Interference Hunting with R&S®FSH Handheld Spectrum Analyzer

Application Note

Products:

- R&S®FSH
- R&S®FSH-K14
- R&S®FSH-K15
- R&S®FSH-K16

This application note explains how to detect, characterize, find and document interferers in cellular networks using the R&S®FSH spectrum analyzer (from now on referred to as the FSH).

First it explains how to use the spectrum and interference analysis functions during each step of interference hunting. It also illustrates the explanations with a common interferer example.

Then it points out the most common interference sources in cellular networks and gives tips on how to identify them.

To execute the tests described in this application note, the FSH handheld spectrum analyzer needs to be equipped with a directional antenna and the following options:

- FSH-K14 or -K15, to work with the spectrogram

- FSH-K15, to work with the mapping triangulation, the tone function and the interference analyzer

- FSH-K16, to work with the geotagging function

- R&S®HA-Z240 GPS receiver unless R&S®HL300 or R&S®HE300 antennas are used

Application Note

Laura Sánchez, Frank Brämer
Paul Denisowski.

7/10/2014- 1EF89_V1.0

ROHDE&SCHWARZ

Table of Contents

1 Why Do We Need Interference Hunting?

Mobile subscribers expect mobile services to be available, reliable and to have good performance in terms of voice quality and throughput.

Based on these criteria, subscribers may pick or change their service provider. This is why service providers are making big efforts to provide their subscribers with a good quality of experience.

New frequency bands are acquired or refarmed to get a wider spectrum and increase network capacity and speed. Many of the initial LTE deployments took place in spectrum that had been refarmed – that is; the previous occupants of the spectrum were moved to different frequencies in order to make room for new services. For example, the LTE band 3 around 1800 MHz, previously allocated to GSM services, is now used for LTE in many countries. And WCDMA band 8 around 900 MHz was previously used for GSM. LTE also uses frequency bands that were previously allocated to analog TV services in Europe (800 MHz) and the US (700 MHz).

Technologies such as LTE/LTE-Advanced are deployed to deliver higher data rates at lower costs compared with older technologies such as GSM, WCDMA.

Increased throughput is obtained through the use of higher-order modulation, for instance by using 64QAM in the downlink and multi-antenna technology (MIMO). But in all communications systems, higher-order modulation schemes typically require a "cleaner" RF environment with a lower noise floor. If the level of noise or interference rises in the network, the network will typically drop to lower-order modulation schemes (16QAM or even QPSK), thus significantly degrading the throughput and other advantages of using LTE.

Interference affects our ability to use wireless communications systems, with the effects ranging from a mild decrease in overall network effectiveness – e.g. slightly reduced throughput – all the way up to a complete failure of the network, but most interference issues tend to fall somewhere in the middle.

Rapid detection, location and resolution of interference problems is a critical component in delivering optimal quality of experience.

2 Interference Hunting Steps

Before going out in the field to measure interference, it is important to make sure that the problem is really caused by interference and not by malfunction of tower-mounted amplifiers or other network components.

Downlink interference is typically caused within the operator's own network. Internal interference problems can normally be solved by changing the antenna tilt or azimuth of the affected cells or making some changes in the network parameters.

Downlink interference can also be caused by jammers (i.e. intentional interferers). In practice this is very rare and would be difficult to detect without turning off the base station.

External interference is almost exclusively an uplink issue, i.e. in the spectrum used by the mobile phones when transmitting to the base station. Interference in the uplink generally causes problems because it impairs the base station's ability to "hear" the relatively weak signals being sent by the user equipment (UE).

Base stations normally can detect the presence of interference in the uplink frequency band – e.g. an excessively high RSSI (typically –100 dBm or higher) or poor performance in certain KPIs such as throughput or call retainability.

In the LTE and WCDMA uplink, all mobile phones transmit on the same frequency. This makes the uplink especially vulnerable to high levels of noise and interference, where highly interfered areas can become coverage holes in the network.

An example of uplink interference in WCDMA networks caused by unlicensed DECT telephones will be shown in the next sections.

2.1 Detecting the Interfering Signal

The first step is to drive around the affected cells' coverage area until the interfering signal is detected. The FSH is typically connected to an omnidirectional antenna like the R&S®TS95A16 on the top of the measurement vehicle, but directional antennas like the R&S®HL300 or the customer's own antennas may also be used.

For use in vehicles, the R&S®HA-Z202 car adapter is available to power the FSH using the standard 12 V vehicle power supply.

The spectrum view in combination with the spectrogram helps to detect interferers that are visible only for a fraction of time. In Fig. 1, the spectrogram in the lower part of the display shows an intermittent frequency hopping interferer (red dots).

The markers M1 to M4 are used to delimit the different frequency channels.

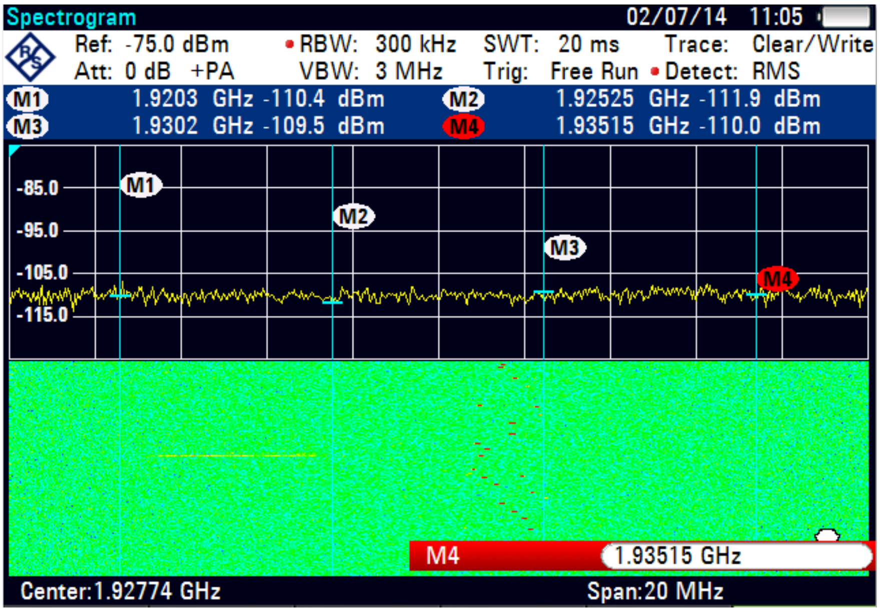

Fig. 1 Spectrum analyzer and spectrogram trace shows the interference signal in UL spectrum (red dots) using the RMS detector.

Once the interfering signal has been spotted, move closer to the area where you assume the interference signal becomes stronger until you can clearly see the interference signal. Fig. 2 shows the same interferer that was spotted in Fig. 1, but from a closer location.

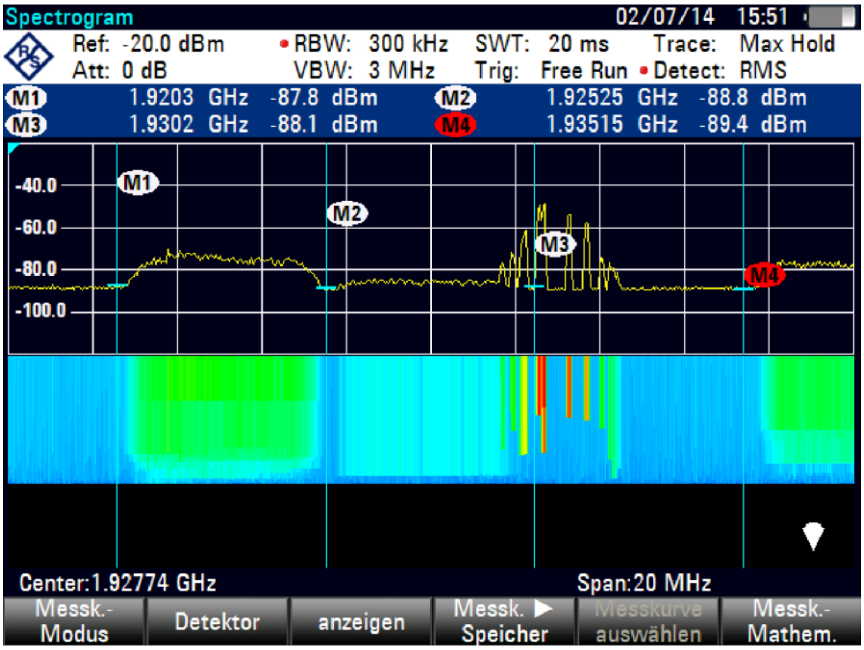

Fig. 2 Interference signal in the WCDMA UL band (right), WCMDA call (left).

The max hold trace is useful in detecting short duration signals or looking for an elevated noise floor. In Fig. 3 the max hold trace shows the maximum signal amplitude versus frequency, indicating signals that are not currently present.

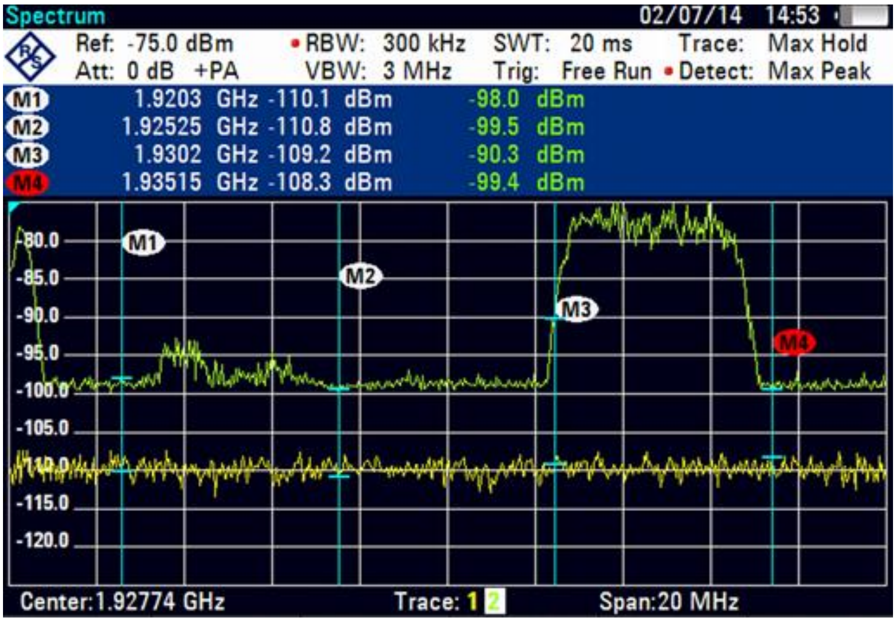

Fig. 3 Combined traces. Trace 1: RMS detector; Trace 2: Max peak detector shows uplink level increase due to phone calls.

While driving around the interfered area, if the interference signal is not easily spotted, make sure the FSH preamplifier is switched on and the input attenuator is switched off.

Operators sometimes use bandpass filters to block other bands that are not the band of interest. This helps to reduce the noise level and find the interfering signal more easily.

If the interferer has not been spotted after a reasonable amount of time, the operator will connect the FSH to the base transceiver station (BTS) antenna to measure the same spectrum that is received by the BTS, in order to see the interferer as well. However, this is usually time-consuming, and sometimes special authorization is needed to access the site.

In some countries, however, connecting to the base station may be done as the first step, to know what the interferer looks like before going out into the field.

In traditional (macro) BTS architectures, where the baseband unit and the antenna system are connected with RF feeder cables, there is usually an RF "sniffer" port. However, many deployments are making use of remote radio heads (RRF), where the antenna system and the RF unit are all mounted up on the tower and the data is carried to the ground over a fiber optic link.

Some remote radio heads do not have an RF sniffer port and need to be shut down to measure through the BTS antenna. On the other hand, RRHs may not be easily accessible (i.e. installed on a tower). That is, in many cases we now have no choice but to "drive the sector" and search a relatively wide frequency span looking for the interfering signal.

