APPLICATION NOTE

Practical Tips on Measuring Interference

Spectrum Master™ MS2721A

1.0 Introduction

This is a practical **Interference Measurement Procedures** application note. The objective of this note is to present measurement tips and procedures which will help a field technician measure signal interference in an operating communications systems. The individual measurement procedures described herein relate to a variety of interference causes and sources referenced in the *"Fundamentals of Interference in Wireless Networks"* application note (Anritsu Publication No. 11410-00302). Section numbers for those references are in bold type in the following format: (**Ref. Fund. 3.4.1**).

1.1 Unlicensed Data Communication Systems can be Primary Sources of Interference

By utilizing the ISM (Industrial-Scientific-Medical) frequency bands, the wireless industry has been able to exploit the increasing popularity of unlicensed communication systems. However, their unlicensed nature carries with it the seeds of serious signal interference problems. As described in the Fundamentals Note (**Ref. Fund. 2.2**), such ISM system designs are type-approved but are then installed by unlicensed owners or contractors. These conditions sometimes lead to signal configurations that unintentionally interfere. When ISM technologies are applied to Wireless LAN applications, the radiated signals are essentially contained within one building. Even though other systems may be installed on adjacent floors or even on the same floor, those systems are designed to perform well in proximity to each other. Transmitter power is low, antenna gain is minimal, and modulation schemes are designed to overlap without interfering with each other. When the ISM technologies are applied to microwave data links, trouble may result when multiple systems are installed near each other. Although the FCC (Federal Communications Commission) specification limit for transmitter power is one watt, the system operator can choose to use very high gain antennas. These provide higher EIRP (Effective Isotropic Radiated Power) and can cause interference for other systems in or near their path.

Since these microwave data link ISM systems have the highest incidence of interference reports, this note will focus on these systems. Operationally, if the antenna gain is increased by 3 dB, the FCC rules require backing off the transmit power by 1 dB which still allows a net increase of radiated power and increases the chance of creating unwanted interference. Although both Frequency-Hopping (FHSS) and Direct Sequence (DSSS) Spread Spectrum technologies work well in the ISM band, DSSS has tended to win out in the commercial race. Nevertheless, there are still a significant number of FHSS systems in place, most of which will stay in place as long as they deliver their specified data performance. These "legacy" systems continue to be possible sources of signal interference.

2.0 Finding the Interference

2.1 Connecting the Field Spectrum Analyzer

The Anritsu MS2721A Spectrum Master™ Handheld Spectrum Analyzer is an excellent tool for troubleshooting interfering signals in the field because it is a lightweight, portable, calibrated measurement receiver. Its large daylight-viewable color display makes comparison of live and stored traces very easy. Since the interfering process often involves overlapping frequencies, a spectrum analyzer is the one instrument that is best suited to capture and display such signal overlaps. The sensitivity of the MS2721A is of great help when using a directional antenna while searching for the source of an interfering signal. Even if the antenna is not aimed properly, the operator will be able to see when an interfering signal comes on the air.

Figure 1 shows the "front ends" of two different types of communication systems. Figure 1(a) shows a typical cellular base station where the antenna signal is split into multiple receiver channels using a passive signal combiner/splitter. The measuring spectrum analyzer connection is made by disconnecting the signal cable at the receiver input and connecting it to the spectrum analyzer input. Figure 1(b) shows a typical configuration of a microwave data link system, revealing how a microwave circulator component permits the use of a common antenna for both transmit and receive functions. The transmit and receive frequencies are offset into different band assignments. The transmit signal goes up in the direction of the circulator arrow and out the antenna. The received signal comes down from the antenna and follows the circulator arrow to the input of the receiver. Two band pass filters are used. One cleans up the transmitter output spectrum and the other rejects the image frequency of the receiver, as discussed in the Fundamentals Note (**Ref. Fund. 3.1**).

