Interference Analysis and Spectrum Monitor Seminar

Handheld RF & Microwave Instruments

Andrew Benn
Business Development Manager
Agilent Technologies

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Agenda

- RF Spectrum Analysis Overview and Back to Basics
- Key Types of RF Interference, Identification and Troubleshooting techniques
- Best Practises in the Field Testing
- More useful tools for Interference Analysis
- Additional resources to learn more
Why Measure the RF Spectrum?

- Look for possible interfering signals
  - Spurious emissions are large problems in most wireless communication systems
  - Frequency domain readings identify individual and specific carriers

- Identify out of band signals

- Detect intermodulation distortion or other possible man-made and natural interferers

- Using a spectral display to aid in locating a radio signal or it’s direction.
Overview
Frequency versus Time Domain Measurements

- Amplitude (power)
  - Time domain Measurements (Oscilloscope)
  - Frequency Domain Measurements (Spectrum Analyzer)
Theory of Operation
Swept Spectrum Analyzer Block Diagram
Types of Spectrum Analyzers

N9912A FieldFox
RF Analyzer
Cable antenna tester with spectrum analysis option

N9340B/42-43-44C
Handheld Spectrum Analyzers
Spectrum Analyzer Initial Settings

- **Frequency** – Adjust the frequency range measured, entered as Start and Stop or Center frequency
- **Span** - Adjust how closely you look at the signal to observe the amount of spectrum to view with the analyzer
- **Amplitude (Ref Level)** – Adjust the view of the signal’s level to measure the power level of the measured signal
Spectrum Analyzer Secondary Settings - Resolution Bandwidth

- Resolution Bandwidth of a spectrum analyzer determines how detailed the spectral display will be and the smallest frequency that can be resolved. The following graphs represent the same signal with varying RBW.

![Graphs showing different RBW settings](image)

- 100 kHz RBW
- 10 kHz RBW
- 1 kHz RBW

Same signal for all 3
Sweep time

- Resolution bandwidth affects sweep time, and we care very much about sweep time. Sweep time directly affects how long it takes to complete a measurement.

- Short sweep time or multiple traces (with max hold) are critical to capture intermittent RF signals.
Adjusting the Sweep of the Spectrum Analyzer

- If you have set the frequency, amplitude and span of the spectrum analyzer, the most important adjustments have been made.

- The following settings allow the user to make adjustments to sweep to get better resolution of the display and more detail of the information contained:
  
  - Single vs. Continuous Sweeps
  
  - Sweep Averaging
Sensitivity / DANL (1)

- Sensitivity is the smallest signal that can be measured.
Sensitivity / DANL (2)

- Effective level of displayed noise is a function of RF Input Attenuation.
- Signal to Noise ratio decreases as RF input Attenuation is increased.
Sensitivity / DANL (3)

- Displayed noise is a function of IF filter bandwidth.
- Decreased IF bandwidth provides decreased noise.
Sensitivity / DANL (4)

- Video bandwidth or Trace Averaging smoothes noise for easier identification of low level signals.
Sensitivity / DANL: Summary

- For best sensitivity use:
  - Narrowest resolution bandwidth
  - Minimum RF Input Attenuation
  - Sufficient Averaging (Video or Trace)

  or simply press ‘high sensitivity’ on Agilent HH SA
Phase Noise what is it

Example: Phase noise, from a source.

Same signal, but at lower level from the source.

Minimal Phase noise
Phase Noise what it can hide

Example: Phase noise, from DUT over-driven amplifier. This is how phase noise can hide a signal.

Signal buried in the Phase Noise, but can be measured below

Minimal Phase noise
Optimizing Dynamic Range – final note

- The ratio, expressed in dB, of the largest to the smallest signals both present at the input of the spectrum analyzer that allows measurement of the smaller signal to a given degree of uncertainty.

- What determines dynamic range? Analyzer distortion, noise level and phase noise.

- How to test for distortion? Increase input attenuation – look for signal amplitude change. Set attenuator at lowest setting without change.
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RF Noise

Natural Noise Sources
• Lightening
• Electrostatic discharge
• Solar flares
• Geomagnetic storms
• Thermal noise

Man Made Noise Sources
• Power line surges and pulses
• Electric motors
• Wireless and radio frequency transmissions
• Television and radio transmitters
• High frequency signals (Microwave, Radar, Doppler)
• Switching power supplies
• Microwave ovens
• Mobile and wireless phones
• Continuously operating spark gaps (welders)
• Industrial, scientific and medical equipment
We classify interference signals in a number of different ways: frequency channel, frequency band, direction of interfering signals...

