

Webinar: Resolving PIM

Thank you for joining us. We will begin shortly

NOTE: This presentation includes Q&A. We will be taking questions during the presentation with answers at the end using the questions section of your control panel.



Agenda

- Welcome and Introductions
 - Lindsay Welch
- TRS-RenTelco: Test & Measurement Solutions
 - Scott Wrinkle, Regional Sales Director
- VIAVI: Resolving Live PIM via CPRI
 - Dan Schmedtje, Wireless Dominion Expert
- TRS-RenTelco: Equipment & Special Promotions
 - Scott Wrinkle, Regional Sales Director
- Q&A – Joint TRS and VIAVI

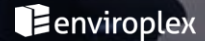
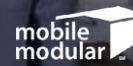
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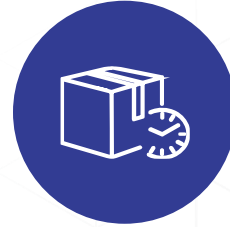


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VI.AVI

VI.AVI Solutions

PIM Mitigation RTWP Testing

With T-BERD-5800 or OneAdvisor-800

Dan Schmedtje

May 2023

Agenda

Welcome/Agenda

What is PIM?

What is CPRI and RFoCPRI?

PIM Detection versus PIM Testing?

PIM Mitigation Methodology

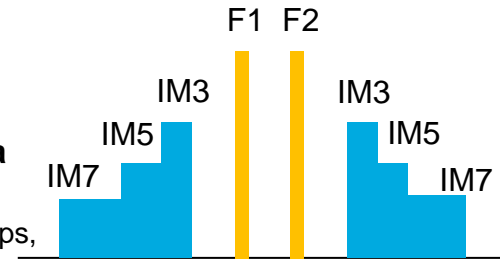
Real World Examples

Live Demo featuring the ONA 800

Q & A

What is PIM? – (Passive Inter-Modulation)

- Passive Inter-Modulation (PIM) can occur in passive (unpowered) devices whenever two or more RF signals encounter non-linear electrical junctions or materials.
- **PIM can be part of the COAX + Antenna system (internal) or beyond the antenna (external)**
 - Compromised 50 Ohm connections, loosely contacting metals, rusted safety chain, pipe clamps, pile of rusted screws buried in the roof-stone, flashing on the parapet, etc.
- The PIM signal(s) generated are mathematically related to the incident frequencies.
- **Wideband signals (LTE) create wideband PIM signals (self mixing and inter-band)**
- If the PIM signal falls in an uplink band, it will raise the noise floor thus desensitizing the receiver
- **LTE exposed the PIM issue when it started to replace CDMA and WCDMA**
 - LTE expects/requires a lower noise floor than those older technologies
 - More signals on the tower means more possible sources and RX spectrum to impact
- PIM power increases about 3:1 in (dB) as incident power increases
 - Downlink power increases 1 dB, PIM increases ~3 dB
 - PIM “breathes’ as the sector gets loaded
- **Mobile phones will need to transmit at a higher power to overcome the noise rise, or may not maintain any connection at all (call drops, bad KPI’s, lost bonus)**



	IM3	IM5
Upper	$2 * F1 - F2$	$3 * F1 - 2 * F2$
Lower	$2 * F2 - F1$	$3 * F2 - 2 * F1$

$$2 * 763 - 739 = 787$$

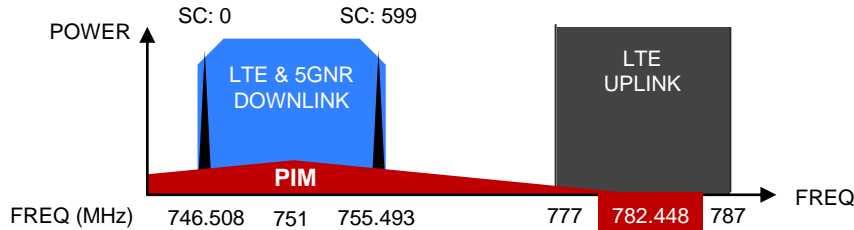
B14 UL is 787 to 798 Mhz

Passive Intermodulation

PIM in LTE Carriers

PIM in Multicarrier Signals

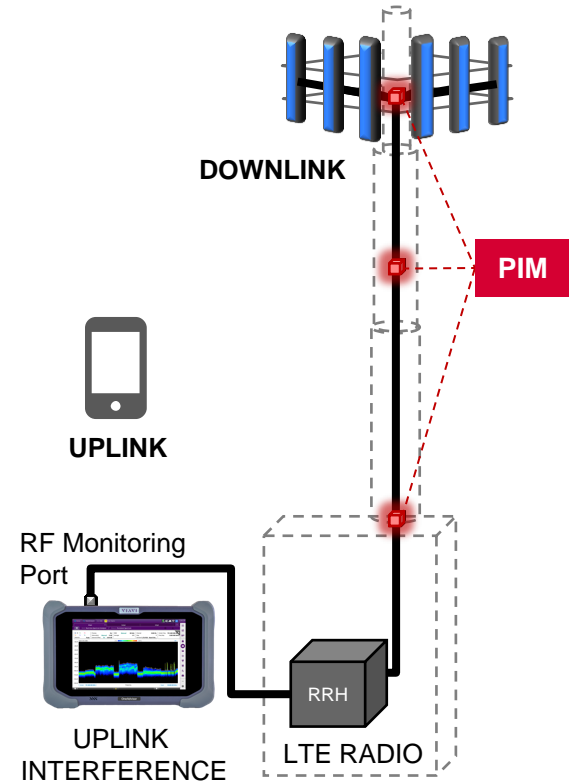
PIM can be generated by multicarrier signals such as LTE which is composed of multiple subcarriers.



$$PIM_{IM7} = 4 \times F1_{SC599} - 3 \times F2_{SC0} = 4 \times 755.493 - 3 \times 746.508 = 782.448$$

PIM Signature

The presence of multiple subcarriers on LTE signals causes a broadband PIM signature, raising the noise floor of the uplink.



