WSA PRODUCT SERIES BROCHURE

WSA (Wireless Signal Analyzer) is a high-performing portable broadband FFT Spectrum Analyzer and 4G/5G Signal Analyzer that is optimized for both indoor and outdoor applications

2026-01-26

SAGE INSTRUMENTS

What is WSA?

WSA stands for Wireless Signal Analyzer. It's an advanced RF signal analyzer (and broadband FFT spectrum analyzer) developed by Sage Instruments. The product series is currently available in the following form factors:

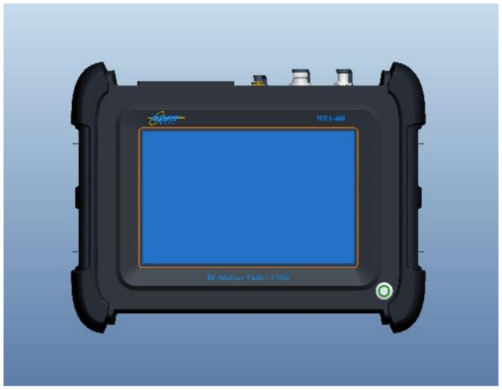


Figure 1, three form factors of the WSA series product: WSA-408 (left), 308, and 208.

- WSA-408 is a complete portable instrument (<3 kg) with built-in battery, touch screen (10.1") and SBC (Single Board Computer);
- WSA-308 is an RF instrument test head designed to work with an external PC through an ethernet (LAN) cable in a lab environment, or deployed in the field operated through the cloud networks. It maintains all the test functionalities of the WSA-408 minus the touch display and battery;
- WSA-208 is identical to WSA-308 except skinnier packaging (< 400g in weight). It's meant to be integrated with an external directional antenna and electronic compass then mounted on an UAV (drone), in or on a car, or in a ship for signal intrusion detection and direction finding and signal coverage drive testing etc.

Why WSA?

The existing portable RF instruments or receivers in the market all have the following shortcomings:

- The OTA (Over the Air) signals are increasingly dominated by the broadband TDD type of OFDM signals (4G-LTE, 5G-NR, Wi-Fi and more) whose spectrum changes rapidly. Such signals demand a broadband real-time FFT Spectrum Analyzer with instantaneous analysis bandwidth greater than the native spectral bandwidth of the signal of interest. Yet almost all spectrum analyzers in the market still operate in the slow and narrow-band sweeping mode. Such products can never capture the wholesome spectrum of an active signal burst and tend to present only false partial-slices of the spectrum (a 100-MHz contiguous spectrum may be chopped up into a few dis-contiguous spectra of 5 MHz, for example);
- Some name brand products and their copycats may have added an RTSA (Real-Time-Spectrum-Analyzer) module, yet such RTSA module is only used when in the "fuzzy" DPX (Digital Phosphorous Display) mode whose detailed performance metrics (in terms

of accuracy, spurs and sensitivity etc.) are impossible to specify. When in the regular Spectrum Analyzer mode, all these products fall back to the slow narrow-band sweeping mode, and these instrument's marketed performance specifications are all based on this narrow and slow sweeping mode, not on the RTSA module;

- Singular functionality. All incumbent products tend to fall into 3 discrete and distinct categories: Spectrum Analyzer, Signal Analyzer (4G or 5G analyzers), and Scanner (multi discrete channel signal analyzer). The market calls for an efficient solution that can offer all these features in one light weight and portable package;
- As for the various open-source SDR (Software Defined Radio) radio receivers that can capture the raw IQ data, they do not qualify as professional test and measurement instruments in terms of precision and accuracy, calibration traceability, sensitivity (or noise floor), out of band rejection and actual dynamic range in a hot signal environment (near a base station or a Wi-Fi AP station, for example). Such SDR receivers also require babysitting by a powerful PC to process the raw IQ data stream. They cannot operate independently or autonomously in spite of the perceived light weight or small package.

How is WSA different?

Knowing the shortcomings of all incumbent products in the market, WSA was designed from the inception to attain the following qualities:

- Consistent full-time broadband signal path for all operation modes. In plain words, WSA's spectrum analyzer is a true broadband FFT analyzer (with 100 MHz instantaneous analysis bandwidth), not a narrow sweeping-mode analyzer. All other tests, including the DPX and 4G/5G analyzer features, have the same performance specifications as the FFT analyzer;
- Multi-functionalities and infinite software expandability. WSA combines spectrum analysis, GSM/NB-IoT/4G/5G signal analysis and multi-channel scanner features into one box. Thanks to its unique architecture (explained below), its software features can be expanded "infinitely" without ever having to change the hardware;
- In-situ real-time-ness and autonomous operations: all WSA platforms have flexible and easily re-programmed DSP processing power built into the embedded hardware system that can continuously process the ADC data streams in true real-time. Unlike other competing products, they do not need an external powerful PC to post-process the raw IQ data streams in non-real-time fashion. Thanks to such elegant design, the WSA308/208 platforms can operate autonomously (scan the spectrum, analyze signal quality, record measurement results along with GNSS information and timestamp based on preset configurations and trigger masks) without being babysat by a PC. The recorded data can either be real-time sent to a cloud server if network connection is available, or be uploaded to a PC later when network connection resumes. This is particularly convenient for mounting the light-weight WSA-208 (<400 g) in an UAV (drone) for performing aerial signal interference hunting, signal intrusion detection and signal coverage testing.

- Although as light and small as a simple receiver and consumes only 20 watts in power, it matches or even surpasses the performance metrics of expensive top lab-grade instruments, yet it's also specifically designed for the tough outdoor field applications where an instrument is required to capture the minute uplink interference signals under the strong influence of powerful downlink signals near a base station. Simply speaking, WSA was designed to maintain exceptional dynamic range and out of band rejection performances when connected through an open antenna in a strong signal environment without sacrificing detection sensitivity. Rapid switching among different test modes is smooth, swift and snappy.
- Powerful, flexible and open-source code software APIs allowing any 3rd party software applications running on a local PC or remote servers to command/control the WSA instruments and obtain test results in real-time.

How has WSA achieved its superior performances?

The short answer is: by superior, and first of its kind, design architecture. Most RF analyzers in the market use the conventional "safe and proven" multi-stage super-heterodyne frequency down conversions and high IF (Intermediate Frequency much higher than the analysis bandwidth) and ADC sub-sampling (where the sampling rate is lower than the IF frequency). Such conventional design architecture entails the following pitfalls:

- Each down convention stage will inevitably lower the SNR, introduce image signals, nonlinearities, LO (Local Oscillator) leakage and input signal feedthrough etc. The more conversion stages, the worse the final instrument's detection sensitivity and spurious signals. To maintain broad analysis bandwidth and also wide frequency coverage (wide frequency tuning range for the 1st LO), the final IF frequency must be much higher than the targeted analysis bandwidth.
- Sub-sampling of the high IF signal requires stringent bandpass filtering of the signal, which can only be accomplished through SAW (Surface Acoustic Wave) filters, but such filters have notorious temperature drifting vulnerability. The strong amplitude response ripple effect and nonlinear phase response are hard to compensate or equalize to satisfy a fine instrument's measurement precision requirement. SAW filter's large physical signal propagation delay (envelop delay up to us) also affects the real-time-ness of the whole system. Sub-sampling also puts strenuous requirements on the ADC itself in terms of sampling aperture and clock jitter control.
- If high Nyquist sampling rate is used, the ADC's effective performance degrades (fewer bits per sample and more spurious signals due to the inevitable interleaved ADC architecture to achieve the high sampling rate). The resulting over-sampled digital IF data stream then requires dedicated DDC (Digital Down Converter) or FPGA to perform digital IF to IQ conversion and then sampling rate decimation. Such DDC/FPGA is not only power hungry, but also adds more quantization noises and introduces unexpected image components due to their finite numerical range and filter length limitations when implementing the taxing FIR (Finite Impulse Response) digital filters at the high ADC sampling clock rate.

By contrast, the WSA design architecture takes the following bold form:

- The multi-stage down-conversions are replaced with a single-stage quadrature conversion. This lowers the overall RF front-end NF (Noise Figure) to as low as 4 dB. Such conversion also eliminates complex image components and spurious signals due to mixer nonlinearities, leakages and feedthroughs.
- The ripple-plagued bandpass SAW filters are replaced with integrated RC filters with temperature stable smooth Butterworth responses. The ADC performs dual-channel synchronous Nyquist sampling with the highest sampling efficiency (in terms of sampling rate to signal bandwidth ratio), highest quantization bits per sample and best SNR and least amount of potential spurious signals.
- The resulting ADC data streams go directly to a multi-core DSP capable of native floating-point complex number arithmetic operations to achieve the best dynamic range for all unforeseen signal inputs. The floating-point DSP also enables rapid software development of complex algorithms required for handling the ever-changing new wireless signal types and standards.
- The inherent IQ imbalance and DC offset issues associated with such direct conversion scheme have been successfully resolved by combined hardware/software designs and dual-domain (both time and frequency domains) algorithms. This is truly a novel and original design with revolutionary breakthroughs in the advanced RF instrument industry.

Targeted applications

The following list is by no means exhaustive. It merely serves as examples only.

- For the mobile phone carrier and base station equipment vendor market, WSA can:
  1. Find the minute uplink interference signals in both time and frequency domains, under the toughest base station environment where the strong downlink signals can easily overwhelm most of the other instrument products in the market;
  2. Optimize the network by precise quantification of downlink signal coverage metrics for 4G-LTE, NB-IoT and 5G-NR signals by searching and synchronizing to the PSS/SSS signals, demodulating and measuring the reference signals and then decoding the PBCH channel to obtain the MIB (Master Information Block) data, and use the MIB data's CRC checking to define the ultimate coverage quality in combination with the signal's level and SNR metrics;
  3. Quickly determine the signal coverage across large areas using the multi-channel and multi-technology scanner drive testing. This is to rapidly perform the test described in item 2 above on many different frequency points and log the test results (along with GNSS and time stamp information) while the instrument is being driven around in a car or flown in an UAV;
  4. Spectral clearance for new base station installation.
- Ensure LAE (Low Altitude Economy) UAV flight safety by:
  1. Monitoring and trigger-recording (along with signal direction finding) GNSS band interference signals with the WSA-208 instrument itself being flown in an UAV;

2. Signal coverage determination in the UAV flight space for 4G/5G/5G-A signals to be used for flight control.
3. Illegal drone intrusion detection by RF signal monitoring.

