

Application Note



Using the Aeroflex 3900 Series for Remote Site Monitoring

by Rob Barden



Introduction

With the proliferation of both analog and complex digital wireless systems and the inherent problems found in many US and international wireless communication frequency bands, there is a growing need for a means of determining interference problems and isolating system performance issues. The move to narrow-band digital and analog operation is also raising the requirement to accurately determine interference issues for optimal system performance.

This is especially true of the unstructured VHF and UHF bands, where the inherent flexibility of these bands can introduce a high level of external noise, inter-modulation and interference susceptibility. When dealing with these issues, there is a requirement to accurately define the minimum, maximum and average noise floor of a site location, over time, before equipment is installed.

As more complex systems are being deployed, there is also a drive to reduce system service costs and to reduce the number of qualified RF engineers required to operate and maintain these systems. Therefore, a system that could monitor system interference problems automatically and remotely determine the cause of wireless system degradation would greatly benefit many RF system operators.

The Problem

Most engineering professionals understand that today's analog and digital communication systems can be severely impacted by co-channel, adjacent-channel and multi-path interference problems. They also know that with the deployment of high performance digital systems right next to older analog systems, there are inherent interference problems that can occur when analog systems (or other digital systems) "stray" into operational frequency bands during system key-up or due to other issues associated with improper system maintenance.

With digital systems that use multiple repeater sites and channels, signal degradation can also be caused by inter-symbol interference, which can cause severe fade conditions in areas that would normally be characterized by good RF levels. These interference problems can cause high BER conditions in digital systems and significantly impact the operating range of mobile equipment.

Traditionally, the spectrum analyzer has been the primary tool for determining the noise floor and associated interference that drive system performance and site placement. It is also used as a troubleshooter for determining the source of interference. The problem with most spectrum analyzer tools is that the user needs to be on-site operating the test equipment and looking for problems that may occur only on a random basis.

In addition to the problem of having to place manpower on location to track down system performance issues, the spectrum analyzer does not give a true indication of the effective sensitivity that the receiver will be expected to deliver. What is needed is an automated way to determine the system's sensitivity range (dBm) and to track potential interference sources when they occur, not just when the engineer is in the field. Optimally, the system should be completely automated and accessible via the Internet thus providing remote connection for diagnostics and test.

Let's take a look at a simple interference issue to understand what can happen with a system in a poor RF environment.

Figure 1.0 shows a channel at 154.1000 MHz receiving a signal at a level of about -97 dBm. This signal would be at a level good enough for most receivers to pick up and decode or demodulate with excellent voice quality. This is shown by the corresponding SINAD meter showing a SINAD reading of 26.6 dB.

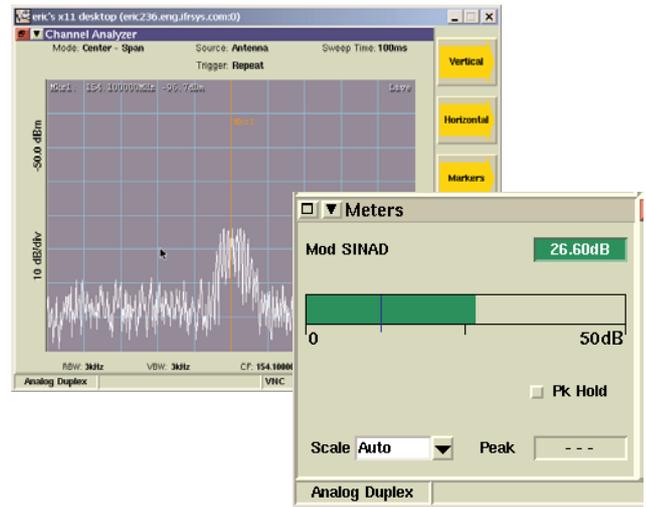


Figure 1.0 A "good" quality signal

However, a strong adjacent channel signal can result in poor performance in the desired channel, even if it is present only for a few seconds. Figure 2.0 shows how an adjacent channel can cause a loss of signal quality in the primary channel. As you can see, the desired signal is practically overwhelmed by the adjacent channel signal. The spectrum analyzer does a good job of showing the adjacent channel, but what is the real quality of the signal being received? The spectrum analyzer doesn't tell you what the system performance really is. As you can see with the SINAD meter, the recovered audio quality has been substantially reduced to an almost unusable level of 1.7 dB.