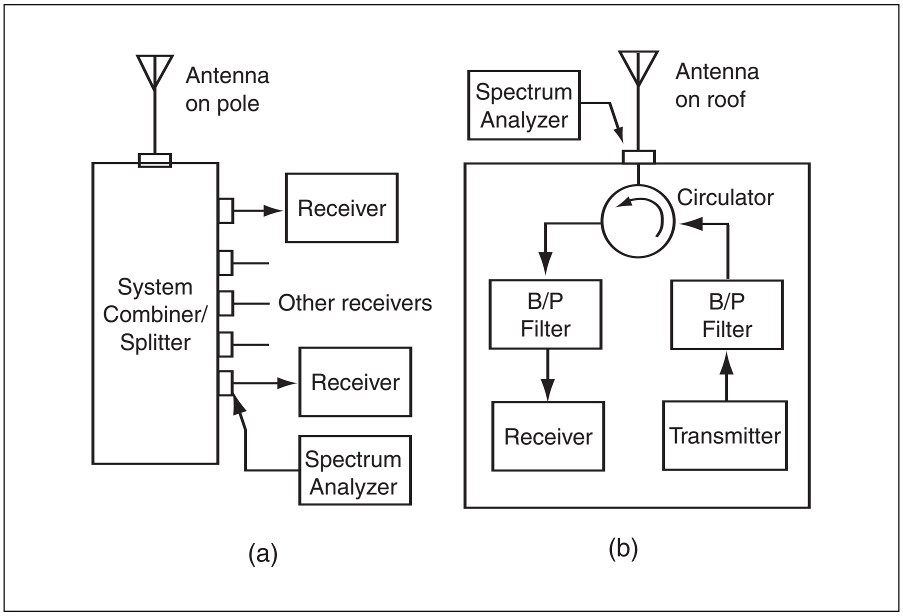

Figure 1. Search for interference usually starts with substituting the spectrum analyzer for the affected receiver by connecting its input at the receiver terminal. (a) The signal comes through a signal combiner/splitter. (b) Diagram shows a typical ISM data link where a common antenna is used for both transmit and receive. This is called a duplex antenna.

2.2 Some Useful Interferer Search Tips

The Anritsu MS2721A has smart measurement functions and control key routines which make the most of the operator's time and skills. Smart Measurements are accessed using the Shift-Measure key sequence. The measurements available under that menu are field strength, channel power, adjacent channel power ratio, and C/I ratio. In addition, the AM/FM/SSB demodulator is accessed via this menu.

Using Markers – Set up the display to show the affected receiver's intended signal spectrum, and adjust the **Span** so it is wide enough to show other overlapping/interfering signals. Use the Marker controls to identify the frequency of the interferer. If the interfering signal is higher than the intended affected channel signal, use the **Marker to Peak** soft key. Access it by using the **Marker** hard key below the screen; use the **Marker 123456** soft key to select a marker. Pressing the **Marker to Peak** soft key will place the active marker on the highest signal on screen. An annotation on the display shows the frequency and power level of the signal at the active marker. If the interferer signal is smaller in amplitude than, but still overlapping the affected signal, either move the marker right or left using the knob or press the **More Peak Options →** soft key then use **Next Peak Left** or **Next Peak Right** to place the marker on the interferer. Once the marker is moved to the center of the smaller interferer signal, read the marker frequency and power level from the marker annotation. You may move the marker position to the center of the display by pressing the **Marker Freq to Center** soft key, after which you can spread out the span containing the interferer signal to measure or identify it.

Max Hold – For a number of system signals, such as 802.11g, the signal transmission is intermittent due to frequency hopping or is only on the air intermittently, such as paging transmitters and land-mobile repeaters. Figure 2 shows an 802.11g signal measured with a single sweep. When you tune the spectrum analyzer to a channel full of such random signals, the spikes of signals come and go, rise and fall. This is a time to use the **Max Hold** soft key, which is accessed by pressing the **Shift-Trace** key sequence and setting the **Trace Mode** soft key to **Max**. The display then shows the highest signal measured over multiple sweeps at each frequency across the band. Wireless channel spectrums slowly fill in and show the time-lapsed activity on those frequencies, providing far more insight to the maximum signals present in that band. Figure 3 shows an 802.11(g) channel using max hold.