RFoCPRI enables Up-Link Spectral measurements

Uplink Analysis / Interference Analysis / PIM Analysis

Why we Originally Perform Uplink Analysis

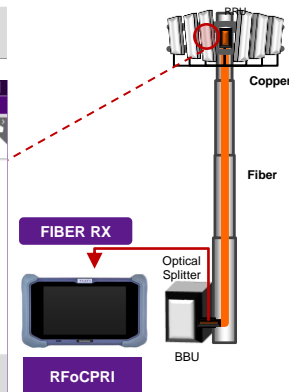
- Noise floor measurements
- Verify the presence of mobiles (uplink traffic)
- Verify all Resource Blocks are being utilized
- Check for RX Diversity issues
 - Wideband
 - Narrowband
 - Intermittent or persistent
 - Frequency stable or hopping
 - And.....

Detect and Visualize PIM in Realtime

- Confirm the presence of PIM using site's transmitters instead of intrusive PIM testing
- Instant feedback mechanism while mitigating PIM
 - Adjusting power
 - Adjusting tilt
 - Covering possible external PIM sources
- Speeds up PIM Mitigation



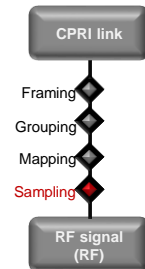
Uplink Spectrogram



What is CPRI? (Common Public Radio Interface)

- CPRI was developed to split the functions of the Radio Equipment Controller (REC or BBU/DU) and the Radio Equipment (RE or RRU/RU)
- The intent was two-fold
 - Create a market where REC and RE could be from competing vendors – this largely failed to materialize
 - Allow aggregation of expensive REC equipment at a central site – this has been realized as CRAN
- CPRI is a Time Domain Multiplexed (TDM) and synchronous signal that carries both overhead channels and the RF payload (I/Q) between the BBU/DU <- -> RRU/RU
- Implemented almost exclusively over fiber optic cable
- CPRI moved the test access point for Sweep, PIM, and Spectrum Analysis (Interference and PIM Mitigation purposes) from the bottom of the tower to the top of the tower
- RFoCPRI restores test access for Spectrum Analysis and PIM Troubleshooting to the bottom of the tower

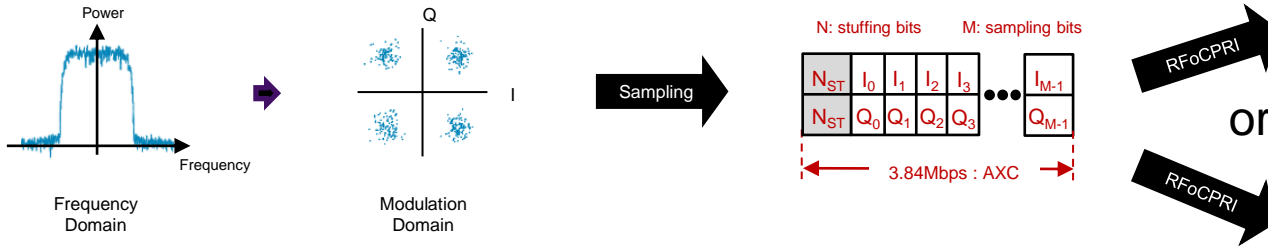
Rate	Gbps
3	2.4576
5	4.9152
7	9.8304
8	10.1376



What is RFoCPRI Analysis?

- RFoCPRI analysis is the term describing the extraction of RF information (AxC) from the CPRI link, converting the CPRI payload (AxC) into an RF waveform and displaying that info in a traditional spectrum analyzer like view.
 - Gives you back the test access and visibility you once had when you connected to a RX diversity coax at the bottom
- The TBERD 5800 or ONA-800 performs RFoCPRI function by connecting to an in-service CPRI link (BBU-RRU), obtaining CPRI sync, extracting the RF data from the AxCs (AxC is RF data for 1 antenna, 1 carrier) and displaying the RF data as an analog waveform in a Spectrum Analyzer or Spectrogram view.

Enables PIM
Detection and
Interference
Characterization



Defining PIM Testing versus PIM Detection

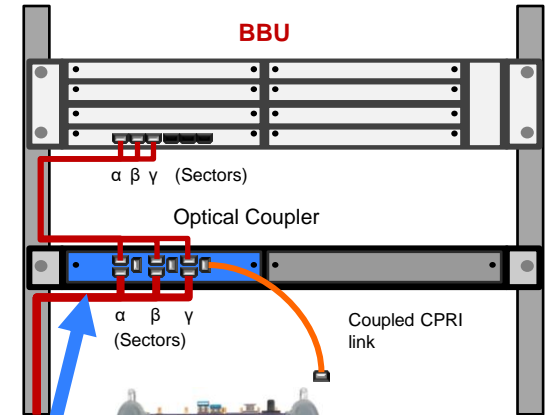
PIM Testing	PIM Detection
Typically employed during initial construction or after physical modifications	Typically employed when troubleshooting PIM on an existing, but impaired site
Quality assessment of the parts, installation, and workmanship	Used to assess PIM that could be internal, external, caused by your signals or other's.
Involves large, heavy, expensive test equipment injecting 2 x 20W tones	Small, lightweight, and versatile equipment that support multi-remote control/viewing
Done on the ground before hoisting or done up on the tower/roof after the RRU	Done from the shelter, cabinet, or CRAN BBU Hotel (ground level)
Requires taking apart existing connections which risks creating new VSWR/PIM issues	Non-intrusive to the Coax system. Only open the connections which have been identified
One branch at a time, narrowband tones, site out of service	See all 4 branches of a 4 x 4 system in real-time with real traffic