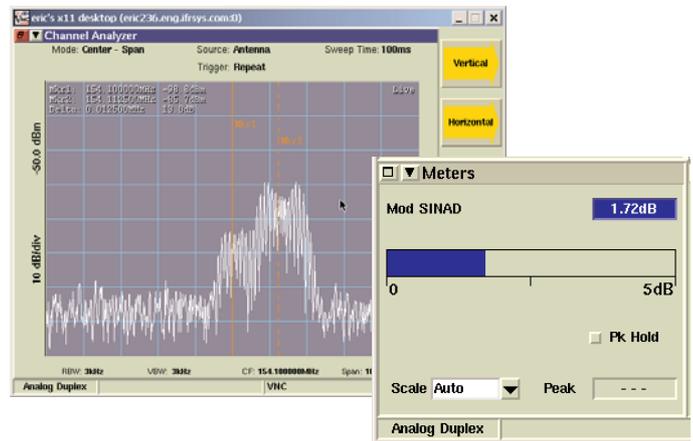


Figure 2.0 The same signal in the presence of high adjacent channel interference

These tests were made using a narrow band FM channel with an FM adjacent channel as an example. This shows the complexity of testing even simple analog systems. As we discussed earlier, signal degradation in digital systems can be even tougher to troubleshoot due to signal fading caused by inter-symbol interference. This condition is a unique problem associated with digital systems that may or may not be viewable with a spectrum analyzer. Inter-symbol interference can occur when a co-channel signal of the same digital modulation format causes a phase, amplitude or frequency degradation of the wanted signal.

So what is the best way to determine what the actual site performance is at any given time?

Capturing Data

Obviously, capturing data at the site is the key to tracking down interference and noise issues. However, capturing data can be a time consuming and elusive project, especially when dealing with intermittent interference issues and long-term site monitoring for establishing noise floor performance. There have been attempts at automating data capture, but this usually requires external computers and expensive equipment and still falls short of determining the real quality of the channel.

Spectrum analysis is the first place to start analyzing site performance and to isolate interference issues. But capturing spectrum data usually requires an operator to be present or a computer setup using cumbersome GPIB commands to capture the data. Once the data are captured, it can be analyzed to track down possible problems. However, this is usually done after the test system is taken down and returned to the "lab" or office to analyze the problem - after the fact. Flexibility in assessing real time issues becomes extremely limited.

What is needed is an easy way to track true system performance with spectral data automatically, without the need for an engineer to spend hours or days on site tracking down problems. This system should be controllable via the Internet and allow the user to download captured data remotely and take control of the test system for more detailed analysis in real time.

The Aeroflex Remote Site Monitoring Solution

Aeroflex understands the needs of today's engineers and the test requirements for tracking down interference in RF systems. With Aeroflex's new innovative test platform, the Aeroflex 3900 Series, affordable and automated site monitoring is now available with standard and optional features.

The Aeroflex 3901 and 3902 are 1 GHz and 2.7 GHz Radio Test Systems respectively, that provide a number of exclusive features for carrying out high performance system analysis with fully functioning signal generators, audio generators, oscilloscope and various power, SINAD, frequency error and modulation meters. As standard equipment, these units feature a high performance spectrum analyzer for determining absolute noise floor levels of the system under test. Figure 3.0 shows the Aeroflex 3901 spectrum analyzer noise floor using the antenna input with the preamp selected.

For simplification, we will refer to only the 3901 in this application note, however all aspects of this feature apply to the 3902 as well, which is the 2.7 GHz version. Also, we highly recommend that you review the 3901/2 operation manual available from the Aeroflex web site at www.aeroflex.com.

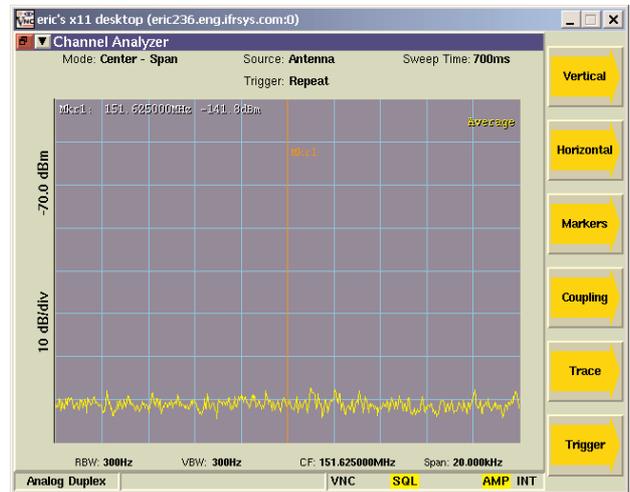


Figure 3.0 The Aeroflex 3901 Spectrum Analyzer showing -141.8 dBm noise floor.

