# Acoustical Measurement of Sound System Equipment according IEC 60268-21

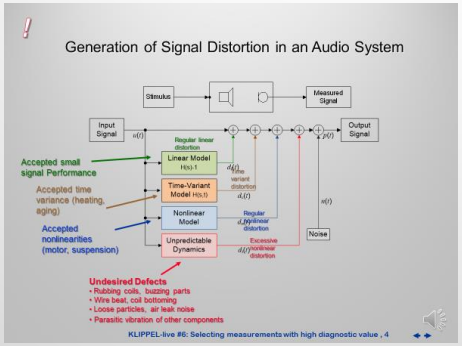
KLIPPEL LIVE

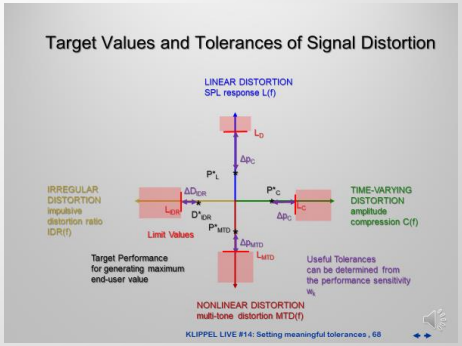
a series of webinars presented by

Wolfgang Klippel

# Previous Sessions

1. Modern audio equipment needs output based testing
2. Standard acoustical tests performed in normal rooms
3. Drawing meaningful conclusions from 3D output measurement
4. Simulated standard condition at a single evaluation point
5. Maximum SPL – giving this value meaning
6. Selecting measurements with high diagnostic value
7. Amplitude Compression – less output at higher amplitudes
8. Harmonic Distortion Measurements – best practice
9. Intermodulation Distortion – music is more than a single tone
10. Impulsive distortion - rub&buzz, abnormal behavior, defects
11. Pitfalls in Testing Wireless Audio Devices
12. Benchmarking of audio products under standard conditions
13. Auralization of signal distortion – perceptual evaluation
14. Setting meaningful tolerances for signal distortion
15. Rating the maximum SPL value for product



15th KLIPPEL LIVE:

# 评定产品的最大SPL值

## Rating the maximum SPL value for product

**今日话题 Topics today:**

- 简短概述行业中（IEC、CEA、其他准标准）使用的定义
  Short overview of the definitions used in the industry (IEC, CEA, other quasi standard)
- 如何选择满足需求的方法?
  How to choose the method satisfying my needs ?
- 如何使测量简单、快速且有意义?
  How to keep the measurements simple, fast and meaningful ?
- 如何确保日常的最佳实践?
  How to ensure best practice every day ?

# Poll:

您喜欢采用哪种定义来评定maxSPL?
Which definition would you prefer for rating maxSPL?

A. 带有明确定义细节的严格标准定义（任何修改均无或具有最小自由度） A rigid standard definition with clearly defined details (no or minimum freedom for any modification)

B. 具有明确定义框架的标准定义，给予了足够的自由度来考虑目标应用中产品的特殊性 A standard definition with clearly defined framework giving enough freedom to consider the particularities of the product in the target application

C. 我想为maxSPL创建自己的定义 I would like to create my own definition for maxSPL

D. 我认为不需要maxSPL或类似术语 I think we do not need maxSPL or a similar term

E. 其他 other

Discussed in KLIPPEL LIVE #1

# 如何根据IEC 60268-21评定$u_{max}$和$SPL_{max}$
# How to rate $u_{max}$ and $SPL_{max}$ according IEC 60268-21?

制造商可以根据以下要求自由评定$u_{max}$和$SPL_{max}$

The manufacturer has freedom to rate $u_{max}$ and $SPL_{max}$ under the following requirements:

- 标准测量条件(额定频率范围、激励、评估点等)
  standard measurement condition (rated frequency range, stimulus, evaluation point, ect. )
- DUT可以至少在100小时内以最大输入电压$u_{max}$重放激励
  DUT can reproduce the stimulus with maximum input voltage $u_{max}$ at least for 100 h
- 满足特定应用的足够音质 sufficient sound quality for the particular application
  - 有效频率范围对应额定频率范围
    effective frequency range corresponds with the rated frequency range
  - 可接受的常规非线性失真(谐波+互调)
    acceptable regular nonlinear distortion (harmonic + intermodulation)
  - 基波的轻度压缩(发热、机械限制、保护)
    low compression of the fundamental (heating, mechanical limiting, protection)
  - 可忽略的脉冲失真(由异常音或任何其他缺陷产生)
    negligible impulsive distortion (generated by rub & buzz or any other defects)

# 实践中如何进行评定?
## How to do the rating in practice ?

1. 收集背景信息 Collect background information
   - 目标应用(客户期望、典型用法) Target application (customer expectations, typical usage)
   - 音频产品的设计细节(若可能) Design details of the audio product (if possible)
2. 指定具有性能限制的标准测试条件 Specify standard test condition with performance limits
3. 通过使用性能限制，找到一个测试电压$u_{test}$作为对应于maxSPL的最大输入电压$u_{max}$的候选。 Find a test voltage $u_{test}$ as a candidate for maximum input voltage $u_{max}$ corresponding to maxSPL by using performance limits.
4. 至少对1个DUT施加$u_{max}$宽带激励100小时
   Apply the broadband stimulus at $u_{max}$ to at least 1 DUT for 100h
5. 功率测试后，检查DUT的特性是否与技术规格相符。如果检查失败，请使用较低的测试电压$u_{max}$重复步骤3-5。 Check that the properties of the DUT after power test are in agreement with the technical specification. If check fails repeat sequence 3 – 5 with lower test voltage $u_{max}$.
6. 将测试输入电压分配给最大输入电压$u_{max}=u_{test}$。确定最大SPL输出的对应值。
   Assign the test input voltage to the maximum input voltage $u_{max}=u_{test}$. Determine the corresponding value of the maximum SPL output.
7. 完成 Finished!

# 利用背景信息 Exploiting Background Information

**目标应用 Target application**

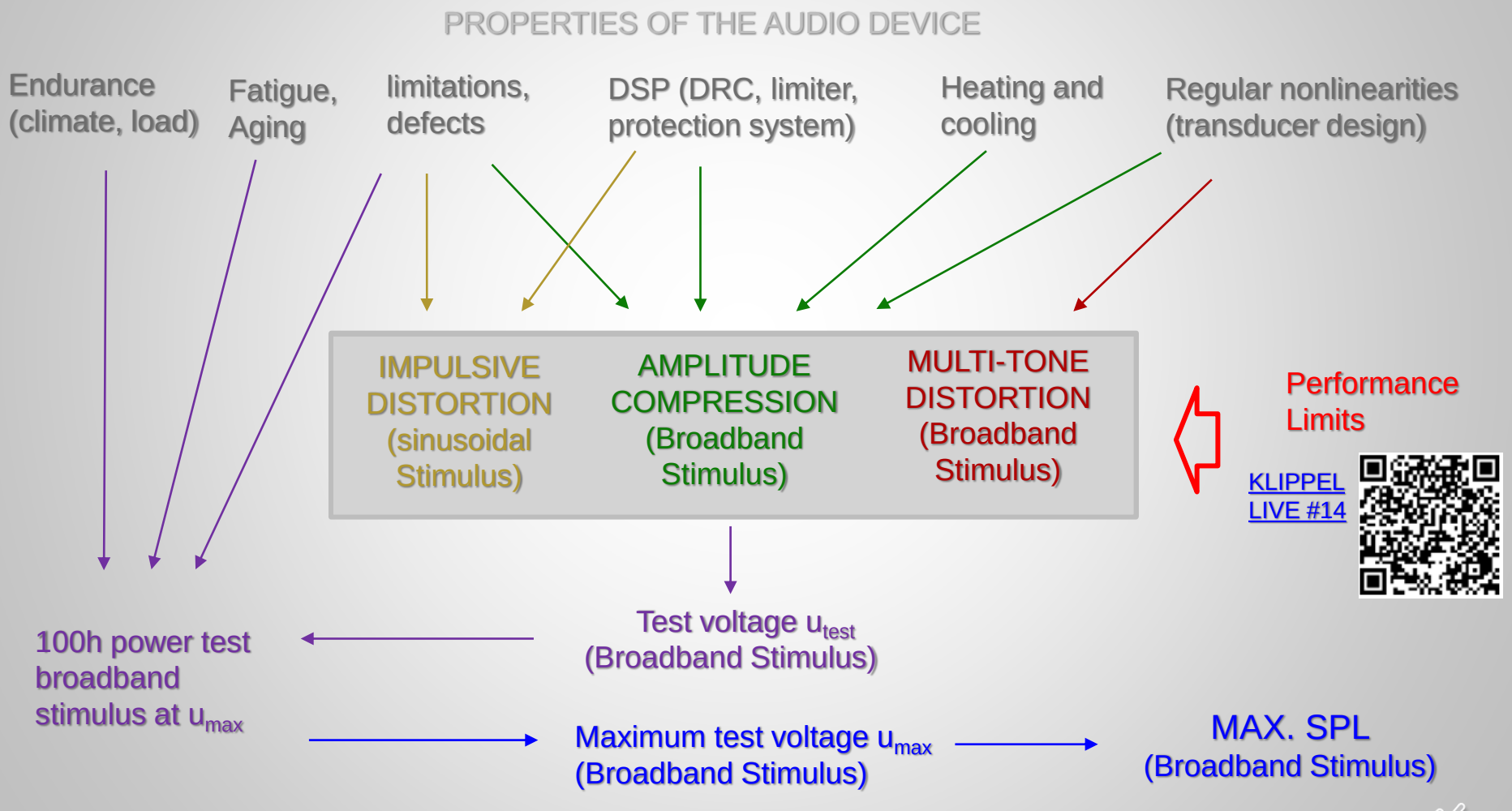
- 竞争产品的市场营销和基准测试提供了客户期望(性能特征) Customer expectations (performance features) provided from marketing and benchmarking of competitive products
- 环境(房间、汽车)的声学特性 Acoustical properties of the environment (room, car)
- 音频设备的位置(聆听范围) Positioning of the audio device (listening area)
- 音频素材(语音、音乐)的特性 Properties of audio material (speech, music)
- …

