Application Note

Anritsu envision : ensure

RF Interference Hunting Concepts

Spot, Find, Fix

Spotting Interference or What Am I looking for?

As wireless services grow, due to a drive for increased download speeds and capacity, interference, once uncommon, becomes a fact of life for wireless and broadcast services. A metropolitan area of a million people may have 1000 licensed two way radios, 600 cell sites, and 100 broadcasters. To this mix, add military, aeronautical, and emergency services. And then there are all the lower powered unlicensed signals such as Wi-Fi or wireless video cameras. If you consider that many of these services are expanding, being modified, aging, or failing, it becomes evident that interference will be an issue.

First Indicators

The first indicators of interference are noisy links, for analog systems. Legacy AM and FM systems indicate interference problems by various noises. Hiss, hum, or even voices from other transmissions can be heard. For digital transmissions, such as HDTV, cellular, or P25, interference shows up as limited range, dropped calls, or low data rate. That familiar waterfall sound on your cellular phone indicates poor reception and a high bit error rate, which might be caused by interference.

A second indicator of interference is a high noise floor in the receive channel. Interference naturally affects reception first, where the signal levels are normally small. Some radio systems, cellular systems in particular, monitor the receive noise floor level specifically to detect poor reception conditions. Broadcasters, who don't receive, rely on customer complaints and field measurements instead.

A high receive noise floor is the diagnostic for interference. This warrants an interference hunt and identifies the geographic starting point.

Spotting Interference in the Field

Once a high receive noise floor has been identified, it's time to get a spectrum analyzer out and take a look. The first and best place to start looking is at the input to the receiver. If the receiver has a pre-filter, it's best to measure the signal after the pre-filter. This will allow you to see what the receiver, and the receiver's antenna, sees. The idea is to 1) measure the receiver's noise floor, and 2) to look for any obvious interference that might be present at the input to the receiver. It's important to get a "visual ID" on the signal at this point so you can be sure you are on the same signal later.

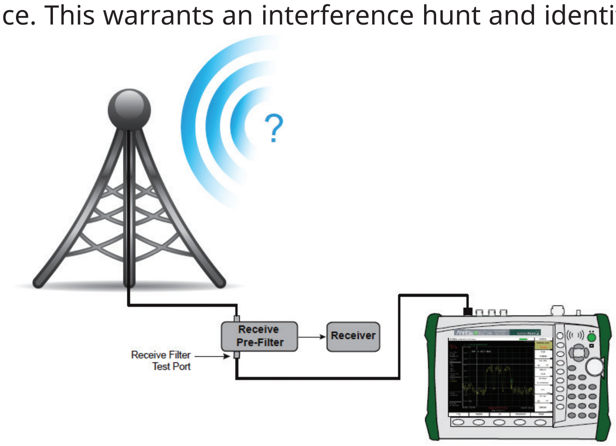

Figure 1. Spectrum analyzer hooked up to the test port of a receive pre-filter

What to look for?

Interference, as we have said before, is a receive issue. This means that you need to be looking for interference on receive frequencies. If you are working a cellular issue, and the base station has a high noise floor, you need to be looking on the uplink channels, not the downlink. If the issue is, instead, cell phone reception in a given area, then you would look on the downlink frequencies, since that is what the cellphone receives. Two Way Radio and other Push-to-Talk systems often use the same frequency for both the uplink and the downlink so this distinction becomes less important for them.

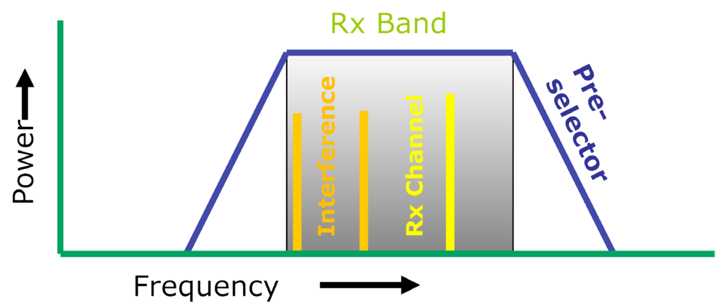

Figure 2. Interfering signals may be off-channel but in-band

A key point is that an interfering signal does not need to be on the receive channel to cause interference. It only needs to be within the receiver's bandwidth, which normally means that it only needs to get past the receiver's pre-filter. Once an interfering signal is present at the input of a receiver, it affects the receiver's front end, causing a reduction in sensitivity. This will cause the effective carrier-to-interference ratio (C/I) to be lower and result in all the symptoms of a weak signal (noisy, waterfall effect, low data rate, dropped calls), except that the received signal strength measurements will be strong due to the high noise floor. It's as if you were at a noisy party, trying to hear a soft-spoken person while the band was playing. Plenty of information is getting to your ears, but much of it is preventing you from hearing the conversation.