- Signal intrusion detection along sensitive border areas or other areas of special interest. For this application, the WSA-308/208 instruments can either be deployed permanently in certain locations and operated through the cloud servers, or being flown in UAVs.
- Rapid signal intelligence (spectral data) acquisition by flying WSA-208s in UAVs over contested areas in preparation for electronic warfare or data collection for RF-AI/ML model trainings.
- Used as a general-purpose lab instrument (WSA-408/308) for high quality spectrum analysis, phase noise determination and signal quality characterization etc., or used as a general-purpose RF receiver (WSA-208) for rapid spectral data or raw IQ data gathering. The WSA-208 can also be embedded into other host systems that require real-time RF signal sensing, detection and analysis.

Key performance specifications

- Frequency coverage: [8 kHz, 8 GHz];
- Typical DANL (Displayed Average Noise Level): -160 dBm/Hz with pre-amp OFF; -170 dBm/Hz with pre-amp ON;
- Typical Max dynamic range (max input – DANL with pre-amp off): 138 dBc/Hz;
- SFDR (Spurious Free Dynamic Range, (2*(IP3-DANL)/3)=116 dBc/Hz;
- Known residual spurs: < 3dB above noise floor;
- Amplitude accuracy: within 0.5 dB;
- Frequency stability: 20 ppb when free running; 10 ppb with reference clock discipling;
- Marker amplitude accuracy: 0.1 dB; frequency accuracy: within 1 RBW setting.

Software APIs to WSA series products

All WSA products permit an open API (Application Interface) access from any 3rd party software to command/control all the test features and obtain test results. From networking point of view, all WSA products permit a UDP (User Datagram Protocol) based network socket connection from any 3rd party software at specified port. Using this connection, a 3rd party software can send forward (from 3rd party software to WSA) commands to change test settings, and obtain reverse (from WSA to 3rd party software) test results from a WSA product. The foundational "driver-level" C-source code will be provided for free to any WSA product customers. More detailed instructions and documentations on the C source code are available upon user request.

List of test functions

Figure 2 shows the test mode (different test features or functions) selection dialog of the WSA product. It is also a natural list of the different test functions.

Figure 2, list of different test functions.

Each test function will be briefly described in the following sections.

Real time SA

This is the foundational test feature of this WSA product. It shows, as in Figure 3, the signal spectrum within 100 MHz (span<=100 MHz). The whole spectrum, from left to right, is obtained at once from the same time-domain signal via FFT, hence it's a result of broad-band real-time FFT analyzer. It's not a result of narrow-band sweeping from left to right. This is particularly important for analyzing the wide-band TDD type of signals. The spectrum in Figure 3 was acquired in a tall office building near a densely populated border area. The weak co-channel interference signals from across the border regions are apparent due to the high sensitivity (low noise floor) and large dynamic range attributes of the WSA product. All active signals spectra are shown clearly and vividly with fine resolutions for both amplitude and frequency. Each active signal event's type is also marked (labeled and annotated) in the side margins.

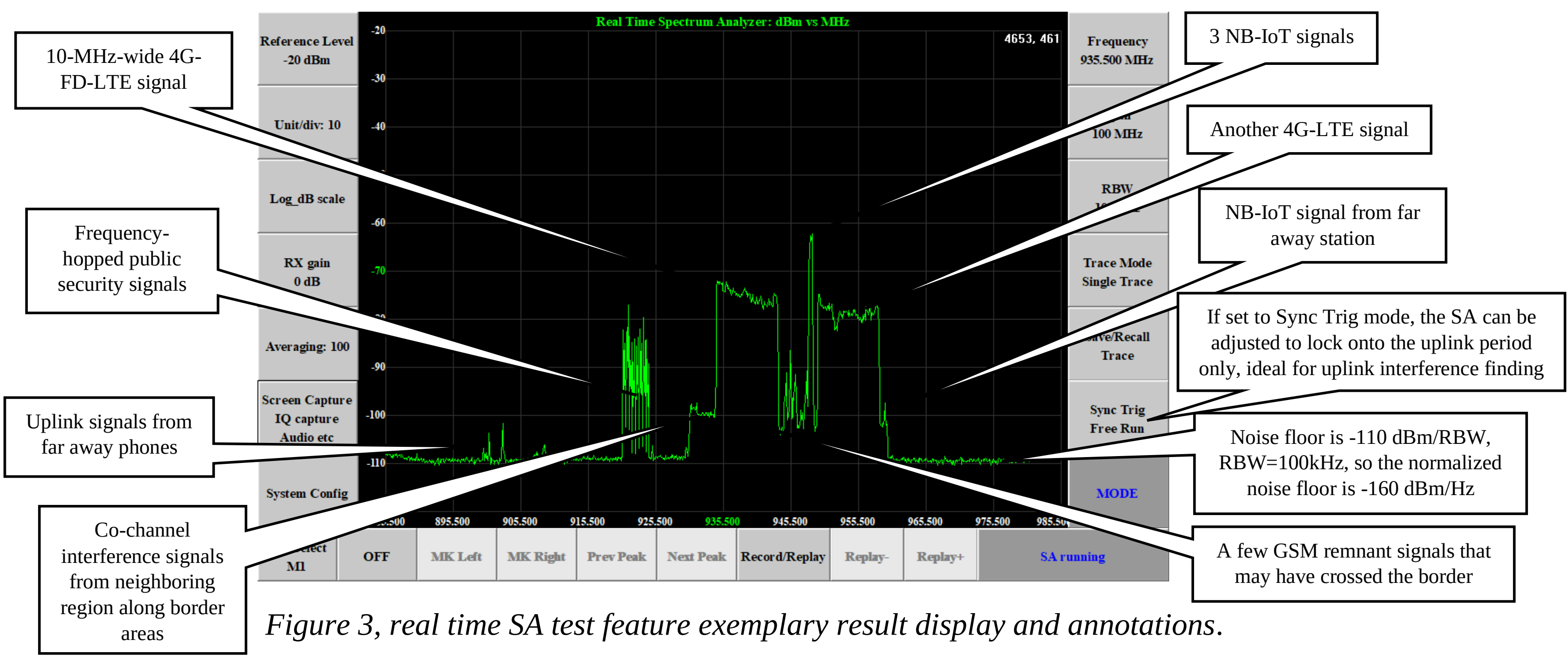

Figure 3, real time SA test feature exemplary result display and annotations.

Wide-span SA

For span>100 MHz, WSA also performs frequency sweeping, but the sweeping is carried out in large stride (frequency step) at either 50 or 100 MHz, hence the sweeping speed can reach >260 GHz/s without distorting the spectra of wide-band TDD type of signals as shown in Figure 4.

Figure 4, even in sweeping mode (span=1000 MHz here), the spectral display shows remarkable resolution for both amplitude and frequency and impressive interception of fast changing signals (TD-LTE, Wi-Fi and 5G-NR) without distorting their respective spectrum.

Continuous DPX (Digital Phosphorous Display)

This continuous DPX operates in the same manner as other instruments in the market except that WSA has much lower noise floor and better frequency and amplitude resolutions. The display is updated continuously with new traces carrying more weights in color rendering than the past traces whose influence is exponentially decayed. An example of this test feature is shown in Figure 5.

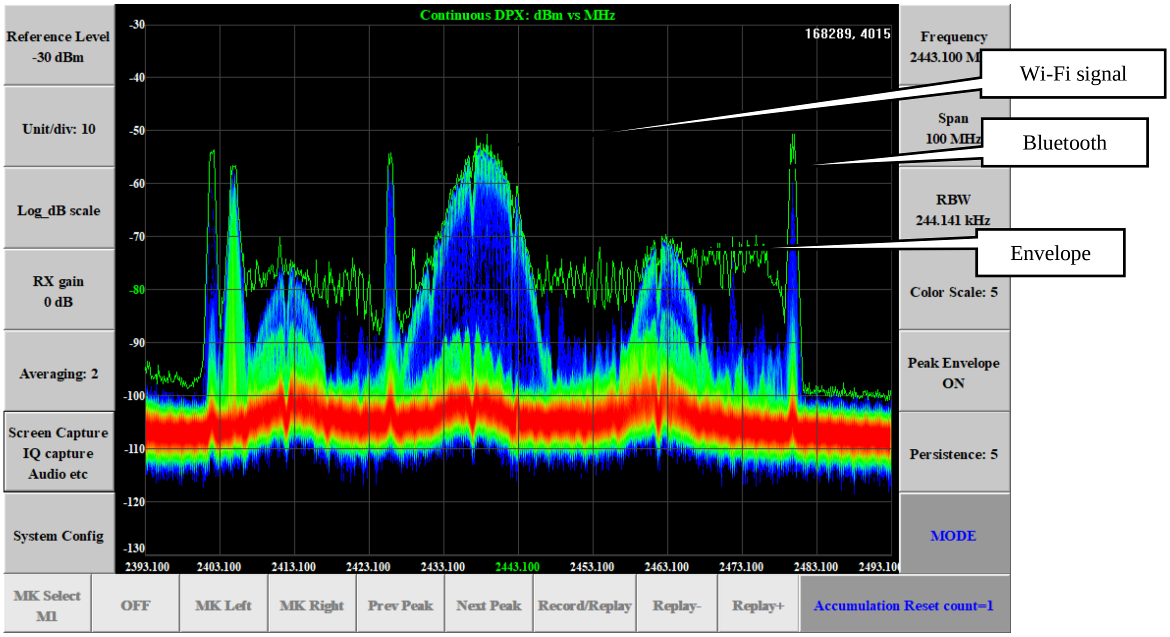

Figure 5, exemplary continuous DPX display of Wi-Fi band signals.

