BTS and Site Master based D-RoF CPRI measurements

the tool to scope with C-RAN architecture and front haul challenges

Ferdinand Gerhardes

April 2016

Anritsu
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Synopsis

Presentation: **BTS and Site Master based CPRI measurements the tool to scope with C-RAN architecture and front haul challenges**

Many cellular networks have begun to deploy a distributed architecture where the traditional radio has been split into a baseband unit (BBU) and remote radio head (RRH). This provides the ability to replace the coaxial RF cable from the radio unit at the base of a tower to the antenna array at the top of a tower with a fiber optic cable. RF cables have limitations in that they suffer power loss and are subject to performance degradation over time due to damage or corrosion.

In D-RoF applications the BBU and RRH are typically connected with a fiber link conforming to the common public radio interface (CPRI). When installing a system with fiber connections, it is important to validate on ground level that the digital RF signals as well as signaling to and from the RRH are performing as wanted. By installing an optical Test Access Point (TAP) or splitter into the link, the spectrum of the uplink and downlink can be monitored for interference, Passive Intermodulation effects and noise.

Anritsu's BTS Master, Cell Master and Site Master product families enable new possibilities to test C-RAN connections in order to avoid unnecessary tower climbing and thus optimize OPEX.

Presenter: Ferdinand Gerhardes

Contact/Info: For further information please contact:
Mr. Ferdinand Gerhardes
Mobile: +49 151 4260 6872
ferdinand.gerhardes@anritsu.com

Agenda

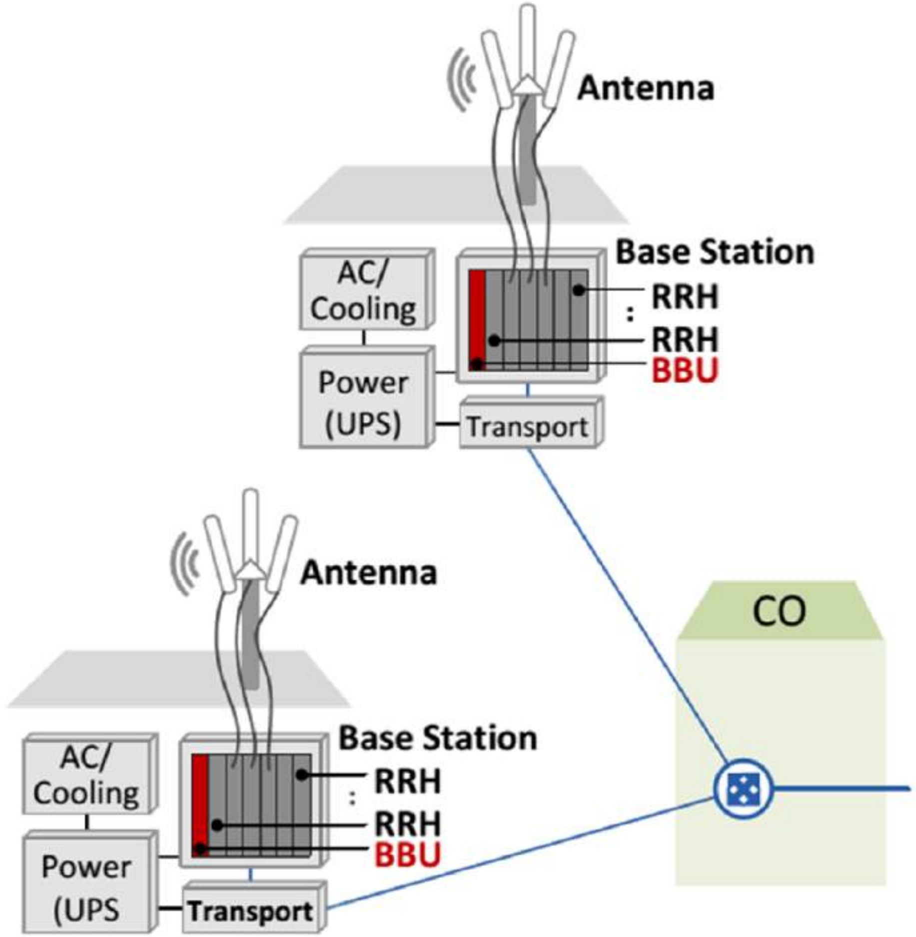
- Evolution of Radio Access Networks
- CPRI versus OBSAI versus ORI
- CPRI System Architecture
- CPRI based D-RoF measurements
- CPRI measurement features

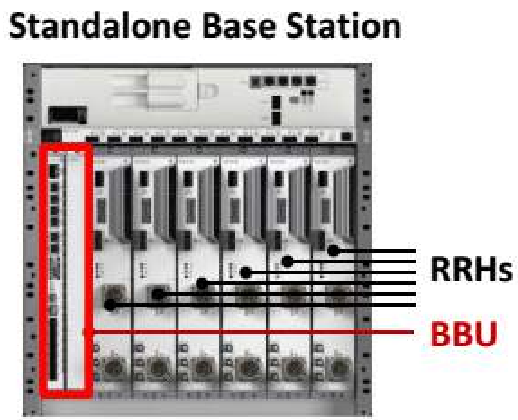
BTS Master

Site Master

Evolution of Radio Access Networks

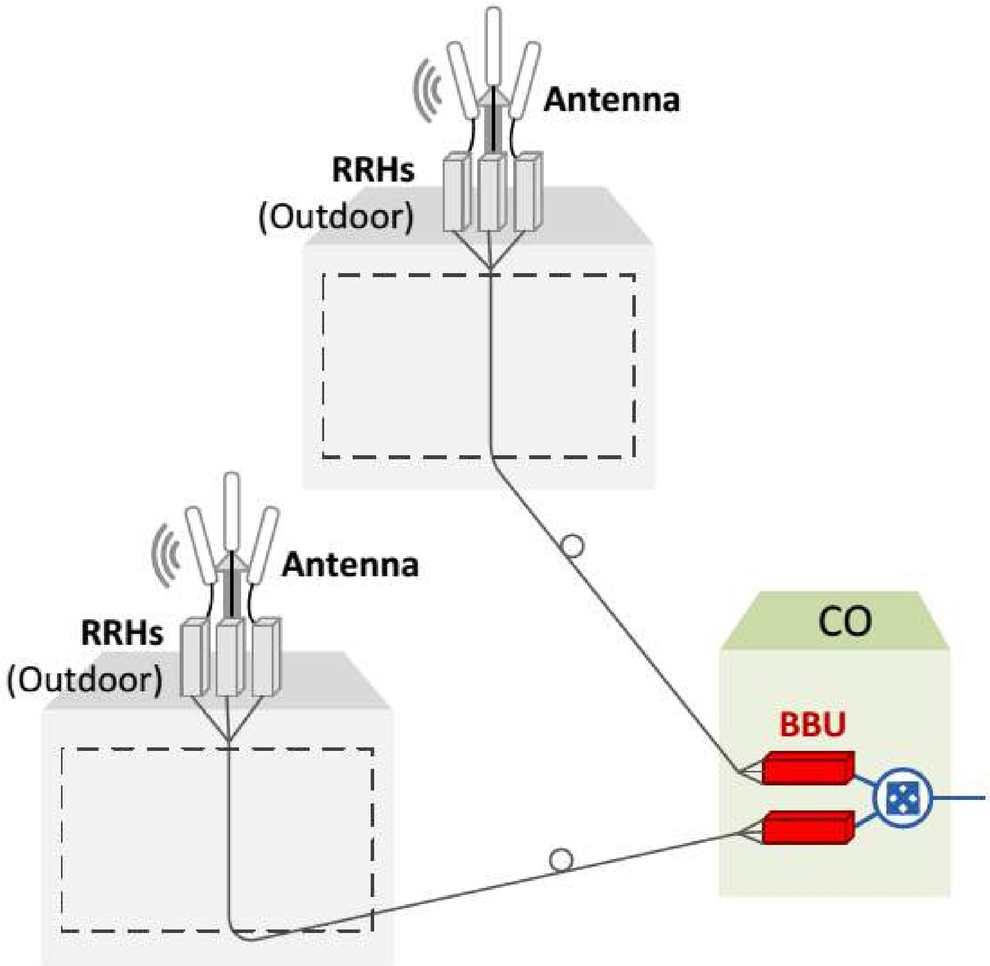
Before (D-RAN) - Standalone Base Station, Distributed RAN

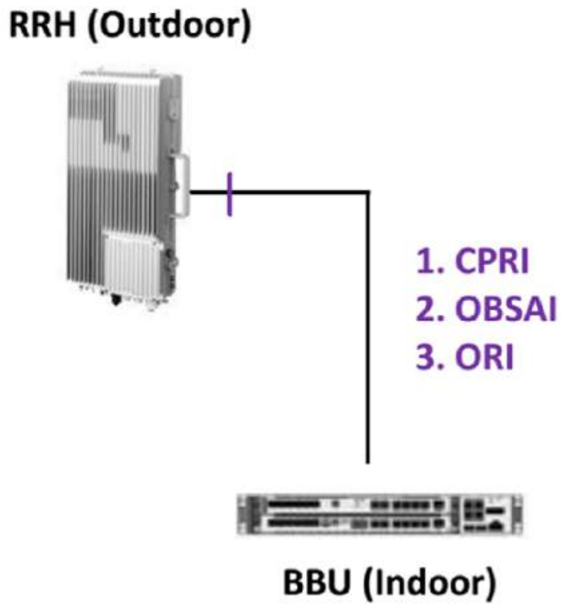




Evolution of Radio Access Networks

After (C-RAN) - Separated Base Station, Centralized RAN





CPRI versus OBSAI versus ORI

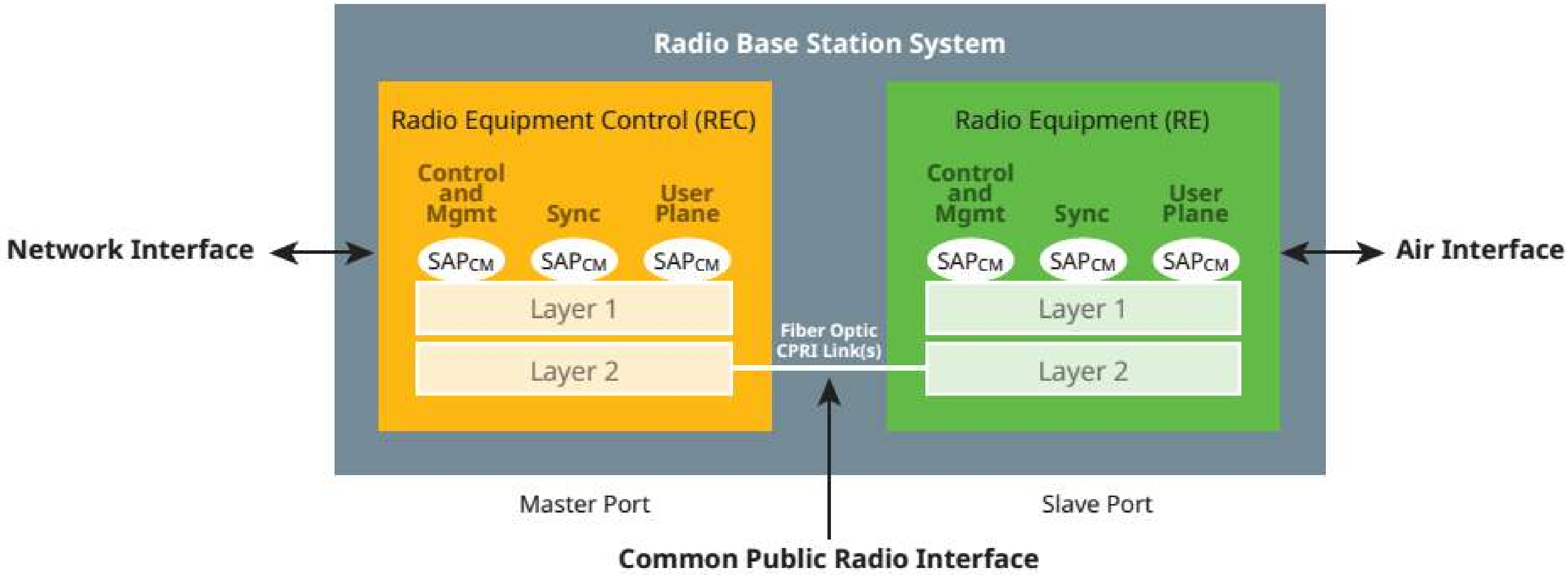
What is CPRI

- CPRI is a digital interface standard for encapsulating radio samples between a radio and a digital baseband processing unit. The interface is not packet-based; rather signals are multiplexed in a low-latency timeslot-like fashion
- The Common Public Radio Interface (CPRI) standard defines the interface of base stations between the Radio Equipment Controllers (REC) to local or remote radio units, known as Radio Equipment (RE).
- The companies working to define the specification include
  - Ericsson AB,
  - Huawei Technologies Co. Ltd,
  - NEC Corporation,
  - Alcatel Lucent and
  - Nokia Solutions and Networks Co. KG
- CPRI interface is supporting wired as well as optical transmission of I/Q-samples

