RF Interference Analysis

Eder EIRAS

Anritsu

Dublin, October 13th 2015

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Agenda

1. Interferences
2. Measurement Techniques and Problems
3. Spectrum Analyzer Basics and Hints
4. Advanced Spectrum Analyzer Measurements
5. Anritsu Portfolio

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Interferences

Indicators

7 Questions

Example: LTE and Digital Dividend

Interference : Indicators

- ❑ Limited range, dropped calls, low data rate, high Bit Error Rate
- ❑ High Receiver Noise Floor

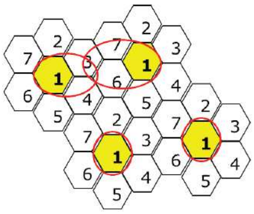
Interference is a receiver issue !

… and comes from so many sources

Q 1/7 Is It On-Channel Interference?

Factors that can cause excessive Cell overlap and subsequent interference include:

- Antenna tilt
- Valleys
- Antennas mounted on high buildings
- Better than expected signal propagation over water
- Errors in frequency settings
- Excessive multi-path



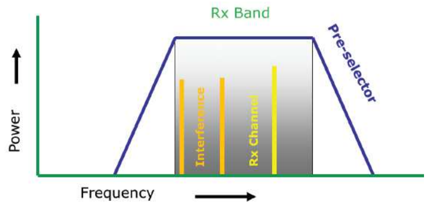
Q 2/7. Can In-band Interference Be My Problem?

Interference is not inside the channel but inside the receiver.

Receiver bandwidth is defined by the frequency selective components present in the receiver chain like Filters, Duplexers …

These signals can be:

- Carriers from other services
- Intermodulation products
- Harmonics of other signals



Q 3/7. Are External Sources Causing Impulse Noise

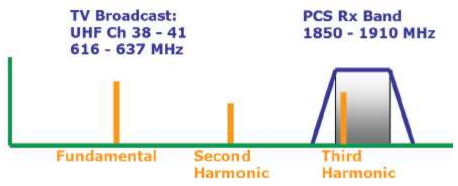
Impulse noise is created whenever a flow of electricity is abruptly started or stopped. A surprising variety of items can create impulse noise:

- Lighting suppression devices
- Electrical motors from elevators or the like
- Electric fences
- Power lines, which may arc and spark
- Light dimmers

Most of these impulse noise sources affect the lower frequencies, generally below 500 MHz. Micro-arcing or fritting is the exception, since it is generated by the RF signal and can affect reception at any frequency. It is typically very broadband, measuring more than 1 GHz wide.

Q 4/7. Can Harmonics Throw My Signal Off

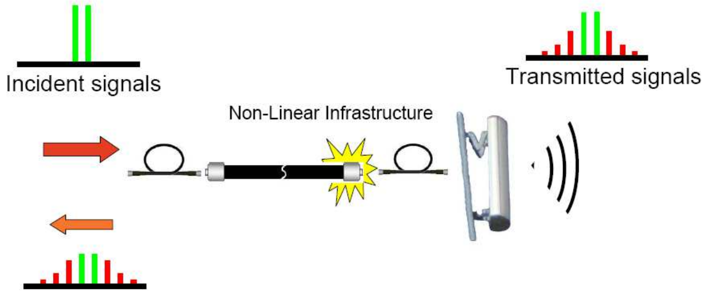
Harmonics are multiples of an RF carrier. For instance, if we had a transmitter at 100 MHz, it might have harmonics at 200 MHz, 300 MHz, 400 MHz, 500 MHz, and so on.



Q 5/7. Is Interference Due To Passive Intermodulation ?