Block DPX

The continuous DPX display shown in Figure 5 continuously adds in new traces and exponentially decays the old traces. For a signal event that appears periodically but only lasts a finite duration, the continuous DPX may not present a stable or persistent picture. Hence in the WSA product, we provide an easier-to-understand Block DPX test feature. In this Block DPX, a user can pre-set a signal block length. Ideally, such block length should be set to integer multiples of the signal event period (Nx10ms for 4G/5G signals, for example). Then within one whole block, this Block DPX test feature will perform analysis on every sample (guaranteed 100% POI down to 8 ns), and each internal trace within the block will be equally weighted, so that for the periodic but short-duration signal events, the Block DPX display will be relatively more stable, persistent and not miss any event. Figure 6 shows an example for signals associated with an UAV (Unmanned Arieal Vehicle, drone). The frequency hopped narrower band uplink signals and stable wider band downlink signals are obvious in the display, along with some Wi-Fi signals from remote devices. Figure 6 demonstrates the fact that this Block DPX display might be the most effective way of detecting the intrusion of an UAV via RF signal monitoring.

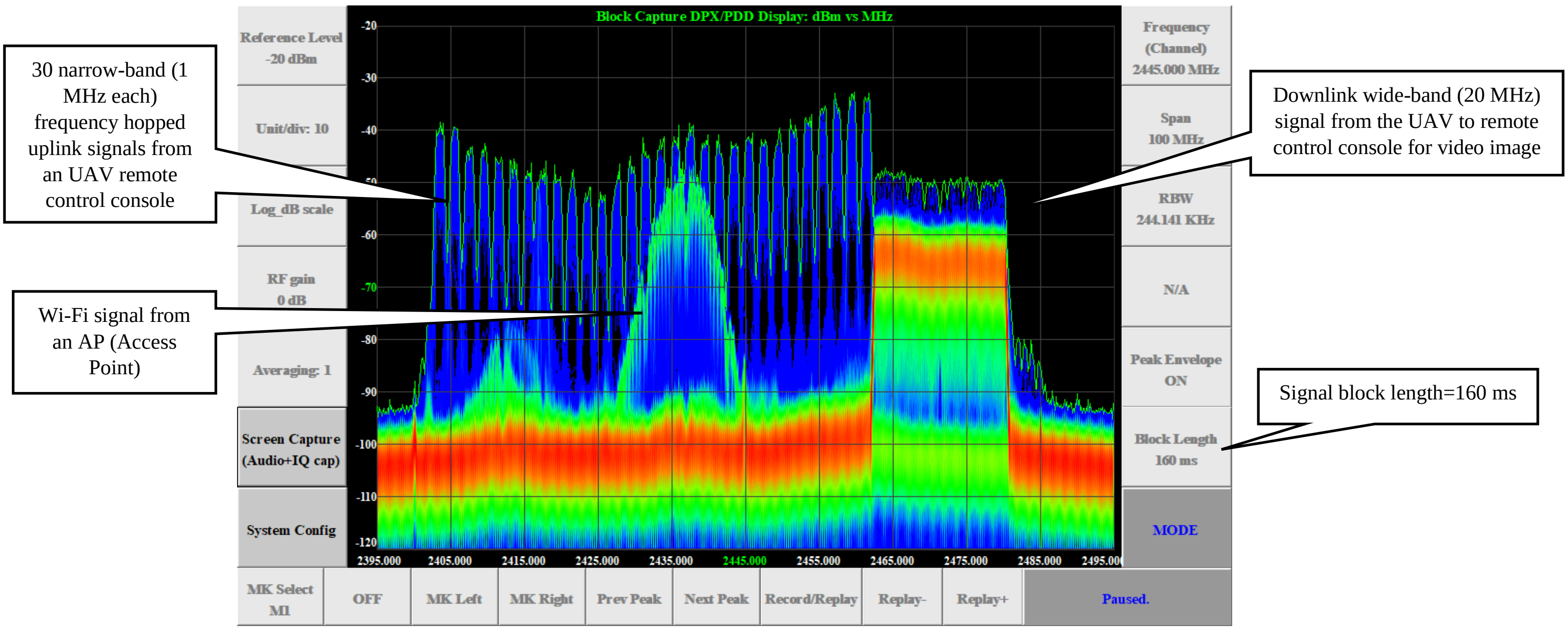

Figure 6, Block DPX display of an UAV flight control signals.

Spectrogram (waterfall display)

The Spectrogram display works in the same manner as the other instruments in the market except for the following two aspects:

1. Each trace is generated via broad band FFT, not through sweeping, hence the effective interception rate is much higher for short duration or frequency hopped signals;
2. The Y-axis can be changed to linear amplitude scale (instead of the conventional log-dB scale) to help discerning certain frequency hopped signals better. See Figure 7.

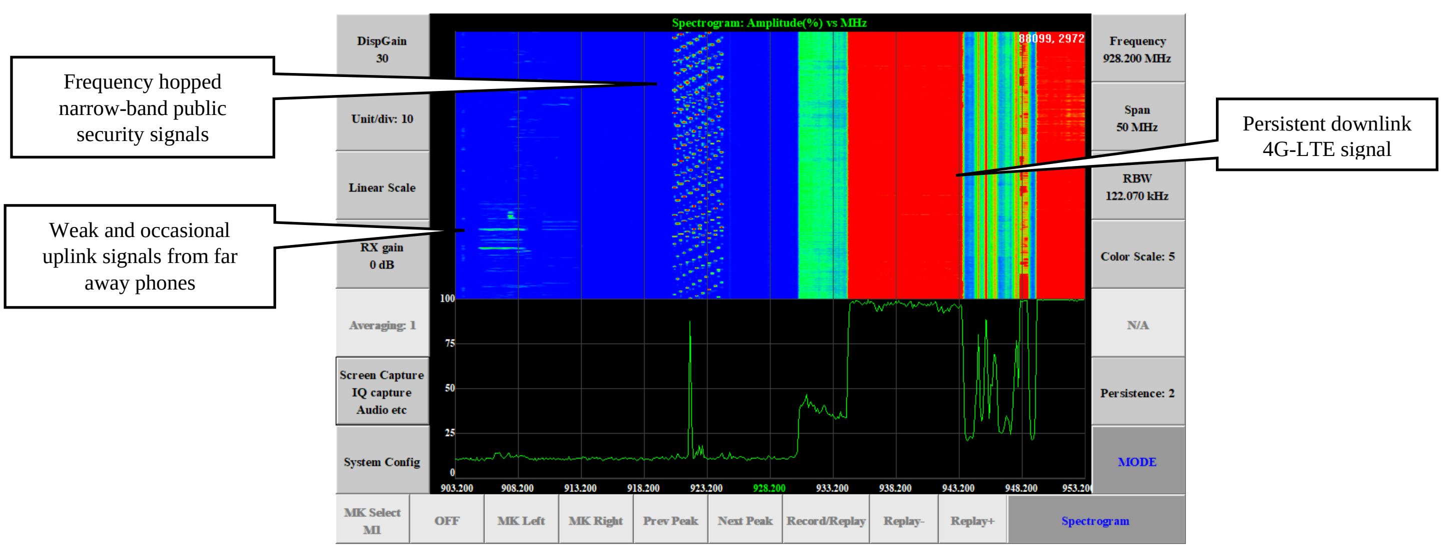

Figure 7, exemplary Spectrogram display.

TD-power+SA

This test name's abbreviation stands for "Time-Domain power plus Spectrum Analyzer". The working mechanism of a broad-band FFT analyzer is such that it internally gathers and analyzes a contiguous block of time-domain IQ baseband signal of certain effective bandwidth corresponding to the original band-pass RF signal of equal bandwidth but centered at the tuned frequency point. The center frequency does not change (not sweeping), so that the IQ complex signal's time-domain amplitude (after appropriate filtering) is the natural time-domain power profile of the original band-pass RF signal. Therefore, an FFT analyzer can naturally present both time-domain and frequency-domain information of a complex RF signal, and both domains are naturally synchronized. If the FFT analyzer has built-in internal precise time-triggering (as the WSA product has) mechanism, the time-domain profile can then be precisely aligned with the time-domain frame structure of a TDD (or FDD) type of 4G/5G signal. This is particularly useful for investigating the tough uplink interference signals, as will be shown below. First, Figure 8 shows an exemplary display of this test for a TDD-LTE signal over the air.

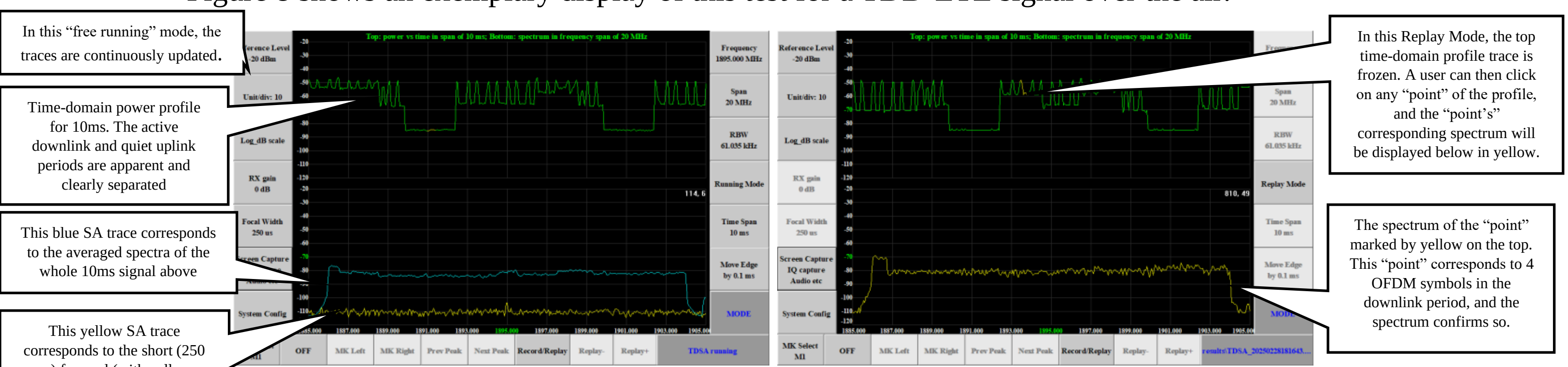

Figure 8, exemplary "TD-power+SA" test display for actual TDD-LTE signal over the air.

