Wrapping Antennas in PIM Blankets

BACKGROUND

PIM blankets were developed to provide cellular operators a method to temporarily suppress PIM on rooftop cell sites. PIM blankets work by reflecting RF energy away from the covered area. If the energy from the antenna is not able to reach a PIM source under the blanket, no PIM is produced by that source. With the PIM sources suppressed at a site, operators can determine the level of improvement that could be achieved with a permanent repair to the covered area.

PIM Blankets Placed Over PIM Sources in Front of an Antenna

The question often arises, "Can a PIM blanket be used to determine if a PIM source is beyond the antenna?" The idea being that if you cover the antenna with a PIM blanket and the PIM goes away, the PIM source must be beyond the antenna. The answer to this question is no, you should NOT test this way. Wrapping the antenna with a PIM blanket sets up standing waves inside the antenna and feed system that can generate higher than normal levels of PIM internal to the system. When this happens, you will falsely conclude that the PIM source you are seeking is inside the feed system.

In addition, when the PIM blanket is wrapped around the antenna a significant percentage of the test power will reflect back to the PIM analyzer. While commercial PIM analyzers are designed to handle high reflected power for a short period of time, damage could occur with prolonged testing. This is not a risk worth taking!

To demonstrate the high reflected power and false levels of PIM that can be created by wrapping an antenna in a PIM blanket, ConcealFab set-up a base station antenna inside its anechoic chamber and measured Return Loss and Swept PIM levels with and without a PIM blanket installed.

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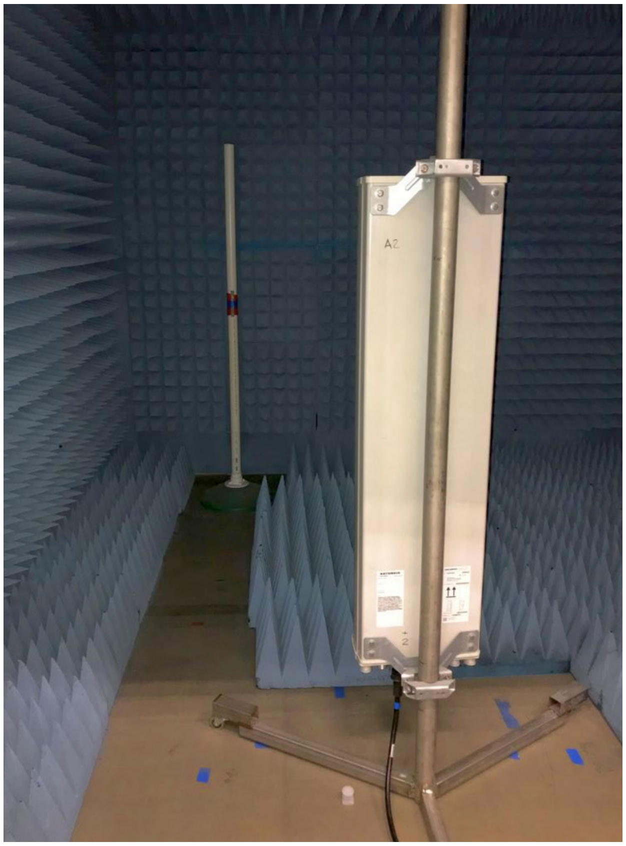
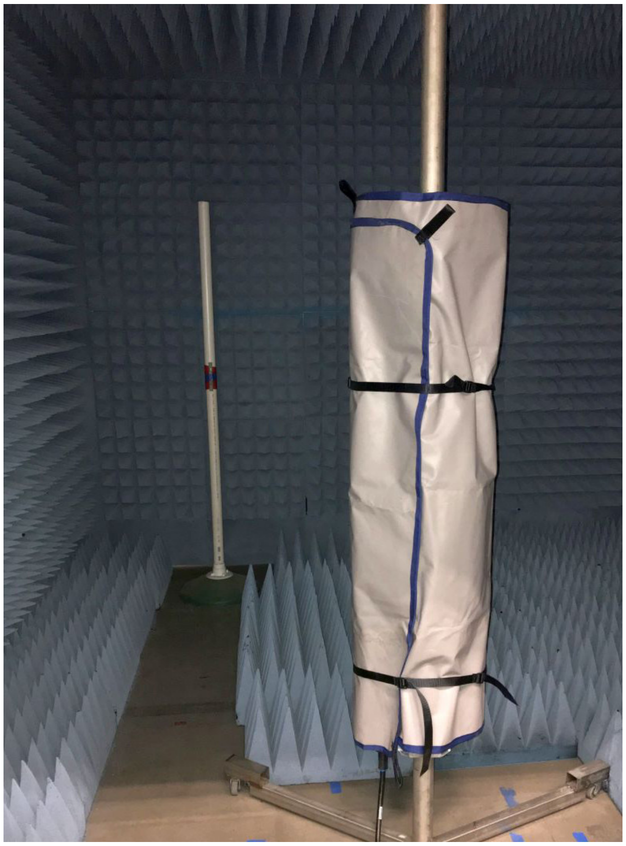


