# **Making PIM over CPRI Measurements**

PIM over CPRI is a new technology that enables users at ground level to measure interference from Passive Intermodulation (PIM) on a live system, using regular CPRI LTE RF traffic. This capability is available on Anritsu test instruments with Option 754. By tapping into the CPRI data on the downlink and uplink between the remote radio head (RRH) and baseband unit (BBU), the PIM desensitization of the LTE uplink is calculated based on the correlated PIM signal detected on all the downlinks being analyzed.

The following instructions describe the procedure to set up and perform PIM over CPRI measurements. For details on the CPRI protocol standard and system requirements and connections, refer to the CPRI Specification and Anritsu's *CPRI LTE RF Analyzer Measurement Guide* (document number 10580-00415).

### **Connection Requirements**

- Optical splitter or TAP (Test Access Point), Single Mode or Single/Multi Mode
- Optical cables
- SFP optical transceivers used to connect the Anritsu test instrument must match the link rate of SFPs on the BBU and RRH.
- Lock down the RRH before disconnecting it from the BBU.

### Connections

The figures below illustrate examples of CPRI link connections in the following PIM scenarios:

1. Single carrier 2x2 MIMO LTE interfering with its own uplink (self-PIM interference) – An example may be a 10 MHz LTE carrier downlink centered at 751 MHz with 7th order intermodulations that fall in the 782 MHz uplink band.



2. Single carrier 2nd order intermodulation (2nd harmonic) – Examples may be a an 850 MHz cellular transmitter's 2nd harmonic landing in the 1700 MHz AWS receive band, or an 860 MHz cellular transmitter's harmonic falling in a 1720 MHz AWS uplink band.



Note For best results in measuring PIM, it is highly recommended to maximize the downlink transmit power to emulate a worst-case scenario where unwanted PIM levels are at a maximum. With Nokia/ALu equipment, for example, set OCNS to turn on maximum power for all resource blocks. A CPRI Fail measurement state will result if downlink power is insufficient for the PIM over CPRI engine to make a measurement.

### **PIM Configuration and Measurement**

- 1. Make sure the instrument is in CPRI Mode, then press the **Measurements** key.
- 2. Press PIM Over CPRI.
- 3. Press PIM Aid to open the configuration dialog.

PIM AID									
Site Configuration SISO C 2x4 MIMO 2x2 MIMO	Pass Fail PIM Desensitization Limit <u>3.0</u> dB								
Downlink     Frequency:     751.000       DL 1 AxC:     0     DL 2 AxC:     1     DL 3       2457.6 Mbit/s     View DL Config	MHz LTE BW: 10 MHz AxC: 2 DL 4 AxC: 3 guration ALu/Nokia DL								
Uplink         Frequency:         782.000           UL 1 AxC:         0         UL 2 AxC:         1         UL 3           2457.6 Mbit/s         View UL Config	MHz LTE BW: 10 MHz AxC: 2 UL 4 AxC: 3 guration ALu/Nokia UL								
	Uplink Under Test Cycle through All ULs UL 1 Save and Measure								

4. Make the appropriate entries and selections in PIM Aid.

#### Site Configuration

SISO – Single downlink, single uplink 2x2 MIMO – 2 downlinks, 2 uplinks 2x4 MIMO – 2 downlinks, 4 uplinks

**PIM Desensitization Limit** – Threshold value for acceptable noise floor degradation. A measurement that exceeds this limit will result in a Fail status and trigger the alarm. Default is 3 dB. For reference, a PIM desensitization value of 10 dB will typically downgrade the uplink data throughput by 50%.

Frequency – Center frequency (MHz) of LTE carrier under test

**LTE Bandwidth** – Bandwidth of LTE carrier under test: 5 MHz, 10 MHz, 15 MHz, and 20 MHz. The uplink bandwidths of two different carriers used in a harmonic measurement can be different.

AxC Group – Associates an AxC group number with each downlink and uplink trace. Start with AxC 0.

**Line Rate** – Press this button to auto-detect the CPRI line rate (e.g., 2457.6 Mbit/s = Line Rate 3) at SFP Port 1 (downlink) and SFP Port 2 (uplink).

Radio Preset – Radio presets are currently available for ALu/Nokia.

**View DL/UL Configuration** – Press this button to apply current settings and display a spectrum view of downlink/uplink LTE MIMO carriers. SISO displays one trace; 2x2 MIMO displays two downlinks or two uplinks; 2x4 MIMO displays two downlinks or four uplinks. If proper DL/UL traces do not display, press the appropriate Trace number key under the Trace Config menu and scroll through the AxC groups until the correct signal is found. Press Back to PIM Aid to return to the configuration dialog.

