DISCUSSION OF THE NEW REVERBERATION CHAMBER TEST TECHNIQUES AS DESCRIBED IN THE ISO 11451-5 STANDARD

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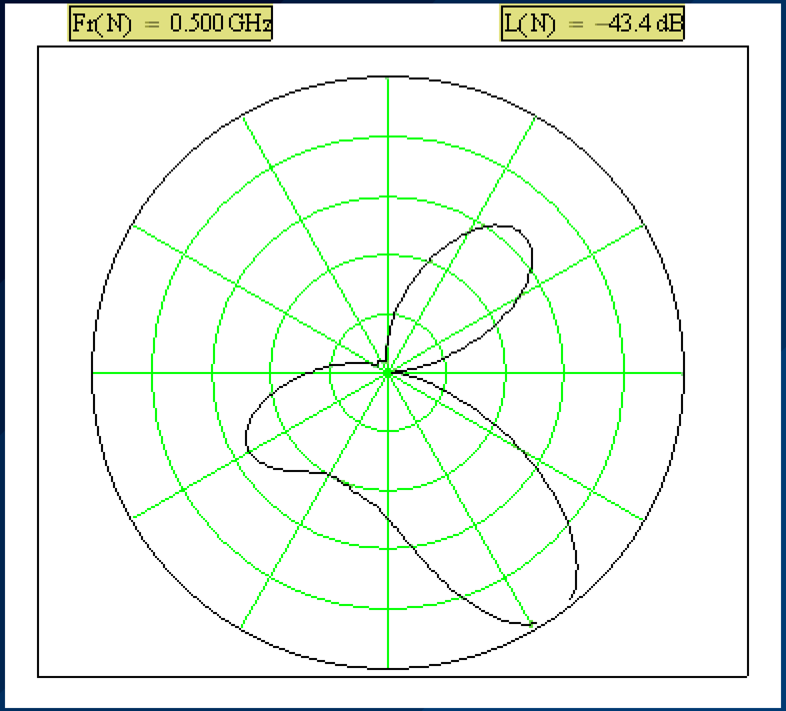
ROHDE & SCHWARZ

Make ideas real



ACK: FOI, Sweden

PART 1 – RC INTRODUCTION AND BASICS

What is a Reverberation Chamber?

- A cavity enclosed by conducting surfaces with a method of exciting the modal structure changes within the cavity
- The Electromagnetic Environment (EME), resulting from repeated reflections from the conducting surfaces is a superposition of plane waves with random phase
- Modal structure changes inside the cavity are established sufficiently large boundary condition change

RC EME

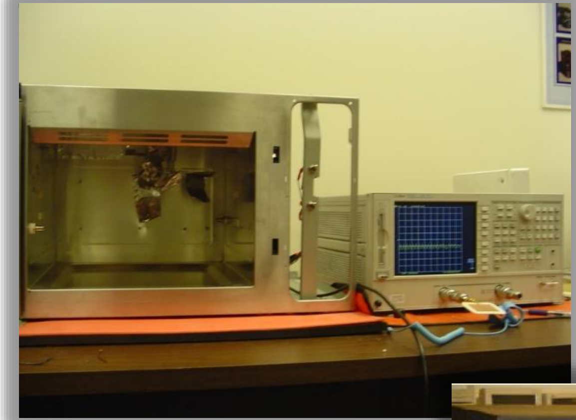
- A well stirred RC provides a test EME that is statistically isotropic, randomly polarized and uniform within an acceptable uncertainty and confidence limit
- ***Isotropic*** implies RC EME is the same in any direction (inside the usable volume)
- ***Random polarization*** implies that the phase relationship between polarized components is random
- ***Uniform*** implies all spatial locations within the usable volume of the RC are equivalent

Why use a Reverberation Chamber?

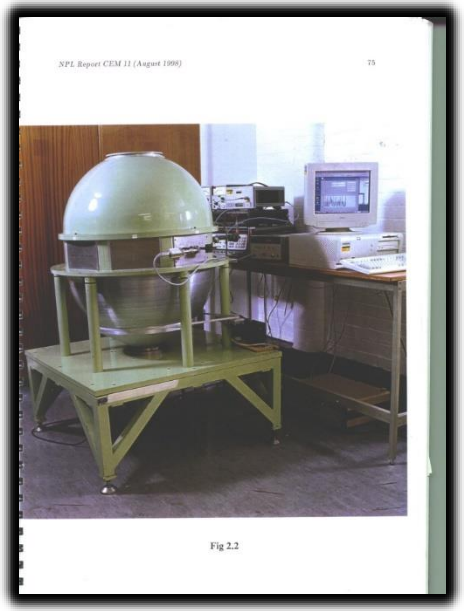
- Robust test
- Repeatability/Reproducibility of tests
- Represents the operational EME for electronics in a cavity
  - Field equivalence

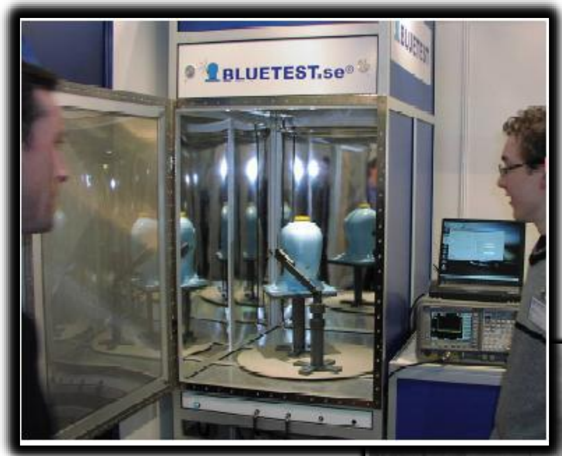
- EMC test results depend both on EUT characteristics and the test facility
  - Test EME is statistically isotropic and uniform with predictable uncertainty throughout the working volume

