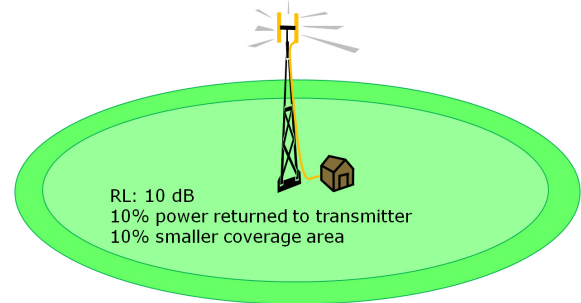


## Antenna Sweeping Why Sweep Antennas? Commissioning Sweeps

**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.

## Antenna Sweeping (continued) Maintenance Sweeps Troubleshooting Sweeps Common Faults

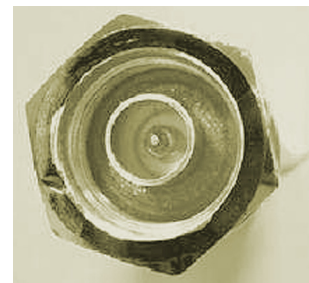
**Maintenance sweeps** can catch faults early, which will increase network uptime, reduce dropped calls, and allow consistently higher data rates.

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 Site Master capability that allows users to change frequency range without a new calibration, which is helpful when troubleshooting.

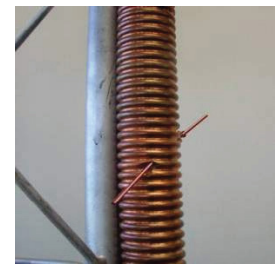
**Common faults** include connector, cable and antenna faults. When looking for faults, it's important to know that most faults are connector related.



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.

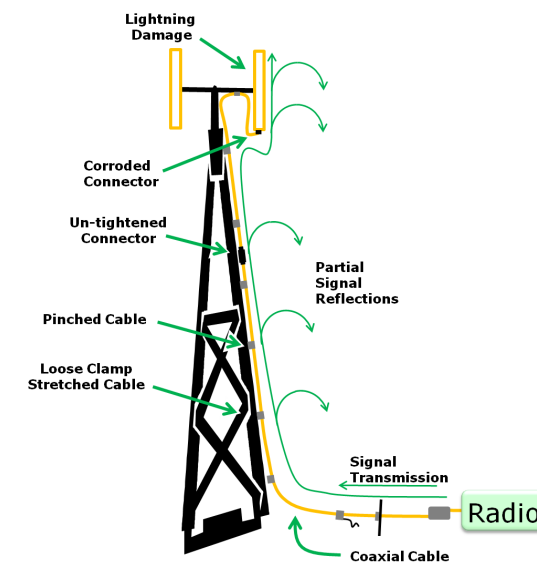
It is possible to damage GPS antennas by sweeping. Their active components are not intended to take higher power levels so they should be replaced by a load (for Return Loss) or a short (for DTF) before measuring the line.



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?

## Transmission Line Concepts

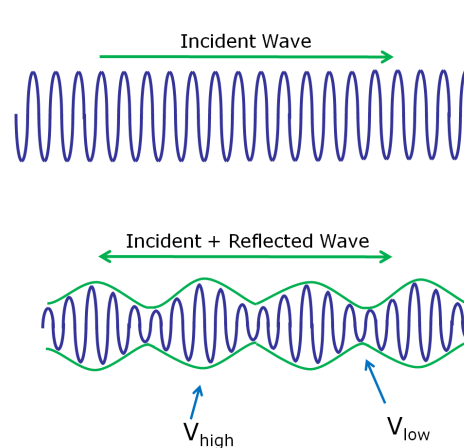
Antenna cables are a type of transmission line, a cable that has constant impedance throughout its length. Any change in impedance causes a partial radio signal reflection.



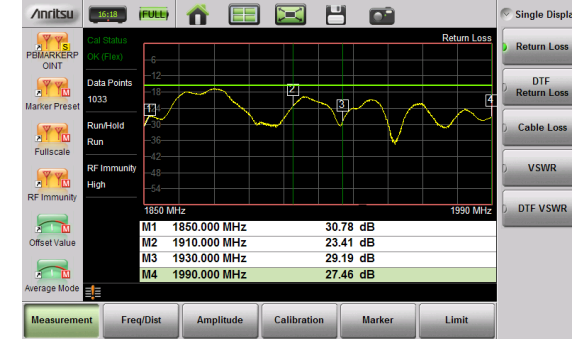
Changes in impedance, in turn, are caused by mismatches, or physical changes in the cable, such as:

- 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.