How to Perform RFoCPRI

- RFoCPRI test applications are all performed by optically tapping the CPRI fiber link between the BBU and RRU.
- Some sites have a CPRI “tray” already installed. If not, a tap can be added in-line in about 30 seconds
- RFoCPRI is a passive monitoring application that is non-intrusive so the RRU-BBU will continue to process calls normally.
- This allows you to monitor the uplink spectrum during normal site operation, during the busy hour, when PIM is most severe
- PIM can be further stimulated with in service load generator functions built into the radio

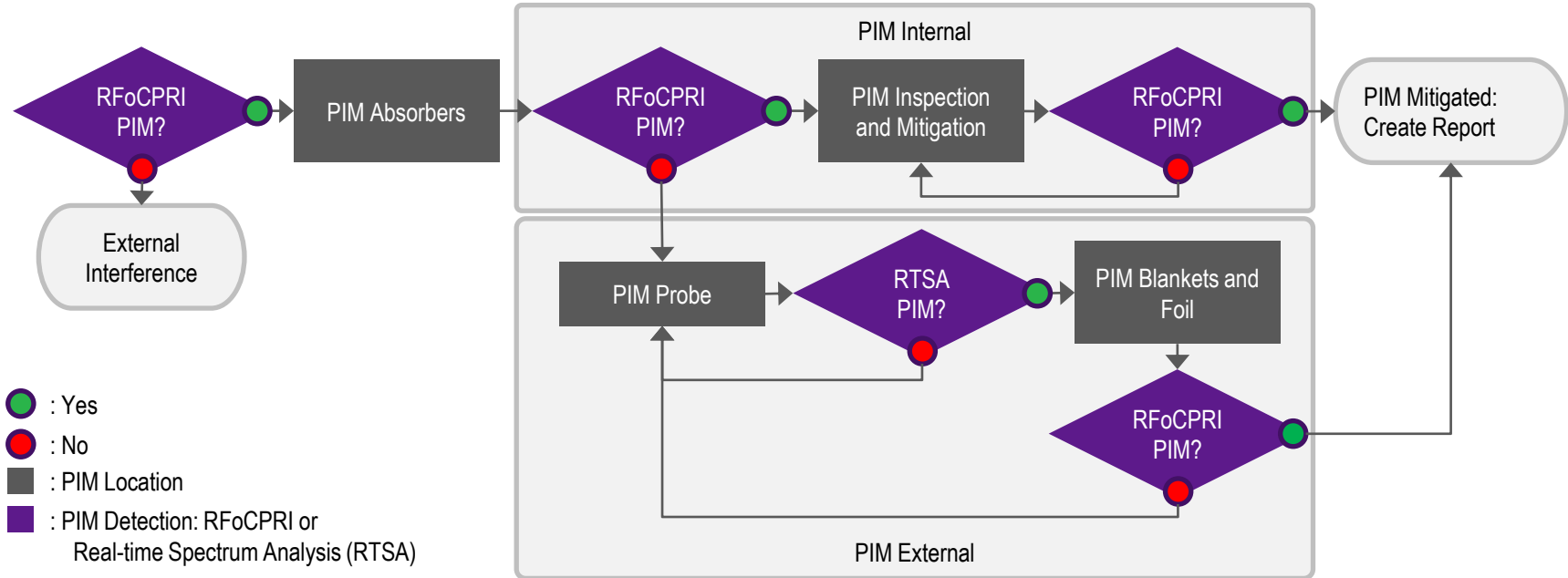
Now cover, shield, shake, tighten, remove possible PIM sources and see instant impact