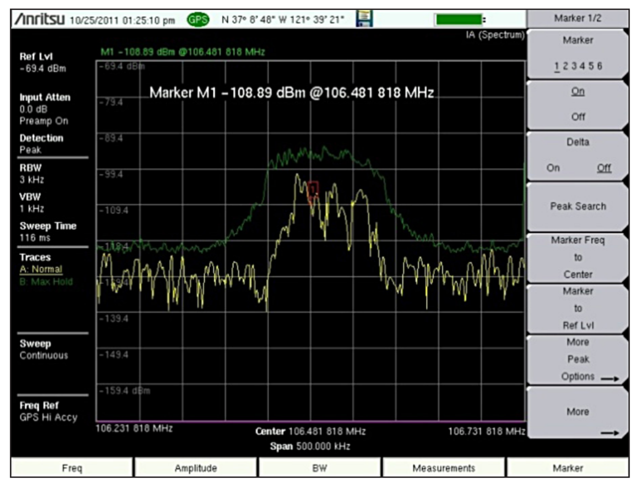

Figure 3. Using a Max-Hold and a Normal trace to characterize an intermittent signal

This interference mechanism is called Receiver De-Sensitization, or Receiver Desense. In extreme cases, it can even result in Receiver Blocking. The key take-away is that interfering signals are 1) on your receive frequencies, and 2) need not be on your receive channel.

Characterizing Interference

Once the interfering signal is spotted, it's important to characterize the signal before disconnecting from the receiver's test port. To characterize the signal, adjust the spectrum analyzer's pre-amp, reference level, span, and resolution bandwidth controls to get the best view that you can. Observe the signals' shape, bandwidth, and behavior over time. Look for frequency drift, amplitude changes, and frequency hopping. If the signal is intermittent, or turns on and off, use the Max-Hold trace function to create an envelope. If you have spectrogram capability, this can be used to check for periodicity. For signals that are intermittent with a long time between appearances, it can be helpful to use a "Save on Event" capability. This capability uses a mask automatically generated from the "normal" signal and only saves a trace when something unusual appears. Once saved, the traces can be examined for time-of-appearance, and signal characteristics. Most of all, make sure you will recognize the signal if you see it in another context.

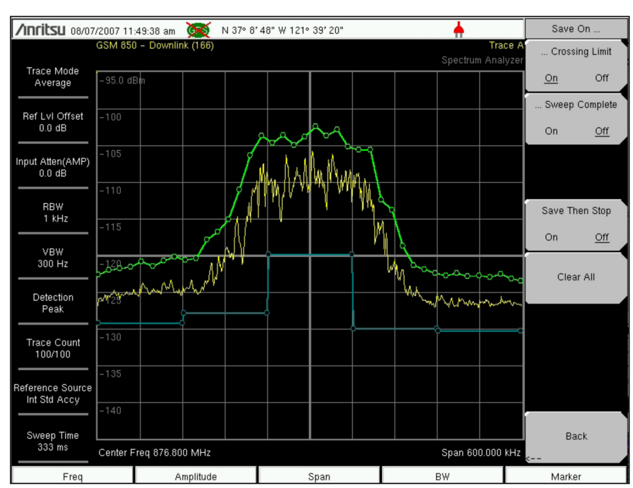

Figure 4. Save-on-Event masks

Identifying Signals

One reason we mentioned using the test port on a receive filter is that this filter will prevent many signals from getting to the receiver. By using the receiver pre-filter test port, these eliminated signals are also not present at the spectrum analyzer input, saving you the time it would take to sort through signals that don't matter, and making your task simpler. If you don't have a pre-filter on the uplink receiver, and have an interference problem, it's likely time to get one!

While you are looking for signals that don't belong on the input to your receiver, it's important to know what signals are typically present in your bands. For instance, if you are chasing inference on a LTE base station, it would be helpful to know what the signal from a LTE cell phone looks like, which is a valid uplink signal, before you start chasing it as if it was interference! It's also important to know what other signals may be present, legitimately. This can save a lot of time when hunting signals. For instance, it's quite possible that a strong signal from a nearby transmitter in an adjacent band is getting through your pre-filter. This is common near band edges. It helps to know just who might be putting out interfering signals, and this knowledge can be an excellent short cut when hunting interference. If you can glance at the spectrum analyzer and confidently say "That's from company XYZ" the problem is much closer to being solved.

If this is not possible, and often, it is not, it may be possible to demodulate the signal and listen for the station ID call sign. Call signs are required to be transmitted at least every half hour. TV and Radio station call signs can be heard when using AM or FM demodulation techniques on the spectrum analyzer. Pagers typically transmit a Morse code station ID at the start of every page. This can be heard, using FM demod, or observed in Zero span.

Sometimes, it is possible to identify a signal by its frequency and location using government databases. For instance, in the United States, the Federal Communications Commission maintains a database of signals and locations, linking them to owners, with contact information. Unfortunately, some of these data bases suffer from being out-of-date.

Intermittent Signals

Some signals may be intermittent. Hopefully, they are periodic, or at least repeat with some discernible pattern. When they are short term intermittent (burst) signals, it can be helpful to use Max-Hold on Trace B, while keeping the Trace A in the normal view. This allows you to see the shape of a bursty signal and may help with visual identification. If your spectrum analyzer has a Burst Detect feature, you will be able to reliably spot signals that are only on for a few hundred microseconds. Burst Detect can change hunting for a bursty signal (Wi-Fi, Bluetooth, and most cellular uplink signals are bursty) from an exercise in frustration to something that you can do quickly and efficiently.

Other signals may be intermittent over a longer period. Spectrum analyzers have two tools for these types of interfering signals. The first is called "Save-on-Event" and uses an automatically generated mask to spot unusual changes in the signal. Once spotted, the trace is saved for later analysis.