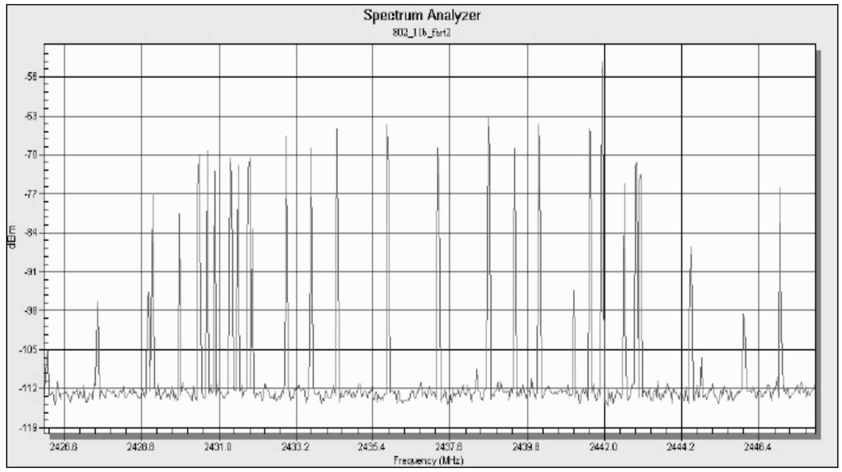

Figure 2. 802.11(g) spectrum, swept too fast

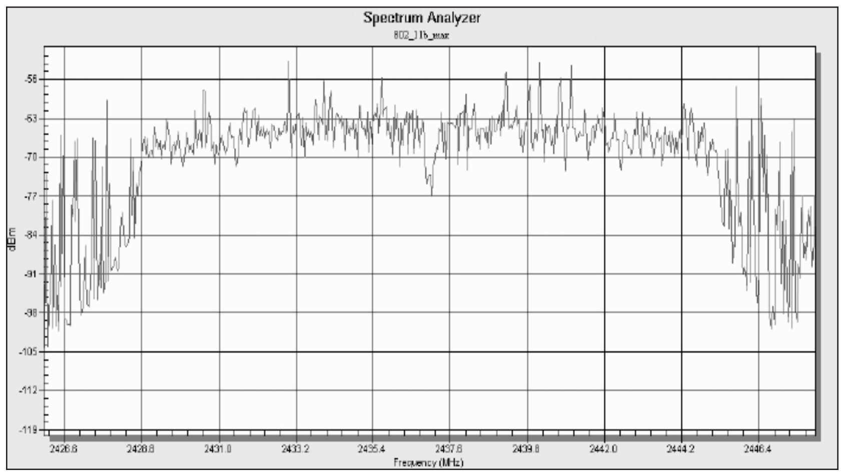

Figure 3. 802.11(g) spectrum with max hold

Setup Save/Recall Menus – The MS2721A leverages the measurement power of a skilled operator by storing the instrument's settings in the internal flash memory. There is space to store over 1000 instrument settings. Use the **Shift-File** sequence and the **Save Setup** and the **Recall Setup** soft keys to make quick changes between commonly-used measurement configurations. Such **Save/Recall** procedures, which pre-set all of the instrument controls to user-defined settings, are quite useful when the field job is routine and repetitive. You can pre-set the analyzer for standardized frequencies and bandwidths of assigned communication systems. If done before driving to the field, this means minimum keyboard setup times for measuring quantities like carrier level in frequency-allocated channel assignments. For example, one **Save/Recall** instrument setting might measure carrier power in an assigned band, and a second **Save/Recall** instrument setting might measure the noise across the same span or the interference levels within that span.

Signal Standards and Channels – In addition to the save/recall capability, the MS2721A also includes a built-in table of signal standards and their corresponding channels that can be selected from the frequency menu. By using that capability, the instrument is automatically set to the proper center frequency and span width for the selected air interface standard.

Display Capture – A very important feature of the MS2721A is the ability to store spectrum measurements which have been measured during a long day in the field. Use the **Shift-File-Save/Recall-Save Measurement** function. This permits the operator to take many measurements, name each one for the measured situation, and bring the instrument back to the office to download the display data. The beauty of this function is that all the numerical annotations of each saved display are available later to aid diagnostic work. Center frequency, span, RBW, and the amplitude settings are all there. The **Recall Display** key brings an index list to the screen for selecting and recalling saved waveforms. Up to 1000 screen displays may be stored for later reference.

Preamplifier – When received signals are weak, which is often the case for field measurements, the preamplifier function becomes important. The preamplifier adds approximately 25 dB of gain right at the front end input. It is not wired in permanently because it can be saturated by other larger signals anywhere in its 100 kHz to 7.1 GHz input range. It must therefore be used judiciously and with knowledge of the signal environment. Turn on the preamp function by pressing the **Amplitude** hard key, then the **Preamp** soft key. When the preamp is engaged, the display shows an annotation **(AMP)** on the left side after the Input Atten label. If the preamplifier becomes saturated, a warning message will appear on-screen. Eliminate the saturation by turning off the preamp. When the preamplifier is turned on the input attenuation can be set to 0 or 10 dB. If the saturation isn't severe, changing the input attenuation to 10 dB may solve the problem.

Demodulator – When the interfering signal seems like it might contain AM or FM modulation, such as in the case of a powerful AM or FM station tower nearby, use the **Demodulator** function to help identify the signal. Enable it by pressing the **Shift-Measure** key sequence, then the **AM/FM Demod** soft key. Use the **Demod Type** soft key to display a list of modulation types. You may select AM, wideband FM, narrow-band FM, USB or LSB, and press the **Back** soft key to return to the demodulation menu. Set the demodulation frequency as needed either by keying in the frequency or by setting a marker on the signal to be demodulated and pressing the **Set Demod Freq to Current Marker Freq** soft key. Press the **On/Off** soft key to turn on demodulation. The demodulation frequency does not need to be within the current span of the instrument; it can be any frequency within the capability of the instrument. Use the **Volume** soft key followed by the knob or the **Up** and **Down** arrow keys to set the desired volume. You can hear the audio on the internal speaker or plug-in a standard cellular telephone-style headset. You probably will want to set the demodulation time by pressing the **Demod Time** soft key and using the arrow keys, the knob or direct entry of the desired time value. The instrument alternates sweeping and demodulating. The longer the demodulation time, the longer between sweeps.

Antenna Accessories – Many field interference measurements will be made with an independent antenna when not connected to the communication system antenna. The most versatile kind of antenna is the so-called "whip" or "rubber ducky" design. A whip antenna is a linear conductor connected to the coaxial input connector on the MS2721A. They are sized for 1/4 wavelength at the specified center frequency. Some whips are also "inductive loaded" which simply means that their physical length is not equal to the 1/4 electrical wavelength just mentioned. Whip designs are omnidirectional and thus insensitive to directional effects. The table lists available MS2721A antenna part numbers and their band coverage. Other manufacturers can serve for other bands, and one Radio Shack® model is mentioned for reference. For additional diagnostic power in certain interference measurement situations, the operator will need to use a directional antenna. Microwave data systems are an example where the system antenna directional performance is highly critical. In those cases, a directional antenna attached to the spectrum analyzer can help determine the direction from which an interfering signal is arriving. A series of directional yagi antennas available from Anritsu is also shown in the table.

