

# Radio Access Networks

## Interference Analysis

### Interference in Wireless Networks

Signal interference in wireless networks negatively affects transmission coverage and mobile capacity, limiting overall network performance. Unavoidable signal interference is becoming more prevalent in wireless networks with the increasing number of active transmitters on the RF spectrum.

The spectrum is shared among different systems and services such as mobile communications, mobile radios, paging, wireless local-area networks, and digital video broadcasting. In addition to the licensed systems, the spectrum is also occupied by unlicensed transmitters, reflections, and fading. The composition of all these signals is creating a very complex environment which must be routinely monitored in order to maximize service performance.

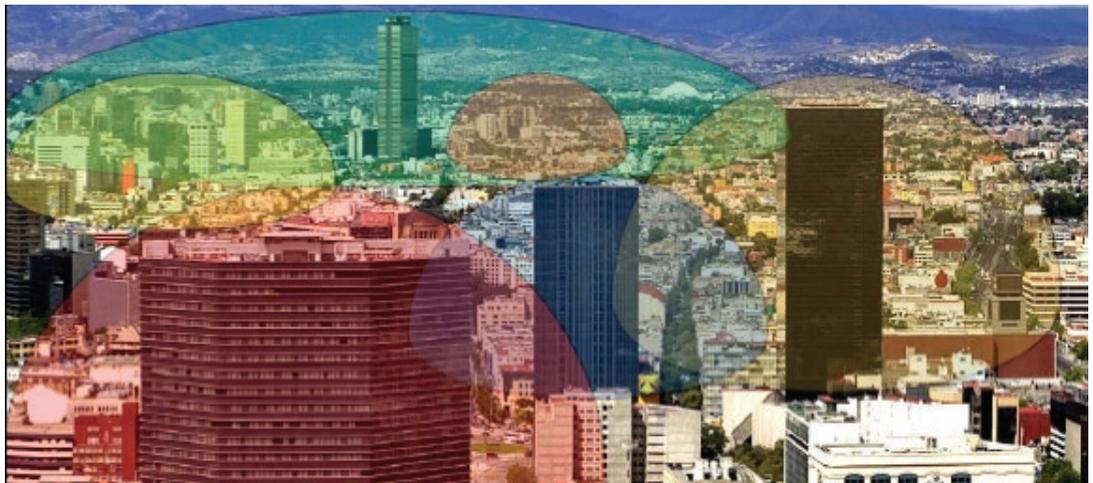


Fig 1. Spectrum Environment

In wireless networks, interference can affect the transmission of the mobile to the cell site (uplink) as well as the transmission of the cell site to the mobile (downlink).

It is, however, the uplink that is mostly affected by interference, since cell sites have higher or no restrictions for power-level transmission. For example, it is common that radios in a cell site are transmitting at a power level of 43 dBm (20W) whereas mobiles have limits on their transmission power levels. LTE mobiles have a transmission power limit of 23 dBm (0.2 W). This means that mobiles transmit at a power level 100 times lower than that of cell sites.

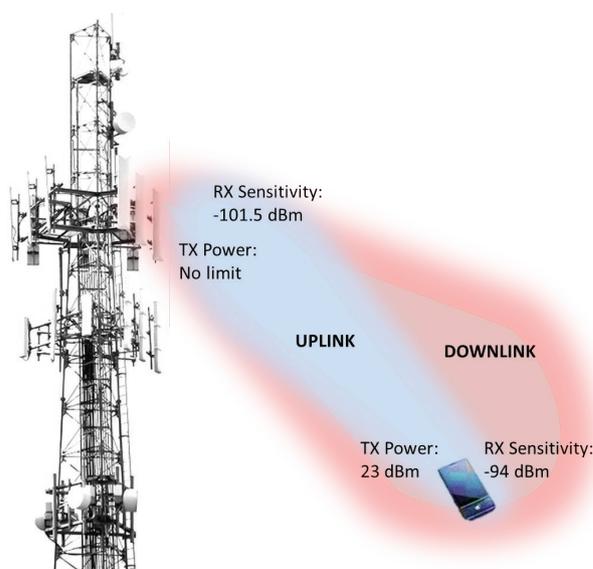


Fig 2. LTE-TDD (10 MHz) Transmission and Sensitivity Requirements

## Interference Analysis

Interference analysis has three main stages:

- 1. Detection** — using metrics that monitor the spectrum activity in frequency and time domain allowing continuous recording of spectrum analysis and spectrogram measurements.
- 2. Identification** — having the ability to identify the type of interference signal through demodulation (for example, FM, AM, GSM).
- 3. Location** — performing directional measurements, recording the geographical coordinates used to triangulate, and find the intersection area which will represent the geographical location of the interferer.