CPRI System Architecture

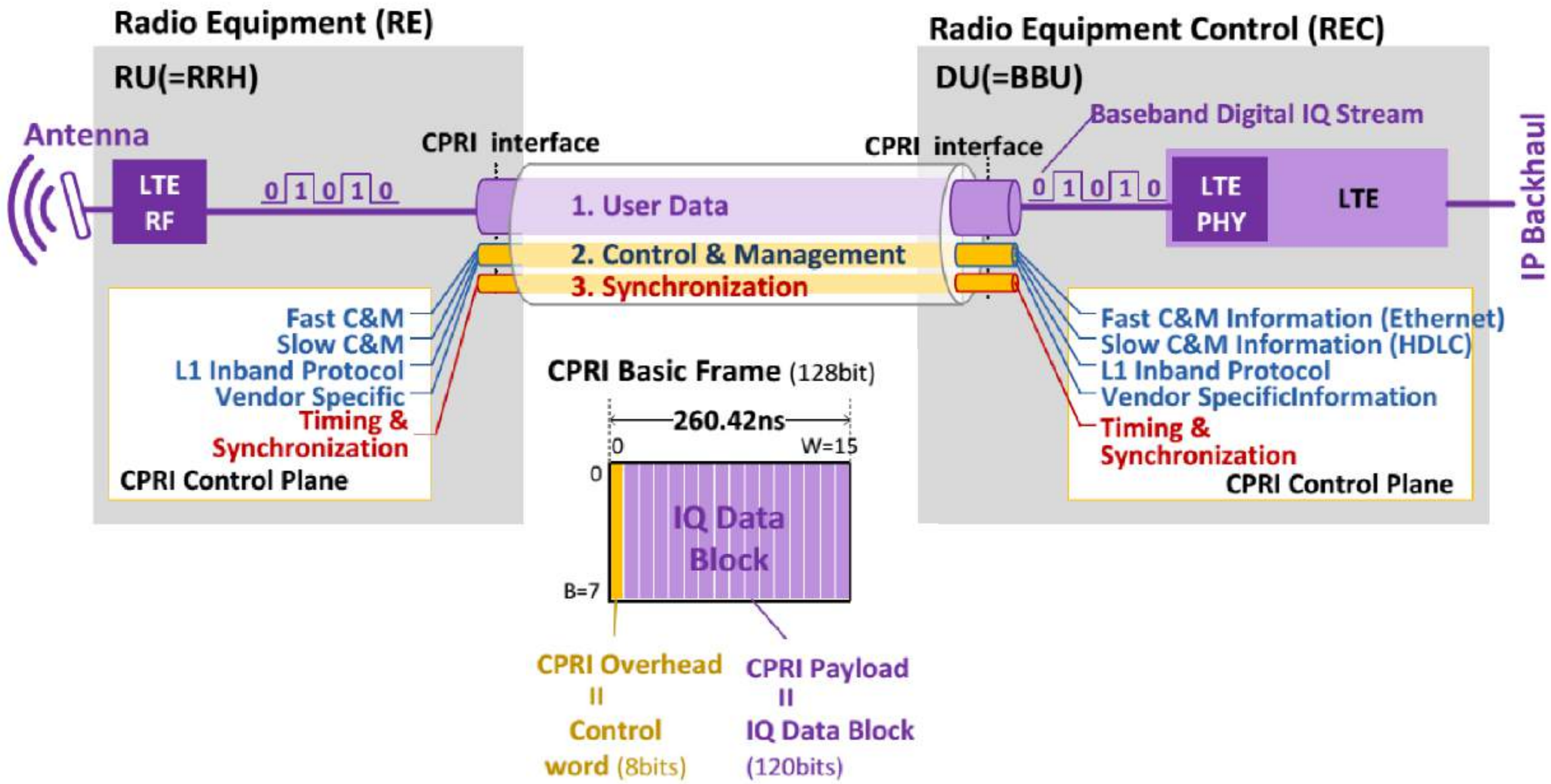
CPRI Basic System Architecture

- Based on a Radio Base Station architecture dividing the Radio Base Station into a radio part and a control part
- CPRI specification defines in a simple and flexible way the Radio Base Station internal interface between these two parts