Anritsu Part Number	Frequency Range, MHz
2000-1200	Rubber Ducky Antenna, 806 – 869 MHz
2000-1035	Rubber Ducky Antenna, 896 – 941 MHz
2000-1030	Rubber Ducky Antenna, 1710 – 1880 MHz
2000-1031	Rubber Ducky Antenna, 1850 – 1990 MHz
2000-1032	Rubber Ducky Antenna, 2400 – 2500 MHz
2000-1361	Rubber Ducky Antenna, 5725 – 5825 MHz
2000-1411	Portable Yagi Antenna, 822 – 900 MHz
2000-1412	Portable Yagi Antenna, 885 – 975 MHz
2000-1413	Portable Yagi Antenna, 1710 – 1880 MHz
2000-1414	Portable Yagi Antenna, 1850 – 1990 MHz
2000-1415	Portable Yagi Antenna, 2400 – 2500 MHz
2000-1416	Portable Yagi Antenna, 1920 – 2230 MHz
Radio Shack Part Number	
20-034	Telescoping Whip Antenna, 27 – 940 MHz

Field Strength Parameters – In many cases interference measurements made with optional whip antennas do not need to be absolutely calibrated for measuring the field strength parameter. Searching out interferer signals often only requires relative quantities (affected signal vs. interferer signal) and can simply be measured in dB ratios. However, there are occasions when you will wish to measure absolute field strength units, for example –(x) dBm/meter. In that case, press the **Shift-Measure** hard key, then the **Field Strength** soft key, then the **Antenna** soft key. If the antenna is not on the list, upload the appropriate antenna via the Antenna Editor part of Master Software Tools. From the displayed list of standard or custom antennas, find the proper antenna option part number, and press **Enter**. This engages the proper amplitude calibration data for that whip antenna. One example of when you might measure field strength is when you wish to determine the field strength present at the affected receiver signal in front of its system antenna. This would be best measured with a directional antenna kit using data calibration numbers uploaded to the spectrum analyzer before going into the field. If you are using a non-Anritsu antenna, you can create an antenna gain table and upload it using your PC and the Antenna Editor. While not directly an interference type of measurement, it can also be useful for troubleshooting a downed receiver by assuring that an adequate system signal is indeed present at the receiver antenna.

Occupied Bandwidth – The MS2721A spectrum analyzer features two computational modes which are very powerful for measurements on wideband data channels such as ISM data links, CDMA, GSM, etc. **Occupied Bandwidth (OBW)** allows the operator to define the band edges of an occupied band by defining the power points either as a % of total power or the number of dB down the skirts. The frequency parameters can be automatically defined by selecting the signal standard and channel from the **Frequency** menu. There is more detail on this feature in section 5.3.

Channel Power – measures the total power contained within its defined bandwidth. This mode integrates the power contained within the defined bandwidth. As with occupied bandwidth, the frequency parameters may be either entered manually or automatically selected using the signal standard and channel number. See Figure 4 for an example of a channel power measurement.

Adjacent Channel Power Ratio – gives data on cleanliness of the output of a transmitter. This automatic measurement gives the power in the channels immediately above and below the channel to which the instrument is tuned. If you suspect that broad band noise from a nearby transmitter is causing interference problems, this measurement could be used to quantify the quality of the transmitted signal. Basically this measurement shows if intermodulation products are being created in a transmitter. For complex modulation formats such as the CDMA signal shown here, this test has replaced the older two-tone intermodulation test used to test AM and FM transmitters. See Figure 5 for an example of this measurement.

C/I Ratio – This measurement helps to quantify how bad an interference problem is. This is a two-step measurement that first measures the power of the carrier, then, with the carrier turned off, measures everything, noise and interference, that is still left on the channel of interest. This measurement is most often used when testing 802.11 systems but also has found uses in the measurement of in-building cellular repeater systems.