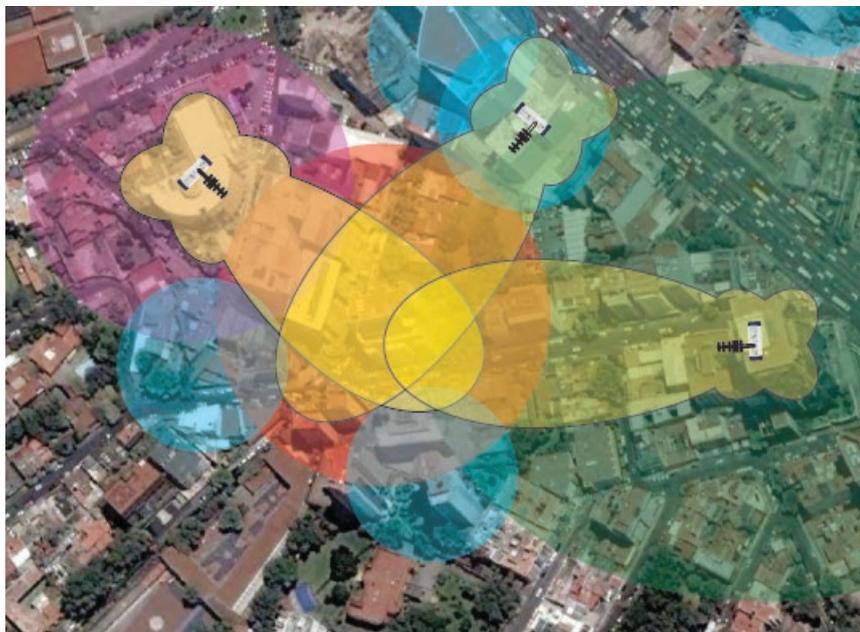


Fig 3. Interference Location

There are different test methodologies to monitor spectrum activity, signal performance, and interference; however, the main metrics for interference analysis are the following:

- Spectrum Analysis — traditionally the most commonly-used metric to identify interference, analyzing signals on frequency domain and providing spectral activity.
- Spectrogram — a measurement that monitors the spectrum through time containing three measurement components: signal power, frequency, and time of occurrence.
- Received Signal Strength Indication (RSSI) — a measurement that tracks signal power through time of up to six different signals simultaneously.
- Interference Finding — an automated geo-triangulation based on three measurement points identifying the geographical location of the interferer.
- Signal Analysis — the ability to demodulate the interferer signal and accurately identify its modulation type.

Interferences are typically intermittent, being active for short periods of time. This makes it difficult to identify; therefore, it is important to continuously record spectrum measurements, either as spectrum analysis or spectrogram measurements.

JDSU RF Test Analyzers have the ability to continuously monitor the spectrum, performing all interference analysis measurements including spectrum analysis, spectrogram, and RSSI, which can be executed unattended and for extended periods of time.

### Interference Detection

The most commonly used test method to detect interference is spectrum analysis, which performs measurements on frequency domain. This indicates the amount of energy or power transmitted at each frequency.

JDSU RF Test Analyzers perform spectrum analysis with configurable filters (for example, resolution bandwidth and video bandwidth) and power adjustments (for example, attenuation, averaging, and pre-amplification) for the proper characterization of interference signals in the spectrum.

These analyzers also provide several tools for signal examination such as maximum hold, trace overlay, and power-limit masks, among others. All are very useful for detecting interference signals.

### Detecting Interference in Frequency Domain

Interference signals can be in close frequency proximity to a wireless carrier, making it difficult to detect. For this reason, one must set the proper filter adjustments into the analyzer in order to detect the interference.

Perhaps the most important filter adjustment of the analyzer to detect interference signals is the resolution bandwidth (RBW), which is the frequency band of the analyzer’s monitoring filter.

Increasing the RBW will widen the filter’s band and the instrument will take fewer test points (lower measurement resolution), performing the measurement in a short period of time (sweep time); conversely, a lower RBW will provide more accurate measurements in a longer period of time.