As you can see, the center frequency of 154.625000 MHz shows a displayed noise floor of -141.8 dBm. This was done using an RBW of 300 Hz and a VBW of 300 Hz with a 20-kHz span and using 5 averages of the sweep. Sweep time was 700 ms. This superior performance allows the user to determine the noise floor of virtually any system.

In addition to high performance spectrum analysis, the Sensitivity Search Option 051 provides additional tests for determining the usable sensitivity of the system by providing the following:

1. Automated Sensitivity Search function that can track the noise floor of the systems and log that information internally without the need of an external computer.
2. Automated capture and internal logging of spectrum information.
3. "Fast logging" of spectral data to capture momentary interference.
4. The ability to remotely control the instrument from the Internet.

Automated Sensitivity Search Configuration

The Aeroflex 3901 provides a unique, automated way to track the effective usable sensitivity of the system. Using the Sensitivity Search feature, the engineer can track the effective 12 dB SINAD point of the system over a given time. When used in conjunction with an external radio (a "golden radio" or high performance radio), this feature will search for any SINAD level the engineer wants to see, and then automatically adjust the RF level to the appropriate level to attain that SINAD value.

Figure 4.0 shows how the Aeroflex 3901 would be set up to perform a Sensitivity search.

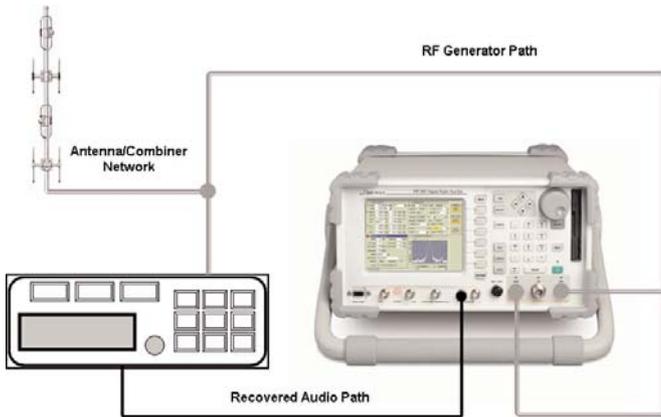


Figure 4.0 Aeroflex 3901 System Configuration

The Aeroflex 3901 is performing a number of tasks. Its primary purpose is to determine the system's 12 dB (or other) SINAD point. To accomplish this, the Aeroflex 3901 is monitoring the base-band audio output of the radio to determine the SINAD level. The RF generator is generating into the system at the radio's receive frequency modulated with a 1 kHz tone. To ensure enough range of the system, the generator port is required as the RF source for the radio. The recovered audio is then analyzed to find the 12 dB SINAD point.

To enable the Sensitivity Search function on the 3901, Option 051 needs to be installed first. Once this option is installed, the Aeroflex 3901 can be set up to perform these tests. Figure 5.0 shows the Sensitivity Search Configuration Screen with the Generator, Analyzer and Spectrum Analyzer tiles enabled. Note that the spectrum analyzer is showing a noise floor of -125.0 dBm with a 200 kHz wide span.

