

How to Investigate Wireless LAN Radio Wave Environment

~ RF Interference Detection
Using Real-Time Spectrum Analyzer ~

Contents

1. Introduction	2
2. Widespread Wireless Use and Communication Failures	2
3. Decreased Speed and Instability in Wireless LANs	3
4. Confirming Communication Quality Using Free Software for Wireless LAN Analysis	4
4.1 Step 1: Understanding communication speed	4
4.2 Step 2: Understanding radio environment overview (1)	4
4.3 Step 3: Understanding radio environment overview (2)	5
5. Confirming Communication Quality Using Spectrum Analyzer	5
5.1 Necessity for measuring radio waves using spectrum analyzer	5
5.2 What is a spectrum analyzer?	6
5.3 Measurement result difference between RTSA and free software	7
5.4 Example of wireless LAN bandwidth monitoring (spectrogram time axis display)	7
5.5 Example of multipath waveform monitoring	8
6. Summary	8

1. Introduction

Our lives are supported by convenient electronic devices, many of which can be connected wirelessly thanks to advances in wireless communications technologies, with wireless LAN being the most popular and widely used. While wireless LAN is license-free and easy to use, the number of connected devices and access points is increasing, such that interference with other wireless communications is becoming an issue. This can cause issues such as poor connectivity, disconnection, and slow communication speeds.

This application note summarizes how to investigate the radio environment when communication issues occur with wireless LANs.

2. Widespread Wireless Use and Communication Failures

With the spread of wireless communications technologies such as wireless LAN and 4G/5G, high-speed data communications are now possible anytime, anywhere. Multiple wireless devices permeate people's lives in homes, offices, factories, hospitals, etc. Wireless communications have become essential to economic activity, including social infrastructure such as airlines, railroads, police, and fire departments.

On the other hand, communication failures have occurred as a result of the following:

1. Radio interference: Radio interference from other wireless or electronic devices may occur, degrading communication quality. Also, electromagnetic noise, that is, unwanted radio waves, radiated from equipment with no radio communication functions (welding machines, power tools, motors, thermostats, etc.) can interfere with communications.
2. Effects of obstructions: Obstructions such as buildings and terrain can interfere with radio wave propagation, resulting in communication interruptions and reduced signal strength.
3. Shielding: Communication may not be possible in locations that are difficult for radio waves to reach, such as inside buildings, underground, or in spaces surrounded by reinforced concrete or metal. In addition, multipath effects may lead to communication being difficult in some areas.
4. Congestion in the 2.4 GHz band: The 2.4 GHz frequency band used by wireless LAN and *Bluetooth*® technologies is also the Industrial Scientific and Medical Band (ISM band), which has been allocated for general use in the industrial, scientific, and medical sectors. As a result, many different wireless communications devices share this bandwidth. This makes the bandwidth very congested and can lead to unstable connections and slow communication speeds due to interference between devices.



To overcome these communication failures, engineers need to check the quality of the communication between the electronic devices used in the environment in which they are installed, and then implement appropriate measures such as effective quality control to prevent radio interference. In the next section, we will explain how to investigate the wireless LANs that are widely used in offices, factories, commercial facilities, and medical institutions.

3. Decreased Speed and Instability in Wireless LANs

As the most common form of wireless communication, wireless LANs are installed in a wide variety of products such as smartphones and smart home appliances. In addition, since they do not require a license, making it easy to provide services, they are used in a wide range of fields, including homes, stores, factories, and municipalities. A wide variety of services, including public wireless LANs, are available for both outdoor and indoor environments.

The use of wireless LANs is only expected to increase in the future.

Wireless LANs currently use mainly the 2.4 GHz and 5 GHz frequency bands; the 2.4 GHz band, as mentioned in Section 2, is congested and prone to interchannel interference. The 5 GHz band is relatively stable with less interference due to its wider bandwidth and use of a different frequency range from other wireless devices.