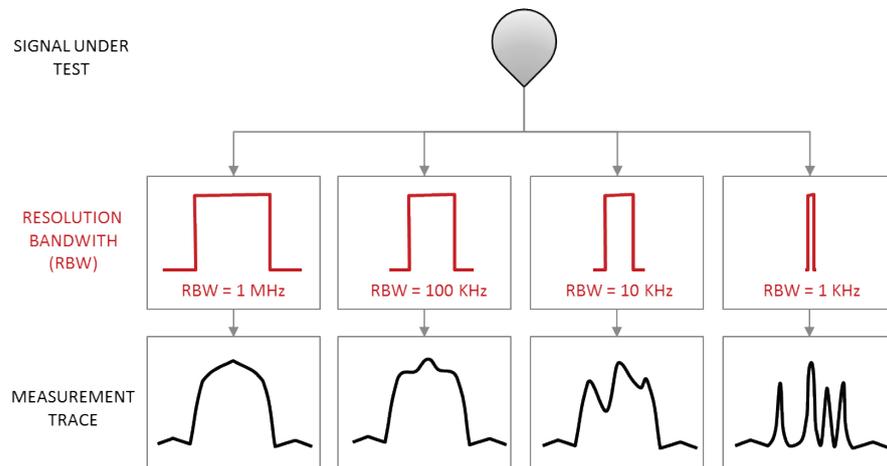


Fig 4. Resolution Bandwidth

For this reason, one must set the adequate RBW in order to have enough resolution and measurement time to detect interference signals. In general, the maximum value of RBW to properly identify a signal is 25 percent of the signal’s bandwidth. For example, to properly detect a GSM signal (a narrow-band, 200 KHz signal) the RBW should be lower than 50 KHz.

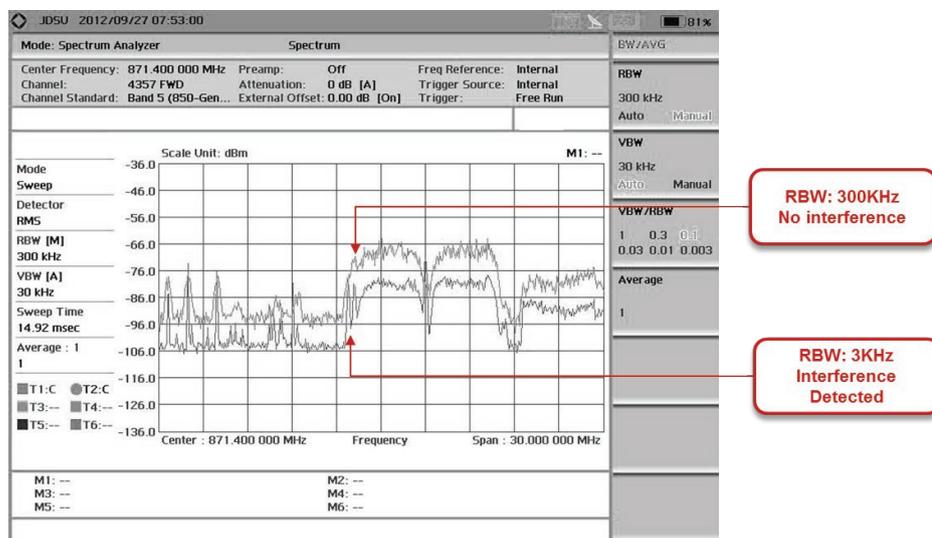


Fig 5. Detecting Interference in Frequency Domain

Another important test methodology on spectrum analyzers to detect intermittent signals is the ability to hold maximum power on the spectrum. This capability also makes a better assessment identifying time domain signals such as GSM.