2.1.1 Working with the Spectrogram Function

With the FSH-K14 or FSH-K15 option, you can view measurement results in a spectrogram. The spectrogram is extremely useful in interference hunting. It lets you observe a signal's behavior over time and helps to detect pulsed or intermittent signals.

The spectrogram shows the spectral density versus frequency and versus time simultaneously. The amplitude is displayed as a third dimension by mapping different colors to power levels.

You can set the color scheme, the reference level and the range for best viewing results.

You can also adjust the level range using the "spectrogram auto range" function so that the weakest part of the signal is mapped to the lower end of the color map and the strongest part of the signal to the upper end.

To get a better result, change the spectrogram reference level to a level near the maximum power level that has been measured. This will eliminate irrelevant, very low amplitudes.

By default, the spectrogram reference level does not affect the spectrum result display, and the spectrum reference level (Amplitude menu) does not affect the spectrogram. But if required, you can couple the spectrogram to spectrum in the Spectrogram Settings menu.

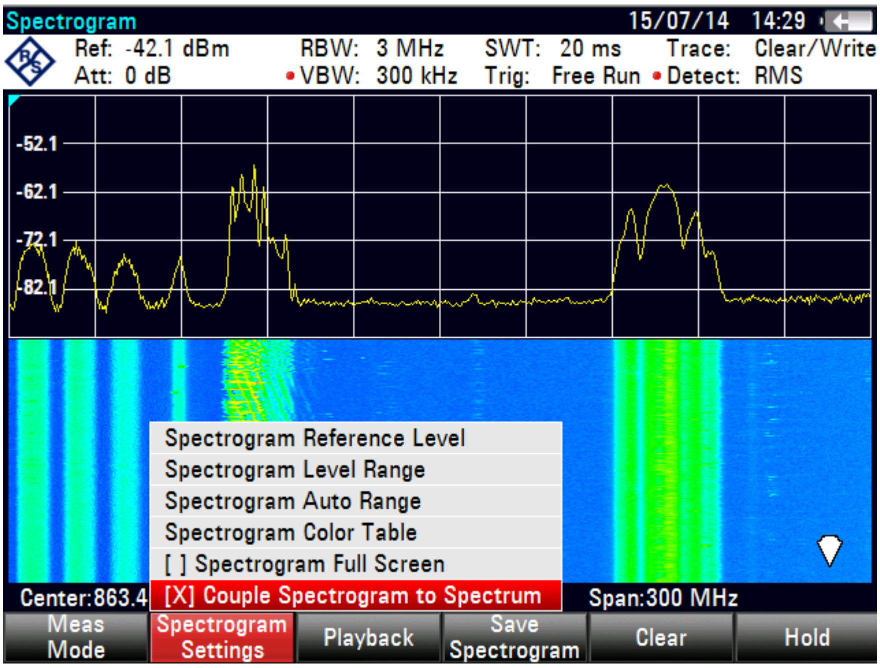

Fig. 4 Spectrogram Settings menu.

Spectrograms can be saved and played back directly on the FSH or by using the R&S®FSH4View software on a PC.

When playing back a spectrogram, the FSH displays two timelines, T1 and T2. The timelines can be set to show the absolute or relative timestamp. By moving the timelines, you can browse through the history of spectra stored in memory.

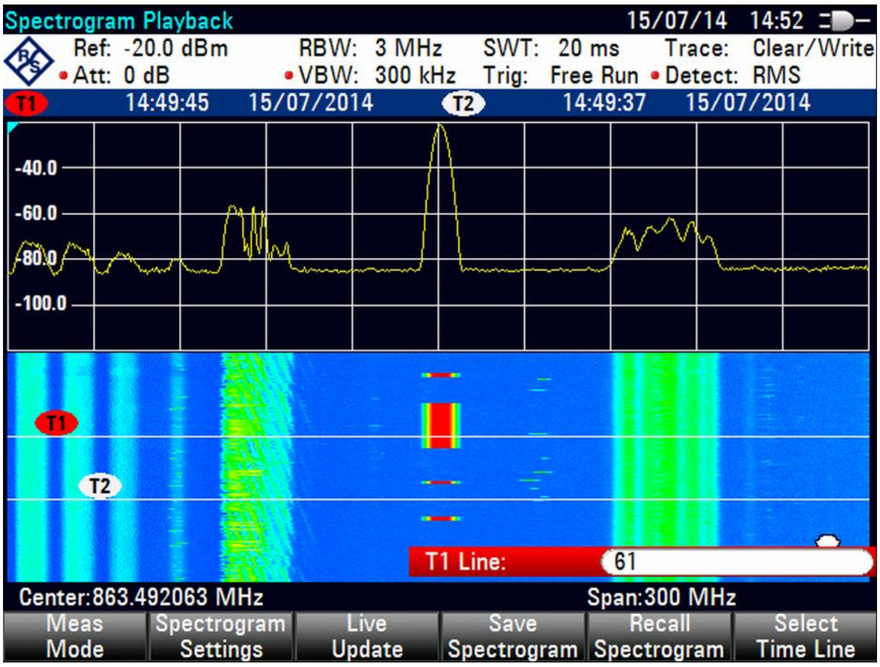

Fig. 5 Spectrogram playback.

Working with the "Save on Event" Function

The spectrogram and the spectrum analyzer mode can be also used in combination with the "save on event" function.

The "save on event" function is standard in the FSH. It allows you to automatically save data sets, screenshots and/or coordinates/bearing information when a certain event occurs.

For example, "save on event" can be configured to save measurement data if a limit line is violated. There are three different modes for handling limit check failures:

- Start on failure: Starts saving measurement data if a limit line is violated

- Stop on failure: Stops saving measurement data if a limit line is violated

- Save only failure: Saves only the sweeps that actually fail a limit check

This can be configured in the User Preference Setup menu (see Fig. 6).

Other events and applications for the "save on event" function are described in section 2.3.5.

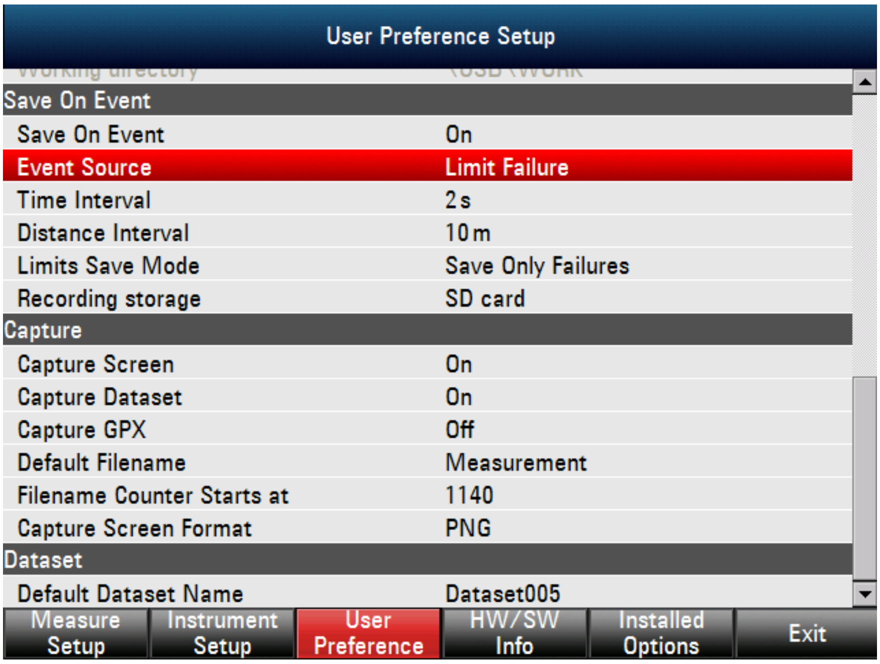

Fig. 6 Save On Event for limit failure in the User Preference Setup menu.

2.2 Characterizing the Interfering Signal

If the detected interfering signal level is strong enough, you can analyze its pattern.

The FSH spectrum analyzer in zero span helps to analyze the characteristics of the interfering signal in the time domain. You have to make sure that the whole signal is within the selected resolution bandwidth, lowering the sweep time in a way that the different signal components are visible.

In Fig. 7, the interferer is a DECT base station erroneously transmitting in the WCMDA UL frequency band. You can recognize the different signal pulses spaced 10 milliseconds apart.

In Europe DECT telephones are allowed to transmit between 1880 MHz and 1900 MHz, whereas DECT phones from the US or Canada will operate between 1920 MHz and 1930 MHz (thus overlapping with the European WCDMA UL band between 1920 MHz and 1980 MHz).

DECT phones from the US or Canada are sometimes imported by users to Europe, without knowing they will interfere with the wireless network. In the worst case (if the interferer is placed close to the base station) it may even block the complete WCDMA BTS from making calls.

Interference in WCDMA UL caused by DECT phones is a common interference source in Europe. Other common interference sources are explained in section 3.

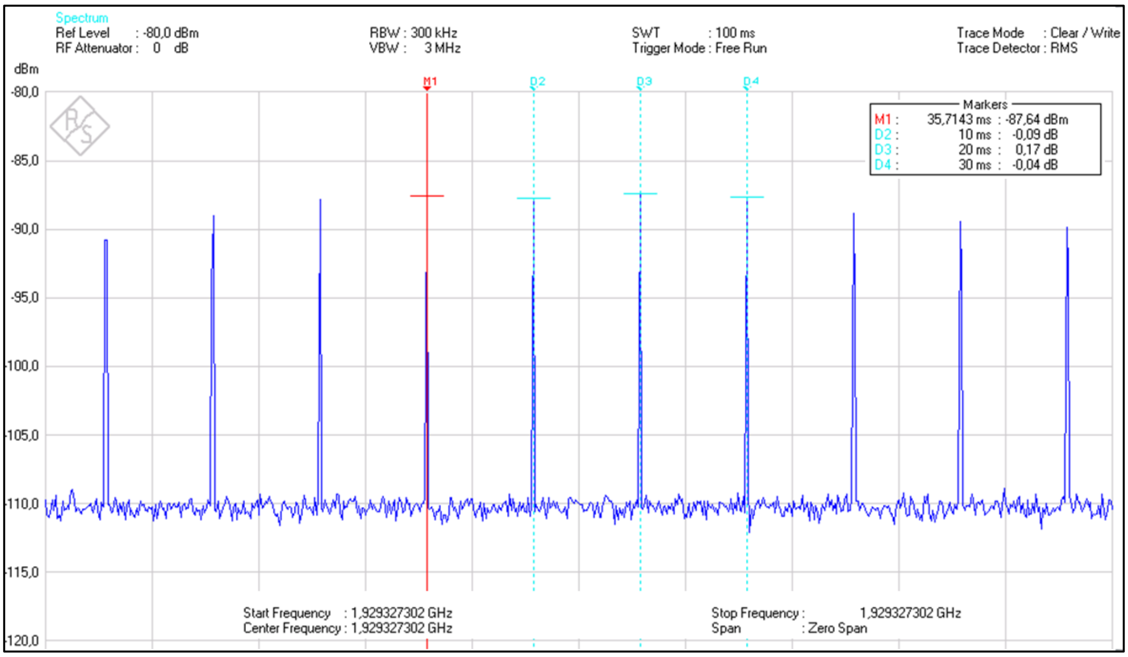

Fig. 7 Interference signal characterization in zero-span.

Fig. 7 shows a DECT burst measured in zero span. When measuring burst signals, you usually apply a trigger. If the video trigger level is at 66 % of the range of the vertical axis, the FSH triggers a measurement if the rising edge of the burst exceeds this 66 % line.