**设计细节 Design Details**

- DSP功能可主动保护换能器和放大器 DSP functionality for active transducer and amplifier protection
- 声音整形、人工低音增强和其他心理声学处理 Sound shaping, artificial bass enhancement and other psychoacoustical processing
- 节能、降噪和其他智能功能 Power saving, noise muting and other smart capabilities
- 数字和无线传输的延迟和伪值 Latency and artifacts in digital and wireless transmission
- 最大信号输入(如24dBU) Maximum signal input (e.g. 24 dBU)
- 换能单元特性(如最大音圈温度)Transducer properties (e.g. maximum voice coil temperature)
- 功放性能(如最大峰值电压) Amplifier properties (e.g. maximum peak voltage)

→ 指定性能限制和测试条件的基础 Basis for specifying the performance limits and test conditions

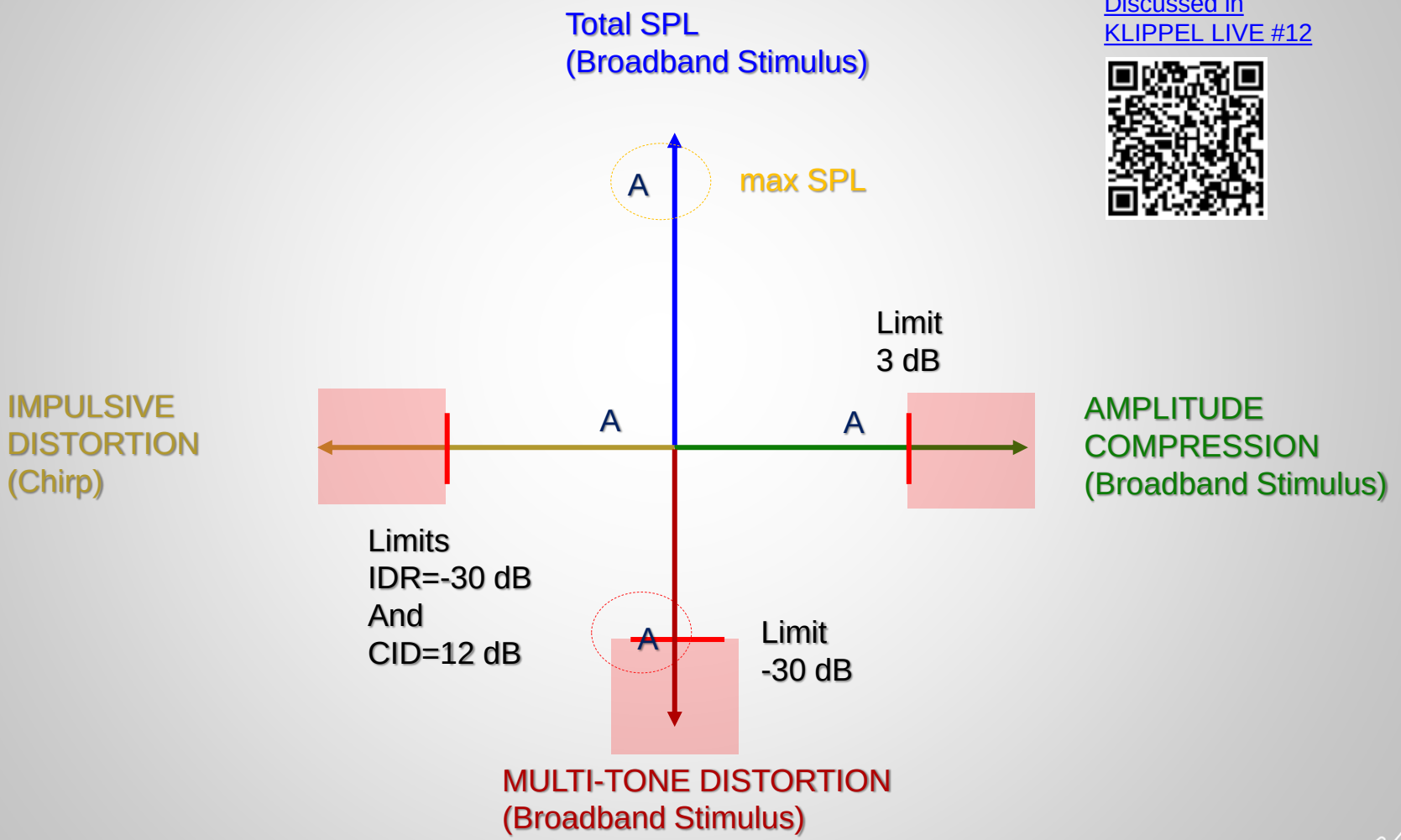
# Essential Test according IEC 60268-21



# Benchmarking by maxSPL rated by customer

## Essential Metrics according IEC 60268-21

Discussed in
KLIPPEL LIVE #12



# 压缩的限制 Limits for Compression

## 由不同部件中的发热引起 caused by heat in different components

由铜线圈中平均温度$\Delta T_v$的增加引起的通带热压缩C： Thermal compression C in pass band caused by the increase of mean temperature $\Delta T_v$ in a copper coil:

$$C(\Delta T_v) \approx 20\lg\left(\frac{R_E(\Delta T_v)}{R_E(0)}\right)$$

$$= 20\lg(1+0.0045\cdot\Delta T_v)$$

→ C= 3,2 dB for $\Delta T_v$ =100 Kelvin

**其他原因 Other factors:**

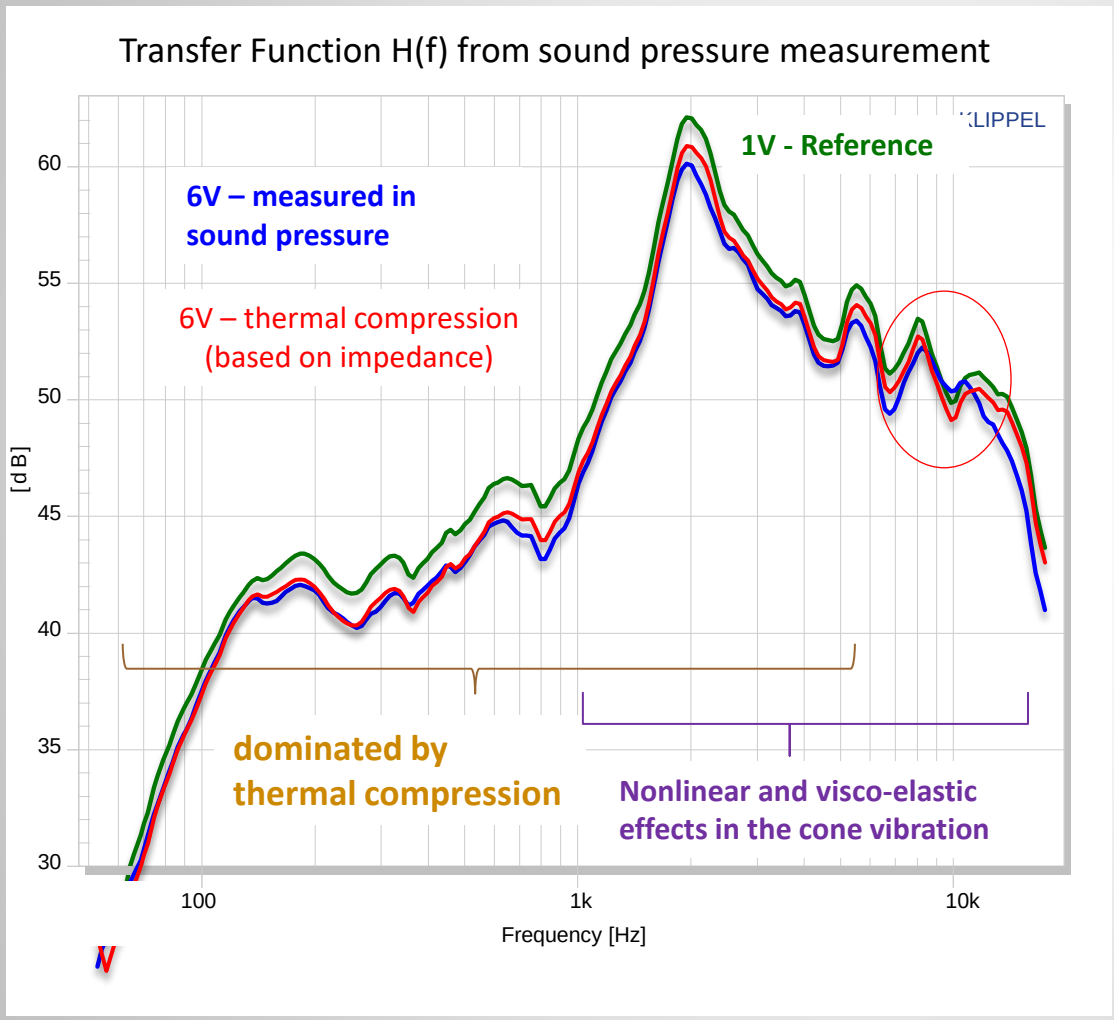
- 温度分布和热流 Temperature distribution and heat flow
- 热力学（时间常数） Thermal dynamics (time constants)
- 强制对流冷却 Forced convection cooling
- 其他组件的热学性能 Thermal properties of other components
- 安全余量 Safety margin