- In-band interference
- Out-of-band interference
- Co-channel interference
- Adjacent channel interference
- Uplink interference
- Downlink interference

Classifications by the source of interference signals include:

- System internal interference
- External interference
Continuous, transient and harmonic interference

- Continuous interference - source regularly emits a given frequency or range of frequencies.
- Pulse, or transient, interference - source transmits or emits a short duration (pulse) of RF energy.
- RF harmonic interference = component frequency of the signal (integer multiple of the fundamental).

HH SA analyzers apply technologies: multi-trace, simultaneous display, Max Hold and Spectrogram, to effectively capture transient or discontinuous signals.
Co-channel interference

- This is probably the most common type of interference - joint operation or action of signals competing for the same frequency in the radio system.

- Receiver co-channel interference is defined as undesired signals with frequency components that fall within the passband of the receiver and are allowed into the passband of the Intermediate Frequency (IF) stages via the radio’s mixer.
Co-Channel Interference Troubleshooting

- First, setup your test set to display a wide span, covering your assigned bandwidth and 25% more bandwidth. Look for obvious signals (also called “Birdies”) on the spectral display. Verify your signal vs. interference by powering down your transmitter. Keep an eye on the display to observe any differences. You should see your signal drop and no other interferers on the display. If there is an obvious offender and it’s of a significant power level you will now need to use triangulation to locate the source.

- Secondly, if the signal is very weak or non-existent, optimize your spectrum analyzer by narrowing the bandwidth to the desired carrier frequency and keeping your RBW as small as possible. Try to remove most of the internal attenuation (don’t overdrive the test set) and use a pre-amp if possible to capture the smallest level of a possible interferer. Caution, a pre-amp may amplify enough noise to hide the interferer signal, try it both ways to find the best settings.

- Lastly, utilize the analyzers Trace Features such as Spectrogram to look for transient or discontinuous signals. Remember, the interference may be intermittent and may take hours, days or weeks to locate.

![Main carrier turned off (captured with trace hold)](image1)
![Co-channel interference](image2)
![No Co-channel interference](image3)
Adjacent channel interference

- Common type of interference. The unwanted signals originate from an adjacent, or nearby channel. These signals are either higher or lower in frequency and are competing for the same frequency in the RF system. These signals must be of a sufficient amplitude to produce non-linear effects within the receiver’s RF amplifier, IF, or mixer stages.

- These signals can also be spectral splatter or re-growth into adjacent channels.
Adjacent Channel Interference Troubleshooting

- Very similar to Co-Channel Interference (see previous Co–Channel troubleshooting page).

However you will **widen the spectral display span** to either the lower or higher frequency range to determine if the noise is indeed encroaching on your carrier’s assigned frequency. Another trick to uses is to turn on OBW measurements and see if you are exceeding your assigned bandwidth.

Example here shows a CDMA signal exceeding it’s 1.3 MHz bandwidth due to an overdriven power amp.
Transmitter noise interference

- Transmitter noise can cause interference problems that are a result of the thermal noise generated in the driver, final amplifier, or Power Amp (PA) stages as well as the noise from lower level transmitter stages.

- This is a broadband noise that usually does not cover the immediate modulation sidebands. The level may be specified as the power per bandwidth as a function of frequency (dBm/Hz) or specified at the Half Power points (3dB) and may be intermittent to distant stations.
Again, this is very similar to Adjacent and Co-Channel Interference (see previous pages) however you will **widen the spectral display span to either the lower or higher frequency range** to determine if the noise is indeed encroaching on your carrier’s assigned frequency.
Intermodulation distortion

- Intermodulation, or “Intermod” for short, and Intermodulation Distortion (IMD) are one in the same. This interference is the result of two or more signals of different frequencies being mixed together, forming additional signals at frequencies that are not, in general, at harmonic frequencies of either.

- IMD can be created by various methods and can be one of the hardest (by far) interference problems to locate and correct.

- One form of IMD is undesired signals that result from the local mixing of a transmitter’s output emission with that of another transmitter. The mixing usually occurs in the non-linear circuits of a transmitter whose antenna receives a high level of RF from another transmitter antenna in close proximity. The mixing products are radiated by the transmitter’s antenna as possible co-channel or adjacent signal interference signals.