Chambers

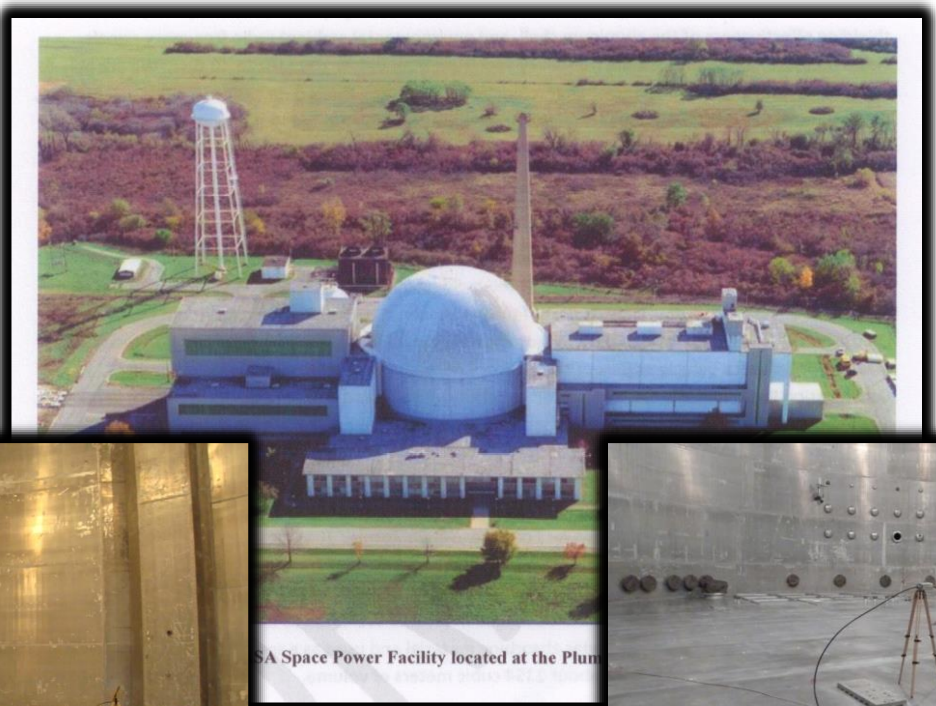


Chambers – cont'd

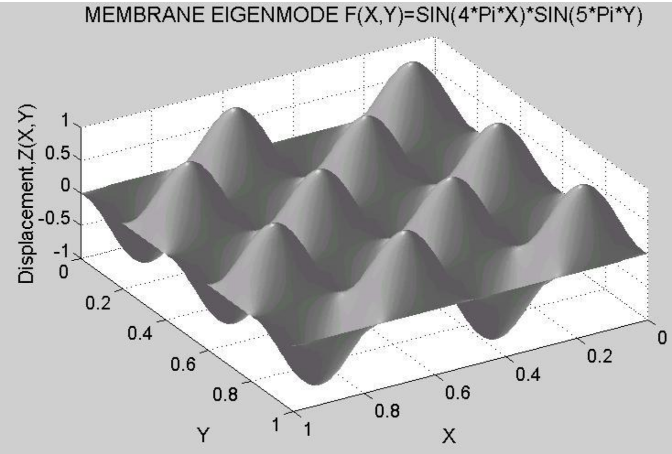


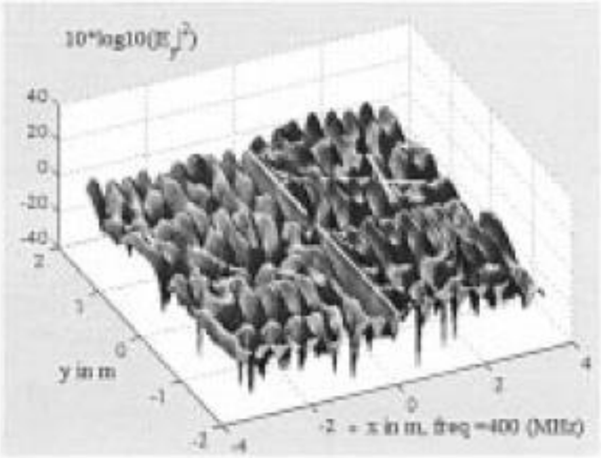


NASA SPF Chamber



Modal structure





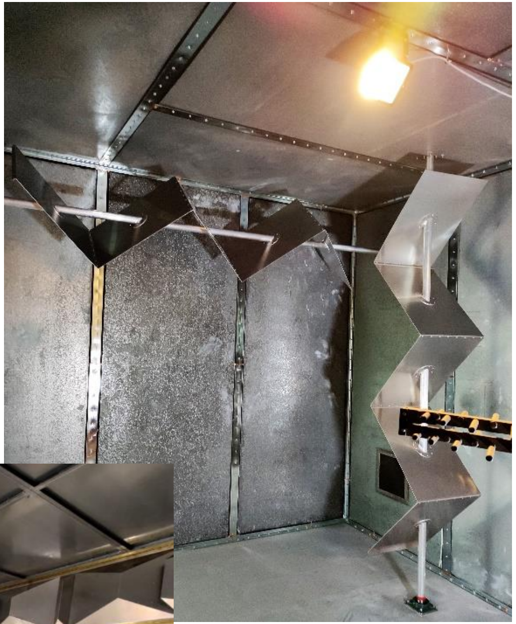
- ► Avoid cubical cavity or cavities that have dimensions as multiples of one side
- ► The more complex the structure, the better the reverberation but also think about structural rigidity and repeatability

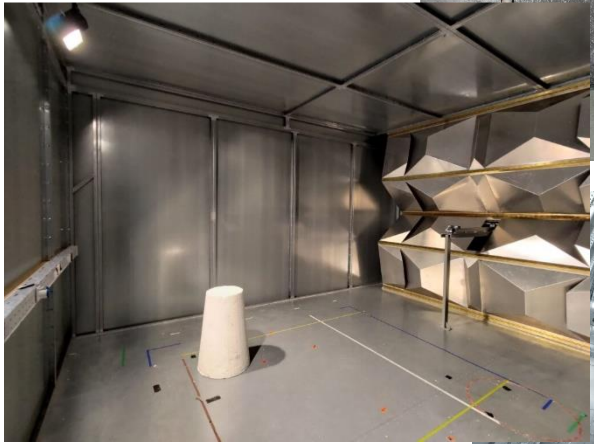
http://aemes.mae.ufl.edu/~uhk/mem2.jpg

C. F. Bunting, *"Statistical Characterization and Simulation of a Reverb Chamber Using Finite-Element Techniques,"* IEEE Trans. on EMC, Vol 44, No.1, Feb 2002.

Tuner

- The tuner is used to stir the field inside the chamber thereby creating a statistically uniform field over a specified volume of the chamber
- Tuner usually occupies considerable (25-30%) volume of the chamber
- Though reverb chamber testing asks for randomness, for repeatability the effects must be deterministic
- Measurement time is also proportional to the tuner settling time



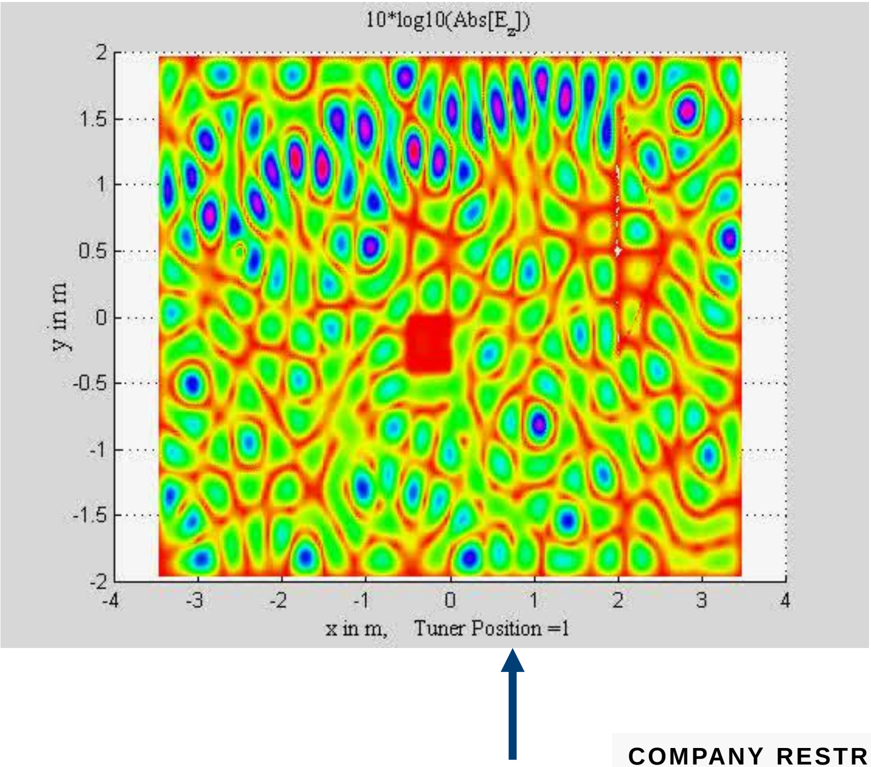


Mode Changes

- The modal structure changes are established by
  - Moving the tuner (Stepping and Stirring)
  - Varying the position, orientation, polarization of the antenna/EUT
  - Vibrating a conducting cloth
  - Changing the input frequency
  - Combination of any/all of the above

Mode tuning

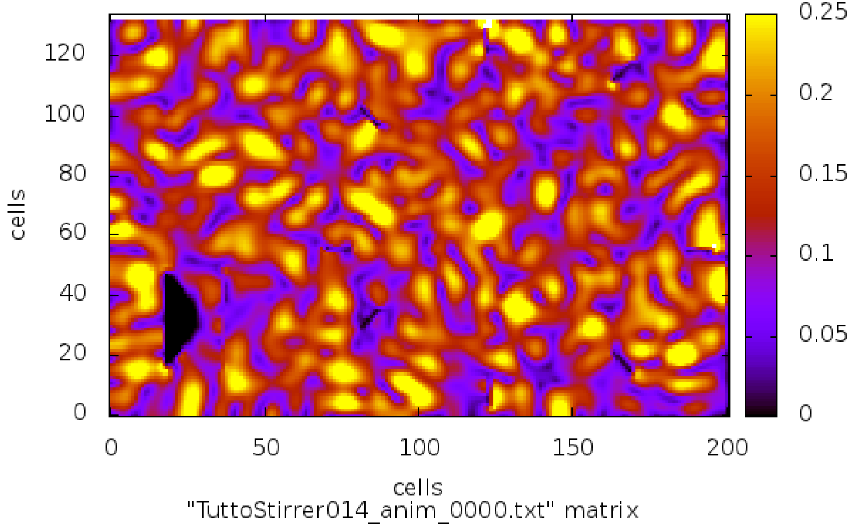
- Repeated fixed tuner positions, consistent with some standards requirements
- Dwell time (amount of time an EUT is exposed to a certain field level, as given by the standard) is controllable
- Provides enough setting/response time for the devices that operate with the chamber (ex: Field probes, antennas, etc…)
- Mathematically less difficult to derive boundary conditions and predict field levels
- Problem: test time can be large



(Source: C. Bunting, Oklahoma State University)

Mode stirring

- The tuner is rotated continuously
- Can utilize all available independent samples
- Highest EME and lowest uncertainty available for the chamber
- Multiple tuners reduce uncertainty even further
- Problems: Mathematically very intense,
- Response/Settling time of devices have be considered



(Source: F Moglie and V Primiani, University of Ancona

Stirring vs Tuning (perceived characteristics)

Tuning (stepped operation)

Slow

Stable

Reliable

Strong theoretical support

Good measurement support

Stirring (Continuous motion)