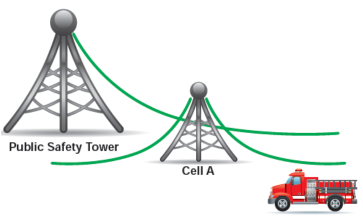
Happens mostly on GSM/DCS/LTE sites

If some components are non-linear, they create Intermodulation products that can fall inside the receiver band: if so, you have an Interference

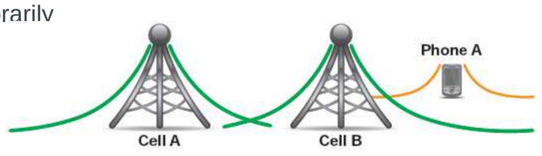


Q 6/7. How Close Am I To Finding A Near-Far Problem

In the case where a wide area RF coverage is overlaid with a smaller area coverage, and the two operating frequencies are close enough to give receivers a problem, the nearby, in-band-but-off-frequency signal can overload a receiver trying to listen to the weaker signal



The near-far problem can also happen between cell towers, as long as the mobile device can't make a handover. This may occur when a device from one operator is broadcasting a strong signal to reach a distant cell tower. If a cell tower operated by another operator is near the mobile device, that second carrier's receiver may be temporarily desensed by the mobile device.



Q 7/7. Is Someone Causing Intentional Interference?

Cell Phone Jammers are a problem, it is generally for civilian use illegal

Often used in:

- Cinemas
- Religious buildings
- …

Example: LTE and Digital Dividend

Switch from Analog to Digital broadcast released some spectrum bandwidth around 800MHz.

Decision from EU was to allocate it to LTE (Band 5).

So DVB-T and LTE are adjacent in the spectrum.

Components from DVB-T infrastructure were designed to receive full 800MHz band … including the portion now given to LTE.

Measurement Techniques and Problems

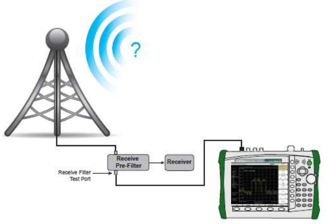
Direct Connect vs Over The Air

Multipath

Antennas

Direct Connect to the receiver

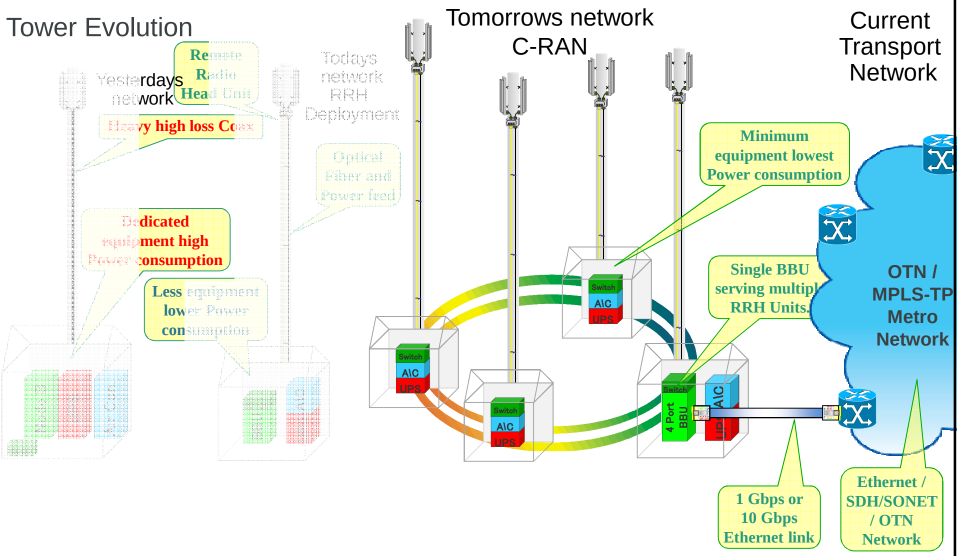
Allows to directly monitor what is received by the system and nothing else



- Most accurate measurements
- Does not allow to locate the source of interference

Issue: How to do it with remote radio heads?