The Spectrogram shows how signals change over time. This colorful display has Frequency on the horizontal axis, Time on the vertical axis, and shows changing power levels as different colors. The time scale can be varied, depending on just how slow it needs to be to capture changes. The Spectrogram color axis can be changed to better show the signal of interest. In general, the Spectrogram is an excellent tool for spotting patterns. The signal in the adjacent figure is unstable in frequency. This clearly shows up in the spectrogram. This sort of oscillation in frequency is characteristic of a repeater with insufficient isolation between its input and output antennas.

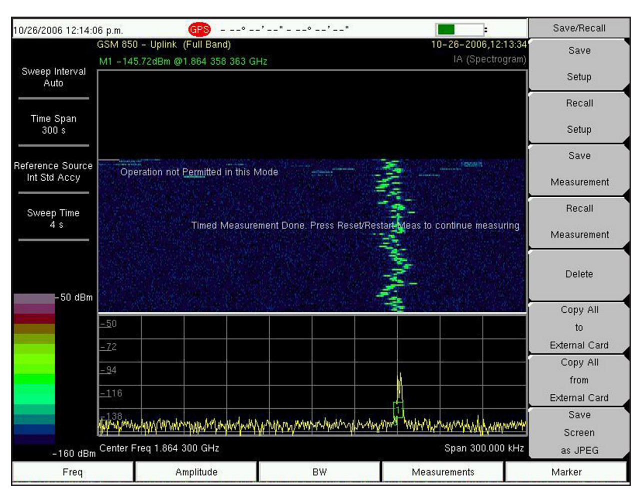

Figure 5. A Spectrogram display shows how signals change over time

Remote Spectrum Monitoring

Sometimes, characterizing signals is not quick or easy. If the signal is only present occasionally, or if a very fast response time is necessary, a short term or long term spectrum monitoring solution may be necessary.

These systems use spectrum analyzers left at a location, or locations, for a period of time. This can be as simple as setting up a handheld spectrum analyzer to record traces and checking back in a week, or as focused as using dedicated rack mount analyzers in combination with networked software to continually characterize the spectrum and locate interference sources. More information is available in these Anritsu application notes:

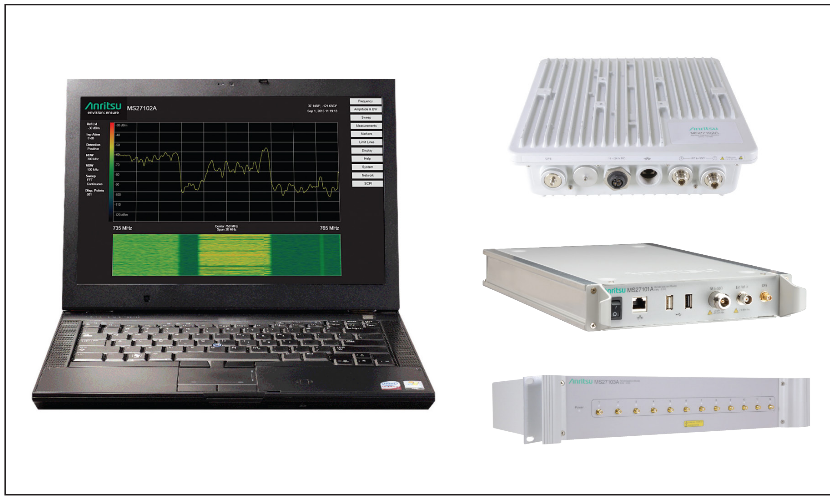

Figure 6. Remote Spectrum Monitoring components

- "*Spectrum Monitoring Techniques*" is focused on the use of a traditional handheld spectrum analyzer for remote monitoring. It covers the setup and capabilities of these analyzers in-depth. The information presented in this document also applies to the rack mount spectrum analyzers.
- *"Applications of Remote Spectrum Monitoring"* covers the dedicated rack mount spectrum analyzers as well as the networked software that can be used with it.

Once an interfering signal is identified and characterized, it's time to find the source. That's what we will cover next.

Interference Mechanisms

When starting to hunt interference, there are a series of questions we need to ask:

- Is it On-Channel interference?
- Is it In-band interference?
- Is it Impulse Noise?
- Is it Harmonics?
- Is it Passive Intermodulation?
- Is it a Near Far problem?
- Is it intentional?

The answers to these questions will let us better identify the source. Let's look into these one at a time.

On-Channel Interference

This can happen to broadcasters due to channel assignments that are close in frequency while also being geographically close. It can also happen due to variations in the ionosphere, which will cause signals to travel further. The classic example of this is how distant AM radio stations can be received easily at night, but not during the day.

