

Analysis of VOR and ILS signals – reliable and highly accurate

The new R&S®FS-K15 measurement demodulator adds the analysis of VOR and ILS signals to the comprehensive facilities of the Rohde & Schwarz R&S®FSMR, R&S®FSU and R&S®FSQ analyzers.

A full range for VOR/ILS

VOR (VHF omnidirectional range) and ILS (instrument landing system) are aircraft navigation aids based on analog modulation, and are in use worldwide. ILS, in particular, is without competition. Because ILS supports the particularly critical landing approach, the requirements for precision, reliability and trustworthiness are extremely high. This applies to both the ground equipment and the on-board equipment.

The R&S®FS-K15 option completes the Rohde & Schwarz portfolio of special measuring equipment for VOR/ILS by adding instruments for use in the calibration laboratory and in development. The R&S®SMA signal generator with the R&S®SMA-K25 option for receiver testing, and the portable R&S®EVS300 ILS/VOR analyzer, the “specialist” for measuring the radio fields on the airstrip and for application in inspection aircraft, are both already in wide use [1], [2].

The R&S®FSMR, together with the new R&S®FS-K15 option, makes a calibration measuring receiver available for the first time. It allows complete and highly precise calibration of the transmission signals from nav/com testers used to test on-board equipment. In addition to the special VOR/ILS signals, it also calibrates general amplitude, frequency or phase-modulated signals and measures the output level of generators with extremely high accuracy. Its accuracy is in fact so good that even signal generators such as the R&S®SMA, which is used together with the R&S®SMA-K25 option as a highly accurate signal source for tests on radionavigation receivers, can be tested.

In the R&S®FSU and R&S®FSQ spectrum and signal analyzers, the R&S®FS-K15 option offers the perfect analysis tools for development, verification or regular maintenance checks of ILS transmitters. It provides the same range of functions and the same accuracy as the R&S®FMAV VOR/ILS modulation analyzer, used as a reference in many laboratories. Its operation is particularly easy. The user only has to enter the frequency and the level, and to choose whether a VOR signal or an ILS signal is to be measured. After having measured all the relevant parameters, the option displays them in a clear table. The important parameter for the system concerned is



FIG 1 Example of the analysis of a VOR signal.

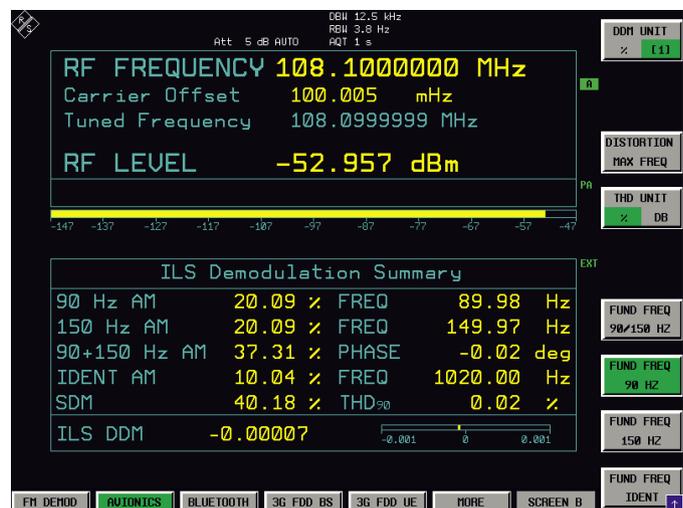


FIG 2 Example of the analysis of an ILS signal. The display is stable and accurate even at a signal level of -50 dBm. -50 dBm is a typical signal level used for testing aeronautical radio receivers; signal generators for receiver tests must therefore be calibrated even at this low level.

emphasized – for ILS this is the difference in depth of modulation (DDM), the measure of the deviation from the ideal landing path, while for VOR it is the phase. This parameter is also visually displayed by a bargraph (FIGs 1 and 2).

As in the R&S®FMAV, analysis with the R&S®FS-K15 is based on the purely digital processing of a digitized IF signal. The non-linearities, frequency responses and phase errors of analog demodulators and audio filters are absent. The measurement uncertainty only results from the linearity of the A/D converter and the influences of the IF selection. The demodulation bandwidth is 8 MHz for the R&S®FSMR and R&S®FSU, while it is 28 MHz for the R&S®FSQ; this bandwidth is considerably larger than the modulation frequency range of the VOR and ILS signals, so that their effect can be neglected.

