expense of hiring a tower crew to bring the TMA down.

TMA tower testing can be done with the BTS Master, and many other Anritsu two port testers, which have:

- A built-in bias tee, with voltage selection, to supply power to the TMA
- High RF power mode (0 dBm) for tower testing
- Lower RF power mode (-35 dBm) for direct gain measurements on the ground
- A current draw display, to check for excessive TMA current drain

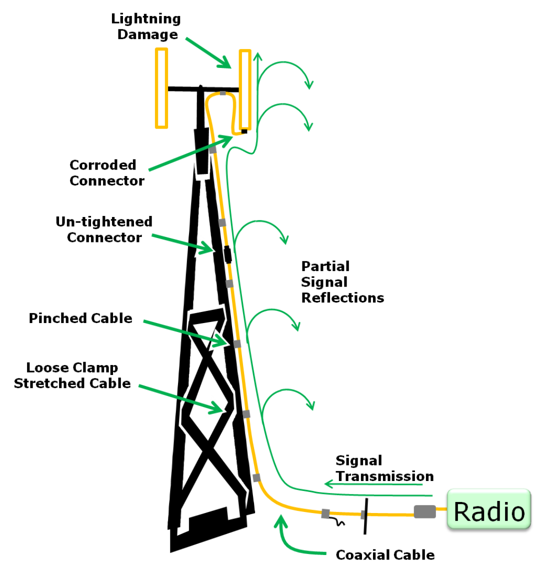
TMA gain can be measured using the two port insertion loss measurement. The procedure is to first measure the TMA noise floor when set up as shown in the illustration. Then, remove TMA power and take a second noise floor reading. The difference between the two readings is the gain of the TMA. The TMA must have a power fail bypass mode for this to work.

When checking TMA gain, it is helpful to save the two traces. This makes it easy to use delta markers to measure the difference. It also makes it easy to check for in-band flatness, pass-band width, and the slope of the TMA filters.

Further information can be found in the application note "Tower Mounted Amplifiers, Diagnostics and Isolation Measurements" and "Practical Tips on Transmission Measurements" at www.Anritsu.com.

Transmission Line Concepts

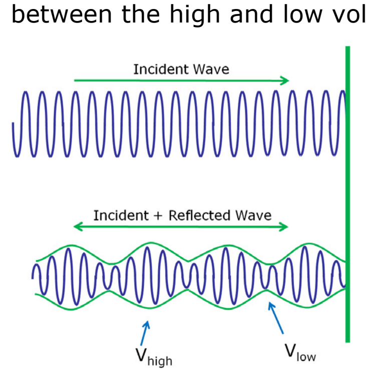
Antenna cables are a type of transmission line, a cable that has constant impedance throughout its length. Any change in impedance causes a partial radio signal reflection.



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 in 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.

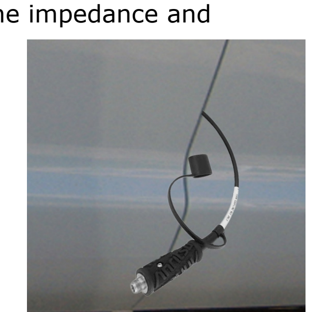
It is important to use a phase stable cable when a jumper is needed. While standard cables can be used for jumpers, and even can be calibrated to very good numbers, a standard cable's reflections can change when it is moved or bent. This can change the noise floor by 20 dB or more. A phase stable jumper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



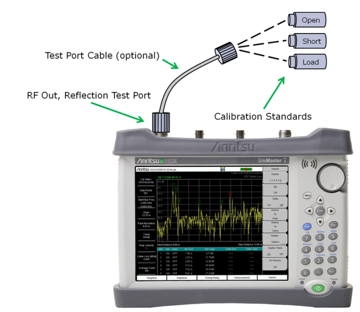
Which Calibration to Use?

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.

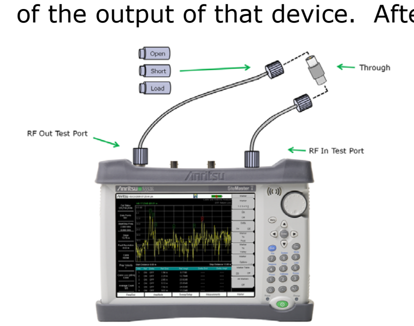


This calibration can be done either at the instrument test port, or at the end of a phase stable cable, in which case it compensates for the length of the cable. This is useful when measuring DTF. One side effect of the high accuracy OSL calibration is that it is dependent on the frequency span of the 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 check 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.

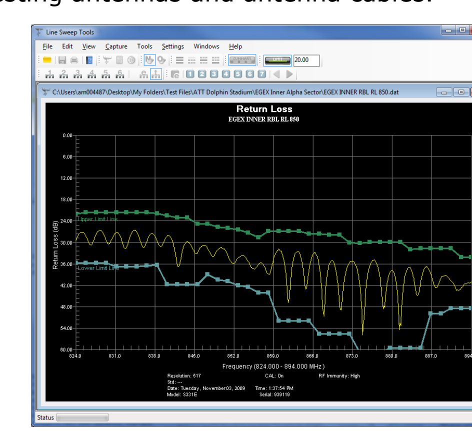
Trace processing tools in LST include:

- 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.
- Report generation – an industry standard report generator.
- 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 copy or save the trace to either a USB memory stick or a Compact Flash RAM. Data can also be transferred 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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