**Uplink Under Test** – During PIM measurements, the Anritsu test instrument displays only the Uplink Under Test and the Correlated PIM as Trace 3 and Trace 4, respectively. Trace 1 and Trace 2 are off. In 2x2 and 2x4 MIMO, you can elect to cycle through all uplinks or measure only one uplink. Choosing Cycle through All ULs will measure all available uplinks one at a time. To measure a single uplink, press the UL radio button then the UL number box to display the UL Under Test menu, and press the desired uplink number.

Save and Measure – Saves the current configuration settings and starts PIM over CPRI measurements.

**Exit** – Closes the PIM Aid dialog without making changes. This button is disabled (grayed out) if you have modified one of the configuration fields. For all configuration settings to be applied properly to the PIM over CPRI measurements, use the **Save and Measure** button.

5. When done with PIM configuration, press Save and Measure to save the new settings and start the PIM measurement. The configuration window will close and a spectrum view of the Uplink Under Test and Correlated PIM traces will display, with a summary table of measurement results.

The first measurement for each Uplink Under Test may take approximately 55 seconds to acquire data, synchronize the downlink carrier or carriers to the individual uplink carrier under test, and perform the measurement.

/INFILSU 10/0	9/2018 06:53	:48 pm								=	
	00 L	os	••	LOF		RAI		SDI	C	PRI Mode	
xC Group No	-40.0 dB										
<b>ine Rate</b> 457.6 Mbit/s 457.6 Mbit/s	-50.0										
ef Lvi 40.0 dB	-60.0										
RBW ) kHz	- 80.0										
VBW 00 Hz	-90.0		n - Artalian	Munder	Land Lat A	a cabra		L. MarA.	M.		
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races	-110.0					··· i · icity	v v myke	adalan dari k			
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	-130.0 dB										
xC Display	774.500 MHz 789.500 MHz 789.500 MHz Span 15.000 MHz										
)ff				UL1		UL2		UL3	UL4		
Correlated PIM	Measureme Pass/Fail:	nt State:		Com PAS	olete S	Acquirir	g				
weep Continuous	PIM Desensitization: Total UL Power:			0.67 -101	0.67 dB -101.12 dBm						
req Ref nt Std Accy	Correlated F PIM Locatio	PIM: on:		-109 Exter	.77 dBm nal						
Frea		Arr	plitude			BW		Mea	surements		Marker

After the initial acquisition and measurement cycle completes, subsequent measurements for each Uplink Under Test will take approximately 6 seconds. The examples that follow illustrate the PIM over CPRI spectrum display and results table in 2x2 MIMO.

Trace 3 (in blue) is the latest uplink where testing has completed, and the corresponding measurement results are highlighted with a yellow border. Trace 4 (purple) is the Correlated PIM. Trace 1 and Trace 2 are always off during PIM over CPRI testing.



If the Uplink Under Test setting has been configured to cycle through all uplinks, the next uplink to be tested will display as Trace 3 when measurements are completed, and the yellow highlight border in the results table will shift to the appropriate UL number.

/Inritsu 10/09	9/2018 06:	54:45 pm									PIM Over CPRI	
AxC Group No 0 1 2 3	-40.0 dE	LOS	••	LOF	••	RAI		SDI		Mode	PIM Aid	
Line Rate 2457.6 Mbit/s 2457.6 Mbit/s	-50.0	Uplin	k Unde	r Test	All UL:						Advanced	
Ref Lvl -40.0 dB	- 70.0	í	And a hard and a second	A. Anthog	Magan	and the second	MARCEN	Martin Contraction	HA .		UL Under Test	
#RBW 30 kHz	-80.0										All ULs	
#VBW 300 Hz	-90.0										Measure	
Display BW 10 MHz	-100.0										Off <u>On</u>	
Traces	-110.0										Reset	
	-120.0	And the second							Konstration	HANK	Measurements	
	-130.0 d	IB									Audible Alarm	
AxC Display	774.500 MHz Center 782.000 MHz 789.500 MHz Sean 15.000 MHz									MHz	Off On	
Off				UL1	UL1 UL2			UL3 UL4			Generate Report	
Correlated PIM	Measure Pass/Fai	ment State I:		Meas PASS	suring S	Complet FAIL	e				·•	
Sweep Continuous	PIM Des Total UL	ensitizatior Power:		0.67 -101	dB .12 dBm	30.70 de -72.66 (	3 1Bm				Back	
Freq Ref Int Std Accy	Correlate PIM Loc:	d PIM: ation:		-109 Exter	.77 dBm nal	- 71.31 ( External	dBm				<u>-</u>	
Freq		A	mplitude			BW		Mea	surements		Marker	

## **Results Table**

The results table is empty if you have not yet run PIM over CPRI measurements or you have performed a reset. The table will populate with data as measurement completes for each Uplink Under Test. The most recent uplink to complete measurement is highlighted with a yellow border.