| Component | Critical application | Critical local temperature in the component | Corresponding thermal compression in passband | Useful limit (mean value) |
|---|---|---|---|---|
| Voice coil | Pro woofer with long coils | 150 - 400°C | 3 - 8dB | **2 - 5dB** |
| Diaphragm | Headphone, microspeaker | 100 - 200°C | 3 - 4dB | **2 - 3dB** |
| magnet | Small neodymium magnet | 100 - 250°C | 3 - 5dB | **2 - 3dB** |
| Spider | Pro woofer | 150 - 300°C | 5dB | **2 - 4dB** |

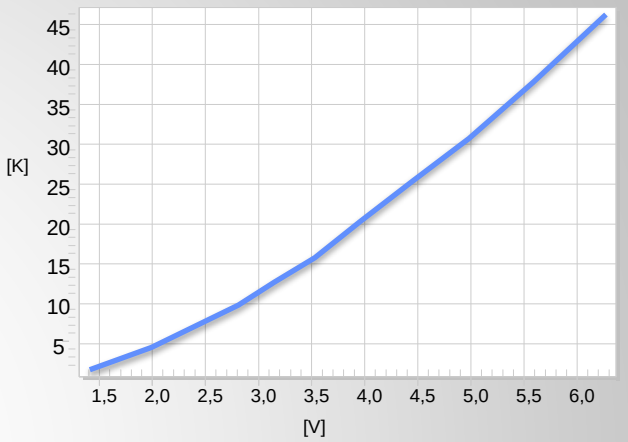
这些界限值适用于音盆分割以下通频带内的平均压缩!

The limits are applied to the mean compression averaged in the passband below cone break up !

# 分离热学和机械压缩
## Separating Thermal and Mechanical Compression

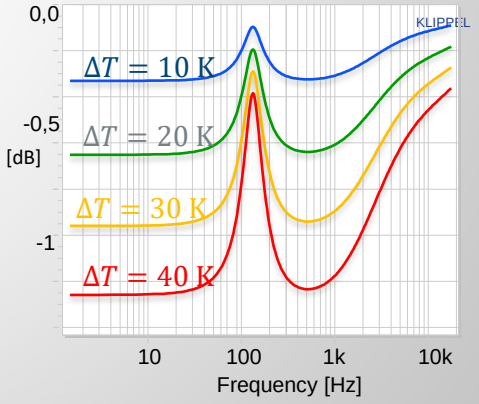



Increase of voice coil temperature




Input voltage

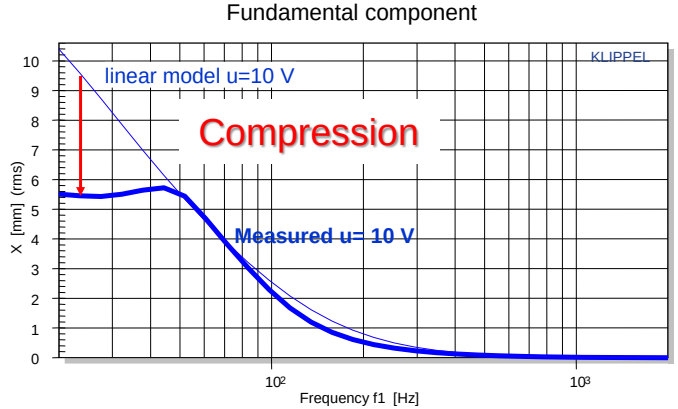
Thermal Compression based on Impedance



# 压缩的限制 Limits for Compression

## 由换能器和腔体内的常规非线性引起

caused by regular nonlinearities in transducer and enclosure




非线性压缩 Nonlinear Compression

- 发生在特定频率带Occurs in a particular frequency band
- 伴随其他非线性失真 Comes along with other nonlinear distortion
- 可指示悬挂的机械过载(→ 脉冲失真和疲劳) Can indicate mechanical overload of the suspension (→ impulsive distortion and fatigue)
- 端口处也会产生调制噪声 In a port, also generates modulated noise

| Nonlinearity | Critical frequency Band | Maximum compression in this band | Useful limit $L_C$ (mean value in this band) |
|---|---|---|---|
| Stiffness of suspension Kms(x) | $f < f_s$ | < 7dB | **2 - 4dB** |
| Force factor Bl(x) | $f < f_s$<br>$f > f_s$ multitone | < 6dB<br>< 2dB | **2 - 3dB**<br>**1dB** |
| Port resistance $R_p(v)$ | $f = f_p$ | < 10 dB | **2 - 5dB** |

开口和带通系统中压缩也是一个很有用的指示

Compression is a useful indicator in vented and bandpass systems

# 压缩的限制 Limits for Compression

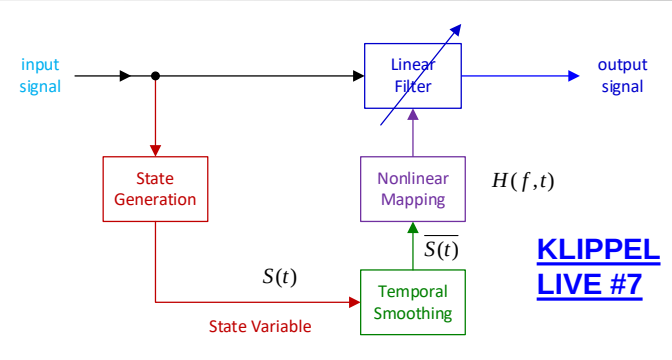
## 由电气方式和DSP引起 caused by electrical means and DSP

DSP算法 DSP Algorithms

- 可提供更多输出(maxSPL) Can provide more output (maxSPL)
- 能可靠保护音频设备 Can protect the audio device reliably

但是 BUT

- 增加延迟 Increase the latency
- 攻击阶段产生脉冲失真 Generate impulsive distortion during attack phase




| Control System | Critical frequency Band | Typical compression in this band | Useful limit $L_C$ (mean value in this band) | Consequences on audio quality |
|---|---|---|---|---|
| Dynamic Range Compressor (DRC) | Full (or selected) band | <15 dB | **2... 8dB** | impairs natural dynamics of audio input |
| Mechanical transducer protection | Low pass ($f < f_s$) | <12 dB | **2 - 7dB** | Impairs bass performance |
| Thermal protection | Full band | <8 dB | **2 - 5dB** | Minor impact |
| Power saving (noise suppression) | Full band, low pass | 12 ...20 dB | **0dB** | Should be deactivated in time (look ahead) |

界限值取决于期望音质!
Limits depend on expected audio quality !

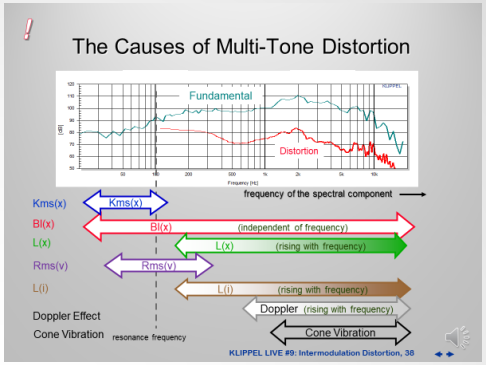
# 多音失真的限制 Limits for Multi-Tone Distortion

设置 Setup

- 激励(典型程序素材)Stimulus (typical program material)
- 平滑失真响应(Voishvillo) Smoothed distortion response (Voishvillo)
- 搜寻最大值 Searching for maximum value

多音失真揭示 Multi-tone Distortion reveals

- 来自常规非线性(换能器)的HD和IMD HD and IMD form regular nonlinearities (transducer)
- 快速变化的时变行为 Fast varying time variant behavior




KLIPPEL LIVE #9

| Control System | Critical frequency Band | Typical distortion this band | Useful limit $L_{MTD}$ (max. value in this band) | Consequences on audio quality |
|---|---|---|---|---|
| Suspension Stiffness $K_{MS}(x)$ | Low frequencies ($f < 3f_s$) | <-15 dB | **-30 ... -20 dB** | Bass performance |
| Force Factor Bl(x), | Full band | < -20 dB | **-40 ... -25 dB** | roughness |
| Inductance L(x) | Higher frequencies ($f > 5fs$) | <-25 dB | **-40 ... -25 dB** | Roughness, sharpness |
| Dynamic Range Compressor (DRC) | Full band, low pass | < -25 dB | **-40 ... -25 dB** | Fluctuation, „Pumping“ |

界限值取决于期望的音质! Limits depend on expected audio quality !

