Application Note

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Understanding the Precision Antenna, Cable, and Power Measurements on the 3550 Radio Test System

The Aeroflex 3550 Radio Test System now includes new methods for more accurately measuring power, distance to fault (DTF), return loss (RL), and voltage standing wave ratio (VSWR). This Application Note includes information that will help you to understand how to use these new methods. The new methods for making these measurements require external components. It is critical to understand how to use these components to make these precision measurements.

The New Method of Measuring DTF, RL, and VSWR

The new Tracking Generator function now has two modes of operation. These are selected in the "Mode" field in the "Control 1" screen of the Tracking Generator. The two selections are "Tracking Gen" and "DTF". The "Tracking Gen" selection is used for all normal frequency domain tracking generator functions including:

1. Tuning duplexers and filters
2. Measuring insertion loss of cables or attenuators
3. Measuring return loss and VSWR (both require the VSWR bridge)

The "DTF" selection is used for finding the distance to fault in a coaxial cable. This selection changes the graph so that the "X" axis (horizontal) is in feet or meters. It also changes some of the setup parameters so that the user can easily setup the distance to fault measurement.

Measuring RL and VSWR

The RL and VSWR measurements are really the same measurement, but with different units for the "Y" (vertical) axis. This measurement, using the tracking generator, requires an external return loss bridge. This bridge is part of the "Precision DTF/VSWR Accessory Kit." This kit contains:

- Return Loss Bridge, 5 - 3000 MHz
- 12 inch coax cable (TNC-M to N-M)
- Power Divider, DC - 3000 MHz
- 7.5 inch coax cable (TNC-M to N-M)
- 50 Ω Termination
- Adapter (TNC-M to N-M)
- Accessory case

Precision VSWR/DTF Accessory Kit

The Return Loss Bridge input and outputs are marked to match the connection to the 3550. The connections of the bridge to the 3550 and to device under test should be as follows:

1. The TNC-M to N-M adapter is used to connect the SWR port of the 3550 to the SWR port of the bridge.

2. The 12 inch coax cable is used to connect ANT port of the bridge to the ANT port of the 3550.

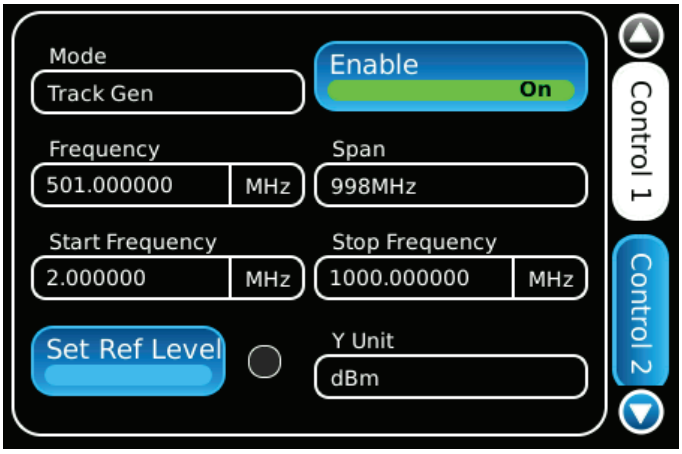
3. The DUT port of the bridge should be connected to the device under test, which would be the antenna or other device.

Next is the setup of the tracking generator of the 3550.

1. In the "Mode" field, select "Track Gen".

2. Make sure the "Enable" field is On (Green).

3. Set the "Span" (select "Span" first) and then the "Frequency" field to match the sweep desired for the antenna or other device.



Setting up the Tracking Generator function for RL and VSWR measurements

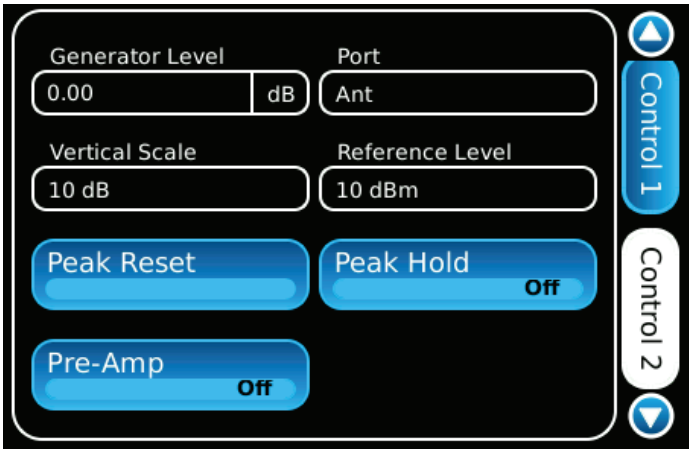
4. Move to "Control 2" screen.