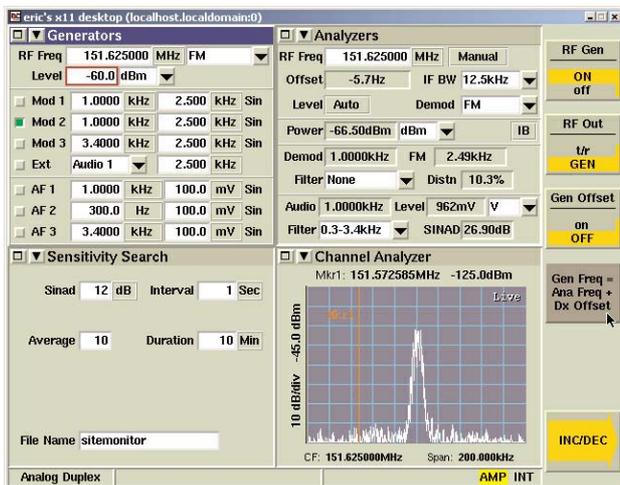


Figure 5.0 The Sensitivity Search Function Configuration Screen

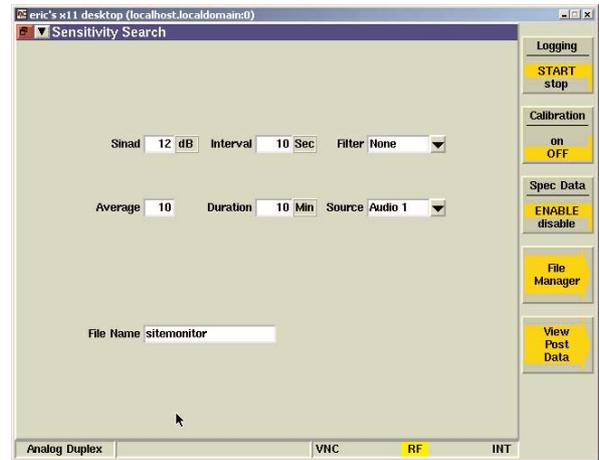


Figure 6.0 Sensitivity Search tile.

Figure 6.0 shows the expanded Sensitivity Search tile. As you can see, this screen provides a number of variables for setting up the 3901 for use in Site Monitoring to determine Effective Receiver Sensitivity (ERS) using the Sensitivity Search function. These include:

- The SINAD Level.** This is the level that the 3901 will search for automatically. Typically, most systems would be looking for an ERS measurement of around -118 dBm. This will vary depending on actual site noise and interference levels.
- The INTERVAL time.** Using unique algorithms within the 3901, the SINAD interval can be read as often as every 1 second. This allows the user to read effective SINAD levels very quickly. This SINAD level will then be correlated automatically by the 3901 to an equivalent sensitivity measurement. This requires that the 3901 be calibrated to the site conditions first. The interval time is also dependent upon the number of averages that the SINAD meter is using.
- The FILTER Setting.** This allows the user to set the various audio filters for use in determining SINAD. Selectable are none, Psophometric, 300 Hz LP, 5 kHz LP, 20 kHz LP, 300 Hz - 3 kHz BP, 300 Hz - 5 kHz BP, 300 Hz - 20 kHz BP, 300 Hz HP.
- AVERAGE.** This determines the number of samples of recovered audio that the SINAD meter uses to determine the actual SINAD measurement. More averaging will produce less variation of the SINAD readout, but will take more time to accomplish.
- The DURATION time.** Since some sites experience interference only at particular times (usually the most inconvenient times for the engineer), the 3901 can monitor a location for up to 7 days (10080 minutes) to catch interference issues. The DURATION is set in minutes.
- SOURCE.** The audio input source for the recovered audio. Audio input 1 or 2, balanced or Microphone input.
- FILE NAME.** This is a name associated with the logged data. It can be used to identify a particular site and date.

Initial Set Up and Calibrating the 3901 for Sensitivity Search

To use the 3901 for Sensitivity Search capabilities, the system needs to be set up and then calibrated. It is recommended that you use the 3901 in a manual mode to establish a good SINAD level before switching to the automated mode. This ensures that all connections have been made correctly and that the unit is configured properly. This includes the following:

- Initial set up of the display. Since the 3901 has various display modes (tiles), we want to display those tiles that allow us to perform the initial set up. To do this, we will select the generator, analyzer, site monitoring (requires Option 051 to be enabled) and the channel analyzer.
- The Radio RF receiver is connected to the appropriate port of the 3901. This will be either the Generator or the T/R port depending upon how the generator is configured. See figure 4.0 again for reference on connecting the 3901 to the radio.
- Ensure that the 3901 is recovering audio through either Audio input 1 or 2. To enable this correctly, select audio input port from the Site Monitoring expanded tile and select either audio in 1 or audio in 2. Audio input 1 is used in figure 4.0.
- The RF generator is configured for the correct frequency and that a modulation tone of 1 kHz is being sent on an FM carrier. See figure 7.0 for proper configuration of the 3901 generator.



Figure 7.0 Proper Configuration of the 3901 Generator

As you can see in this example, the frequency is set to 151.625 MHz with FM modulation. For the automated test, the RF level does not need to be set, as the Sensitivity Search feature will automatically control the RF generator level. However for the purpose of first attaining a SINAD measurement manually, a level of -60 dBm will provide more than enough signal to attain a good SINAD reading if everything is connected correctly.