Antenna Inside Anechoic Chamber



Antenna Wrapped in PIM Blanket

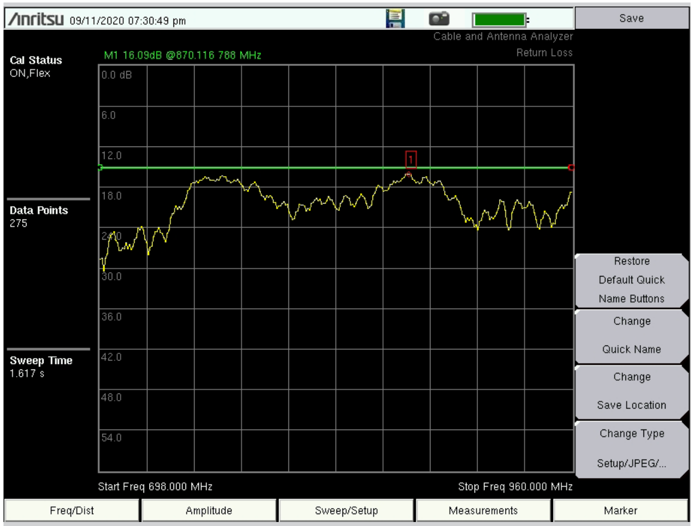
RETURN LOSS MEASUREMENTS

Return loss is measured using a Cable & Antenna analyzer such as the Anritsu Site Master. The Cable & Antenna analyzer transmits signals into a system and measures the amount of power "returned" to the analyzer across a range of frequencies. The ratio of power transmitted to power reflected at each frequency is displayed in decibels (dBs) on the instrument screen. Markers can be set to determine the worst-case Return Loss value over the frequency range of interest. Typical antenna systems require that the Return Loss be greater than 15 dB, meaning the maximum allowed reflected power at any frequency in the range is 3.2%.

The Return Loss plots below show the impact of covering our Kathrein test antenna with a PIM blanket. For both the high frequency range ports (1695 – 2690 MHz) and the low frequency range ports (698-960 MHz) the Return Loss was better than 15 dB without the PIM blanket installed (PASSING) and worse than 15 dB with the PIM blanket installed (FAILING.) For this antenna, the reflected power in the low frequency range port increased from 2.5% to 44.7% and the reflected power in the high frequency range port increased from 1.4% to 9.7%. It is likely that the high frequency range was impacted less by the PIM blanket due to the greater spacing (with respect to a wavelength) between the radiating elements inside this antenna and the antenna radome. Results will be different for different antenna models.