The migration to C-RAN



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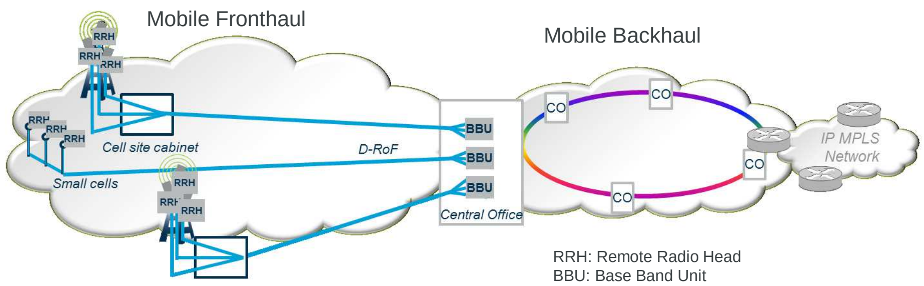
CPRI where it fits IN – Mobile Fronthaul

- This move to centralized BBUs creates a new domain within the mobile network.
  - The new network between the BBU and the RRH in the cell site is referred to as the fronthaul network
  - The network between the BBU and the core network is still the mobile backhaul network



RRH: Remote Radio Head
BBU: Base Band Unit
D-RoF: Digital Radio over Fiber (CPRI/OBSAI)

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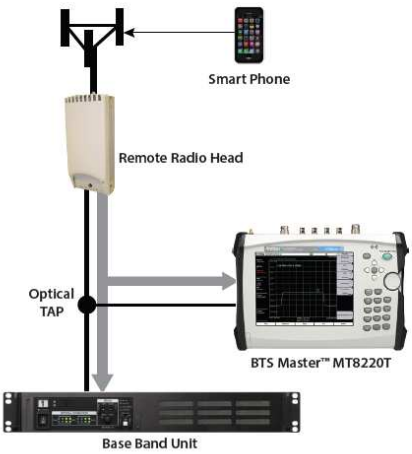
Direct Connect to the receiver

Radio Remote Heads have a fiber interface, not coaxial.

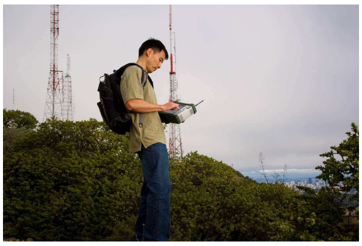
The fiber is carrying a protocol stack named CPRI.

Some Anritsu RF Analyzers have an optical CPRI interface



Over the Air (OTA) Measurements

Allows to see all signals inside and outside the receiver band



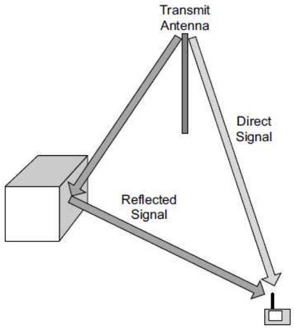
- Not so accurate measurements
- Multipath Problems
- Allow to see outside the receiver
- Allows to find the direction

Multipath

This is a challenge mainly in urban areas where signal are reflected by buildings.

Direction Finding becomes challenging as there is only one emitting source but signals gets to the receiver by various paths.

Finding the source requires experience, knowledge of the antenna and principles of reflexion.



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Antennas

A directional antenna is an antenna which receives greater power in one or more directions. We use 2 different type of antennas:

- Yagi
  - Best Directivity and specs
  - Narrow Band

- LogPeriodic
  - Less Directivity
  - Broadband

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Antennas

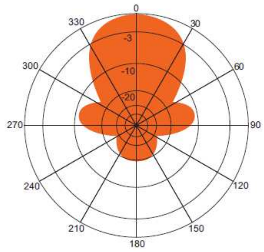
Directional Antennas have a radiation path that you need to take in account when doing measurements

Three main specs:

Good directivity, which means that it is easy to figure out when the antenna is pointing at the signal

Good front-to-back ratio, which means that you will not likely be misled by signals coming from exactly behind the antenna.