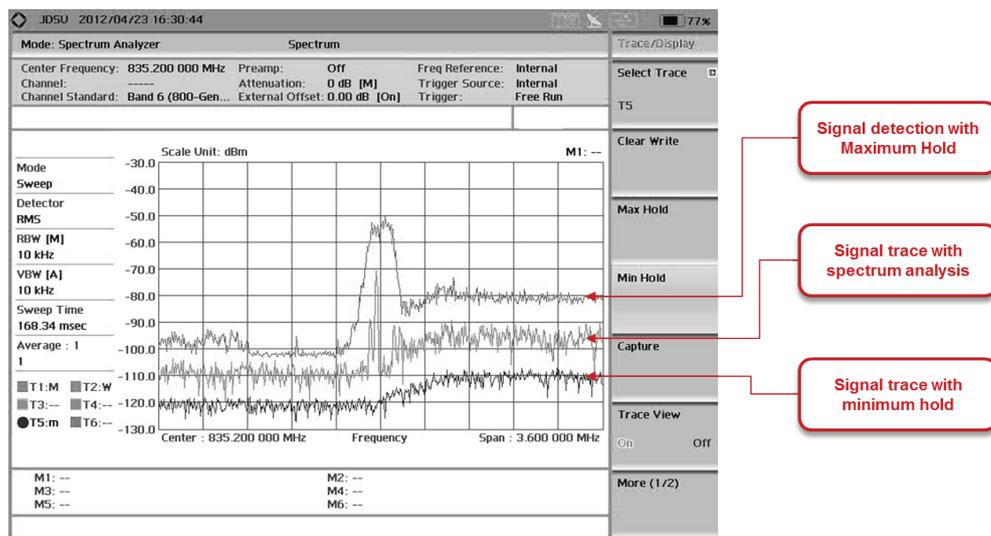


Fig.6 Detecting intermittent signals with maximum power hold

This methodology is perhaps the first measurement taken on spectrum with suspected interference, and the basis to proceed with an interference analysis such as the signal occurrence or periodicity through a spectrogram testing.

### Detecting Interference in Time Domain

Time-division-duplex signals such as LTE-TDD and WiMAX transmit the uplink and downlink signals on the same center frequency, making the communication possible by multiplexing the signal in time, assigning time slots for uplink transmission and a different set of time slots for downlink transmission.

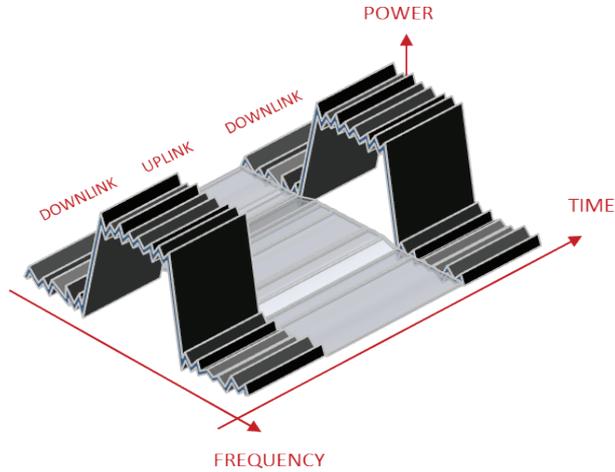


Fig 7. TDD Signal Structure

Detecting uplink interference with a conventional spectrum analyzer based on frequency domain is very difficult since the frequency is shared between the downlink and the uplink. In this case, one must analyze the signal in the time domain.

The JDSU RF Test analyzer examines the signal in time domain (zero span), and it includes the ability to trigger the test in specific timing (gated sweep) in order to easily analyze uplink transmissions. This makes it possible to detect interference in time-based signals.

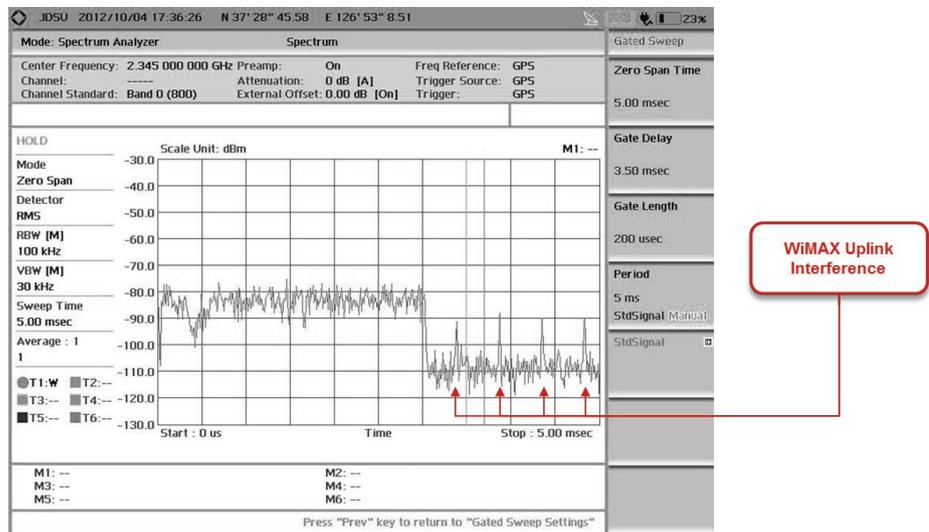


Fig 8. Detecting Interference in Time Domain

### Spectrum Clearance

Spectrum is managed by governmental agencies to regulate and control air interface for the purpose of national defense and to promote the safe use of radio communications. For example, in North America the spectrum is controlled by the Federal Communications Commission.