For the TDD type of 4G-LTE or 5G-NR signal, Figure 8 demonstrates that the signal's complex nature in both time and frequency domains can easily analyzed and dissected using this elegant "TD-power+SA" test feature. Of course, the fine dissection of complex signals is not just for satisfying academic interest, but for practical usage in finding the most esoteric uplink interference signals.

Actual case study of uplink interference finding using the "TD-power+SA" test

Figure 9 shows actual field test results for a tough yet also perfect interference signal finding case study. The location is inside a mall for indoor FD-4G-LTE service in a Chinese city. The uplink channel at 1.95 GHz (20 MHz wide) had been detected by the base station as having severe interference, yet, after months of trouble-shooting with the conventional sweeping mode spectrum analyzers, no interference signals had ever been found. When a WSA-408 product was finally brought to the site, the interference signal was detected within a few minutes, as shown in Figure 9. As for interference source, it was determined to be the security, surveillance, and sensing system that happened to be operating in the exact same frequency band.

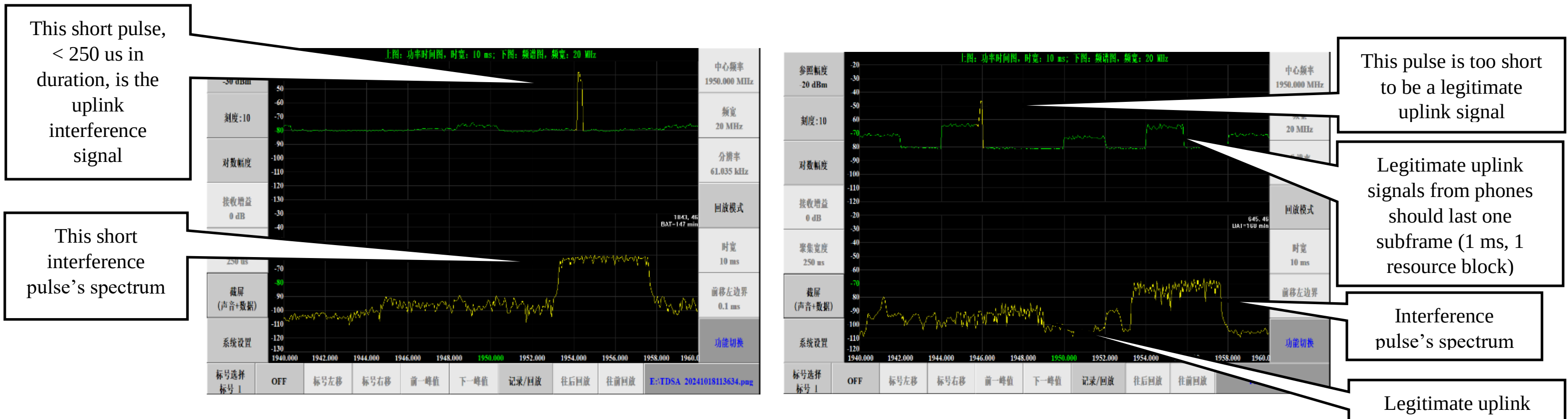

Figure 9, actual test results obtained inside a mall in the city of Changsha, China.

Adjacent Channel Power (ACP)

The purpose of ACP test is to measure the ACLR (Adjacent Channel Leakage Ratio) or ACPR (Adjacent Channel Power Ratio) with very flexible settings:

1. A user can set up 1, 3, 5 or 7 adjacent channels with arbitrary channel spacing and channel bandwidth;
2. A user can set up an arbitrary spectral emission mask;
3. This ACP test can also be used as a flexible multi-channel power meter.

Figure 10 shows an example of this test, where 5 channels are selected; channel spacing is 20 MHz and channel bandwidth is 18 MHz (for 20-MHz LTE signal). No spectral emission mask was set for this test.

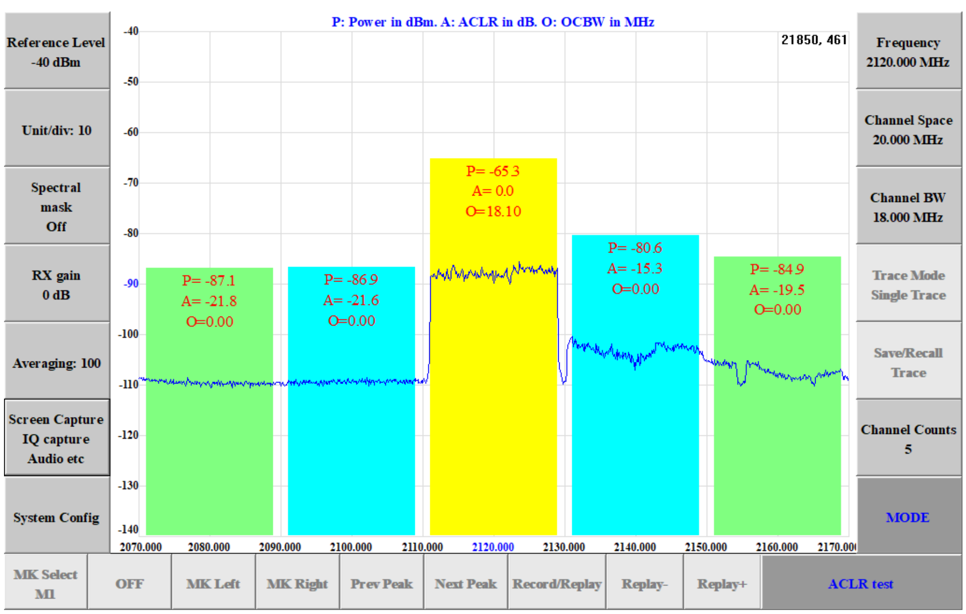

Figure 10, ACP test example.

Phase Noise Test

Phase noise measurement of a single frequency signal source is one of the classic applications of a Spectrum Analyzer in the lab environment. To fulfill the lab application scenario, WSA series products also offer such Phase Noise Test as shown in Figure 11. The principal test tone input (1300 MHz in Figure 11) from a signal source under test should be set to -30 dBm in level. Notice that the vertical scale unit is dBc/Hz and the horizontal frequency scale is logarithmic.

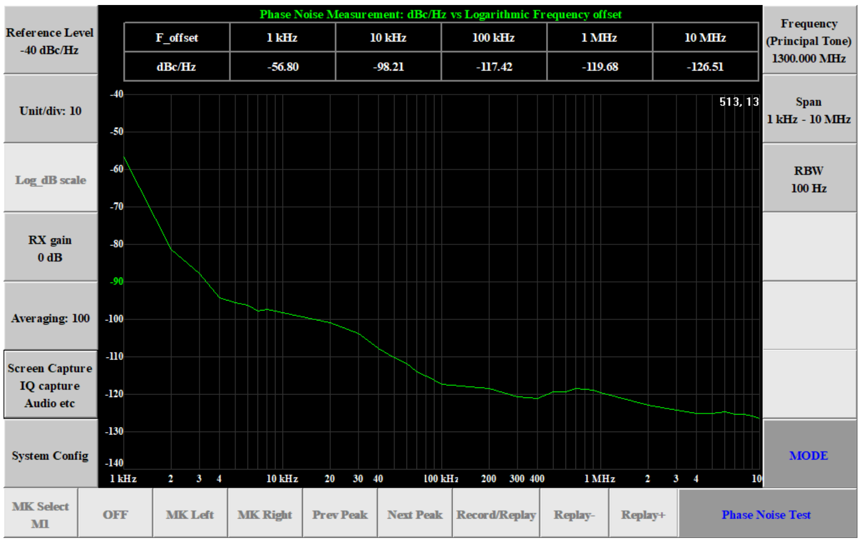

Figure 11, phase noise measurement example.

4G-LTE Analyzer

For complex 4G/5G signals, spectrum analysis alone isn't enough to determine the signal's actual coverage quality, hence this 4G-LTE Analyzer test actually searches for all possible PSS (Primary Synchronization Signal) and SSS (Secondary Synchronization Signal) combinations; determines the associated cell-IDs; finds and descrambles the associated RS (Reference Signals) sets; uses the RS equalization and MIMO information to decode the PBCH (Public Broadcast Channel); obtains the MIB (Master Information Block) and performs CRC checking on the MIB data. Along the way, detailed power and SNR (or EVM) measurements are also performed on the PSS, SSS, RS, and PBCH signals. If the MIB CRC checking passes, the signal coverage quality is deemed good, otherwise, the detailed metrics of SNR of RS and/or PBCH signals along with signal powers should be used as criteria for coverage quality determination. Figure 12 shows an example of this test. The top table lists all the power and SNR measurements of the PSS, SSS, RS, and PBCH signals. The MIB data is also displayed (in hexadecimal) if CRC checking passes and the carrier frequency offset is also measured and displayed along with the real-time SFN (Super Frame Number). The MIB data content decoding is displayed in the middle between the top lower graphs. The lower graph display comes in 3 different modes: displaying the SSS correlation trace; displaying the time-domain symbol power within a 10 ms frame; or displaying the modulation constellations of the PSS, SSS, RS signals and equalized and de-MIMOed PBCH signals. The latter two display modes are shown in Figure 13.