Coupled Monitoring



Passive Intermodulation

Mitigation Process

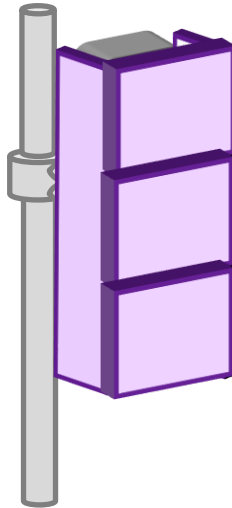


Passive Intermodulation

External PIM or Internal PIM



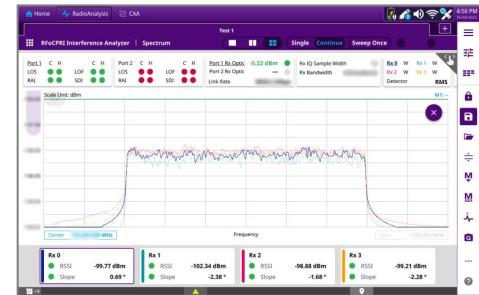
OneAdvisor 800 (RFoCPRITM)
PIM Detected



PIM Absorbers



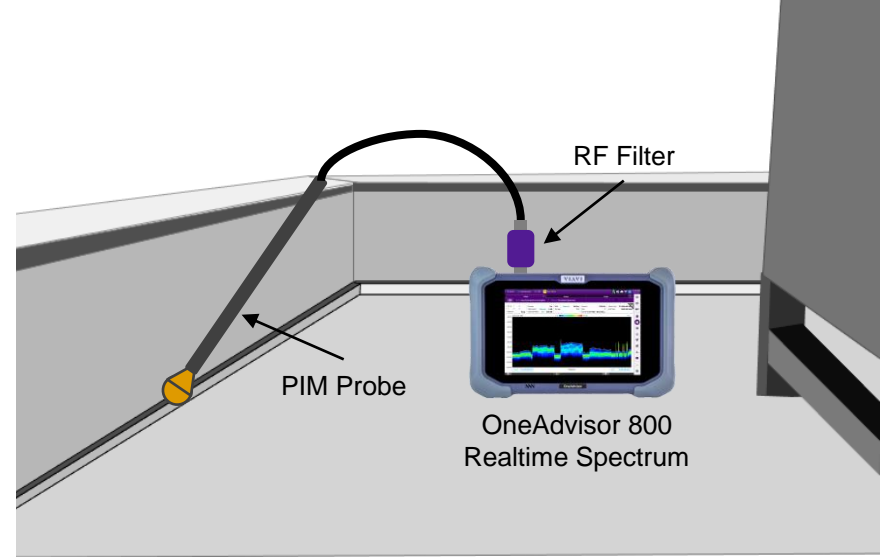
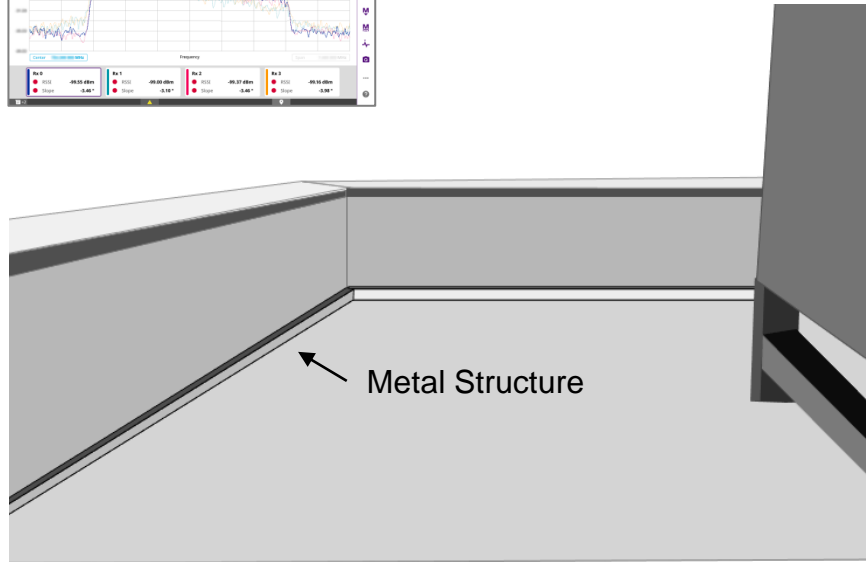
OneAdvisor 800 (RFoCPRITM)
PIM Detected: Internal



OneAdvisor 800 (RFoCPRITM)
PIM Not Detected: External

Passive Intermodulation

External PIM



Passive Intermodulation

External PIM



Advantages of RFoCPRI Method for PIM Mitigation

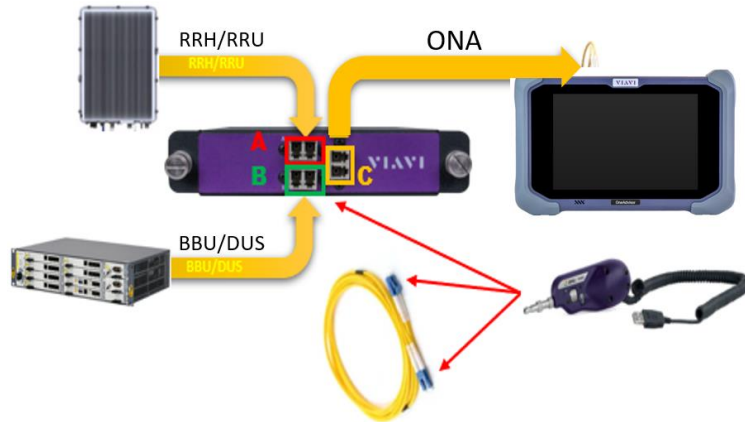
- Band independent – PIM testers are large, heavy, expensive and band specific.
 - RFoCPRI is band agnostic.
 - One unit to test them all.
 - Up to 4 branches at once plus BTS is live
- See real PIM from all potential incident sources (F1, F2, F3,.....Fn).
 - Rather than only 2 tones emitted from only one or perhaps 2 unique antennas.
- Performed from the ground – triage before the climb.
 - Is it on pole, off pole, one path, all paths?
 - Climb with a plan.
- Stay focused on PIM that reaches your RX antenna.
 - Everything else is a waste of time and resources



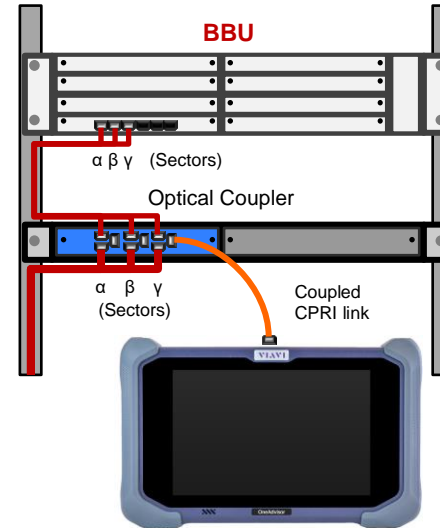
The Setup

How to Perform RFoCPRI

- RFoCPRI test applications are all performed by optically tapping the CPRI fiber link between the BBU and RRU.
- If the link does not already have an optical test port, a temporary splitter can be inserted in under a minute
- The Uplink fiber path is sent to the RX port on the ONA-800