## 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.

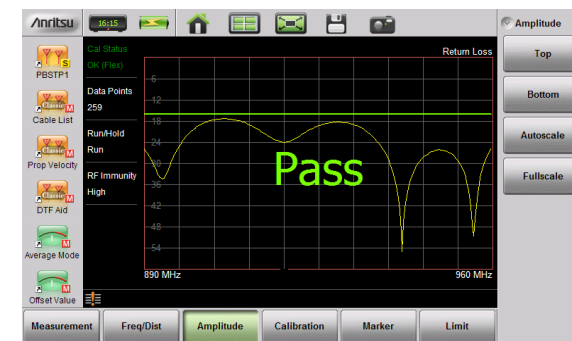
**Reflections are measured** using either VSWR or Return Loss. These are two different ways to measure the same thing. Return Loss is a logarithmic scale, and Voltage Standing Wave Ratio (VSWR) is a linear scale. Your choice can be made by personal preference, the unit's limit numbers are given in, or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

$$\text{Return Loss} = 20 \log \left[ \frac{\text{VSWR} + 1}{\text{VSWR} - 1} \right]$$

$$\text{VSWR} = 1 + 10^{-\text{RL}/20} / (1 - 10^{-\text{RL}/20})$$

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

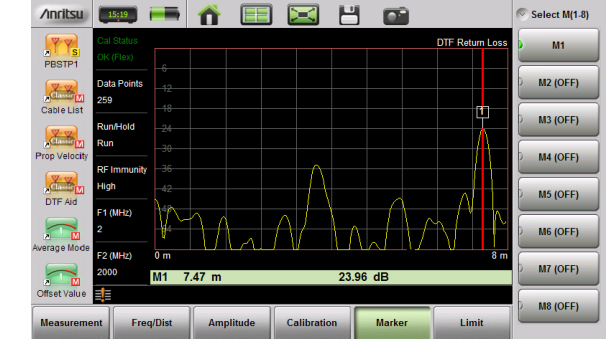
**Limit lines** can be created on the S331L Site Master and limit pass/fail or limit alarms can be activated as desired. This makes judging results fast and easy.



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](http://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	15 to 25 dB
Connectors	30 to 40 dB

**Propagation velocity** (PV or Vp) is sometimes referred to only as Velocity, or Velocity of propagation. It is commonly specified as either a decimal value Eg: 0.87 or as a percentage Eg: 87%, and it is a measure of how quickly the RF signals can propagate through the cable. The value is referenced to the speed of light, so 87% Vp means the signals will travel at 87% of the speed of light. Vp directly affects distance accuracy in DTF measurements. Vp must be set either manually or by selecting a cable type from the built-in cable list.

**Cable Loss** also needs to be set accurately, either manually, or by selecting a cable type. Incorrect 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, but 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** on DTF testing can be found in the application note "Distance To Fault" at [www.Anritsu.com](http://www.Anritsu.com)

## 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 test port extension cable. While standard cables can be used, and even can be calibrated to very good numbers, a standard cable’s phase response can change significantly when it is moved or bent. The result of this can change the instruments calibrated noise floor by 20 dB or more. A phase stable cable will minimize these errors when flexed, to maintain a high level of accuracy in the measurement.

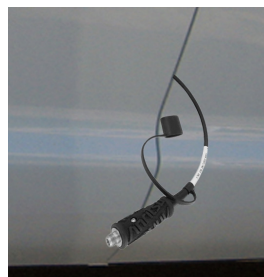
## Caring for Precision Cables and Connectors

Precision cables, calibration kits, and connectors require proper handling to prevent damage, and to prolong their useful life. You should always carefully inspect the cable or device under test to make sure it does not have a damaged connector **before** connecting your precision cable or adapter to it. It only takes **one** connection to a badly damaged device connector to permanently damage your precision cable, adapter, or your precision calibration kit. Failure to use proper handling can quickly destroy the accuracy of an OSL calibration kit.



Do not twist the body of the connector when making connections, always hold the connector steady and rotate the outer portion of the male connector. Twisting the entire connector will damage the center pin assembly by wearing off the gold plating (shown in the picture) which in turn will increase contact resistance, thus resulting in poor and unpredictable performance.

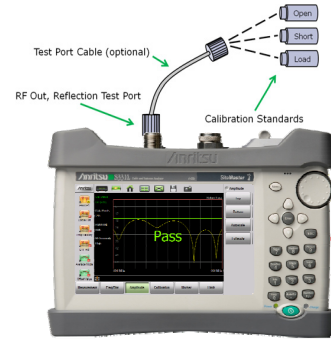
All cables, including precision test port phase stable cables have a minimum bend radius. If the cable is bent too sharply, or pinched, the center conductor moves closer to the shielding, changing the impedance and causing a reflection. At this point, the abused cable is no longer a precision cable. Care should be taken to avoid excessive bending of the cables whenever possible, particularly after a calibration has been completed.