Data from previous measurements remain in the results table until they are updated with new measurements or cleared with the Reset Measurements key.

Measurement State – Indicates the current stage in the uplink's PIM over CPRI measurement cycle.

- Acquiring The PIM over CPRI engine is acquiring data and synchronizing the downlinks and uplinks.
- Measuring PIM over CPRI measurement is being performed on the uplink.
- Complete Measurement has completed for the uplink and results are displayed in the table.
- Switching UL The PIM over CPRI engine is finishing the operation currently in progress before starting acquisition or measurement on the uplink newly selected with the UL Under Test menu key.
- Idle The measurement is running but cannot complete, possibly due to error conditions like insufficient transmit power, or incorrect configuration settings such as AxC group or radio manufacturer. Verify the current settings in the PIM Aid window and make changes as necessary, then press Save and Measure.
- CPRI FAIL An error occurred on the CPRI link, as indicated by any of the SFP port connection status dots at the top of the display being red or gray, and not green. SFP 1 (left dot) is the downlink, SFP 2 (right dot) is the uplink. In the event of a CPRI link failure, the measurement will turn off and must be manually restarted. The new measurement will start with a new acquisition cycle.

**Pass/Fail** – The measurement Pass/Fail status is based on the acceptable noise floor degradation level specified as the PIM Desensitization Limit configuration setting.

**PIM Desensitization** – This is the rise in noise floor level that can be attributed to PIM on the uplink contributed by the downlinks being analyzed. It is calculated from the correlated PIM value and the total uplink power.

**Total UL Power** – This is the measured total RF power of the uplink signal displayed as the blue trace in the spectrum view. The power value can be converted from dBm to dBFS and back via the Advanced Settings dialog.

**Correlated PIM** – This is the total calculated PIM power within the Uplink Under Test, based on PIM contributions from all available downlinks. It is displayed as the purple trace on the instrument screen.

**PIM Location** – Indicates whether the PIM source is internal or external to the antenna system. If internal, a tower crew would typically disconnect the RRH and antenna and locate the faulty component using an RF-based PIM tester. The PIM over CPRI measurements normally start from antenna 0 to antenna 3 for each MIMO uplink, and the results can help identify the RF cable that is causing PIM. If PIM location is external, a spectrum analyzer and antenna such as Anritsu's PIM Hunter<sup>™</sup> antenna can be used to walk the area and look for RF signal spikes. Various products are available to absorb or deflect RF signals to reduce PIM in the antenna system.

After all major contributors to PIM are detected and resolved, run the measurements again to retest the system and validate the PIM mitigation fixes.

### **Other Actions**

Other key functions under the PIM Over CPRI menu are:

Advanced Settings - Opens the Advanced Settings configuration dialog.

- PIM Desensitization Limit Sets the limit for acceptable rise in noise floor level caused by PIM on the uplink. A measurement that exceeds this threshold will result in a Fail status and trigger the alarm.
- Radio Noise Figure Manufacturer-specific value used in dBFS to dBm conversion. Default is 2.0 dB.
- Thermal Noise Floor Manufacturer-specific value used in dBFS to dBm conversion. Default is -64.40 dBFS.
- Bandwidth Applies either the uplink bandwidth or the CPRI bandwidth specified by the radio manufacturer.
- Results Units Displays results in dBFS or dBm. Choose dBm only if you know the Radio Noise Figure and Thermal Noise Floor values. dBm measurement results will be inaccurate if entered values are incorrect.

UL Under Test – Allows for manual control of which uplink is tested for PIM.

**Measure** – Stops and restarts PIM over CPRI measurements. If measurements are currently running, Measure Off will show the most recent results without the data continually updating. Data for each Uplink Under Test will be re-acquired and measurements will restart with the current configuration settings when you press Measure On.

**Reset Measurements** – Stops current measurements and clears all uplink data from the results table. Configuration settings that were last saved will remain in effect.

Audible Alarm – If on, an alarm will sound when a PIM Desensitization measurement result exceeds the set limit.

**Generate Report** – Generates a PIM measurement report. In the virtual keyboard screen that opens, enter a report file name. Two files are created and saved in the instrument internal memory for each measured uplink: a measurement results file (extension .cpri) and a screen capture (.jpg) of the PIM over CPRI spectrum display.