Coupled Monitoring



Passive Intermodulation

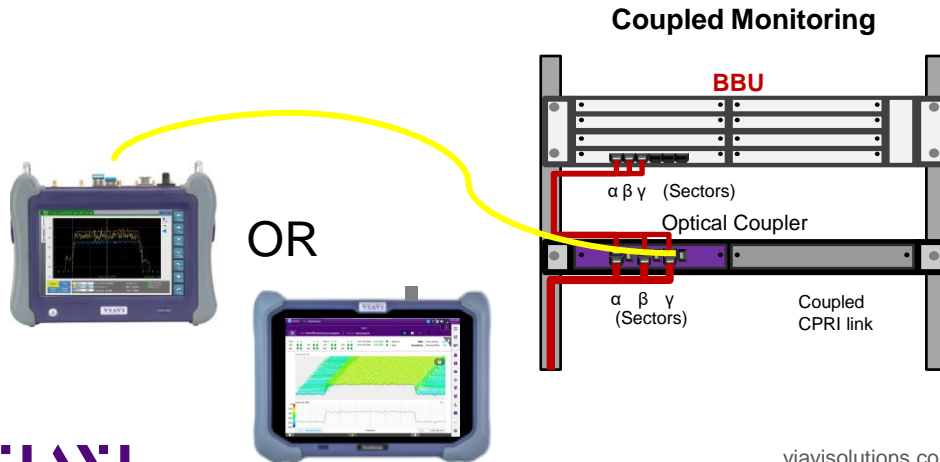
RF Mapping and Flexible Configuration

- Auto Configuration
- RF Mapping: identification of RF data
- Flexible Configuration: Applicable to all variables of CPRI mapping, including:
 - IQ Sample With
 - Stuffing Bits
 - Exponent Bits
 - AxC Size for Carrier Bandwidths
 - Flexible Groups
 - Branches: SISO, MIMO 2x, 4x, 8x

The screenshot displays the RFoCPRI Interference Analyzer software interface. The main window is titled "RFoCPRI Spectrum" and shows a "All Rx Map (Port 1)" grid with frequency (0 to 1120) on the x-axis and sample rate (0 to 76) on the y-axis. A red callout box labeled "RF Mapping" points to a specific area in the grid. On the right side, a "Flexible Configuration" panel is highlighted with a red border, containing settings for Port 1, Carrier 1, and 4xMIMO. The configuration includes Technology (LTE), IQ Sample Width (15), Stuffing Bit (0), Exponent Bit (0), BandWidth (10 MHz (4 AxC)), and Map Position (Antenna 1). Below these are fields for AxC 0 through AxC 7, with values 0, 15, 30, 45, and dashes for the remaining fields. A "Done" button is at the bottom right of the configuration panel. The software interface also shows a top navigation bar with "Home" and "RadioAnalysis" tabs, and a bottom status bar with "RFoCPRI : RF Mapping and Flexible Configuration".

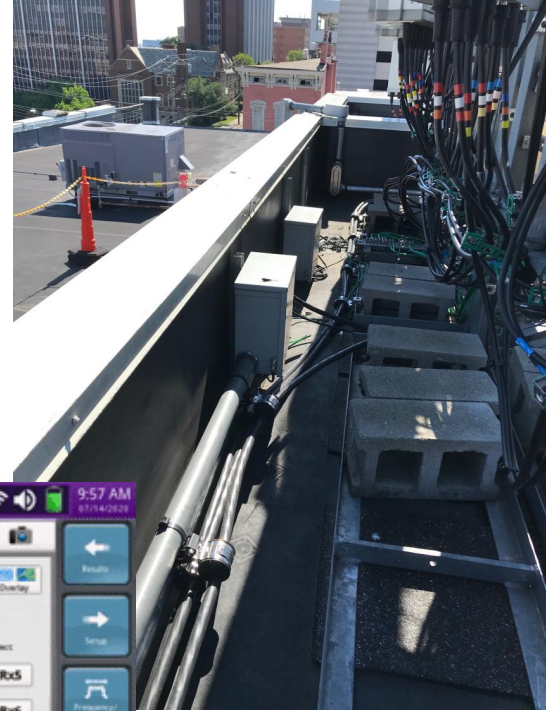
Real World PIM Example

- Rooftop site with a Nokia 700 MHz RRH
- Carrier reported PIM using OCNS (full power mode)
- Local Tech dispatched to investigate
- TB5800/ONA tapped into the CPRI fiber link



Live PIM on Site

- RFoCPRI method provides visibility to PIM and/or external interference in real-time
- In most cases PIM can be seen on the live signal. Calls are being blocked as the DL power increases
 - Recall that 1 dB more DL power is 3 dB more PIM



PIM breaths with volume of live traffic

Using Load Generation to stimulate More PIM

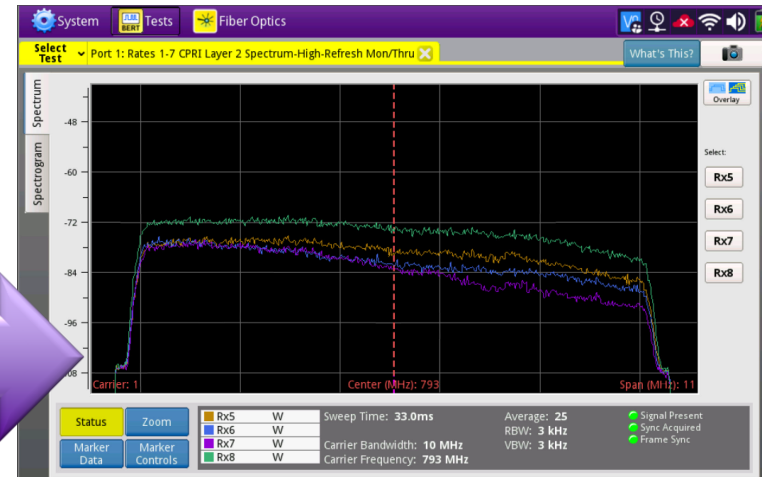
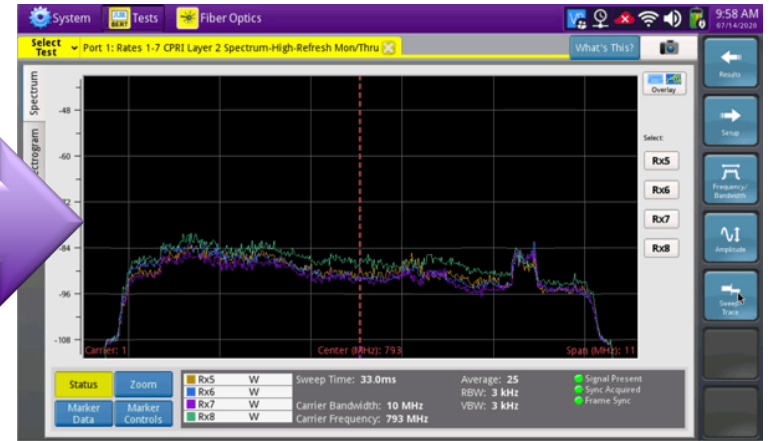
OFF

PIM visible. Mobiles are using upper part of the band

- OCNS – Orthogonal Carrier Noise Simulation
- AILG – Air Interface Load Generator
- Increase DL Power by X, get 3X more PIM
- Simultaneous PIM measurements on ALL Antennas (2 x 2 and 4 x 4)
- OCNS all calls to continue and PIM to be analyzed **WITHOUT** disconnecting the Antennas or lugging heavy gear to the site.