Cellular providers have a wider variety of issues. Often, they use a tiling pattern for the cells, assigning frequency or codes in this pattern, which helps control cell overlaps. Factors that can cause excessive overlap, as shown between two cells near the top of the illustration include:

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

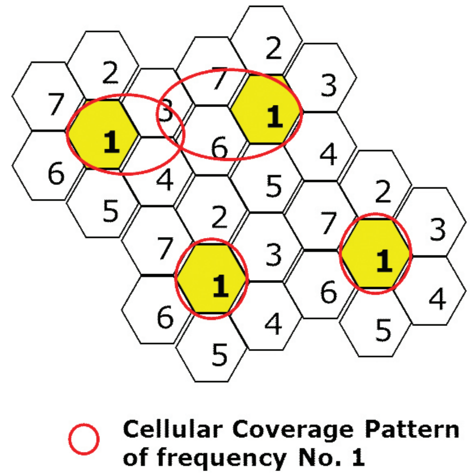

Figure 7. Cellular tiling patterns

Antenna tilt, valleys, and antennas mounted on high buildings all have a common cause. The antenna is transmitting further than intended because it is aimed too high. Water, oddly enough, allows radio waves to propagate better than over land. It is similar to how sound travels better over water than land. This can be a particular issue at national borders where a river or gulf forms part of the border.

CDMA systems are quite tolerant of multipath. However, when the multipath exceeds the capability of the phone’s rake receiver to delay signals, the resulting “extra” paths are seen as interference. Typically, phones can handle 4 or 5 signal paths and still get signal gain. If there are more paths, they are seen as interference.

LTE systems, which are typically all on the same channel, are sensitive to sector overlap issues. The most common effect of excessive overlap is lowered system capacity.

Another common in-channel interference issue is passive intermodulation (PIM) which can come from within the victim antenna system or from an external source. We will discuss this further later in this paper.

In-Band Interference

As we noted before, interference does not need to be on the receive channel. If the interfering signal is within the pass band of the receiver’s receive filter, that is often sufficient to cause receiver desense. These signals can come from:

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

The key point is that a signal does not need to be on the receive channel to cause interference. It only needs to make it through any receive filter to the front end of the radio receiver.

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:

- Lightning suppression devices at a site
  - These arc suppressors work by allowing excess voltage to arc to a ground. Over time, as they age, the breakdown voltage tends to lower, to the point where the higher power legitimate RF transmissions can cause arcing, which can create receive interference.

Figure 8. Lightning suppression device

- Electrical motors from elevators, floor buffers or even FAX machines
  - Many types of electric motors have brushes, which can create quite a bit of arcing and sparking. Have you ever looked into the back end of an electric drill and seen the blue sparks around the brushes? That's a good example of impulse noise caused by an electric motor.

Figure 9. Bakery oven

- Bakery ovens
  - Bakery ovens have high wattage heating elements (over 2,000 watts). The ovens are typically regulated by turning the heating element on and off as needed to maintain the desired temperature. This switching action generates impulse noise.

Figure 10. Welder

- Welding
  - This is a large electric arc that starts and stops every time the welder draws a bead. Need we say more?
- Electric fences
  - Electric fences generate a short pulse of high voltage then turn it off for a second or two. This allows shocked animals time to move away from the fence before it shocks them again.
- Power lines, which may arc and spark
  - Have you ever been near a high voltage transmission line on a damp or foggy day? Enough said.
- Light dimmers
  - Light dimmers operate by suddenly turning the AC power off part way through the power cycle of the sine wave. This creates impulse noise.
- Micro-arcing or fritting
  - Micro-arcing or also called fritting, is created when RF connectors do not make firm contact. Micro-arcing first shows up at peak RF power levels as wideband, intermittent jumps in the noise floor. This can be a 5 to 20 dB jump.

Most of these impulse noise sources affect the lower frequencies. It's hard to give a specific number, but it's unlikely to see impulse noise above 500 MHz. Micro-arcing or fritting is the exception, since it is generated by the RF signal itself, and can affect reception at any frequency. It is typically very broad-band, over a GHz wide. Micro-arcing or fritting can be caused by this sequence of cable mishandling:

1) Over torquing a 7/16 DIN connector - This causes the center pins to move back into the cable a bit
2) Re-opening the connection, perhaps as part of a test
3) Re-connecting the cables at the right torque, but now with a pair of center pins that do not make firm contact

There are many possible sources of impulse noise. This section is intended to give you an appreciation of possible sources. When looking for impulse noise, it is important to keep an open mind!

Harmonics

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. Typically, the odd numbered harmonics (300 MHz, 500 MHz and so on) are stronger than the even harmonics. Governing bodies normally regulate the power level of harmonics. However equipment does fail or go out of specification. Many of those failure mechanisms create high harmonic levels. Also, if the original broadcast is at a high power level, even legal harmonics can be powerful enough to cause problems.

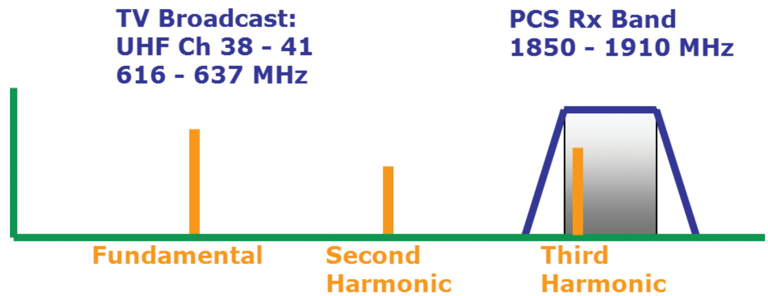

Figure 11. Harmonics can reach receive bands

For instance, if you have a 1 mega-Watt transmitter in your area, it may be required to have a third harmonic 60 dB lower than its effective radiated power. However, 60 dB down from 1,000,000 watts is 1 Watt. Your receiver is looking for power levels in the neighborhood of 0.000,000,1 Watt. You can see how a 1 Watt harmonic could be a serious problem if its frequency is within the pass band of your receive filter. Here's an example: A third harmonic of the TV channels between 616 and 637 MHz lands in the PCS receive band, which goes from 1850 to 1910 MHz. If a Cellular PCS band tower is physically near a high channel TV transmitter, this can be a problem.