Generally low side lobes, which means that it's not too likely you will be misled by signals received from a minor lobe, which would throw off the direction finding



Spectrum Analyzer Basics and Hints

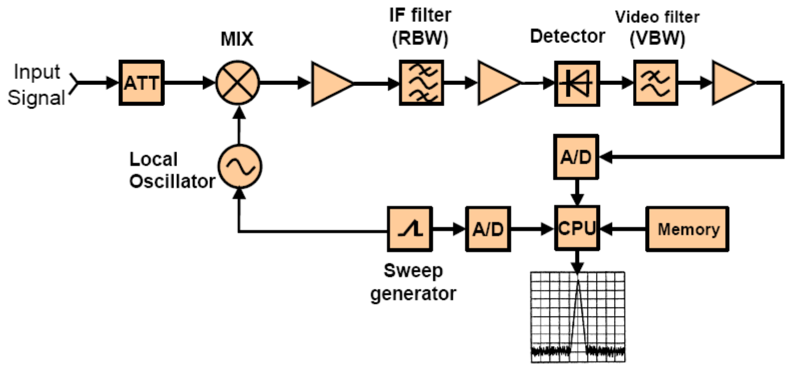
Block Diagram

Internal RF Attenuator

RBW Filter

Preamplifier

Spectrum Analyzer Block Diagram



Block Diagram of a Super-Heterodyne Spectrum Analyzer

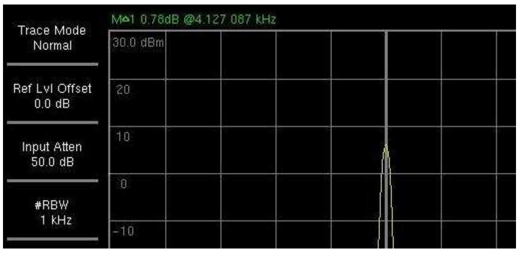
Internal RF Attenuator

- Optimum input level for mixer
  - Maximum dynamic range
    - Additional attenuation increases Noise Level
  - Minimum distortion
    - Unwanted mixing product due to high mixer input level
- Attenuator prevents overload of the input mixer
  - Attenuator range
    - e.g. 0 - 65dB
    - in 5dB Steps
      - Mechanical attenuator
- Optimum Level at the mixer input?
  - Depends on the mixer design
    - -10dBm …. -30dBm

Attenuator can prevent the mixer from damage!

Internal RF Attenuator

- Manual and automatic settings of the attenuator
  - Automatic mode
    - Always coupled to the reference level (... Semi Automatic)
      - +30dBm Ref. level = 50dB Attn (-20dBm at mixer)
      - +10dBm Ref. level = 30dB Attn (-20dBm at mixer)
    - The mixer can be saturated also in automatic mode!

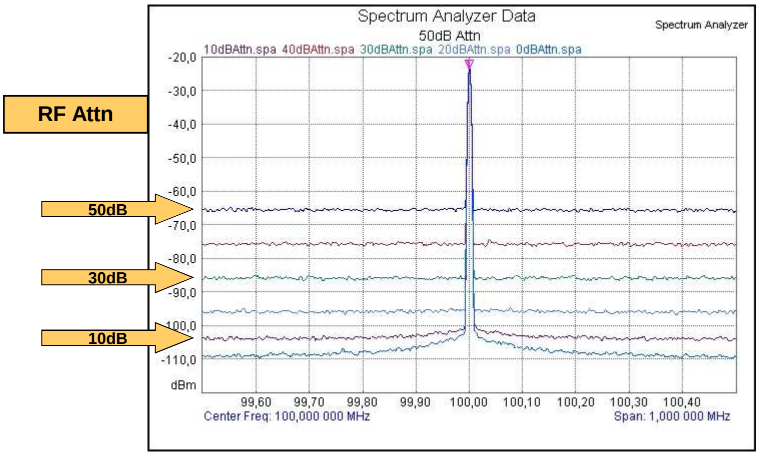


The mixer also sees signals outside of the displayed spectrum!