Wireless LANs are becoming increasingly important in the wireless communications infrastructure, given that we live in a world that is increasingly relying on data with the proliferation and increased sophistication of IoT devices. Wireless LAN standards continue to evolve to enable next-generation use cases such as high-definition video streaming, Internet gaming, and AR/VR. Wireless LANs have been enhanced with "Wi-Fi 6" for the IEEE 802.11ax standard, using the 2.4/5 GHz band and "Wi-Fi 6E" for the 11ax standard, using the 6 GHz band. Wi-Fi 6/6E has realized significant improvements by reducing latency and interference, while improving capacity, reliability, and security, in addition to providing more efficient communications. Wi-Fi 6/6E offers significant advancements in communication efficiency. Moreover, it is set to continue to evolve into 11be "Wi-Fi 7," which will offer a data throughput of over 30 Gbps with technology enhancements such as a maximum channel width of 320 MHz and the 4096QAM modulation format.

Frequency Bands Used for WLAN

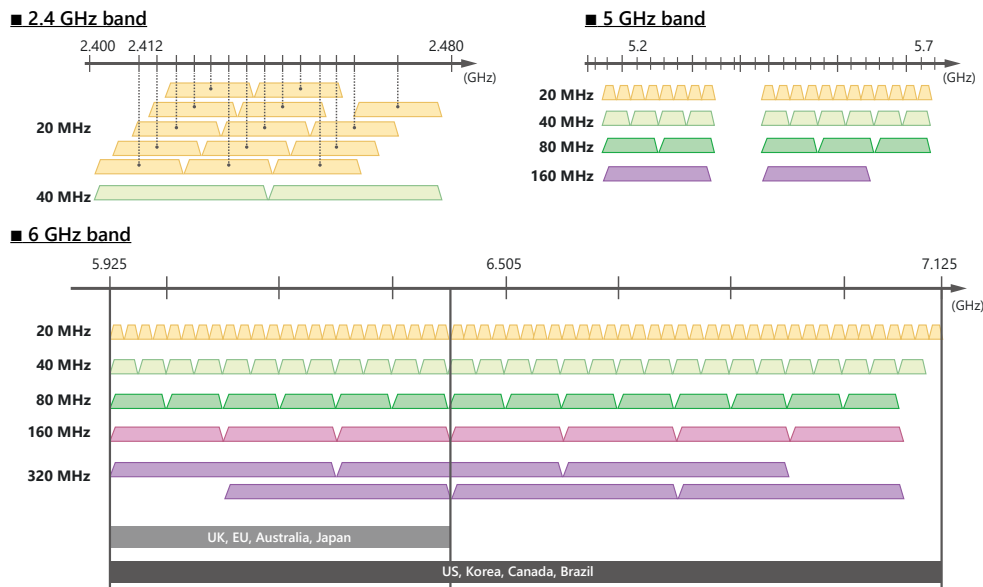


Figure 1 Frequency Bands Standardized for Wireless LAN

On the other hand, wireless LANs have issues such as "slow and unstable communication," depending on the situation. The following three points have been identified as causes of these issues.

1. Even in a good radio environment, communication speeds may decrease when many devices connect to a single wireless router leading to a large amount of data passing through a single point.
2. If other wireless LANs are using the same or adjacent channels and the other wireless LAN signals are strong, data retransmission will increase, slowing down the communication speed and, in the worst case, making communication impossible.
3. The system is affected by radio waves emitted from devices in the vicinity, including Bluetooth devices, other wireless devices, microwave ovens, and motors. In this case, as in 2, the data retransmission increases, communication speed decreases and, in the worst case, the connection may be terminated.

As described above, a variety of reasons can lead to "slow and unstable communication". Therefore, engineers need to isolate the cause and implement countermeasures.