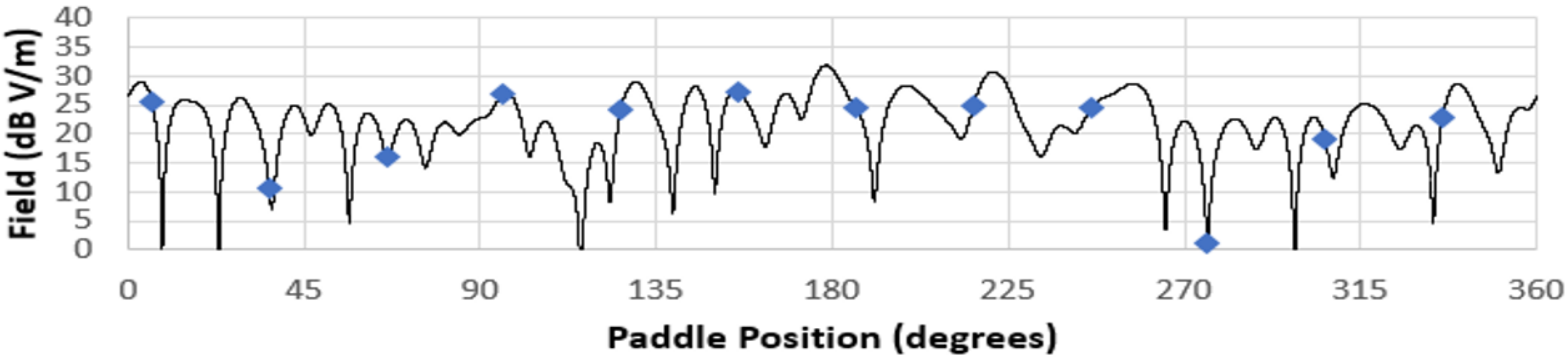
Fast

More thorough

Simple

Higher fields

More accurate



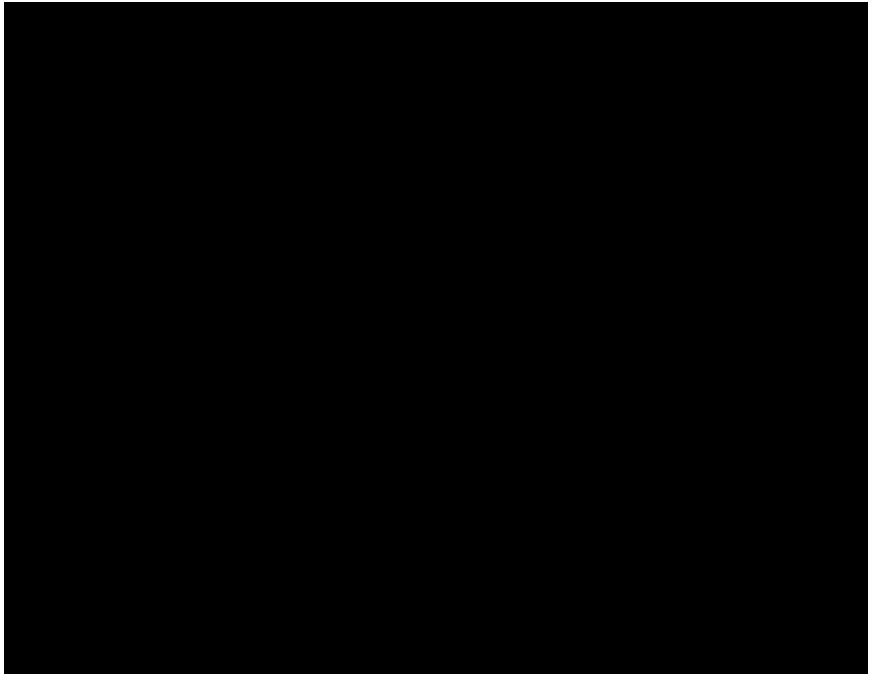
ACK: J Ladbury - NIST

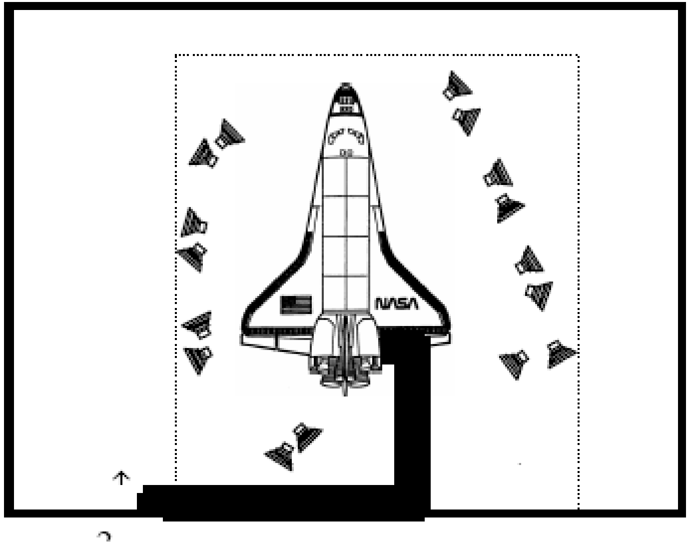
Shaking the walls - VIRC

- Must obtain a sufficient number of independent EME configurations through cavity modal structure changes
- Boundary condition changes are obtained by shaking the walls of the chamber

Frequency Stirring and Position Stirring

(Source: C. Bunting, Oklahoma State University





Shielding measurements of the space shuttle (part II - testing the nasa endeavour)
Kempf, D. ; Brezinski, B. ; Scully, R.; EMC 2006

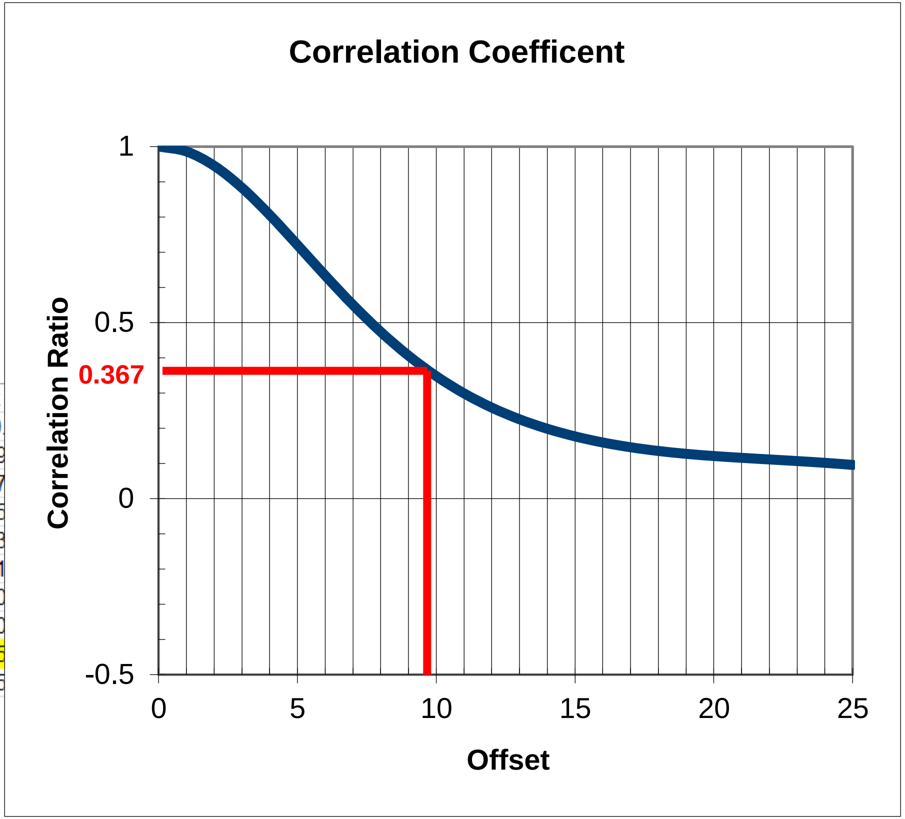
Independent samples

- An independent modal structure occurs when a sufficiently large boundary condition change occurs typically through the rotation of one or more tuners or when a sufficiently large frequency change occurs
- Many of the statistical parameters of the RC EME are functions of the number of IS excited during a test
- Test conditions are based on the estimation of IS
  - Necessary for predicting Max test fields
  - Necessary for predicting uncertainties
- Typically, 12 is the absolute minimum and 200 is the maximum IS that will be seen

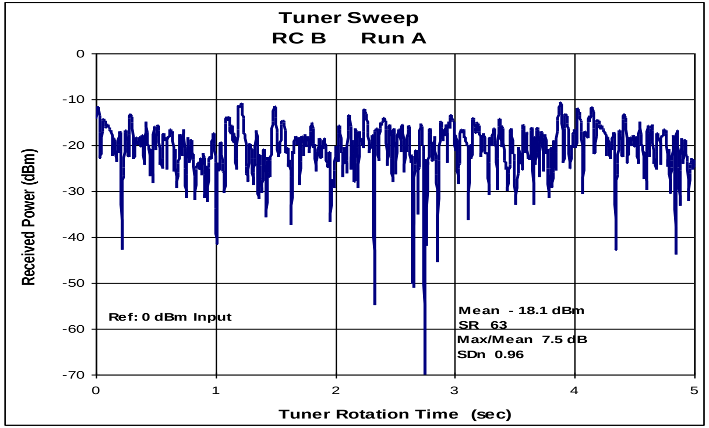
Autocorrelation

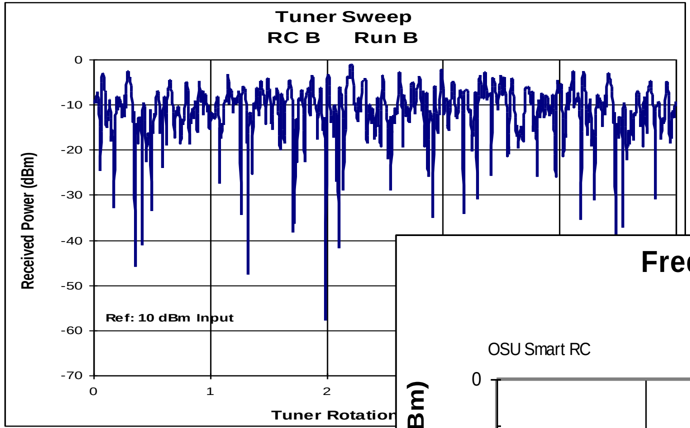
- The correlation of a signal with a delayed copy of itself as a function of delay
- Informally, it is the similarity between observations of a random variable as a function of the time lag between them