The influence of the A/D converter and of the IF selection filters are already tested in the base unit by means of other parameters. Nevertheless, all the measurement parameters for VOR and ILS are separately calibrated once again. The R&S®FS-K15 option thus excellently satisfies the requirements for accuracy, reliability and trustworthiness placed on ILS and VOR measurements. The VOR/ILS analysis is performed in the entire frequency range of the particular base unit used. In the case of the R&S®FSMR and R&S®FSQ with the baseband input option (R&S®FSQ-B71) it is also carried out directly on a modulation signal.

Summary

The R&S®FS-K15 option in the R&S®FSMR enables calibration laboratories for the first time to calibrate all the relevant parameters of VOR/ILS generators using a single instrument. In the R&S®FSU and R&S®FSQ, the option expands the already versatile range of applications of these analyzers, combining extremely accurate analog modulation measurements with universal facilities for analyzing digitally modulated signals. The importance of such signals is also set to grow in the aeronautical radio field.

Herbert Schmitt

References

- [1] R&S®EVS300 ILS/VOR Analyzer: The specialist for terrestrial radionavigation analysis. News from Rohde & Schwarz (2005) No. 188, pp. 32–35.
- [2] R&S®EVS300 ILS/VOR Analyzer: High-precision level and modulation analysis of ILS and VOR signals. News from Rohde & Schwarz (2007) No. 194, pp. 30–33.

ILS measurement parameters

- DDM (difference in depth of modulation), the difference in the modulation depth of the 90 Hz and the 150 Hz signals
- SDM (sum of depth of modulation), the arithmetic sum of the modulation depths of the 90 Hz and the 150 Hz signals
- Total depth of modulation
- Modulation depth of the 90 Hz signal, the 150 Hz signal, and of the identifier signal
- Phase between the 90 Hz and 150 Hz signals
- THD, selectable for a fundamental frequency of 90 Hz, 150 Hz, for both, or for the identifier signal
- Display of the modulation spectrum for the separate analysis of distortion products (FIG 3)

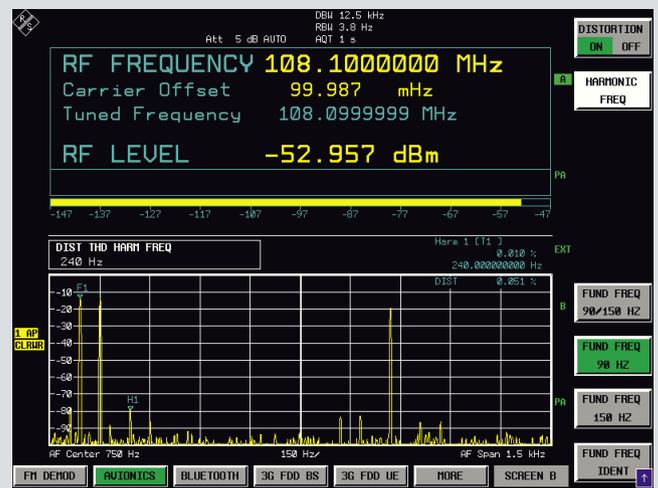


FIG 3 Distortion analysis of an ILS signal. The sum signal derived from 90 Hz and 150 Hz is at 240 Hz, and produces a total harmonic distortion of 0.5 %.

VOR measurement parameters

- VOR phase
- Modulation depth and modulation frequency of the 30 Hz signal, the 9.96 kHz subcarrier, and of the identifier signal
- Deviation and modulation frequency of the 9.96 kHz auxiliary carrier
- THD (total harmonic distortion), selective for the 30 Hz fundamental frequency and for the identifier signal

Condensed data of the R&S®FS-K15

Frequency range	107 MHz to 120 MHz and 319 MHz to 341 MHz specified, usable in the frequency range of the base unit
Level range	-60 dBm to +30 dBm
DDM measurement range	0 to 0.4 DDM
DDM measurement uncertainty	0.0002 DDM + 1 % of measured value
VOR phase	0 to 360°, resolution of 0.1°
VOR phase measurement uncertainty	0.003°