## Which Calibration to Use?

**Open, Short, and Load (OSL)**  
**InstaCal, FlexCal**  
**Open, Short, Load (OSL)**

**OSL** (standard) 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™** is built-in to the S331L Site Master. It provides a fast and accurate one connection calibration, but with a very slight loss of accuracy compared to using a precision OSL cal kit. It changes the open, short, and load electronically, making calibration faster.



**FlexCal™** is excellent for troubleshooting tasks, and may also be used for measurements, but it comes with a slight degradation in accuracy. Most users will not see any difference, but there can be situations where the reduced accuracy is evident in the measurement. Some operators will not accept final measurements made using the FlexCal method. You should always verify with the end user to see if FlexCal measurements are acceptable. FlexCal can be used with both OSL cal components, or with the built-in InstaCal module. FlexCal will measure additional points across the entire frequency range during the calibration process which the analyzer stores internally. This allows users the flexibility to change the sweep start and stop frequencies as needed to better resolve a fault without needing to recalibrate the instrument every time.

## Line Sweep Tools (LST)

**Collect traces**  
**Verify traces**  
**Report results**

LST is a PC based tool that makes life easier for people testing antennas and antenna cables. It helps with collecting traces from the instrument, verifying that the traces are correct, and reporting results. LST has several features that make life simpler for the users of Anritsu’s cable and antenna analyzers:

- Marker and limit line presets allow markers and a limit line to be applied to the selected trace with just one button click. This is much quicker and more accurate than setting markers individually.
- A trace naming grid allows quick and accurate renaming of Trace Filenames, Trace Titles, and Trace Subtitles. The renaming grid is setup to allow users to enter portions of file names, for instance, a color code, a sector name, or a test type. Once entered, the name segments can be applied quickly, with one button click per segment.
- A Report Generator allows quick and easy generation of PDFs, with included company contact information.
- Trace conversions allow Return Loss traces to be converted to Distance-to-Fault. This is helpful when a required trace was not taken at the site.



These capabilities greatly reduce the time required to prepare traces for delivery and generate reports.

For those used to working with Anritsu’s legacy software, Handheld Software Tools, or are looking for a tool to open DAT files, LST is the choice. LST works with DAT files and is the new version of HHST. The user interface will be familiar to HHST users and the files LST produces may be viewed in HHST.

## SweepMasters DIRECT Online Trace Delivery Service

<b>Capture</b>	Capture and upload multiple traces from the Anritsu S331L.
<b>Deliver</b>	Deliver multiple traces in a timely manner Prevent un-authorized users from accessing the traces.



### What is SweepMasters DIRECT?

SweepMasters DIRECT, available from SweepMasters™, is an easy-to-use online trace delivery service for your cable and antenna analyzer test results. It allows you to capture, upload, and deliver traces. Every Anritsu S331L instrument is authorized to use the SweepMasters DIRECT online trace delivery service.

### How are results delivered?

When you are ready to deliver results, links to the organized traces, as well as a PDF report, are sent via e-mail to the project management company or wireless carrier you specify. These links can be resent if they are misplaced. Passwords prevent unauthorized access to your data.

This fulfills two of the usual requirements for cable and antenna system testing.

### Who is SweepMasters™?

SweepMasters™ is one of Anritsu’s business partners, providing web-based services for Anritsu’s cable and antenna analyzers.

## Handy VSWR/RL Conversion Chart

VSWR	RL(dB)	VSWR	RL(dB)
1.00	∞	2.50	7.4
1.01	46.1	2.60	7.0
1.02	40.1	2.70	6.8
1.03	36.6	2.80	6.5
1.04	34.2	2.90	6.2
1.05	32.3	3.00	6.0
1.06	30.7	3.10	5.8
1.07	29.4	3.20	5.6
1.08	28.3	3.30	5.4
1.09	27.3	3.40	5.3
1.10	26.4	3.50	5.1
1.12	24.9	3.60	5.0
1.14	23.7	3.70	4.8
1.16	22.6	3.80	4.7
1.18	21.7	3.90	4.6
1.20	20.8	4.00	4.4
1.25	19.1	4.10	4.3
1.30	17.7	4.20	4.2
1.35	16.5	4.30	4.1
1.40	15.6	4.40	4.0
1.45	14.7	4.50	3.9
<b>*1.50</b>	<b>*14.0</b>	4.60	3.8
1.55	13.3	4.70	3.8
1.60	12.7	4.80	3.7
1.65	12.2	4.90	3.6
1.70	11.7	5.00	3.5
1.75	11.3	5.50	3.2
1.80	10.9	6.00	2.9
1.85	10.5	6.50	2.7
1.90	10.2	7.00	2.5
1.95	9.8	7.50	2.3
2.00	9.5	8.00	2.2
2.10	9.0	8.50	2.1
2.20	8.5	9.00	1.9
2.30	8.1	9.50	1.8
2.40	7.7	10.00	1.7

\*Typical antenna value