R&S®EMC32-S EMC Measurement Software

Immunity measurements in reverberation chambers

New options expand the R&S®EMC32-S EMC measurement software for immunity measurements in reverberation chambers in accordance with EN61000-4-21 as well as for manufacturer-specific measurement methods (GMW3097 and Ford).

Alternative to anechoic chambers

During conformance tests, electronic devices and systems (e.g. vehicles) are exposed to electromagnetic interference fields. These immunity measurements are normally made in an anechoic chamber above 80 MHz (radiated). For a complete test, the EUT has to be radiated from different sides and also with horizontally and vertically polarized signals.

Since investments in an anechoic chamber infrastructure are high and the measurements to be performed are complex, alternative test methods are in demand throughout the world. One alternative, quite common particularly in the USA but also in Europe, is the reverberation chamber which is mainly used in military applications. For a description of how the reverberation chamber operates and the associated measurements, see the generic standard EN61000-4-21. The manufacturer-specific standards GMW3097 and Ford ES-XW7T-1A278-AC for measurements in the automotive field are related to this generic standard. Reverberation chambers are also approved for military EMS measurements in accordance with the MIL-STD-461E and RTCA DO 160D standards.

How reverberation chambers work

A reverberation chamber principally operates like a cavity resonator into which RF energy is injected. The modes (cavity resonances) excited in the resonator form the electromagnetic field to which the EUT is subjected. To generate a statistically uniform and isotropic electrical field, a unit referred to as a tuner (stirrer) is used which turns and thus changes the mode distribution in the chamber. The advantage of this mode modification is that all sides of the EUT are subjected to the statistically homogeneous electrical field which means that neither a turning device is required for the EUT nor that the antenna polarization has to be modified. The transmitting antenna is not oriented toward the EUT but radiates toward a corner of the chamber.

A distinction is made between the mode-tuned method, where the tuner is turned in defined stages, and the mode-stirred method, where the stirrer is turned continuously. The following discussion addresses solely the mode-tuned method (where the number of tuner positions must be large enough to obtain a statistical field distribution).

When performing measurements with pulse-modulated interfering signals, the chamber must have a certain capacity (Q factor of cavity resonator). This is due to the structure and characteristics of the chamber (shielding panels, antennas). This factor limits the minimum pulse width of the pulse-modulated signal and is determined during calibration.

Test system for measurements in reverberation chambers

For EMS measurements in reverberation chambers, Rohde & Schwarz offers a standard system solution which can conveniently be configured with the R&S®EMC32 measurement software (FIG 1). Depending on the frequency range, a log-periodic or horn antenna generates the electrical field in the chamber. An antenna of the same type is used to mea-

More information and data sheet at www.emc32.rohde-schwarz.com

REFERENCES
- DIN EN61000-4-21, Verfahren für die Prüfung in der Modenverwirbelungskammer [methods for performing measurements in reverberation chambers], August 2004
- GMW 3097, Revision 4, February 2004.
- Versatile EMS and EMI measurements for the automobile sector: EMC Measurement Software R&S®EMC32-A: News from Rohde & Schwarz (2003) No. 178, pp 36–40
- "Required Amplifier Power in Automotive Radar Pulse Measurements", EE-Evaluation Engineering (http://www.evaluationengineering.com/archive/articles/0806/0806 required_amplifier.asp), August 2006

sure the received power. This antenna is connected to a spectrum analyzer, e.g. to the R&S®FSP7. While the chamber is being calibrated, the field strength (x, y, z, and |xyz|) is measured with a broadband field probe. A positioning device moves the mode tuner to the desired positions by remote control. Depending on the required field strength and the desired frequency range, several power amplifiers are used to generate the power fed to the reverberation chamber. The R&S®SML03 signal generator together with an R&S®AM300 function generator creates the RF signal and the radar pulse packets stipulated in the GMW3097 and Ford standards. An R&S®NRVD power meter evaluates the power. The R&S®TS-RSP switching unit establishes the signal paths between the generator and the amplifier and those required for measuring the forward and reflected power.

Options for all measurement methods

The key component of the system is the R&S®EMC32-S EMC measurement software which, together with the new R&S®EMC32-K3 and R&S®EMC32-K4 options, covers the measurement method in accordance with EN61000-4-21 in the reverberation chamber. These options are available with software version 6 or later (FIG 2).

