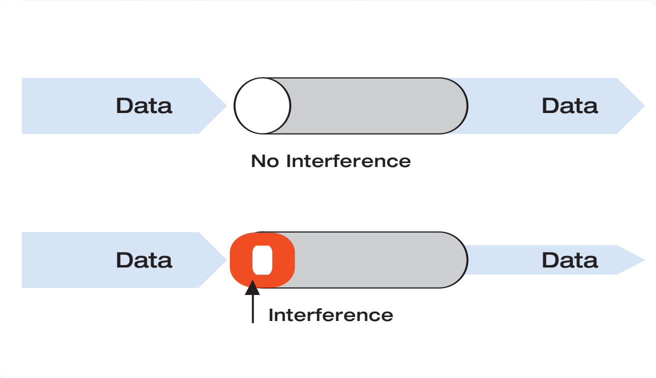
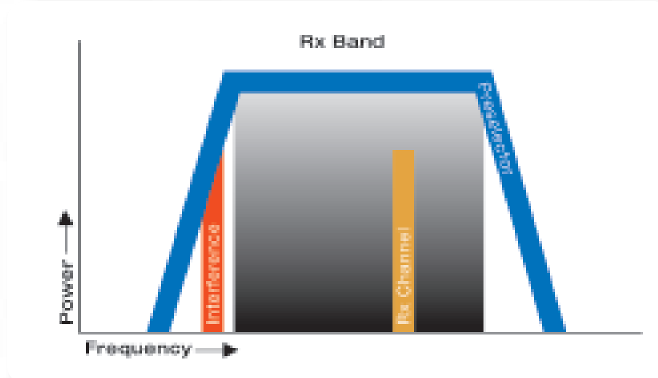
Hunting Interference with the Tektronix RF Scout

Interference in Today's Wireless Networks

Today's cellular systems often experience interference. This can show up as poor voice quality, dropped calls, or low data rates. As network operators add voice and 3G data services, the licensed bands become even more susceptible to interference. In addition, the trend to co-location of wireless systems, while desirable from some points of view, contribute to the potential for interference. This application note will discuss potential sources and types of interference and provide a simplified process to aid in the process of locating, troubleshooting and mitigating RF interference on your network.



▶ **Figure 1.** *RF interference restricts or limits the amount of data that can be transmitted through a RF path.*



▶ **Figure 2.** *Unwanted signals appearing in the uplink band of a transmitter can desensitize the receiver, or in extreme cases, block all reception.*

3G data services are particularly sensitive to interference. In this case, interference directly affects the data rate. As signal quality degrades, 3G systems add protection bits to the data stream. These extra bits ensure that the connection stays up, but slows the actual data. Even worse, if bits are still lost, higher data layers can force re-transmissions of the packets, slowing transmission rates even more. So data services don't normally fall into a "Pass/Fail" categories like voice calls usually do. Rather, data rates are affected, sometimes dramatically, by signal quality issues such as interference.

A data pipe makes a good analogy. One with little interference allows maximum bandwidth to pass. However when there is interference, the resulting data protection added by the 3G system reduces data throughput. This reduction can be dramatic.

In the wireless world, interference is simply defined as any undesired signal that diminishes the quality of voice or data traffic over the RF or Air Interface. This interference, often referred to as noise, is often the cause of dropped calls, noisy connections, and slow date rates. The fix is usually either installing more base station capacity or eliminating the interference. While interference has many causes, the result of interference is lower quality voice signals, lower data rates, and ultimately, user dissatisfaction.

Finding and fixing interference problems requires the ability to recognize potential sources of interference and the tools to locate those sources. So the first step in recognizing sources of interference is to understand how interfering signals do their damage.

Receiver De-Sense and Blocking

The mechanism of interference is a receiver characteristic called De-Sense, or in extreme cases, Blocking. It turns out that other people's signals appearing in your uplink band can reduce the sensitivity of your receiver. The interfering signals do not need to be on your channel, but may be in the same receive band. This is commonly called Receiver Desensitization or "De-Sense".

Because of this, receivers normally have a band pass filter, or pre-selector, designed to limit the frequency bands allowed into the receiver input. For instance a GSM 900 BTS receiver would have a band pass filter that passed signals between 880MHz and 990MHz (uplink band). By allowing these signals and rejecting others, the receiver is allowed to operate in a quieter environment. This allows the receiver to be more sensitive and receive quieter signals.

However, receiver pre-selectors do not normally have a sharp cut-off frequency. This is due to equal parts economics and limitations of the technology. If a legitimate signal is present in a nearby frequency band, as shown above, the receiver will sum the power of this signal with the power of the desired, in-band signal, and reduce its gain accordingly. This can cause the desired signal to be reduced to the point were it is noisy. The sensitivity of the receiver has been reduced, and that's where the term De-Sense comes from.

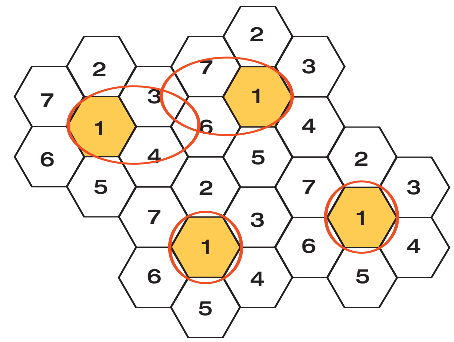
When a De-Sense problem becomes severe, reception may be completely prevented. The fault is now termed "Receiver Blocking."

▶ **Figure 3.** *RF interference is a reception issue.*

A low signal to noise ratio is the root cause of the poor reception. While De-Sense mimics a weak signal, it's important to remember that a weak carrier can cause as much trouble as interference. It's all about the signal to noise ratio.

Once reception is impaired, the receivers' effective signal to noise ratio is lowered, and the bit error rate goes up. This causes 3G systems to add more protection bits to the transmission, slowing it down. This effect can be dramatic. For example, in one popular 3G data standard, this effect can slow a data transmission from over a megabit per second to 36 kilobits per second. To make matters worse, higher layer protocols may call for retransmitted packets. The bottom line is that a clean data network is a fast data network.

The key points to remember about interference are that first, it's a reception issue. Second, the interfering signal must be within the pre-selector's frequency band, or at least within the skirts of the filter. Third, the interfering signal need not be on your channel. Now, let's look at sources of interference.



▶ **Figure 4.** *An improperly configured or faulty transmitter may result in a cell site exceeding its coverage area, thus interfering with neighboring cells.*

Sources of Interference

Sources of man made interference include co-channel interference, impulse interference, intermodulation, harmonics, and the near-far problem. We will look at each of these in turn.

Co-channel Interference

Improperly Configured Transmitter

In this case, another wireless system may be transmitting on or near your frequency. This is referred to as co-channel interference. This is usually the result of a fault or incorrect setting, so the other wireless system operator is usually glad to correct the mistake. Any time a new service is installed, there is potential for co-channel interference.