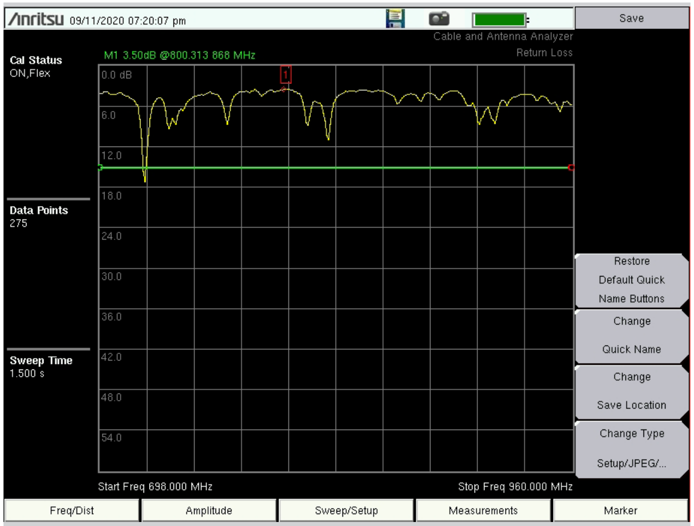
Return Loss: Low Frequency Port

Antenna Only



- **16.09 dB Return Loss**
- **2.5% Power Reflected**

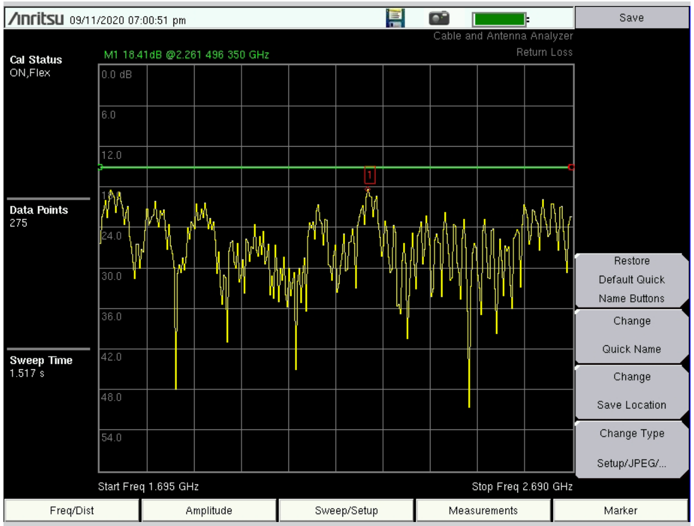
Antenna with PIM Blanket



- **3.50 dB Return Loss**
- **44.7% Power Reflected**

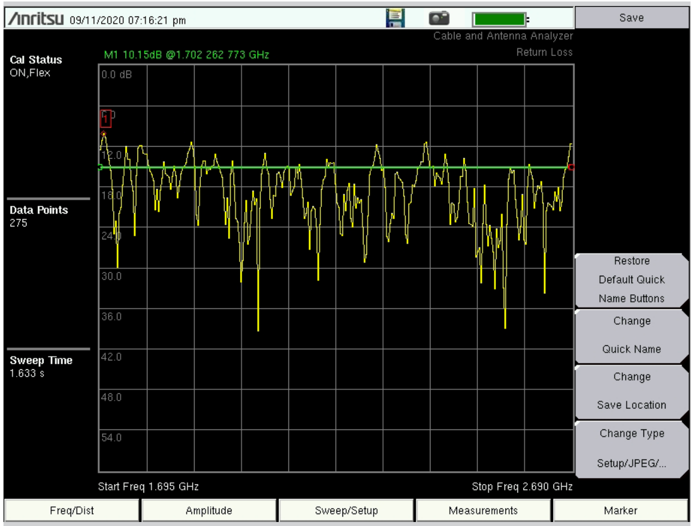
Return Loss: High Frequency Port

Antenna Only



- **18.41 dB Return Loss**
- **1.4% Power Reflected**

Antenna with PIM Blanket



- **10.15 dB Return Loss**
- **9.7% Power Reflected**

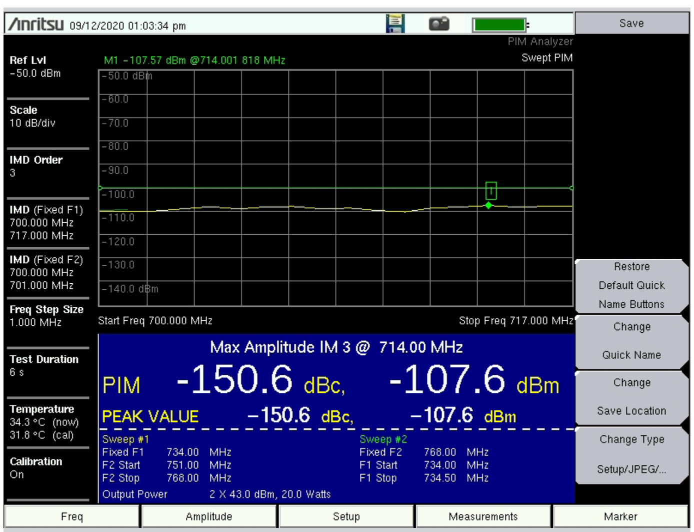
SWEPT PIM MEASUREMENTS

Passive intermodulation (PIM) measurements are made using a PIM Analyzer. The PIM analyzer transmits two high power test signals (typically 20W or 40W) into the system under test while measuring and displaying the magnitude of the third order intermodulation product (IM3) in decibels on the instrument screen. For external PIM testing the "Swept PIM" or "PIM vs. Frequency" measurement mode is used to generate and display the magnitude of IM3 over a range of test frequencies. The acceptable IM3 level for a given site depends on the frequencies in use at that site and on the power being transmitted by the site radios. The acceptable IM3 when testing with 2 x 20W test tones for a macro site will typically be somewhere between -100 dBm and -118 dBm. (To be specified by the operator commissioning the test.)