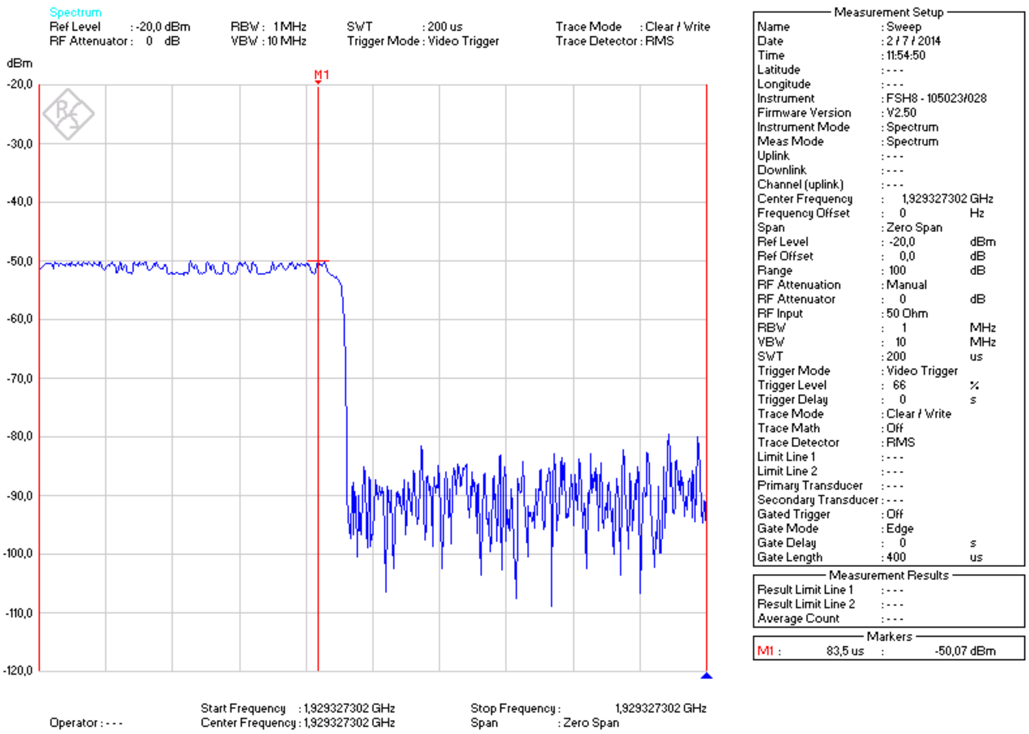

Fig. 8 Interfering signal in time domain (zero span, sweep time 200 µs). DECT short burst.

2.2.1 Documenting the Results with R&S®FSH4View

Once the interferer has been found, the results may need to be reported to the responsible frequency regulation authority. For this purpose, the network operator needs to document all relevant information related to the interference case, such as:

- Affected network element, i.e. sector(s) or cell(s) and address
- Effect of the interference (i.e. calls dropped, service inaccessibility)
- When does it happen: continuously, or at certain times or on certain days
- Interfered frequency band and frequency channels
- Measured interference levels (frequency, level, date and time of the measurements)
- Suspected interference source: interferer type, location

In addition, signal plots like those shown in Fig. 7 and Fig. 8 as well as screenshots of maps may be added to the report.

The R&S®FSH4View software is extremely useful for editing and preparing the measurement results to report. It allows you to transfer files between the instrument and the PC and edit measurement results (edit/add markers, limit lines, etc.). It also enables you to perform many other tasks, such as generating reports, setting up templates for limit lines, channel tables, cable models, etc.

In addition, the R&S®FSH4View software lets you control the FSH remotely via a LAN or a USB connection from any Windows-based PC using the remote display application within R&S®FSH4View.

R&S®FSH4View is delivered with the FSH as standard and is available for download on the Rohde & Schwarz website:

http://www.rohde-schwarz.com/en/software/fsh/

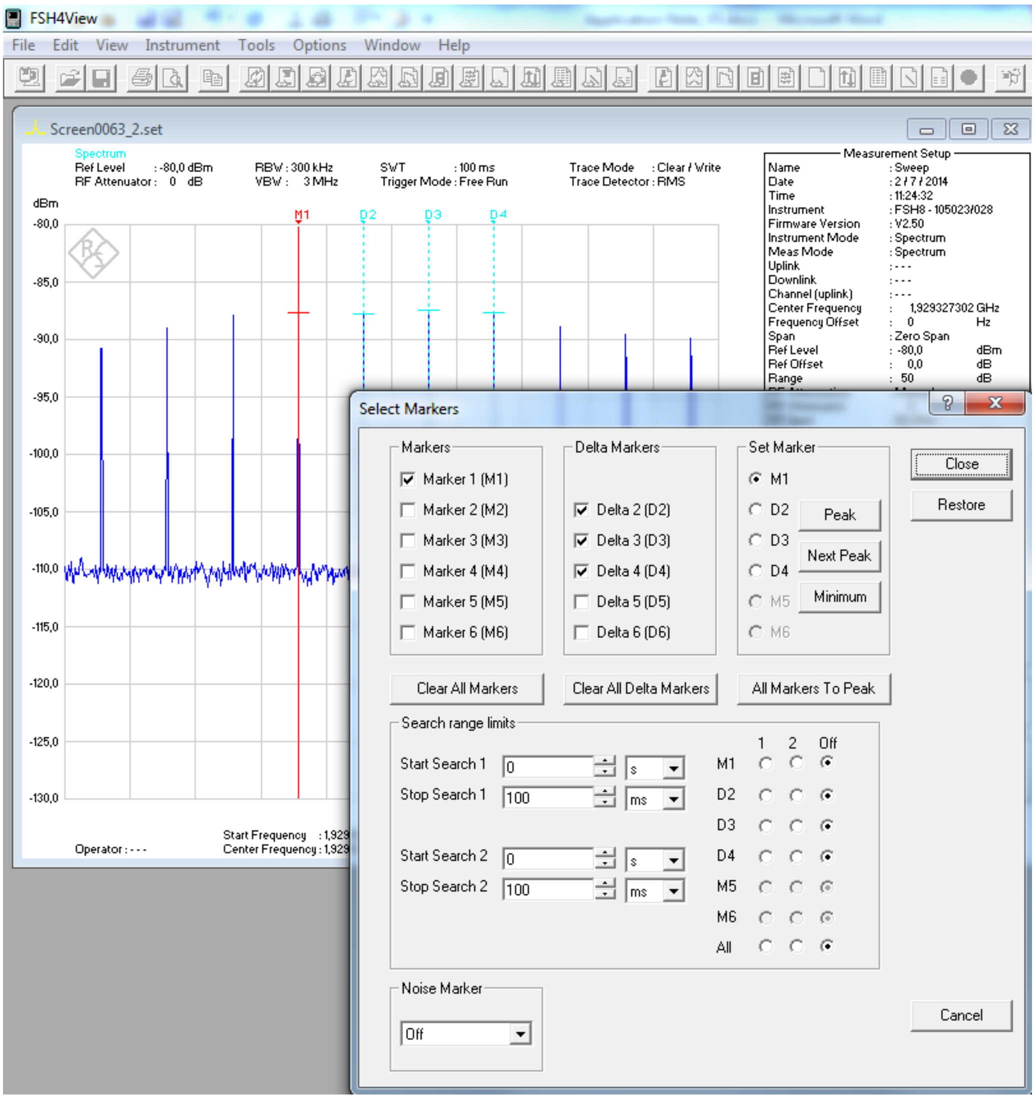

Fig. 9 Editing a measurement setup using R&S®FSH4View.

2.2.2 Working with the Interference Analyzer

The interference analyzer (available with the FSH-K15 option) provides, in addition to the spectrogram and the mapping functions, the ability to visualize and measure spectrum, similar to the spectrum analyzer mode.

Fig. 10 Interference analyzer mode.

It also supports measurements such as carrier to noise, carrier to interference, and trace mathematics (Diff Mode).

The carrier-to-noise (C/N) measurement places two markers on the trace. The first marker is placed on the peak power level, which the FSH assumes as the level of the carrier. The second marker is positioned on the lowest level that has been measured (Min Peak). The difference between the two signal levels is the displayed carrier-to-noise ratio.

The carrier-to-interference ratio measurement is a tool used to determine if a signal is affected by interference from neighboring channels. It places two markers on the trace. The first marker is placed on the peak power level (i.e. carrier level). The second marker is positioned on the second strongest level that has been measured ("Next Peak" or interferer). The difference between the two signal levels is the carrier-to-interference ratio.

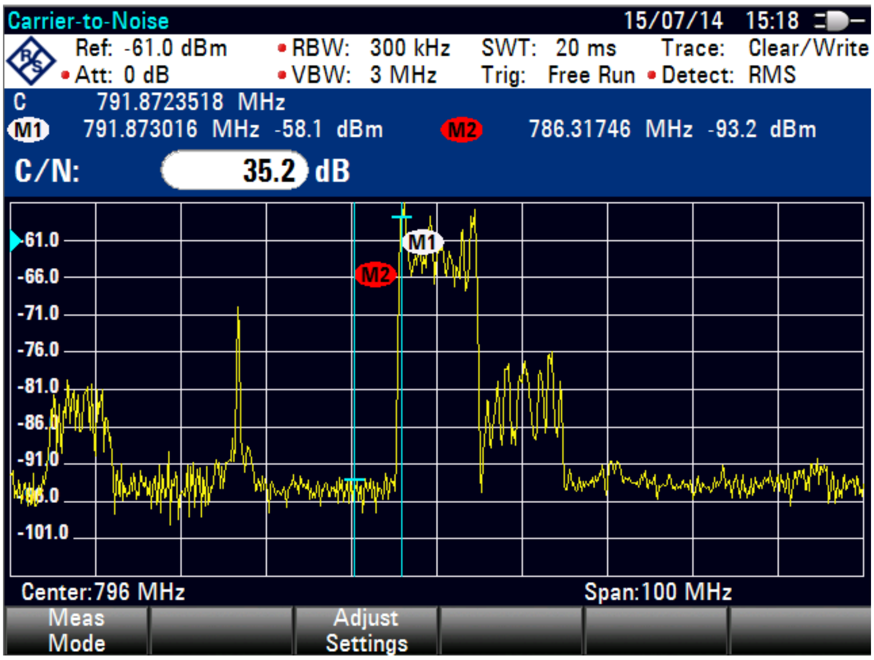

Fig. 11 Carrier to noise measurement.

The interference analyzer also provides a quick way to compare the current results with a previous one. When you turn on the Diff Mode, the FSH saves the current trace and will subtract this trace from the live traces resulting from future sweeps. This makes it easy to detect changes in the spectrum (see Fig. 12).

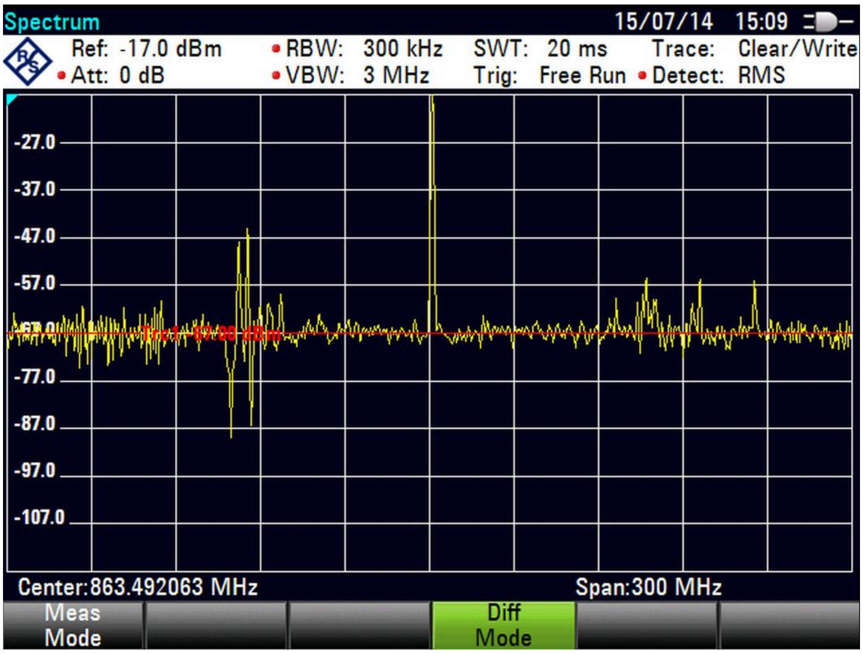

Fig. 12 Diff Mode measurement display.