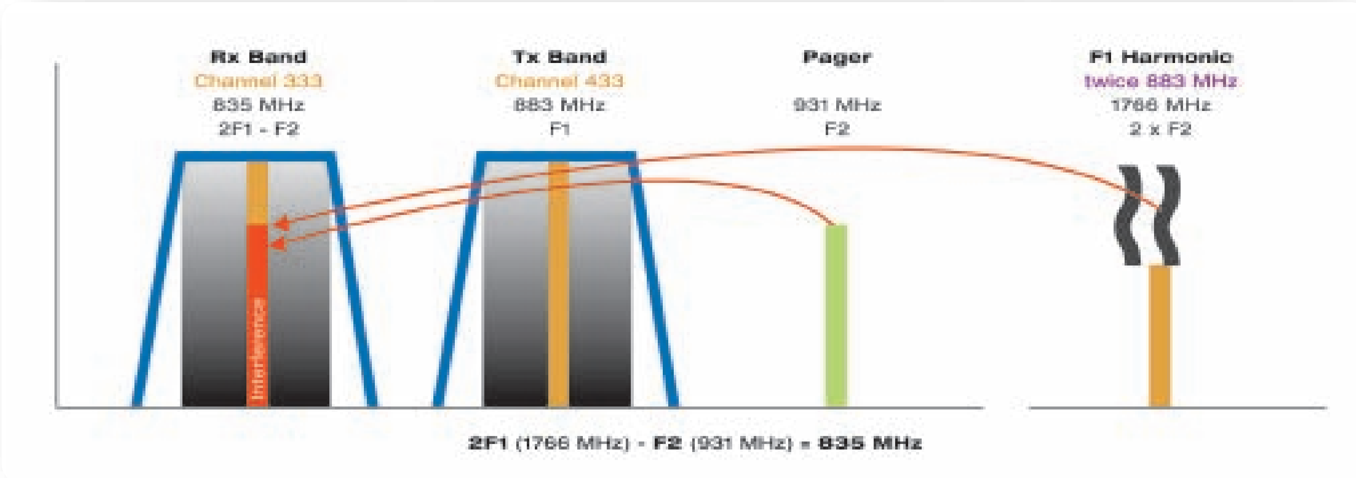
Unauthorized Transmitter

Intentional illegal transmitters, while rare, can also cause co-channel interference. Unintentional transmissions are more prevalent. Some cable TV boxes are infamous for this.

Cell Overlap

A cell from your own network, or others, may exceed the specified coverage area in one or more channels. Incorrect antenna tilt, excess transmitter power, or a change in the environment can cause overlap (for example, someone may have cut down a forest of trees that had been blocking the signal from that site. RF travels further over water, and this also can unintentionally extend the reach of cells.

In CDMA systems this effect is referred to as pilot pollution. Basically this is another form of co-channel interference since both of these cells are using the same frequency.



▶ **Figure 5.** *Third Order Intermodulation Products for a GSM system in the 850 MHz band.*

Intermodulation (IM)

Anytime you have at least two strong signals and a non-linear device, such as a diode, semiconductor junction, or even rust, intermodulation signals can be produced. Using an example of two strong signals (+10 dBm or greater), it is possible for faulty equipment to produce signals as shown in the next illustration.

In this case, a GSM 850 transmitter at 883 MHz is co-located with a pager at 931 MHz. If intermodulation occurs, one of the third order intermodulation products will be at 835MHz, squarely in the GSM 850 uplink band, where it can interfere with reception.

The calculation for the third order intermodulation products is simple. If we assign F1 to the frequency 883 MHz and F2 to 931 MHz, then the products can be found by the calculations:

2 x F1 + F2 and 2 x F2 + F1.

In this case, 2 x 833 – 931 = 835 MHz.

When dealing with more than two possible sources of IM, and also including the effects of fifth order intermodulation, the number of possible IM products become very large. Thankfully, there are computer programs available to deal with this.

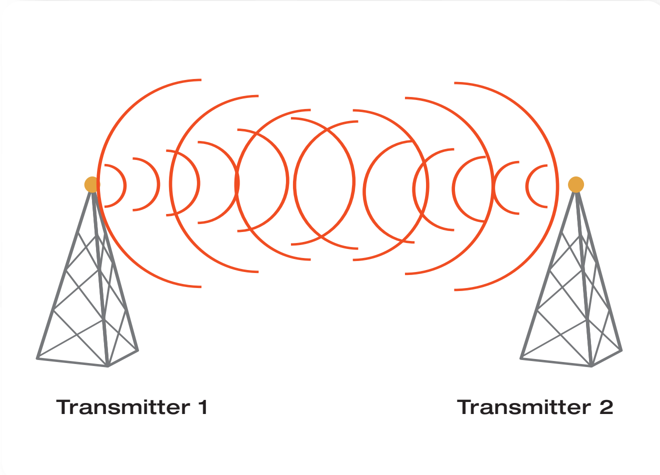
So how is intermodulation distortion generated?

Intermodulation from Another Transmitter

Intermodulation interference can be the result of one or more external radio signals getting into a transmit antenna and entering the offending transmitter's non-linear final amplifier stage. The external signals mix with each other and with the transmitter's own signal, creating intermodulation products that appear as "new" (and often very undesirable) frequency components in the communications band.

It is also possible for two other external signals to produce an interfering signal when neither one is from the offending transmitter, they just use its non-linear output stage to mix together. In this case neither of the two signals that are mixing together is at fault – the transmitter that is doing the mixing is the culprit.

The solution to this problem is a bit difficult, since it may require changes to a transmitter that appears to be functioning properly. A narrowband filter can be added to attenuate the outside signals as much as possible along with a ferrite isolator that lets RF pass from the transmitter to the antenna and attenuates signals coming back from the feeder. Tower owners at shared sites where many different frequencies are in use often require the installation of such filters and isolators in all transmitters.



▶ **Figure 6.** *RF signals from a neighboring transmitter can inadvertently mix inside an otherwise properly functioning transmitter, resulting in unwanted intermodulation products in the communication band.*

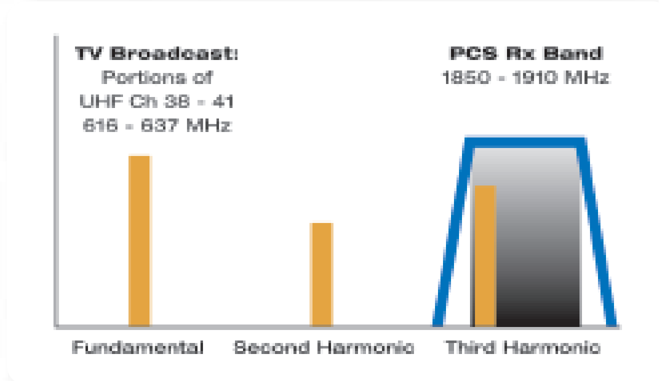
Intermodulation in a Rusty Fence, Roof, etc.

Transmitters are not the only breeding ground for intermodulation products – the non-linear junction could be a nearby rusty tin roof or fence. In the presence of high-power radio transmissions, the rust between the individual roof sections can act as a non-linear diode.

The intermodulation effects from physical structures such as these are difficult to pin down, since they vary with weather conditions – as wind presses parts of the rusty metal together and apart and rain alters the characteristics of the rust. Seriously offending structures must be repaired or replaced in order to restore reliable communications.