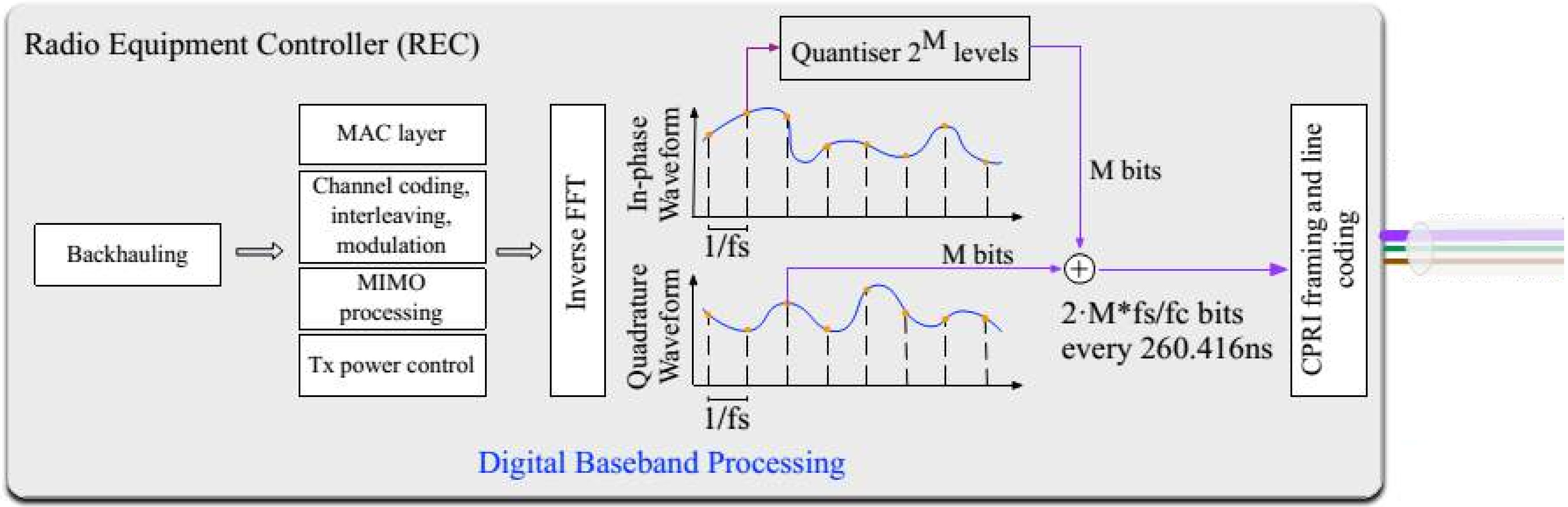
CPRI System Architecture

CPRI Transport Concept



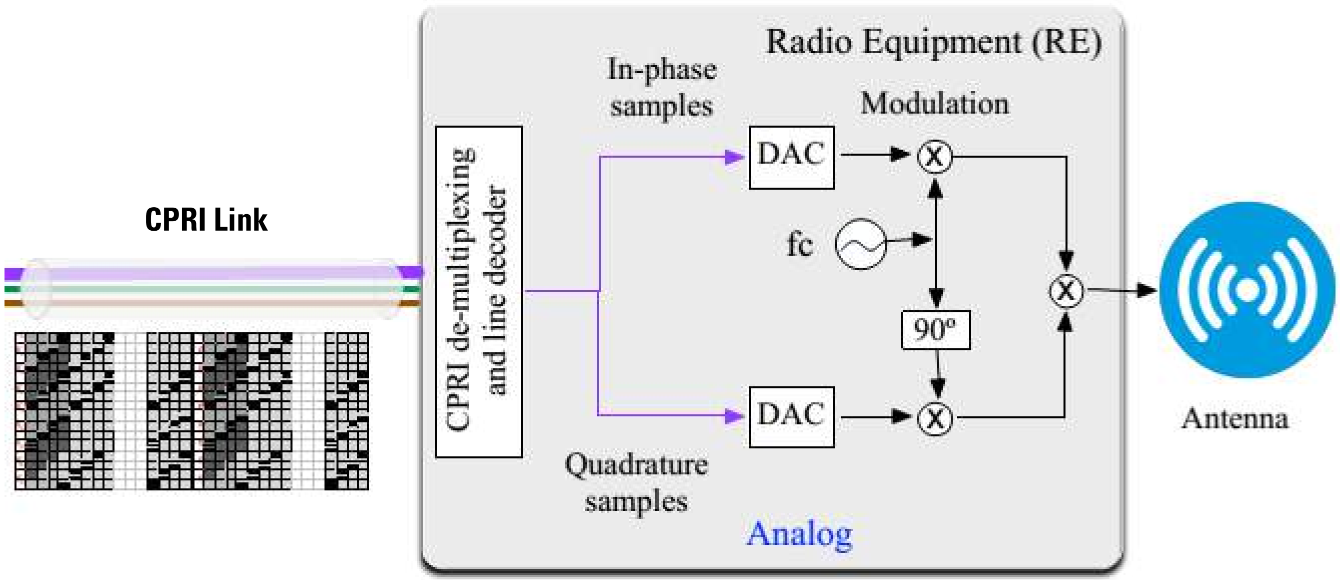
CPRI System Architecture

CPRI RCE – RE functional description



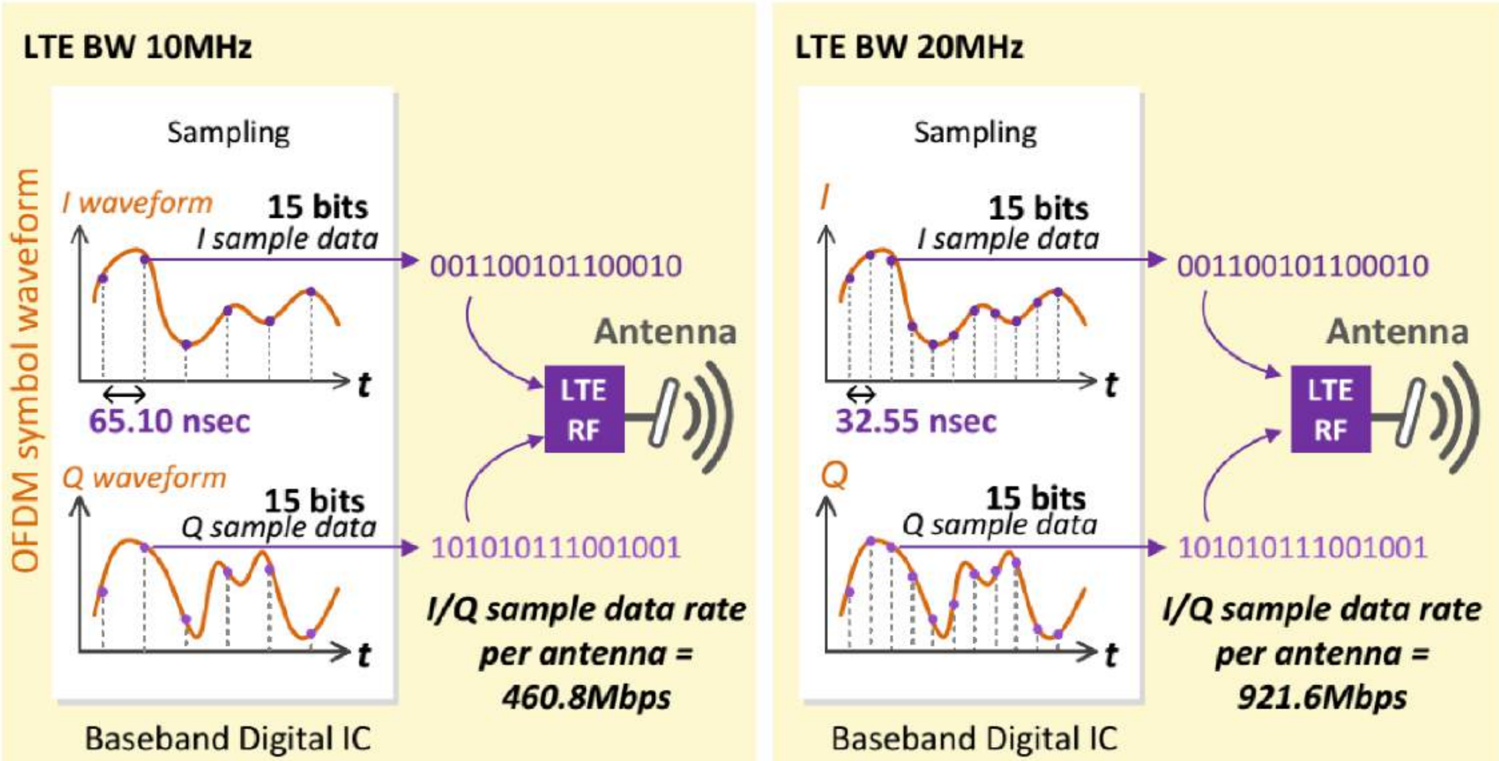
CPRI System Architecture

CPRI RCE – RE functional description



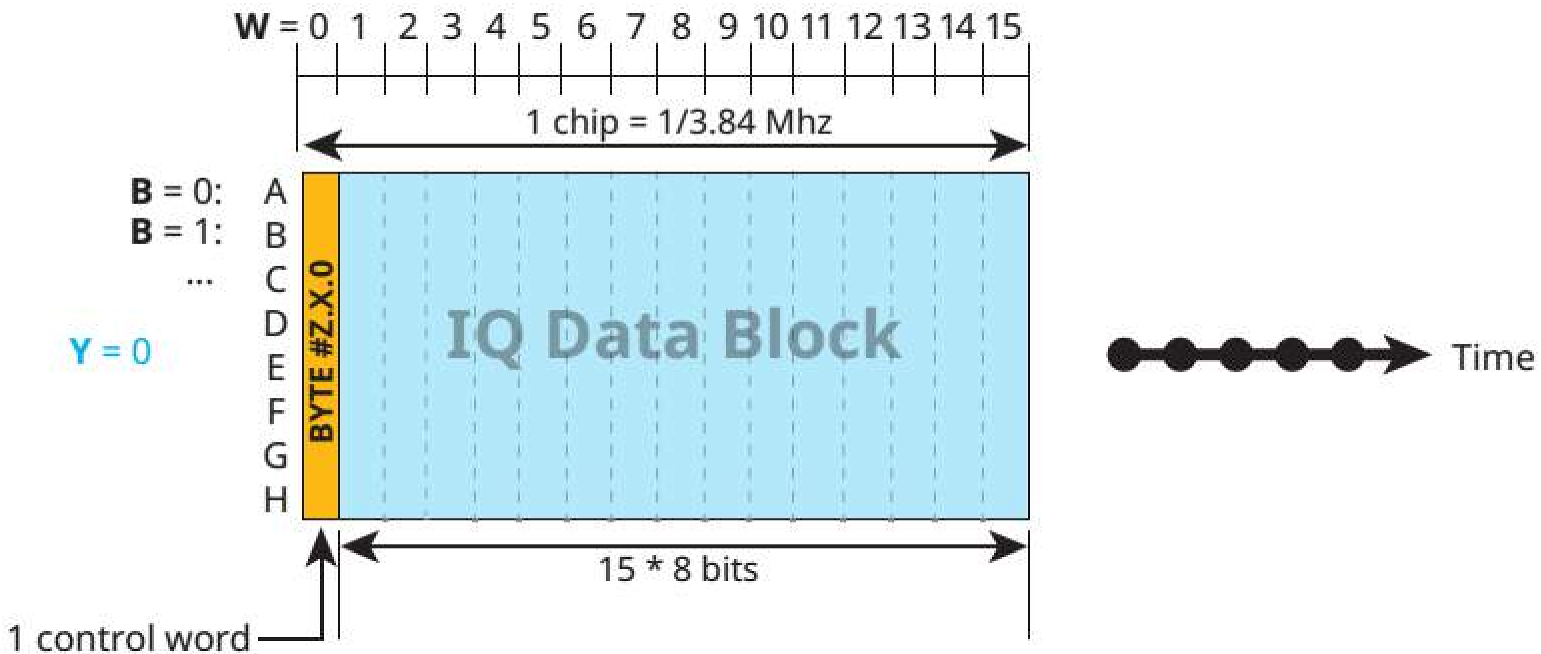
CPRI System Architecture

I/Q sample data rate in function of radio technologies



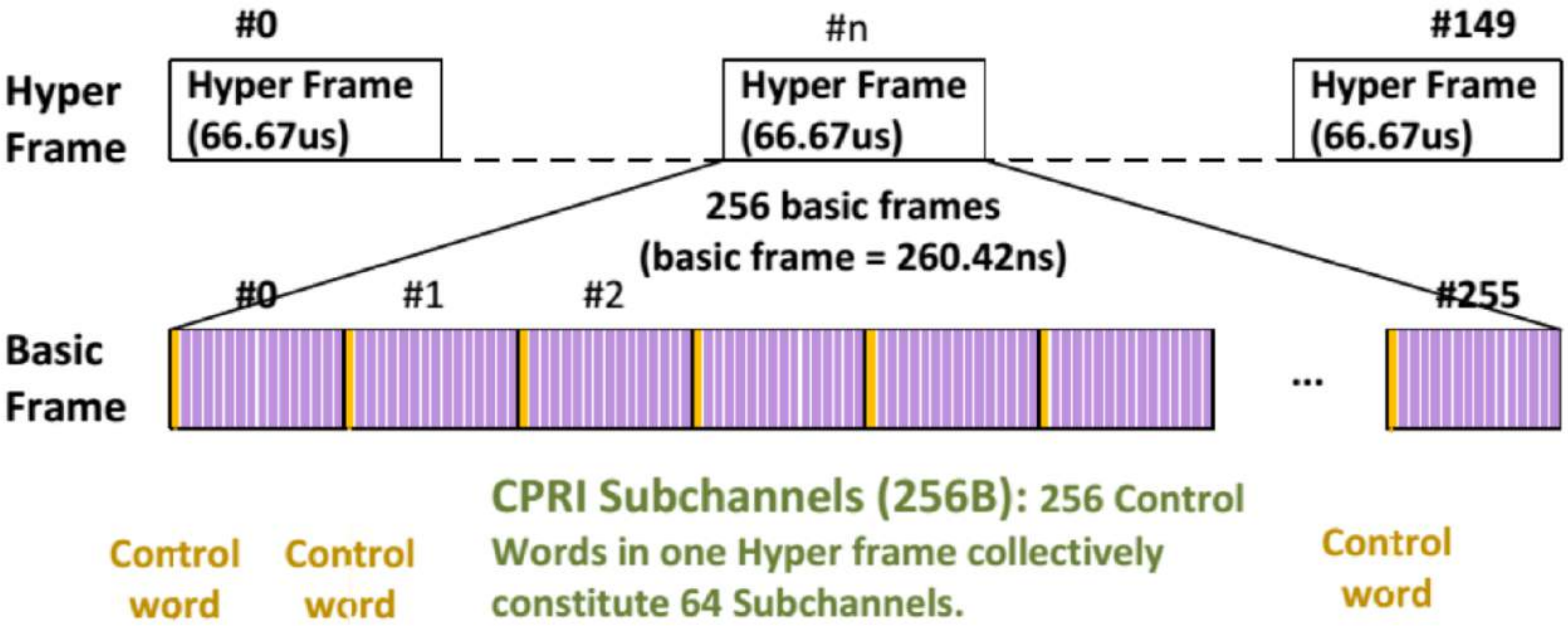
CPRI System Architecture

CPRI option 1 basic frame structure (128 bits)



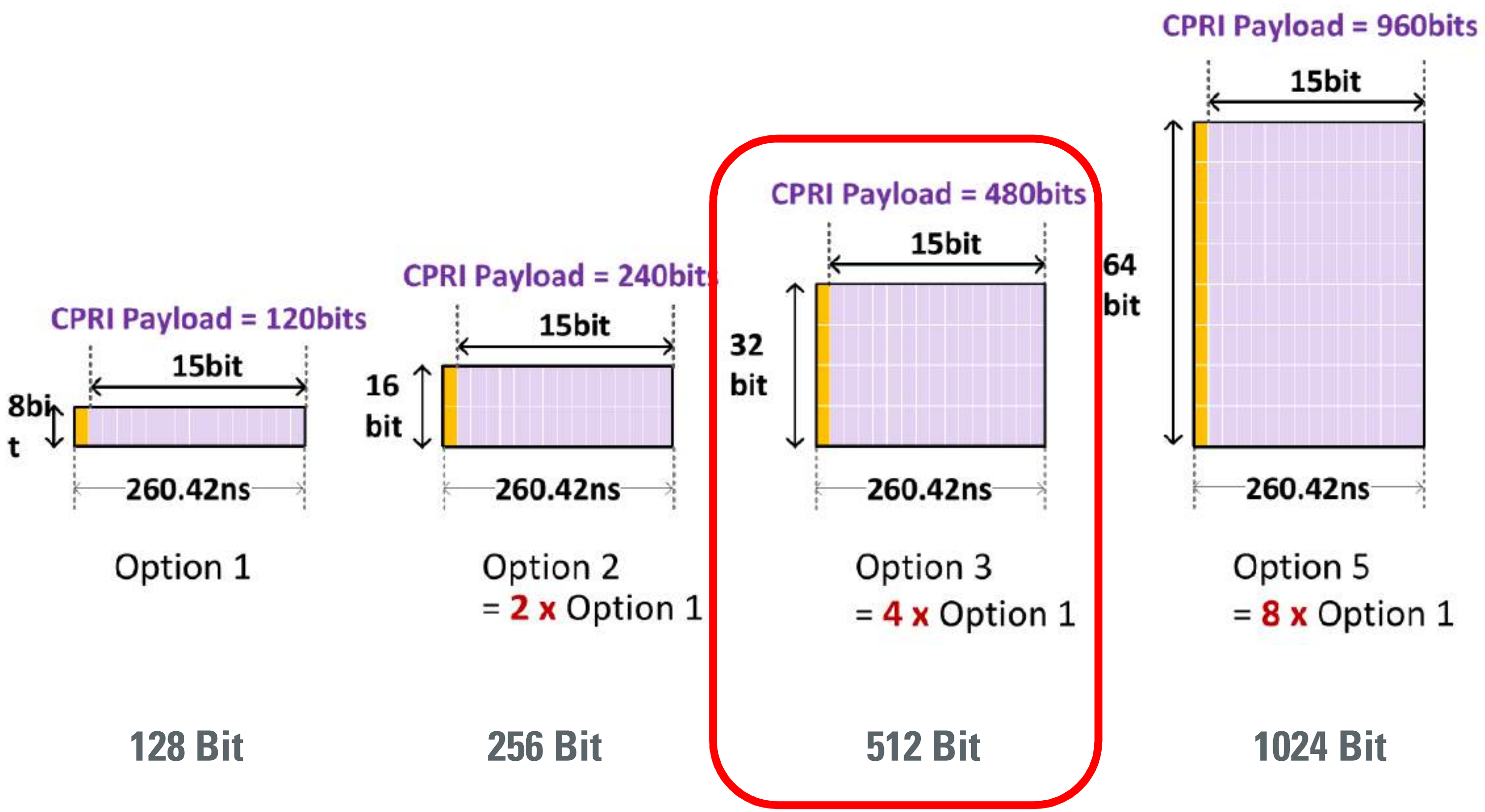
CPRI System Architecture

CPRI Frame & Subchannel (Control Plane) Architecture – CPRI Frames



CPRI System Architecture

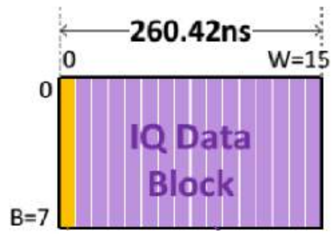
CPRI basic frame structures per option



Standard configuration for many configurations in practice!