2.3 Locating the Interference Source

Once the interference signal has been spotted and characterized, the next step is to find it.

Now is the time to set the FSH center frequency to the interferer's frequency and drive or walk around with the FSH and a directional antenna.

Depending on the environment, there are different location techniques and antenna types you can use.

The Homing Technique: (Dense) Urban Areas

With this technique, you walk with the FSH and a directional antenna, going in the direction where the interfering signal is the strongest, until the signal source is reached.

To determine the direction from which the signal arrives, hold the directional antenna and rotate in place slowly (around 30 seconds for a complete turn), attempting to determine the direction from where the maximum level is coming from; that direction will be the direction in which you have to walk in order to find the interferer. Then move slowly in the direction toward the interferer, moving the antenna slightly side to side.

Pay attention to make sure the measured signal is coming directly from the interfering source and not being reflected by a building nearby or by other reflective objects such as vehicles.

This technique makes sense if either of the following holds true:

► The source is likely to be located nearby or indoors: in these cases, maps and bearing information are not necessary.

- You are in a (dense) urban area where tall buildings close to one another cause many signal reflections. Yagi or planar antennas usually only cover a single frequency band per antenna but have a narrower beam width and a higher gain, which helps to speed up the direction finding in dense urban areas.

The Triangulation Technique: Suburban or Rural Areas

In suburban or rural areas, the FSH mapping function allows you to triangulate the interferer, narrowing down the search to a much smaller area.

The quality of the measurement results depends on the choice of the measurement sites. These should be elevated and ideally have line of sight to the signal source. Since the location of the signal source is unknown, the success of triangulation in dense urban areas is limited, since signal reflections in buildings, multipath and shadow effects will falsify the measurement results.

Log-periodic antennas such as the R&S®HL300 or R&S®HE300 cover all frequency bands up to 8 GHz and 7.5 GHz, respectively, which makes it possible to measure harmonics of the main interfering signal. In addition, they feature a built-in GPS and electronic compass, which allows the FSH to display the user's position and the antenna's direction.

You can configure the FSH to play an audio signal when it receives a signal. The audio signal will increase its frequency and volume as the interference signal level increases, thus helping you to find the strongest direction without constantly looking at the FSH screen.

Sections 2.3.2 and 2.3.4 explain how to set up the triangulation and tone functions in the FSH.

Fig. 13 Locating interference source with the FSH and the R&S®HL300 directional antenna.

2.3.2 Downloading Maps and Loading Them to the FSH

Before you can use any features based on maps, you have to download and install the maps on the FSH. The FSH supports the map material supplied by the Open Street Maps project (http://www.openstreetmaps.org).

To transfer maps to the FSH, use the R&S®OpenStreetMap Wizard (OSM wizard). The OSM wizard is available for download on the FSH product homepage (http://www.rohde-schwarz.com/product/fsh.html).

The OSM wizard establishes a connection to the Open Street Maps database and therefore requires a connection to the Internet. To select your area of interest, navigate by dragging the map and using the zoom +/- buttons. The zoom level is adjustable from levels 1 to 18. To download the maps, click the Start button. Use the Browse button to specify the destination folder.

In a scenario where the “Current Zoomlevel” is set to 10 and a "Download Zoomlevel" of 14 is selected, the OSM tiles from zoom levels 10, 11, 12, 13 and 14 within the current map area will be stored on disk. In order to avoid huge downloads, which are not permitted by the Open Street Map server, you cannot set wide map areas and deep zoom ranges. For example, if a "Current Zoomlevel" of 10 is set, then the "Download Zoomlevel" may only be increased to 14.

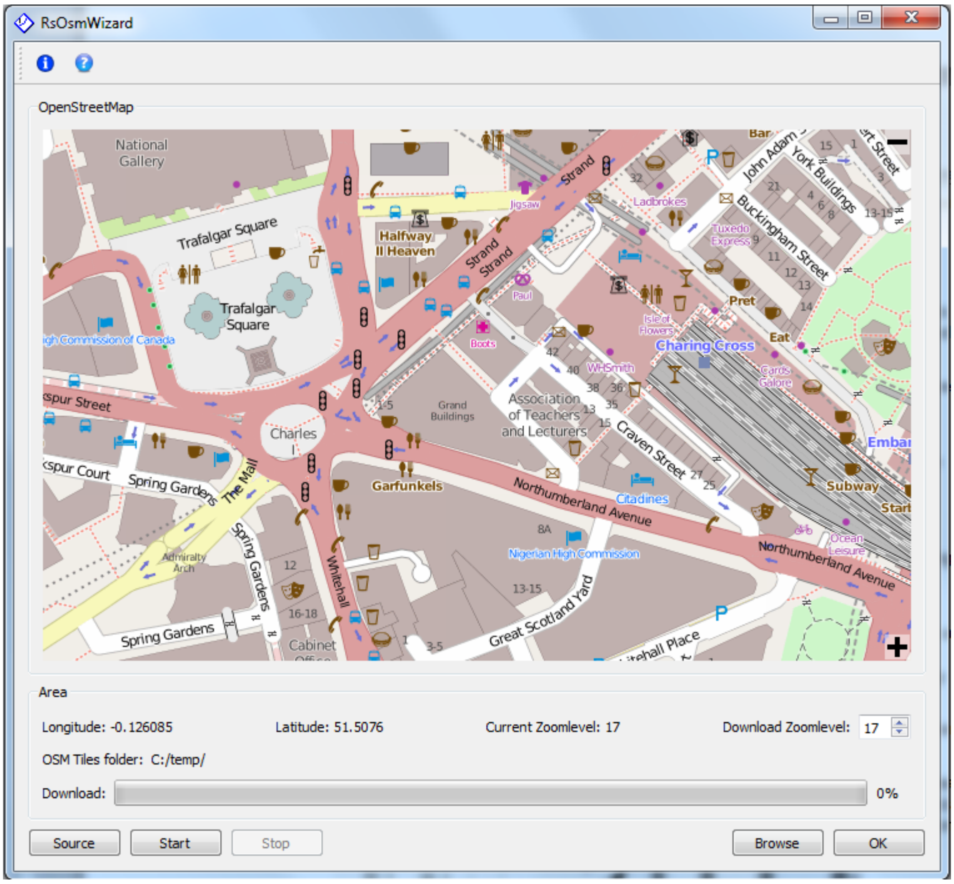

Fig. 14 OSM wizard with OSM map displayed.

After you have downloaded the maps you need, save them to an SD card, which you can use with the FSH:

► Enter the "Maps" mode.

► Press the MEAS key.

► Press the "Map" softkey.

The FSH opens a menu that contains all maps that you have stored on the SD card (the names correspond to the folder names for every area you have downloaded).

Fig. 15 FSH Map menu with OSM maps, map display settings.

The "Auto Select" menu item automatically selects the map that is most fitting for your current location. To use automatic selection, you need a GPS receiver.

Under the Settings menu, you can configure which settings to display on the map screen. If no screen element has been selected, the FSH only shows the map.

2.3.3 Working with the Triangulation Function

With the FSH-K15 option and a directional antenna, the FSH is able to triangulate the interferer location. Triangulation is based on measurements coming from different sites. Ideally these measurement bearing lines intersect at the signal source's position.

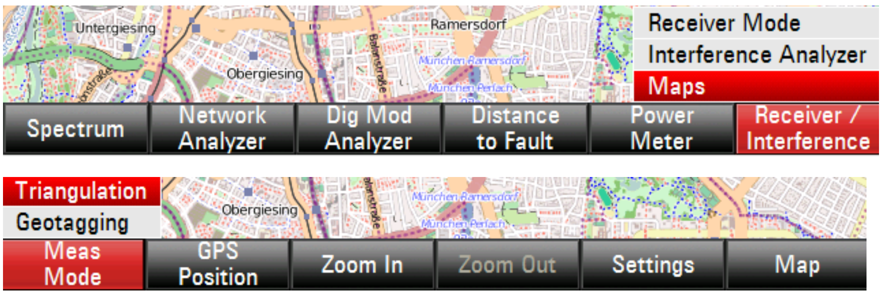

Fig. 16 Triangulation function menus.

The FSH performs triangulation measurements using any directional antenna.

If you use the R&S®HL300 or R&S®HE300 (with built in GPS and electronic compass) to do the triangulation, configure them under the Instrument Setup menu (Fig. 17):

► Connect the GPS/compass cable of the R&S®HL300 to the AUX port on the left side of the FSH.

► Connect the GPS/compass cable of the R&S®HE300 to the power sensor jack on the top of the FSH.

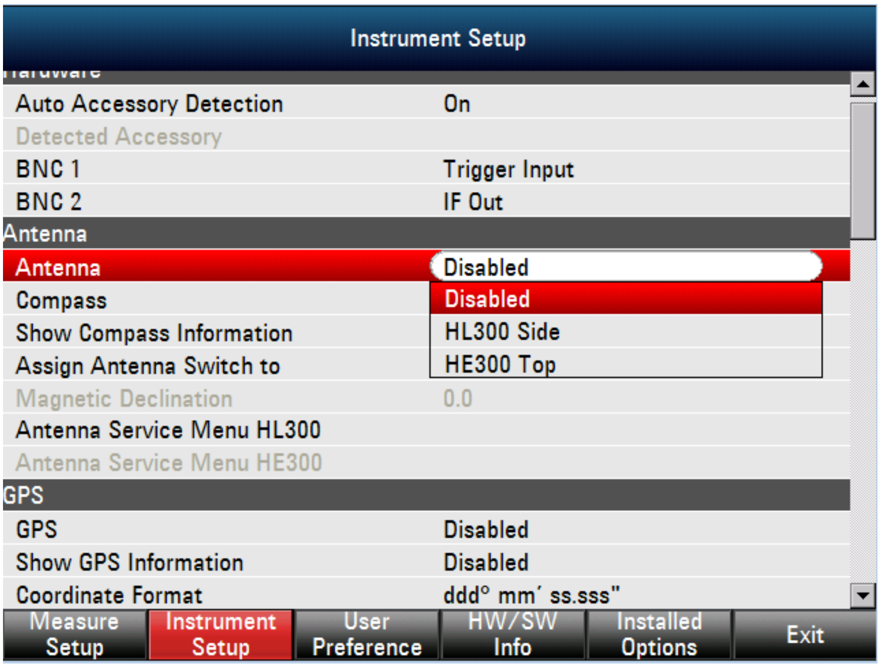

Fig. 17 Antenna setup menu.

The R&S®HL300 antenna switch can be set up to either make a measurement (i.e. "Save Current GPS Position", default setting) or switch on the FSH preamplifier, as indicated in Fig. 18.

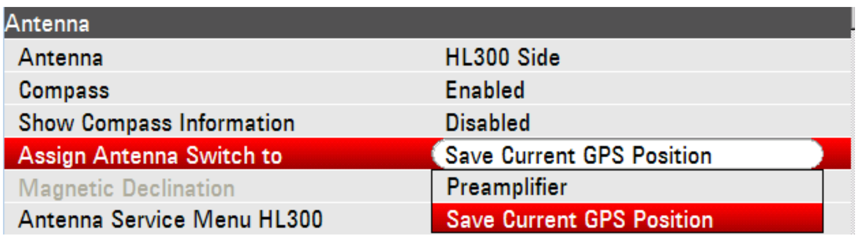

Fig. 18 FSH HL300 setup menu.

To use the FSH triangulation function, select three measurements from different locations with GPS location and azimuth information and display them on the map.

To make a measurement, set the FSH center frequency to the interferer's frequency. To determine the direction from which the signal is arriving, hold the directional antenna and rotate in place to complete a full circle within 30 s in order to get a general idea of the direction from which the signal is being received at the maximum level.

If possible at the selected site, repeat this rotation a few meters away from the first position in order to eliminate any secondary maximum levels.

The direction from which the maximum level is transmitted must be determined precisely. Especially when working with long distances, even deviations of just a few degrees can lead to major errors.