	Rx Pwr	Rx Pwr	Rx Pwr	Rx Pwr	Rx Pwr	Rx Pwr	Rx Pwr	Rx Pwr	Rx
TP 1	0.51188	0.13736	0.1479	0.17884	0.22247	0.27623	0.33618	0.40084	0.
TP 2	0.51058	0.51188	0.04348	0.07634	0.17888	0.34631	0.56999	0.77548	0.9
TP 3	0.4648	0.51058	0.51188	0.04348	0.07634	0.17888	0.34631	0.56999	0.7
TP 4	0.40084	0.4648	0.51058	0.51188	0.04348	0.07634	0.17888	0.34631	0.5
TP 5	0.33618	0.40084	0.4648	0.51058	0.51188	0.04348	0.07634	0.17888	0.3
TP 6	0.27623	0.33618	0.40084	0.4648	0.51058	0.51188	0.04348	0.07634	0.1
TP 7	0.22247	0.27623	0.33618	0.40084	0.4648	0.51058	0.51188	0.04348	0.0
TP 8	0.17884	0.22247	0.27623	0.33618	0.40084	0.4648	0.51058	0.51188	0.0
TP 9	0.1479	0.17884	0.22247	0.27623	0.33618	0.40084	0.4648	0.51058	0.5
TP 10	0.13736	0.1479	0.17884	0.22247	0.27623	0.33618	0.40084	0.4648	0.5

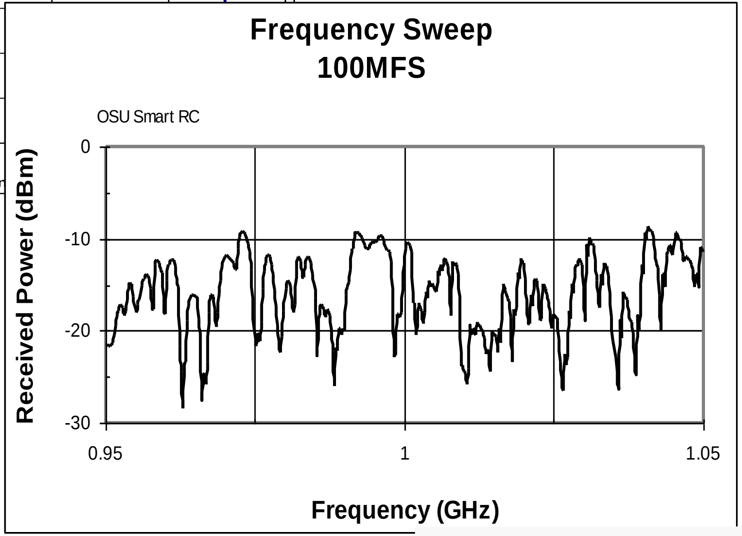


RC Tuner Sweep (TS) and Frequency Sweep





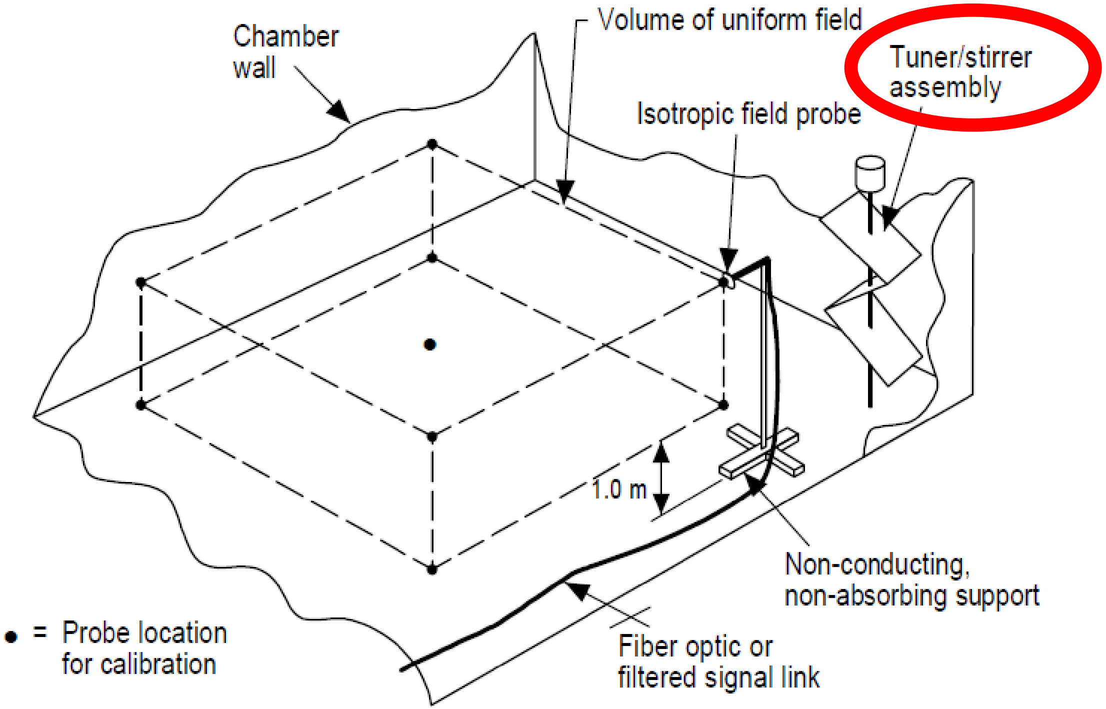
TS samples RC EME at fixed frequency and spatial location for multiple tuner positions



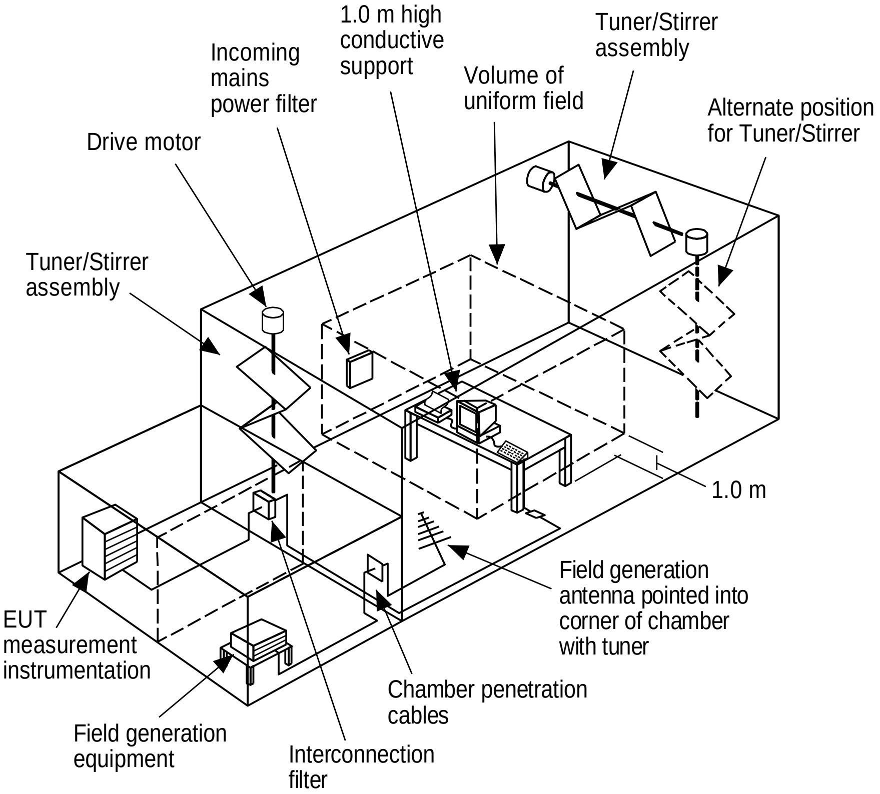
FS samples - RC EME at fixed spatial location and fixed tuner position for multiple frequencies

Calibration

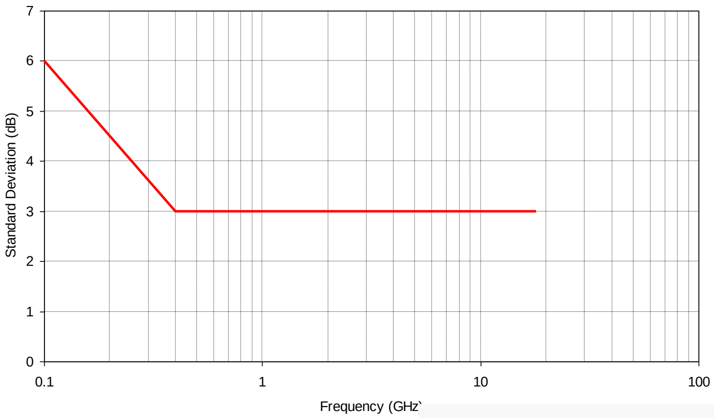
- 8 or 9 probe locations
- 3 orthogonal sensors/probe
- ***Stepped*** paddle
- *N* paddle positions



Calibration – cont'd



- RCs certified by demonstrating acceptable uniformity (and isotropy) for empty chamber at specified frequencies for specified number of tuner positions
- Recertification required for major modification (possibly periodically)



RC Calibration Procedures (cont'd)

- Linear, input power normalized, 3 axes probe measurements

$$\overleftrightarrow{E}_i(f)\Big|_{N,M} \qquad \overleftrightarrow{E}_{3i}(f)\Big|_{N,M}$$

- Calculate linear means over M locations of max of 3 components and sum

$$< \overleftrightarrow{E}_{i,max}(f)\Big|_N >_M \qquad < \overleftrightarrow{E}_{i,max}(f)\Big|_N >_M$$

- Calculate linear standard deviation of above

$$\sigma_i(f)\Big|_M \qquad \sigma_{3i}(f)\Big|_M$$

- Calculate logarithmic standard deviation of above
- Compare to required standard deviation

Working Volume

- Volume defined at the lowest usable frequency, ~λ/4 to λ/2 away from any metals
- If the EUT has to be tested on a ground plane, chamber floor can be used
- For a well stirred chamber there must be no shadowing
- When EUT is placed inside the working volume, before the test, it must be ensured that the EUT did not load the chamber badly
- In some cases if the Q is too high, the chamber can be intentionally loaded to increase the time constant associated with the chamber
- Some do multiple unit testing at one run - as far as all the units are placed inside the usable volume, this is possible

Summary – What do you need for a good test?