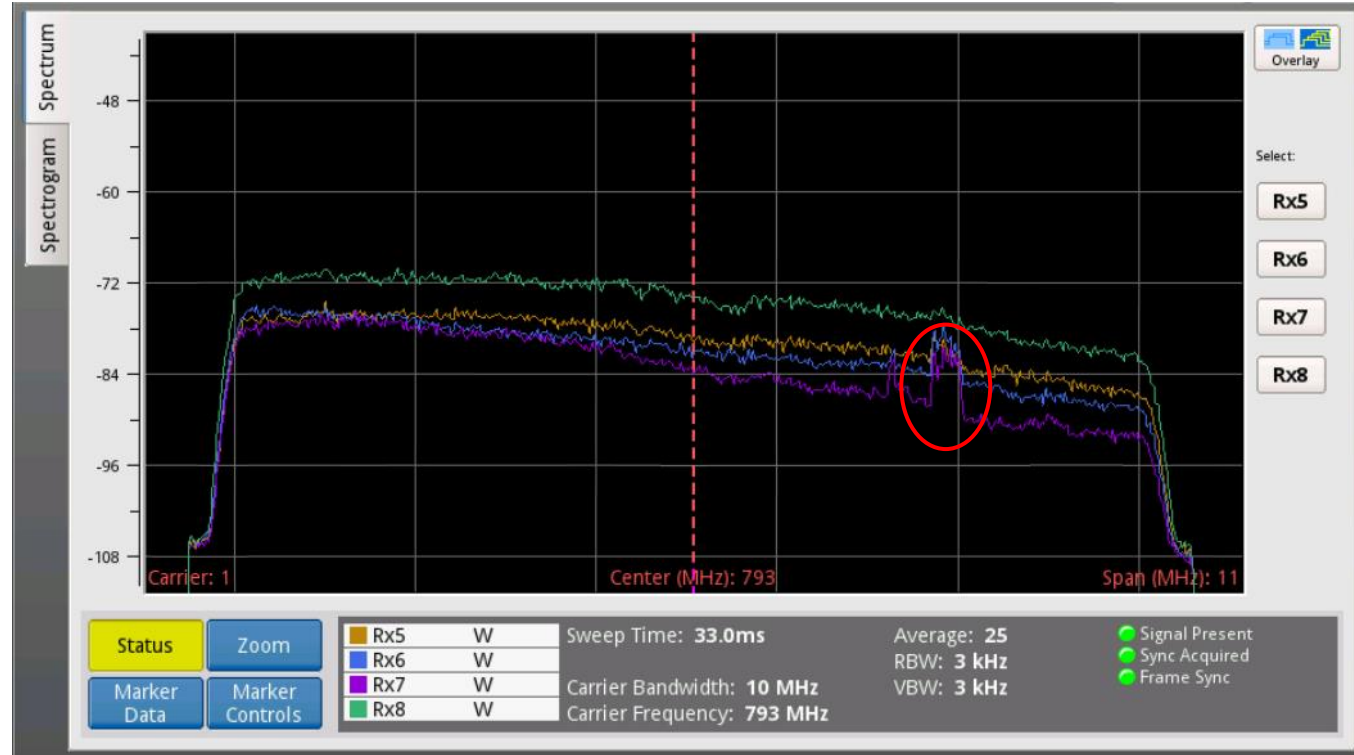
ON

PIM obvious on ALL Antennas with OCNS ON



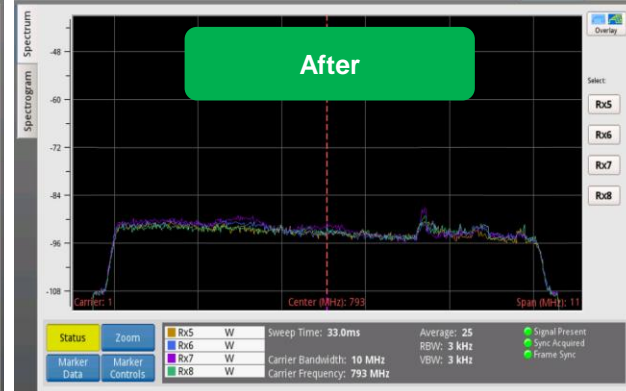
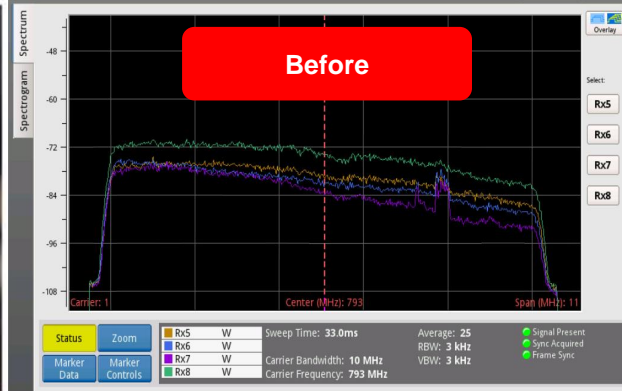
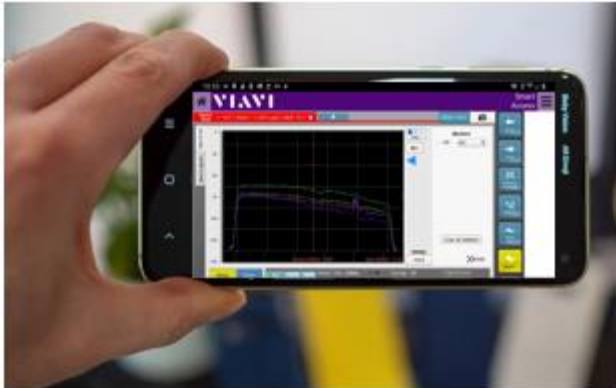
Trace View explanation