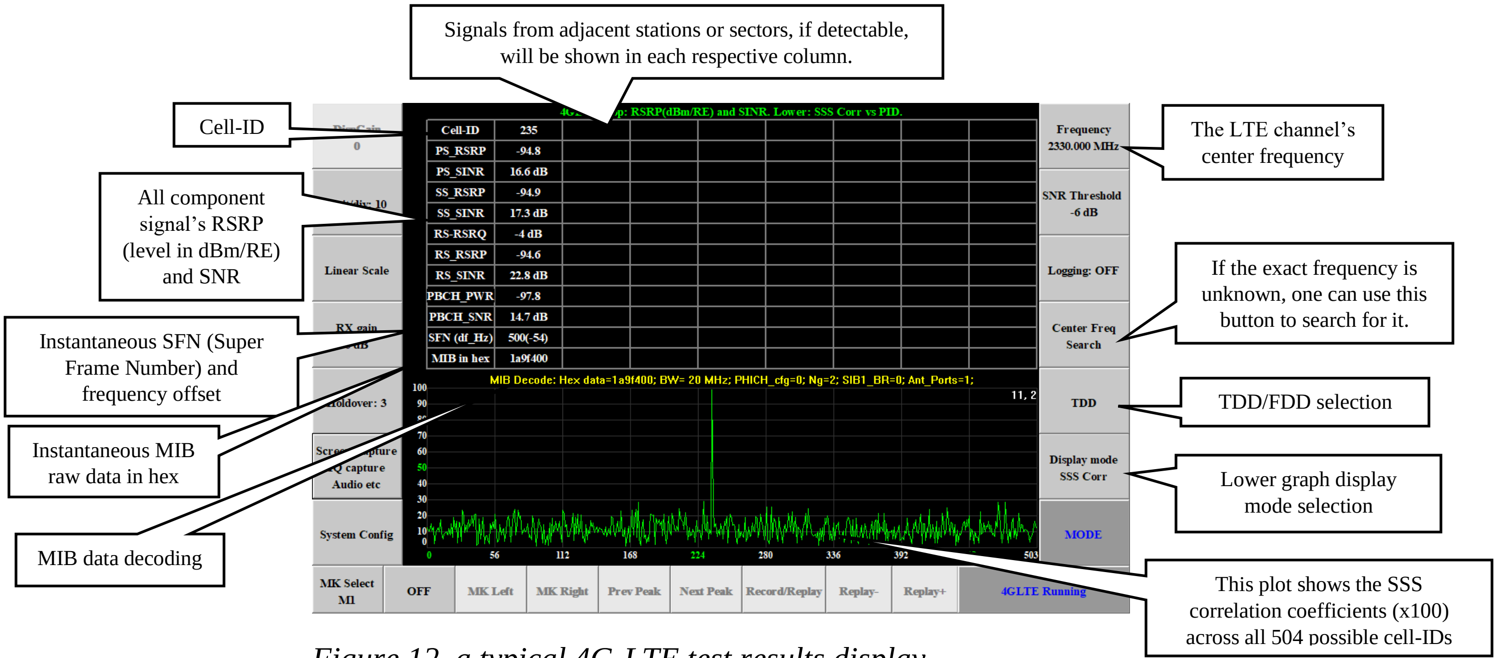

Figure 12, a typical 4G-LTE test results display.

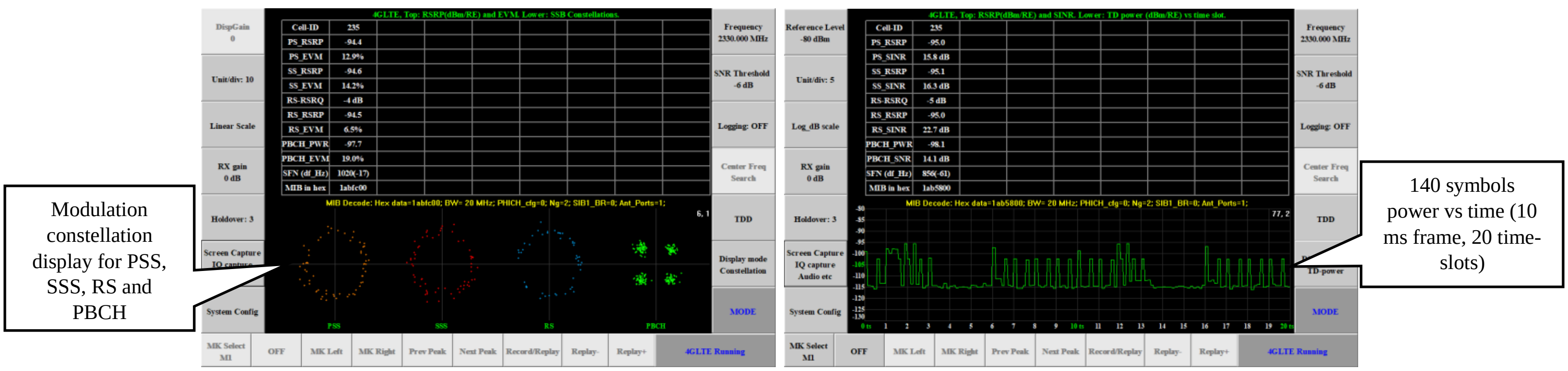

Figure 13, the same LTE test as in Figure 12, except that the lower graph displays are in different modes. The left is in modulation constellation display mode and the right is symbol-power vs time mode.

5G-NR Analyzer

The 5G-NR Analyzer test works in the same principle as the 4G-LTE Analyzer test, hence all the test results display format and the lower graph display modes are identical between the two, except that in 5G-NR, the center frequency is not necessarily the channel's center frequency, but the center frequency of the SSB (Synchronization Signal Block). If such frequency is unknown, the "SSB Freq Search" function can be used. However, when doing so, the SSB frequency is assumed to be assigned according to the SSB-GSCN (Global Synchronization Channel Number) channel raster. This is generally true for the actual over the air 5G signals, but may not be true for the general lab test environment where the signal may come from a signal generator set to an arbitrary SSB frequency. In such case, the exact SSB frequency must be known and then entered numerically using the top right button in Figure 14, where exemplary 5G test results are shown.

Each 5G base station's sector may contain multiple beams, and each detected beam's PCI (physical cell ID) and Beam Index (Bix) are displayed at the top.

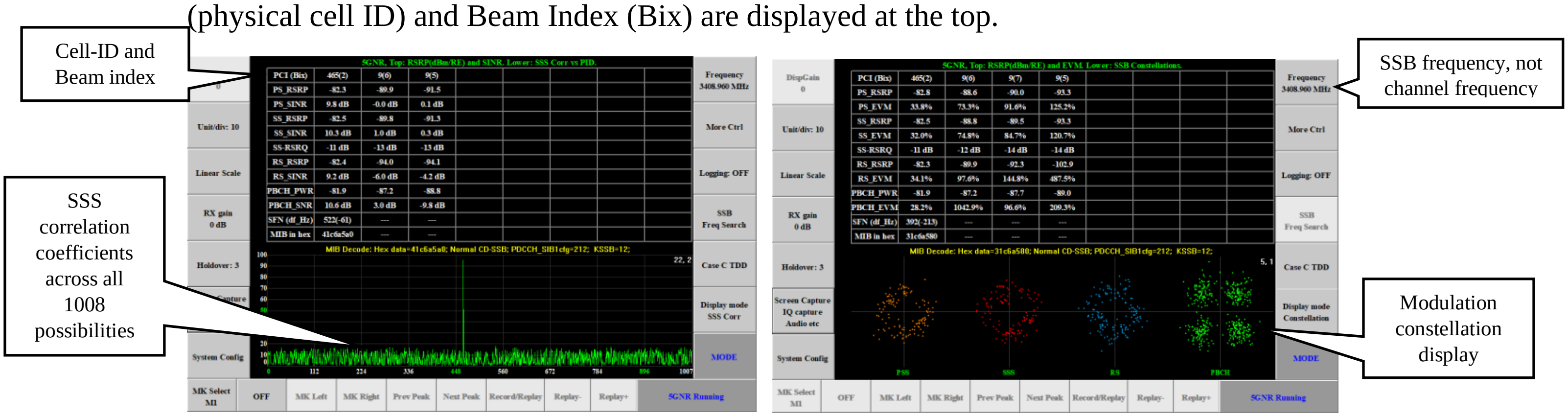

Figure 14, 5G-NR test results examples. Left: SSS correlation display mode; right constellation display mode.

NB-IoT Analyzer

The NB-IoT Analyzer test also works in the same logic as the 4G-LTE Analyzer test shown in Figure 12. Figure 15 shows an example test result.

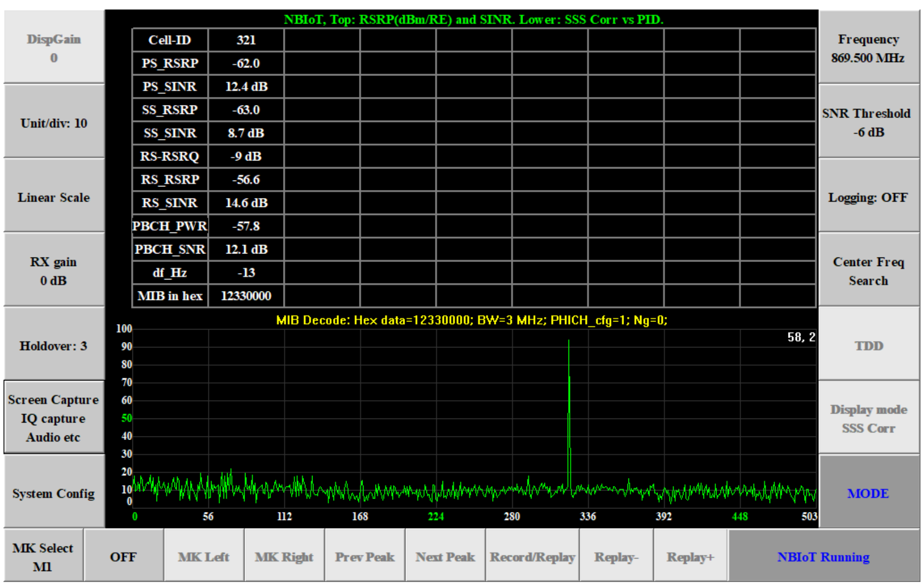

Figure 15, NB-IoT test result example.