The R&S®EMC32-K3 option provides all evaluation algorithms for calibrating the reverberation chamber and for EUT testing. It requires the R&S®EMC32-K4 EMS automatic test functionality option. The EMS automatic test (FIG 3) further automates the measurement since additional loop parameters can be defined for the actual frequency scan (test sequencer). The following loop parameters can be used for measurements in a reverberation chamber:

- Tuner position
- Sensor position (only for calibration)
- Modulation (only for EUT test)
- Antenna frequency range (switching of transmitting / receive antennas)

Easy chamber calibration

In contrast to anechoic chambers (homogeneous areas), reverberation chambers have a defined test volume that is usually cuboid in shape. The field distribution for both the unloaded and maximum loaded reverberation chamber (loaded with absorber material) is determined for this test volume. This measurement is performed only when putting the chamber into operation and repeated only in the case of structural modifications to the chamber or to the test volume.

During the calibration, the field probe is positioned to the eight corners of the test volume and the receive antenna is set up at different positions within the test volume. The EMS automatic test then performs a frequency scan at each tuner position (FIG 4).

The calibration yields parameters (standard deviation of field strength, maximum load factor, and insertion loss) providing information on the performance of the chamber (FIG 5). Also a table with the averaged normalized maximum E field strength is created. When performing measurements on the EUT, these values are useful in calculating the required RF power for creating the desired interference field in accordance with the following formula:

$$P_{\text{Input}} = \left[\frac{E_{\text{Test}}}{\overleftrightarrow{E} \times \sqrt{\text{CLF}}} \right]^2$$

E_{Test}	required field strength for EUT test
$\overleftrightarrow{E}$	averaged normalized maximum E field strength
CLF	chamber loading factor

EUT tests in the reverberation chamber

Prior to performing a test, the loading of the reverberation chamber by the EUT has to be evaluated. The loading must not be higher than maximum loading determined during the calibration. Otherwise, false measurement results will be obtained (attenuation of cavity resonances).

The EMS automatic test processes the configured loops for all mode tuner positions and modulation modes. This is done for each test frequency. Moreover, you can define whether the R&S®EMC32 software searches for the immunity threshold when detecting an EUT malfunction (susceptibility method) or whether it only documents EUT faults without changing the test level (qualification method).

During the measurement, EUT faults can either be detected automatically by the EUT monitoring system or marked manually by the user in the R&S®EMC32 software using the keyboard. You can evaluate the individual immunity threshold for each EUT fault. The measurement software then performs a worst-case analysis over all mode tuner positions and modulation modes, i.e. only one frequency scan is required (FIGs 6 and 7).

After completion of the test, you will obtain a table with all detected faults and also a graphical overview with the immunity thresholds of all tested systems.

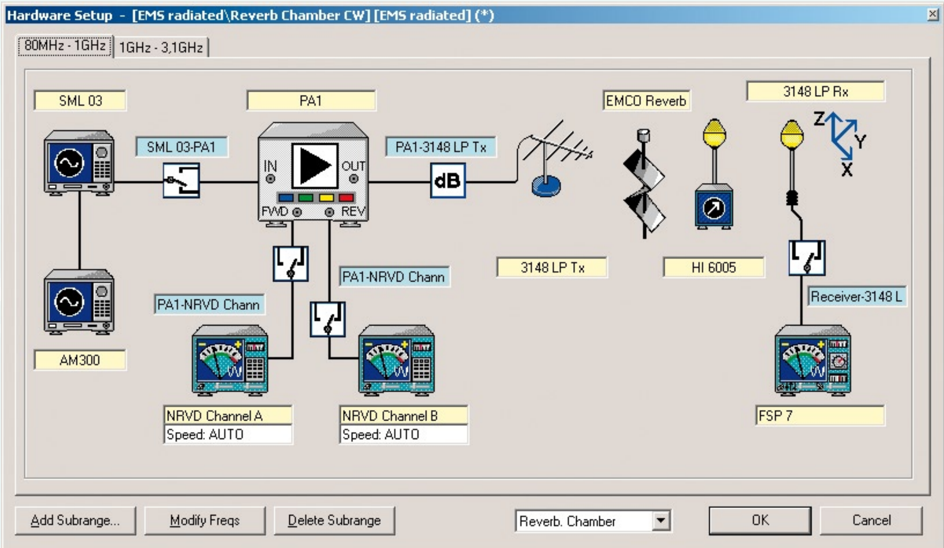

FIG 1 Measurements in a reverberation chamber: With the R&S®EMC32 software, you can conveniently make device configurations (in this example for the frequency range from 80 MHz to 1 GHz).