Transmitters do break. If one transistor of a class B transmitter goes out, the transmitter will produce only half of the sine wave it should be transmitting. This will create high power harmonics across much of the RF spectrum. This sort of harmonic display is called a comb or a "picket fence" signal.

Passive Intermodulation (PIM)

This is also called the Rusty Bolt Effect. It is caused when two or more strong RF signals combine in some sort of non-linear device, such as a transistor, diode, or even the crystals found in corrosion or rust. This corrosion may even be outside the radio system. It can be caused by a rusty fence, rusty bolts, corroded rooftop air conditioners, or even a rusty barn roof. Of course, it's also possible that loose or dirty connectors in an antenna feed line or poorly configured transmitters can be the cause.

Figure 12. Rusty Bolts can cause PIM.

PIM requires at least two strong signals and a non-linear device of some sort. Once generated, PIM frequencies are very predictable. If you have two original frequencies, F1 and F2, the third, fifth, and seventh order intermodulation products will be found equally spaced above and below the two original signals. For instance, if the two original signals are at 900 and 910 MHz, other PIM products will be found at 920, 930, and 940 MHz. They also will be found at 890, 880, and 870 MHz. There are many cases were legitimate transmitters can produce PIM that falls into another radio's receive band. There are calculators available on-line that help predict where PIM might fall, given two or more source signals.

For more detail, Anritsu has an application note available called "Understanding PIM" that covers concepts, causes, and testing for PIM in detail.

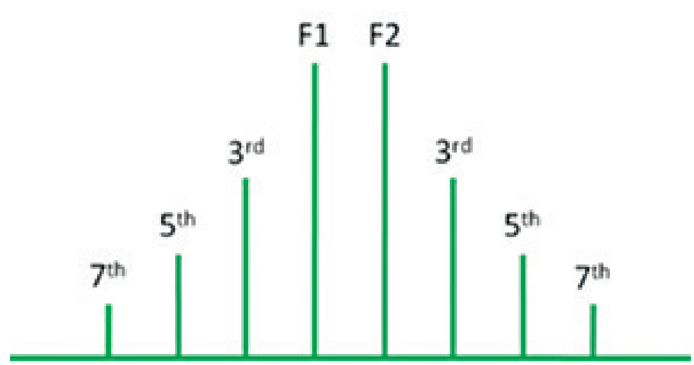

Figure 13. Harmonics can reach receive bands

Near-Far Problem

The Near-Far problem is the RF equivalent of two people trying to talk across the room at a loud party. The surrounding noise tends to make conversation difficult or impossible. 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.

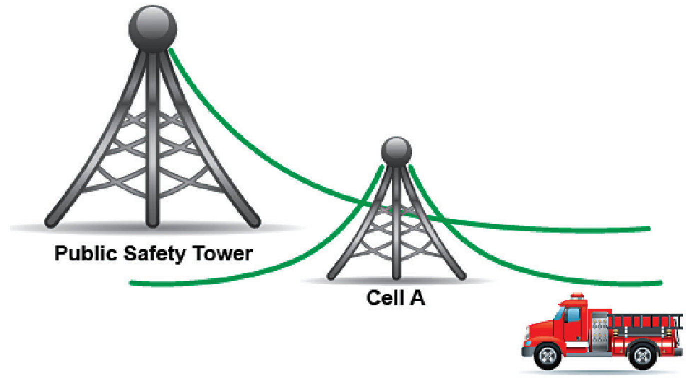

Figure 14. Near-far problems with cellular and point-to-multi-point transmissions

In the figure to the right, the green lines represent field strength of the respective transmitters. In this case, the fire truck is trying to listen to the public safety signal but has a radio receiver that is overwhelmed by the nearby cell tower signal. Two conditions must be present for this to happen: 1) The interfering carrier must have a frequency that is passed by the receiver's pre-filter and 2) The interfering carrier must be strong enough to desense the receiver. Solutions might include adjusting transmitter frequencies or improved filtering on the fire truck's radio receiver.

The near-far problem can also happen between cell towers, as long as the cell phone cannot make a handover. This may be the case near the edge of a metropolitan market where a cell phone of carrier "A" is broadcasting a strong signal to reach the distant cell tower of carrier "A." If there is then a cell tower operated by carrier "B" near that phone, the "B" carrier receiver may be temporary desensed by the loud Phone "A."

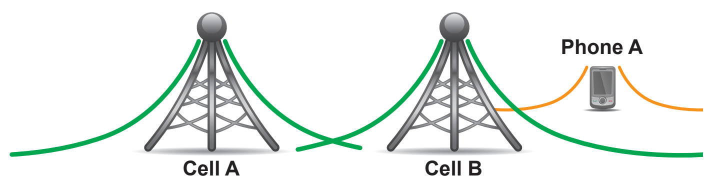

Figure 15. Near-far problems with cellular transmissions

Intentional Interference

Some sources of interference are intentional. A quick search of the internet using terms like "Cell Phone Jammer" will find dozens of companies specializing in jamming. Regulators take a dim view of this practice, as you would expect. Jammers can be found in shopping malls, where employers want to ensure employee productivity, in cars, or even in military bases. Generally, civilian use of jammers is illegal.