5. Make sure the "Gen" field is set to 0 dB.

6. Select "Ant" for the "Port" field.

7. Set the Vertical scale to 10 dB and the Reference Level to 10 dBm.

8. Pre-amp should be off for this measurement.



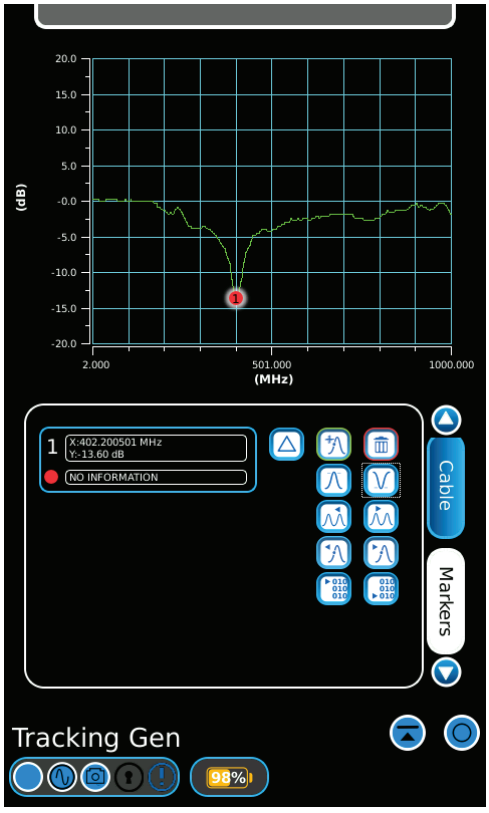
Setting the Tracking Generator "Control 2" function for RL and VSWR measurements

The next step is to go to the "Control 1" screen and select the "Set Ref Level" button. This will change the sweep of the 3550 from an absolute level of dBm to a relative level of dB (relative is referenced to the measured sweep that resulted from pressing "Set Ref Level"). In the "Y Unit" field (Vertical) you can select dBm,

dB, or VSWR.

- Units of dB are selected for Return Loss measurement.
- Units of VSWR are selected for VSWR measurement.
- dBm can be selected to go back to an absolute measurement of the signal level on the Antenna port.

After selecting your Y units, connect your antenna or other device that you wish to display return loss or VSWR.



Return Loss Sweep in the Tracking Gen

Measuring Distance to Fault (DTF)

The DTF sweep can also be made in the Tracking Generator screen. This measurement requires a power divider, which is also part of the "Precision VSWR/DTF Accessory Kit." The ports on the power divider are marked to indicate the port that they connect to on the 3550.

1. The SWR port on the power divider should be connected to the SWR port of the 3550 using the TNC-M to N-M adapter.

2. The ANT port on the power divider should be connected to the ANT port of the 3550 using the 7.5 inch coax cable.

3. The DUT port on the power divider connects to the coax cable that is being tested.

The setup for measuring DTF is different than the setup was for measuring RL or VSWR. This setup should be completed as follows:

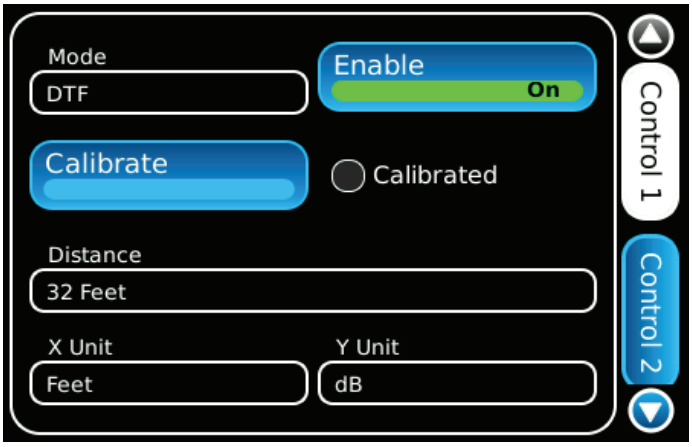
1. In the "Mode" field, select "DTF." This will change other fields to further configure DTF tests.