# 脉冲失真的限制 Limits for Impulsive Distortion

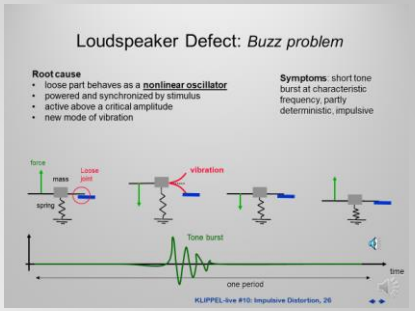
设置(符合IEC60268-21) Setup (according IEC 60268-21)

- 激励(chirp) Stimulus (chirp)
- 脉冲失真比IDR Impulsive distortion ratio IDR
- 波峰系数脉冲失真CID Crest factor impulsive distortion CID

脉冲失真揭示 Impulsive Distortion reveal

- 换能单元的非常规行为(过载、缺陷) Irregular behavior of transducer (overload, defects)
- DSP伪值(攻击阶段) Artifacts of DSP (attack phase)

See KLIPPEL LIVE #10




| Cause | Critical excitation frequencies | Typical impulsive distortion ratio (IDR) | Useful limits (max. value in this band) | Consequences on audio quality |
|---|---|---|---|---|
| Defect in Woofer ($f_s \approx 50$ Hz) | 20 Hz – 200 Hz | -60 … - 20 dB | **$-50 < L_{IDR} < -30$ dB**<br>**$12 < L_{CID}$** | low masking of impulsive distortion in worst case |
| Defect in Microspeaker ($f_s \approx 500$ Hz) | 200Hz – 2kHz | -50 … - 20 dB | **$-40 < L_{IDR} < -30$ dB**<br>**$12 < L_{CID}$** | Some masking by fundamental, regular distortion and hearing threshold |
| Mechanical Protection System for woofer with low latency | 20 Hz – 200 Hz | -60 … - 30 dB | **$-40 < L_{IDR} < -30$ dB**<br>**$12 < L_{CID}$** | low masking of impulsive distortion in worst case |
| Dynamic Range Compressor (DRC) or Limiter with low latency | Full band | -60 … - 30 dB | **$-50 < L_{IDR} < -30$ dB**<br>**$12 < L_{CID}$** | low masking of impulsive distortion in worst case |

界限值取决于目标应用(位置)和期望音质! Limits depend on target application (positioning) and expected audio quality !

# 最大SPL的完整测试方案 Integral Test Solution for max. SPL

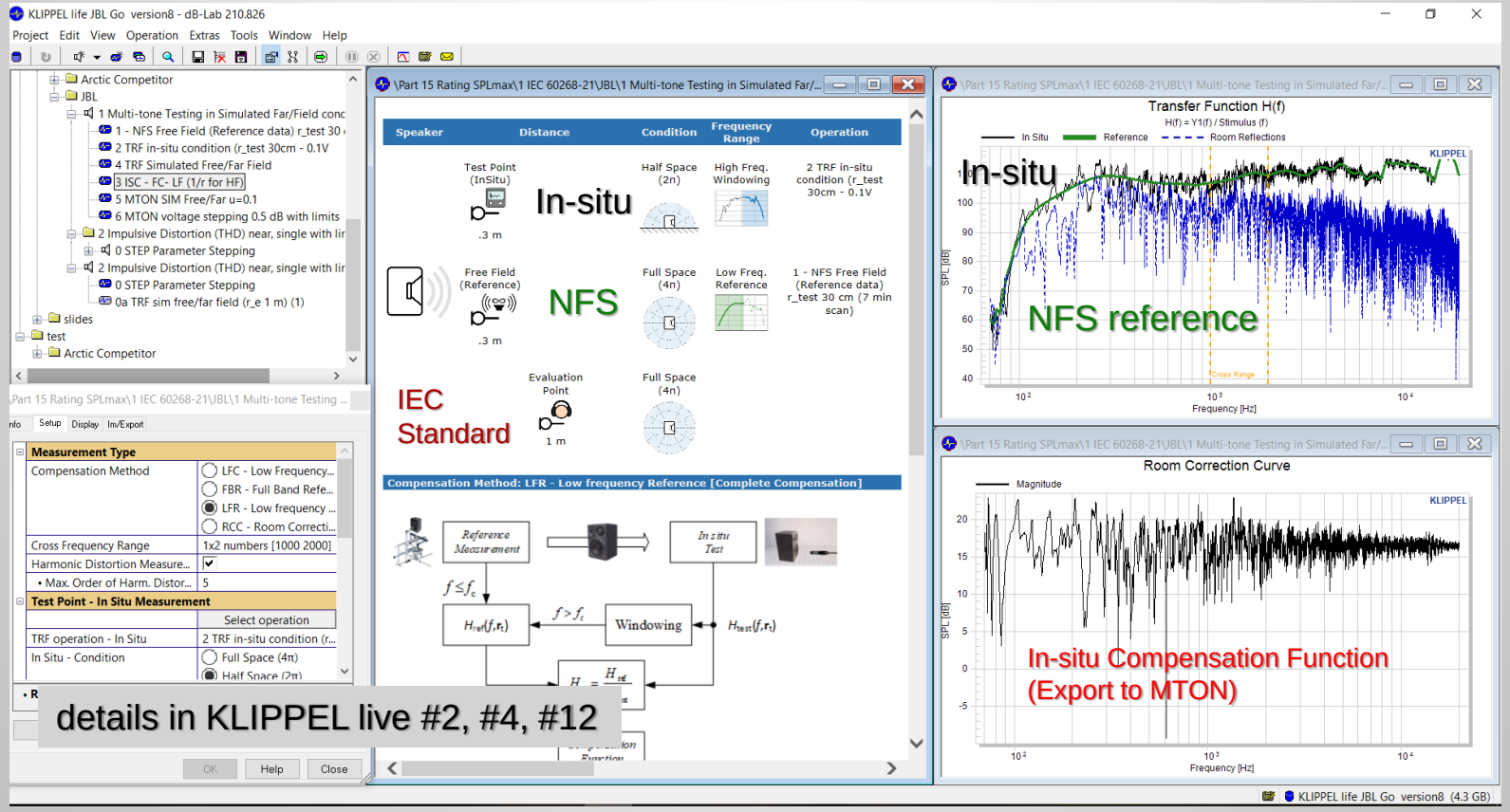
IEC 60268-21

**步骤0：准备(如果声学条件不充分) Step 0: Preparation (if acoustical conditions are not sufficient)**

a) 确保固定的房间校正曲线对音频设备有效(→ISC模块)
Ensure fixed room correction curve is valid for the audio device (→ ISC module)

KLIPPEL Analyzer

b) 通过为麦克风位置r>0.3m创建现场补偿函数来生产模拟自由场/远场条件(→ TRF, NFS, ISC modules) Generate simulated far/free field condition by creating an in-situ compensation function for microphone position r>0.3m (→ TRF, NFS, ISC modules)