R&S®EMC32-S	Basic package for EMS measurements
R&S®EMC32-K1	Enhanced EMS functionality for automotive/MIL measurements
R&S®EMC32-K3	Expansion modules for performing measurements in reverberation chambers in accordance with EN 61000-4-21 (R&S®EMC32-K4 also required)
R&S®EMC32-K4	EMS automatic test functionality
R&S®EMC32-K6	Measurements in accordance with MIL-STD-461E CS103/4/5
R&S®EMC32-K7	Generic driver for RF generators, power meters and oscilloscopes
R&S®EMC32-U6	Upgrade of R&S®EMC32-S (earlier than V 6.0) to V 6.x

FIG 2 Available expansion modules for the R&S®EMC32 EMC measurement software.

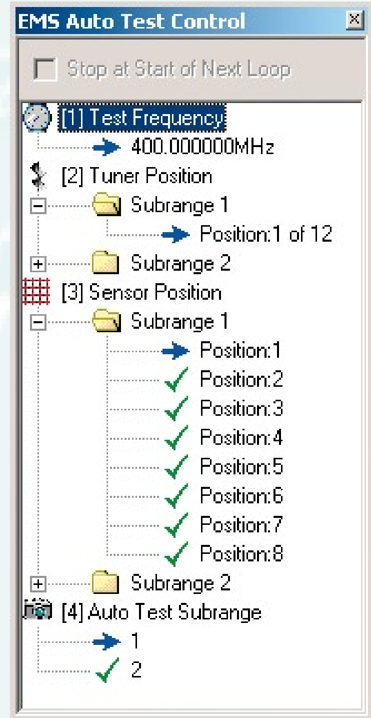

FIG 4 Dialog of EMS automatic test during calibration.

FIG 3
Flowchart for EMS automatic test.

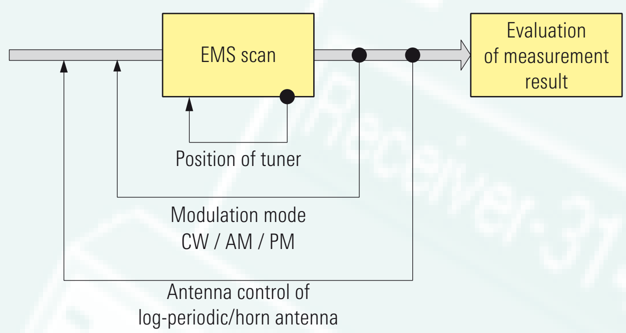

FIG 5 Result of calibration in a reverberation chamber.

Table Editor - [Reverb Calibration UNLOADED 400 MHz-3]

Name	Frequency	ACF	Insertion Loss	Standard Deviation X	Standard Deviation Y	Standard Deviation Z	Standard Deviation XYZ	P Input	P Ave Rec	P Max Rec	Avg Norm Max E-Field	Estimated E-Field	E-field Delta
Unit	MHz	dB	dB	dB	dB	dB	dB	dBm	dBm	dBm	V/m/SQR(W)	V/m/SQR(W)	dB
Interpol.	Lin	Lin	Lin	Lin	Lin	Lin	Lin	Lin	Lin	Lin	Lin	Lin	Lin
1	400.000000	10.993	6.373	2.476	2.895	1.739	2.483	39.980	28.987	35.450	49.726	40.954	1.686
2	419.764000	11.731	7.506	1.335	2.763	2.653	2.438	40.022	28.291	34.121	41.419	37.847	0.784
3	440.504539	11.157	6.605	1.336	2.867	2.698	2.637	40.017	28.860	34.528	48.987	44.367	0.860
4	462.269869	12.140	7.016	2.203	1.360	2.064	1.994	40.003	27.862	34.728	55.470	44.280	1.957
5	485.110623	12.518	7.411	1.666	1.961	1.874	2.186	40.016	27.498	34.667	46.555	44.297	0.432
6	509.079939	11.718	7.228	1.810	2.156	1.351	1.732	40.009	28.291	34.490	55.334	47.564	1.314
7	534.233578	12.320	7.714	1.783	1.852	1.832	1.696	40.007	27.687	34.046	46.943	47.020	-0.014
8	560.630060	13.064	8.002	1.342	1.733	1.343	1.699	39.989	26.925	33.894	49.339	47.355	0.356
9	588.330791	13.628	8.935	1.359	1.270	2.055	1.778	40.031	26.404	32.720	46.487	45.039	0.275
10	617.400215	13.556	8.633	1.702	2.568	2.331	2.174	39.986	26.430	33.599	51.627	48.990	0.455
11	647.905960	13.608	8.590	2.278	2.393	1.765	2.188	40.062	26.454	32.938	47.372	51.801	-0.776