- For good chamber performance we want a large number of independent samples
- For each independent sample the RC supports a new set of complex modes which may or may not look like modes at any other sample
- Each independent sample is equivalent to creating a new but statistically equivalent cavity
- As number of independent samples approaches infinity all orientations are equally likely
  - Requires large overmoded cavity
  - High quality factor: Q
  - Complex boundary conditions

- Convenient to use the statistics of random variables to evaluate properties of interest
- Testing in reverberation chambers is a statistical process
- Different parameters of interest (e. g.., received power, electric field component) have different statistical distributions
  - Must consider in defining test procedures and data processing / analysis

STATISTICS

Statistical Distributions of Interest

- Statistical distribution functions can be derived which describe a measurement (ensemble of N samples) of the measurands of interest:
  - $E_{component}$ $E_{component(max)}$
  - E_{total} $E_{total(max)}$
  - P_{rec} $P_{rec(max)}$
- Provide an estimate of the mean, standard deviation and the maximum

Statistical Distributions of Interest

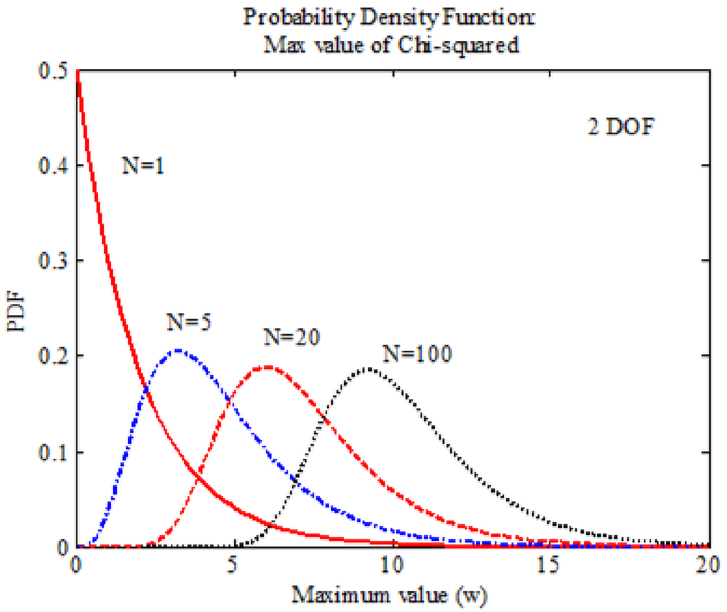
- Mean normalized distribution functions are independent of
  - Location in chamber
  - Interior test configuration
  - Cavity shape
  - Cavity volume
  - Cavity quality factor
  - Input power
- Imply that RC tests should be
  - Repeatable
  - Reproducible
  - The correct environment for measuring performance of electronic systems located in a cavity

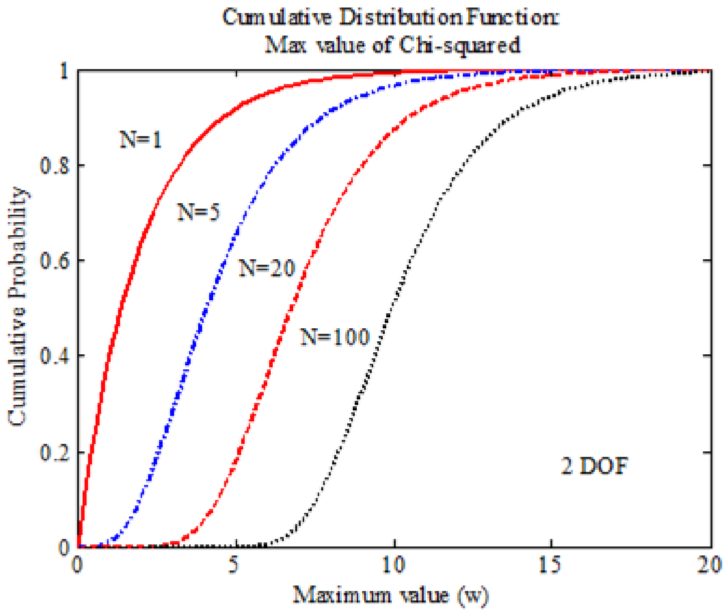
These functions define a measure for Statistical Equivalence for all RCs

Statistical Distributions of Interest

- If one measures E_i^2 or P_{rec} (or related parameter that includes two random polarizations) of an arbitrary component, the data should have a ***chi - square distribution with 2 dof***
- If one measures E_i (or related parameter that includes two random polarizations) of an arbitrary component, the data should have a ***chi distribution with 2 dof***
- If one measures total field (e.g., E_t) the data should have a ***chi distribution with 6 dof***
- Also of interest: Distribution of maximums
- Mean normalized distributions are also useful for
  - Comparing experimental results to theory
  - Comparing EME
    - In same chamber under different conditions
    - In different chambers

Statistical Distributions of Interest





Expanded view of Max/Mean ratio of Chi-squared PDF and CDF

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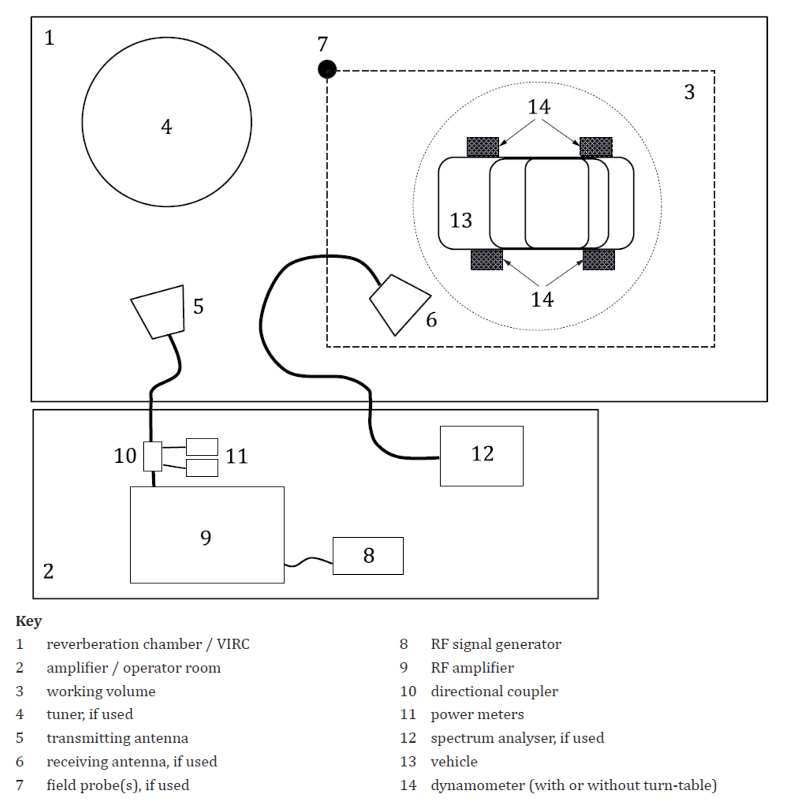
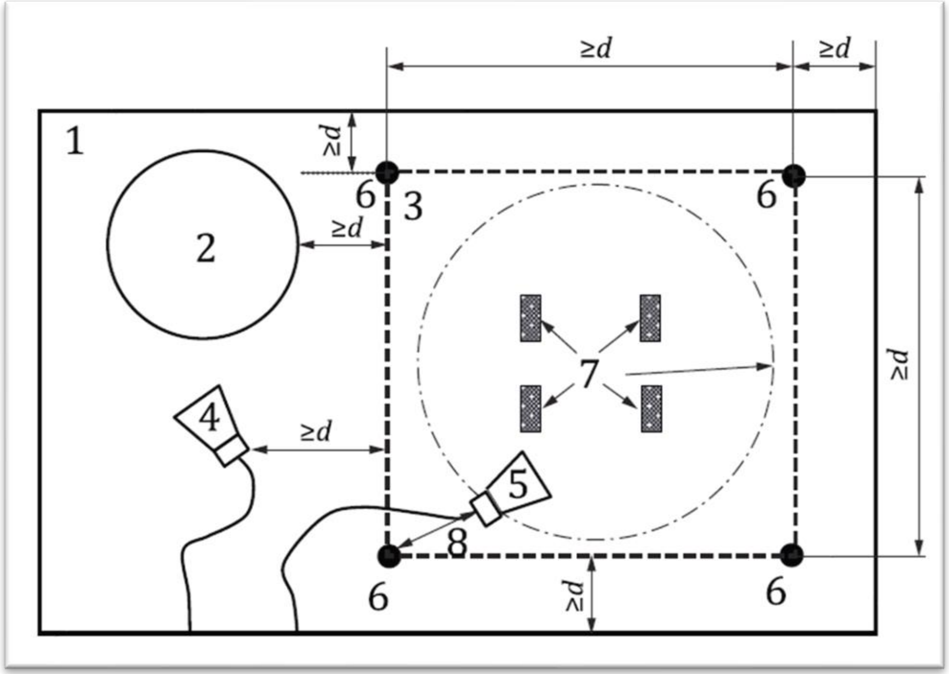