details in KLIPPEL live #2, #4, #12

# 最大SPL的KLIPPEL测试方案

## KLIPPEL Test Solution for max. SPL

## IEC 60268-21

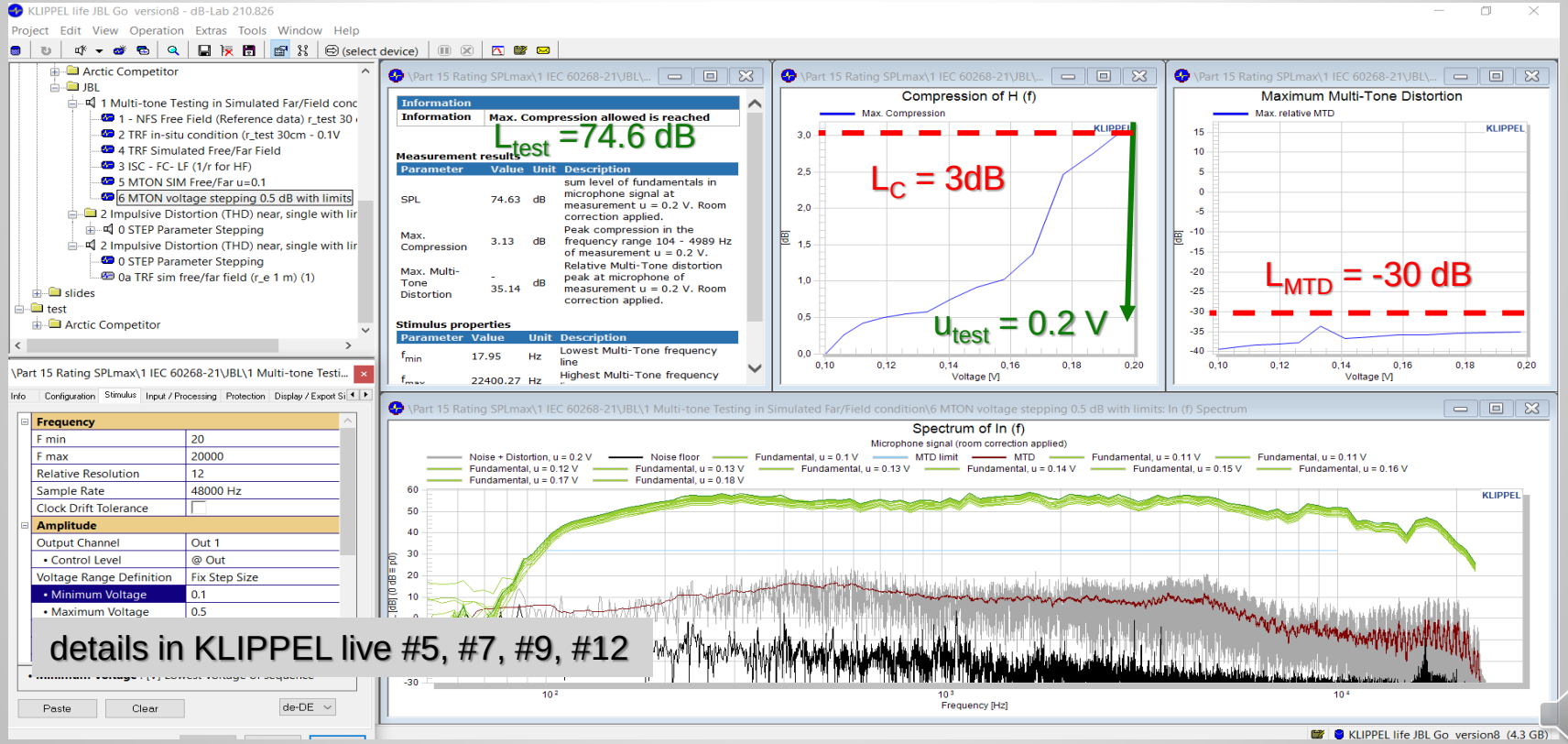
**步骤1：远场/自由场测量(多音) Step 1: Far/Free Field Measurement (multi-tone)**

a) 将麦克风放在评估距离(r=1m)或现场测试位置(r=0.3m)
Place microphone at evaluation distance (r=1m) or in-situ test position (r=0.3m)

b) 电压增加的整形多音激励 shaped multi-tone stimulus with increasing voltage

c) 自动搜索压缩或失真达到极限的最大输入电压$u_{test}$和$L_{test}$ (→ 新模组MTON) Automatic search for maximum input voltage $u_{test}$ and $L_{test}$ where either compression or distortion hit the limits (→ new MTON module)

KLIPPEL Analyzer



# 最大SPL的完整测试方案 Integral Test Solution for max. SPL

IEC 60268-21

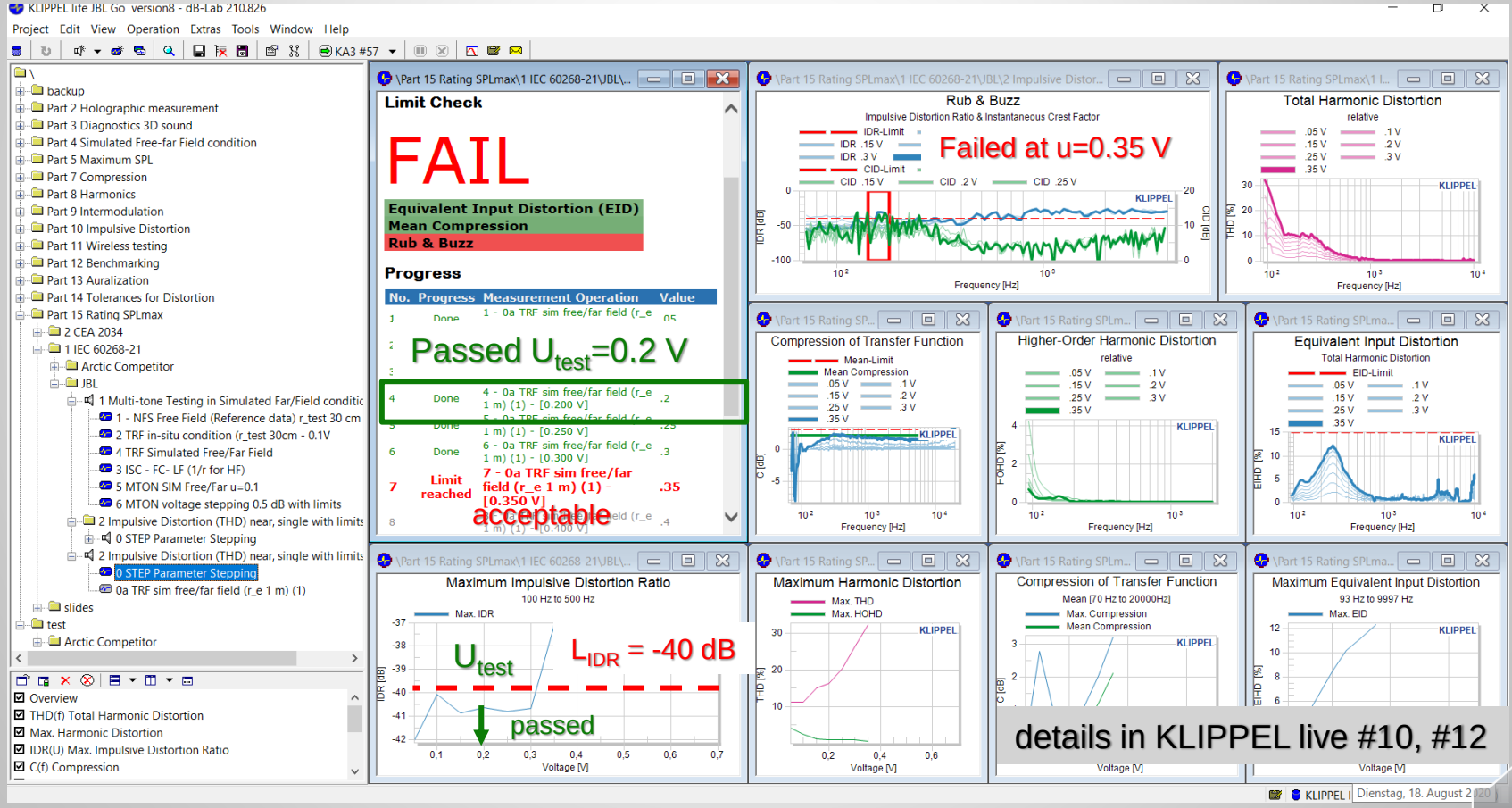
**步骤2：近场测量(Chirp) STEP 2: Near Field Measurement (chirp)**

a) 麦克风靠近振膜r<5cm (最佳SNR) Place microphone close to the diaphragm r < 5 cm (best SNR)

b) 在0.1$u_{test}$<u< $u_{test}$ 内增加电压u测量**脉冲失真**(IDR和CID)及谐波失真(可选)，同时检查极限(→新模组TRF STEP) Measure **Impulsive Distortion** (IDR and CID) and harmonic distortion (optional) with increasing voltage u with 0.1$u_{test}$<u< $u_{test}$ while checking the limits (→new TRF STEP Module)

c) 如果IDR和CID超出限制，创建一个更低的$u_{test}$值 IF IDR and CID exceeds the limits create a lower value for $u_{test}$

KLIPPEL Analyzer



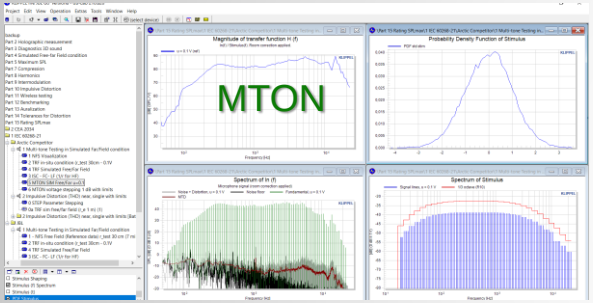
# 最大SPL的完整测试方案 Integral Test Solution for max. SPL IEC 60268-21

**步骤3：100小时长时测试(多音) 3 Long-term test 100 h (multi-tone)**

KLIPPEL Analyzer

a) 使用$u_{test}$的多音信号让DUT工作100小时(MTON → Wave Player)
Operate the DUT for 100h with the multi-tone signal at $u_{test}$ (MTON → Wave Player)

b) 检查DUT的性能并指定$u_{max}=u_{test}$和maxSPL= $L_{test}$
Check the performance of the DUT and assign $u_{max}=u_{test}$ and maxSPL= $L_{test}$