CPRI System Architecture

CPRI link capacity per option



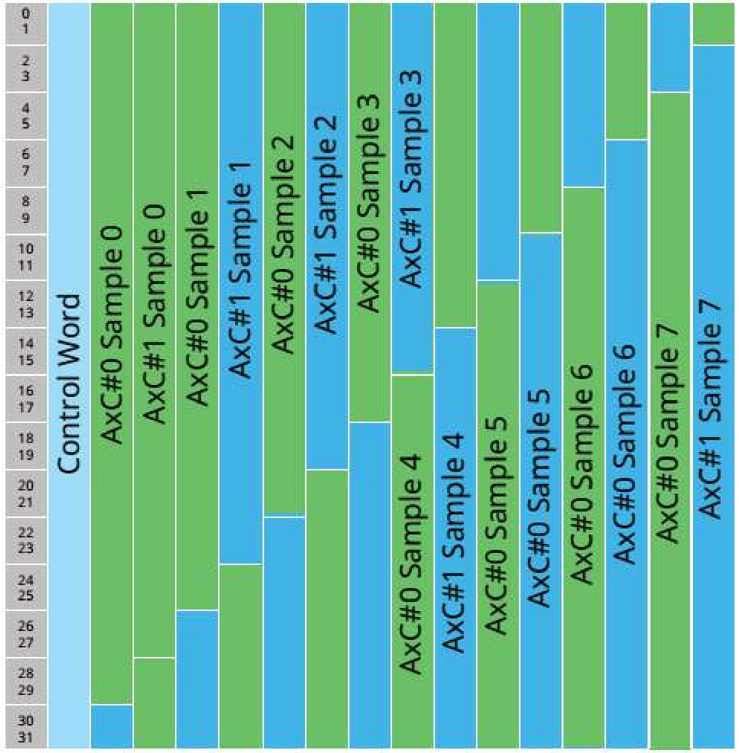
CPRI Option	CPRI Rate (After 8B/10B) ←	Including CW ←	Payload rate	Length of CW [bit]	Length of payload [bit]	# of option1 basic frames/1 chip (260.42ns)
1	614.4Mbps	491.5Mbps	460.8Mbps	8	120	1
2	1.2288Gbps	983.0Mbps	921.6Mbps	16	240	2
3	2.4576Gbps	1.9661Gbps	1.8432Gbps	32	480	512 Bit 4
4	3.0720Gbps	2.4576Gbps	2.3040Gbps	40	600	5
5	4.9152Gbps	3.9322Gbps	3.6864Gbps	64	960	8
6	6.1440Gbps	4.9152Gbps	4.6080Gbps	80	1200	10
7	9.8304Gbps	7.8643Gbps	7.3728Gbps	128	1920	16
8	10.1376Gbps	9.8304Gbps	9.2160Gbps	128/160	2400	20

CPRI System Architecture

Bitstream example - 20 MHz LTE, 2 Carriers

- **Two LTE 20 MHz carriers with 15-bit IQ samples mapped onto a Rate 3 (2457.6 mbps, 32 bit words)**
- **Basic frame with mapping method 1 or 3 with no interleaving**

- **Two LTE 20 MHz carriers with 15-bit IQ samples mapped onto a Rate 3 (2457.6 mbps, 32 bit words)**
- **Basic frame mapping method 3 with interleaving**



CPRI System Architecture

Required CPRI link capacity in function of radio technologies

CPRI Line Rate

Antenna Configuration		LTE BW 10MHz
		Required CPRI link capacity / *I/Q sample data rate*
Antenna Configuration	1x	IP 37.5Mbps – B – Option 1: 0.6144Gbps/0.4608Gbps – R
	2x	IP 75Mbps – B – Option 2: 1.2288Gbps/0.9216Gbps – R
	4x	IP 150Mbps – B – Option 3: 2.4576Gbps/1.8432Gbps – R
	8x	IP 300Mbps – B – Option 5: 4.9152Gbps/3.6864Gbps – R

Antenna Configuration		LTE BW 20MHz
Antenna Configuration	1x	IP 75Mbps – B – Option 2: 1.2288Gbps/0.9216Gbps – R
	2x	IP 150Mbps – B – Option 3: 2.4576Gbps/1.8432Gbps – R
	4x	IP 300Mbps – B – Option 5: 4.9152Gbps/3.6864Gbps – R
	8x	IP 600Mbps – B – Option 7: 9.8304Gbps/7.3728Gbps – R

CPRI System Architecture

CPRI basic frame structures per option

CPRI Option	Line Rate [Mbit/s]	#WCDMA AxC	#20 MHz LTE AxC
1	614,40	4	---
2	1.228,80	8	1
3	2.457,60	16	2
4	3.072,00	20	2
5	4.915,20	32	4
6	6.144,00	40	5
7	8.110,08	64	8
8	9.830,40	64	8
9	10.137,60	80	10
10	12.165,12	96	12

Each 20 MHz LTE AxC stream requires ~ 1 Gbps!

CPRI based D-RoF measurements

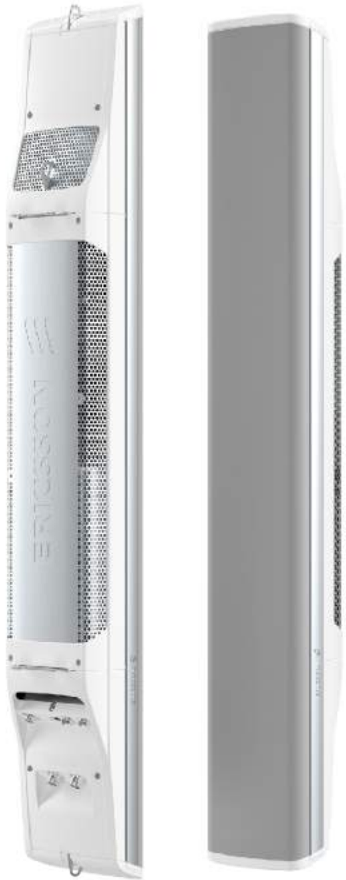
Why is there a need for CPRI based measurements?

- Lower OpEx costs (Operational Expenses)
  - Check functionality and potential RF Interference at ground level
    - Minimize calls for a Tower Crew
    - Typical cost $2000 to $5000
  - Verify interference
    - In-Band interference
  - Verify PIM
    - Noise floor measurement
    - “Implied” PIM Diversity imbalance
  - Based on measurements make decision
    - Call in Tower Crew
    - Do Not call in Tower Crew

CPRI based D-RoF measurements

Why is there a need for CPRI based measurements?

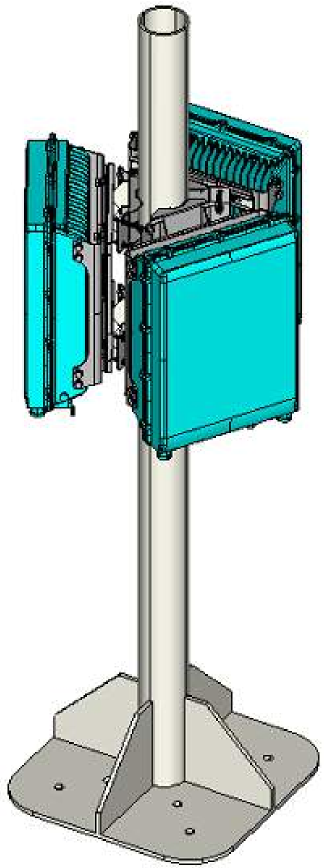
- Test Layer 1 - Physical transport
  - Is light on the fibre?
  - What is the optical power?
  - Optical transmission can be SM or MM
    - SM = Single Mode (long runs)
    - MM = Multi-Mode (short runs)
- Test Layer 2 - Several areas
  - L1 in-band protocol; understanding this area allows operator to troubleshoot alarms and errors
  - IQ data is the actual data carried and can be analysed for performance such as interference (CPRI RF)



CPRI based D-RoF measurements

Why is there a need for CPRI based measurements?

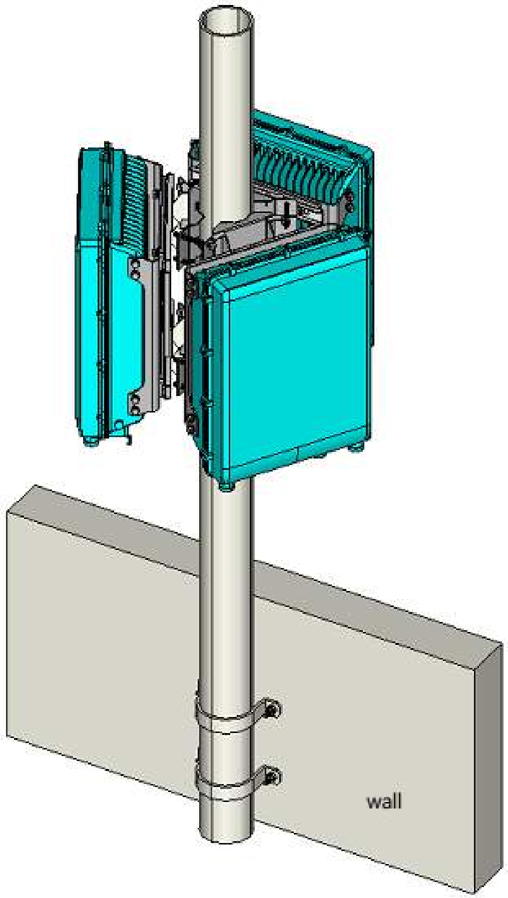
- Common Installation Problems
  - “Seeing what the RRH sees”
  - Fiber could be connected to the wrong CPRI port
  - Supporting proprietary CPRI interfaces
  - Distances between REC and RRH can be 100m+
- Common Equipment Problems
  - RRH will not communicate
  - Incompatible cable connections
- OVP Installation Problems
  - DC power wired incorrectly
  - Fibers swapped/bent at LGX
  - Incorrect alarm wiring