However, even passive components (not powered or boosted) can perform in a non-linear manner and cause Intermodulation. Passive Intermodulation (PIM) occurs in passive components. Intermod calculators are often used and available on the web to assist in determining possible frequency combinations.
Final tips - Avoid saturation or overloading of the handheld spectrum analyzer

1. Connect with bandpass filter to filter out strong signals, e.g. the downlink signals from a base station.

2. Do not point the directional antenna to a transmitter

2. Turn off preamplifier and tune up attenuation – if the sensitivity allows
Summary: Steps for Interference Troubleshooting

• If you suspect interference problems.
  ➢ Review reports from users, optimization engineer or system tests.
  ➢ Monitor and listen for telltale signs.
  ➢ Pay attention to verbal clues like a stated location or a station ID.
  ➢ Try to determine internal or external noise source.
  ➢ Perform a antenna line sweep to identify possible problems.

• Analyze the RF system and confirm the existence of interfering signal
  ➢ Check system receive power levels using system antennas.
  ➢ Identify if problem is on one or several system frequencies.
  ➢ Monitor or demodulate suspect signals.
  ➢ Determine the type of interference in reference to the carrier signal being interfered with.

• Detect the source of interference
  ➢ Utilize the spectrum analyzer features to increase sensitivity and directivity to produce and record a spectral representation of the offending signal.
  ➢ Confirm the type of interference suspected in causing the problem.
  ➢ Power off suspect systems in an effort to isolate the interfered source.
  ➢ Characterize the signal source and attempt to isolate common elements (motors, welders, microwave ovens, transmitters) within close proximity.

• Locate the source of interference
  ➢ Utilize the spectrum analyzer features to increase sensitivity and directivity.
  ➢ Utilize existing sector antennas in the area of the suspect signal.
  ➢ Use a directional antenna and get as high as possible to avoid signal direction changes caused by reflections.
  ➢ Test at several locations to plot multiple receive vectors on a local map source.
  ➢ Narrow down the suspected source area by driving or walking.
  ➢ Now find the owner and start negotiating a mitigation strategy.
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Other useful tools for interference measurement

Peak table tracks the top/bottom signals

Use AM/FM and ASK/FSK tuner to “decode” the interference signals

Remote measurement capability
Spectrogram – capture transient signals over time

- Spectrogram record and playback. Save to internal memory (64 MB) or external USB memory flash
- Dual-view: spectrum and spectrogram
- Two markers available to display frequency, amplitude and time information
- Audio alert to indicate signal strength in a specified frequency range
- GPS information can be tagged to spectrogram data

<table>
<thead>
<tr>
<th>Update interval</th>
<th>Recording time by a .trc file (1500 frames Max, 4 MB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 second</td>
<td>Approximately 38 minutes</td>
</tr>
<tr>
<td>10 seconds</td>
<td>Approximately 4.5 hours</td>
</tr>
<tr>
<td>30 seconds</td>
<td>Approximately 12.8 hours</td>
</tr>
<tr>
<td>300 seconds (5 minutes)</td>
<td>Approximately 5 days</td>
</tr>
</tbody>
</table>

Two markers available with readout include time info

Save spectrogram files into external USB memory devices
- Faster
- Larger memory
Typical wireless signals using Spectrogram

GSM uplink

CDMA uplink

WCDMA uplink

GSM downlink

CDMA downlink

WCDMA downlink
Task Planner – automate routine tests in the field

Task planner (opt TPN) saves up to 95% test setup time on regulatory checks of multiple base stations or radio transmitters

- Execute a series of tests following a pre-defined test task plan
- No external PC required for field measurements
- Share the task plan easily via email or USB flash drive

3 SIMPLE STEPS...

Create the task planner file with the free HSA PC software

N9344C will execute tests automatically

Report will be generated with screenshot
Additional resources to learn more

- [www.agilent.com](http://www.agilent.com)
- [www.agilent.com/find/hsa](http://www.agilent.com/find/hsa)
- [www.agilent.com/find/fieldfox](http://www.agilent.com/find/fieldfox)


- YouTube URL: [http://www.youtube.com/watch?v=q_EPkF7tUkg](http://www.youtube.com/watch?v=q_EPkF7tUkg)

Thank you for your time!

Questions?