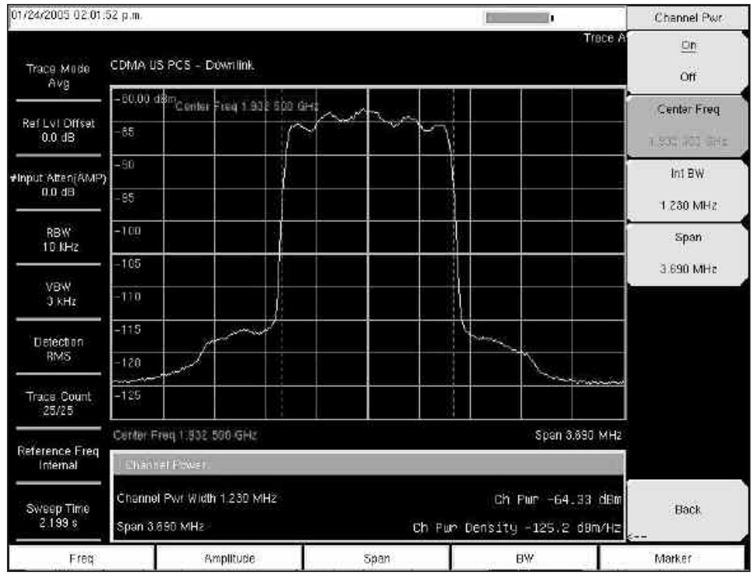

Figure 4. Channel Power Measurement

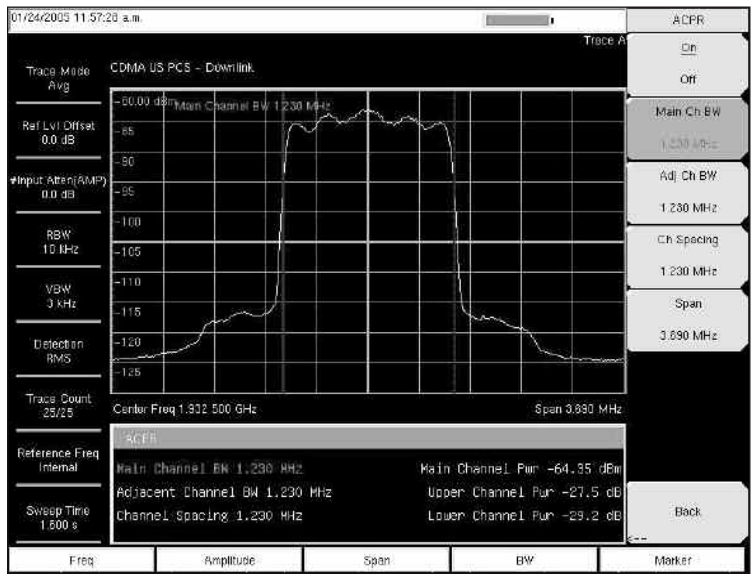

Figure 5. Adjacent Channel Power Ratio

3.0 Two Basic Types of Interference

Causes and sources of interference are covered extensively in the Fundamentals Note (**Ref. Fund 3.0**). This section will briefly review the two basic types of interference. For both licensed and unlicensed systems, there are two basic types of interference: a) In-channel signals and noise, and b) Out-of-channel signals.

3.1 In-Channel Interference Causes

3.1.1 Licensed Interfering Signals

In most licensed systems, the frequency allocation process and antenna positioning application and approvals minimize overlapping signal paths and unexpected interference. No two systems are deliberately licensed to use identical channels and physically-interfering signal paths. So, in-channel interference from other systems is basically not to be expected, although unintended antenna misalignment can put signals where they don't belong. If licensed systems interact, the likely cause is out-of-channel signal effects.

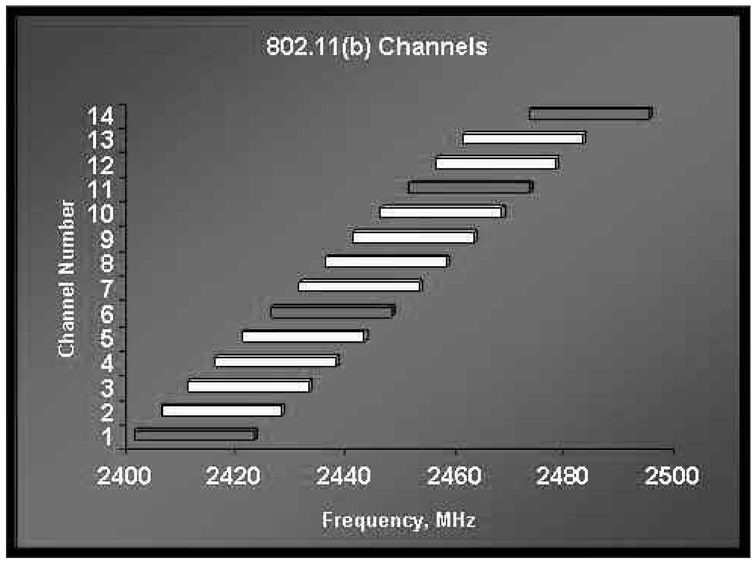

Figure 6. 802.11 (b and g) Channel Overlap

3.1.2 ISM-band Signal Conflicts

In the ISM bands, signal interference is inherent because the installation of systems is uncontrolled except for the general type-approval of the basic specifications of the design. Wireless LANs and short-range microwave data links are common and are installed by companies wishing to create a convenient and relatively inexpensive communications capability, such as an Ethernet bridge from one company location to another.

The channel spacing and modulation bandwidth of 802.11 signals is such that adjacent channels overlap significantly as shown in Figure 6.