4. Confirming Communication Quality Using Free Software for Wireless LAN Analysis

A simple way to identify the cause of "slow or unstable communication" in a wireless LAN is to use free software such as "WiFi Analyzer". This section describes examples of checking the communication quality using a PC and a smartphone in the 2.4 GHz band, where radio interference is most likely to occur.

4.1 Step 1: Understanding communication speed

First, we would check whether the communication speed is satisfactory. Generally, the standard transmission speed for comfortable video viewing is said to be 3 to 25 Mbps for downstream transmission. YouTube recommends 1.1 Mbps for SD 480p, 5 Mbps for HD 1080, and 20 Mbps for 4K.

<How to check the communication speed>

Enter "netsh wlan show interface" at the Windows command prompt and check the "wireless LAN type".

Check the wireless LAN communication speed using the network speed measurement site "<https://fast.com>", etc.



Figure 2 Display example of wireless LAN standards and communication speed

4.2 Step 2: Understanding radio environment overview (1)

Next, use free software to check the Received Signal Strength Indicator (RSSI). As a general guideline for determining whether the RSSI of a wireless LAN is satisfactory, a wireless connection is said to be stable if the RSSI is above -40 dBm, and communication is possible if the RSSI is above -60 dBm. However, an RSSI of -70 to -65 dBm or lower may be indicative of an unstable wireless connection. The free software can also check whether the channel in use overlaps with the channels of other wireless LAN devices based on the visualized wireless LAN channel usage.

The height of the waveform represents the signal strength.
The higher the waveform, the better the communication.

The overlap of waveforms shows that multiple wireless LAN signals are using the same or nearby channels. Weak signal strength and, furthermore, signals that overlap other wireless LANs can lead to a deterioration in the communication quality, such as the inability to increase the communication speed.

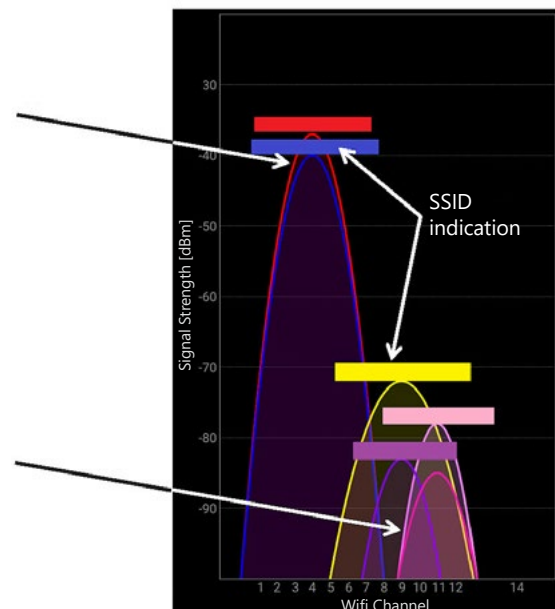


Figure 3 Display Example of RSSI

4.3 Step 3: Understanding radio environment overview (2)

Even if the RSSI is confirmed as being -40 dBm or higher in Step 2, long-term monitoring may be necessary because the radio environment changes over time. Figure 4 shows the time variation (time graph) of the radio environment, with the horizontal axis representing time and the vertical axis representing signal strength. The red and blue lines indicate the signal strength of the wireless LAN access point (AP) and station (STA), respectively. The other colored lines indicate other wireless LAN signals with overlapping channels. If these signals are present and their strength is greater than that of your own station, communication problems are likely to occur.

Using the above method, check for other wireless LAN devices using the "same channel" as your wireless LAN, and confirm that the RSSI of your wireless LAN is strong enough to be unaffected by other wireless LAN devices.