PART 2 – ISO 11451-5 TESTING IN A REVERBERATION CHAMBER

Reverb chamber – Full vehicle and component

- Reverb chambers gain momentum as a complementary EMC test method
- Using a reverberation chamber higher field strengths can be achieved for relatively low input power
- Test object can occupy up to 50% of the chamber volume
- The most recent ISO 11451-5 (and 11) standard supports using the reverb chamber at frequencies below the normal lowest usable frequency of a RC, using different RF injection methods

Test method	Subclause
Reverb method with substitution method power control + Loading factor method	8.5.2
Reverb method with substitution method power control + Field calibration with vehicle present	8.5.3
TLS method	Annex E
Cavity mode method	Annex F
Reverb method with closed-loop power control	Annex G
Reverb method with substitution method power control + Chamber time constant method	Annex H
VNA method	Annex I



Reverb method with substitution method power control + Loading factor method

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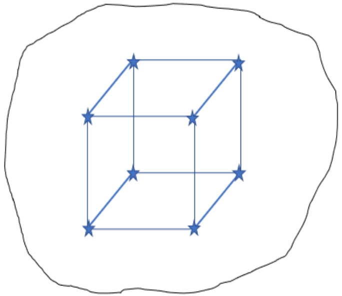
Methodology

- This procedure is the same as defined in **IEC 61000-4-21**
- This subclause describes a field calibration procedure that is based on the field calibration of the empty chamber and uses a power compensation of the vehicle loading
- Uses the mean of the normalized received power to quantify the loading effect
- The method is performed in four phases:
  - field calibration of the empty chamber
  - determination of the maximum loading factor
  - determination of the chamber loading factor
  - vehicle test

Field Calibration



- Calibration is performed **without** a vehicle in the test location and performed with an unmodulated sinusoidal wave
- A receiving antenna placed within the working volume is used to measure received power
  - In place of the receiving antenna, a calibrated isotropic field probe may be used

$$P_{\text{rcv}} = \frac{\lambda^2 E_i^2}{320\pi^2}$$

where

P_{rcv}	is the received power for a single stirring configuration in W;
λ	is the wavelength at the test frequency in m;
E_i	is the measured component of the electric field strength in any direction x, y or z in V/m.

- Field measurements are made with calibrated isotropic field probes that are placed at the 8 locations (edge of the usable volume)
- For each test frequency, record the readings of the three electric field components, the forward power, the reverse power, and the received power for all stirring configurations

Field Calibration – Cont'd

- For each test frequency, calculate:
  - the reached test level E_{RC} in V/m according to $$E_{\text{RC}} = \frac{1}{24}\sum_{p=1}^{8}\left(\max_{\text{sc}}\left(E_{x,p}\right)+\max_{\text{sc}}\left(E_{y,p}\right)+\max_{\text{sc}}\left(E_{z,p}\right)\right)$$
  - the mean forward power $<P_{f,p}>_{sc}$ $$\left\langle P_{\text{f}}\right\rangle_{\text{sc}} = \frac{1}{8}\sum_{p=1}^{8}\left\langle P_{\text{f},p}\right\rangle_{\text{sc}}$$
  - and the mean received power $<P_{rcv,p}>_{sc}$ (direct antenna measurement); if a field probe is used $$P_{\text{rcv}} = \frac{\lambda^2 E_i^2}{320\pi^2}$$
- For each test frequency, calculate the chamber gain $G_{RC,empty}$ of the empty chamber using $$G_{\text{RC,empty}} = \frac{E_{\text{RC}}}{\sqrt{\left\langle P_{\text{f}}\right\rangle_{\text{sc}}}}$$
- For each test frequency, calculate the receiving antenna characterization factor of the empty chamber $A_{ACF,empty}$

$$A_{\text{ACF,empty}} = \frac{1}{8}\sum_{p=1}^{8}\frac{\left\langle P_{\text{rcv},p}\right\rangle_{\text{sc}}}{\left\langle P_{\text{f},p}\right\rangle_{\text{sc}}}$$

subscript p denotes the probe position

Determination of Maximum Loading Factor

- This check is performed to determine if the chamber is adversely affected by a DUT which "loads" the chamber by installing a sufficient amount of absorber to load the chamber (to be carried out only once in the life of the chamber or after major modification to the chamber)
- Perform field calibration as discussed before
- Repeat the calculation of the field uniformity using the data from the (at least) eight locations of the E-field probe
  - If the chamber loading results in a rectangular component of the fields exceeding the allowed standard deviation, or if the standard deviation for all vectors (i.e. σ) exceeds the allowed standard deviation or the number of independent stirring configurations **becomes less than 12**, then the chamber has been loaded to the point where the performance of the chamber is unacceptable

Frequency range	Tolerance requirements for standard deviation[a]
below 100 MHz	6 dB[b]
100 MHz to 400 MHz	6 dB [b] at 100 MHz decreasing linearly to 3 dB at 400 MHz
above 400 MHz	3 dB

- Maximum chamber loading factor $F_{\mathrm{MLF}} = \dfrac{A_{\mathrm{ACF,empty}}}{A_{\mathrm{ACF,maxload}}}$
- A value of 16 (12 dB) for F_{MLF} should be considered as a nominal amount of loading

Determination of Chamber Loading Factor

- Procedure shall be carried out prior to each test
- For each test frequency, record the readings of the forward power and the receive power for all stirring configurations
- If the value of $\langle P_{rcv} \rangle_{sc}$ is within (i.e. neither greater nor less than) the values recorded for all eight locations during the field calibration of the empty chamber, calculation of the CLF is not necessary and the value of F_{CLF} should be assumed to be 1
- At each test frequency, the chamber characterization factor A_{CCF} can be calculated using

$$A_{\mathrm{CCF}} = \frac{\langle P_{\mathrm{rcv}} \rangle_{\mathrm{sc}}}{\langle P_{\mathrm{f}} \rangle_{\mathrm{sc}}}$$

- At each test frequency, the chamber loading factor F_{CLF} can be calculated using

$$F_{\mathrm{CLF}} = \frac{A_{\mathrm{ACF,empty}}}{A_{\mathrm{CCF}}}$$

Determination of Chamber Loading Factor – Cont'd

- If the chamber loading factor F_{CLF} is greater than the maximum loading factor F_{MLF} determined during the chamber characterization for more than 10 % of the frequencies, the chamber may be loaded to a point where field uniformity could be affected
- In such case the field uniformity measurements for the loaded chamber shall be repeated with the vehicle in place or with a simulated loading equivalent to the vehicle
- For each test frequency, the chamber gain $G_{RC,\,veh}$ can be calculated using

$$G_{RC,veh} = \frac{G_{RC,empty}}{\sqrt{F_{CLF}}}$$

Vehicle Test

- The test is conducted by subjecting the vehicle to the test signal based on the calibrated value as predetermined in the test plan

$$P_{\mathrm{f,test}} = \left(\frac{E_{\mathrm{RC,test}}}{G_{\mathrm{RC,veh}}} \right)^2$$

- Tests shall be conducted for all stirring configurations over the test frequency range
- For pulse modulation, the pulse duration should be long enough to reach a steady-state of the fields in the chamber and the switch-on transients must have decayed

Reverb method with substitution method power control + Field calibration with vehicle present

Methodology

- This subclause describes a method to determine the chamber gain $G_{RC,veh}$ with the vehicle present
- The method is performed in two phases:
  - calibration procedure
  - vehicle test

Calibration

- Calibration is performed with the **vehicle in the test location** and with an unmodulated Sine wave
- Field measurements are made with calibrated isotropic field probes that are placed at the 8 locations (edge of the usable volume)
- For each test frequency, record the readings of the three electric field components, the forward power, the reverse power, and the received power for all stirring configurations
- For each test frequency, calculate:
  - the reached test level E_{RC} in V/m
  - the mean forward power $\langle P_f \rangle_{sc}$
- For each test frequency, check that the field uniformity requirements are met and calculate the chamber gain $G_{RC,veh}$ with the vehicle using

$$G_{RC,veh} = \frac{E_{RC}}{\sqrt{\langle P_f \rangle_{sc}}}$$

- For lowest test frequency f_c that fulfils the field uniformity requirement, determine the number of independent stirring configurations N
  - The LUF of the chamber is determined when $N_{ind} \geq 12$

Vehicle Test

- The test is conducted by subjecting the vehicle to the test signal based on the calibrated value as predetermined in the test plan
- At each test frequency the necessary forward power is $P_{\mathrm{f,test}} = \left(\frac{E_{\mathrm{RC,test}}}{G_{\mathrm{RC,veh}}} \right)^2$
- Tests shall be conducted for all stirring configurations over the test frequency range
- For pulse modulation, the pulse duration should be long enough to reach a steady-state of the fields in the chamber and the switch-on transients must have decayed