The modulating tone is 1 kHz at 2.5 kHz deviation sine wave. It has been enabled as shown by the green select button next to the MOD 1 source.

- Enable the analyzer tile correctly to verify that the recovered audio is the correct frequency and that valid SINAD

measurements are being recovered. To do this, select the analyzer tile and then select the "Noise Meters" softkey. This allows you to select AF SINAD as the displayed value. Figure 8.0 Shows a properly configured analyzer tile.

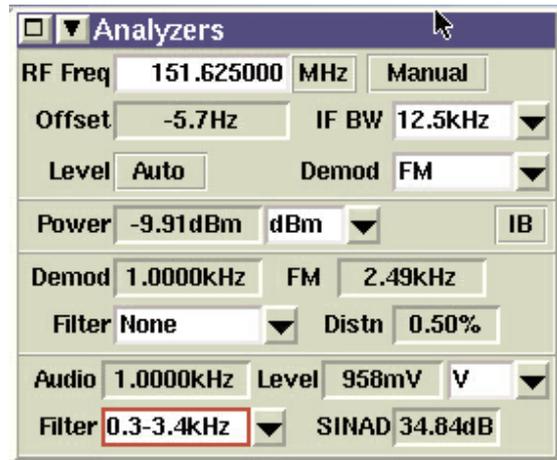


Figure 8.0 Proper Configuration of the 3901 Analyzer Tile

As can be seen, the analyzer has been configured to show the SINAD level on the minimized tile (refer to the operations manual on how 3901 tiles operate). The audio shows the frequency (1.0000 kHz) and the level (958 mV) and the currently selected audio filter is shown (using a bandpass filter will improve the SINAD level - it is up to the user to determine if any audio filtering is needed - in this case a 300 Hz to 3 kHz bandpass is used). Selecting the audio filter here will maintain that selection during the automated process. As you can see, we have a SINAD reading of 34.84 dB which is good.

The RF portion of the analyzer will be used to tune to the frequency that is being monitored off the air for spectral data. We need to make sure this is using the antenna port since this input port provides the most sensitivity for the 3901. To select the antenna port, tab or select the analyzer tile and then select the RF in softkey as "ant".

- Configure the Channel Spectrum Analyzer. To properly configure the analyzer, select the analyzer tile and expand the tile to full screen. Here we can set the captured bandwidth (up to 5 MHz wide), the RBW and the VBW and the sweep rate. Remember that the wider the bandwidth selected, the higher the noise floor, since we are letting in more spectral noise. The settings established for the spectrum analyzer will be those settings used during the capture of spectrum data. For more on setting up the spectrum analyzer, refer to the operations manual.

The relevance of the spectral data is dictated by the sweep speed of the analyzer when initially set up. For example, if you set the interval to 1 second, but the sweep of the spectrum analyzer is 2 seconds, you will get two of the exact same spectrum shots for the two consecutive logs. To ensure that you get an updated spectrum shot, set the interval time slightly higher than the sweep speed of the analyzer.

- Turn on the Generator. This is done by tabbing to or selecting

the Generators tile and then selecting the RF Out softkey to the right of the display. Once this is done, the SINAD level should be shown on the analyzer tile as shown in Figure 8.0.

You may be thinking at this point, "Wow, this is a lot to setup!" You are right - but you only have to do this once! Once all the above information is entered, you can save this configuration for recall at a later time. Once this is saved, you can reuse this setup time and time again for that site or as a basis for another site. All you need to do is vary the Generator and Receiver frequencies. See the 3901 operational manual on how to save a configuration.

To assist you in setting up a site monitoring test, go to www.aeroflex.com to download a preconfigured set up for Sensitivity Search. You can use this to use as a baseline for your Sensitivity Search tests.

Once we have obtained a good SINAD level, we can now calibrate the system to the actual conditions of the site being monitored. The calibration builds a dynamic SINAD to Sensitivity conversion table applicable to the existing conditions of the site location.

To calibrate the 3901, we will tab over or select the Sensitivity Search tile and select the "Calibration" Softkey. Figure 9.0 shows the calibration in process on the 3901. Allow approximately 2 minutes for the 3901 to calibrate the SINAD level.