3.1.3 Intermodulation (Transmitted)

Intermodulation cross-products can be inadvertently transmitted by the power amplifiers of wireless system base stations (**Ref. Fund. 3.1.2**). The final power amplifier circuit configurations are designed with many amplifier sub-modules running in parallel amplifying a common signal. That way, if one sub-module fails, the entire base station keeps operating, at some reduced power level 1-2 dB down from the specified output level. The result, however, is that the dynamic range of the power amplifier combination degrades which can cause non-linear performance. This induces intermodulation cross-products which get transmitted. These intermodulation cross products can fall within the pass-band of an affected receiver and interfere with the system.

3.1.4 Harmonics and Parasitics

It is possible for base station power stages to also create spurious signals (parasitics) which are random signals that can be launched at relatively high power levels. All transmitters generate harmonics of their operating frequencies. Generally those harmonics are well controlled and don't cause major problems unless the transmitter's output stage is defective. Likewise, powerful transmitters, such as broadcast emitters, might deteriorate or be mistuned causing them to produce harmonics or parasitics which fall in-channel or in-band with sufficient amplitude to cause problems.

3.2 Out-of-Channel Interference Causes

Out-of-channel signals which happen to cause problems for an affected receiver are generally found in areas close to high-power transmitters. These conditions are not unusual when the affected communications system shares common real estate with the high-power transmitters such as the tops of urban mountains that are prized for the large signal footprint they afford broadcast stations. There are primarily two interference mechanisms caused by high power signals; desensitization and intermodulation.

3.2.1 Desensitization

This mechanism for interference is that the legal high power transmitted signal enters the typical affected receiver and overpowers the designed rejection capability of the front end RF filter. The RF filter is intended primarily to reject signals and noise outside the passband of a superheterodyne receiver (**Ref. Fund. 3.2.1**). Desensitization can happen even though the affected receiver is designed to reject interfering signals. As the high power signal comes in, the AGC (automatic gain control) of the affected receiver cuts back its own amplification. In that action, it reduces the amount of gain required for proper signal-to-noise processing of the intended signal. It can also clip off the crest factor peaks of digitally-modulated signals, inducing bit errors. You might have experienced this effect while riding in your vehicle listening to a favorite AM radio station. As you drive close to the broadcast tower of a different radio station, its powerful signal pushes through the front-end RF rejection filter and causes your receiver's AGC to reduce the sensitivity to the station you are tuned to. As its audio becomes weaker, the audio of the interferer predominates until you drive a kilometer or so away. Then the regular RF input filter begins to be effective again with more reasonable signal levels. This out-of-channel effect does not show up as an interfering signal inside the passband of the affected receiver. If you were to tune your diagnostic spectrum analyzer to the band of the affected receiver, you would see no interfering signal there.

3.2.2 Intermodulation (re-transmitted)

A second way out-of-channel signals interfere is that high-power, out-of-channel transmitters can interact together to create new signals which do appear in the passband of the affected receiver. In order for such signals to intermodulate, there must be an external electrical non-linear element present. This means it is apart from the affected receiver itself. This could be an appearance of the "rusty fence" syndrome or so-called "environmental diodes" (**Ref. Fund. 3.2.1**). In crowded real estate with many high power transmitters, non-linear detection can cause the re-generation of multiple intermodulation cross-products. If any of these fall within the affected receiver passband, they reduce the Carrier-to-Noise ratio (C/N) of the system.

4.0 Why the Carrier/Interference Ratio is Important

Every communications system is designed to reliably transmit and receive information (be it data or voice) at some warranted data rate and with a specified data bit-error rate for a reasonable price. For example, one manufacturer of a point-to-point microwave system in the 5.8 GHz ISM band uses QPSK modulation for robustness in operation, and requires only a 13.5 dB average C/N ratio. This system delivers a warranted, uncorrected BER (bit-error-rate) of 1×10^{-6}. The terms Signal and Carrier tend to be used interchangeably. We will use the term Carrier. The parameters Carrier-to-Noise ratio (C/N) and Carrier-to-Interference ratio (C/I) are both important as system specifications and as measured quantities in an interference situation. Since this is an interference note, we will focus on C/I. Noise and interference both degrade the performance of an operating system. Interference tends to produce a slightly worse effect since it is coherent and the affected receiver tries to lock on to it. The result is inter-symbol errors, which degrade the BER. Once your field test determines the C/I ratio as measured at the receiver input connector, you can learn whether there is enough carrier margin for reliable data transfer by referring to the manufacturer's required C/I ratio specification.

5.0 Measuring Carrier/Interference Ratio

C/I measurement is very important when commissioning or troubleshooting systems, particularly in the 2.4 GHz ISM band. The MS2721A makes it easy to make this measurement. Here is how to do it.

5.1 Setup

Connect the system antenna to the spectrum analyzer in place of the transceiver as shown in Figure 1(a) on page two. Use the **Frequency** key to access the **Signal Standard** soft key. Select the proper signal standard for the measurement to be done (for example 802.11g). Press the **Channel** soft key and enter the desired channel number.

