Convenient manual solutions for tricky measurement tasks

Despite the availability of software for fully automatic EMI measurements, manual EMI measurements still have a place in test laboratories when it comes to handling tricky measurement tasks. State-of-the-art EMI test receivers offer special functions for this purpose – and help to reduce measurement time.

Valuable functions in state-of-the-art test receivers

There are quite a number of tools that support you in handling tricky manual EMI measurement tasks. The following three functions have proved to be particularly helpful and effective:

IF (spectrum) analysis – an efficient tool

The purpose of IF analysis is to provide a continuous spectral display of the RF input signal around the receiver frequency over a definable range. Ideally, this display is shown at the same time as the numeric measurement at the current receive frequency (FIG 1).

Because the center frequency of the spectrum always corresponds to this receive frequency, the test receiver can be tuned to the signal to be analyzed very reliably and – most importantly – very quickly. In addition, the user has a very accurate overview of the spectrum occupancy around the measurement channel and, with a sufficiently large IF bandwidth, of the spectral distribution of a modulated signal in the measurement channel. Receive signals can thus be classified quickly as either disturbance or useful signals, regardless of whether they are CW signals that appear as unmodulated carrier signals or impulsive disturbance appearing as narrow lines across the screen.

In addition, by adding parallel audio demodulation for AM or FM, identifying the measured signals becomes even easier; for example, ambient disturbance signals can be detected and excluded during open-area tests.

State-of-the-art test receivers can display traces together with various weighting information, such as Max Hold, Min Hold, or Average Value (AVG). By using this feature on traces from the IF analysis, the user has additional options for characterizing the input signal:

With modulated signals, the spectrum is gradually filled within the Max Hold display until all occurring spectral maxima have been reached. Pulse-like signals also fill the Max Hold display until the complete spectrum is displayed and the worst-case level can be reliably determined. In contrast, pulse-like signals are suppressed by the Min Hold display, while sinewave signals are shown unchanged. The combination of the Max Hold and Min Hold displays allows you to easily identify CW interferers with very low levels within a TV signal, for example.

Another helpful feature is the analysis of the displayed trace(s) using numerous marker functions, e.g. for quickly and accurately determining frequencies and relative levels on the trace. Also of note is the "Center = Marker Frequency" function: At a keystroke, the receiver frequency can be set such that the signal to be measured is situated exactly at the center frequency (FIG 1).

In addition to the numeric display, the measured values weighted by the various CISPR detectors are also visualized in a bargraph. This allows you to quickly recognize the effects that technical modifications have on the device under test. Even when the receiver frequency is changed, the bargraph will follow the signal without interruption, making it easier to search for the highest signal level. The highest level value and the associated frequency are also registered and displayed by the receiver. The "Add to Peak List" button sends this frequency to a separate frequency list and stores it for subsequent final measurement.

FIG 1 R&S®ESU EMI test receiver, (split-screen display) in the IF analysis mode.
***Top*: numeric display of receiver frequency and level for max. three different detectors including Max Hold display for level and frequency as well as parallel, quasi-analog bargraph (RBW 120 kHz; measurement time 1 s). *Bottom*: spectrum around the receiver frequency (RBW 10 kHz; span 1 MHz). Trace 1 (yellow): ClearWrite; trace 2 (blue): Max Hold with marker peak measurement. Second menu bar at right: optional marker functions for trace analysis.**

IF analysis is thus a very useful tool for precisely tuning the test receiver frequency as well as for rapidly identifying signals and analyzing their surrounding spectrum.

Drifting disturbance signals – immediate and correct weighting with "Threshold Scan"

Regardless of whether disturbance voltage, disturbance power, or disturbance field strength is being measured, the time needed is considerable. To reduce this problem, EMI test receivers have for many years used special measurement routines that minimize the time required for the measurement. For many years, one of the methods practiced in the EMC world has been to perform preview measurements with a peak detector, determine the frequencies with significant disturbance, and then perform a standard-conforming final measurement on a limited number of frequency points. However, this method is limited if the disturbance signals are unstable and drift in frequency. Because the final measurement is not always performed immediately after the preview measurement when the above method is used, the critical disturbance frequency determined during the preview measurement sometimes shifts so much by the time the final measurement is run that the maximum noise level can no longer be measured correctly.

In these cases, a modified procedure, the "Threshold Scan" [1], is used. Here, too, preview measurement and final measurement are separate measurements thus helping to save time. However, the measurement is different in that when a definable limit value is exceeded, the preview measurement is stopped immediately and the final measurement is performed with standard-conforming receiver settings (FIG 2). The preview measurement is then continued with the next frequency step. As soon as the limit value is exceeded again, the next final measurement is performed.

This process has a distinct advantage: The final measurement, which might include a quasi-peak weighting, always immediately follows the preview measurement. This minimizes measurement errors caused by frequency drift of the interferers. At the same time, the receiver stores the final measurement values in a separate table (Peak List) for later analysis and documentation.

Time-domain analysis – oscilloscope function for test receiver

The measurement sequence described above – consisting of preview measurement, data reduction, and final measurement – of course helps to reduce the overall measurement time. However, preview measurements for radiated disturbance measurements can take several hours. The decisive parameter here is the measurement time per frequency step. For example, to accurately detect impulsive disturbance signals, the duration must at least equal the reciprocal value of its pulse repetition frequency (PRF). For an impulsive disturbance signal of 100 Hz PRF, a measurement time of at least 10 ms is required.