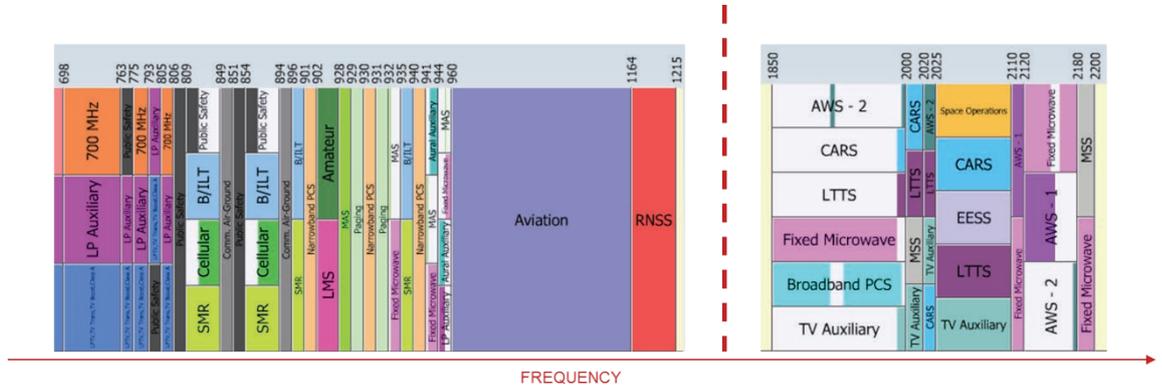


Fig 9. FCC Spectrum Allocation

Spectrum is a scarce resource that requires constant monitoring to ensure that no transmitters are using unassigned spectrum. JDSU RF Test analyzers monitor the spectrum and set power-limit masks in order to capture any signal that exceeds such limit.

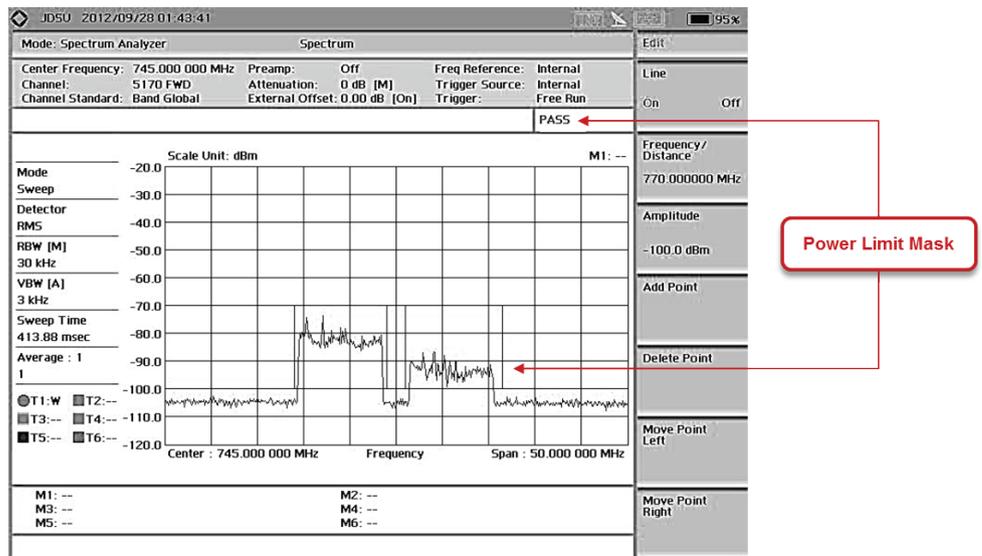


Fig 10. Spectrum Clearance Mask

### Detecting Intermittent Interference Signals

Intermittent interference can be difficult to detect due to the uncertain nature of time and duration of the interference signal. To detect intermittent signals, one must continuously monitor and record spectrum measurements using a spectrogram that constantly measures and records power variations of the spectrum.