The Swept PIM measurements below show the impact of covering our Kathrein test antenna with a PIM blanket. For the high frequency range ports the IM3 degraded by 25 dB with the PIM Blanket installed. For the low frequency range ports the IM3 degraded by 7.2 dB with the PIM Blanket installed. This increase in PIM generated by the reflected power can be much higher in a cell site environment, making the "cover the antenna with a PIM Blanket" test method ineffective in many cases.

Swept PIM: Low Frequency Port

Antenna Only



-107.6 dBm Worst Case Swept PIM

Antenna with PIM Blanket

-100.4 dBm Worst Case Swept PIM

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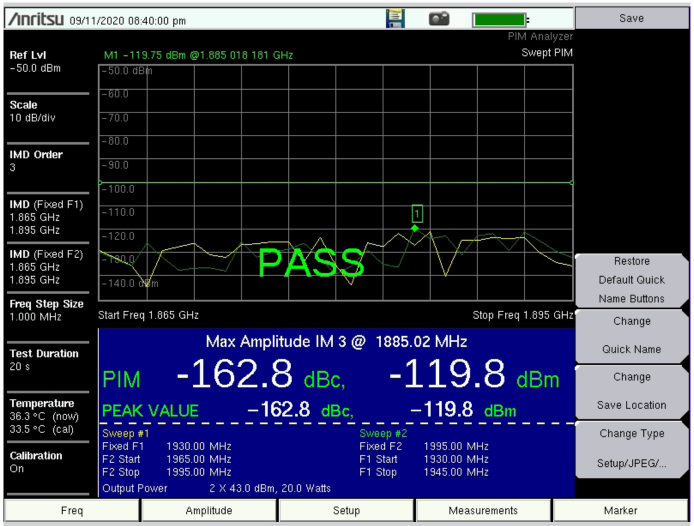
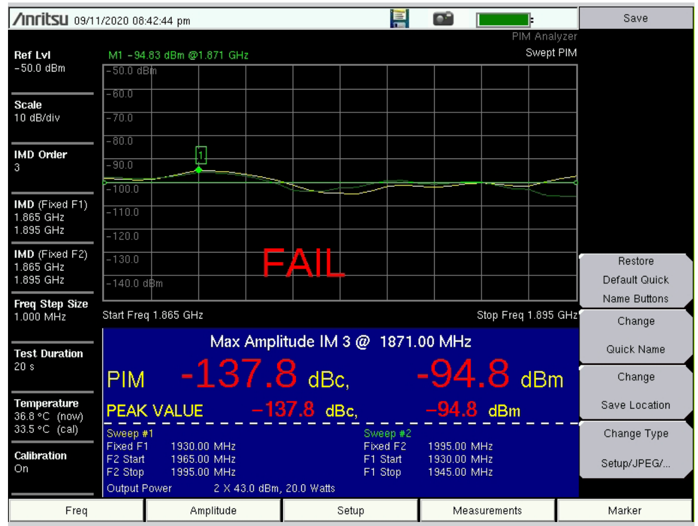
Swept PIM: High Frequency Port

Antenna Only



-119.8 dBm Worst Case Swept PIM

Antenna with PIM Blanket



-94.8 dBm Worst Case Swept PIM

A BETTER METHOD FOR DETERMINING PIM SOURCE LOCATION

A much more effective tool for determining if a PIM source is beyond the antenna is the Distance-to-PIM (DTP) measurement mode. The most accurate method is to tape a high magnitude PIM source (such as ConcealFab PN 900643) directly to the front face of the antenna and measure Distance-to-PIM. This establishes a "PIM marker" at an electrical length equal to the front face of the antenna. Remove the PIM source and measure DTP again. This second measurement determines the electrical distance to the "site PIM source." If the distance to the site PIM source is less than the distance to the PIM marker on the front of the antenna, the site PIM is inside the feed system. If the site PIM source is farther away than the distance measured to the PIM marker on the front of the antenna, the site PIM is beyond the antenna. As shown below, the Anritsu PIM Master provides the capability to overlay DTP measurements on the instrument screen and automatically set-up a delta marker to show the distance between peaks.