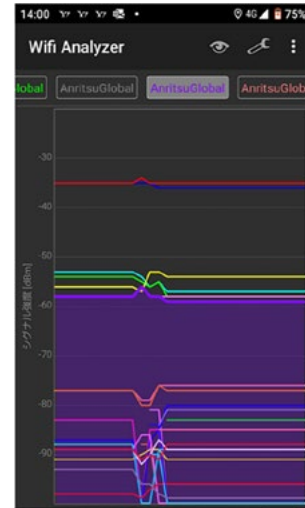


Figure 4 Example of RSSI vs. Time Graph

If there is a possibility of a device being affected by other wireless LAN devices, the following measures are effective.

- Change the location of the wireless LAN AP of your own station.
- Adjust the tilt of the antenna.
- Move to another available channel so that channels do not overlap.
- Block radio waves on the same channel emitted by another wireless LAN device from reaching the device.

5. Confirming Communication Quality Using Spectrum Analyzer

Even if you use free software for wireless LAN analysis, you may not find problems in your wireless LAN communication environment. In such cases, you should suspect and investigate another cause.

5.1 Necessity for measuring radio waves using spectrum analyzer

As mentioned earlier, wireless LANs using the 2.4 GHz band may be subject to interference due to radio waves emitted by various other devices.

Devices that may cause radio interference include the following:

- Wireless devices such as game consoles
- Microwave oven
- Wireless mouse
- Cordless phones
- Bluetooth devices
- Other items using the 2.4 GHz band, such as radio controls, automatic doors, etc.

The free software introduced in the previous section cannot help us understand the causes of such radio interference. Even if the RSSI value is sufficient, the communication quality will deteriorate if excessive interference is affecting a given signal. The alternative is to use a "spectrum analyzer" to check the radio wave conditions in the operating environment.

5.2 What is a spectrum analyzer?

Spectrum analyzers are "radios that can see radio waves". They measure the distribution of frequency components (spectrum) in radio waves by displaying the frequency on the horizontal axis and the radio wave strength on the vertical axis.

There are three types of spectrum analyzers: the "sweep type," "fast Fourier transform (FFT) type," and "real-time type," the use of which is selected according to the measurement to be performed. The "sweep type" is the most basic type of spectrum analyzer that has been in use since the analog era, while the "FFT type" has been developed as a result of advances in digital technology. Both types have characteristic measurement methods, and there are periods when measurement is not possible.

The figure below shows the measurement screen of a swept-tuned spectrum analyzer observing radio waves in the 2.4 GHz ISM band. Many signals are displayed, but individual signals cannot be identified. The blue Max Hold waveforms (the areas marked ①, 2, and 3) can be used to locate Bluetooth Low Energy advertisement packets, but it is difficult to capture the WLAN activity.

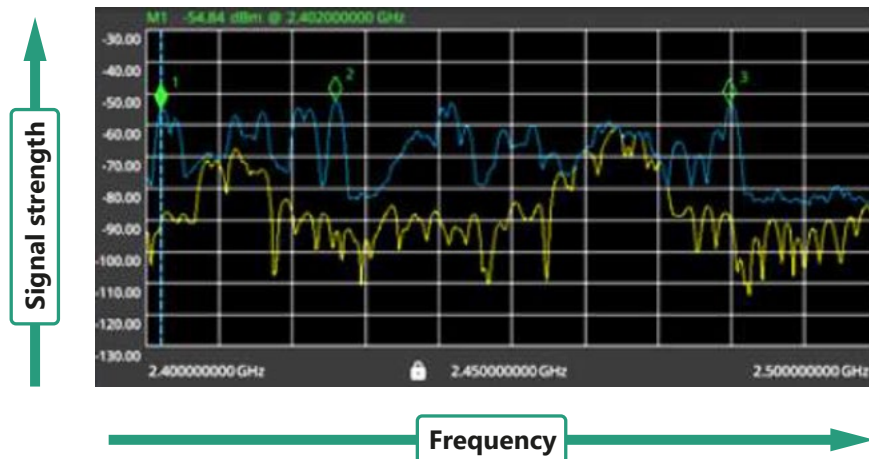


Figure 5 Measurement Screen of Swept-tuned Spectrum Analyzer

In contrast, by utilizing a "real-time spectrum analyzer (RTSA)," a radio signal of a certain frequency band can be acquired, just like the "FFT type". Given that signals are processed in parallel, continuous signal acquisition is possible. Therefore, even signals that appear only for a short period of time can be displayed on the measurement screen.