Intermodulation in Antennas or Connectors

Antennas and connectors on the antenna's cable are exposed to weather and humidity. As a result, they can quickly develop corrosion. While not enough to cause signal loss or a VSWR problem, the corrosion can act like a very poor diode and can cause intermodulation. If there are several transmitters near the faulty antenna or connector, the resultant intermodulation can be strong enough to cause dropped calls. If the culprit is an antenna, the symptoms tend to be consistent. If the problem is a connector in the antenna system, and you loosen and re-tighten the connector in the course of troubleshooting, it may go away for a few months. In this situation you may want to take the extra time to carefully note which connectors you are re-loosening or re-tightening and test for a while after each.



▶ **Figure 7.** *Example of harmonic interference, where the 3rd harmonic of the UHF station is strong enough to interfere with the PCS Rx band.*

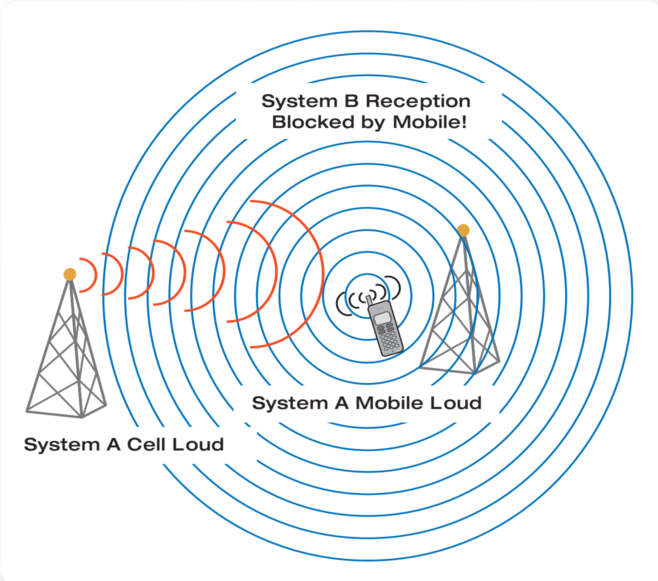
Then if the problem goes away after touching a particular connection, it is the likely culprit.

When looking for intermodulation problems, it's helpful to remember that intermodulation distortion depends on non-linear devices such as transmitter output stages, corrosion, perhaps in a faulty antenna, and multiple strong signals. If one or more of the strong transmitted signals come and go, the intermodulation will also come and go. This can be very visible on a spectrum analyzer.

Harmonics

Harmonics are another source of interference. The term refers to a type of transmitter fault that creates spurious signals at multiples of the transmitter's carrier frequency. Many transmitters product harmonics at low levels, and these are not normally a concern. But in two cases, they can cause interference. The first case is when the transmitter has a fault and produces larger than normal harmonics. Compression, clipping, a failed output transistor, or high VSWR due to antenna system damage can cause this sort of failure. The second case is when the transmitter is so powerful that the harmonics can cause interference problems even when the harmonics are 60 to 80 dB down from the transmitted signal. Broadcast television, with a high transmit power, is one example of this potential problem.

The illustration shows an example from the U. S. frequency bands. In this case, a PCS band base station was co-located with a UHF TV station operating on channel 38. The third harmonic of the TV station, while legal, was still strong enough to dramatically interfere with BTS reception, causing Receiver De-Sense.



▶ **Figure 8.** *Receivers that are receiving a weak signal can be desensitized by nearby stronger signals as depicted in the "near far problem".*

Near-Far Problem

Another classic source of interference goes by the snappy name of "The Near Far Problem." As signals get further from a transmitter, such as a base station, they get weaker. This means that radios receiving that weak and distant signal can be de-sensed by nearby, strong signals. As an example, when a mobile is transmitting and is a long ways from its base station, it will transmit with high power. This can make the mobile a "nearby, strong signal" for someone else's network. This is likely to happen around the edges of a network where one network operator has built out further than another. So if a mobile from network A is near network B's base station while transmitting strongly to reach the distant network A BTS, the mobile will produce a strong out-of-channel signal that affects network B. This is another way receivers can be de-sensed.

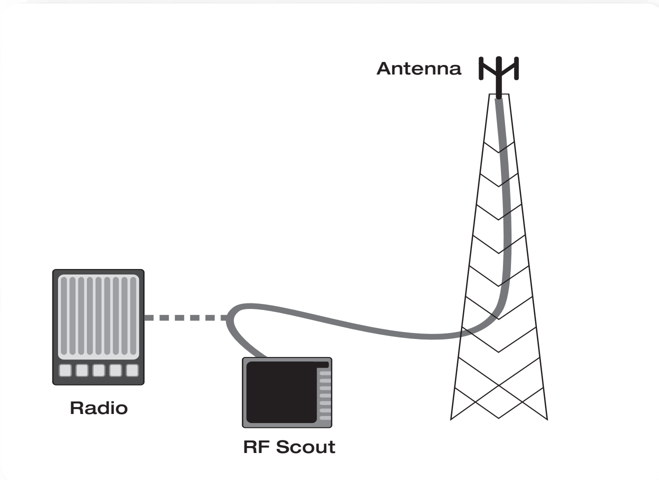
Impulse Noise

Impulse noise is a common term for interference from the wide range of frequencies generated by large power pulses. The defining characteristic of these pulses is that the power must suddenly flow or be stopped. Electrical arcing is the classic example. Impulse noise could from an electrical disturbance, lightning or even like industrial equipment or welding machinery. This issue becomes very important when operating in an industrial environment. Communication systems must be designed to be very robust in terms of impulse noise. Applications include systems for gas pipeline or power company equipment monitoring. This information is often transmitted using some type of RF communications. Cellular systems are not immune to impulse noise. Network operators must pay attention to sources of impulse noise in their coverage area.

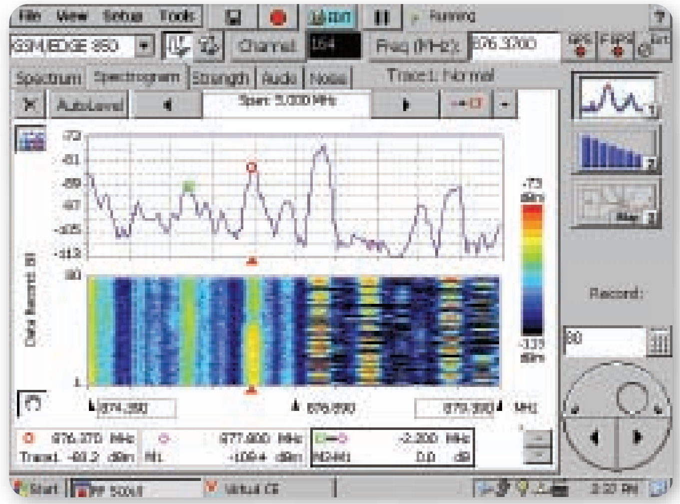
Coverage

While this paper has focused on interference, it's important to remember that signal strength can also be an issue. It's all about the Signal to Noise ratio after all, and while interference is the noise, signal is the other half of the ratio. There are many things that can weaken your signal. Antenna down tilt, fading, and reflections, can all affect your signal strength. For this reason, it's handy to have a scanner built into your interference tool.