GSM/EDGE Analyzer

The GSM/EDGE Analyzer test works in similar logic as the above 4G-LTE, 5G-NR and NB-IoT tests, but since the GSM signal structure is totally different, hence the tabulated numerical results format and the plotted graph are quite different. Nevertheless, the goal is to determine the actual signal coverage quality by searching and measuring each signal burst, determining the signal burst type, decoding the embedded control information bits and displaying as much measurable parameters and decodable information as possible. A test result example is shown in Figure 16.

Figure 16, GSM/EDGE test results example.

Multi-Channel Scanner

The purpose of this test is to "simultaneously" measure the 4G-LTE (as in Figure 12) or 5G-NR (as in Figure 14) signal coverage quality in up to 8 different channels. Such feature is generally termed as drive testing or channel scanner. The original channel scanners decades ago were just measuring the channel power within each 30 kHz band, but today, such scanner is to quickly measure and decode multiple 4G and 5G signals as fast as possible, while the instrument itself might be driven around in a car, or even flown in a drone (UAV), and the measured results are used to map out the signal coverage quality across certain areas of interest, so generally, this test's results are logged into a CSV file along with timestamp and GNSS information. WSA's Multi-Channel Scanner test has accomplished all these requirements with even more: MIB data decoding and CRC checking, as the definitive coverage quality determination criterion. Examples of Channel Scanner test results displays are shown in Figure 17, and sample data logging format is shown in Figure 18.

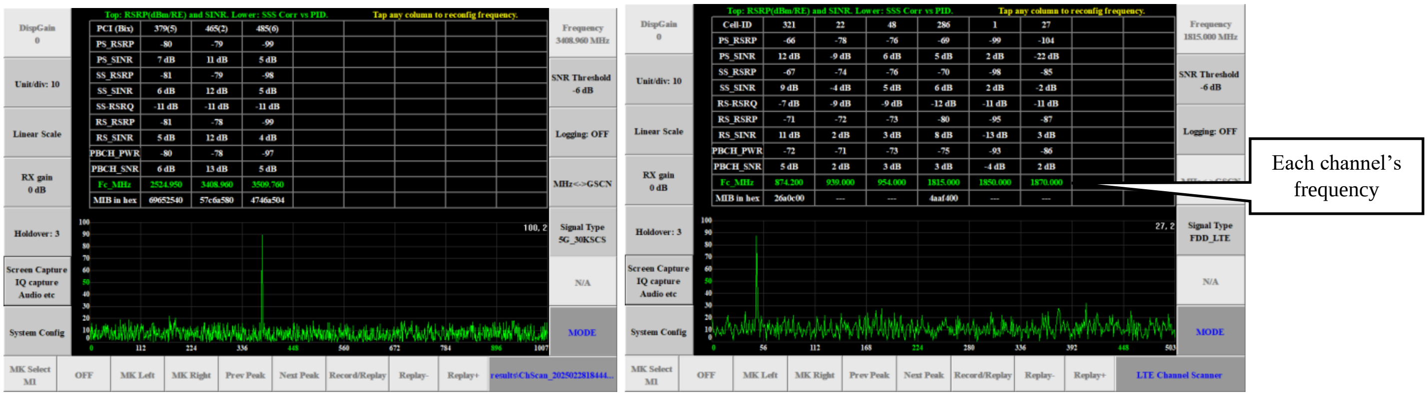

Figure 17, Multi-Channel Scanner test results display. Left: three 5G-NR channels; right: six FD-LTE channels.

Record_c	PCI_count	longitude	latitude	PCI	Bix	PSS_PWR_	PSS_SNR_	SSS_PWR_	SSS_SNR_	RS_PWR_(	RS_SNR_d	PBCH_PW	PBCH_SNI	SFN(df_H	MIB(hex)
1	1	113.9082	22.48503	465	2	-77.9	6.9	-78.1	7.2	-77.5	7.3	-76.8	4.6	534(-89)	c52560
1	2	113.9082	22.48503	465	1	-88.5	1.8	-89	-0.1	-88.4	0.8	-85.3	-1.1	(-89)	-
2	1	113.9082	22.48504	465	2	-78.5	6.7	-78	6.1	-77.4	7.3	-76.7	4.2	698(-78)	c525a0
2	2	113.9082	22.48504	465	1	-88.5	1.8	-89	-0.1	-88.4	0.8	-85.3	-1.1	(-89)	-
3	1	113.9082	22.48504	465	2	-78.4	6.1	-78.4	6.4	-77.2	6.5	-77	-2.1	780(-81)	c525c0
3	2	113.9082	22.48504	465	3	-99	-17.4	-88.5	-5.5	-100.4	-17.8	-82.5	-2.1	(-81)	-
4	1	113.9082	22.48505	465	2	-77.9	6.6	-78.3	6.4	-77.7	6.6	-76.6	-12.8	(-81)	-
5	1	113.9082	22.48505	465	2	-78.3	7.5	-77.7	7.1	-77.6	7	-76.7	4.9	164(-84)	c52540
6	1	113.9082	22.48504	465	2	-78.2	7.6	-78.1	6.5	-77.3	7.9	-76.8	5.9	326(-89)	c52560
7	1	113.9082	22.48503	465	2	-78.4	7	-78.2	6.6	-77.6	7.5	-76.7	-1.6	326(-89)	c52560
8	1	113.9082	22.48502	465	2	-78.5	6.4	-78.5	6.3	-77.7	6.6	-76.9	-12.4	566(-78)	c52560
9	1	113.9082	22.48501	465	2	-78.2	6.4	-78.7	6.2	-77.8	6.4	-76.9	-15.7	716(-64)	c525c0
10	1	113.9082	22.48499	465	0	-78.4	6	-78.6	6.9	-77.8	6.4	-76.9	-1.8	(-64)	-
10	2	113.9082	22.48499	465	7	-78.2	6	-78.6	6.1	-77.3	6.8	-76.8	-5.2	(-64)	-
10	3	113.9082	22.48499	465	2	-78.2	6.4	-78.7	6.2	-77.8	6.4	-76.9	-15.7	(-64)	-
11	1	113.9082	22.48499	465	2	-78.1	6.1	-78.3	6.5	-77.8	6.1	-76.4	-8.7	(-64)	-
11	2	113.9082	22.48499	465	0	-78.5	6.1	-78.2	6.4	-77.7	6.4	-76.5	-1.6	(-64)	-
11	3	113.9082	22.48499	465	7	-78.2	6	-78.6	6.1	-77.3	6.8	-76.8	-5.2	(-64)	-
12	1	113.9082	22.48497	465	0	-78.2	6.7	-78.6	5.9	-77.5	7.2	-76.9	-2.5	(-64)	-
12	2	113.9082	22.48497	465	2	-78.1	6.1	-78.3	6.5	-77.8	6.1	-76.4	-8.7	(-64)	-
13	1	113.9082	22.48496	465	2	-78.6	6.2	-78.6	6.5	-77.8	6.1	-76.8	4.7	428(-75)	c525c0
13	2	113.9082	22.48496	465	0	-78.2	6.7	-78.6	5.9	-77.5	7.2	-76.9	-2.5	(-64)	-
14	1	113.9081	22.48495	465	2	-78.4	5.8	-78.7	6.2	-77.7	6.7	-76.7	4.5	580(-60)	c52540
15	1	113.9081	22.48494	465	2	-78.6	5.9	-78.2	6.5	-77.7	7.1	-76.9	4.4	782(-55)	c525e0
16	1	113.9081	22.48494	465	2	-78.5	6.1	-78.3	6.1	-77.6	6.2	-76.8	4.8	932(-56)	c52540
16	2	113.9081	22.48494	465	1	-88.3	1.6	-89.1	0.6	-92.4	-5.3	-85.7	-2.5	(-56)	-
17	1	113.9081	22.48494	465	2	-78.7	5.8	-78.1	6.5	-77.7	6.3	-76.6	-4.1	932(-56)	c52540
17	2	113.9081	22.48494	465	1	-88.3	1.6	-89.1	0.6	-92.4	-5.3	-85.7	-2.5	(-56)	-
18	1	113.9081	22.48495	465	2	-78.8	5.9	-78.1	6.8	-77.8	7	-76.8	-1.5	158(-44)	c525e0
19	1	113.9081	22.48495	465	2	-78.1	7.3	-78	6.5	-77.8	6.9	-76.7	4.5	404(-51)	c52540
20	1	113.9081	22.48496	465	2	-78.4	6.5	-78.3	6	-77.3	7.4	-76.8	4.9	568(-55)	c52580
20	2	113.9081	22.48496	465	1	-87.7	1.9	-88	0.8	-101.2	-15.6	-85.2	-0.6	(-55)	-

Figure 18, Multi-channel scanner logging data example.

4G-LTE (and 5G-NR) Blind Scanner

The purpose of Blind Scanner is to "blindly" search for all possible 4G-LTE signals within a frequency band set by the user. Technically speaking, the "Center Freq Search" button shown in Figure 12 for 4G-LTE and "SSB Freq Search" in Figure 14 for 5G-NR are doing exactly the same thing as this test here, but this feature is extracted out as an independent test to satisfy certain legacy test equipment requirements. Figure 19 shows an example this test in action.