Power at the input of the mixer is the sum of all signals!

Internal RF Attenuator

- 10dB Attn (RF Attenuator) will change Noise Level by 10dB

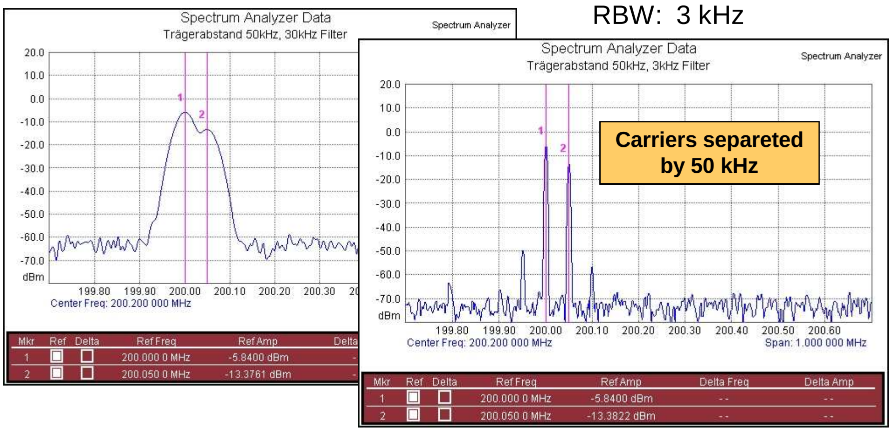


RBW Filter: Separation of adjacent signals

RBW filter determines the 'signal' resolution

RBW: 30 kHz

RBW: 3 kHz



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RBW Filter: Minimization of Internal Noise

Sensitivity of a spectrum analyzer is limited by the internal generated noise.

Thermal Noise
+
Noise added by internal components
(mixers, amplifier…)
================================
= Displayed Noise

Thermal Noise power:
- Bandwidth = 1kHz
  - N = -144dBm/1kHz
- Bandwidth = 1Hz
  - N = -174dBm/1Hz

Thermal Noise: N = kTB

N = Noise power (in Watt)
k = Boltzmann Constant (1.38 x 10^{-23} J/K)
T = Absolute Temperature (Kelvin)
B = System bandwidth (Hz)

The smaller the bandwidth of the RBW filter, the smaller the noise power

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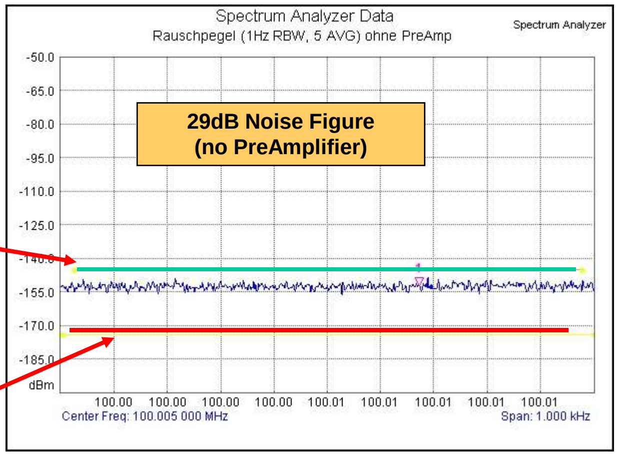
Noise Level (DANL) without PreAmp

- Noise Energy from a 50 Ohm Termination
  - -174dBm/Hz (1Hz Filter)
  - Thermal Noise



-145dBm (1Hz RBW)

-174dBm (1Hz RBW)

