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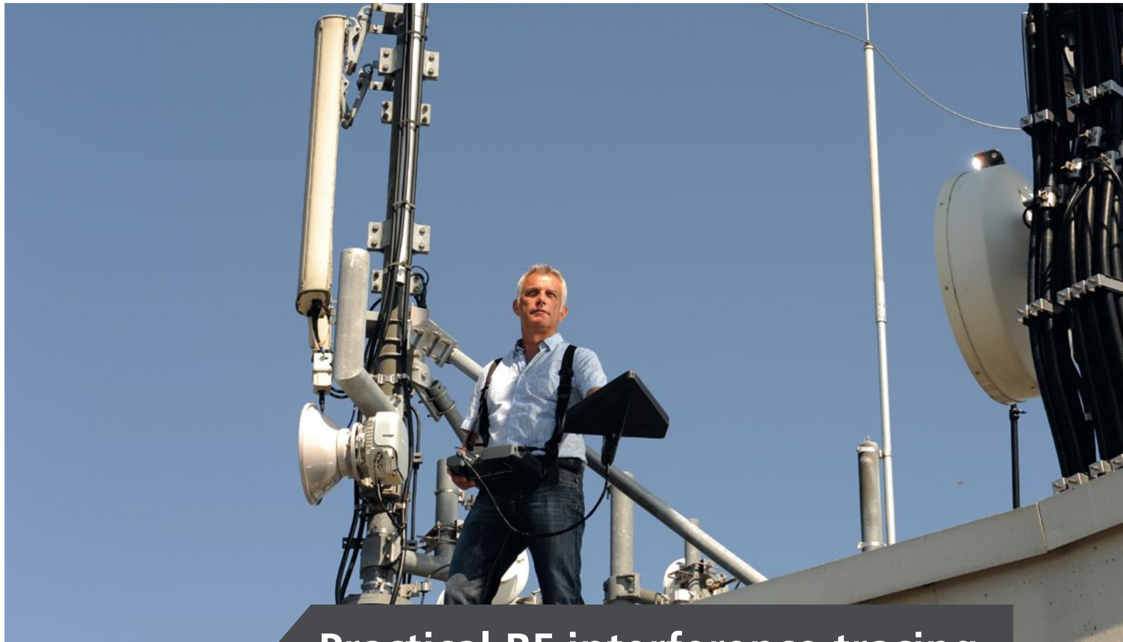

Practical RF interference tracing

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Practical interference tracing

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Dear Reader:

Studies undertaken by telecommunications authorities have shown that there may be several thousand widely differing potential sources of interference within the range of a wireless receiver. The interference can get into the receiver "through the air", down the power supply line, over the casing or through other "loopholes", and cause problems. Countless combinations of useful signal and interference are therefore possible, which would be beyond the scope of much larger studies to deal with, let alone this publication.

This guide therefore makes no claim to be complete; rather, it is oriented towards practical measurements. Some of the explanations of basic relationships also include measurement tips, indicated by blue triangles. These are mainly based on the features of the Interference and Direction Analyzer IDA from Narda Safety Test Solutions, which is also used for the practical measurement examples. This information applies in a similar way to most measuring receivers and spectrum analyzers.

The measurement examples are taken from everyday situations. The useful signals free of interference are always shown as they appear in real life. The representations shown can therefore be compared with your own measurements. Some typical interference is also shown. This was sometimes introduced by feeding it in through a T-piece in the antenna lead to make it reproducible and to avoid causing interference in the surroundings.

"Practical interference tracing" builds on information in the "Pocket glossary of interference localization". We have chosen a larger format to make it easier for you to see the details in the many screenshots. We wish you every success in your efforts to track down interference.

Your Team at Narda Test Solutions

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1 Useful signals and noise

Every useful signal can also be seen as interference, depending on the situation. The "useful" signal in each case is the one that needs to be preserved from unacceptable degradation by an "interference" signal (for acceptable interference, see [1]). Examples:

- A neighboring cellular phone station generates frequent, short humming in a loudspeaker.
- TV picture is distorted when a bus passes by outside.
- Aircraft radio traffic interferes with a radio set in a house beneath the airport approach flight path.

1.1 Conditions leading to interference

Interference signals do not always cause interference. The interference only occurs when certain conditions occur together.

1.1.1 Frequency

The frequencies of the useful signal and the interference must be such that interference can occur. Here's a list of some of the conditions that cause interference:

- Interference frequency is in the useful frequency band
- Interference frequency is an image frequency of the useful frequency band
- Interference frequency is a harmonic or spurious emission of a transmission with a distant fundamental frequency
- Interference is generated in the receiver itself by intermodulation caused by overmodulation
- Interference frequency is generated by intermodulation close to the receiving antenna
- Interference frequency is not in the useful frequency band but is in the pass band of the affected receiver

▶ Take time to think through all the possibilities.