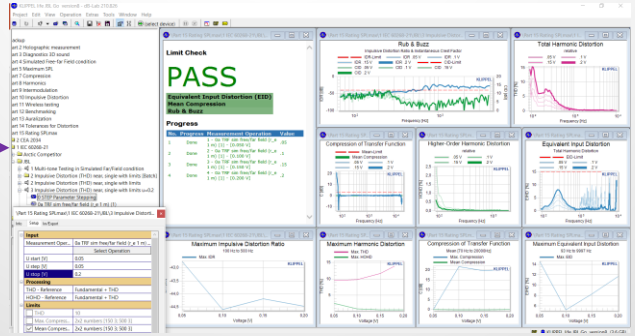



Broadband Stimulus

Wave Player →

(新的KET模块针对耐久性测试进行了优化，即将推出new KET module optimized for endurance testing coming soon)

TRF Stepping →




Rate maximum SPL

74.6 dB

details in KLIPPEL live #5, #12

Check Performance

# 额外测试 Additional Tests

## 定义测试电压$u_{test}$ for defining the test voltage $u_{test}$

KLIPPEL LIVE series

**测试音质 Testing audio quality**

- → 谐波失真(THD、EHID、chirp激励、IEC 60268-21) → #8
  Harmonic distortion (THD, EHID, chirp stimulus, IEC 60268-21) → #8
- → 无发热的谐波失真(猝发激励CEA 2010) → #15
  Harmonic distortion without heating (burst stimulus CEA 2010) → #15
- → 互调失真(双音信号、IEC 60268-21) → #9
  Intermodulation distortion (two-tone signal, IEC 60268-21) → #9
- → 非相干性(白噪或粉噪激励) → #13
  In-coherence (white or pink noise stimulus) → #13
- → 残差(音频信号)和信号失真可听化→ #13
  Residuum (audio signal) & auralization signal distortion → #13

**测试产品的可靠性和鲁棒性 Testing reliability and robustness** of the product

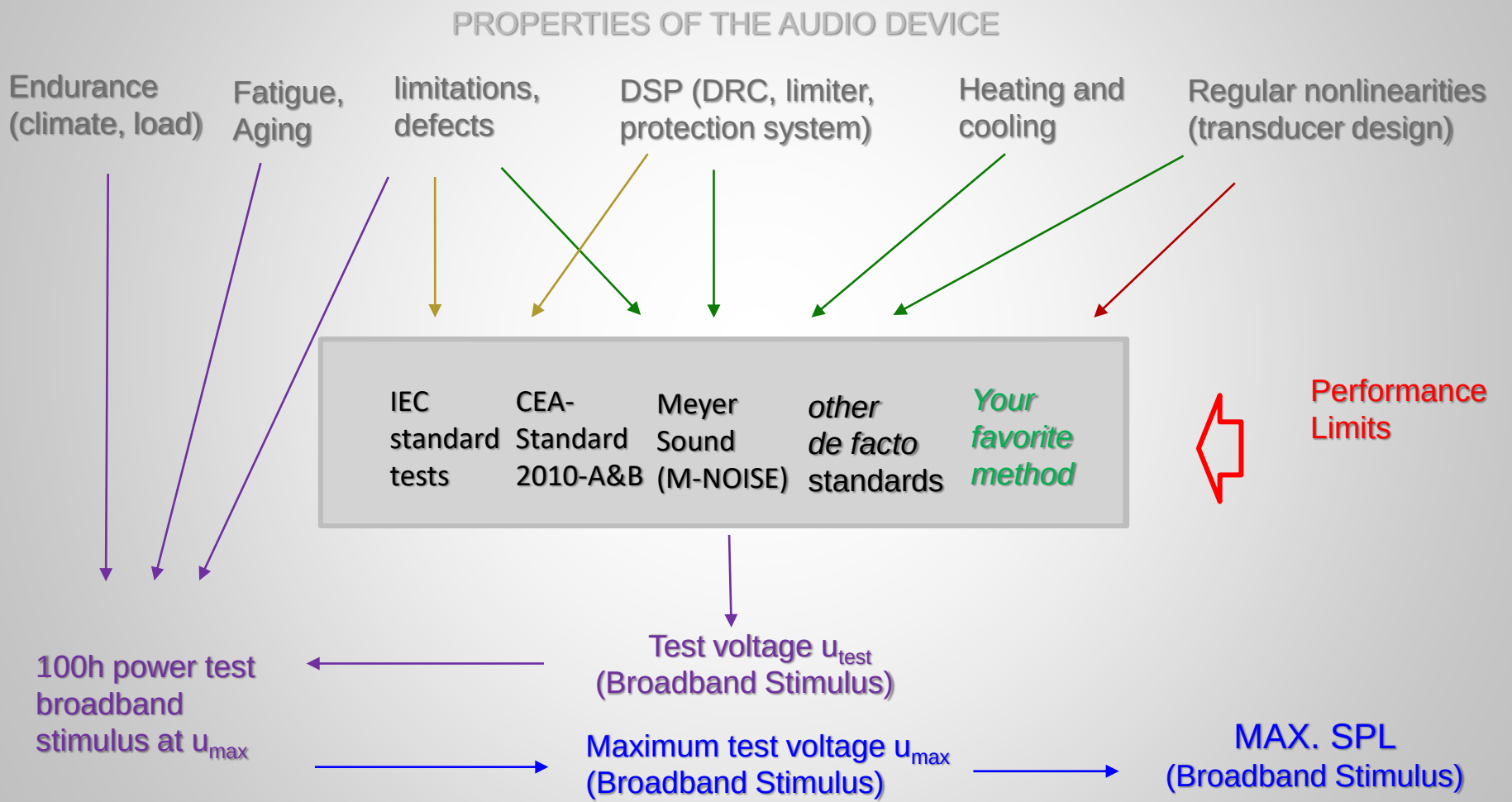
- → 破坏性测试(短时和长时最大SPL、IEC 60268-21)
  Destructive testing (short-term and long-term maximum SPL, IEC 60268-21)
- → 加速寿命测试(关键多音激励) → #5 Accelerated life test (critical multi-tone stimulus) → #5
- → 环境测试(IEC 60268-22) Environmental testing (IEC 60268-22)

# 和其他方法的比较 Comparison with Other Approaches

| | IEC STANDARD 60268-21 | CEA-Standard 2010-A&B + 2034 | Meyer Sound (M-NOISE) |
|---|---|---|---|
| 最大SPL值<br>Max. SPL value | 根据特定应用额定该值<br>Rated value according to particular application | 根据固定限制的两个测试计算该值<br>Calculated value based on two tests with fixed limits | 单次测试的测量值<br>Measured value in a single test |
| 要求<br>Requirements | DUT产生最大SPL且能承受最大输入电平(需要**100h测试**)DUT generates max. SPL and handles maximum input level (**100h test** required) | DUT达到**长时**压缩(3dB)和谐波失真固定限制时产生最大SPL DUT generates max. SPL at fixed limits **in long-term** compression (3 dB) and in harmonic distortion | DUT达到**长时**压缩(2dB)固定限制时产生最大SPL<br>DUT generates max. SPL at fixed limits in **long-term** compression (2 dB) |
| 激励<br>Stimulus | 用户定义的**宽带**激励(整形的多音) User defined **broadband** signal (shaped multitone) | • 整形的粉噪(预热1min) Shaped **pink noise** (preheating 1min)<br>• 猝发信号 Burst Signal | 有预热(5min)的特殊**M-NOISE**信号(密集全频带)<br>Special **M-NOISE** signal (dense full band) with preheating (5 min) |
| 音质<br>Audio quality | 不包含在IEC 60268-21范围内(取决于目标应用)<br>not in the scope of IEC 60268-21 (depends on target application) | 尚未完全定义(缺少重要的物理和感知方面内容) not completely defined (important physical and perceptual aspects are missing) | 尚未完全定义(缺少重要的物理和感知方面内容)<br>not completely defined (important physical and perceptual aspects are missing) |