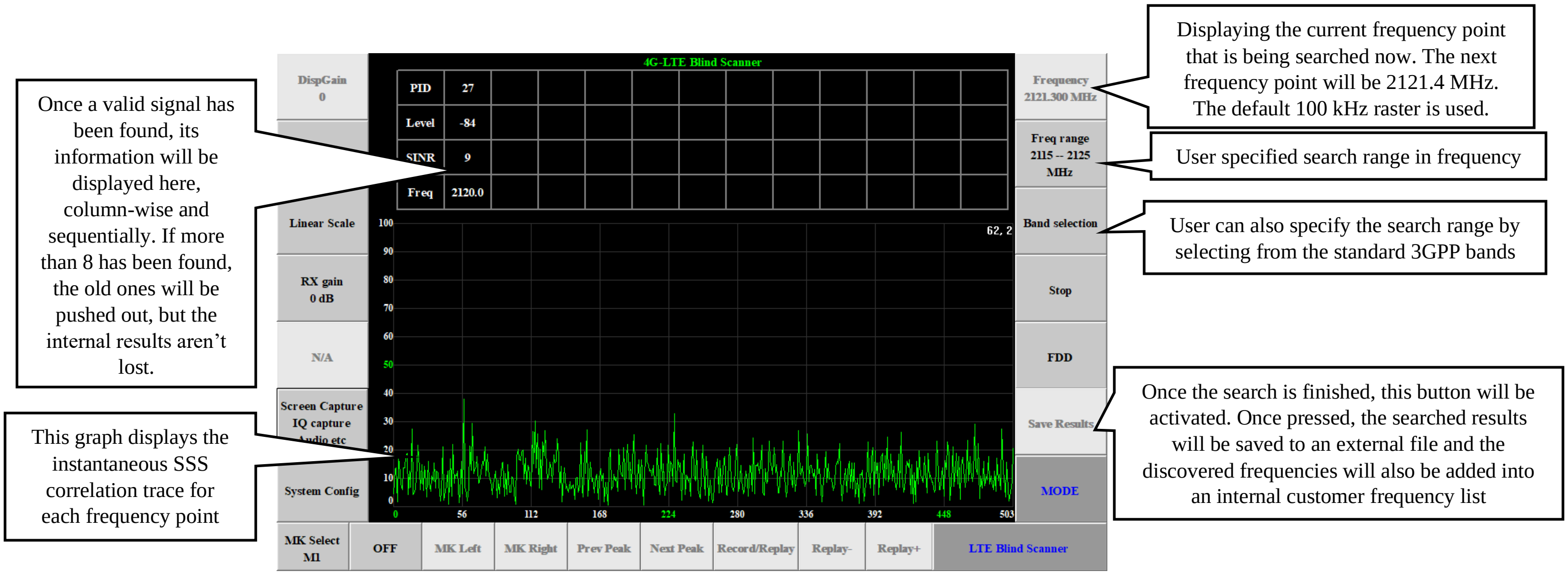

Figure 19, 4G-LTE Blind Scanner test in action.

Multi-channel SA auto Recording

The real-time SA in Figure 3 presents signal spectrum within WSA's instantaneous analysis bandwidth of 100 MHz. The wide-band sweeping analyzer in Figure 4 can show spectrum across a contiguous band beyond 100 MHz. However, practical applications may require the following:

1. Perform real-time SA of 100 MHz span at 1.2 GHz center frequency, then another real-time SA of 100 MHz at 1.6 GHz, nothing in between, as fast as possible.
2. Perform the above autonomously, by the WSA-208 only, without the intervention of any external PC running any software. The WSA-208 can be flown in an UAV for example.
3. At each center frequency point, determine if the measured spectrum has exceeded certain threshold (either single peak value or total channel power). If yes, save the spectral data along with time-stamp and GNSS information into the internal DDR memory, or if network connection to a cloud server is available, also send a copy of the data in real-time to the cloud server.
4. When the WSA-208 unit is reconnected with a PC running the WSA PC software again, the saved spectral data will be uploaded to the PC and then saved to a file instantly. The saved file can later be opened by another PC application software to display the captured spectral data over a map.
5. The purpose of the above steps is to autonomously find anomalous signal intrusions or interference signals within certain frequency bands of interest while the instrument is being driven or flown or even installed over certain areas. This is the purpose of this Multi-channel SA auto Recording test. An exemplary test setup is shown in Figure 20.

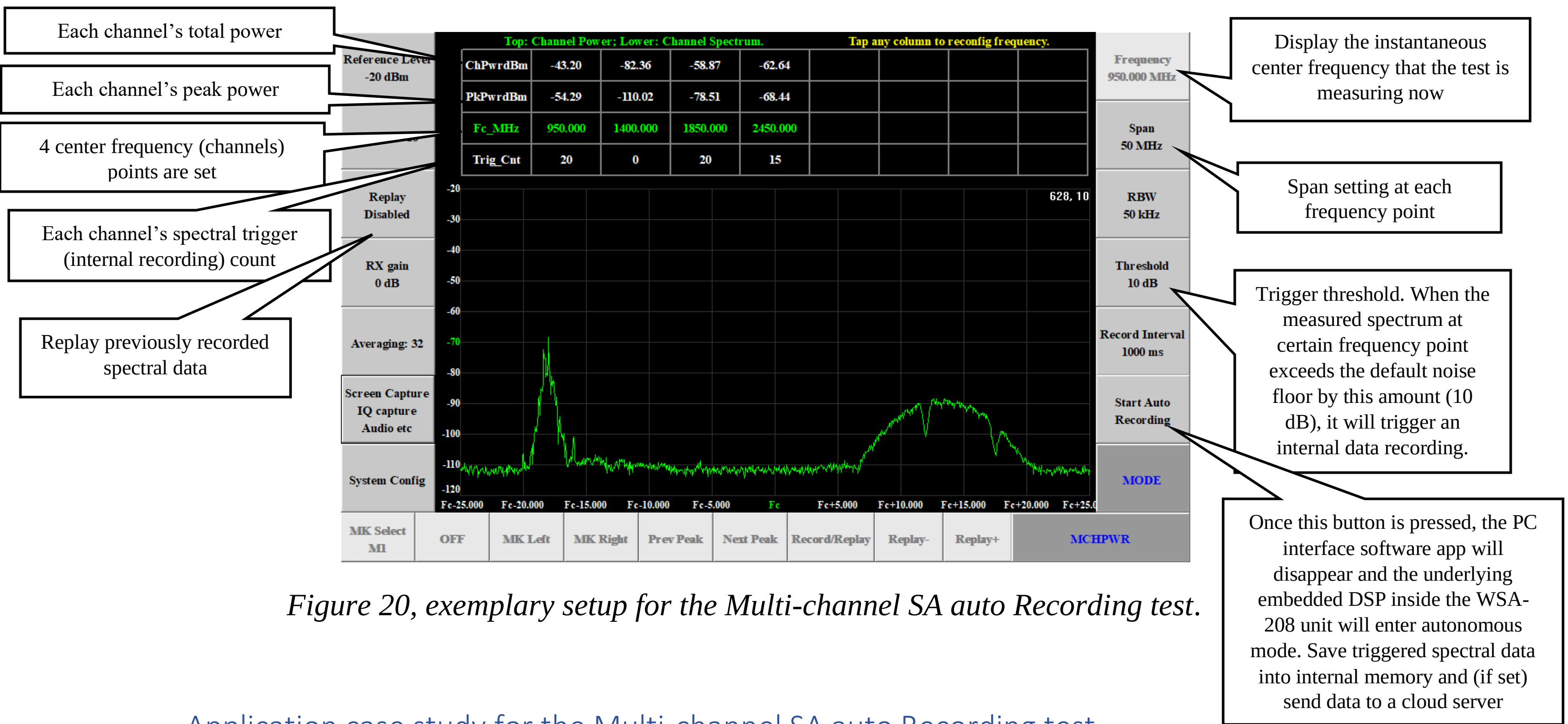

Figure 20, exemplary setup for the Multi-channel SA auto Recording test.

Application case study for the Multi-channel SA auto Recording test.

The above test was specifically designed to find the intentional GNSS signal jammers that are affecting the flight safety of UAV (drone) delivery service that's part of the LAE (Low Altitude Economy) project undergoing in China at the moment. A WSA-208 unit has been flown in such UAV while recording spectra over the GNSS bands of interest. Figure 21 shows the replayed results of the recorded spectrum captured by the WSA-208 while flying in the air. The spectrum provides clear evidence of intentional GNSS band interference (1.575 GHz) by a broad-band sweeping signal source, very likely, from certain anti-drone jamming devices.

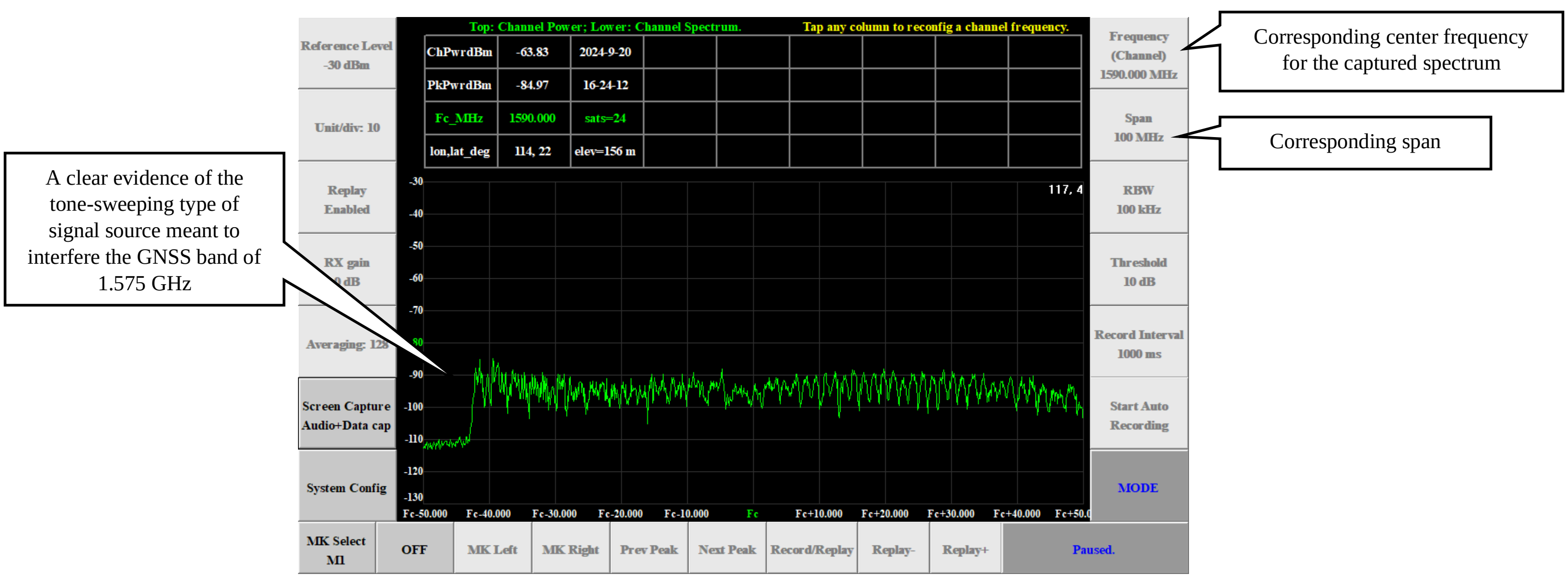

Figure 21, replaying the recorded spectral data, captured when WSA-208 was flying in air.