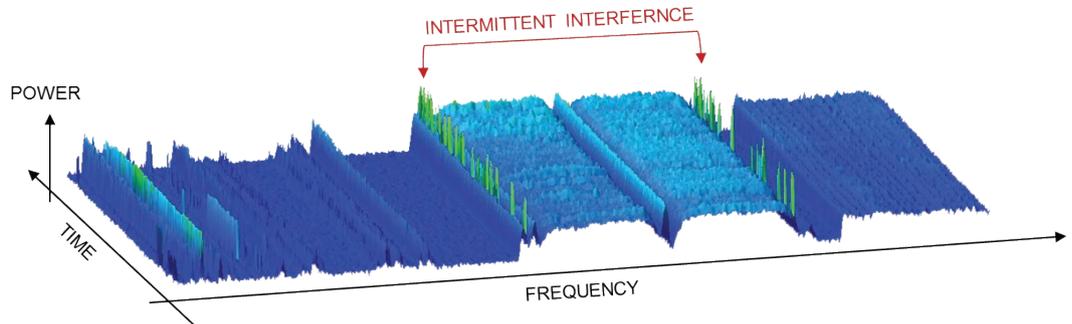


Fig 11. Intermittent Interference

JDSU RF Test analyzers perform spectrogram measurement that can be executed in an unattended manner for several days, continuously recording the results and having the ability to perform post-analysis of the results. This provides useful information to identify and locate the interference signal.

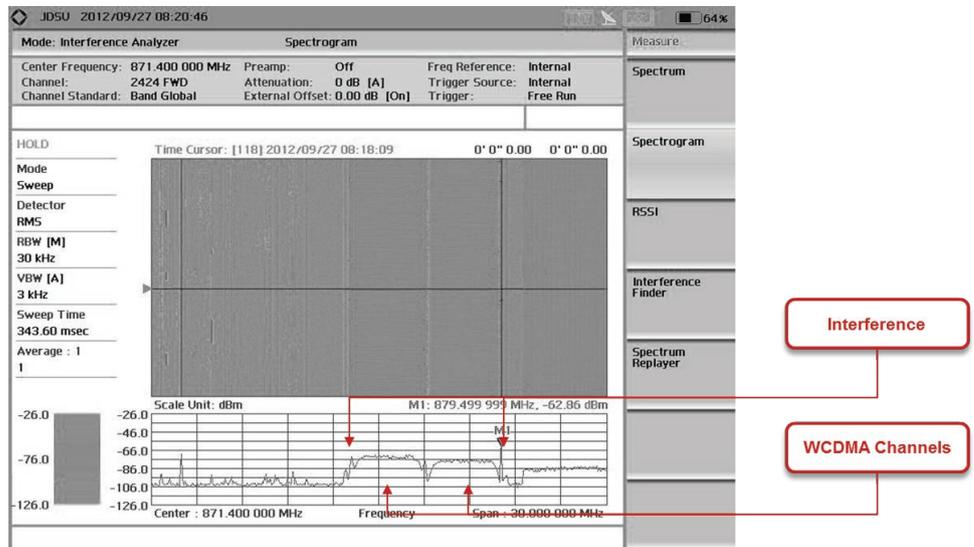


Fig 12. Detecting Intermittent Interference Signals

### Interference Identification

A best practice for interference analysis is to identify the type of signal of the interference; this will considerably expedite troubleshooting.

For example, it is common for a cell site to support multiple technologies such as GSM, WCDMA, and LTE. Some users still use mobile devices primarily for voice communication supported by GSM, and others use mobiles for voice as well as gaming or data applications, demanding heavy data transfers supported by WCDMA and LTE.

Mobile operators have to properly serve all their customers' demands in a limited spectrum, and at times, the transmission channels of the different technologies are commissioned with no guard-bands. This can cause overlaps and interference between channels.

The following example shows two WCDMA channels with interference in their lower and higher frequencies.