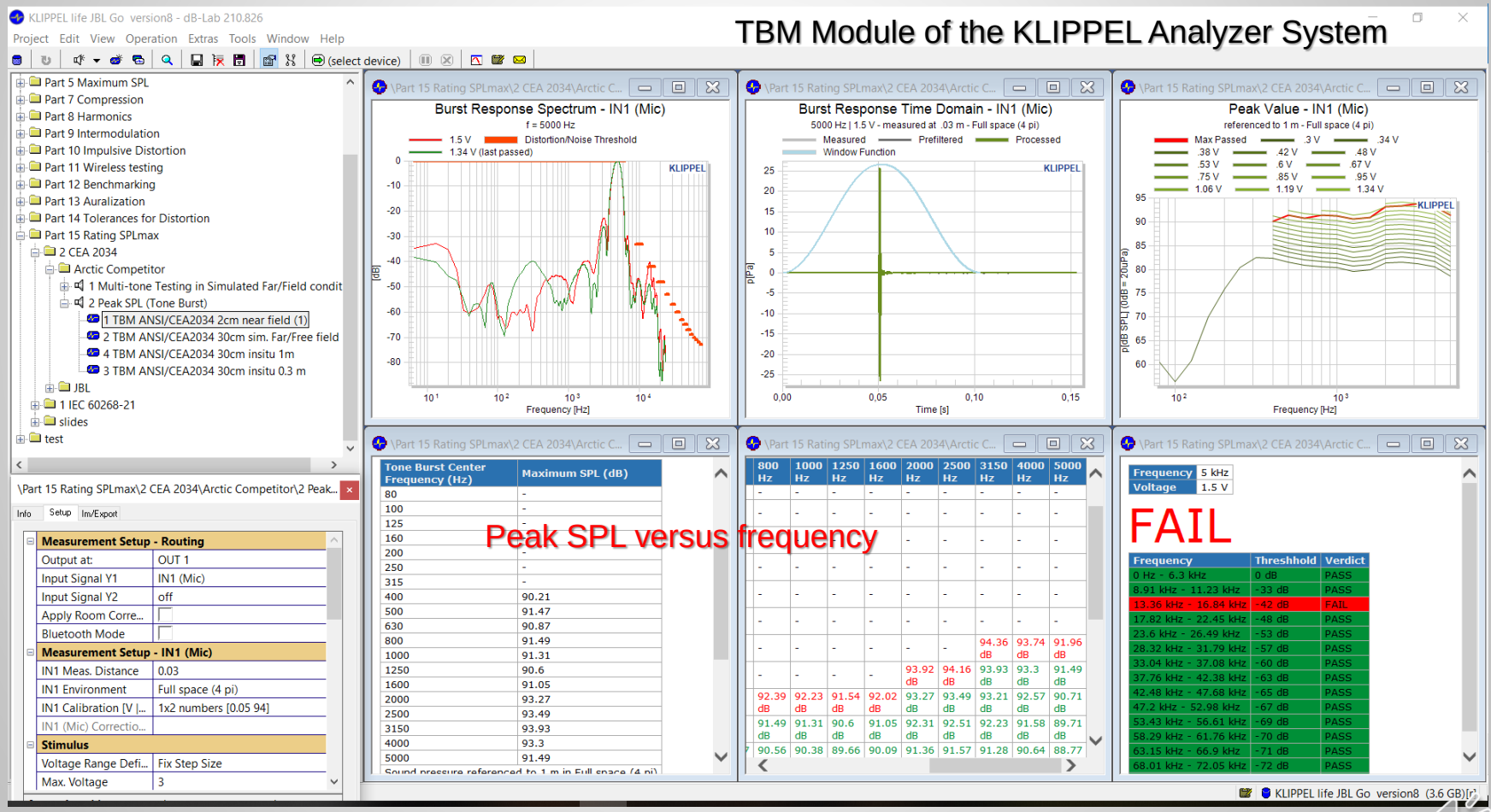
# Harmonizing other Standards or Practices

## with IEC 60268-21



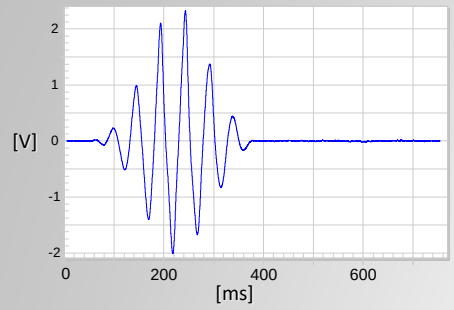
# Tone Burst Measurement

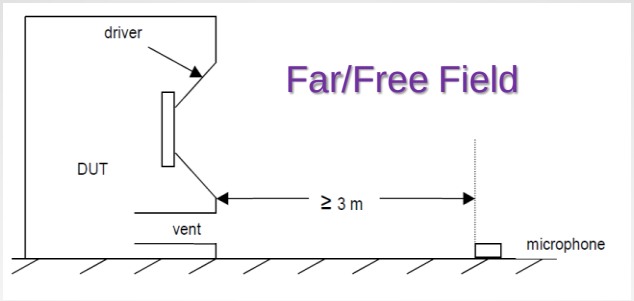
## according CEA 2010-A and CEA 2034



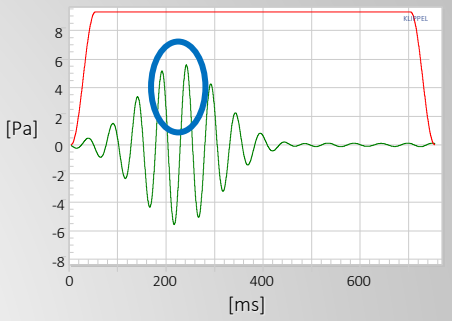
# Burst Test (CEA-2010-A)

Stimulus




Microphone Signal




Limit Check


Not sensitive for impulsive distortion

Peak Value

Increase Voltage

PASS

FAIL

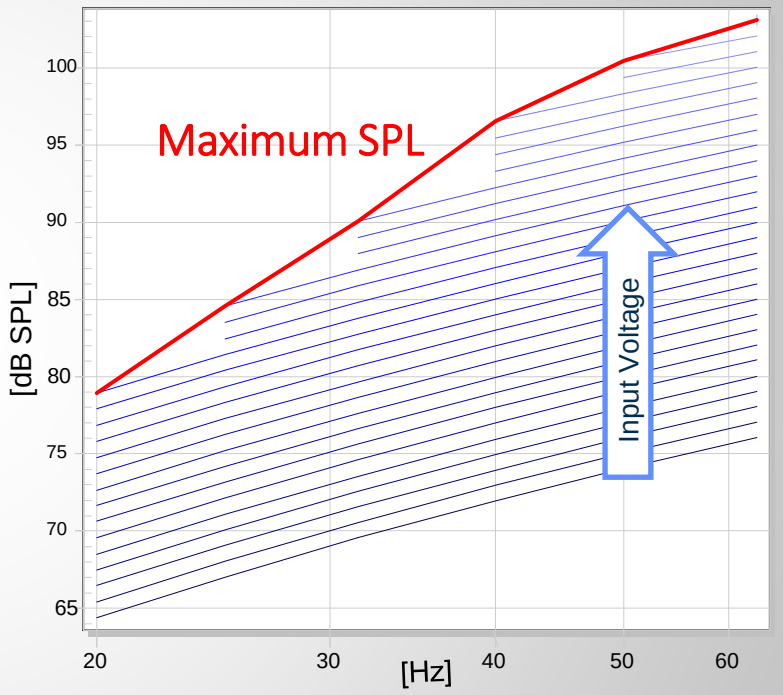
**Maximum $SPL_{burst}$**

(last passed peak value)

# Burst Test Results

SPL$_{MAX}$ referenced to 1m and 2.83V

| Tone Burst Center Frequency (Hz) | Maximum SPL | CEA-2010 Rating |
|---|---|---|
| 20 | 79 | 84 |
| 25 | 85 | |
| 31.5 | 89 | |
| 40 | 96 | 100 |
| 50 | 101 | |
| 63 | 104 | |




低频的房间效应必须补偿 Room effects must be compensated for low frequencies

# CEA 2010A中的猝发测试
## Burst Test in CEA 2010 A

优点 Benefit:

人耳对f<200Hz低频猝发的谐波失真、脉冲失真和(调制)噪声非常灵敏 Human ear is very sensitive for harmonic distortion, impulsive distortion and (modulated) noise for low frequency bursts f < 200 Hz

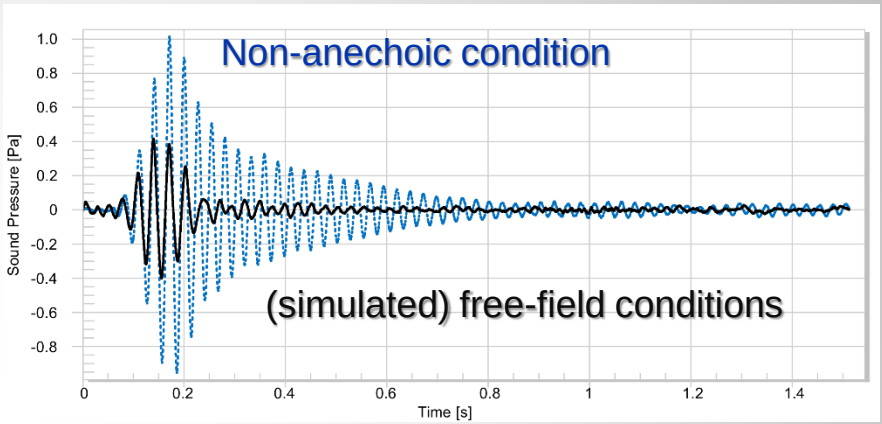
问题 Problems:

- 需要远场/自由场(房间模式能引起严重误差！) Far/free field condition required (room modes can generate a significant error !!)
- 对脉冲失真的测试不灵敏(基于能量) Test is not sensitive for impulsive distortion (energy based)
- 不良SNR(环境噪声)降低最大SPL！ Poor SNR (ambient noise) reduces max SPL!