CPRI based D-RoF measurements

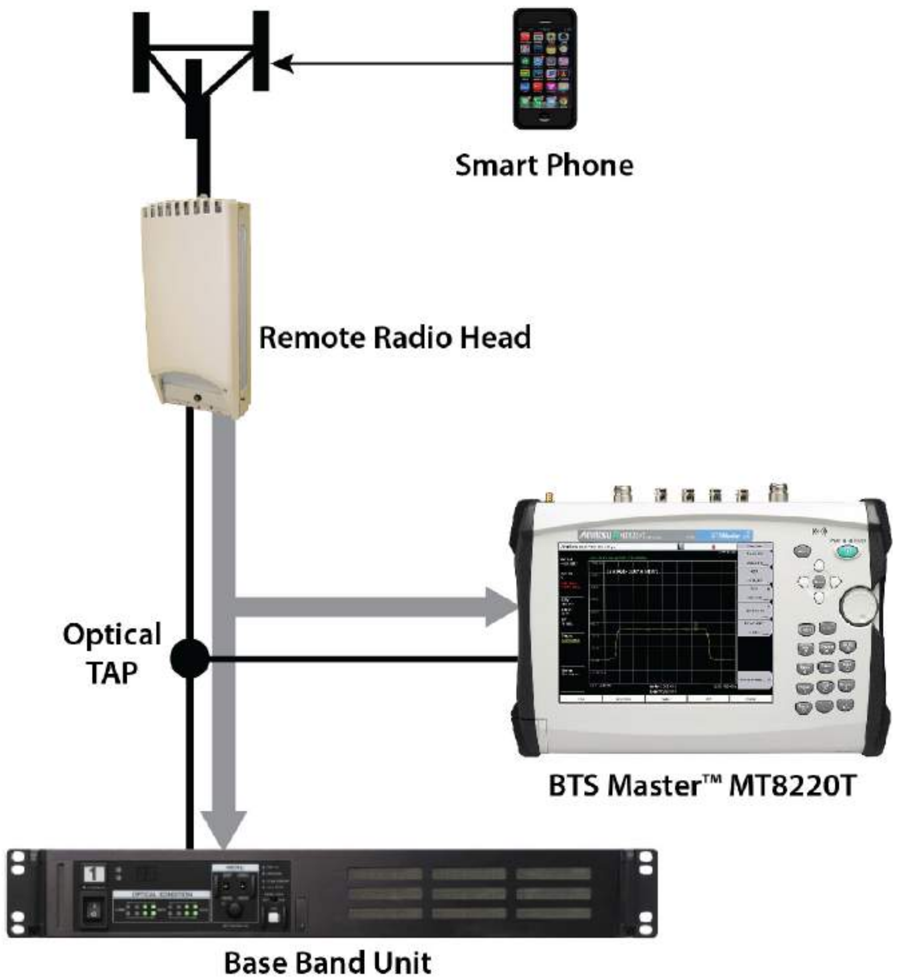
Why is there a need for CPRI based measurements?

- External Problems
  - High RSSI from external interference
  - GPS signal is too weak
- Coax/antenna Installation Problems
  - Cables for RRHs cannot be terminated in the field
  - Up to 15 remote radios per site (5 per sector)
  - Loose/faulty antenna jumpers and/or connected



CPRI based D-RoF measurements

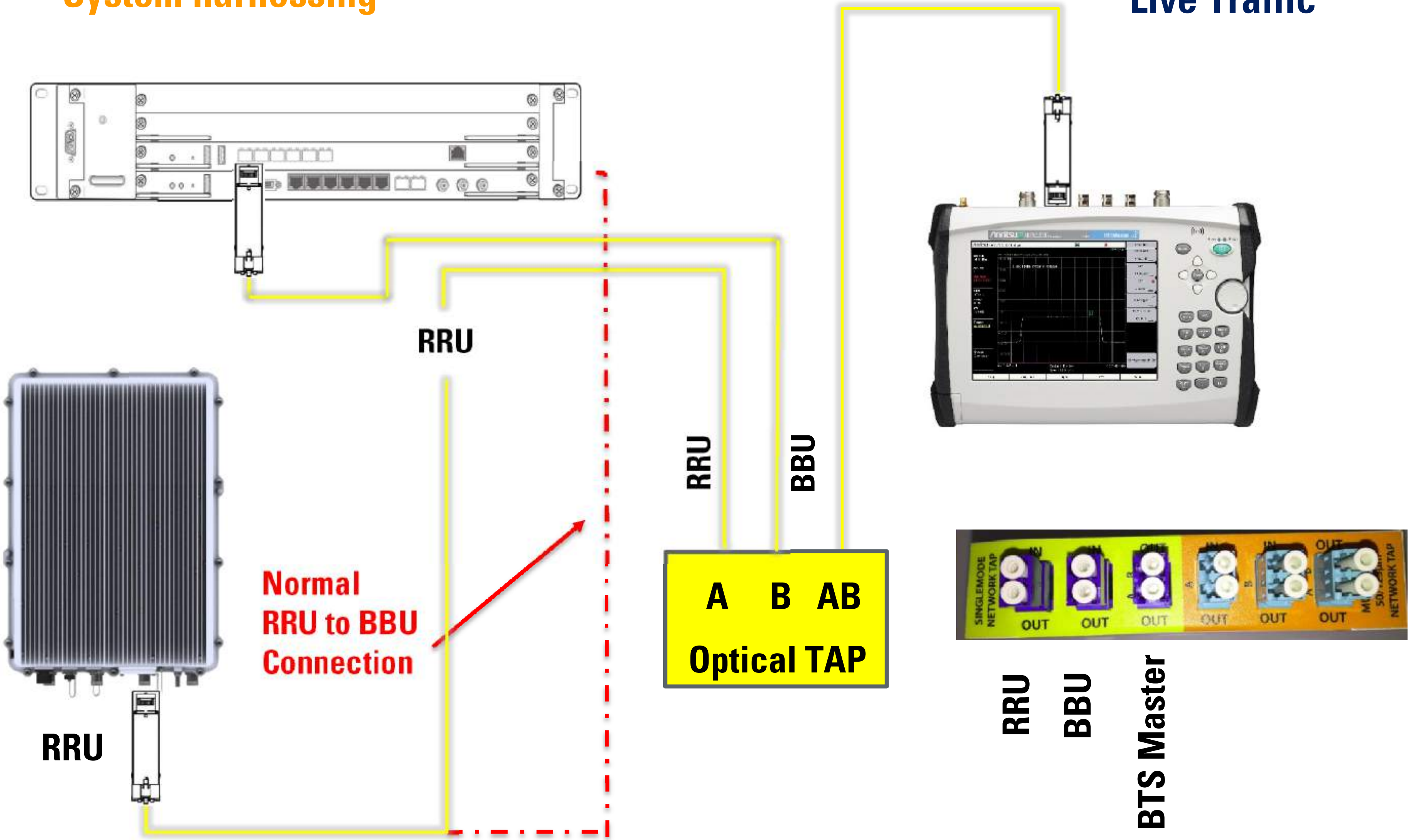
Typical test configuration for CPRI RF testing



CPRI based D-RoF measurements

System harnessing

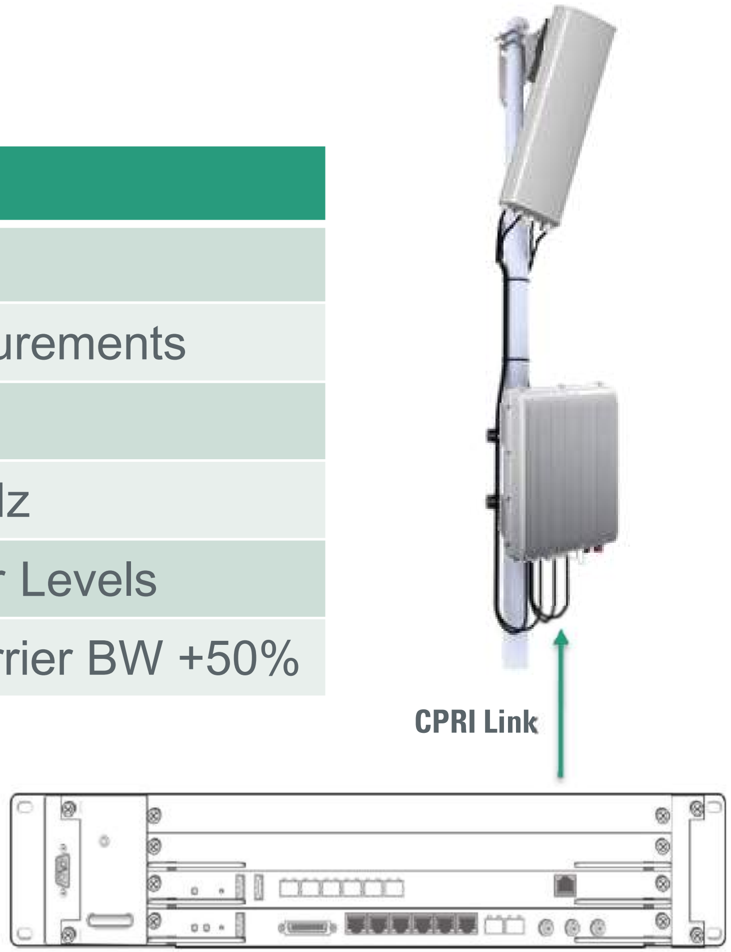
Measure with Live Traffic



CPRI based D-RoF measurements

Differences with Traditional RF

RF	CPRI
Analog	Digital
Absolute Measurements	Relative Measurements
dBm	dB
Specific Center Freq.	Base Band 0 Hz
Absolute Power levels	Relative Power Levels
Full Span capable	Max Span: Carrier BW +50%

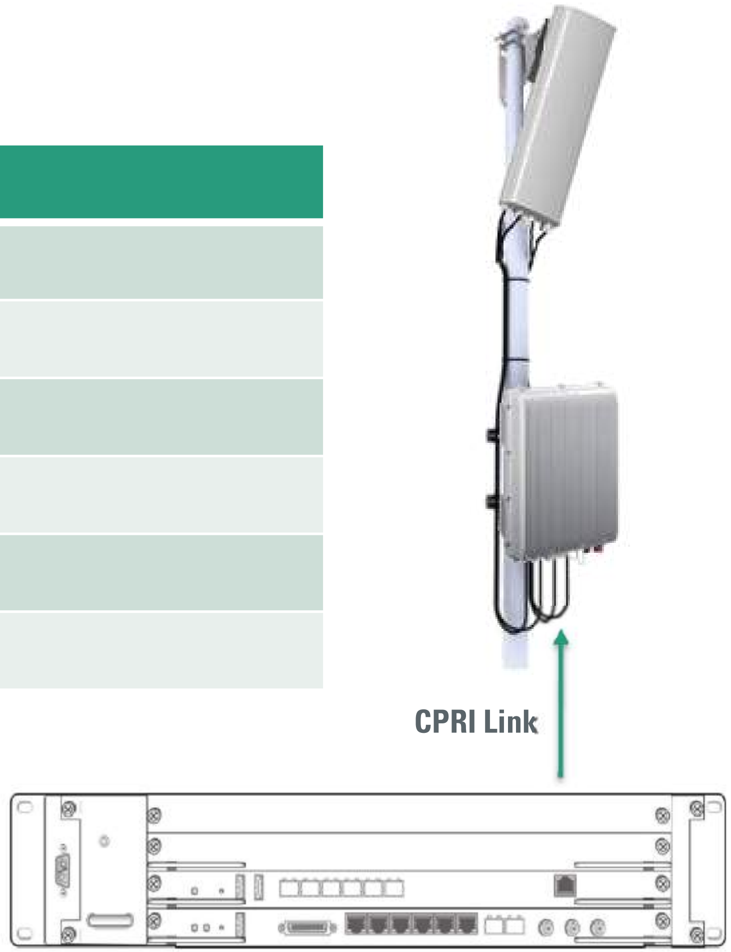


CPRI based D-RoF measurements

Configuring CPRI link

Key CPRI Parameters
• Line Rate (rates 1 to 7 supported)
• AxC (Antenna Container: 0 to 10)
• CPRI BW (Bandwidth of LTE carrier)
• IQ Bit Width (10, 12, 15, 16)
• Reserve / Stuffing Bits (0 to 10)
• Aggregation (On / Off)