In the United States, the Federal Communications Commission has concentrated legal action on companies selling cell phone jammers, citing potential harm from interfering with emergency communications.

There are a wide variety of scenarios that can cause interference. Interference can be directly on a receive channel, in a receive band, impulse noise, originate as a harmonic, or come from passive intermodulation. In addition, it can be a near-far problem or even be intentional. Other common sources of interference include leakage from signals distributed on RF cable, such as cable TV or Last Mile signals, or even cordless phones. Knowing specific mechanisms that cause interference will help you spot interference in the field.

Figure 16. Intentional interferers

Spotting the Signal at Ground Level

If the signal is visible from multiple towers, the received power level can give you a rough guide to the signal location and the time of occurrences. If needed, there are commercial signal monitoring systems available from Anritsu that can refine this location and time data, providing the information needed to dispatch interference hunting teams.

Once a signal has been spotted and characterized using the tower's receive antenna, the next task is to find the same signal using a ground level antenna. The issue here is that a signal that is clearly visible at the altitude of the tower antenna may be obscured by terrain or structure at ground level.

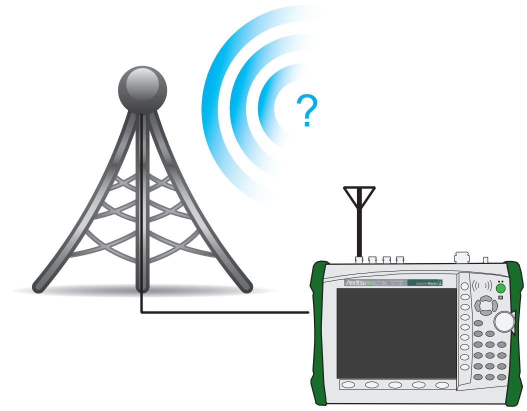

Figure 17. Spotting an interfering signal from the ground

If you have a monitoring system, you will have a fairly precise area to start the interference hunt in, and if you go to that location, it's quite likely that the signal will be visible at ground level. If not, the first thing to try is to see if the signal is visible near the base of the tower. If it is, the signal has been spotted at ground level and it's time to move to the next task, locating the source. If not, there are several things to try:

1. Check other sectors for the interfering signal. As mentioned above, the relative power levels can give you an idea of the signal location.
2. Try looking for the interfering signal from a nearby rooftop or top floor. In an urban area, this may be the best way to direction find. You are up above all the buildings that cause RF reflections with, hopefully, a clear line of sight to the source.
3. Try moving to a hill of some sort. This can also give you a clear (or clearer) line of sight to the RF source.
4. Investigate nearby valleys, swales, or other low spots. If a RF interference source is in a valley, the radiation pattern will be only visible when you have a direct line-of-sight inside the low spot.

Locating the Source

Once the signal has been spotted at ground level, it's time to move to the next step, locating the RF source. Anritsu offers a number of methods to do this.

Mobile InterferenceHunter™

Anritsu's Mobile InterferenceHunter is a quick way to locate characterized signals. Using an Omni antenna, a tablet, and an Anritsu handheld spectrum analyzer, the system allows you to reliably locate signals to within a block. It's ideal for multi-emitter sources, such as cable TV system leakage, spotting pulsed or bursty signals, and even some spectrum clearing tasks. It's robust enough to deal with reflections, shadowing and multi-path. For more information, please see the Anritsu application note "Mobile Interference Hunting System." This note covers a number of use cases in-depth.

Handheld InterferenceHunter™

The Handheld InterferenceHunter is a spectrum analyzer based mapping system that makes taking directional bearings to an interference source simple. Using GPS technology, it can be used to locate signals from a distance, in situations where there is a clear line-of-site to the source.

Figure 18. The Hand Held Interference Hunter in-use

It’s also ideal for locating interference sources previously localized by the Mobile InterferenceHunter. It’s accurate enough that it is possible to walk up to and touch a source with the antenna, if the source is accessible by foot. Available accessories include directional antennas and band pass filters to ensure best performance. For more information, see the application note “Hunting Interference with Anritsu’s Handheld InterferenceHunter.”

Spectrum Analyzer and a Directional Antenna

A basic interference hunting method uses a directional antenna and a spectrum analyzer without signal mapping. The technique is powerful, but does require a knowledgeable user. It’s quite helpful to have one trace live, and a second trace on Max-Hold. This will give you a visual indication when the antenna is pointing towards the strongest signal. When using this method, you need to be aware of possible RF reflecting surfaces.

Figure 19. Using a directional antenna, a Max-Hold and a Normal trace to detect the direction of the largest signal

Spotting the Source

Using one or more of the techniques listed above, you should be able to find the interference source. As mentioned above, it is possible to even end up with your antenna touching the source, if it is accessible from ground level.

It’s helpful to look around for possible sources of the interference. If you are chasing a PIM signal, look for rust or loose connections. If in a residential neighborhood, look for consumer grade RF devices, like the TV remote pictured here, or a cable TV box that’s been damaged. Intentional jammers are also a possibility, and may be in a car or a place of business.