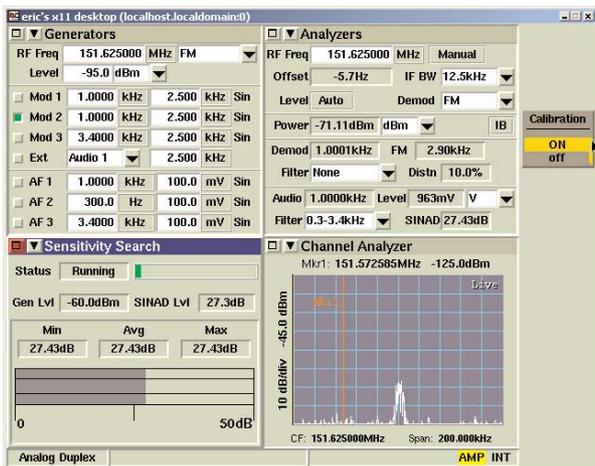


Figure 9.0 Calibrating the Sensitivity Search Mode

Starting the Sensitivity Search Mode

Now that we have the unit set up and calibrated, we can start the test. The Sensitivity Search function searches for the SINAD level entered and display the corresponding level associated at that time in dBm. At that time, the system will optionally capture spectrum data.

Before starting the Sensitivity Search, we need to review the operation of each function of the test mode.

Figure 10.0 shows the expanded Sensitivity Search tile.

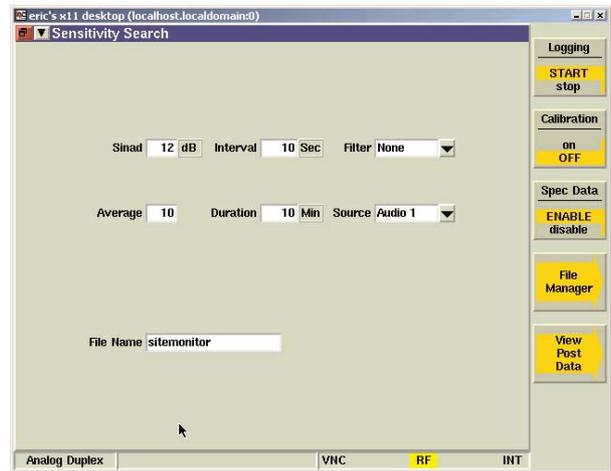


Figure 10.0 The Expanded Sensitivity Search Tile

On the right side of the screen, we can see the various softkeys associated with the Sensitivity Search functions. We will cover the "View Post Data" key later on in the next section. The Logging key starts and stops the logging process. The user can start the process and leave and the unit will log data for the time specified in the Duration field.

The Calibration function is used to calibrate the system to the environment. This will require that the radio be connected and a proper SINAD reading is obtained. The calibration mode will then build an internal SINAD to Sensitivity database for use in track the ERS of the system.

The Spec Data key allows the user to turn on and off the logging of spectral data. In some instances the user may chose to log just the ERS of the system without tracking spectral data.

The File manager key allows the user to manage the files saved. Since the 3901 has a 30 GB harddrive as standard equipment, users can log multiple files and save them internally. Selecting the File manager enables the file manager view as shown in figure 11.0



Figure 11.0 The File Manager View

From this view, users can select stored files to view after the logging has been completed. By selecting a file name and then selecting the "Set as Current" softkey, that file is recalled for

viewing the various information stored. They can also use this utility to remove stored files.

Once all the parameters are correctly set, we simply enable logging by selecting the Logging softkey. The system will start logging automatically, taking spectrum data (if enabled) as fast as the sweep time allows and then will log the SINAD level, ERS in dBm, and the spectrum data with a time and date stamp to the corresponding file on the 3901's hard drive. This file can then be retrieved later for display on the front screen of the 3901.

Viewing Post Data - Interpreting and Retrieving Data

Once we have data logged, we can then recall the data by selecting the View Post Data softkey. Figure 12.0 shows the corresponding screen to view logged data. The user can select one of two views, either the log file itself or the log file plotted.