Based on the approximate maximum level, move the directional antenna to the left and to the right until the displayed level value changes by +/- a few dBs to determine the maximum level's direction as precisely as possible. Save the position once the maximum level's direction has been determined.

To save a position, move the R&S®HL300 antenna switch back and forth, or click "Save Current Position" under the GPS Position menu. The message "Saving GPS Position" will shortly appear on the FSH screen, indicating that the measurement has been saved correctly.

Fig. 19 Measurements using the FSH and the R&S®HL300 antenna in the R&S®HA-Z222 carrying holster.

If you perform measurements with the FSH and a directional antenna for longer periods, we recommend that you use the R&S®HA-Z222 carrying holster. It includes a chest harness, which eliminates the need to carry the FSH in your hands, and a rain cover.

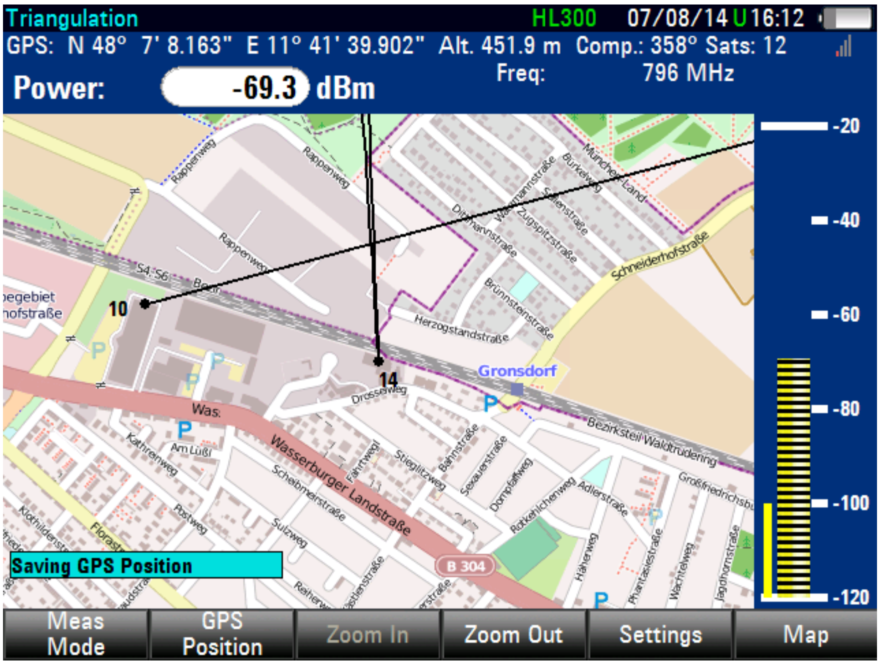

Fig. 20 Message in map triangulation display. Saving a GPS position with bearing using R&S®HL300 switch.

If you are using an R&S®HE300 antenna, to save a position you have to click "Save Current Position and Azimuth" under the GPS Position menu. The switch on top of the R&S®HE300 antenna only turns on the R&S®HE300 preamplifier.

If an antenna other than the R&S®HL300 or R&S®HE300 is used, the antenna does not need to be set up. We recommend using the R&S®HA-Z240 GPS receiver; it needs to be enabled under the Instrument Setup menu. To save measurements, click "Save Azimuth Only". This will automatically save the measurement with GPS position data from the FSH. The bearing data can either be typed in manually or selected using the rotary knob.

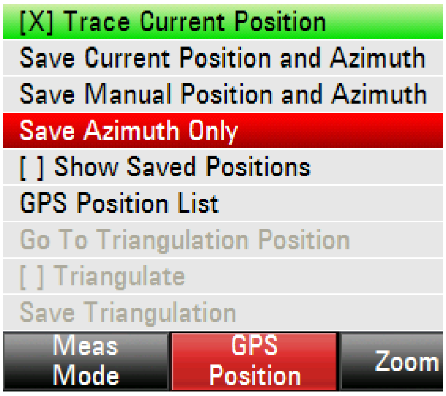

Fig. 21 FSH rotary knob and GPS Position menu.

Triangulation requires at least two but preferably three measurements from different sites. If three measurements are used for triangulation, the overall result will be more precise than if only two measurements are used and will avoid any unambiguity.

After saving measurements from different locations, select three measurements from the GPS Position List menu (Fig. 22).

Fig. 22 GPS Position List menu. Three positions selected to triangulate.

Next, go to the GPS Position menu and click "Triangulate".

The FSH calculates the intersection point of the selected measurement bearing lines. The result is displayed on the map as a dot surrounded by a circle (Fig. 23); the circle radius is indicated on the screen. The circle indicates the area where the signal source can be expected.

In Fig. 23, the dot and circle are blue and the measurement bearing lines are black. However, you can assign a different color to the triangulation results and to the measurement lines.

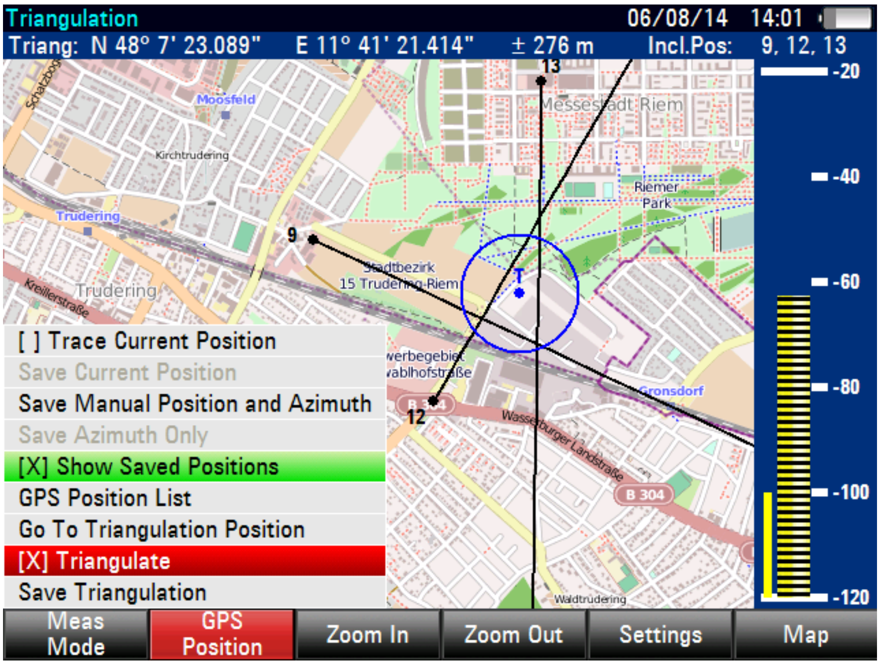

Fig. 23 Triangulation result.

The environment, the antenna, the choice of measurement sites and the exact determination of the direction of the maximum level influence triangulation accuracy.

The result of triangulation is not the direct, physical discovery of a signal source, but it helps to narrow down the target area. Then the homing technique can be used to determine the signal source.

2.3.4 Working with the Tone Function

The FSH can be configured to play an audio signal (or a "tone") when it receives a signal. The audio signal changes its volume and frequency, depending on the strength of the received signal.
This function is helpful for finding the direction/bearing from which the strongest signal is coming from, without you having to constantly look at the received level displayed. It does not matter whether the homing or the triangulation technique is being used.

The higher the measured level is, the higher the frequency of the tone.

Changes in the level that occur while rotating with the antenna can be heard as well as seen (on the display).

There are different parameters you need to set in order to use this function. To optimally configure the tone so that you can hear variations in the signal level, we recommend the following:

Squelch level: Defines the signal level above which the audio signal starts to play.

=>Set the squelch quite low (i.e. to around –90 dBm).

Tone threshold: The audio signal has a specific frequency that is coupled to a specific signal level. As the received signal gets stronger or weaker, the audio signal frequency goes up or down. You can define the threshold of the base tone as necessary.

The tone threshold must be adjusted continuously, especially when the homing method is used, because ideally the user comes closer and closer to the signal, causing the level of the received signal to rise. The tone threshold should be set so that the FSH emits an audible tone, allowing you to easily perceive even small changes in the level.

=> Set the threshold level as high as possible so that you can barely hear a very low tone, and increase the threshold as you come closer to the interferer.

Tone gain: The change of frequency in the audio signal is either one octave per 20 dB or one octave per 40 dB.

=>Select Octave/20 dB so that the tone is more sensitive to changes in signal level.

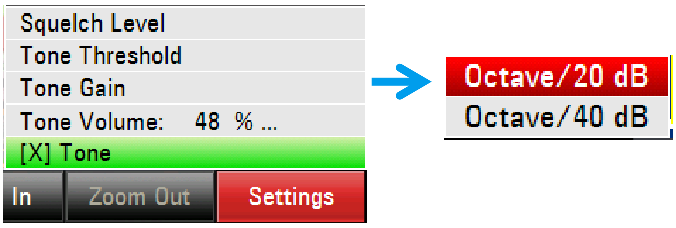

Fig. 24 Tone Settings menu.

We recommend using headphones with the tone function.

2.3.5 Working with the Save on Event and the Geotagging Function

The FSH geotagging feature (FSH-K16 option) saves a geotag (position and level information) automatically when user-defined criteria are met. These criteria may be level, distance traveled, or elapsed time. The main applications for this function are:

- Analysis of the coverage/interference conditions around the BTS area (signal strength measurement)
- Interferer search support: record measurements based on level, distance or time threshold (save on event)
- Site position reporting and documentations by BTS service teams: Save own position on the map

Geotagging results can be viewed directly on the FSH map or exported to kmz files to be displayed in Google Earth.

To use this function the FSH requires any antenna and the R&S®HA-Z240 GPS receiver option (unless the R&S®HL300 or R&S®HE300 antenna is used).

To automatically record measurements, the FSH uses the "save on event" function. This function can be activated from the Geotagging Settings menu. A green "S" at the top of the screen indicates that the "save on event" function is active and measurements are being recorded.

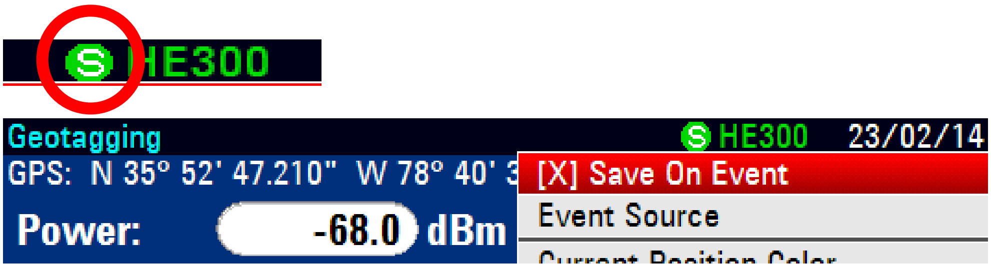

Fig. 25 "Save on event" icon.

When "Save On Event" is selected, an event source must be specified. The event source can be set under the Settings menu in the geotagging mode or under the FSH User Preference Setup menu.

There are four different event sources:

- Time Interval – saves measurement every X seconds
- Limit Failure – saves measurement if a limit line is violated
- Distance Interval – saves measurement after moving a given distance
- Every Sweep – saves measurement for each sweep performed

Geotagging defines three received power levels: good, average and bad. The values for these levels and their colors are defined by the user.

Note that the FSH stores the actual measured values – the coverage levels are only used to define how these results are displayed (i.e. which colors to use for which levels).

The colors used to represent current position as well as good, average and bad coverage are all user-definable. This allows you to define higher signal levels (interference) as red and lower signal levels (normal noise floor) as green.

The FSH can save different types of information when an event occurs. Screen capture (.jpg or .png), data set (.set) for the sweep containing the event, an entry in a .gpx file (containing GPS coordinates and bearing information) or combinations of these are also possible.

Captured data is stored in the Save On Event Results directory on the SD card.

Make sure that the SD card is not locked and has enough free space to save the measurements.