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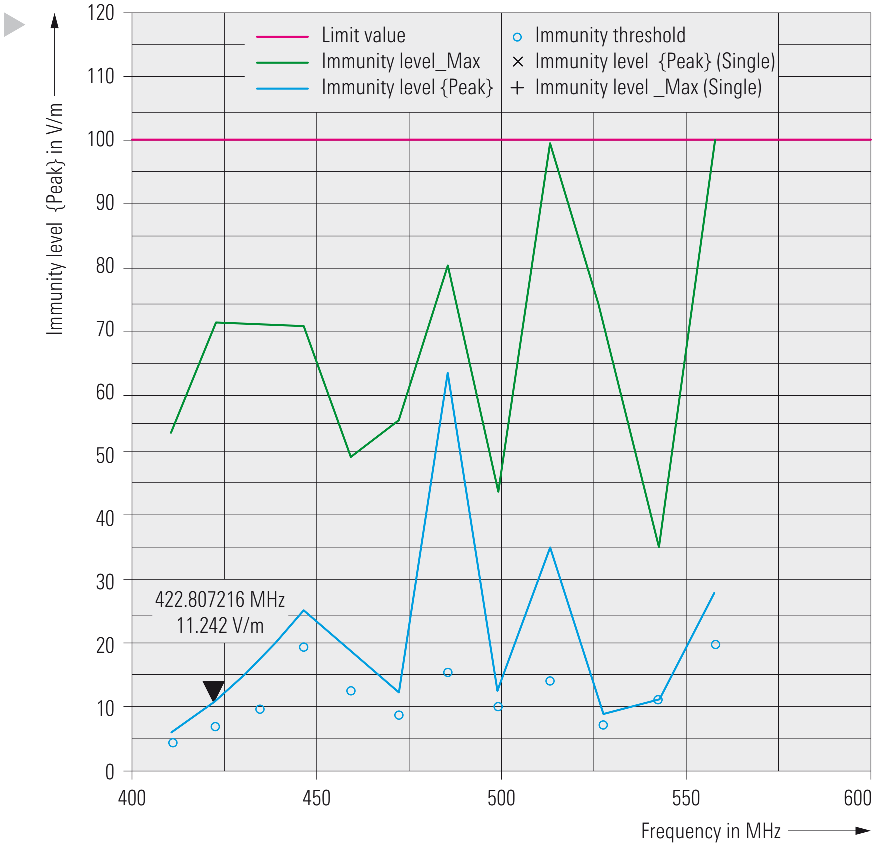

FIG 6 **Graphical result of EUT testing with determination of immunity thresholds.**

Summary

Measurements in reverberation chambers are an attractive alternative to EMS measurements in anechoic chambers. The tried and tested R&S®EMC32-S software used for measurements in anechoic chambers together with its new R&S®EMC32-K3 / -K4 expansion options cover all EMS measurement tasks in reverberation chambers in accordance with the EN61000-4-21 standard. This includes the calibration of the test chamber and EUT testing. Since the software is modular in structure, it can be easily adapted to any standard modifications or manufacturer-specific test methods. Owing to its open EUT monitoring interface, it supports automated EUT testing and is thus future-oriented.

Robert Gratzl

FIG 7 **Result of EUT testing in a table with determination of immunity thresholds.**

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(6) 1.000000 | Frequency | Frequency

Name	Frequency	EUT Failure Mode	GO Value	Thres. Imm. Level	Target Imm. Level	Margin	Ampl. Power	Gen. Level	Tuner Positions	Tuner Position
Unit	MHz			V/m	V/m	dB	W	dBm		
Detector										
1	411.245531	Deviation Exceeded	-	4.37	100.00	-27.2	0.122	-41.4	12	2
2	422.807216	Deviation Exceeded	-	6.98	100.00	-23.1	0.287	-37.2	12	4
3	434.693945	Deviation Exceeded	-	9.84	100.00	-20.1	0.454	-35.1	12	3
4	446.914855	Deviation Exceeded	-	19.54	100.00	-14.2	1.546	-29.0	12	5
5	459.479342	Deviation Exceeded	-	12.54	100.00	-18.0	0.590	-32.9	12	9
6	472.397065	Deviation Exceeded	-	8.79	100.00	-21.1	0.277	-36.5	12	6
7	485.677954	Deviation Exceeded	-	15.55	100.00	-16.2	0.883	-31.1	12	9
8	499.332220	Deviation Exceeded	-	9.89	100.00	-20.1	0.430	-34.6	12	6
9	513.370359	Deviation Exceeded	-	14.08	100.00	-17.0	1.291	-29.9	12	11
10	527.803164	Deviation Exceeded	-	7.18	100.00	-22.9	0.553	-32.9	12	1
11	542.641731	Deviation Exceeded	-	11.18	100.00	-19.0	1.436	-28.1	12	12
12	557.897467	Deviation Exceeded	-	19.89	100.00	-14.0	3.368	-24.1	12	2

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