5.2 Sweep with the Affected Carrier Turned On

Press **Shift-Measure** combination then the **C/I** soft key. Check the center frequency and span as shown on the soft keys to verify they are correct. If they are not the values needed the values can be manually entered by pressing the **Frequency** or **Span** soft key and entering the desired values.

5.2.1

Press the **Carrier Signal Type** soft key and select the proper type of signal. The choices are:
NB FHSS (narrow band frequency hopping spread spectrum) – such as 802.11(b)
WB FHSS (wide band frequency hopping spread spectrum) – such as 802.11(a)
Broadband – such as CDMA, GSM and the like.

5.2.2

Select a value for **Min Sweep Time** that gives a good view of a spread spectrum signal. The default value is 1 second.

5.2.3

Press the **On/Off** soft key to start the measurement and press **Enter** to make the measurement. The carrier level is stored in trace B.

5.3 Sweep with the Carrier turned off

5.3.1

Follow the on-screen prompt to turn off the carrier and press **Enter** to measure the noise/interference amplitude.

5.4 Read C/I Ratio

The on-screen measurement box displays the carrier amplitude, the interference amplitude given three different assumptions regarding the type of interferer and the corresponding C/I ratio based on those assumptions. Simply read the C/I value that matches the type of interference being experienced.

6.0 An Example for Diagnosing Desensitization Effects

By definition, desensitization is caused by a large signal getting into a receiver input enough to cause the receiver's automatic gain control circuit to reduce amplification in the IF. This upsets the affected system communication signal and its modulation. In most cases, a desensitizing signal comes from out-of-channel since by the time an in-channel interferer gets large enough to saturate the front end, it has already disrupted the affected signal's data. There is one case where an in-channel signal could cause desensitization, and that is in the case of the ISM band. Since most of the ISM communications systems are designed to operate spread-spectrum, they can tolerate large single-frequency interferers, such as leaking microwave ovens, which operate in the center of their band. But if an oven or other industrial microwave source leaks significantly, it might arrive in a given ISM receiver large enough to drive the receiver into saturation. When desensitization is suspected, the best way to detect it is to connect the spectrum analyzer to the system antenna at the input connector of the affected receiver. Set the analyzer **Span** to the operating channel span of the affected receiver. Turn off the affected transmitter if you can. If you don't detect a large unexpected signal in that span, the desensitizing signal is not coming from an in-channel source. Next, set the spectrum analyzer to its widest span, for example 100 kHz to 7.1 GHz, which will provide a panoramic display of the entire signal environment at the system antenna. By analyzing this ultra-wide display for signal strength, you should be able to identify a responsible high power emitter. If the signal strength of the possible interferer is in the range of 20-30 dB higher than the affected receiver signal, it is very possible that is the desensitizing source. It may be necessary to scan narrower bands, instead of the full 7.1 GHz in one scan, in order to get better resolution. Choose 500 MHz segments at a time. Once a possible interferer is identified, the best way to make a final determination is to insert an external RF bandpass or highpass filter into the antenna path which passes the affected signal, but attenuates the desensitizer signal. If the system operates correctly, you can be confident that the interferer you have tentatively identified is the source of the desensitizing phenomena.

7.0 An Example for Interference in Cellular Base Stations

With an installed base of tens of thousands of wireless base stations, it is not surprising that weather and moisture would ultimately creep into the cabling and radomes of even well-designed antenna installations. One of the common outage complaints is that of intermodulation interference caused by corroded connectors and other cable components. This interference complaint is most common in systems which are designed with a so-called "duplex" antenna installation. In the duplex design, the same physical antenna is used for both the base station transmitter signal and its receiver signals, similar to the diagram of Figure 1(b). Technically, there is no inherent downside in such a design since the transmitter signal frequency is offset from its receiver frequency. With proper bandpass filters on the receiver and transmitter sections (for example a duplexer), the channel signals normally will pass in and out of the shared antenna without causing problems.

The specific cause of this interference is the intermodulation from non-linear external elements, as described in section 3.2.2. What happens is that a broadband signal, say 30 MHz wide, of TDMA or CDMA spectra from a transmitter propagates to the antenna. But the signal hits a wet, corroded cable connector which acts like a non-linear diode mixer. When multiple signals on a broadband channel hit a non-linear element, cross-frequency inter-modulation products are created which in effect spread out the frequency spectrum. These intermodulation products end up right in the adjacent assigned band of the base station receiver which uses the same antenna. This effect can be seen by doing an ACPR measurement on the transmitted signal. The cross-products head back down the same cable to the base station receiver and interfere with legitimate mobile signals to the receiver. Knowing that corrosion is a common complaint, the operator can immediately use the spectrum analyzer to measure the background signal level of the assigned receiver channel. It is necessary for the operator to consult the system specifications to find the normal receiver noise level under proper operating conditions. When non-linear effects caused by corrosion are present, the noise and interference level will increase depending on the seriousness of the non-linearity. When serious, the noise level will usually be 15 to 20 dB higher than a properly operating system. An easy diagnostic test is to simply turn off the associated base station transmitter since when its broadband signal goes away, so will the intermodulation interference. By the way, in wireless base stations that don't use the duplexed antenna design, corroded connectors can still intermodulate a transmitter's signal. But those illegitimate cross-frequency interference products now have to be transmitted into space to reach the receive antenna; therefore, this effect is unlikely to cause significant problems in systems with independent antennas because of the free-space loss between the antennas (which, in a well-designed system will be greater than 60 dB).