1.1.2 Amplitude

The interference emission must be strong enough at the receiving location to affect the useful signal. Example:

- An oscillating antenna amplifier generates very strong signals at roof level, but very little can be measured at street level.

▶ You may need to determine the effects of several weak signals before you can identify the one causing the interference.

1.1.3 Signal to noise ratio

Only useful signals with so-called useful field strengths (as defined by ITU and others) can reasonably be protected. Reception is free of interference only when the useful signal has a certain amplitude above the interference or noise signal.

This necessary signal to noise ratio (S/N) was easy to determine for AM and FM signals, but in this digital age, the required ratio is more complex as it depends on the combination of convergent modulation types.

▶ The following S/N ratios can be used for an initial estimation of how relevant a signal is in causing interference: AM 40 dB, FM 30 dB, digital to digital 20 dB (RMS).

1.1.4 Time correlation

In analog radio services, the cause and effect occur simultaneously. This is not necessarily the case with digital services. Error correction and data processing can cause effects to be masked or delayed in time.

▶ The effects can be time-correlated and analyzed from the display of I/Q data: There are no retention times, so cause and effect can be recognized immediately.

1.1.5 Location

In particular, low frequency interference can be carried over long distances and then leapfrog e.g. from the power supply network to the antenna, right at the last meter. The important thing is its presence at the point of reception.

▶ Trace weak interference back from the point of reception.

1.2 Separating useful signals from noise

Separating the useful signal from noise and interference becomes more difficult the more complex the modulation processes and the dynamic frequency assignments are. Nevertheless, some rules can be derived.

Correlated signals emanate from the same source. If the measurement bandwidth is less than the signal bandwidth, the measured level will increase by 6 dB if you double the measurement bandwidth. Noise is not correlated, so its measured level increases by only 3 dB when you double the measurement bandwidth.

▶ Play around with the resolution bandwidth until you can see a correlated signal beneath the noise.

▶ Most digital signals resemble noise, so the measured level of such signals will only change by 3 dB if you double the measurement bandwidth.

2 Device settings

2.1 Bandwidth

There is a difference between the channel bandwidth (CBW), which the receiver uses to capture a section of the frequency spectrum, and the resolution bandwidth (RBW), which the measuring receiver uses to resolve the spectrum within the channel bandwidth.

CBW, channel bandwidth. The channel filters are usually raised cosine filters with steep cosine-shaped edges that give a high degree of channel separation, at the expense of relatively long settling times and possible resultant flattening of the rising edges in the time domain.

RBW, resolution bandwidth. Gaussian filters are usually used for resolving the signal within the spectrum. These have fast response times but less steep slopes. Measurement of brief events is therefore more precise, but crosstalk from neighboring frequencies – spurious reception – is greater.

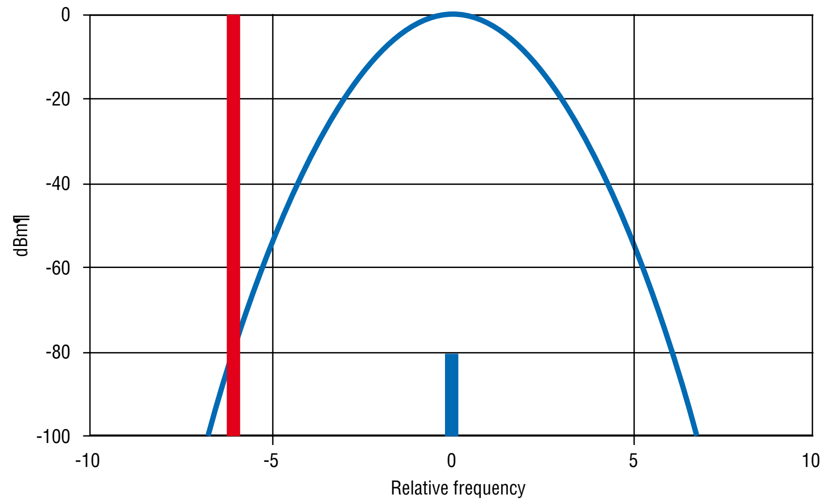

Figure 1: Example of spurious reception

Figure 1 shows how spurious reception occurs. The blue carrier signal has a level of -80 dBm. It passes through the filter unchanged. The red carrier signal has a level of 0 dBm. It is attenuated by 80 dB by the filter, so it gives the same readout as the blue signal.