While the Signal to Noise ratio (S/N), or the Carrier to Interference ratio (C/I) is the analog measurement of signal quality, Bit Error Ratio (BER) is the digital measure of signal quality. The cleaner the signal, the better the S/N, C/I and BER. It's important to know that when looking for the cause of a poor BER, you come right back to the strength and quality of the signal as well as the amount of interference.



▶ **Figure 9.** *A noise floor measurement is best made using the cell's receive antenna.*



▶ **Figure 10.** *A spectrogram display is ideal for identifying intermittent RF signals.*

What can you do to solve interference problems?

There are numerous ways to solve interference problem and the resolution obviously depends on the type of interference. Let's take a look at techniques to identify and solve interference problems, starting from the first things to try and working up to the more complex issues.

Interference Hunting Techniques

One of the first signs of interference is a high receive noise floor. This can sometimes be checked from the switch, by means of built-in monitoring tools. Once found, the next steps are detailed below.

1. Once at the base station, the first thing to do is to verify that you can see the problem. This is normally done by hooking up a spectrum analyzer, such as the Tektronix RF Scout, to the receive antenna. A noise floor measurement, on the receive channel, can give you a measure of BTS reception quality. By hooking up to the sector's receive antenna, the instrument will measure exactly what the base station sees on that sector. If you do the noise floor measurement using a ground level antenna you will not have the same antenna pattern or range as the sector and may miss the interference.

2. If the noise floor is higher than normal, look at the spectrum analyzer trace and check for unusual signals. Unusual, in this case, is most any signal that is not from your system's mobiles. It may be that the interference is intermittent. In this case, a spectrogram will be helpful. A spectrogram is designed to spot intermittent signals. It's also important to characterize the interference at this point. In later steps, you will be hunting for the signal, so take the time now to understand what the signal looks like and how it behaves. Finally, it's worthwhile to look at the signal shape. In the appendix to this paper, there is a "Field Guide to Signals" which may be helpful. Visual identification can help shortcut the search for the interference.

3. Once you characterize the interference, the next step is to locate it. If the signal can be seen from a ground level antenna, the interference hunting process is off to a good start. If not, it may be necessary to go to various roof tops in the area and take bearings with a directional antenna.

▶ **Figure 11.** *Built-in signal plotting using the RF Scout.*

4. Once near the source of the interference, reflections can make finding the source harder. One method to work around this is to use an omni-directional antenna, perhaps a magnetically mounted antenna placed on your vehicle's roof, and drive around seeking the strongest signal.

5. Even with this technique, it will be hard to locate some interfering signals. One of the best ways to locate interfering signals is to take bearings and plot the results on a map. Some spectrum analyzers allow plotting signals on the analyzer, making resolution of signals simpler even in complex RF environments.

When to Look for Interference

Other than a high receive noise floor, there are four times in the life cycle of a radio system that will require interference hunts.

▶ **New site or "Green Field Installation"**
Frequency Clearing is normally done prior to installing a new radio system. Frequency clearing is similar to an interference hunt, with the big difference that you are normally looking for standard signals, not products of equipment failure. Spectrum analyzers are one of the best tools to use for this task, since they are the most flexible RF tool available, able to find most any signal and present the results visually. Spectrum analysis combined with mapping capability is just the right tool for frequency clearing.

▶ **Existing /Established system**
When a base station's receive noise floor degrades, it's time to start looking for interference.

▶ **A co-located transmitter has changed or upgraded their site**
One of your first symptoms may be a sudden jump in dropped calls or a slow down in throughput. If another network operator or broadcaster has changed something or added a new service, it will pay to find out exactly what they did.

▶ **New technology install or upgrade (3G)**
Data services in particular are sensitive to interference. Whenever a new 3G technology is installed, it is important to search for interference. Existing interference, even if it is tolerated by voice calls, can slow down data sessions dramatically. Slow data sessions, in turn, lower system capacity, since it takes more system resources to get a fixed amount of data to the user. If not dealt with, interference will discourage your customers and perhaps even lead to installation of an excessive number of transmitters or base stations.

Troubleshooting In-Building Systems

In today's mobile environment, customers demand increased coverage and productivity. Network operators are now offering reliable coverage inside office buildings, hotels and airports as well as tunnels, subway systems and other underground facilities. Public safety agencies are also getting involved in in-building issues. There are even systems now being deployed that support multiple types of service (phones, PDAs, computers) over one integrated system.

▶ **Figure 12.** *Portable RF interference hunters, such as the RF Scout, are ideal for locating interference in an indoor environment.*

There are a number of differences when troubleshooting an in-building system. First, in-building systems may use a distributed antenna system (DAS). This means the test access points vary from a traditional outside system. Second, the signal may come from a dedicated in-building BTS or a repeater antenna. If from a repeater, it is best to first check the external signal to make sure that any problem is definitely an in-building problem. Third, in the event that the system is fed through a fiber optic system, you may not have a electrical test port, so measuring near an in-building antenna may be your only choice. Finally, it is possible, and educational, to look at the RF signal under "Near Field" conditions. Typically, this involves putting your hand-held antenna in contact with the plastic case of the in-building antenna. This method can give a consistent relative RF Channel Power measurement and is useful to troubleshoot cable and connector problems in a distributed antenna system.

You should initially look at several key measurements that are almost identical to outside systems. Some of these are listed below:

- Receive noise floor measurements can be used to identify interference issues on the in-building system's receive channel.
- Near-field RF Channel power measurements can be used to check cable and connector issues.
- Field strength measurements can be used, with a calibrated antenna, to verify coverage.
- If a scanner for your standard is available, it is one of the preferred coverage tools.
- EVM measurements spot all sorts of signal quality issues.
- Signal mapping is helpful for analysis and documentation. If it can be done in the field, it's even better.

The ultimate goal is to ensure that you have a quality signal with no interference.

What are some examples of in-building problems?

As in any environment there are numerous types of problems that can affect the quality of your reception. Examples may be as simple as numerous carriers in an airport fighting for spectrum. There are also other sources that are more common with in-building coverage that range from electrical disturbances caused by industrial equipment to unusual lab equipment and microwave ovens.

Cable and connector issues are the biggest faults, of course. Cabling is installed in the building, with connectors installed on the spot, without any type of "factory floor test." This predictably leads to problems. The near field approach can be powerful when troubleshooting cable and connector issues in a distributed antenna system.

Identifying Signals

When looking for interference, it is important to be able to recognize RF signals that do not come from your system. The table below shows some examples of other signals and their bandwidth. The width of the signal can be an extremely useful way of identifying the signal. The signal width, combined with some knowledge of the signal shapes will enable you to identify many different signals. The “Field Guide to Signals” in the appendix will get you started in this area.