8.0 A Measurement Example for Cellular Base Station Interference Testing

It is instructive to note that in conversations with experienced field technicians, there is little hard-and-fast test procedural information available. The main guidance is to bring good test equipment (a MS2721A Spectrum Master and Anritsu Site Master™ are a good start). Add in a directional antenna kit, a protocol analyzer for identifying specific signals, and a clear mind for working with many clues to ultimately determine an interference culprit. The protocol analyzer is created by using a laptop hooked to a phone line. You can run software which obtains the RF signal level and neighboring base station information, as well as GPS location information. Experience shows that more interference occurs in the 800 MHz band than the 1900 MHz band, mostly because there are more shared system functions in the lower (earlier-implemented) band. As new wireless services like 3G and others crowd into the upper band, time will tell whether more interference will also arrive there. A first line of measurement at a downed site is to use an omni-directional whip antenna on the MS2721A to see if there is a super-high level interferer on the air. This might be a UHF TV station with 5-50 kW emitted power. While this station might have been anticipated at the first installation of the base station, perhaps the TV antenna pattern has shifted or a reflecting surface of a new building has emerged in the interim. The TV transmitter also might have deteriorated, producing higher harmonics. Another arrival procedure would be to shut down the base station transmitter and then utilize the system antenna (100 feet up on the mast) by connecting the MS2721A to the antenna cable. Since the spectrum analyzer has a sensitivity greater than the wireless receiver, regular environment signals and interferers can be easily seen on the display. By knowing ahead of time the expected mobile phone traffic levels at the assigned receiver channels, the operator can read the received channel signals by tuning the analyzer to the assigned receiver band and seeing if excessive interfering signal strengths are present. If the outage complaint call indicates a sporadic or random interferer over long periods of time, the MS2721A can be configured into a time-lapse monitor of sorts. Set up the analyzer for **Max Hold** on the channel with random signals, and it will capture and display the maximum signals versus frequency over time. After an appropriate wait time for the random signals to accumulate, use the **Save Display** function to name and record the annotated display for downloading display captures and analysis back at the office with Master Software Tools.

9.0 Setting Up A Directional Signal Survey

After finding a suspected high power interferer using the affected system antenna connected as in Figure 1, disconnect the MS2721A from the system. Set up the spectrum analyzer with its own omni-directional antenna by choosing the optional Anritsu antenna which matches the affected band. Measure the affected signal amplitude using the operating antenna calibration factors of the accessory antenna. If these factors are not in memory, up-load them from your computer using the Antenna Editor in Anritsu's Master Software Tools. Use the procedure covered in Chapter 6 of the *MS2721A User's Guide,* Anritsu Publication No. 10580-00103. The display should show a simultaneous display of the affected system and the interferer. Since the receiving antenna is now omni-directional, the ratio between the affected signal and the interference will be changed. Because the spectrum analyzer is no longer directly connected to the affected system, there will be a reduction of the affected signal while the interfering signal remains about the same. Next, replace the omni antenna with a directional antenna. This will permit you to diagnostically determine the direction of the interferer signal. For this step, it will also be useful to have the directional antenna factor calibration numbers uploaded into the analyzer memory. The directional antenna will have considerably more sensitivity in its "boresight" direction, so the amplitude sensitivity settings of the analyzer may need to be less sensitive. Use the same center frequency and span settings as in the previous steps. Turn the antenna in a full 360° azimuth pattern while watching the amplitude changes on the display of the interfering signal.

This step should identify the approximate direction the interfering signal is coming from. The direction of the highest signal will generally be the direction of the interferer since reflections are normally not involved. It is useful to have a compass handy for plotting the bearing to the interferer on a map. Often it will be necessary to go to another location to obtain a second directional data point, especially if the emitter isn't nearby. This second data point will allow you to draw two lines on the map to determine the position of the identified interferer. Go to that point and see what is there. Sometimes, especially in cities or hilly areas, the signal has been reflected and isn't arriving by a direct path. In that case further sleuthing will be needed to find the emitter. If the interferer is legitimate, and the transmitter is not emitting out-of-channel signals, you will have to solve the interference by other means at your own site. Perhaps more bandpass filtering or antenna realignment will work.

10.0 Conclusion

This note is intended as a guide for using the Anritsu MS2721A Spectrum Master Handheld Spectrum Analyzer to search out interference sources that conflict with operating communication systems. While experienced field engineers and technicians will acknowledge that a logical measurement sequence leads to good solutions, they also admit that creativity and persistence are valuable field test traits when tracking down sources of, and solutions to, interference.

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