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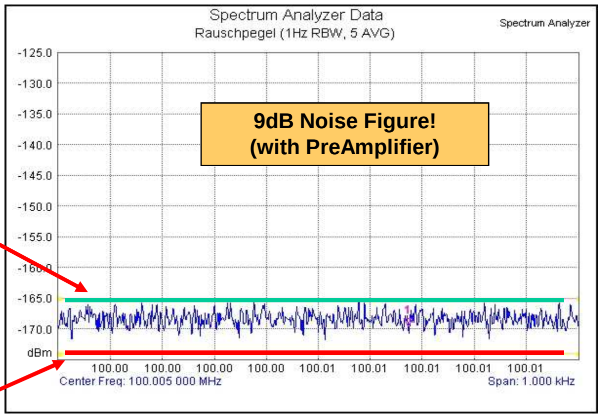
Noise Level (DANL) with PreAmp

- Noise Energy from a 50 Ohm Termination
  - -174dBm/Hz (1Hz RBW Filter)
  - Thermal Noise



-165dBm (1Hz RBW)

-174dBm (1Hz RBW)

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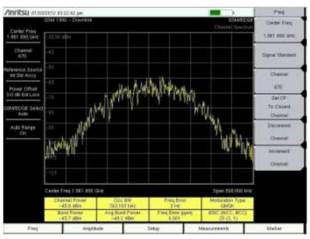
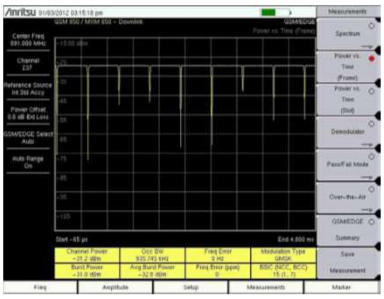
Advanced Spectrum Analyzer Measurements

- Time Domain Measurements
- Max Hold
- Save on Event
- Burst Detect
- Demodulations
- Spectrogram
- Mapping

Time Domain Measurements

- Also called ‘0 Span’
- Displays Amplitude vs Time (envelope of the signal)
- Allows for example to identify ‘real’ GSM signals or illegal transmitters.



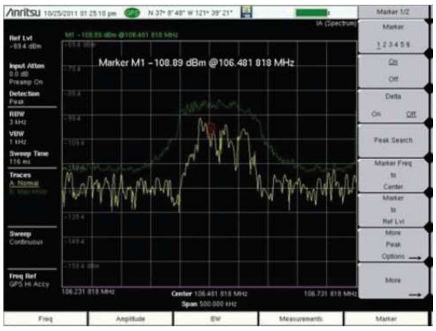


Max Hold Trace

Analyzers keeps displaying the highest signal (like a memory)

Allow to spot intermittent signal

You can overlay a 'Normal' trace with a 'Max Hold'

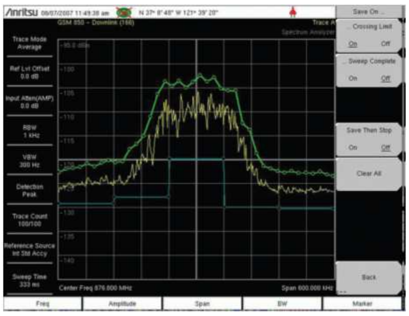


Save on Event

Generate automatically a Mask or Limit Line.

A trace is automatically saved if the spectrum violates the limit.

Allows long term monitoring of intermittent interferences.

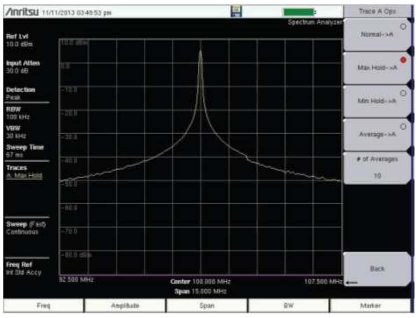


Burst Detect

Analyzers takes 20.000 measurements per second

Emitters as narrow as 200 µs can be captured every time.