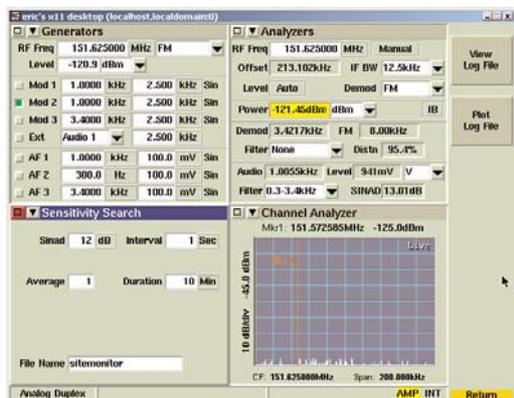


Figure 12.0 The Sensitivity Search View Post Data Options

Selecting the "View Log File" key will allow the user to simply view the data as a logged file. The Plot Log File is the most useful in that it allows the user to see the entire plot over time. It also provides data and time information and the ability to select a particular section of the plot to then view the spectral data.

Figure 13.0 shows the expanded Plot Log File view.

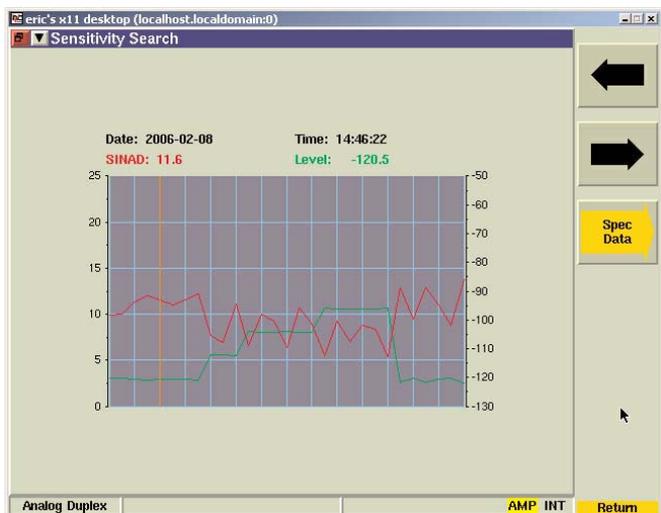


Figure 13.0 The "Plot Log File" View

The main focus of this view is the marker. The marker can be moved with a mouse (if attached), the right and left arrow softkeys

shown, the right and left arrow keys on the front of the 3901 and the scroll knob on the front of the unit as well.

As you can see, this view allows the user to note the date and time of the marker position. It then shows the corresponding SINAD (in red) and ERS level (in green). Notice that the ERS reading started "climbing up" over time and then went back down.

The user can set the marker to a particular point on the plot and then view the spectral data by selecting the "Spec Data" softkey. In this instance, we want to look at the data at 14:46:22 on the 8th of Feb, 2006. Figure 14.0 now shows the corresponding spectral data show when the "Spec Data" key is selected.

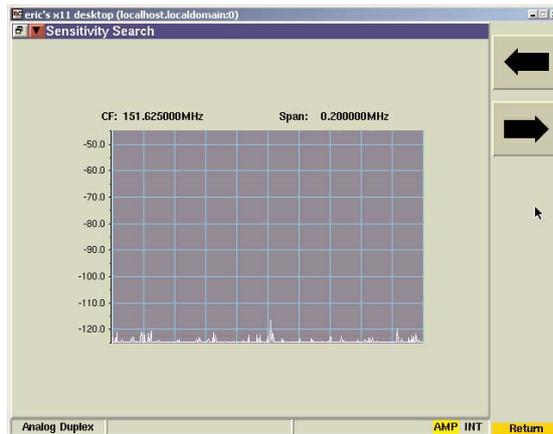


Figure 14.0 The Corresponding Spectral Data for the Date and Time Selected

As you can see, the spectrum at this time looked fine. There were no interference and you can just see the modulation of the 3901 at center frequency that is producing a 12 dB SINAD level. Now, if we move the marker to the right to view the time where the ERS went above -100 dBm, we can then view the spectrum data at that point. Figure 15.0 shows the selected date and time of 14:46:37 (15 seconds later) and Figure 16.0 shows the corresponding spectral data.