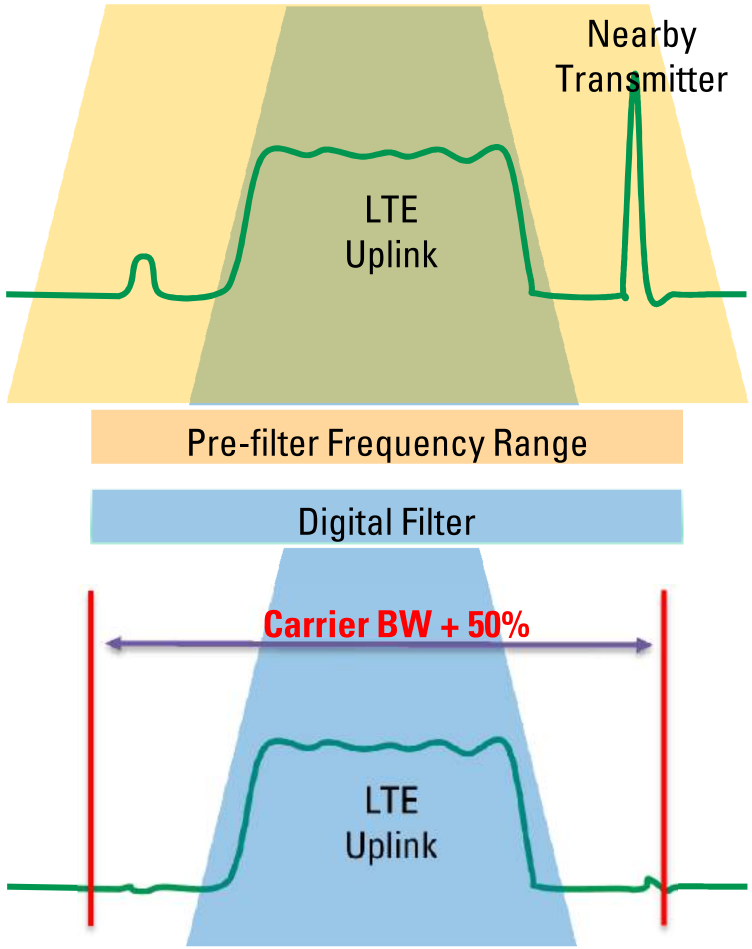
Note: Configurations can be different on UL & DL



CPRI based D-RoF measurements

CPRI Digital Filter – Limitations for Interference Hunting

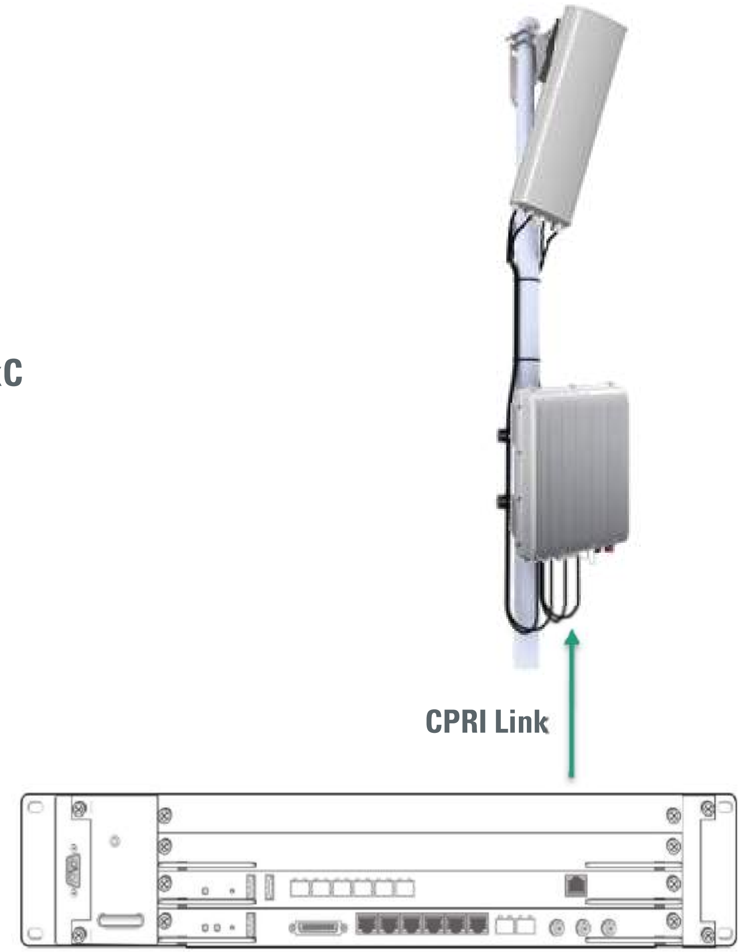
- Traditional filtering
- CPRI Digital Filter Only Tx Carrier IQ
- CPRI based Interference Testing
  - In-Band only



CPRI based D-RoF measurements

Key CPRI Parameters

- AxC = Antenna Carrier
  - Location of IQ data for a given carrier/signal
    - Though it's possible to combine two in one AxC
    - AxC mapping
      Mapping = 1:1 carrier/signal per AxC
      Mapping = 3:2 interleaved carrier/signals per AxC
  - AxC's can range from 1 up to 192
    - 1 ↦ Option 1 and LTE 10 MHz
    - 192↦ Option 9 and LTE 1,25 MHz
- CPRI BW = the bandwidth of the LTE carrier
  - LTE carrier bandwidth can be
    - 1.25 MHz
    - 2,5 MHz
    - 5 MHz
    - 10 MHz
    - 15 MHz
    - 20 MHz



CPRI based D-RoF measurements

Key CPRI Parameters

- **IQ Bit Width or Sample Width**
  The CPRI standard has different IQ bit width lengths per frame: one I sample and one Q sample
  - The standard has IQ bit width of 8 to 20 for the Downlink
    - Most common are 10 , 12, 15, 16
  - The standard has IQ bit width of 4 to 20 for the Uplink
    - Most common are 10 , 12, 15, 16
- **Reserved/Stuffing Bits**
  Are vendor specific and used with Sample Width (IQ Bit Width) to complete the CPRI frame length.
  - Most common stuffing/reserve bit values are 0 & 6 for LTE
- **CPRI Aggregation**
  This refers to the aggregation of smaller carriers to make one large carrier within one AxC
  - Example two 5 MHz carriers aggregated to make a single 10 MHz carrier
    - Very common with some LTE NEM's.

CPRI measurement features

SFP monitoring and alarm monitoring

Loss of Signal (LOS)
Loss of Frame (LOF)
LSS (Loss Sequence Synchronization)

CPRI measurement features

SFP monitoring and alarm monitoring – BTS Master 2 SFP slots

CPRI measurement features

SFP monitoring and alarm monitoring – BTS Master 2 SFP slots

CPRI measurement features

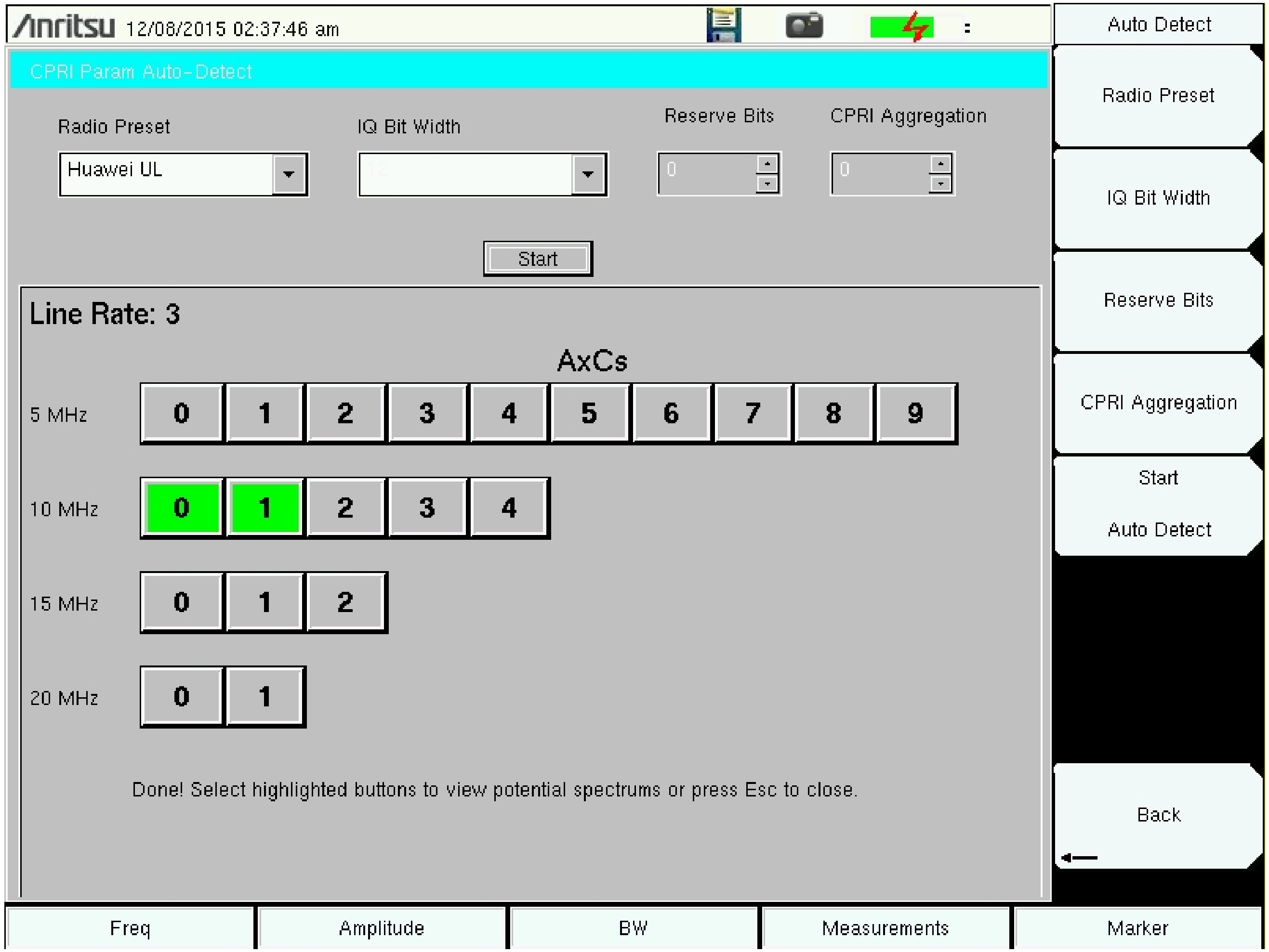
SFP monitoring and alarm monitoring – E-series Site Master 1 SFP slot

CPRI measurement features

AcX Auto Detect mode (ERICSSON, ALU, HUAWEI)

CPRI measurement features

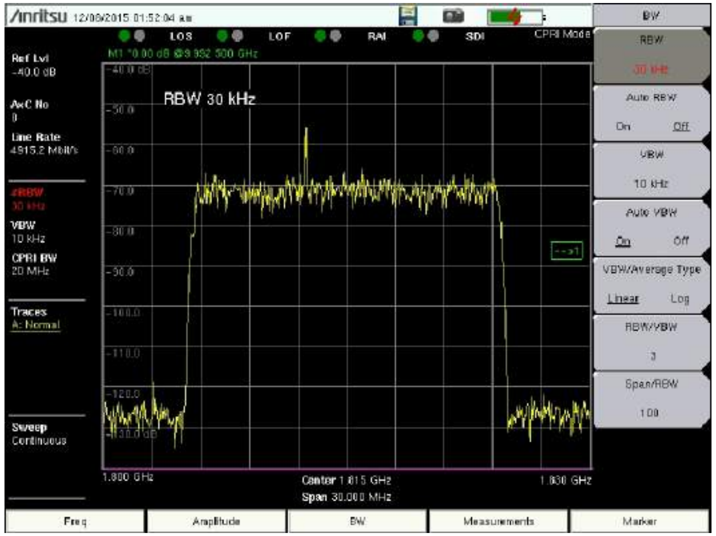
AcX Auto Detect mode (ERICSSON, ALU, HUAWEI)