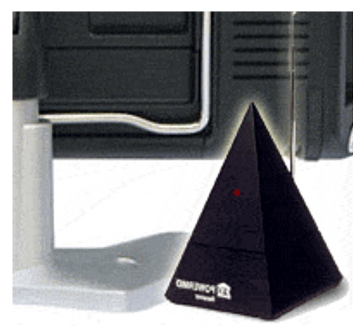

Figure 20. A RF TV remote can cause interference

Nearby radio transmitters are always a possible source of RF interference. They have the signal strength, and only need the right (or wrong) frequency, to become a problem. Antennas that are shared by multiple carriers or near rust are possible PIM generators. Finally, security cameras, wireless phones, and wireless microphones can be an issue. The RF linked video cameras seem to be a particular problem as they seem to be freely exported/imported without regard to local RF spectrum assignments.

What to Look for in a Signal Hunting Spectrum Analyzer

Some spectrum analyzers are more capable than others when looking for interference. Handheld spectrum analyzers clearly have an edge over bench instruments, since they can easily go to where the signal is.

Long battery life is important. If you are going to be spending hours away from power sources, good battery life is critical. 12 volt adapters for use in a car help, but in the end, you are likely to end up with the instrument in your hand, walking towards the interference source.

The ability to see small signals in the presence of large signals that may be nearby in the RF spectrum is important. This is specified as dynamic range. There are several different meanings to this term, depending on whose specification sheet you are looking at. However, for our purposes, we are talking about a spectrum analyzer that can see a small signal 90 or 100 dB below a strong signal, while both signals are present.

Another key capability is a fast sweep speed with a low resolution bandwidth. This allows the spectrum analyzer to sweep fast while still seeing a lot of detail. It’s hard to pin down a set of numbers here, because there are so many combinations of sweep speed and resolution bandwidth possible. However, a 1 MHz span is useful for many types of interference hunts. A good spectrum analyzer can use a 1 kHz resolution bandwidth to create a noise floor at –126 dBm, with a update rate of 3 sweeps per second.

Mapping is very useful when interference hunting. A key question during this process is “Where?” This is reflected in the common questions of “Where am I?”, “What direction is the signal coming from?” or “Where is the interfering signal strongest?” Mapping provides the “Where."

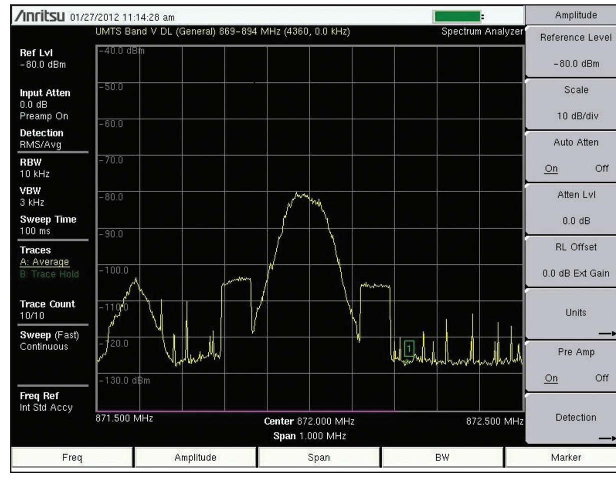

Figure 21. A fast sweep speed with good resolution

Fixing Interference – Reporting and Resolving Problems

Once interference problems are identified, the next task is to deal with the issues. The mapping capabilities of many handheld spectrum analyzers or interference hunting systems can be used as evidence. In addition, screen shots with a GPS location tag are useful for the same reason. These screen shots can be embedded in reports and in addition to the GPS information, include time, date, and signal strength information. This can clearly show the effects of the interference.

Many times interference issues can be solved without recourse to legal action. Often, a calm and clear explanation of the issues is enough to convince everyone involved to move towards a resolution. During this explanation, a handheld spectrum analyzer can be convincing. In some cases, this may be enough to resolve the issue at the time of discovery. If the interfering signal affects emergency services, or emergency cell phone locating services, the potential for harm can be very persuasive, as can the potential for fines.

Resolving the Problem

Filtering is often a solution. Earlier, we mentioned that interference needs to make it past the receiver’s pre-filter. Changing or enhancing the pre-filter often eliminates the problem.

Another solution, if the problem is related to passive intermodulation, is to clean up environmental diodes. This can range from tightening a rusty bolt, or replacing a RF connector to replacing a fence, air conditioner, or even a barn roof.

When the interference is from a co-located transmitter, the co-location contract often specifies remedial action in the event of interference. This can include filtering, turning off a transmitter, or even relocating.

Getting illegal or poorly preforming transmitters turned off is another solution. In the case where the signal is clearly illegal, the solutions are simpler.

Figure 22. Filtering can solve many interference problems

Band reject filters, or notch filters, on the receive input are quite useful. These can be used to reject or reduce the amplitude of a specific signal. A tighter band pass filter can be used to reduce the overall frequency range that reaches the receiver. After all, the receiver only really needs to have access to its receive channel frequency or frequencies. These additional filters can reduce the amplitude of out-of-channel signals and may even reduce or eliminate the effects of passive intermodulation interference.