This is where some EMI test receivers can help: You can perform a scan on the defined receive frequency in the time domain, similar to the zero span of the spectrum analyzer.

This time-domain analysis measures disturbance over time – comparable to an oscilloscope. For example, you can determine the pulse rate of a disturbance signal with broadband characteristic so as to set the measurement time optimally; that is, as short as possible but also as

FIG 2 R&S®ESPI test receiver: screen display in the "Threshold Scan" mode after detection of a drifting disturbance signal with broadband characteristic. Quasi-peak limit line in accordance with EN 55022. The number of final measurements in the 150 kHz to 1 MHz range was limited to twelve measured values, and each disturbance signal was accurately determined.

long as necessary. You can also determine whether and how strongly a disturbance signal with a narrowband characteristic is fluctuating, as well as whether it is amplitude-modulated or pulsed.

A special application is click rate analysis [2]: Thermostatic or program-controlled electrical devices, such as washing machines and air conditioners, generate discontinuous disturbances. Because of their aperiodic timing, these click disturbances have higher limit values than continuous interferers. CISPR 14 or EN 55014 contain disturbance voltage limit values with click rate weighting [3]. To use these higher limit values, the duration of the clicks, their repetition rate (click rate), and their levels must be measured in order to determine the limit values that must be met (FIG 3).

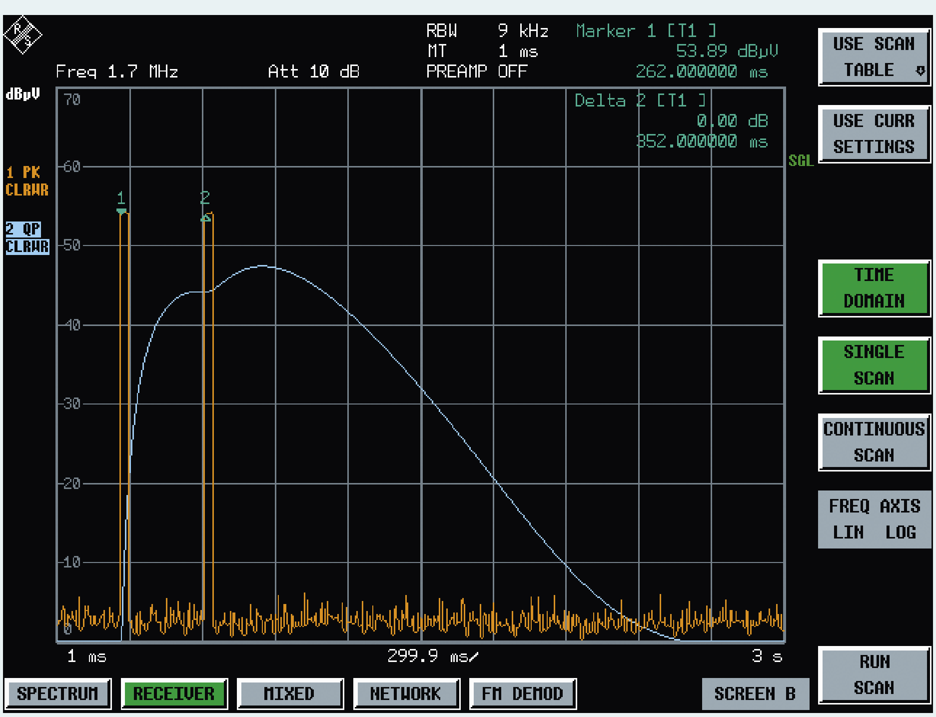
Clicks are typically measured with special click rate analyzers. Alternatively, however, a time-domain analysis integrated into the test receiver can consecutively determine the pulse height and duration of each of the frequencies specified by the standard, thus replacing the functionality of the expensive click rate analyzer. In this case, the test receiver must fulfill the requirements of CISPR 16-1-1 with respect to the accuracy of the pulse duration measurement for pulse durations of 10 ms and greater. In addition, the result memory must be large enough to record the peak value and quasi-peak value for at least two hours without gaps. But state-of-the-art EMI test receivers with a memory capacity of up to two million values per trace are capable of doing this.

Summary

Additional functions of state-of-the-art EMI test receivers such as IF analysis, threshold scan, and time-domain analysis make tricky measurement tasks much easier to perform. Thus, an investment in such state-of-the-art receiver technology is definitely worthwhile.

Karl-Heinz Weidner

FIG 3 R&S®ESCI EMI test receiver: screen display in time-domain analysis mode (measurement frequency 1.7 MHz; resolution bandwidth 9 kHz; measurement time 1 ms; monitoring time 3 s): two click disturbances at an interval of about 350 ms, display of peak value (orange) and quasi-peak value (blue).



More information on comprehensive range of EMC test equipment at www.rohde-schwarz.com (search term: type designation)

REFERENCES

[1] R&S®ESPI Precompliance Test Receiver: Improved, patented EMC test method for drifting interference signals. News from Rohde & Schwarz (2004) No. 181, pp 42–43

[2] R&S®ESCI EMI Test Receiver: Click rate analysis in accordance with CISPR 14. News from Rohde & Schwarz (2005) No. 185, pp 32–33

[3] EN 55014, Electromagnetic compatibility – Requirements for household appliances, electric tools and similar apparatus; Part 1: Emission