2. Make sure the "Enable" field is On (green).

3. The "Distance" field is the maximum range of the sweep and should be longer than the length of the cable under test.

4. The "X unit" field can be set to either "Feet" or "Meters."

5. The "Y unit" field can be set to either "dB" or "VSWR." Selecting VSWR does not mean that you have changed modes to measuring VSWR, but is a selection for the units used as the vertical scale of the magnitude of the fault.



Enabling DTF testing in the Tracking Generator feature

6. Next move to the "Control 2" screen.

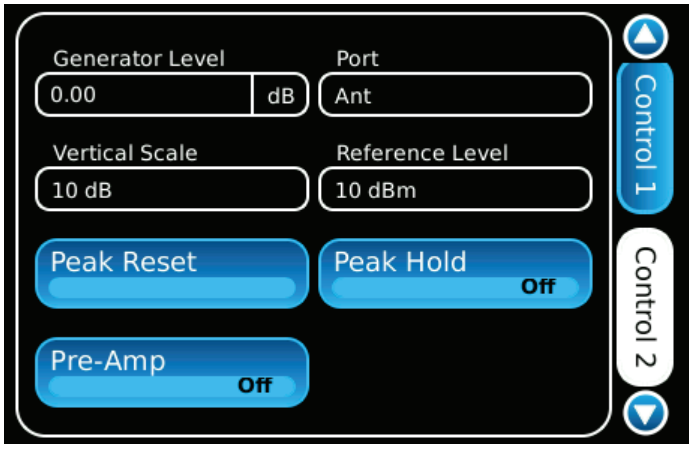
7. The generate level should be 0 dB.

8. The Port should be "Ant."

9. Set the Vertical Scale to "10 dB." This can be adjusted later if needed to get a clearer picture of the DTF plot.

10. Make sure the Reference Level is "10 dB." This level must be greater than the generate level.

11. Pre-Amp should be "Off."



Setting Generator and Reference Level in the "Control 2" screen of the Tracking Generator feature

12. Next move to the "Cable" screen.

13. In this screen, the user selects the Velocity factor and cable loss.

The Velocity factor is especially important as it determines the accuracy of the distance to fault plot. These parameters are part of the specification for a coax cable. The Loss (cable loss) is the amount of loss in dB per 100 ft. Since this varies over frequency, for most PMR applications, you should use the mid-point value, the value close to 500 MHz. Velocity (velocity factor) is the speed

at which the waveform travels through the cable, relative to the speed of light. This value determines the accuracy of the location of the fault, so it is important that it is correct. You can also select from a list of cables that automatically selects the "Velocity" and "Loss" for you.

Setting Velocity Factor for Enhanced DTF measurements

Once this setup is complete, the next step is to calibrate the measurements. This is a critical step and must be done in order to obtain accurate results. To do this, connect the 50 Ω termination, which is part of the Precision DTF/VSWR Accessory Kit, to the DUT port on the power divider. Select the "Calibrate" button and in about 2 seconds the calibration is complete and the circle next to "Calibrated" will turn orange. Now connect the cable to the DUT port of the power divider. The distance to fault plot will appear with update rates of less than two seconds.

Now determine the position of the fault or end of the cable.

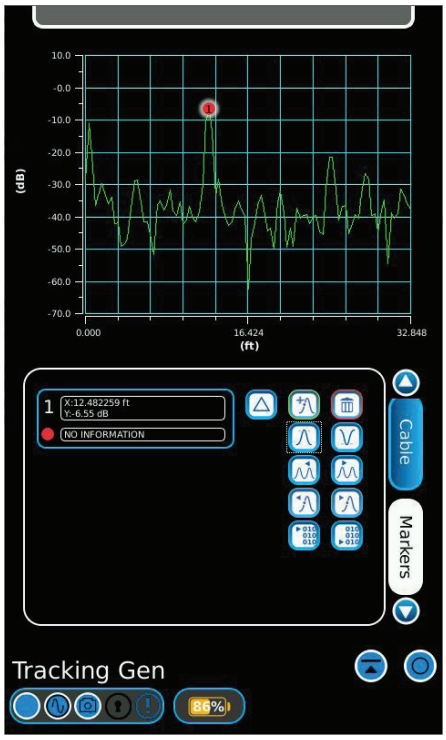
1. Move to the "Markers" screen.