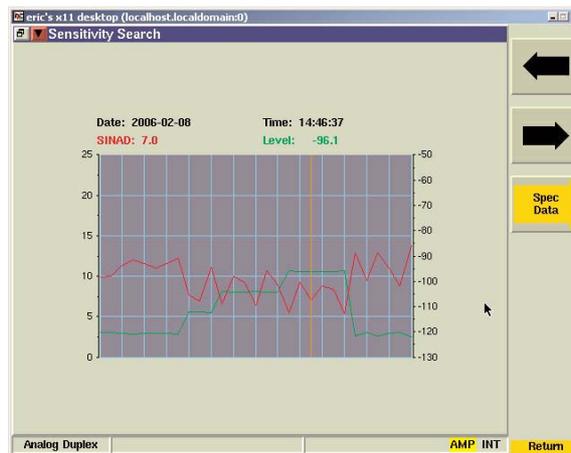


Figure 15.0 The "Plot Log File" with the Marker at a Higher ERS level

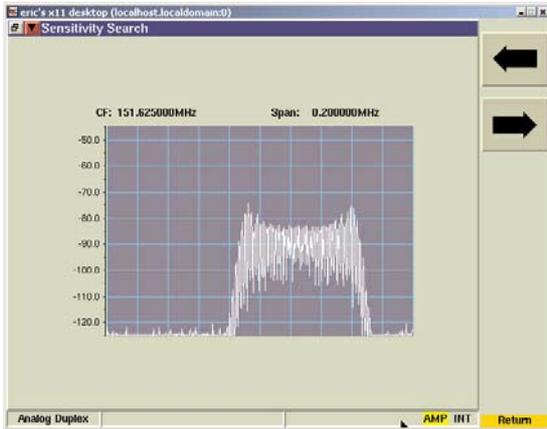


Figure 16.0 The corresponding spectral data for the Higher ERS level

As you can see, we can see significant interference that is causing problems in the band. By using the spectrum data, the user can see where potential sources of interference are coming from and document system and site performance before and after installation of a base station.

Internet Remote Operation

The Sensitivity Search is an automated test. You no longer have to sit and monitor SINAD and spectrum data manually for an extended amount of time. As an added benefit to the Sensitivity Search function, the 3901, as part of its standard configuration, can be remote controlled via the Internet!

The Aeroflex 3901 utilizes TightVNC, which is a free, remote control software package. With TightVNC, you can see the front panel of a remote Aeroflex 3901 and control it with your local mouse and keyboard, just like you would do by sitting in the front of the unit. TightVNC is a free, GPL-licensed, program available from www.tightvnc.com.

The ability to control the instrument via the Internet is important in remote monitoring applications. With the Aeroflex 3901, you simply assign an IP address to the device and then, after installing TightVNC on your computer, you can take control of the Aeroflex 3901 no matter where you are located. (Make sure Firewall issues are resolved first!) Figure 17.0 shows where to set up the IP address of the 3901. To get to this screen, simply select the UTILS key twice and go to hardware settings and then network.

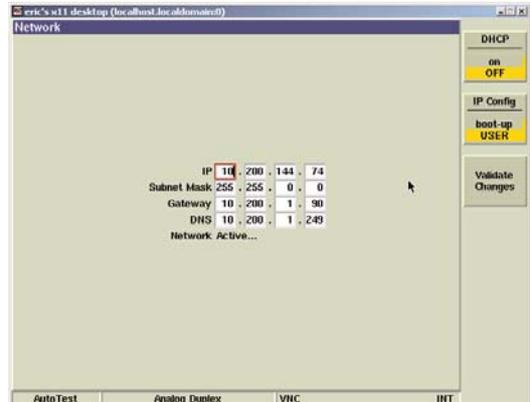


Figure 17.0 Showing IP configuration screen for the 3901

This will allow the engineer to remotely control the 3901 for viewing logged data via the Sensitivity Search function. The VNC connection emulates the front panel operation of the unit on your remote computer.

However, probably the biggest benefit of using the 3901's remote control internet feature is the ability to take control of the unit and do additional tests. The spectrum analyzer can be viewed remotely allowing the user to look around for potential sources of interference from a remote location rather than being on site. The generator can also be remotely controlled to generate back into the network to check for proper operation of the base site, effectively allowing end-to-end testing of the radio network.

Note: All of the pictures of the 3901 in this application note were done by using the internet remote function.

Conclusion

The Aeroflex 3900 series radio test sets represent a quantum leap in radio test technology. The ability to log SINAD levels, ERS and spectral data give the RF technician or engineer new tools in identify sources of RF interference and the ability to quickly and remotely qualify new potential RF sites. With the 3902's useful range to 2.7 GHz, this unit can be used to test emerging RF technologies in many of the Land Mobile, Satellite, Microwave, Military and Cellular bands.

The internet remote feature provides the ability to remotely control the 3901 or 3902 from the comfort of the technician's or engineer's office or lab reducing time spent traveling to and from a site location to track down intermittent RF interference issues.

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