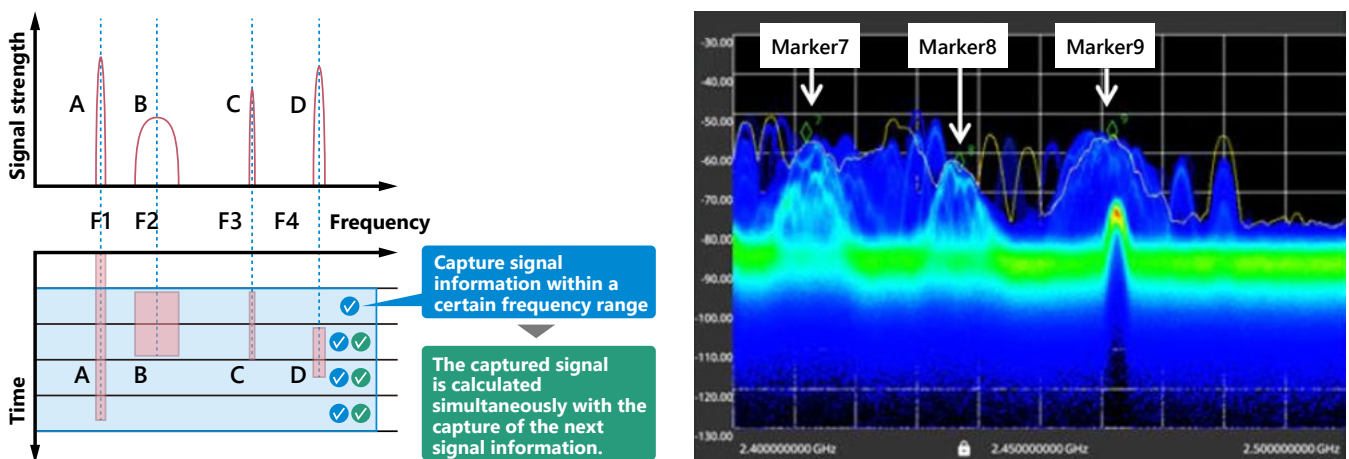


Figure 6 Principle and Measurement Screen of RTSA

Using the RTSA to look at the same spectrum as that shown in Figure 5, Figure 6 clearly shows three WLAN access points (markers 7, 8, and 9) at 2.412, 2.437, and 2.462 GHz. The other signals are those of Bluetooth devices in the area.

5.3 Measurement result difference between RTSA and free software

Compare the results of measurement by RTSA and those obtained with free software. The left side of Figure 7 shows the results obtained with the RTSA, while the right side shows the results of simultaneous measurement by the free software. In the left figure, colored lines are inserted into the signal waveform to clearly indicate the wireless LAN signal.

The free software displays only a partial result for the wireless LAN AP and cannot display the radio wave state of the PC connected to the AP, or Bluetooth signals. RTSA, on the other hand, can observe all these signals.