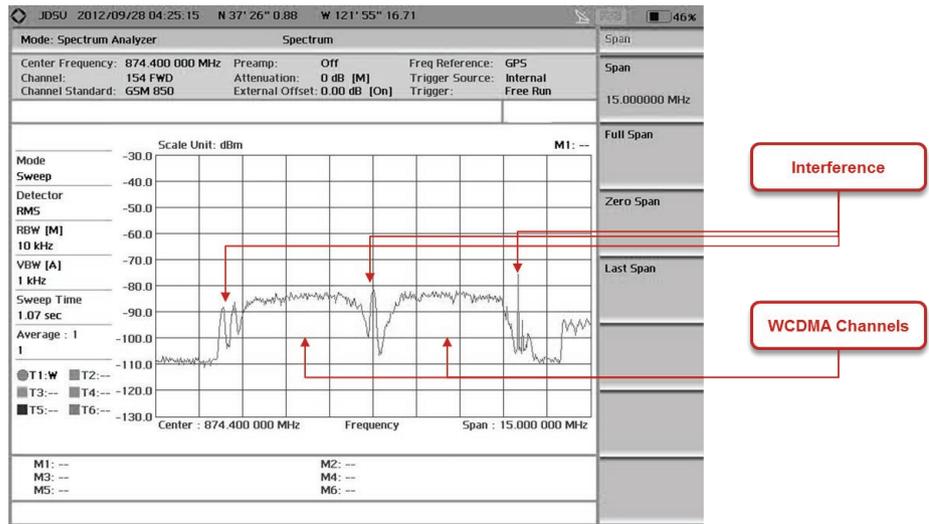


Fig 13. WCDMA Channels with Interference

Traditionally, once an interference signal was detected (from the above example at 874MHz), the immediate troubleshooting step was to locate the source of the interferer. This involves making multiple measurements at different geographical locations with directional antennas, finding areas where the interference signal is stronger and then performing a triangulation of the measurement points in order to obtain the intersection area where the interferer is located.

This location process can take several hours, and if the interference is intermittent or mobile, even weeks. The ability to perform signal identification through signal analysis prior to interference location can save a significant amount of troubleshooting time.

JDSU RF Test analyzers can perform signal analysis that demodulates the interference signal in order to obtain in-depth information about the signal and expedite troubleshooting.

In the above example, there are two WCDMA channels with interference detected at the lower and higher frequencies of each channel. The interference signal between the WCDMA channels was analyzed and identified as signal-modulated with GSMK (GSM technology). Furthermore, the analyzer obtained the cell identity of the site transmitting the signal.

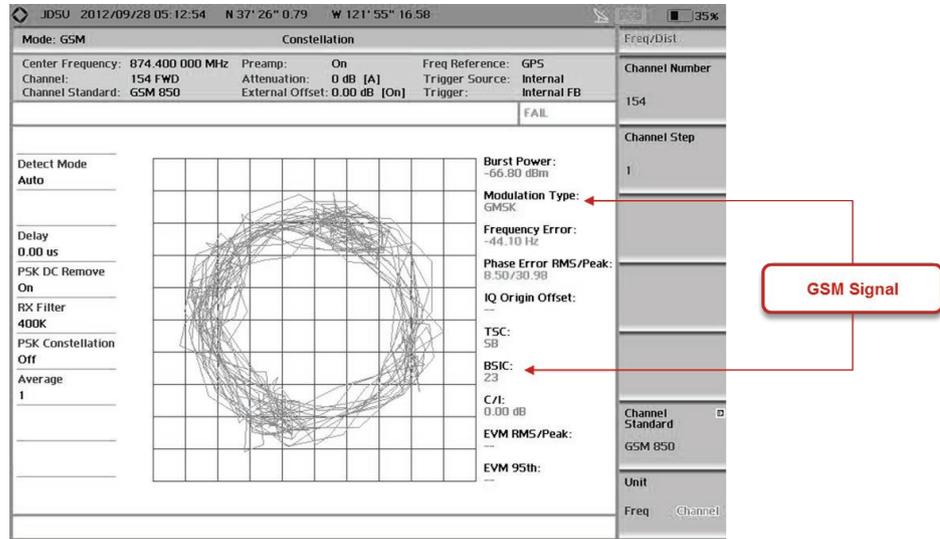


Fig 14. Interference from GSM

The results obtained with JDSU RF Test analyzers gave all the information required for the mobile operator to identify the interferer signal as one of their own GSM signals. Instead of spending hours or weeks locating the interference, they simply re-assigned channel frequencies, eliminating interference.

Other possible source of interference can be harmonics or spurious AM or FM signals that are at the same frequency as uplink signals. For this reason, JDSU RF Test analyzers can also demodulate AM and FM signals for proper interference identification.

### Interference Location

After an interferer signal has been detected, its transmission frequency obtained, and signal analysis performed for its identification, the next step is to obtain the geographical location of the interferer.

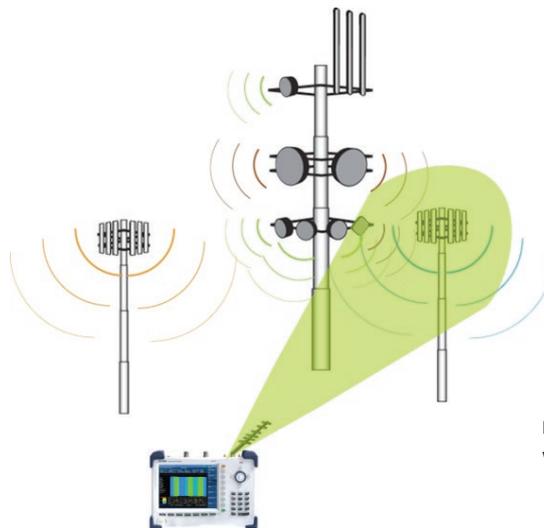


Fig 15. Interference Location with Directional Antenna

At the interferer location, it is formally requested to cease its transmission, generally by giving a warning or proceeding legally against the interferer. The interferer may be subject to fines of tens of thousands of dollars per instance.