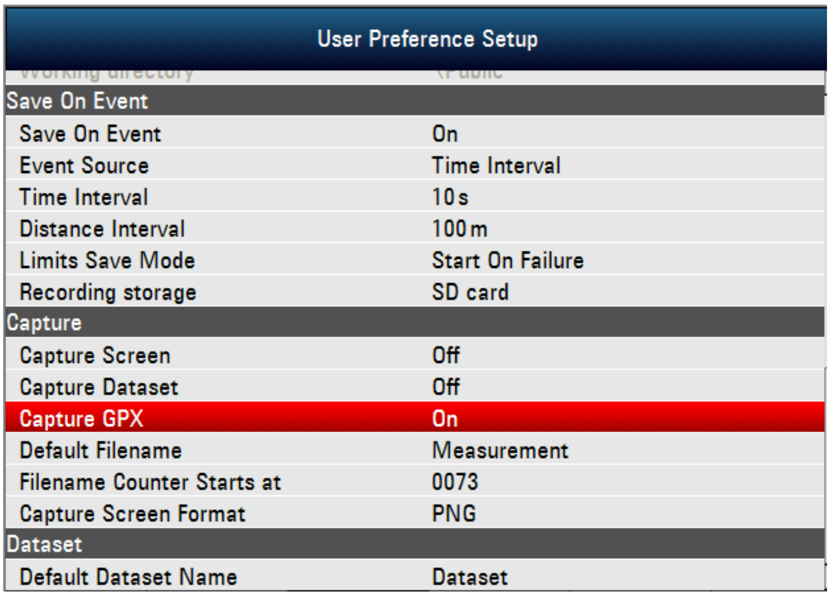

Fig. 26 Save On Event settings in the User Preference Setup menu.

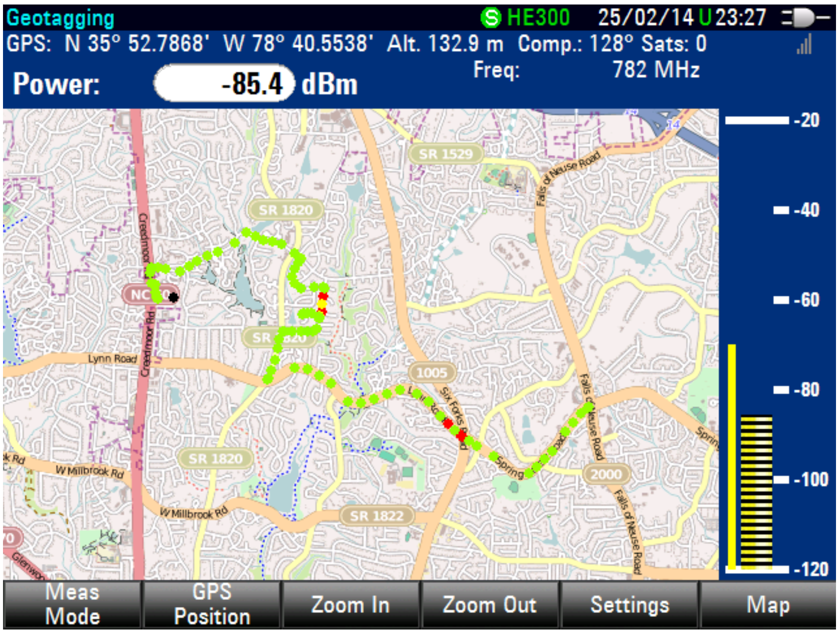

Fig. 27 FSH map display with geotagging measurement results.

The standard R&S®FSH4View software provides an interface that allows you to export and review your recorded data with Google Earth. This interface transforms .gpx files into .kmz files (required by Google Earth). It also contains a plug-in that illustrates the signal levels measured at the GPS coordinates that you have added to the .gpx file:

► First transfer the GPX file to the PC using R&S®FSH4view.

► In R&S®FSH4View, use the GPX conversion function. Make sure the settings are correct, then click the “Save as KMZ” button to save the file in Google Earth format and export it to Google Earth.

Please refer to section 2.2.1 for more information about the R&S®FSH4view software.

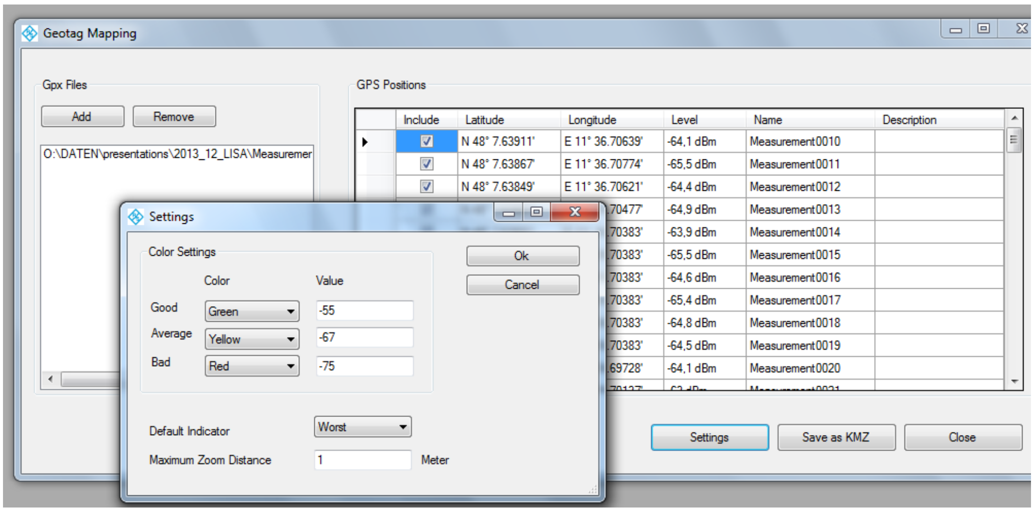

Fig. 28 Google Earth export interface using R&S®FSH4View software.

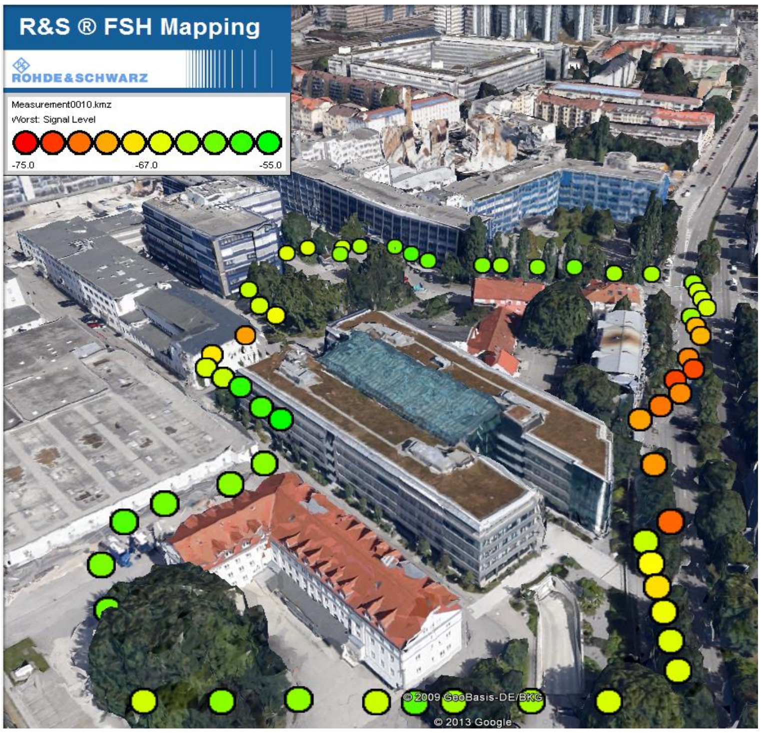

Fig. 29 Geotagging measurement results displayed in Google Earth.

3 Common Interference Sources

The variety of interference sources is almost endless. It will vary depending on the country and RF environment.

A large number of interferers often share common characteristics. An awareness of these frequently recurring interference sources can save a substantial amount of time and effort when investigating interference.

This section describes the most common external interference sources in wireless networks.

For more information, refer to the Rohde & Schwarz Interference Hunting Learning Center: http://www.rohde-schwarz-wireless.com/IH/

3.1 Noise and Spurious Emissions

Electrical noise sources tend to be many megahertz wide and periodic in frequency and/or time. Examples are emissions from electric motors, welding equipment, vehicle ignition systems, electrical fences, faulty transformers/ballasts, etc.

Electrical noise shows up as jumps in the noise floor or as a wide, random spectral pattern.

Noise from electronic sources, sometimes also referred to as "spurious emissions" or "spurs", is usually less than one megahertz wide and tends to be continuous, although in some cases it may vary in frequency, i.e. be oscillating or drifting.

Most consumer and commercial electronics can radiate spurious emissions at numerous frequencies. It is the level of these emissions that determines whether or not they are truly sources of interference.

For example, a plasma TV can generate unacceptable levels of noise that interfere with the cellular UL. Satellite transmitters' emissions in the IF band between 950 MHz and 2150 MHz as well as lighting ballasts and mains adapters are also a source of interference.

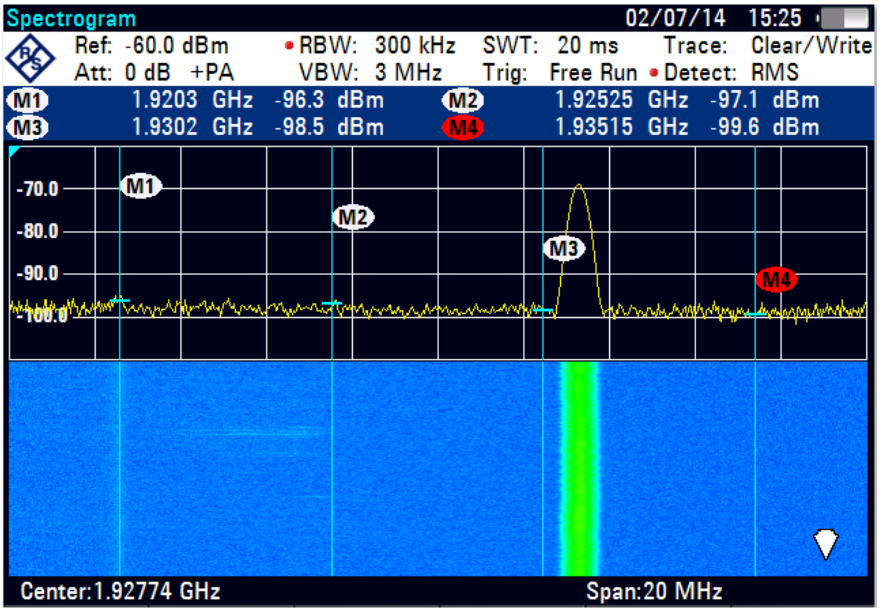

Fig. 30 Spurious emission generated by a power supply at 1.9311 MHz (WCMDA UL).