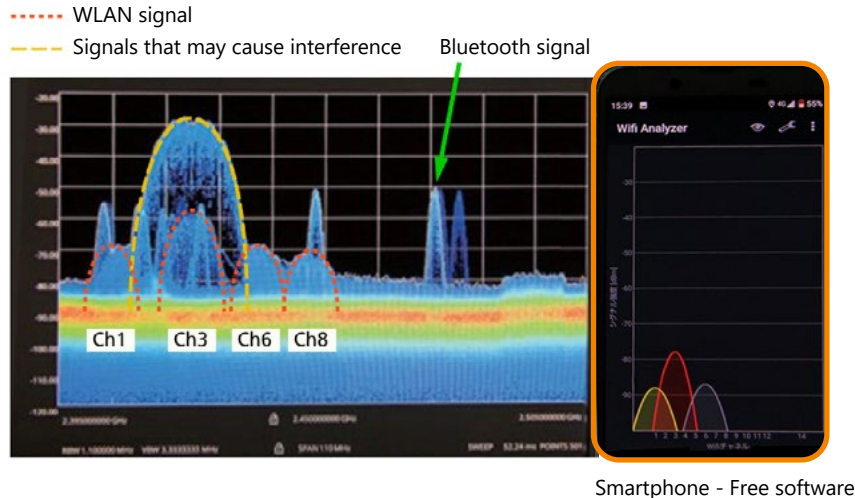


Figure 7 Display of Free Software and RTSA

In Figure 7, if channel (3) of the wireless LAN causes a "communication speed slowdown and unstable communication", the factors could be due to the PC's 2.4 GHz wireless device connection, USB connection, or Bluetooth communication. To identify the cause, engineers should investigate the source of the signal by turning off the PC or Bluetooth device to eliminate the signal.

5.4 Example of wireless LAN bandwidth monitoring (spectrogram time axis display)

In addition, the use of the RTSA allows the evaluation of the time-related variation of radio wave strength versus frequency, called a spectrogram. The horizontal and vertical axes of the spectrogram represent frequency and time, respectively, and the radio wave strength is displayed according to a user-specified color scale. When the RTSA and spectrogram are displayed simultaneously, the time-related variation can be confirmed by the RTSA screen. In the following figure, the center WLAN signal and the Bluetooth advertising signal are output continuously, with the Bluetooth wireless signal hopping regularly.