2. Enable a marker by selecting the icon at the top of the left column of icons.

3. Touch the "Marker 1" display box to expand it.

4. Touch the "Peak" icon (the 2nd icon down in the left column).

The screen should now look like this:



DTF sweep in the Tracking Generator screen

The Marker 1 information shows the location of the peak fault in the cable. The "X" value is the distance to the fault. In the case of this example plot, the "fault" was the end of the cable. In some cases, there may be the fault in the cable and the end of the cable. This will show up as two peaks in the plot of the cable.

Measuring Power with the Bird 5017B Wideband Power Sensor

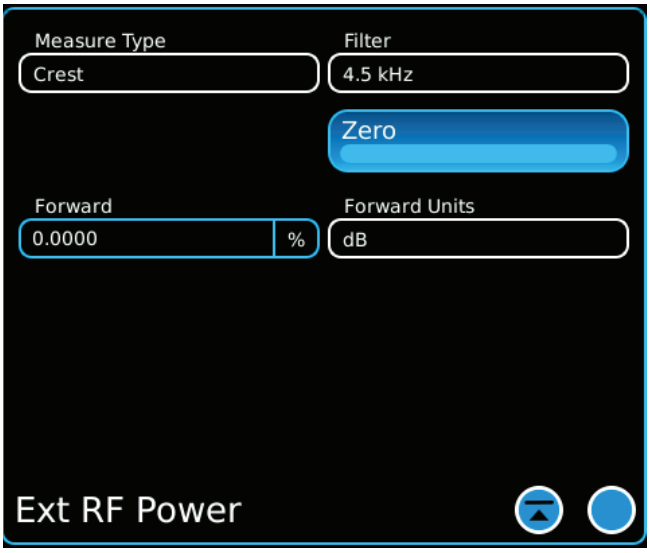
With the addition of the "Precision Thru-Line Power Meter" option along with the "Bird Wideband Power Sensor; 5017B," the 3550 has an even more accurate method of measuring RF power. This option also adds the capability to the 3550 of measuring higher power levels, forward and reverse power, and measuring power of a repeater or base station while it is in-service. Use of this power meter requires the user to purchase option 3550OPT14 and acquire the "Bird Wideband Power Sensor; 5017B." The 5017B is also available from Aeroflex. When the option is installed and the 5017B is connected to the USB port of the 3550, this meter is displayed as the "Ext RF Power" meter and is accessed from the "Meters" menu.

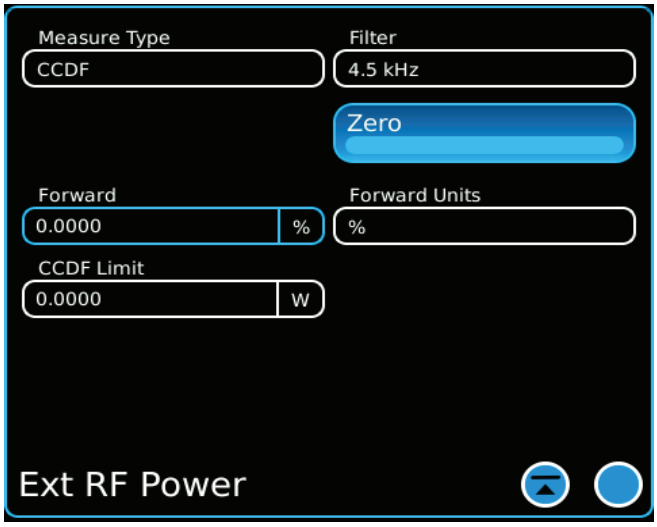
This power sensor has the following specifications:

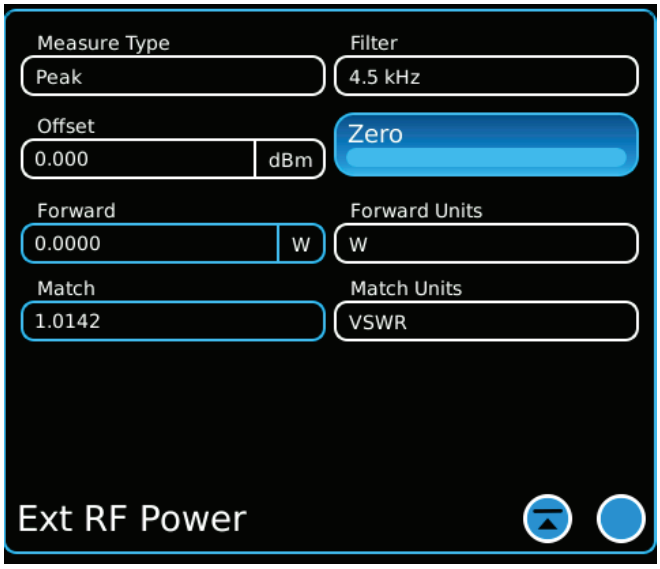
- Frequency Range: 25 MHz - 1.0 GHz
- Power Range: 500 mW - 500 Watts Avg., 1300 Watts Peak
- Accuracy: ±4% of reading, +0.17 W