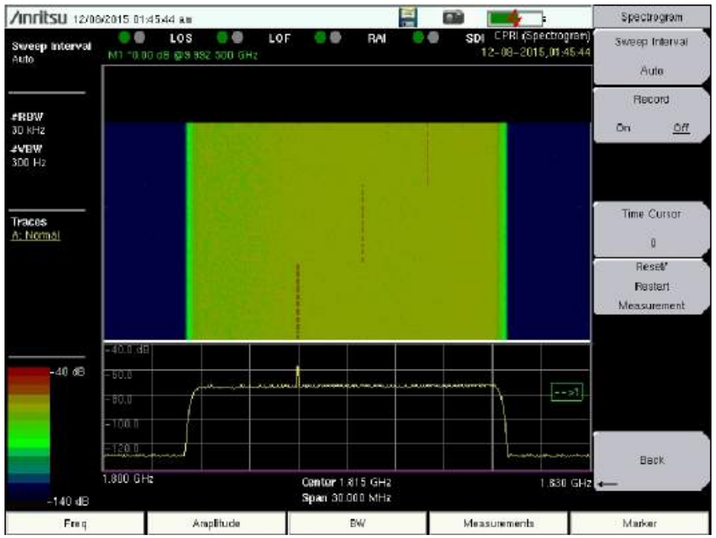


CPRI measurement features

Measurement Display Types

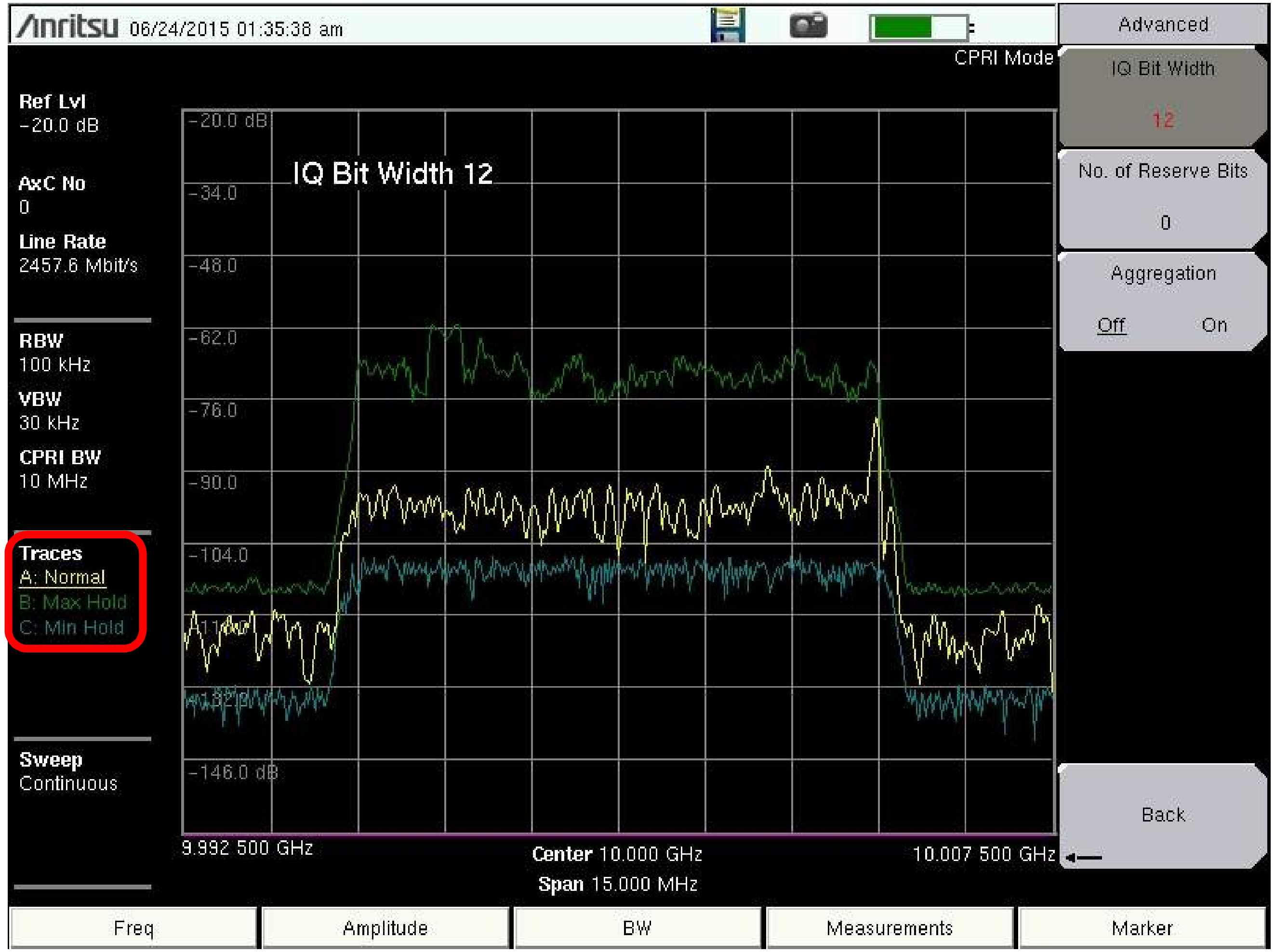
- Spectrum and / or Spectrogram is useful for intermittent signals
- Use the spectrogram to look for signals that change over time
  - Unstable regarding frequency and / or level
    - Passive Intermodulation
    - From a cell phone booster with insufficient input to output isolation
    - Common consumer grade equipment issue
  - Temperature sensitive
  - Sensitive to changing reflections
    - People
    - Cars
    - Etc





CPRI measurement features

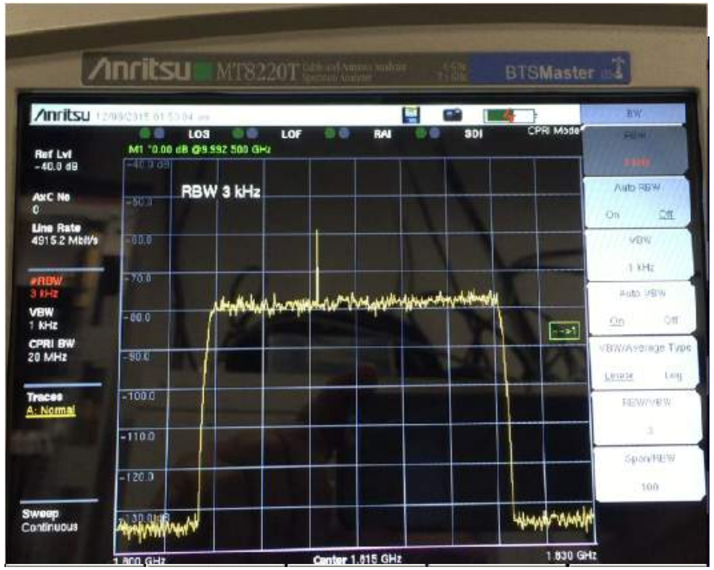
Parallel trace operations

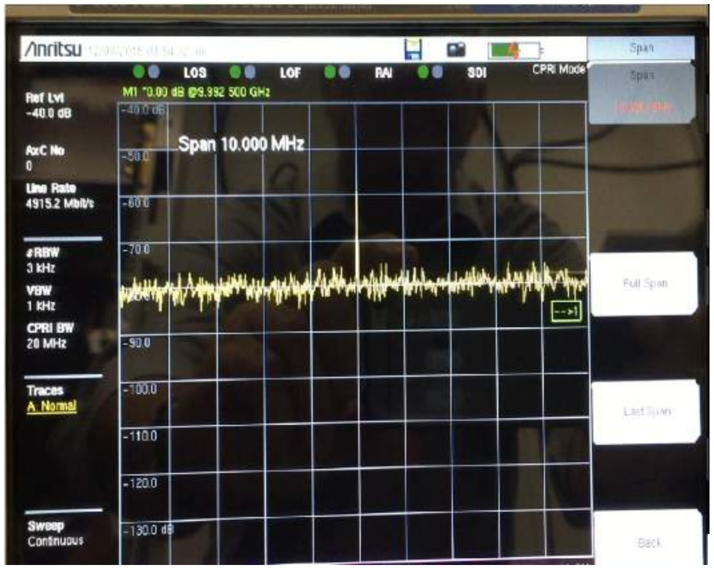


CPRI measurement features

Tune & Zoom functionalities

- Use case: Identification of narrow band interferers
  - Place marker on an off-center frequency interferer
  - Use “Marker Freq to Center”
  - Reduce span to zoom in on the interferer





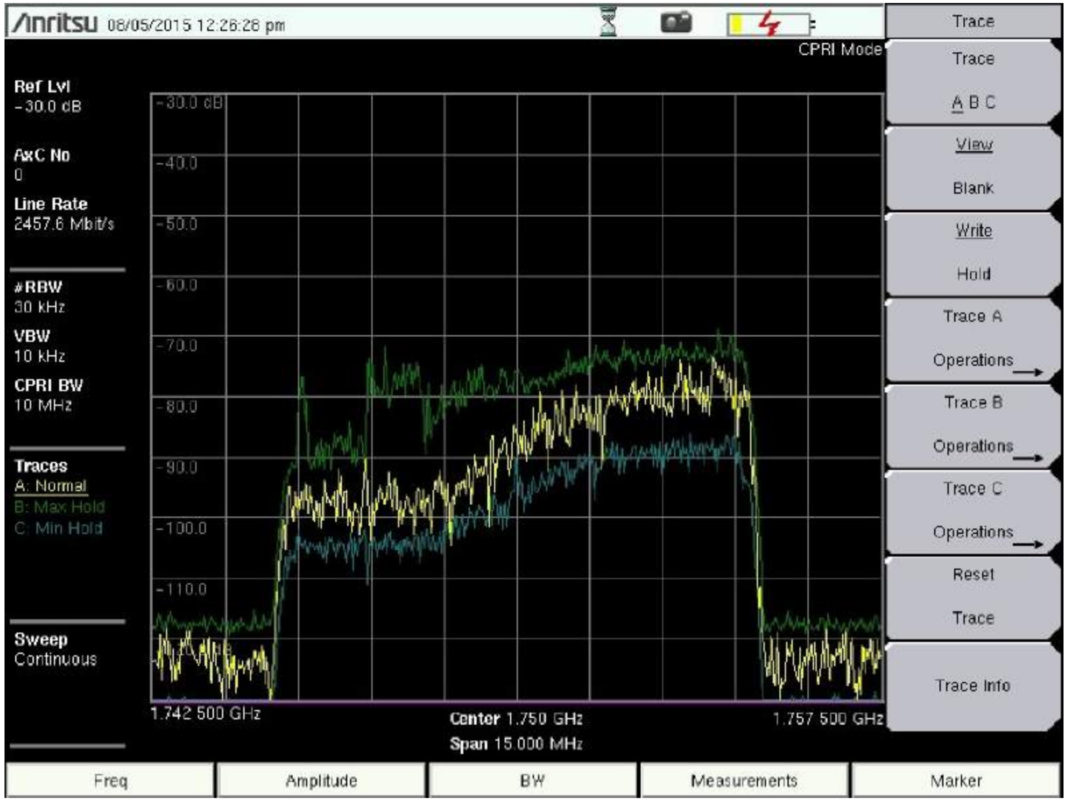
CPRI measurement features

Recording & Replay of measurement data

CPRI measurement features

PIM detection via CPRI link

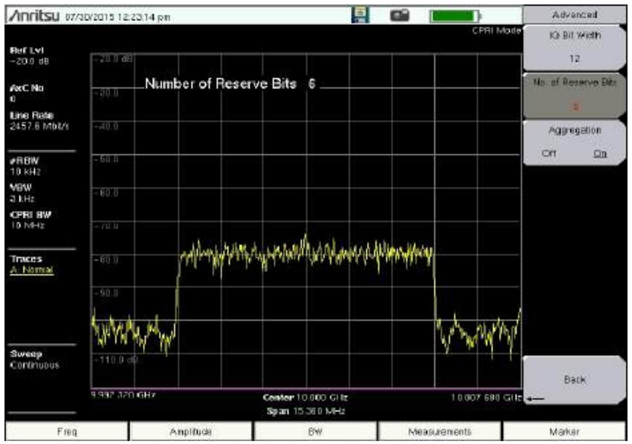
- "Shark Fin" shape is a usual indication for PIM
- IM 3 to IM 5 transition
- Turn OCNS on
  - Does Uplink rise?
  - Maintenance window