- 25 averages applied to trace to smooth the trace
- As all the Antennas are effected by PIM (external PIM is suspected)
- PIM is effecting 1 antenna more than the rest (Green trace)
- Customer traffic still processing on this site (red circle) on 3 of the 4 antennas
- Suspected location near the highly effected antenna



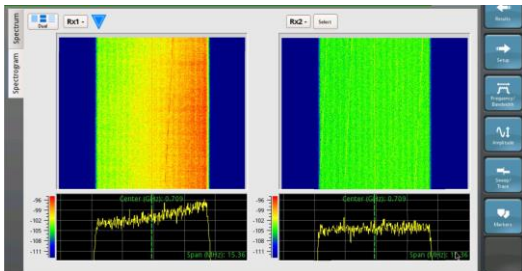
Next Steps

- After review of traces
 - Cover suspected area with PIM blanket(s)
Recommended Conceal Fab PIM Blanket
- Take it with you – Use Phone/Tablet to view changes to the UL as you tap, cover, tighten, etc. possible PIM sources



Additional RF Examples # 1

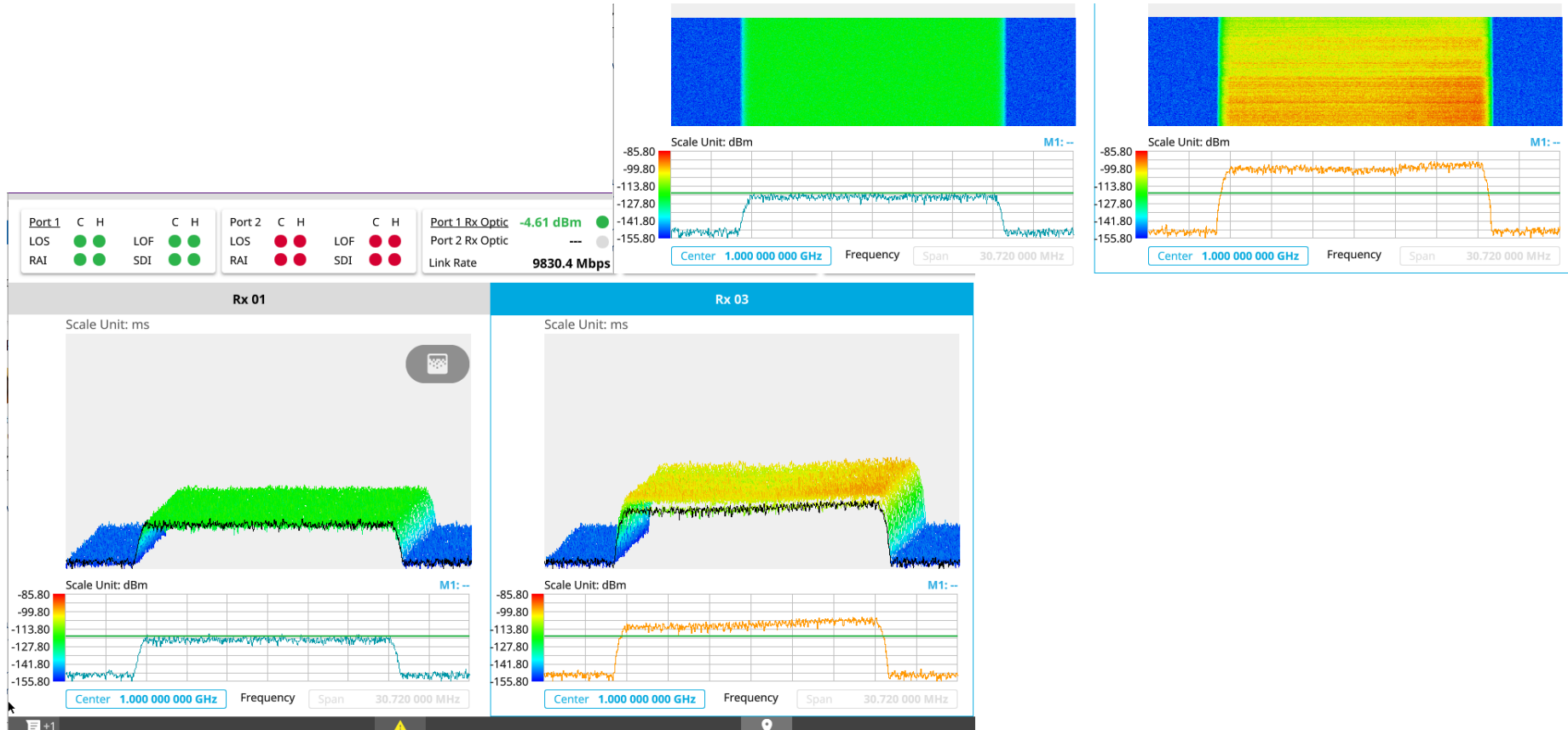
- PIM is internal (On Pole)
- PIM shows on 1 of 2 antennas
- Investigate the feedline
- Traces include min/max/current



IM3

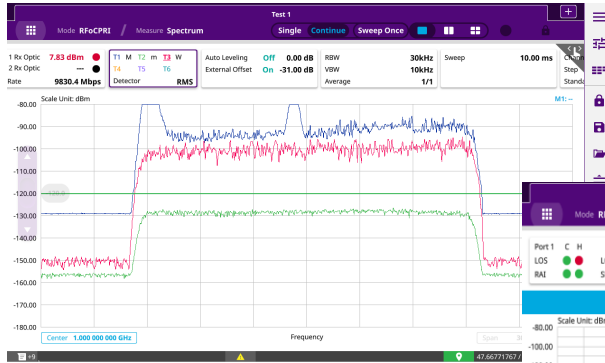
Why the tilt?