Measurement types:

- True Average Power
- Peak Power
- Burst Power
- Crest Factor
- CCDF (Complementary Cumulative Distribution Function)







Setting the External RF Power Meters for use with the Bird Power Meter

The power sensor can measure both peak power and average power. Crest factor is the ratio of the peak power to the average power. CCDF measures the amount of time the power is above a user defined threshold.

Note: The Burst power requires bursts of 1 us to 5 ms and repetition rates of 200 Hz minimum, so Burst mode will not work for P25 Phase 2 HCPM subscriber measurements or DMR TETRA subscriber measurements. It will, however, work for P25 Phase 2 HDQPSK repeaters and DMR repeater operation, since the downlink from the repeater to the subscriber is not a TDMA burst.

Forward/Reverse Power Calculations:

- VSWR
- Return Loss (RL)
- Reflection Coefficient (Rho)

VSWR measures the relation between forward (PF) and reflected (PR) average power. Rho and RTL are also the same measurement, but in different units:

$$Rho(\rho) = (\sqrt{(PR/PF)})$$

$$VSWR = (1+\rho)/(1-\rho)$$

$$RTL(dB) = 10\log/(PR/PF)$$

Using the Bird Power Sensor is very simple.

1. Plug the power sensor into the USB port. The 3550 automatically senses that it is present.

2. Select the Ext RF Power meter from the “Meter” menu.

3. Select the bandwidth of the filter (4.5 kHz or 400 kHz). Selection should be as narrow as possible while still being larger than the demodulated signal bandwidth. Narrowing the filter limits the noise contribution caused by interfering signals. For narrow band applications, this should be set to 4.5 kHz.

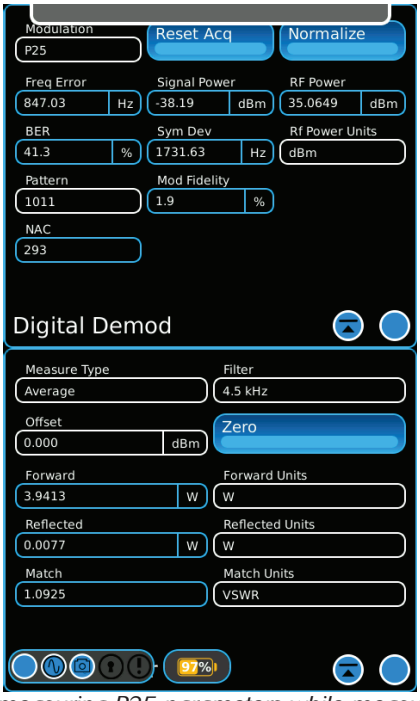
4. Select the “Offset” setting to compensate for cable or other losses.

5. Choose the units for the Forward and Reflected power (W or dBm).

6. Select the units for match (VSWR, RTL, or RHO).

7. The meter should be “Zeroed” before measuring power. This is done by pressing the “Zero” button. Ensure that no power is applied before performing this operation.

The sensor can now be inserted between the transmitter and the antenna, or you can terminate the output of the sensor into a suitable load. You could also terminate the output of the sensor into the T/R port of the 3550 if the power is less than 20 Watts. If it is more than 20 Watts, you should use a 20 dB pad to reduce the power going into the 3550. Using the Bird Power Meter terminated into the 3550 allows the user significant flexibility, as other measurements can also be made at the same time such as Deviation, Frequency Error and digital demodulation decode functions.



Example of measuring P25 parameters while measuring power

- The advantage of terminating into the 3550 is that you will be able to make all of the 3550 capable measurements while at the same time using the power sensor to measure power.
- The advantage of terminating into the antenna is that you can measure the power of the radio while the radio under test is still in-service. In addition, you can measure the match of the antenna at the frequency the radio is transmitting.

Conclusion

Using these new methods for measuring power, VSWR, return loss, and distance to fault makes the 3550 an even more valuable tool for field testing. Understanding the operation is critical for getting precision measurements. For more information or to order these precision components, contact your Aeroflex sales office.

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