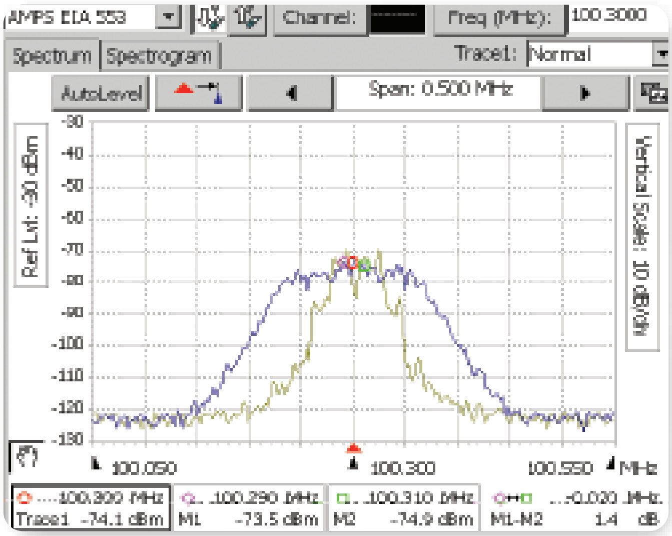
Summary

Interference issues are becoming more and more important, particularly as the new 3G data services are becoming wide spread. These 3G services must coexist in a complex RF environment with previous generations of mobile systems. To do so, the new 3G systems are designed to be reliable. But by adding protection, the 3G systems slow data sessions down. Data sessions are particularly vulnerable to interference. The other issue, for voice services, is that as new services are installed the RF spectrum becomes more crowded and this makes interference more likely.

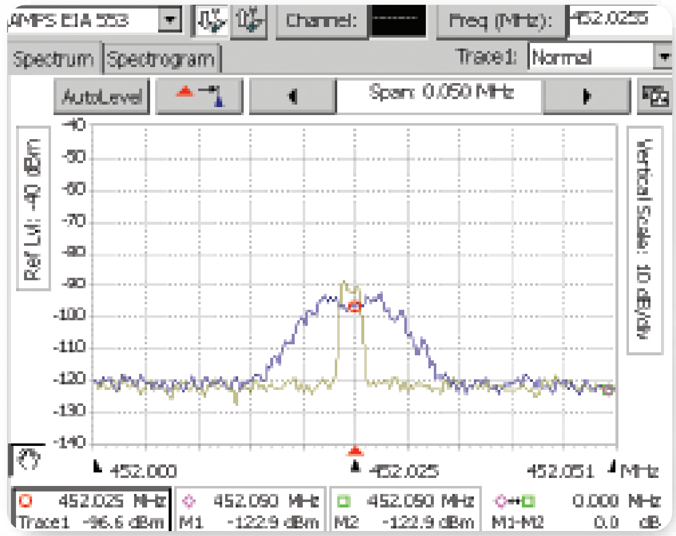
Cellular data services command a premium price. This is due to both the widespread coverage, compared to standards such as WiFi, and the data speed. It’s important to deliver a high data rate to customers since they do have a choice. Every attempt should be made to ensure high speed and reliable data sessions because, in the long term, that’s what sells data services.

▶ **Figure 13.** *Instruments like the RF Scout are optimized for exploring, discovering, analyzing, and documenting interference issues.*

The manufacturer’s switch statistics provide information that gives you a good place to start when hunting for interference issues. But identifying a sector or a base station with an issue is only the staring place. Tools such as the Tektronix RF Scout are fully equipped to compliment existing network elements and provide you with an integrated set of tools that are optimized for eliminating interference issues.



▶ **Figure 14.** *Broadcast FM.*



▶ **Figure 15.** *Two-way radio (FM).*

Appendix – Field Guide to Mobile Wireless Interference Testing

Now that we have become familiar with the tools and techniques, let's look at some examples of typical signal types with descriptions of some of the possible sources. Any of these signals, or related ones, may show up as interference to your system. These descriptions may also be generally useful in simply identifying your RF neighbors.

Analog Signals

Broadcast signals have some telltale characteristics. FM signals for voice or music vary in width. During quiet times, FM appears as a CW carrier without modulation. At other times it will vary in width up to the approximate maximum shown in Figure 16.

This changing width is its most distinguishing feature. While AM also varies, it is narrower than FM. The best way to confirm this type of interference is to demodulate it and listen to it – you might also pick up the station identification.

FM Broadcast

Figure 14 shows signals from an FM broadcast station that is playing rock-and-roll music. The signal varies rapidly from full-width to a much narrower one and sometimes to a signal with very apparent sidebands. The orange trace shows a more quiet time and the blue trace was taken during a louder passage.

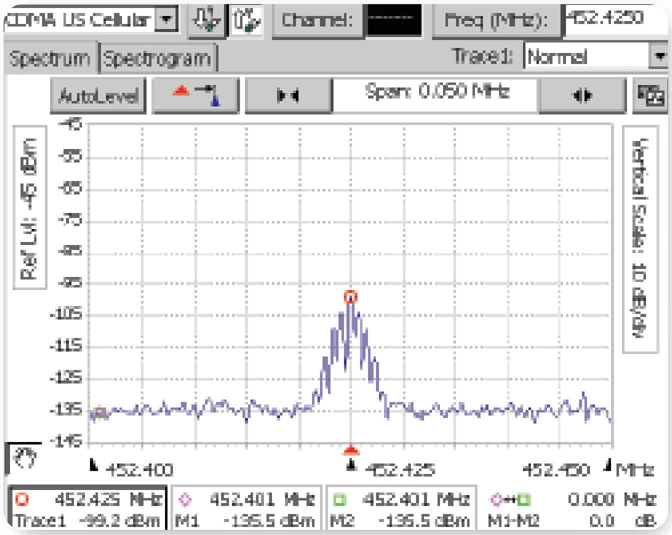
Signal Type	Width
2-Way FM	15 kHz
Analog Cellular	7 - 30 kHz
Paging FM	15 kHz
FM Broadcast	250 kHz
TV Sound	70 kHz
Broadcast Audio STL	250 kHz
Broadcast Video STL	15 or 30 MHz
AM Voice	6 kHz
SSB Voice	3 kHz

▶ **Figure 16.** *Spectrum Width Characteristics of Selected Analog Signals*

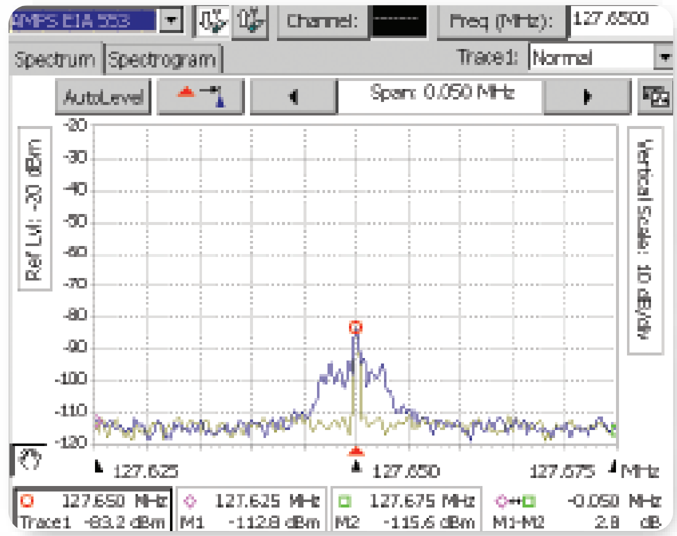
FM Two-Way Radio

The signal from an FM two-way radio is shown in Figure 15. The signal width varies with the loudness of the voice of the radio user. The orange trace was saved while the user was not talking at all (and there was no background noise). Only occasionally did the signal collapse into a completely quiet carrier. Many two-way radios have either a continuous low-frequency tone squelch such as shown in the orange trace, or they have a digital squelch modulation, which has a similar appearance.