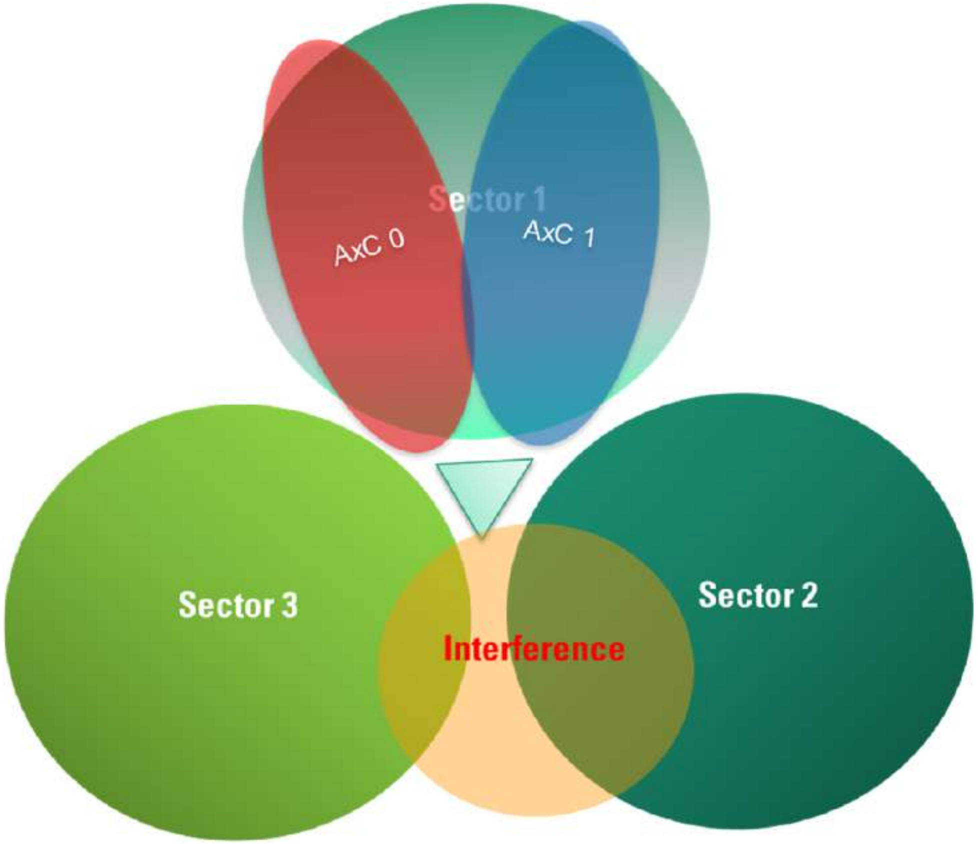


CPRI measurement features

RX Diversity

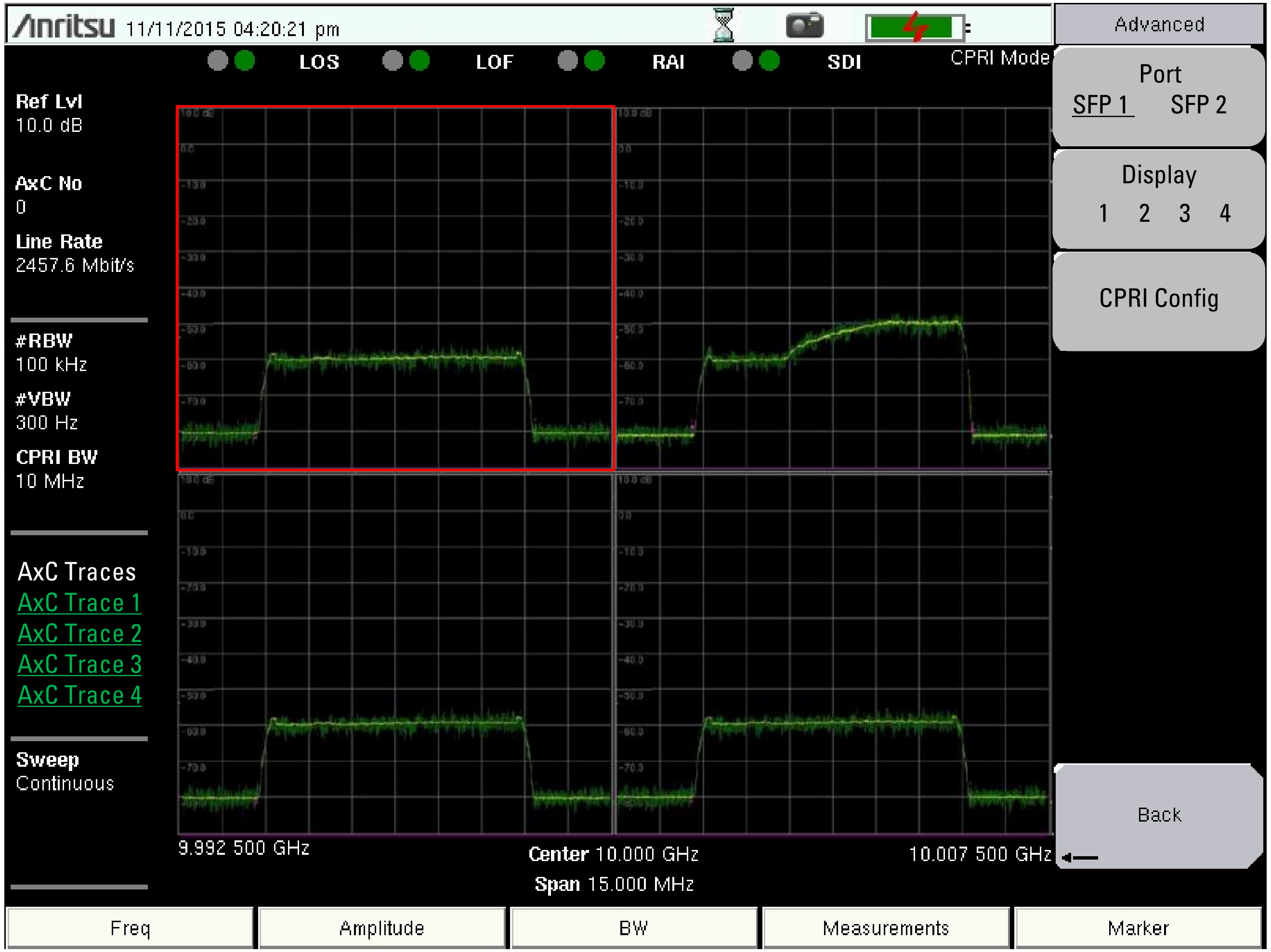
- Diversity Testing
  - Compare Multiple Traces
    - AxC 0 & AxC 1
- Multi – Band Loading
  - Compare Multiple Traces
    - AxC 0 & AxC 1 – 700 MHz
    - AxC 0 & AxC 1 – 2100 MHz





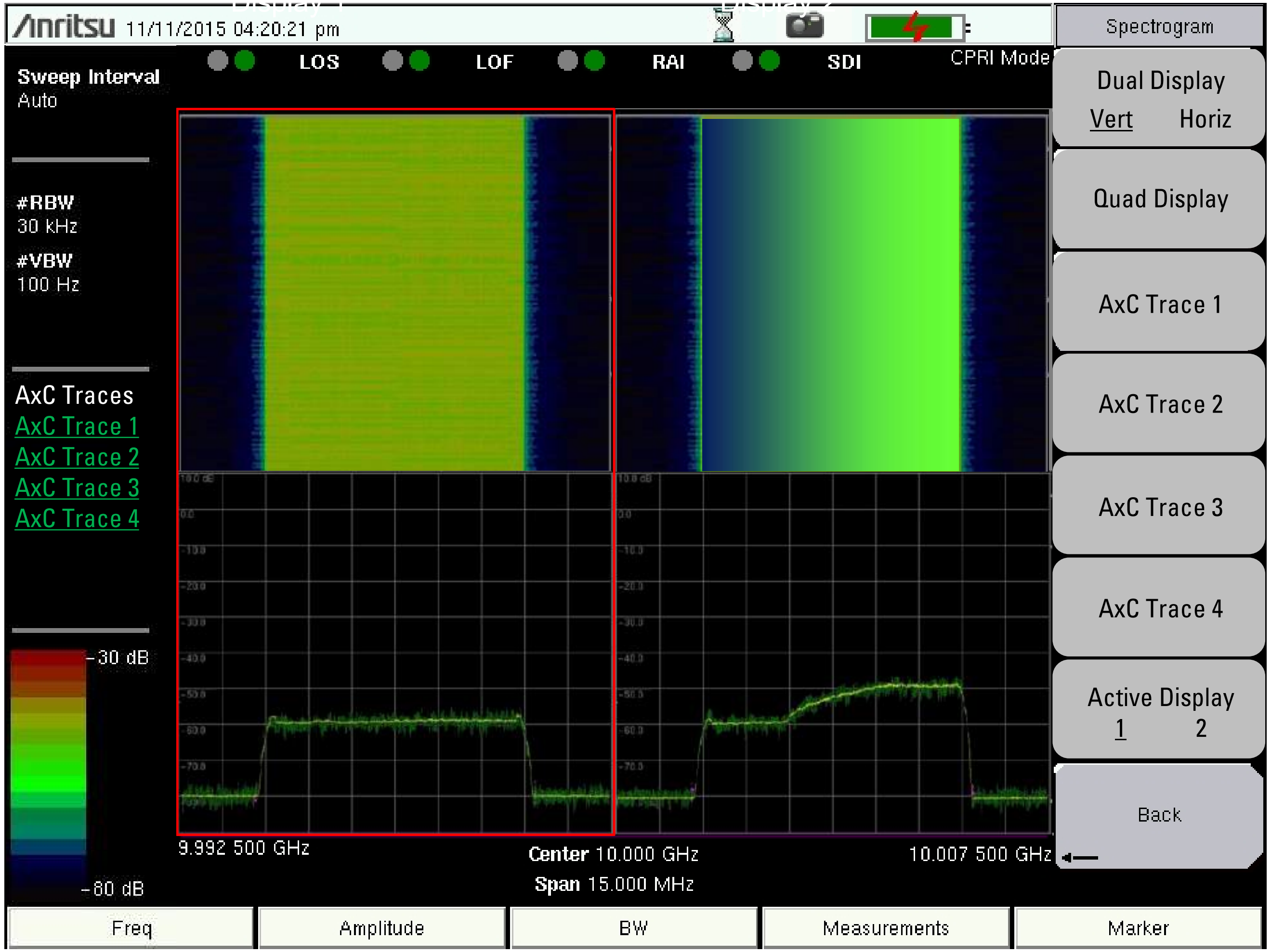
CPRI measurement features

Multiple AcX for Spectrum and Spectrogram measurements – Quad Display



CPRI measurement features

Multiple AcX for Spectrum and Spectrogram measurements – Dual Display



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