Reverb method with closed-loop power control

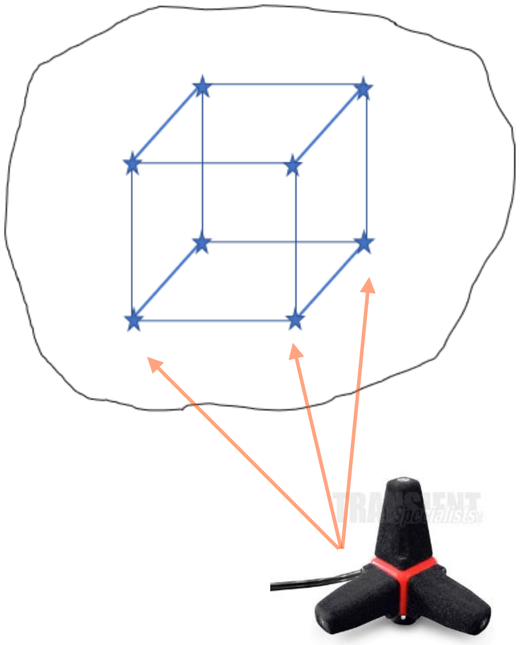
Methodology

- This is based upon the use of a field probe measurement system that allows the **measurement of the electric field strengths and the calculation of the test level and the field uniformity in real time**
- Applicable frequency range is LUF to 18000 MHz
- This method can be used to test the vehicle directly and no calibration is required

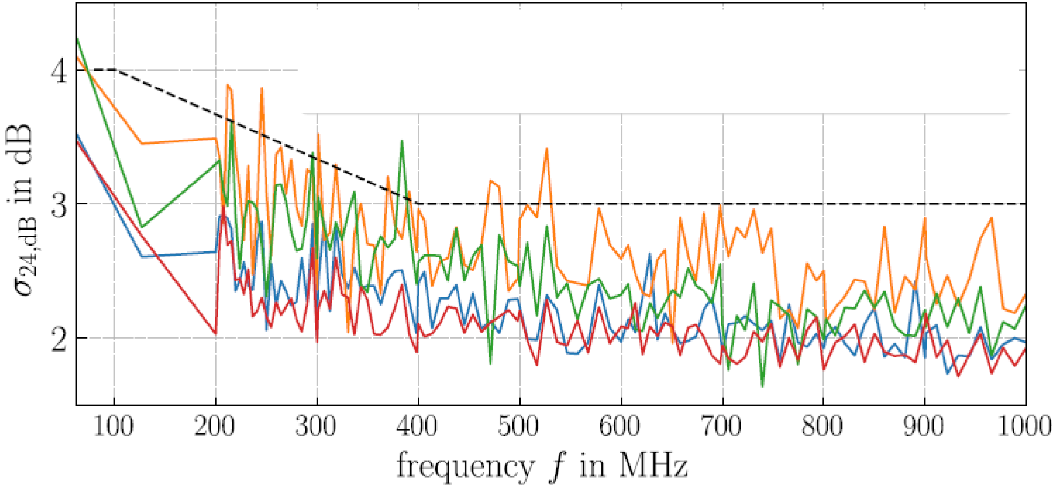
- Implementing the power control loop for closed-loop testing based directly on measurements of E_{RC} might lead to either an **unacceptable long levelling time or to the risk of over-testing if the stirring speed is not fast enough**
- Using mean values or CDF-values (e.g. 80 % percentile) for the power control loop and correcting by the proper maximum to mean or maximum to CDF value is allowed
  - Since the E-field is Rayleigh distributed in a well stirred chamber, one can adjust the transmit power to affect the density of the electrical field samples above a certain test level

Test

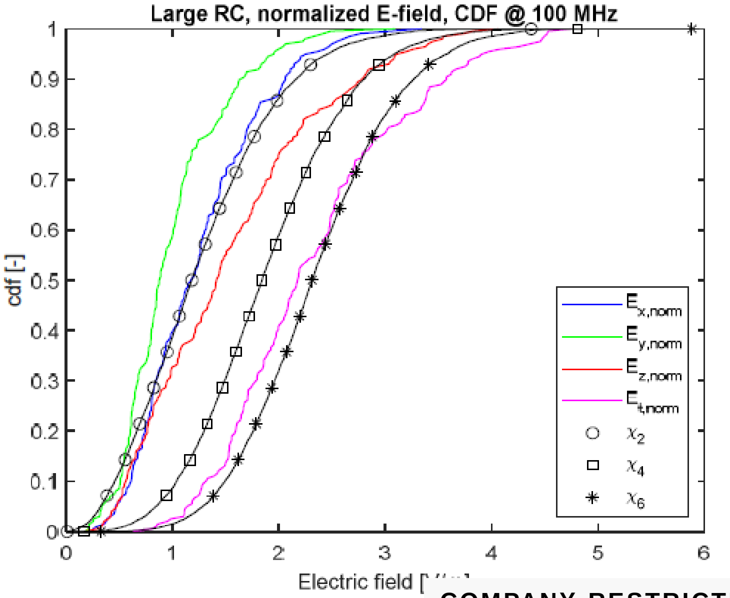
- Place eight calibrated isotropic field probes at the reverb reference points
- The output power of the amplifier shall be increased until the required test level is indicated by the field measurement system
- The mean of the 24 maximum field components and the four standard deviations as required for field uniformity evaluation shall be recorded
- Tests shall be conducted for all stirring configurations over the test frequency range
- Continue testing until all frequencies, modulations, stirring configurations and vehicle orientations specified in the test plan are completed
- For pulse modulation, the pulse duration should be long enough to reach a steady-state of the fields in the chamber and the switch-on transients must have decayed



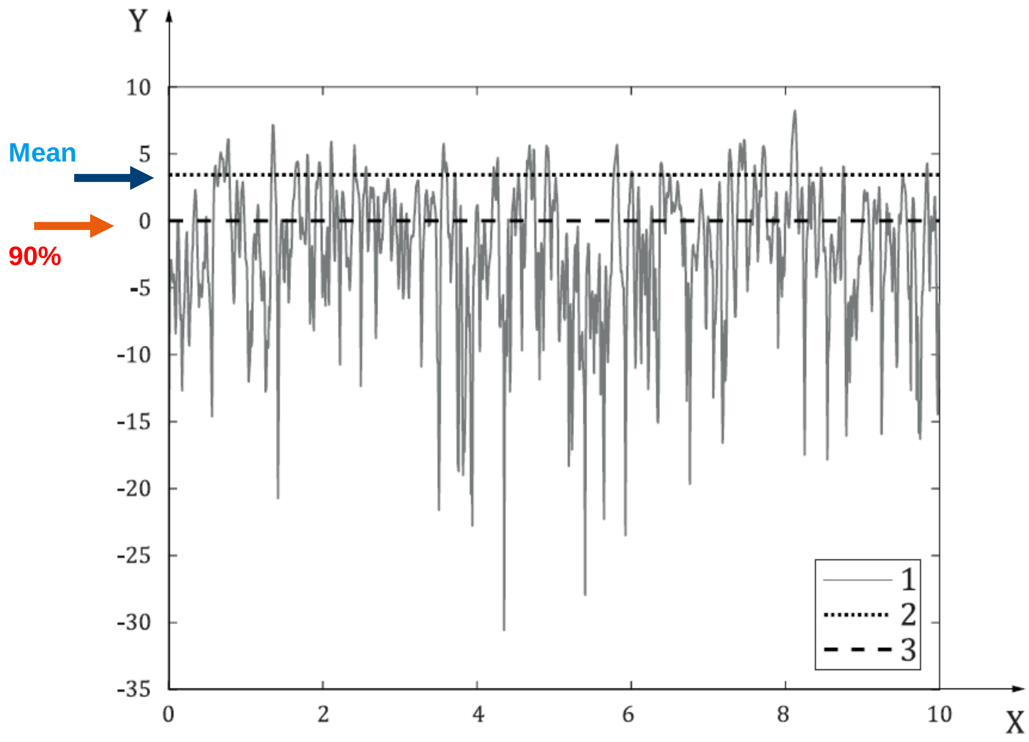
$$E_{RC} = \frac{1}{24}\sum_{p=1}^{8}\left(\max_{sc}\left(E_{x,p}\right)+\max_{sc}\left(E_{y,p}\right)+\max_{sc}\left(E_{z,p}\right)\right)$$



$\sigma_{24,\mathrm{dB}}$ in dB
frequency f in MHz



Large RC, normalized E-field, CDF @ 100 MHz
cdf [-]
$E_{x,norm}$
$E_{y,norm}$
$E_{z,norm}$
$E_{t,norm}$
χ_2
χ_4
χ_6



Key

X time, s

Y S_{21}, dB

1 measured samples, S_{21}, dB

2 90 % test quantile, dB

3 mean power, dB

Adjusted Level

- Since the E-field is Rayleigh distributed in a well stirred chamber, one can adjust the transmit power to affect the density of the electrical field samples above a certain test level