The blue trace is the spectrum of the signal when the user was talking loudly and with lots of high frequency energy (such as the spoken "S" sound.) This type of FM communications signal will be continuously varying between the two widths shown and will have no steady state.



▶ **Figure 17.** *Two-way radio with tone burst.*



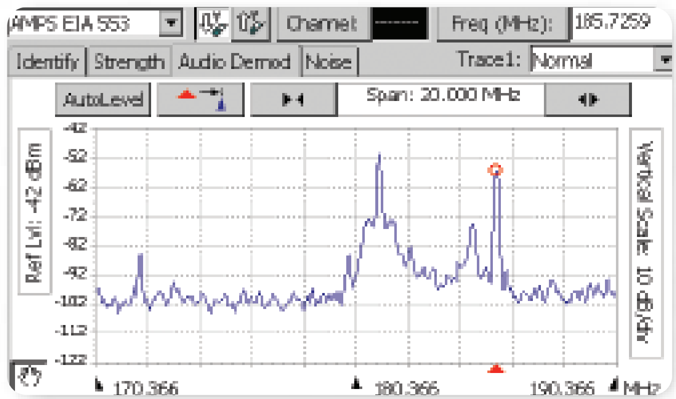
▶ **Figure 18.** *An AM transmission.*

Tone-Burst Modulated Two-Way Radio

Figure 17 illustrates a tone-burst modulated two-way radio, where the modulating tone is about 800 Hz. A higher modulating frequency would produce more widely spaced sidebands. Most tone-bursts have clearly visible sidebands in this span.

AM Aircraft Voice Radio

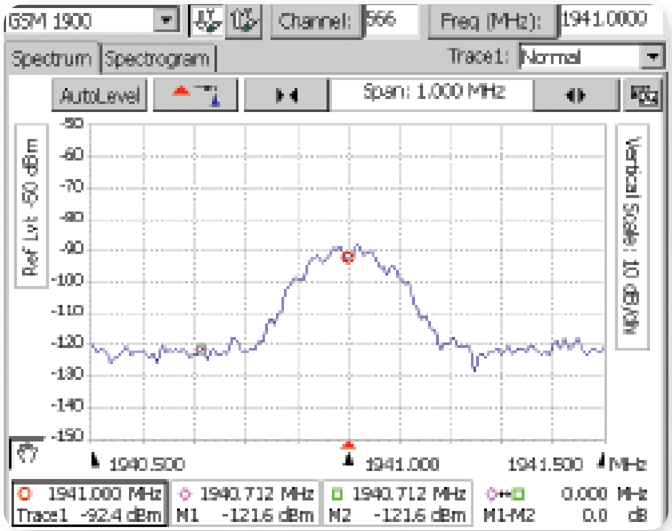
Figure 18 shows an AM aircraft voice communications radio. Like FM voice, this signal is constantly changing with the voice sounds. But unlike the FM signal, it tends to have its wide part move up and down in strength rather than change in width; although it will change width somewhat with the modulating frequency. Again, the two traces shown were stored during the quietest and loudest times of this particular transmission.



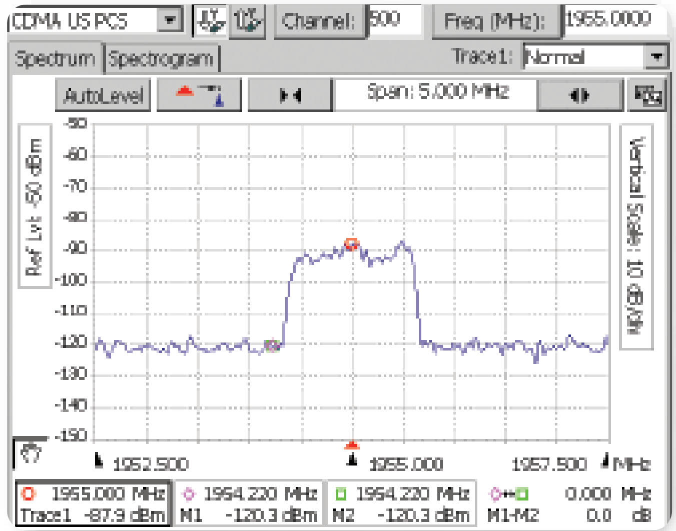
▶ **Figure 19.** *Analog TV (U.S.A type).*

Analog Television Broadcast

This signal is quite distinctive. Although there are some differences from one country to another, TV broadcasts usually have both the main video signal (AM) and a separate sound signal at a fixed frequency spacing from the Video. In the United States, the spacing is 4.5 MHz; in much of Europe it is 6 to 7 MHz. The sound is usually FM and can be demodulated to listen for the identification of the station to validate its source. In Figure 19, the video carrier is near the center of the screen and the marker has been placed on the sound carrier about 4.5 MHz higher in frequency.



▶ **Figure 20.** *A GSM cellular signal.*



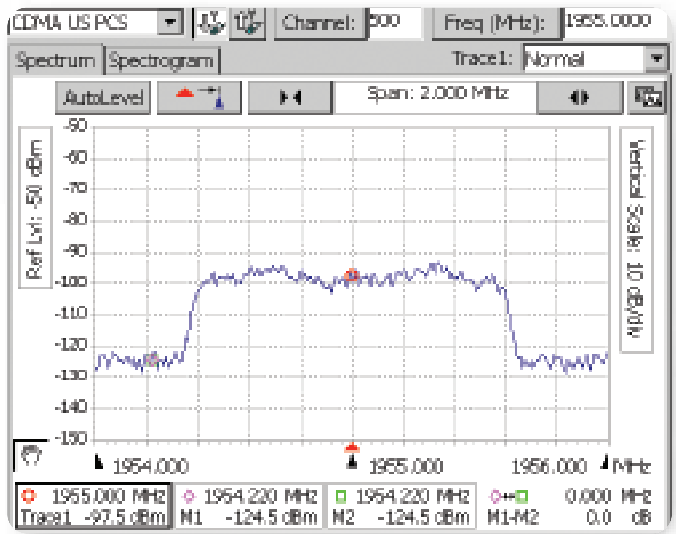
▶ **Figure 22.** *CDMAOne (using 5 MHz span).*

Digital Communication Signals

Digital signals also have some generally identifying characteristics. They often have a more constant envelope than the analog ones. This is due to the fact that digital bits ar e usually being transmitted whether the voice is loud or low .