MADF, Multi-Antenna Direction Finding

Each WSA product has only one physical RF-in antenna input port, yet practical field applications may require the following:

1. Signal Direction Finding: once a signal of interest has been detected, a user may want to further determine the signal direction (which direction is the signal coming from?). One way to accomplish this goal is to interface the WSA-208/308/408 with a directional antenna system. Such system internally contains N discrete directional antennas, with each one of them aiming at a specific angle uniformly spanning across a horizontal plane's 360-degree azimuth range for 2D direction finding, or even across the whole 4-pi spherical solid angle surface for 3D signal finding. One principal antenna is aligned (and fixed) with an electronic compass, and its direction at any moment is determined by the compass readings on heading (azimuth angle), pitch (elevation angle or N-S tilt) and roll (E-W tilt angle).
2. Multi discrete band Spectrum Analysis: to detect minute signals across different frequency bands "simultaneously", high gain and high-performance antennas must be used, yet by the laws of physics, such high gain (passive directional gain) antennas always have narrow operating frequency range. To achieve simultaneous multi-band signal monitoring, a multi-band antenna system consisting of many discrete antennas of different frequency bands must be used.

Both of the above applications require each WSA unit to provide the following interfacing option:

1. Connecting WSA's single RF-in antenna port to the multiple discrete antennas through an electronic RF switch.
2. WSA must provide TTL hardware interface and software logic to rapidly control the RF switch at the sub-millisecond level.
3. WSA must also provide the hardware and software interface to an electronic compass.

Thankfully, the WSA product, especially the WSA-208 module, has been designed with the above interfacing requirements in mind. More specifically, each WSA-208 module provides the following:

1. Four TTL (5V) GPIO (General Purpose Input/Output) lines for controlling an RF switch;
2. An RS-232 serial port for interfacing to an electronic compass.

Figure 22 shows an integrated package that contains a WSA-208 module and a 6-antenna-element system by itself and when mounted on an UAV (drone). Naturally, such system can also be installed on a vehicle, a ship, a robotic dog or any other carrier machine that can handle a total weight of 1 kg, a size of roughly 1 cubic foot and can provide a 12V/2A DC power supply.

Figure 23 shows an exemplary test result of the MADF feature.

Figure 22, Left: the package containing a WSA-208 integrated with a 6-antenna-element; Right: such package mounted on a drone.

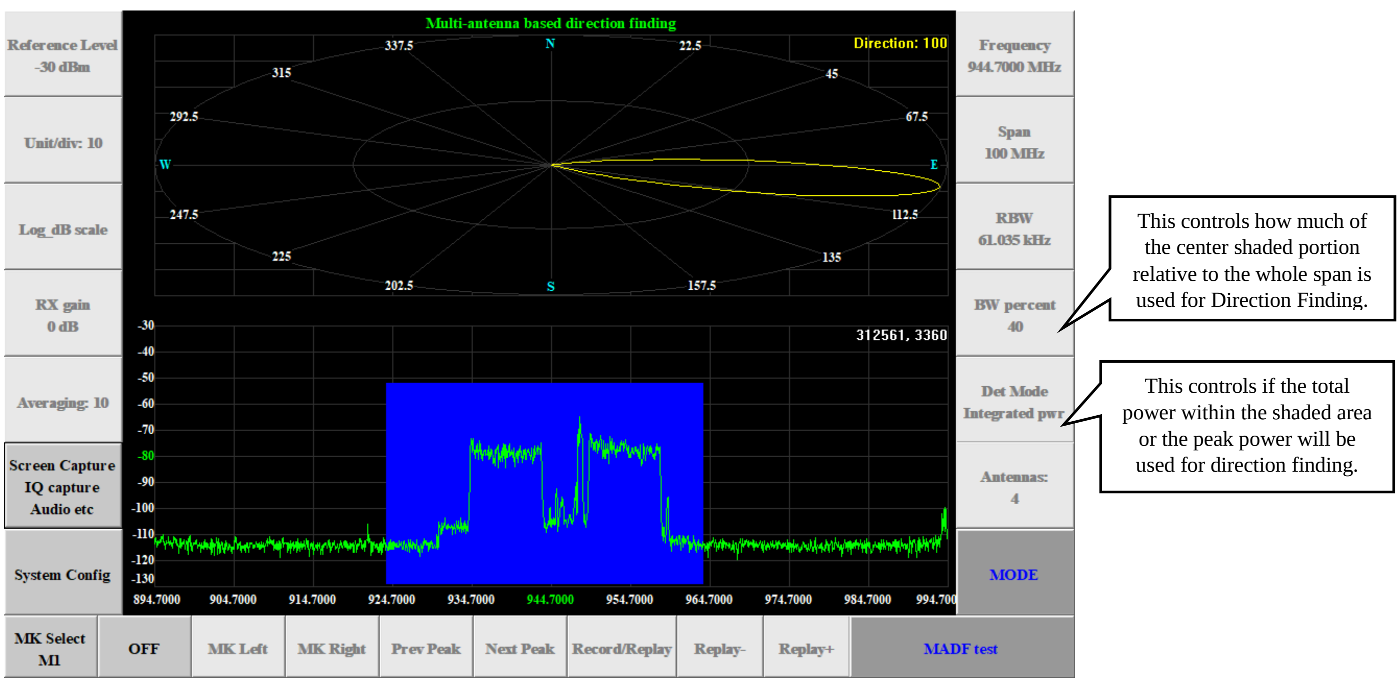

Figure 23, MADF (Multi-Antenna-Direction-Finding) test result example. This shows a simpler 4-antenna system, and the signal direction shows up on the upper polar graph as coming from 100 deg from the North (slightly passing the East direction at 90 deg).

Legacy Signal Modulation Format Detection

Although the WSA series products were designed to handle the modern wide-band OFDM type of signals (4G-LTE, 5G-NR and Wi-Fi etc), the WSA software feature also includes, hidden under the Spectrum Analyzer feature, a mechanism that can detect the common legacy signal's modulation format. By "legacy signal", we mean the single carrier (non-OFDM type) narrow-band (bandwidth typically under 1 MHz) type of signals such as those from an FM radio station. The WSA detection algorithm can detect the modulation formats by the following list:

"CW, 2ASK, 4ASK, BPSK, QPSK, OQPSK, Unknown, 2FSK, 4FSK, 8FSK, QAM256/64/16, FM, AM, Pi/4-QPSK"

Figure 24 shows an example of this test feature that lists the detected modulation formats with certain probabilities.

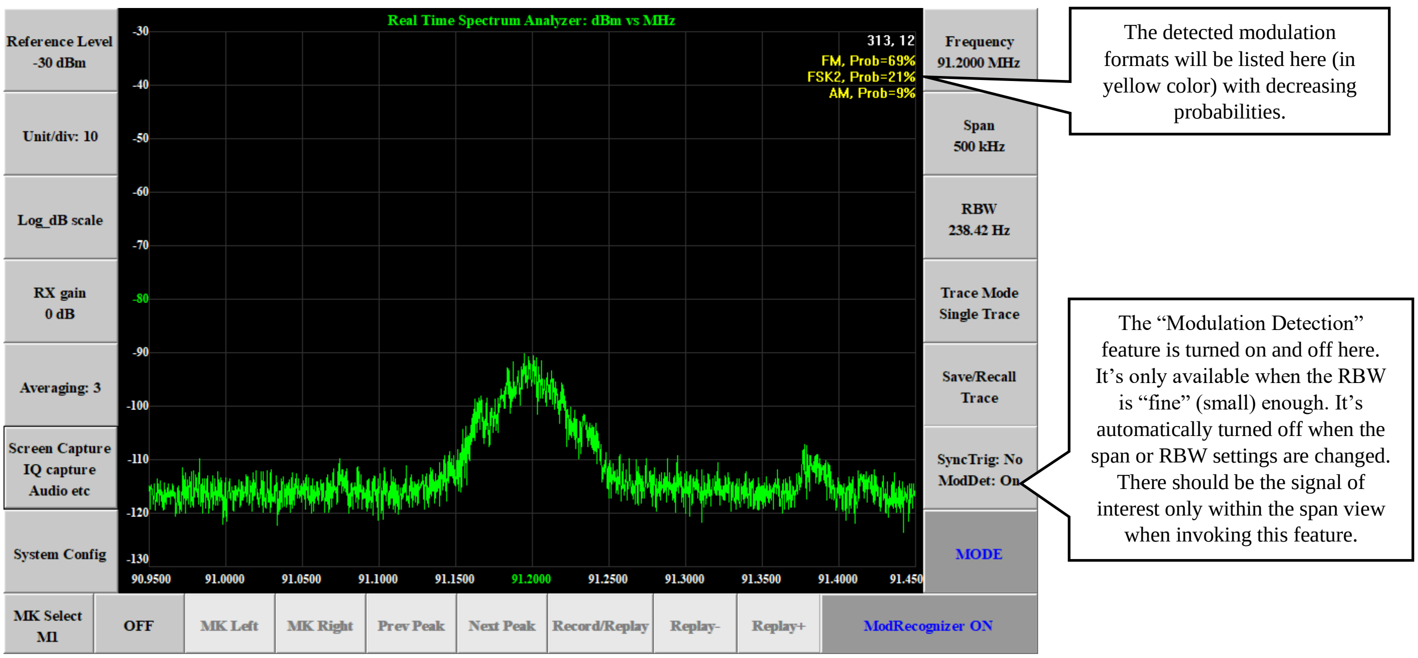

Figure 24, test result example for the Legacy Signal Modulation Detection feature.