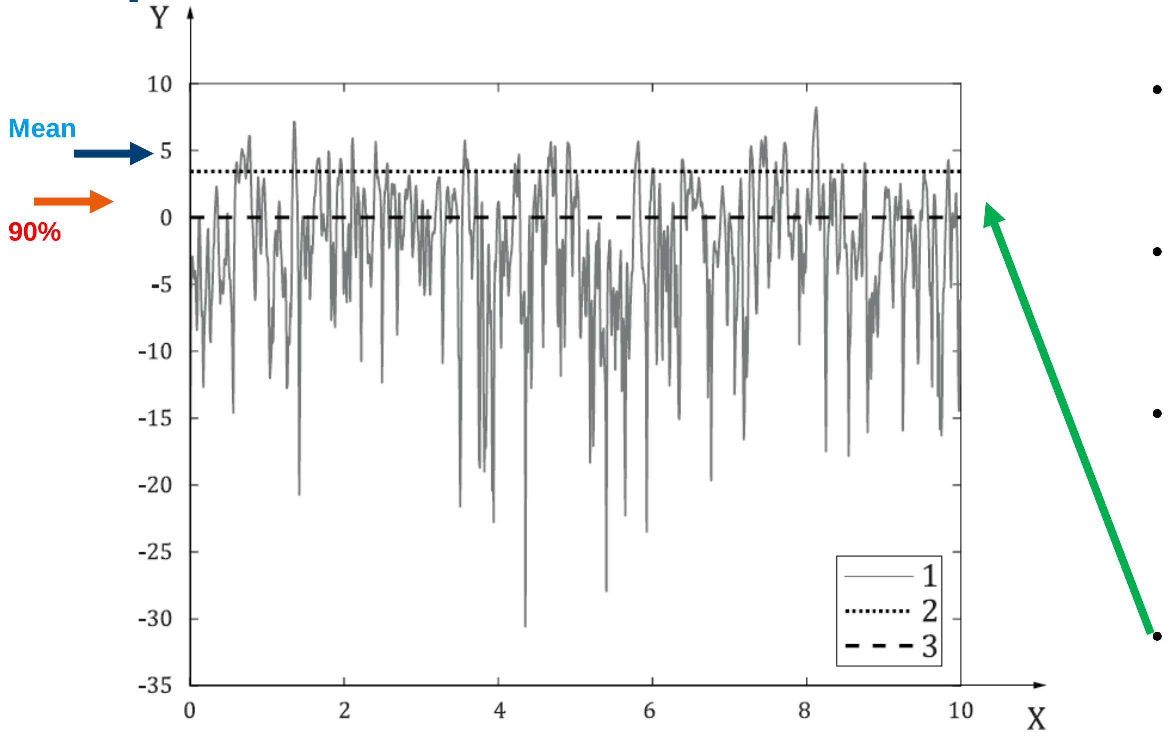
$$\Delta_{p,\text{dB}} = 10\log_{10}\left(\ln\left(\frac{1}{1-p}\right)\right)$$

$$P_{f,\text{test,dBW}} = P_{f,\text{avg,dBW}} - \Delta_{p,\text{dB}}$$

- Test level and power adjustment

Test quantile [%]	$\Delta P_{,\text{dB}}$ [dB]
70	0,81
80	2,07
90	3,62
95	[illegible]

Exposure time



Key

X time, s

Y S_{21}, dB

1 measured samples, S_{21}, dB

2 90 % test quantile, dB

3 mean power, dB

- In a stirred RC, generating a constant field over a specified dwell time is not possible
- Instead dwell time is aggregated over a specific exposure time (aggregated dwell time)
- For p=0,9, 10 % of the test time results in electrical fields equal to or above the test level.
- For an immunity test at 1 GHz during 10 s, the aggregated dwell time over the 90% percentile was 1.0059 s

TUNER OPERATION

Tuner operation – Mode Tuned

- Repeated fixed tuner positions, consistent with the standards requirements
  - Neither the frequency nor the stirring configuration are changed during the measurement or dwell time.
- **Dwell time** (amount of time an EUT is exposed to a certain field level, as given by the standard) is controllable
- Provides enough setting/response time for the devices that operate with the chamber (ex: Field probes, antennas, etc.)
  - Often, the settling time of mechanical tuners is larger than the dwell time, so typically, the change of stirring configuration is implemented as the outer loop and the change of frequency as the inner loop in the test automation software to optimize the total time needed for calibration or test
- Problem: Test time is large, and test does not utilize all available independent samples

Tuner operation – Mode Stirred

Mode Stirred

- The tuner is rotated continuously
  - Frequency is kept constant while the stirring configurations are changing continuously during the measurement or dwell time
- Can utilize all available independent samples
- Highest EME and lowest uncertainty available for the chamber
- Multiple tuners reduce uncertainty even further
- Problem: Response/Settling time of devices must be considered and CW testing in stirred mode is impossible

Tuner operation – Mode Stirred (Quasi Tuned)

Mode Stirred - Quasi Tuned

- Quasi-tuned mode which means that the reaction of the vehicle or electronics is quicker than the field changes
- In order for the cavity field to remain in the same steady-state as during mode-tuned operation (ignoring stepping transitions), an upper limit for the permissible stirring rate is given by the order-of-magnitude relation:

$$\Omega_m(f) < \frac{c^3}{8f^2 Q \sqrt{N}\ V}$$

where

$\Omega_m(f)$ is the mechanical stirring rate (in revolutions per second (rps)) at the operating frequency f (in Hz),

c is the velocity of light in free space, approximately 3×10^8 m/s,

Q is the chamber quality factor at frequency f,

N is the maximum number of independent samples at frequency f (see Clause A.3), and

V is the working volume of the chamber (in m^3).

Ref: IEC 61000-4-21:2011, Annex C

Speed of the Tuner

- No standard is going to provide precise limits on the stirrer speed and detailed test procedures for ensuring that the tuner speed is adequately slow (or fast) for equipment under test to respond

- Suggestions include, adequate response for an immunity tested EUT requires the stirrer speed to satisfy

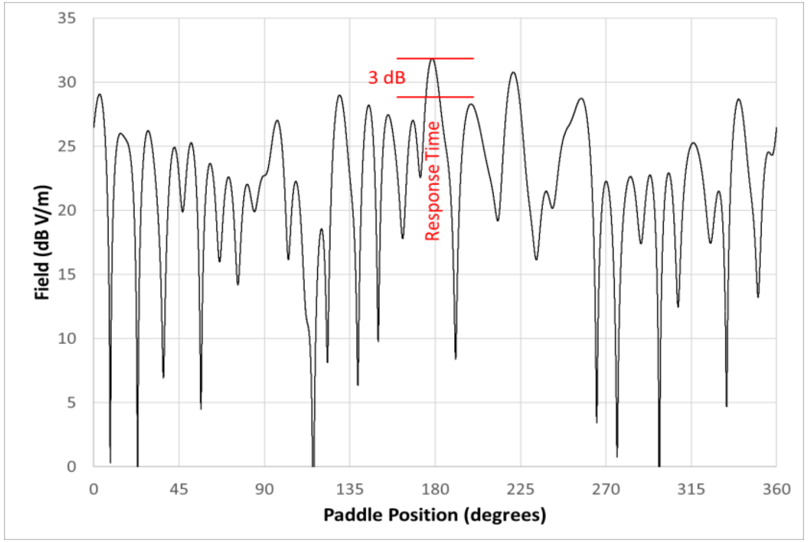
$$\Omega_m(f) < \frac{c^3}{16\pi f^3 \tau_{EUT} \sqrt{N}\, V}$$

where

τ_{EUT} is the maximum time constant (response time) (in s) for any critical component within the EUT.

Ref: IEC 61000-4-21:2011, Annex C

Consider Response Time – Proposed in DO 160



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- Rotation rate slow enough that DUT is exposed to peak field (within 3 dB) for duration of response time
- Peak width (and therefore rotation rate) decreases ~proportionally with frequency.
- Rotation rate will depend on: frequency, chamber size, response time

"Tuner" operation - Shaken

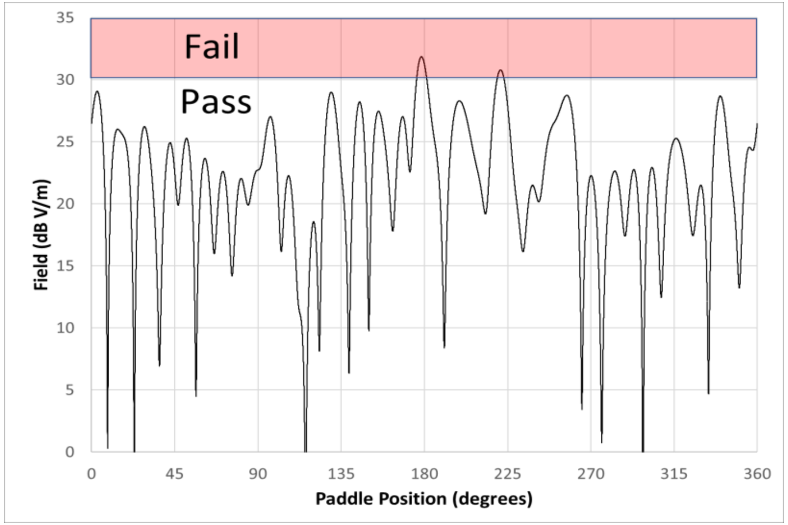
Shaken

- VIRC is excited by a shaker and this creates a constantly changing field pattern and the field values at any position are never constant during the dwell time.
- For VIRCs, the positions of the fabric walls practically cannot be fixed in their position. So, the tuned mode method is practically impossible to implement for a VIRC

- Autocorrelation for VIRC: number of shakes per second
- Coherence time - time interval between two independent stirring configurations in stirred mode

Stirred mode - Considerations

- Turbo-stirred mode where the field changes are faster than the slowest reaction time
- Stirring can be a fast and efficient test method provided the tester has a solid knowledge of EUT being tested
  - In cases where the EUT is capable of averaging or integrating the field to which it is being exposed, rapidly turning stirrers may be advantageous.
- Test exposures can vary from chamber to chamber
  - Since each reverberation chamber is quite unique, the generated test signals differ from chamber to chamber and are not identical. As a consequence, different responses in different chambers cannot be absolutely excluded.
- Test levels can depend on the EUT, not just the controlled variables.



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THANK YOU!

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