- Shifting the filter to the right by one unit reduces the measured level of the blue carrier by 3 dB, and that of the red carried by 20 dB. This is a useful trick to reduce spurious reception, and works particularly well with steep channel filters.

Rules:

- RBW filters are good for rapid, accurate level analysis.
- CBW filters are better for tracking / direction finding when clear separation from adjacent frequencies is needed.
- A narrower bandwidth reduces noise but the level of continuous signals stays the same.
- A wide bandwidth can show up impulses swamped by noise.

2.2 Detector and Trace

2.2.1 Detector

The detector combines the many measured values obtained during the measurement time into a single, representative value. It can therefore help to better separate the useful signal from the interference for measurement purposes in conjunction with the bandwidth. When averaging is applied, the averaging time has an additional effect.

PEAK displays the highest value reached. Reacts to every impulse, regularly covers weaker signals.

AVG displays the arithmetic mean of the measured values (voltage average). Considerably reduces the display of impulses so that signals of longer duration are shown more clearly.

RMS displays the square root of the sum of the squares of the measured values (power average). Digital transmissions generally correspond to narrow band noise and are configured for constant power levels, so they show as constant values if the RMS detector is used. Has similar properties to the AVG detector for impulses.

QP (quasi-peak) is a special detector for weighted measurement of impulse interference as given in CISPR16 [2]. This is useful if all the CISPR conditions (bandwidth, display time constant, overmodulation resistance, etc.) are fulfilled.

The rule: “What PEAK doesn’t show can’t be in QP” is frequently useful in practice but often cannot be used for authoritative statements of limit values.

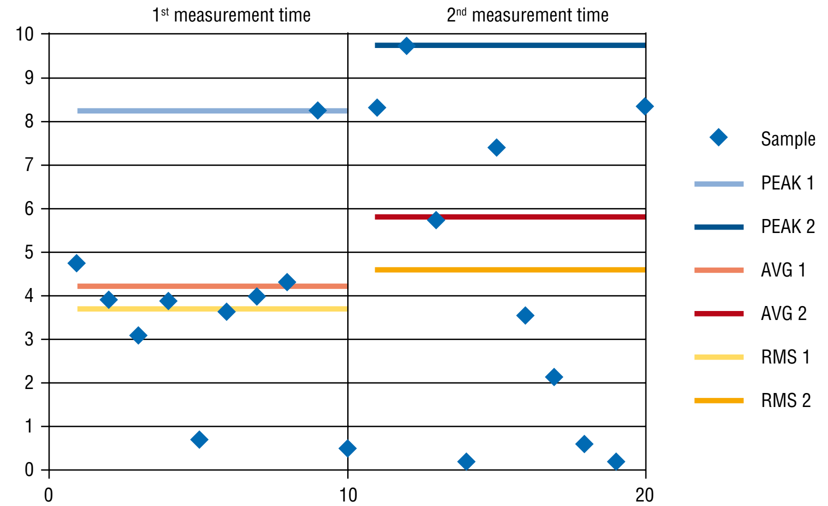

Figure 2: Examples of measured values, each formed from 10 samples

Rules:

- PEAK emphasizes narrow pulses
- RMS treats noise and digital signals in the same way.
- QP is not higher than PEAK.

2.2.2 Trace

The Trace is the moving line written on the display. The Trace function determines how the next display will be built up after each sweep.

The trace is the pixel by pixel combination of several sweeps.

Actual (CLRW, Clear/Write) writes a new curve for each sweep.

MaxHold writes the highest value pixel in each case and retains it.

MinHold writes the lowest value pixel in each case and retains it.

AVG according to CISPR 16 [2] is a pixel by pixel voltage average over a selectable number of sweeps.

Avg (IDA) is a pixel by pixel power average over a selectable number of sweeps.

- Trace functions can be very useful for analysis but always carry the risk that signals may be hidden.