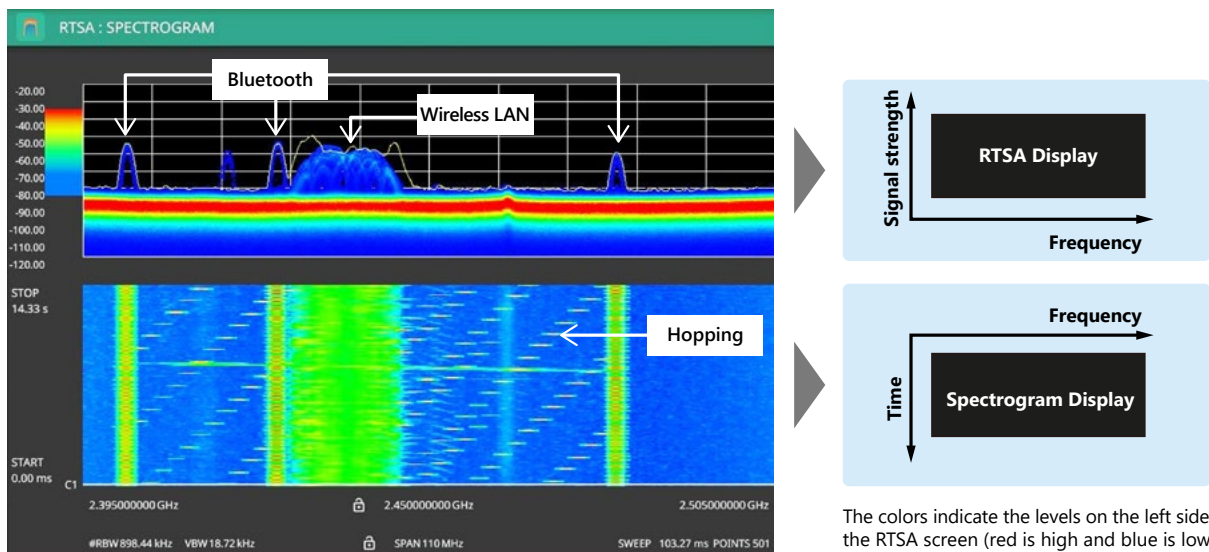


Figure 8 RTSA Screen

5.5 Example of multipath waveform monitoring

A cause of slow and unstable communication is multipath interference. Multipath is a phenomenon in which radio waves follow multiple paths other than the direct transmission path due to reflections caused by obstacles. Radio waves emitted by the Tx hit various obstacles such as walls, ceilings, people, and equipment between the Tx and Rx, and reach the Rx despite reflection, diffraction, attenuation, and other phenomena. Thus, in a multipath situation, a slight difference in the arrival time occurs between directly delivered radio waves and other radio waves, resulting in radio wave strength fluctuations due to mutual interference.

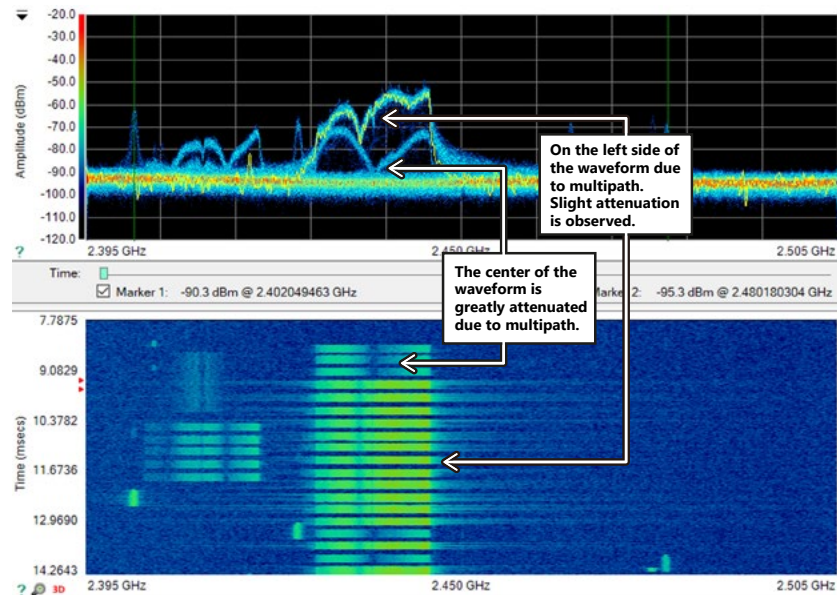


Figure 9 Spectrum Waveform at Multipath

Figure 9 shows the spectrum of the RTSA and spectrogram when the phenomenon that appears to be multipath is captured. Appropriate countermeasures can be implemented by checking the occurrence of multipath while changing the location of access points and obstacles.

6. Summary

This application note introduced how to use RTSA and free software to investigate the radio environment of a wireless LAN. The following is a summary of the key points.

Wireless LAN communication quality can be evaluated simply by using free software. However, with free software, it is difficult to check the effects of radio interference other than wireless LAN. On the other hand, RTSA can capture signals that fluctuate at very high speed and in a short period of time within the bandwidth of a wireless LAN, and can also observe overlapping interference waves within the signal bandwidth. By utilizing the spectrogram function, changes in the signal strength of the spectrum over time can be visualized.

Of the three types of spectrum analyzers, the "sweep type" will remain the tool of choice for general RF measurements, but the RTSA will become the new standard for spectrum measurements when monitoring rapidly changing signals, complex modulations, and highly variable signals.

To counter radio interference, we recommend that you first implement the following.

- Turn off the power to the equipment that is causing radio interference.
- Shield radio waves from interference sources, by using metal sheets, etc.
- Change the location of the wireless LAN router.
- Change the channel.
- Use a router in the 5 GHz band.

Related Web Page: [Field Master Pro MS2090A Product Page](#)

Note: The Bluetooth® word mark and logos are registered trademarks owned by Bluetooth SIG, Inc. Any use of such marks by Anritsu is under license.