Finding the interference location is a time-consuming process because it involves multiple measurements in the area where the interference is detected. These measurements are done with directional (yagi) antennas which limit the signal reception to a span of 30 to 45 degrees.

At least three measurements on different locations should be made in order to perform a triangulation; and, at each location, the direction or azimuth should be collected where the strongest interference was received. This indicates the intersection area and the geographical location of the interferer.

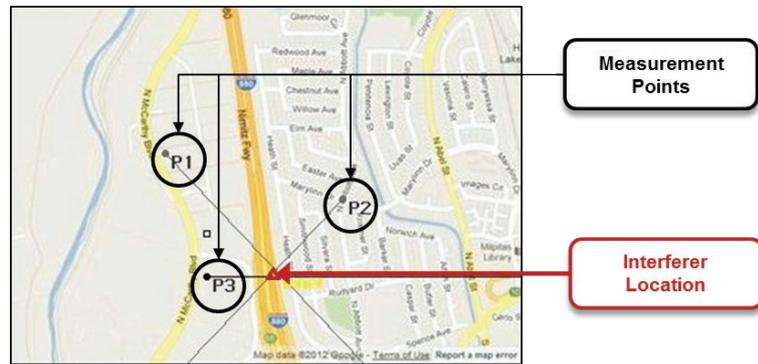


Fig 16. Triangulating the Interferer

JDSU RF Test analyzers use geographical maps, providing a reference for the measurement’s direction and the position of each measurement point.

The analyzers also perform automated triangulations from measurement points, indicating areas of intersection in the map and, therefore, the location of the interferer.

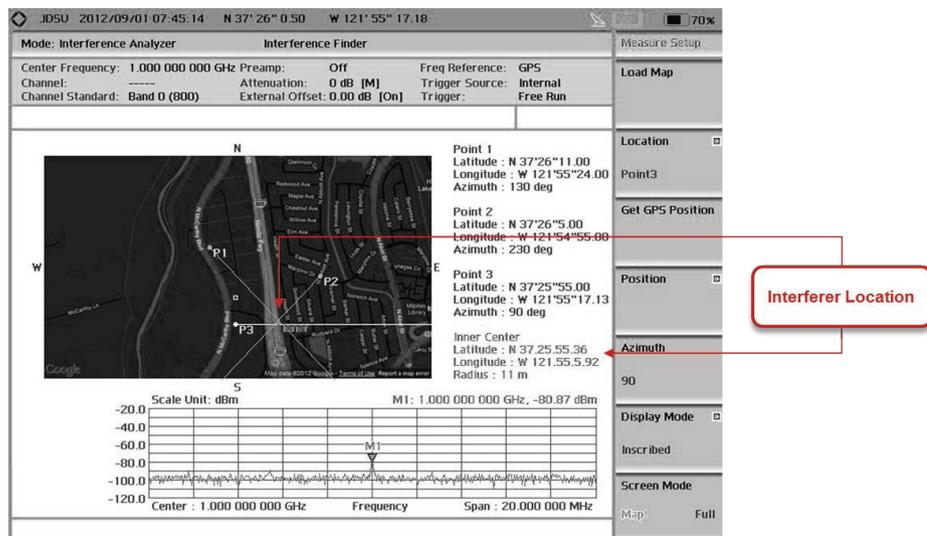


Fig 17. Interference Location

### Conclusion

Interference analysis in wireless networks is a fundamental testing procedure to monitor the spectrum’s environment, which is heavily used by different sources and organizations. An accurate and comprehensive analysis of the spectrum should be made in order to ensure service coverage of wireless services and the identification of any interfering signals which may degrade the intended service.

The three main stages in the process of interference analysis are detection, identification, and location. Each stage requires a complete testing procedure to minimize troubleshooting time and, ultimately, service interference.

JDSU RF test solutions perform all the necessary measurements that characterize the condition of radio access networks including the proper identification of impairments, transmission conformance, and modulation quality.

In addition, JDSU RF test solutions perform thorough spectrum clearance assessment as well as interference analyses covering the detection, identification, and location of interference in 2G, 3G, and 4G networks.

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