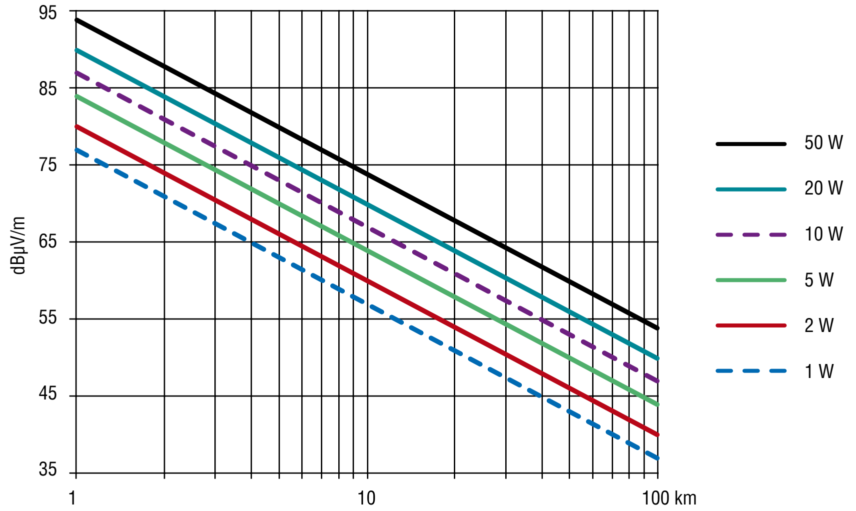

Figure 3: Free space propagation

This diagram can be used primarily for comparisons:

- Absolute field strength at the same location. Example: A transmitter with 1 W output power produces a field strength of 57 dBµV/m at a distance of 10 km, a 10 W transmitter will produce 67 dBµV/m.
- ▶ Estimate: What is the field strength that a transmitter can reasonably produce at a given distance?
- Change in field strength as you approach the transmitter. Example: A 10 W transmitter produces a field strength of 67 dBµV/m at a distance of 10 km, this rises to 87 dBµV/m at a distance of 1 km.
- ▶ If the field strength changes by 20 dB when you move closer to the transmitter, you have covered 90% of the distance to the transmitter from where you were, assuming free space conditions apply.

You can expect considerable deviation from these rules in actual terrain due to shadowing, reflections and changes in polarization, so they can only be used as a rough guide.

3.2 Propagation in actual terrain

ITU R has provided helpful information in documents such as Recommendation P.370-7 [4]. These describe the field strength value using statistical methods for probability of location and time at a certain distance, namely for a useful field strength at 50% of locations with a probability of 50% (Figure 4). No absolute values but some guidelines can be derived from this in the case of a single emission.

The range of an emission is reduced by the following effects (in approximate order of lowest to highest influence):

- Large distance
- Losses caused by different polarization of the signal and the receiving antenna. Every reflection can rotate the polarization. Losses of up to 20 dB are common (ITU-R Report 1008-1 [6])
- Emissions in a built up area
- Emissions in a forest or jungle. Losses of up to 1 dB/10 m (see next section)
- Reflections and the signal can attenuate each other by up to 40 dB. he effect occurs in urban canyons and tunnels. Example: 10 W of transmitted power “disappears” after 800 meters in a tunnel.

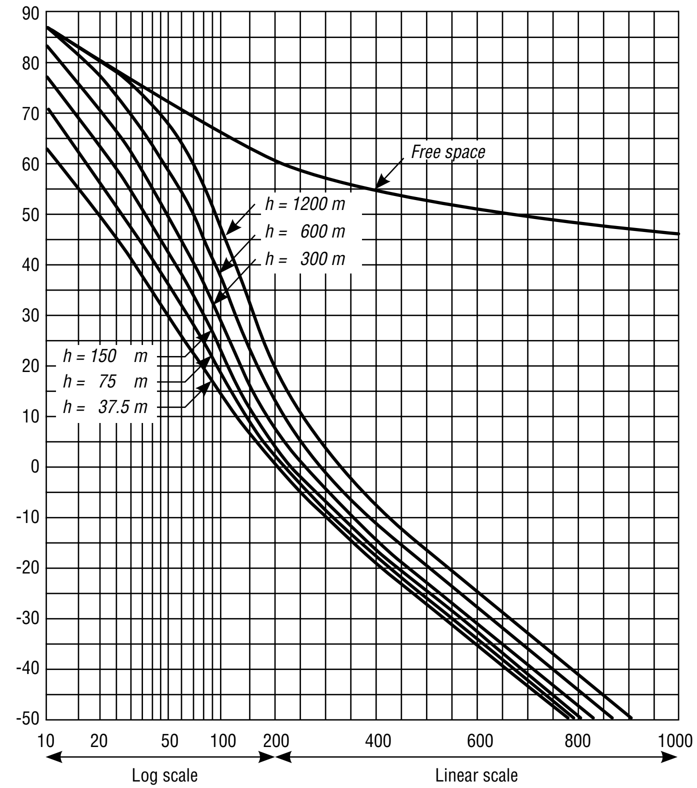

Figure 4: Field strengths for 1 kW radiated power (ERP) as a function of the height of the transmitting antenna h; receiving antenna height = 10 m; unevenness in terrain = 50 m; frequency range 30–250 MHz. Source: ITU-R Recommendation P.370-7 [4]