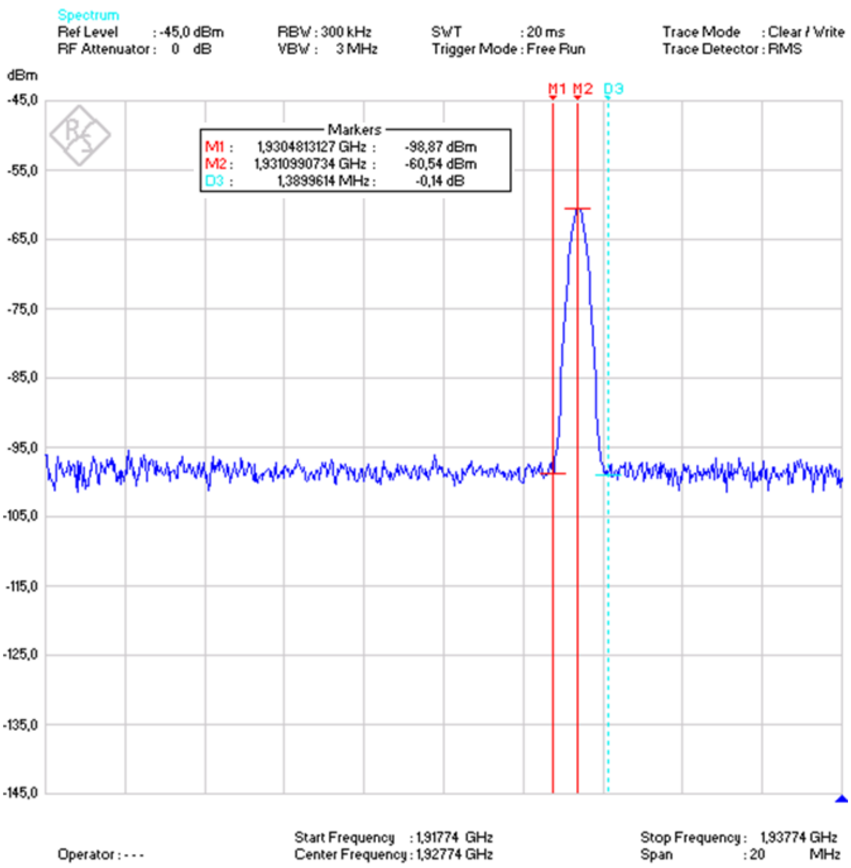

Fig. 31 Spurious emission generated by a power supply at 1.9311 MHz, 1.38 MHz wide (WCMDA UL).

3.2 Harmonics and Intermodulation

Harmonics are a normal by-product of almost all RF transmitters. A harmonic is a copy of the fundamental signal appearing at whole number multiples of the original frequency. For example, a transmitter operating at f = 450 MHz can produce harmonics at 2x f = 900 MHz, 3x f = 1350 MHz, etc.

Although the level of harmonics normally decreases as the frequency increases, many narrowband interferers turn out to be harmonics of signals operating at lower frequencies.

A good rule is to always check whether a narrowband interferer is a harmonic.

Since the fundamental signal is always significantly stronger than its harmonics, it is often easier to track down the fundamental itself.

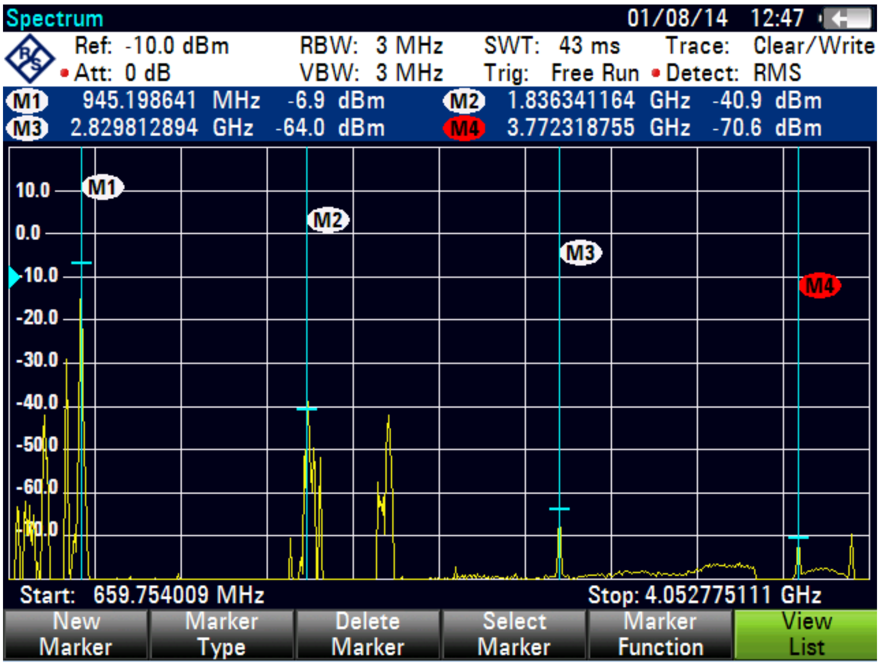

Fig. 32 Harmonics of fundamental frequency at 945 MHz with harmonics at 1.83 GHz, 2.82 GHz and 3.77 GHz.

Intermodulation is caused by two or more signals appearing in a nonlinear circuit. Sum and difference frequencies can be created from the mixing of fundamentals and harmonics, and these intermodulation products can occur at frequencies substantially removed from their component signals.

Interference due to intermodulation can appear when high-power transmitters share an antenna, feeder line or tower system. It is caused by the nonlinear behavior of corroded metals in RF joints.

Defective components such as old GSM base station antennas can cause intermodulation in the WCDMA UL, thus disturbing the cellular communications in the affected sector. This problem is usually solved by replacing the damaged GSM antenna.

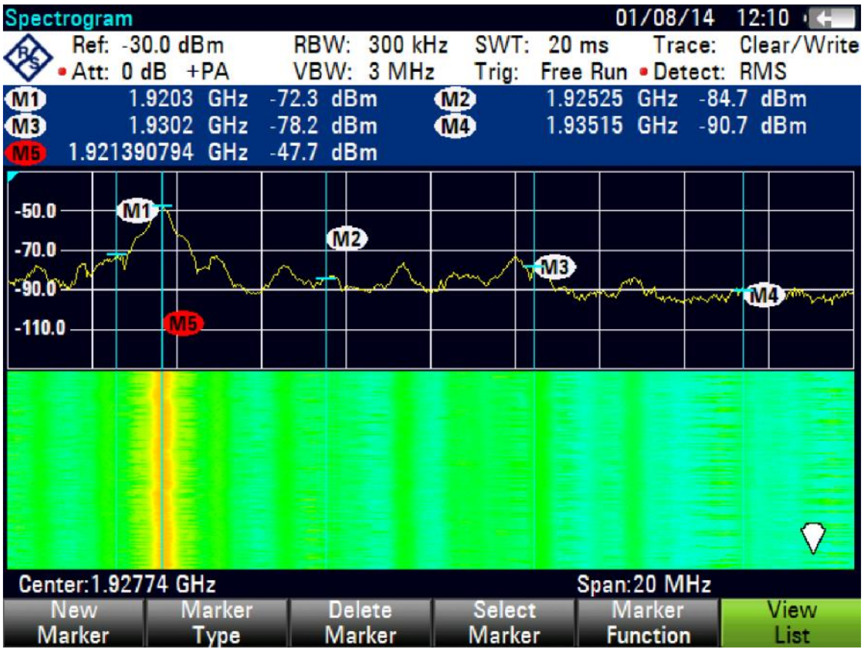

Fig. 33 Intermodulation product of a GSM900 mobile phone signal repeater interfering with the WCDMA uplink. M1 to M4 mark the WCDMA bands boundaries.

3.3 Bidirectional Amplifiers

Bidirectional amplifiers (BDA, also called cellphone repeaters or signal boosters) are devices used to extend cellular coverage within buildings or in other areas with poor reception. They operate by amplifying and retransmitting both downlink and uplink signals and are not a source of interference when properly installed and operated.

They most commonly cause interference when there is insufficient physical separation between the serving and donor antennas, leading to a feedback loop that substantially increases the noise floor over the entire uplink band (typically a range of 30 MHz to 40 MHz) or when the BDA is malfunctioning.

The presence of a small Yagi or directional antenna on a building roof, or of panel or dome type indoor antennas, is a good visual clue as to the presence of a bidirectional amplifier.

The BDAs are difficult to troubleshoot but a very common source of interference in the cellular bands.

Unlicensed use is illegal in many countries.

Fig. 34 Typical bidirectional amplifier installation.

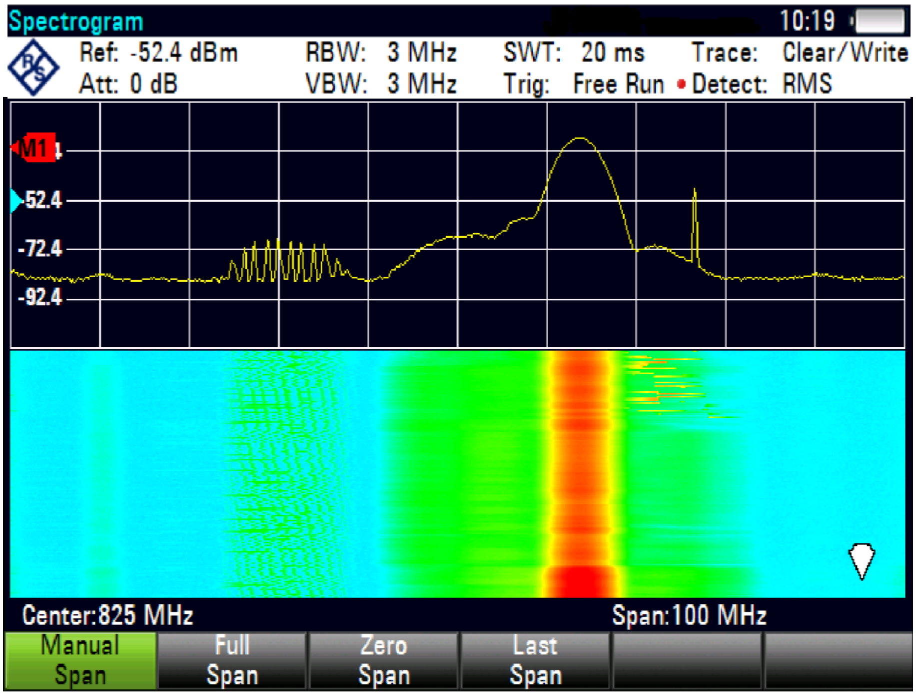

Fig. 35 Oscillating BDA signal in 800 MHz LTE band.

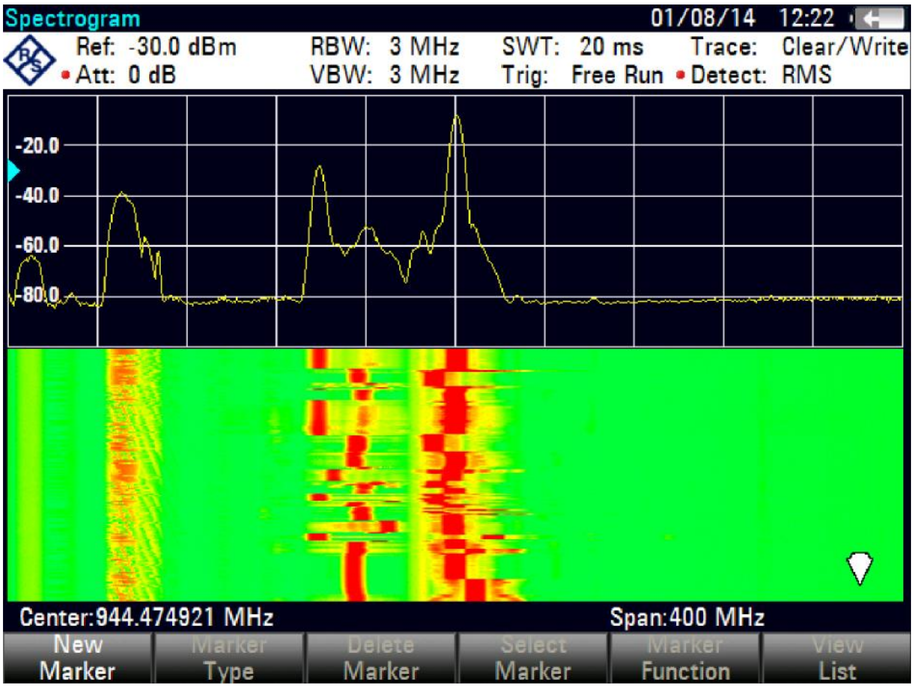

Fig. 36 GSM900 mobile phone signal repeater interference signal.

3.4 Cable Leakage

Cable egress or leakage occurs when the RF signals used in cable television systems escape from the shielded cables and devices that carry them. Since the frequencies used in cable television systems can extend up to 1 GHz, there is an overlap with many commercial, government and cellular services. The most common cause of egress is the presence of physical faults in the cable infrastructure such as cracked/damaged cables, faulty splices, unterminated connectors and loose amplifier and tap housings.

Fortunately, cable egress is very easy to diagnose due to its regular, continuous pattern of 6 MHz wide channels.