Signal Type	Width
CDMA (IS-95)	1.23 MHz
W-CDMA	4 MHz
TV Digital Broadcast	5 to 7 MHz
TV Digital STL	7 MHz
Paging FSK	10 kHz
US-TDMA	30 kHz
GSM	200 kHz
SMR	20 kHz

▶ **Figure 21.** *Spectrum Width Characteristics of Selected Digital Signals*



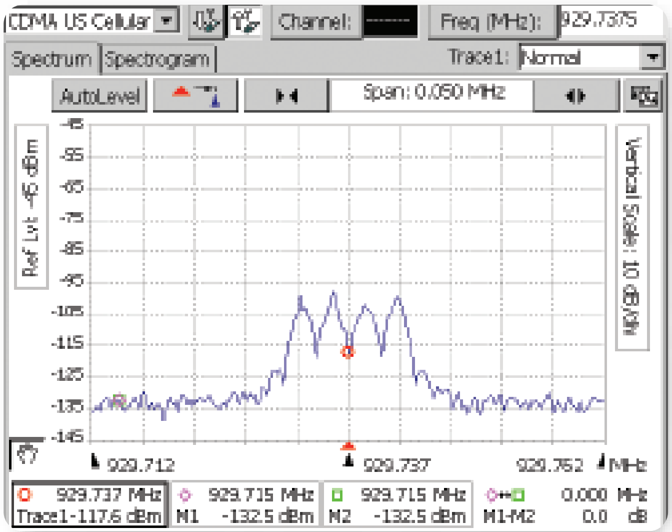
▶ **Figure 23.** *CDMAOne (using 2 MHz span).*

GSM Cellular

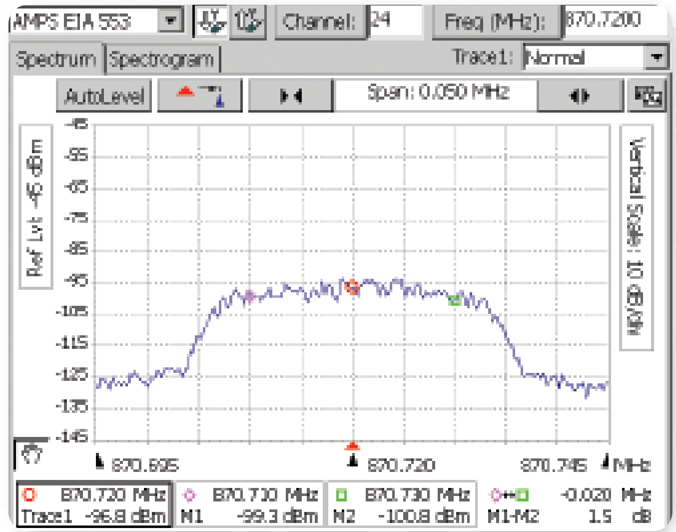
GSM has a distinctive rounded look due to its GMSK modulation, as shown in Figure 20. Since it is a TDMA signal, it may appear and disappear intermittently, depending on how many timeslots are active. Voice channels usually come and go quite rapidly as the individual timeslots ar e transmitted. The BCCH channel (like the paging channel in AMPS) is usually continuous.

CDMAOne Cellular

The CDMA signal in Figure 22 has the familiar “Bart’s Head” appearance. It is spread evenly across the entire 1.2288 MHz bandwidth. As more phone calls are added to this signal, it will simply increase slightly in amplitude, it will not have any noticeable change in its shape in a spectrum view. In Figure 23, the CDMA signal is displayed using a 2 MHz span.



▶ **Figure 24.** *4FSK paging.*



▶ **Figure 25.** *IS-136.*

4FSK

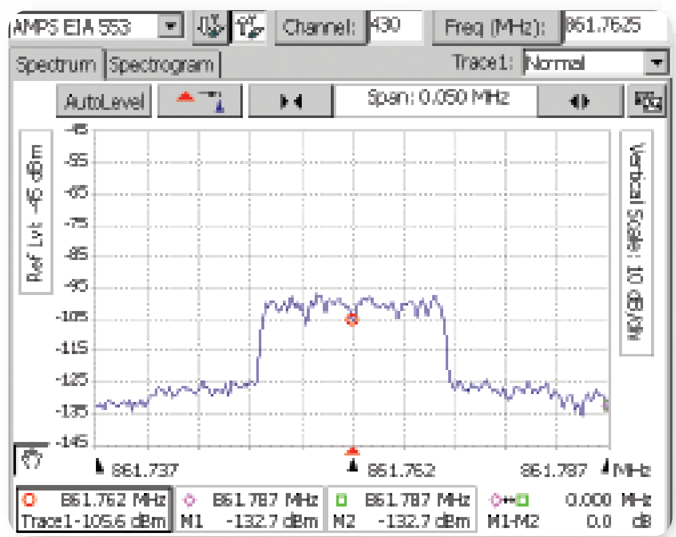
4FSK is another digital transmission type used for paging and public-safety transmissions. This signal has four distinct frequencies that will tend to merge and fill in the gaps between the frequencies as the data rate increases, as shown in Figure 24.

IS-136

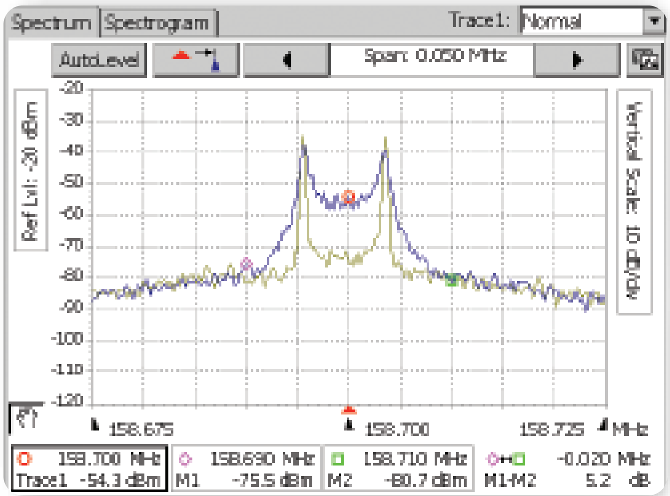
Originally known as NADC (North American Digital Cellular), this signal is about 30 kHz wide, as shown in Figure 25. It was designed to fit into one AMPS FM cellular channel. It has a much flatter top than GSM, but not quite as flat as CDMA.

Specialized Mobile Radio (SMR)

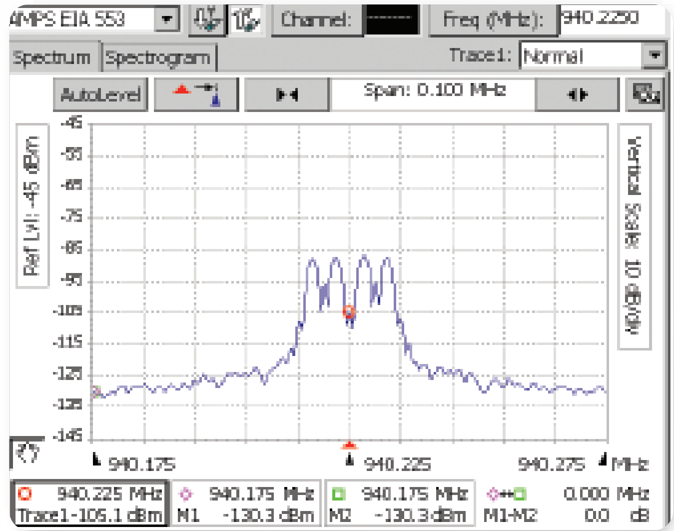
Figure 26 shows a signal from SMR, which is marketed as a cellular service in the U.S.A. Its assigned transmission frequencies lie directly between U.S.A. cellular receive and transmit bands. The signal is usually a bit narrower than IS-136, and has a much flatter top. This example is from a system marketed under the Motorola trademarked proprietary name of IDEN.