Limited to 15MHz bandwidth



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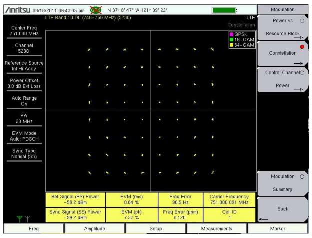
Demodulations

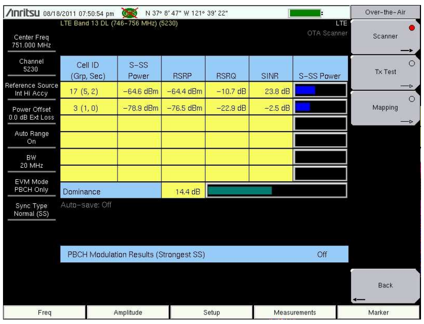


Display the I/Q constellation

Decode the Cell ID

Measure the synchronization channels

…



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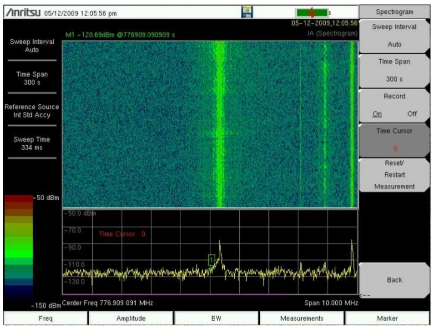
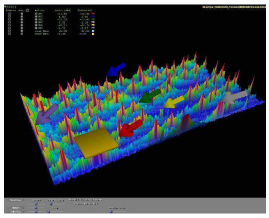
Spectrogram

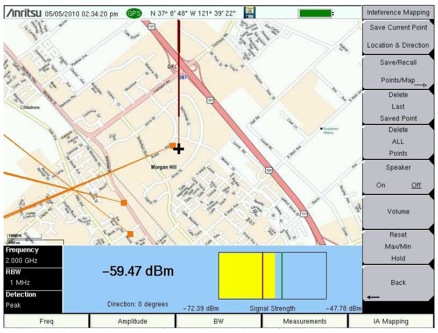
Used to monitor Spectrum Vs. Time, useful to identify intermittent interferences





Interference Mapping

Locate the source of Interference by triangulating the signal



Anritsu Portfolio

	MS2711E	MS2712E	MS2713E
Frequency	3 GHz	4 GHz	6 GHz
RBW	100 Hz	1 Hz	1 Hz
VBW	10 Hz	1 Hz	1 Hz
DANL *	-142 dBm in 100 Hz RBW	-162 dBm	-162 dBm
Phase Noise (@10K offset, 1 GHz)	-90 dBc/Hz	-100 dBc/Hz	-100 dBc/Hz
Preamplifier	Option	Standard	Standard



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Demodulations

MS2720T

Option 709 9 kHz to 9 GHz
Option 720 9 kHz to 20 GHz
Option 743 9 kHz to 43 GHz
Option 713 9 kHz to 13 GHz
Option 732 9 kHz to 32 GHz

Option: CPRI Interface

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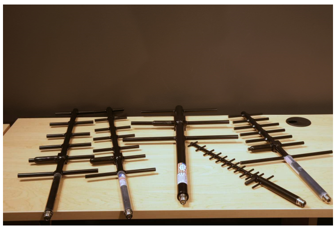

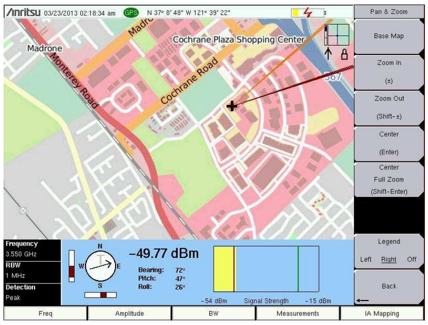

Demodulations

MS27101A
½-Rack mount single input

MS27102A (IP67)
1 Port *(2 Port Optional)*

MS27103A
Full rack 12/24 Port

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