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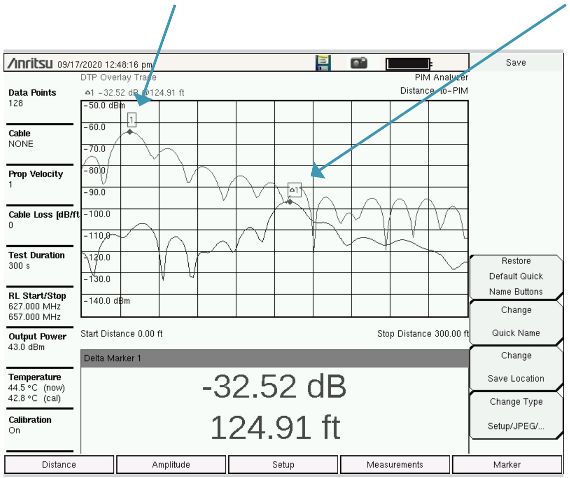
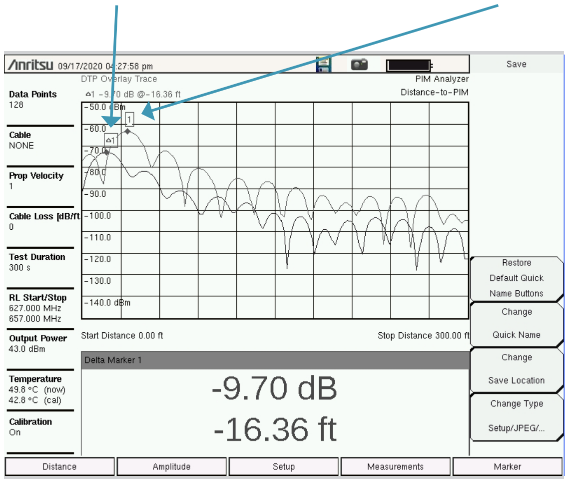
DTP: PIM Source on Antenna DTP: Site PIM



PIM Source Beyond the Antenna

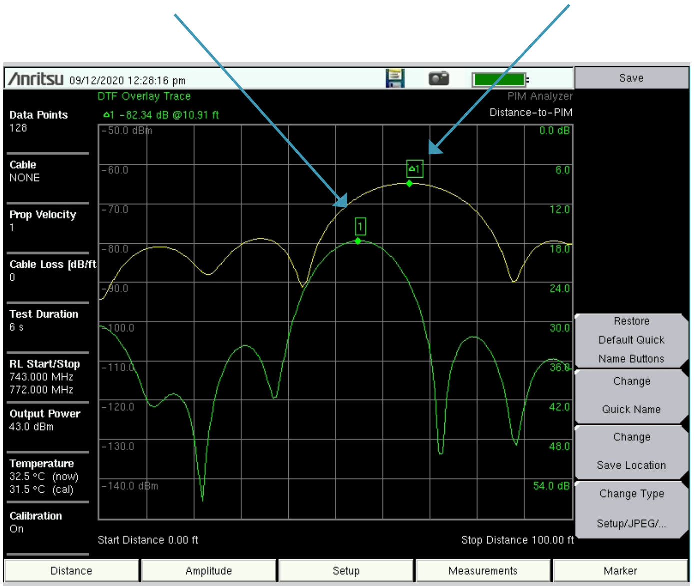
DTP: Site PIM DTP: PIM Source on Antenna



PIM Source Inside the Feed System

If you do not have access to a high magnitude PIM source or do not have easy access to reach the face of the antenna, a DTP (Distance-to-PIM) / DTF (Distance-to-Fault) overlay can be used to perform the same analysis. In this case, rather than creating a PIM marker at the front face of the antenna the reflections occurring within the antenna will be used to “mark” the antenna location. PIM analyzers from Kaelus and Anritsu both include the capability to automatically measure DTF and DTP and overlay the traces on the instrument screen. Here again, if the DTP peak is farther away than the DTF peak, the PIM source is beyond the antenna. If the DTP peak is closer than the DTF peak, the PIM source is inside the antenna or inside the feed system.

DTF: Reflection at Antenna DTP: Site PIM



PIM Source Beyond the Antenna

For additional information on DTP and DTF measurements, contact your PIM analyzer equipment manufacturer.