2 Antenna as seen through CPRI (PIM) Detected

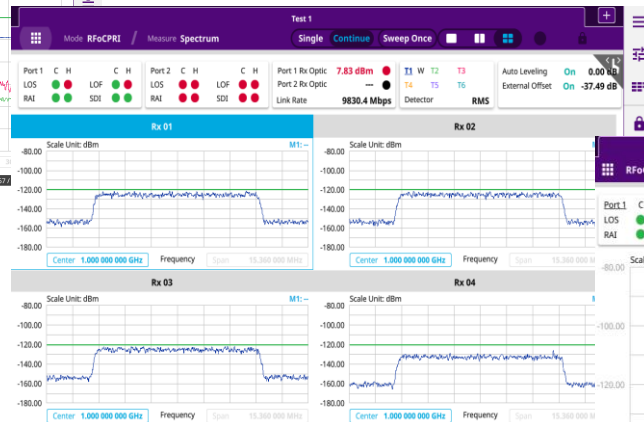


Basic Spectrum Analyzer view of RF from a CPRI Link

Single Antenna



Quad Antenna



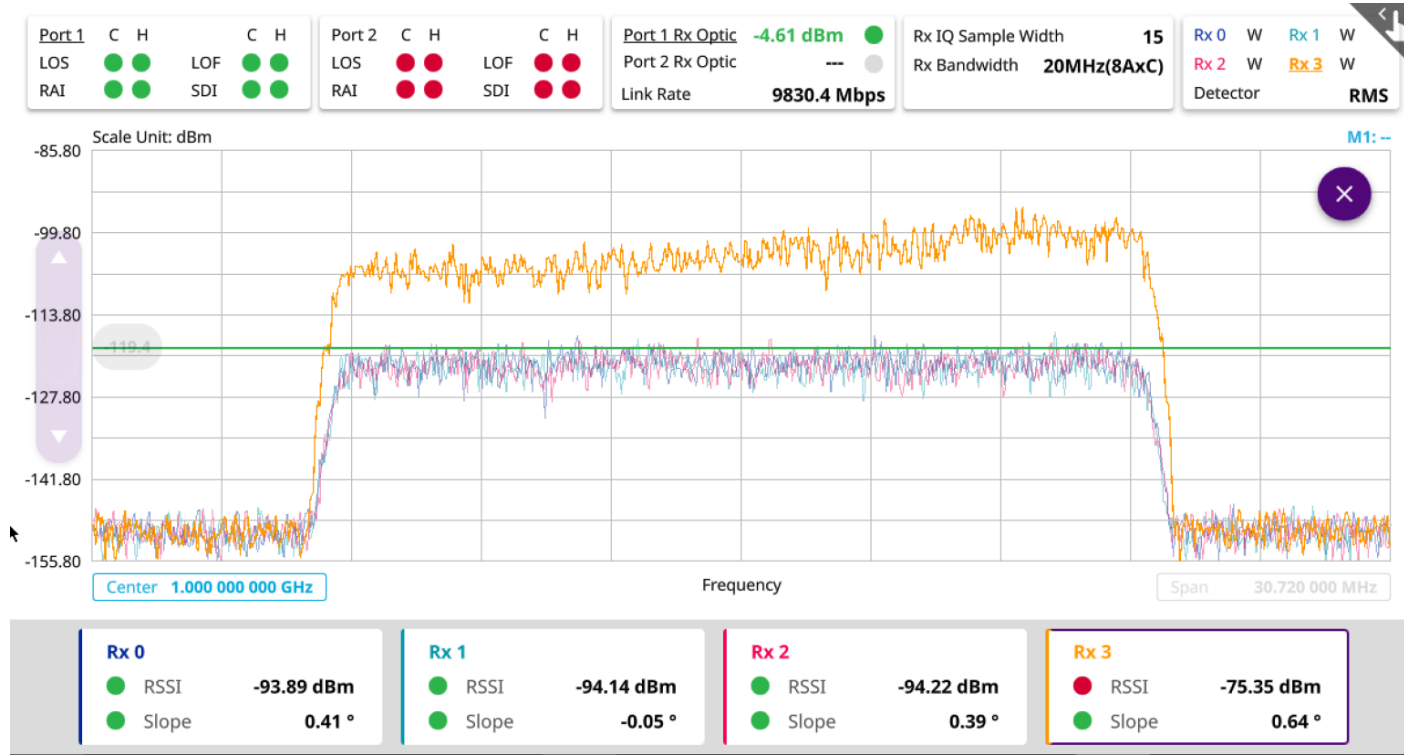
Quad Antenna Overlay



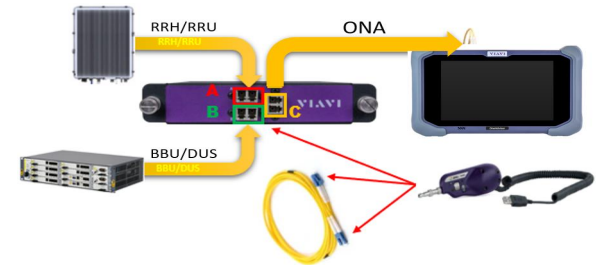
4 Antennas as seen through CPRI (PIM) Detected



PIM RSSI and Slope Metrics for Easy PIM Testing



Live Demo



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Questions?