Cable egress is a very common interference source in countries such as the US, where cable TV providers use the same frequency band as LTE.

3.5 Unlicensed or Wrong Band Operation

This kind of interference is caused by the use of transmitters designed for use in countries with different frequency allocations, or it can also result from spectrum refarming.

Unlicensed transmitters operating around 1930 MHz, such as DECT telephones brought from overseas, can transmit with power up to 250 mW. If unlicensed DECT telephones are being used near a WCDMA base station, it may become impossible for a UE to increase its power above the noise floor to communicate with the base station, i.e. calls cannot be established and data services are not accessible in the cell coverage area.

Interference in the WCDMA UL caused by DECT phones operating in the wrong frequency band is a common interference source in Europe. Sections 2.1 and 2.2 show an example and explain how to detect and characterize this type of interference.

Some frequency bands previously used for other services have been refarmed for use with LTE or WCDMA. But there are still devices transmitting in bands that cause interference.

Wireless microphones are often used by clubs, organizations, schools, churches, etc., and most commonly transmit analog, narrowband FM signals. Problems can occur when these microphones operate outside of their allowed frequency ranges. Wireless microphone can also be very powerful transmitters for their size.

Audio demodulation is an excellent way of tracking down interference from wireless microphones and other narrowband interferers.

Fig. 37 FM modulated wireless microphone operating in the 800 MHz band. Marker Function menu.

3.6 Jammers and Deliberate Interference

There are also cases of deliberate interference.

Deliberate narrowband interference is usually unlicensed/pirate analog modulated voice signals transmitted in licensed bands. Sometimes these signals may be intermittent in nature, making it very difficult to locate the source. Recording the content of these transmissions is important if legal action needs to be taken.

Deliberate wideband interferers are known as jammers: devices designed to limit or deny the ability to use a certain frequency range by raising the noise floor to a high level (typically around –50 dBm in the affected area). Jammers generate a wide, strong, continuous signal and are therefore relatively easy to identify and locate.

Jammers are often designed to affect particular services (GPS, Wi-Fi, etc.) and/or frequency bands (850 MHz, 1900 MHz, etc.) but often create problems for services and frequencies well outside of their target range.

Jammers typically have one antenna per jamming band/technology. Battery-powered jammers are small but have a limited jamming radius (10 to 25 meters). More powerful jammers usually require AC power and tend to run hot (so you should look for devices with fans and/or large heat sinks). Jammers may also be placed at certain public places like cinemas, churches and mosques to prevent the use of mobile phones.

4 Appendix

4.1 LTE Frequency Bands

FDD LTE BANDS & FREQUENCIES						
LTE BAND NUMBER	UPLINK (MHZ)	DOWNLINK (MHZ)	WIDTH OF BAND (MHZ)	DUPLEX SPACING (MHZ)	BAND GAP (MHZ)	REGION
1	1920 - 1980	2110 - 2170	60	190	130	Africa, Asia
2	1850 - 1910	1930 - 1990	60	80	20	America
3	1710 - 1785	1805 -1880	75	95	20	Africa, America, Asia, Europe, Middle East, Oceania
4	1710 - 1755	2110 - 2155	45	400	355	America
5	824 - 849	869 - 894	25	45	20	Asia, Europe
6	830 - 840	875 - 885	10	35	25	
7	2500 - 2570	2620 - 2690	70	120	50	America, Asia, Europe, Middle East
8	880 - 915	925 - 960	35	45	10	Asia
9	1749.9 - 1784.9	1844.9 - 1879.9	35	95	60	Asia
10	1710 - 1770	2110 - 2170	60	400	340	
11	1427.9 - 1452.9	1475.9 - 1500.9	20	48	28	Asia
12	698 - 716	728 - 746	18	30	12	America, Oceania
13	777 - 787	746 - 756	10	**-31**	41	America
14	788 - 798	758 - 768	10	**-30**	40	
15	1900 - 1920	2600 - 2620	20	700	680	
16	2010 - 2025	2585 - 2600	15	575	560	
17	704 - 716	734 - 746	12	30	18	America
18	815 - 830	860 - 875	15	45	30	Asia
19	830 - 845	875 - 890	15	45	30	Asia
20	832 - 862	791 - 821	30	**-41**	71	Africa, Asia, Europe, Middle East
21	1447.9 - 1462.9	1495.5 - 1510.9	15	48	33	Asia
22	3410 - 3500	3510 - 3600	90	100	10	
23	2000 - 2020	2180 - 2200	20	180	160	
24	1625.5 - 1660.5	1525 - 1559	34	-101.5	135.5	
25	1850 - 1915	1930 - 1995	65	80	15	America, Oceania
26	814 - 849	859 - 894	30 / 40		10	America
27	807 - 824	852 - 869	17	45	28	
28	703 - 748	758 - 803	45	55	10	Asia
29	n/a	717 - 728	11			
30	2305 - 2315	2350 - 2360	10	45	35	
31	452.5 - 457.5	462.5 - 467.5	5	10	5	

TDD LTE BANDS & FREQUENCIES			
LTE BAND NUMBER	ALLOCATION (MHZ)	WIDTH OF BAND (MHZ)	REGION
33	1900 - 1920	20	
34	2010 - 2025	15	
35	1850 - 1910	60	
36	1930 - 1990	60	
37	1910 - 1930	20	
38	2570 - 2620	50	Africa, America, Europe, Middle East
39	1880 - 1920	40	
40	2300 - 2400	100	Africa, Asia, Europe, Middle East, Oceania
41	2496 - 2690	194	America, Asia
42	3400 - 3600	200	Europe, Middle East
43	3600 - 3800	200	
44	703 - 803	100	

Sources:

http://www.radio-electronics.com/info/cellulartelecomms/lte-long-term-evolution/lte-frequency-spectrum.php

http://en.wikipedia.org/wiki/List_of_LTE_networks#General_information

4.2 WCDMA/UMTS Frequency Bands

Operating band	Frequency band (MHz)	Common name	REGION
1	2100	IMT	Latin America, Europe, Asia, Africa, Oceania
2	1900	PCS A-F	North America, Latin America
3	1800	DCS	China
			Asia
4	1700	AWS A-F	North America, Latin America
5	850	CLR	North America, Latin America, Asia, Oceania
6	800		
7	2600	IMT-E	
8	900	E-GSM / U-900	Latin America, Europe, Asia, Africa, Oceania
9	1700		Japan
10	1700	EAWS A-G	
11	1500	LPDC	Japan
12	700	LSMH A/B/C	USA, Canada
13	700	USMH C	USA, Canada
14	700	USMH D	USA, Canada
17	700	LSMH B/C	USA, Canada
19	800		Japan
20	800	EUDD	
21	1500	UPDC	
22	3500		
25	1900	EPCS A-G	USA
26	850	ECLR	USA

Source: http://en.wikipedia.org/wiki/UMTS_frequency_bands

4.3 GSM Frequency Bands

System	Band	Uplink (MHz)	Dow nlink (MHz)	Channel number	Equivalent UMTS/LTE band	Region
T-GSM-380	380	380.2–389.8	390.2–399.8	dynamic		
T-GSM-410	410	410.2–419.8	420.2–429.8	dynamic		
GSM-450	450	450.6–457.6	460.6–467.6	259–293	31	
GSM-480	480	479.0–486.0	489.0–496.0	306–340		
GSM-710	710	698.2–716.2	728.2–746.2	dynamic	12	
GSM-750	750	747.2–762.2	777.2–792.2	438–511		
T-GSM-810	810	806.2–821.2	851.2–866.2	dynamic	27	
GSM-850	850	824.2–849.2	869.2–894.2	128–251	5	North America, Latin America
P-GSM-900	900	890.0–915.0	935.0–960.0	1–124		Europe, Middle East, Africa, Australia, Oceania Asia, some countries in Latin America
E-GSM-900	900	880.0–915.0	925.0–960.0	975–1023, 0-124	8	
R-GSM-900	900	876.0–915.0	921.0–960.0	955–1023, 0-124		
T-GSM-900	900	870.4–876.0	915.4–921.0	dynamic		
DCS-1800	1800	1,710.2–1,784.8	1,805.2–1,879.8	512–885	3	
PCS-1900	1900	1,850.2–1,909.8	1,930.2–1,989.8	512–810	2	North America, Latin America

Source: http://en.wikipedia.org/wiki/GSM_frequency_bands#GSM_frequency_usage_around_the_world

5 References

[1] R&S®FSH4/8/13/20 Operating Manual

[2] Rohde & Schwarz white paper: An Introduction to Interference Hunting, by Paul Denisowski

[3] R&S®PR100 Locating a Signal Source. Application brochure

[4] R&S®OSM Wizard User Manual

[5] DECT Technology

http://en.wikipedia.org/wiki/Digital_Enhanced_Cordless_Telecommunications

http://de.wikipedia.org/wiki/Digital_Enhanced_Cordless_Telecommunications

6 Ordering Information

Designation	Type	Order No.
Handheld Spectrum Analyzer, 9 kHz to 3.6 GHz, with preamplifier	R&S®FSH4	1309.6000.04
Handheld Spectrum Analyzer , 9 kHz to 8 GHz, with preamplifier	R&S®FSH8	1309.6000.08
Handheld Spectrum Analyzer, 9 kHz to 13.6 GHz, with preamplifier	R&S®FSH13	1314.2000.13
Handheld Spectrum Analyzer, 9 kHz to 20 GHz, with preamplifier	R&S®FSH20	1314.2000.20
Spectrogram Measurement Application	R&S®FSH-K14	1304.5770.02
Interference Analysis Measurement Application (software license)	R&S®FSH-K15	1309.7488.02
Geotagging Measurement Application (software license)	R&S®FSH-K16	1309.7494.02
Handheld Log-Periodic Antenna, 450 MHz to 8 GHz	R&S®HL300	4097.3005.02
Active Directional Antenna, 20 MHz to 7.5 GHz, with mechanical compass	R&S®HE300	4067.5900.02
Active Directional Antenna, 20 MHz to 7.5 GHz, with GPS and electronic compass	R&S®HE300	4067.5900.03
Loop Antenna for R&S®HE300, 9 kHz to 20 MHz	R&S®HE300-HF	4067.6806.02
GSM/UMTS/CDMA Antenna, with magnetic mount 850/900/1800/1900/2100 band, N connector	R&S®TS95A16	1118.6943.16
GPS Receiver	R&S®HA-Z240	1309.6700.03
Carrying Holster, including chest harness and rain cover	R&S®HA-Z222	1309.6198.00
12 V Car Adapter	R&S®HA-Z202	1309.6117.00

About Rohde & Schwarz

Rohde & Schwarz is an independent group of companies specializing in electronics. It is a leading supplier of solutions in the fields of test and measurement, broadcasting, radiomonitoring and radiolocation, as well as secure communications. Established more than 80 years ago, Rohde & Schwarz has a global presence and a dedicated service network in over 70 countries. Company headquarters are in Munich, Germany.

Regional contact

Europe, Africa, Middle East
+49 89 4129 12345
customersupport@rohde-schwarz.com

North America
1-888-TEST-RSA (1-888-837-8772)
customer.support@rsa.rohde-schwarz.com

Latin America
+1-410-910-7988
customersupport.la@rohde-schwarz.com

Asia/Pacific
+65 65 13 04 88
customersupport.asia@rohde-schwarz.com

China
+86-800-810-8228 /+86-400-650-5896
customersupport.china@rohde-schwarz.com

Environmental commitment

- Energy-efficient products
- Continuous improvement in environmental sustainability
- ISO 14001-certified environmental management system

Certified Quality System
ISO 9001

This application note and the supplied programs may only be used subject to the conditions of use set forth in the download area of the Rohde & Schwarz website.

Rohde & Schwarz GmbH & Co. KG
Mühldorfstraße 15 | D - 81671 München
Phone + 49 89 4129 - 0 | Fax + 49 89 4129 – 13777

www.rohde-schwarz.com

PAD-T-M: 3573.7380.02/02.01/EN/