Cleaning up sources of passive intermodulation can go a long ways towards restoring full service at a radio site. For a roof mounted site, cleaning up old pipes or air conditioning units can often solve the problem. In other cases, rusty fences, barn roofs, or even electrical armored sheathing will need to be removed or replaced. In some cases, making a good electrical connection between the two pieces is enough to eliminate the problem. With a good low resistance connection, the environmental diodes are bypassed and no longer carry current.

Figure 23. Cleaning up sources of PIM can cure interference problems

Figure 24. Replacing old gas filled lighting arrestors can cure some impulse noise problems

Gas filled lighting arrestors protect the radio by arcing when the voltage on the antenna line exceeds a pre-set value. These lighting arrestors' trigger voltage often drifts lower as they age. Eventually, the radio transmissions may trigger arcing. Because this behavior is associated with aging, it can be wide-spread across a cellular system. Changing the lighting arrestors will cure this issue.

Micro-arcing or fritting is another source of impulse noise. Viewed on a spectrum analyzer, the results looks quite a bit like bad lighting arrestors, but has a different cause. In this case, there are small arcs between the two center pin connectors, caused by insufficient pressure between the pins. This lack of pressure, in turn, is normally caused by over-torquing the connector at some point in its past. The over tightening will move the pins back into the cable a small amount, and will result in a poor fit the next time the connector is tightened. Micro-arcing may happen at peak power levels or when temperature changes make the fit a bit worse than usual. The fix is to replace the connectors and use a torque wrench every time the new connector is tightened.

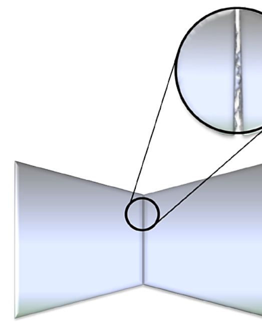

Figure 25. Cleaning up sources of PIM can cure interference problems

Summary

In this paper, we covered how to Spot, Find, Fix and Report on interference.

Spot

Interference can be spotted by a raised receive noise floor. The extra power on the receiver input, which is an un-desirable signal, will lower the receiver's sensitivity, or the receiver. A number of spectrum monitoring techniques were mentioned.

A good way to speed up the interference hunting process is to be able to recognize common signal types normally present in your bands. Sometimes, this will allow you to shortcut the interference hunting process and move directly to solving the problem.

If the signal is intermittent, a spectrogram display will help. This display type shows signal changes over frequency, power, and time. It is particularly useful when characterizing a signal that changes over time.

Find

The first place to look for interference is on a test port, or similar tap, on a radio's receive antenna. This gives the spectrum analyzer or monitoring system the same signal as the radio is seeing.

The second step in finding an emitter is to be able to see the signal with a portable antenna. Preferably, this is done at ground level, although in some cases, the search will need to start somewhere higher, perhaps on the roof of a tall building. In other cases, the search for a ground level signal will need to be done in a car, simply because of the pattern of the emitter.

Locating the source may be done with a combination of distributed spectrum monitoring systems, car mounted interference hunting systems, and handheld interference hunting systems. These tools can be used to resolve the most complex cases in the quickest possible manner.

Fix and Report

Once found, the measurements you gathered during the search can be used to document the interference. Documentation alone is often enough to resolve the issue. However in some cases, other action may need to be taken. This includes lowering signal strength, adding receive or transmit filters, adjusting antenna down-tilt, fixing passive intermodulation sources, or removing defective or illegal transmitters from service.

Appendix: Signal Monitoring, Interference Hunting, and Coverage Mapping Application Notes from Anritsu Company

Monitoring

- **Spectrum Monitoring Techniques (11410-00849)**
  This is a Techniques application note focused on using a handheld spectrum analyzer to best advantage in remote monitoring situations. It covers instrument setup and the concepts behind those setups, as well as a variety of techniques for gathering and analyzing data.

- **Applications of Remote Spectrum Monitoring (11410-00908)**
  This application note is focused on Anritsu's dedicated remote monitoring solutions and the software that goes with those solutions. Many of the tips and concepts from the Techniques application note apply to using these headless units.

Interference Hunting

- **Interference Hunting Concepts (11410-00972)**
  This is a concepts application note focused on Interference. It's essential to recognize signals that are, and are not, causing interference to your radio system. This application note covers the definition, causes, and solutions to many common interference problems.

- **Mobile Interference Hunting System (11410-00845)**
  Anritsu's Mobile InterferenceHunter provides a reliable way to locate interfering signals by their strength, to within a block. This application note covers five use cases with detailed instructions for each case.

- **Identifying and Locating Cable TV Interference (11410-00907)**
  This application specific primer covers how to use the Mobile InterferenceHunter to locate cable TV egress. This is a common cause of LTE uplink interference when cable TV installations are present.

- **Using Anritsu's Handheld InterferenceHunter MA2700A (11410-00973)**
  Anritsu's Handheld InterferenceHunter, in combination with an Anritsu handheld spectrum analyzer, provides an easy way to locate signals by direction finding. The white paper covers how to use the tool both with maps, in stand-alone mode, and in combination with the Mobile InterferenceHunter.

Coverage Mapping

- **In-building Mapping with the Anritsu S412E LMR Master and the MA8100A Series TRX NEON Signal Mapper (11410-00926)**
  This application note covers how to use Anritsu's in-building geo-referenced signal mapping solution.

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