▶ **Figure 26.** *SMR (specialized mobile radio) signal.*



▶ **Figure 27.** *FSK paging.*



▶ **Figure 28.** *N-PCS transmission.*

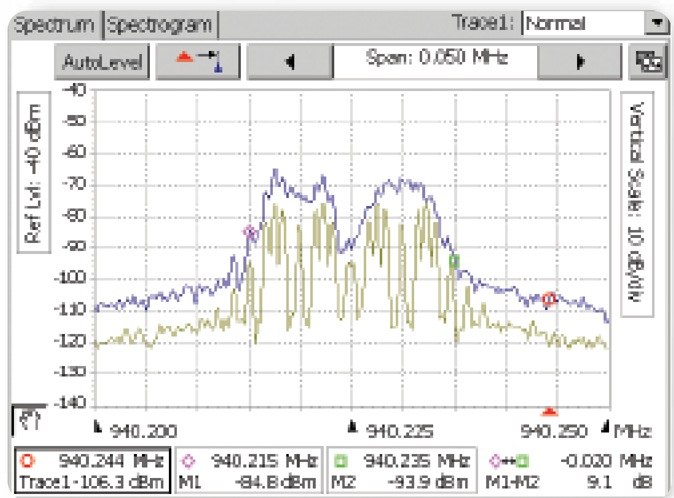
FSK Paging

This signal has two distinct frequencies for the digital "ones and zeros" when it is idling. As the data rate and random transmission data increase, the frequencies will become less distinct and the trough in the middle will fill in. In Figure 27, the orange trace is the typical idling spectr um – much of the time this signal will be mor e filled-in, as with the blue trace. The amount of fill usually changes continu-ously with the various data payloads being transmitted.

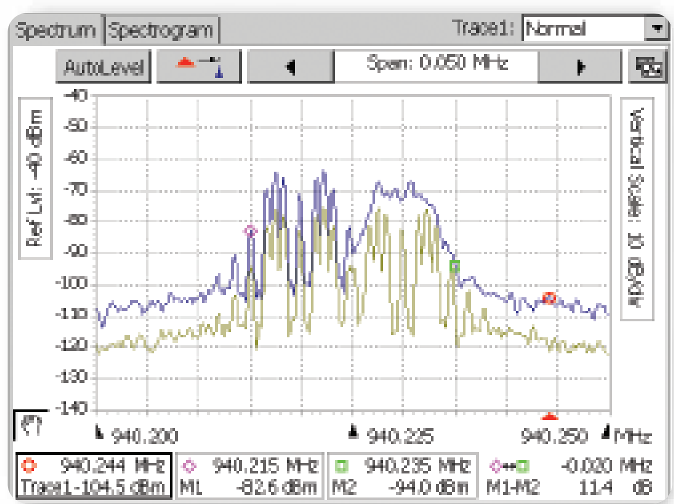
Narrow-PCS

This digital signal is from a Narrow PCS cellular system in the U.S.A. In a wide span it wiggles slightly, as shown in Figure 28.

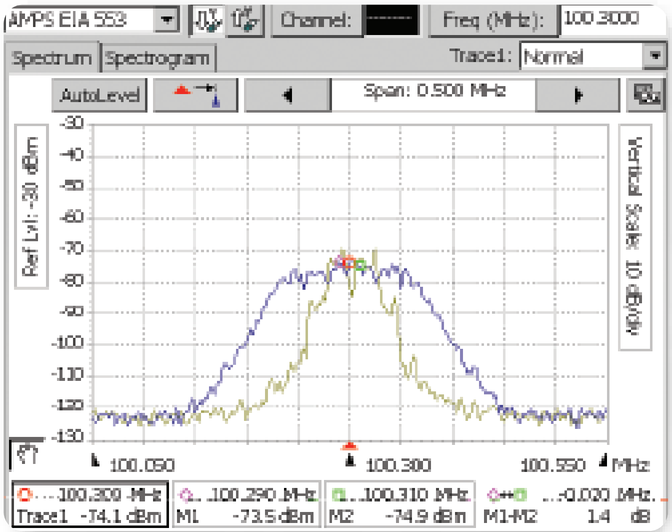
However, in a slightly narrower span, as shown in Figure 29, it has a unique manner of alter nating between the orange trace of distinct frequency sidebands, and the blue trace showing broad filled-in sidebands. Even more unusual is the fact that the upper and lower sidebands may change independently at times, as shown in Figure 30.



▶ **Figure 29.** *N-PCS seen in a narrower span.*



▶ **Figure 30.** *N-PCS spectrum varies continuously.*



► **Figure 31.** *Broadcast FM.*

STL Systems

Digital STL (Studio-to-Transmitter Link) systems are operated in the 2 GHz band. These are usually QAM modulated with approximately 7 MHz of bandwidth. Their spectrum looks similar to IS-136, except for the much wider frequency span. Analog STL for audio may be at 900 MHz or 2 GHz. Analog STL for TV video signals are 15 or 30 MHz wide FM. The spectra of both are similar to broadcast FM, as shown in Figure 31.

Appendix Summary

These have been some selected example signals that you may see in everyday use while you look at all of the RF signals that surround your wireless system. These examples can help you identify what is and what is not a problem for you.

Contact Tektronix:

ASEAN / Australasia (65) 6356 3900
Austria +41 52 675 3777
Balkan, Israel, South Africa and other ISE Countries +41 52 675 3777
Belgium 07 81 60166
Brazil & South America 55 (11) 3741-8360
Canada 1 (800) 661-5625
Central East Europe, Ukraine and the Baltics +41 52 675 3777
Central Europe & Greece +41 52 675 3777
Denmark +45 80 88 1401
Finland +41 52 675 3777
France +33 (0) 1 69 86 81 81
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India (91) 80-22275577
Italy +39 (02) 25086 1
Japan 81 (3) 6714-3010
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Middle East, Asia and North Africa +41 52 675 3777
The Netherlands 090 02 021797
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People's Republic of China 86 (10) 6235 1230
Poland +41 52 675 3777
Portugal 80 08 12370
Republic of Korea 82 (2) 528-5299
Russia & CIS +7 (495) 7484900
South Africa +27 11 254 8360
Spain (+34) 901 988 054
Sweden 020 08 80371
Switzerland +41 52 675 3777
Taiwan 886 (2) 2722-9622
United Kingdom & Eire +44 (0) 1344 392400
USA 1 (800) 426-2200
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