# 问题：房间模式
# Problem: Room Modes

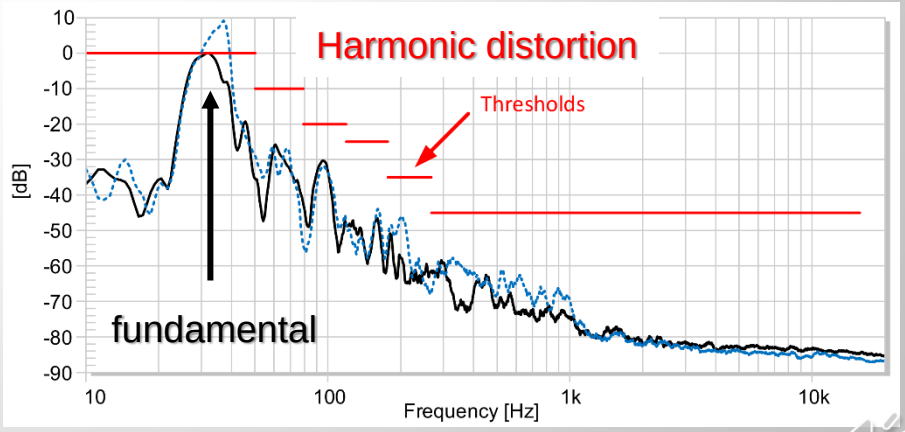
问题 Problems:

- CEA 2010需要(模拟)远场/自由场条件 CEA 2010 requires (simulated) far/free field conditions
- 房间模式是窄带共振，会影响远场中测得的声压 Room modes are narrow band resonances which affect the measured sound pressure in the far field

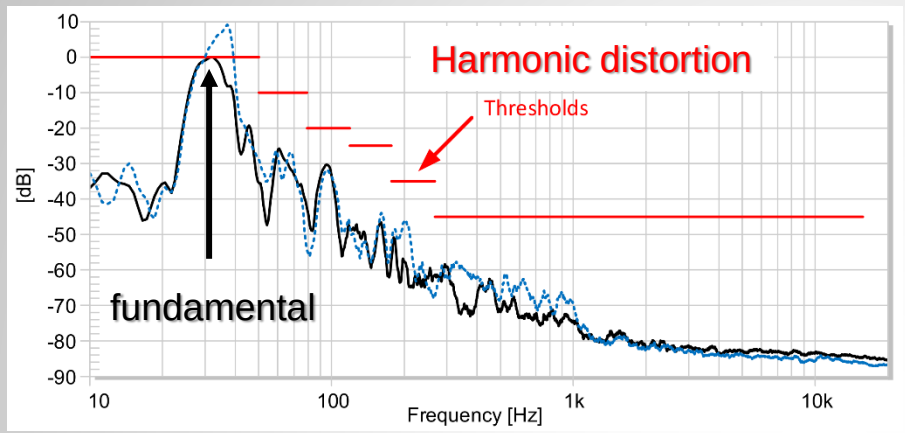


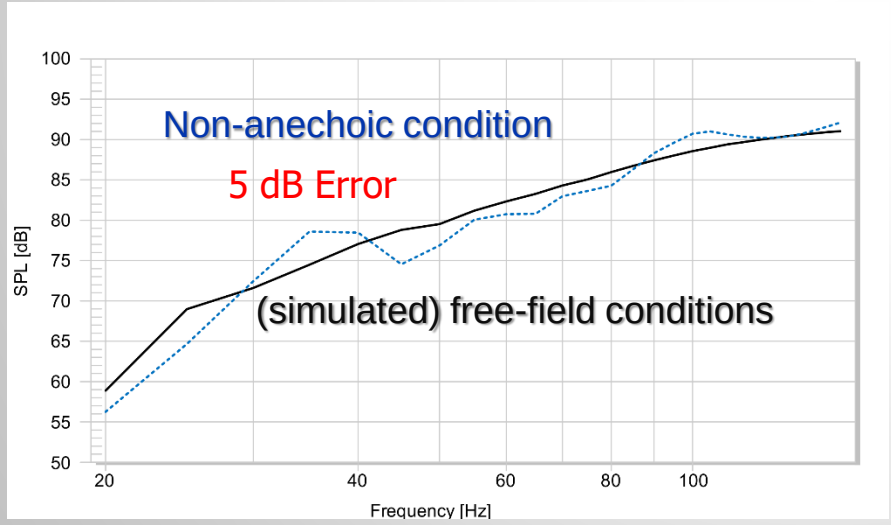

症状 Symptoms:

- 再现猝发音信号有不对称包络(振铃) Asymmetrical envelope of the reproduced burst signal (ringing)
- 影响谐波失真 Harmonics distortion affected
- 较大的声压级SPL峰值(10dB) Larger sound pressure SPL peak value (10 dB)



# 房间模式(2) Room Modes (2)




问题 Problem:

房间模式会导致最大SPL值的显著误差 The room modes generate a significant error in the maximum SPL value

用于模拟远场/自由场的复补偿滤波器可解决此问题 a complex compensation filter for simulated far/free field can solves this problem

观看KLIPPEL live #4

See KLIPPEL live #4

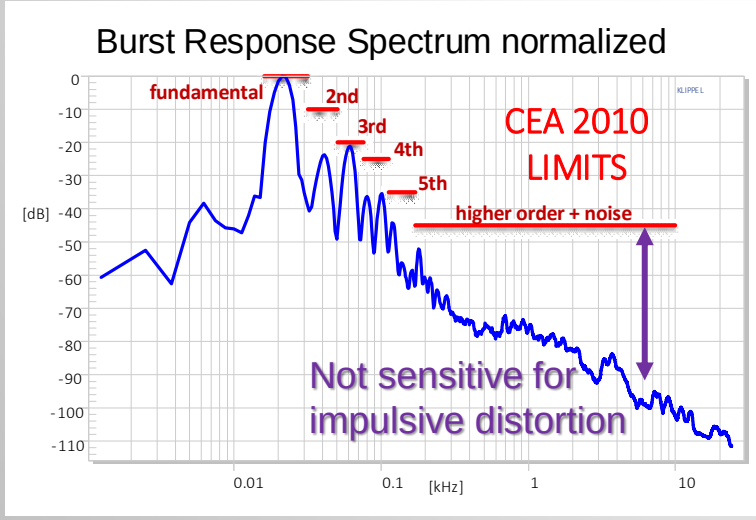
# CEA 2034中的猝发测试
# Burst Test in CEA 2034

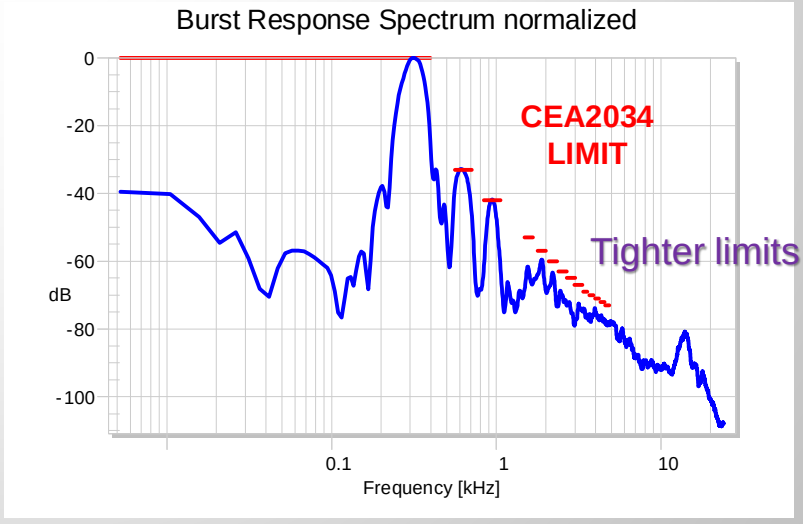
动机 Intention:

- 将猝发测试应用于其他(全频)消费类产品
  Applying burst test to other (full-band) consumer products
- 提高非常规失真、异常音、缺陷的灵敏度
  Improving sensitivity for irregular distortion, rub&buzz, defects

解决方案 Solution:

谐波失真和噪声有灵敏的限制 Sensitive limits for harmonic distortion and noise



# 宽带SPL峰值数据 Broadband Peak SPL Data calculated in CEA 2034

Results from Burst Measurement

| Frequency [Hz] | Peak SPL [dB] |
|---|---|
| 20 | 119.95 |
| 25 | 120 |
| 32 | 120.03 |
| 40 | 120.04 |
| 50 | 120.07 |
| 63 | 120.07 |
| 80 | 120.07 |
| 100 | 120.07 |
| 125 | 120.07 |
| 160 | 120.07 |
| 200 | 120.08 |
| 250 | 120.08 |
| 315 | 120.08 |
| 400 | 120.08 |
| 500 | 120.08 |
| 630 | 102.68 |
| 800 | 120.08 |
| 1000 | 120.07 |
| 1250 | 120.08 |
| 1600 | 120.06 |
| 2000 | 120.07 |
| 2500 | 120.01 |
| 3150 | 120.04 |
| 4000 | 120.03 |
| 5000 | 119.75 |

## 数据后处理 Data Post-processing

- 使用均值限制加权SPL值 Limiting the weighted SPL values using an average value
- 声压平方之和 Summing the squared pressure

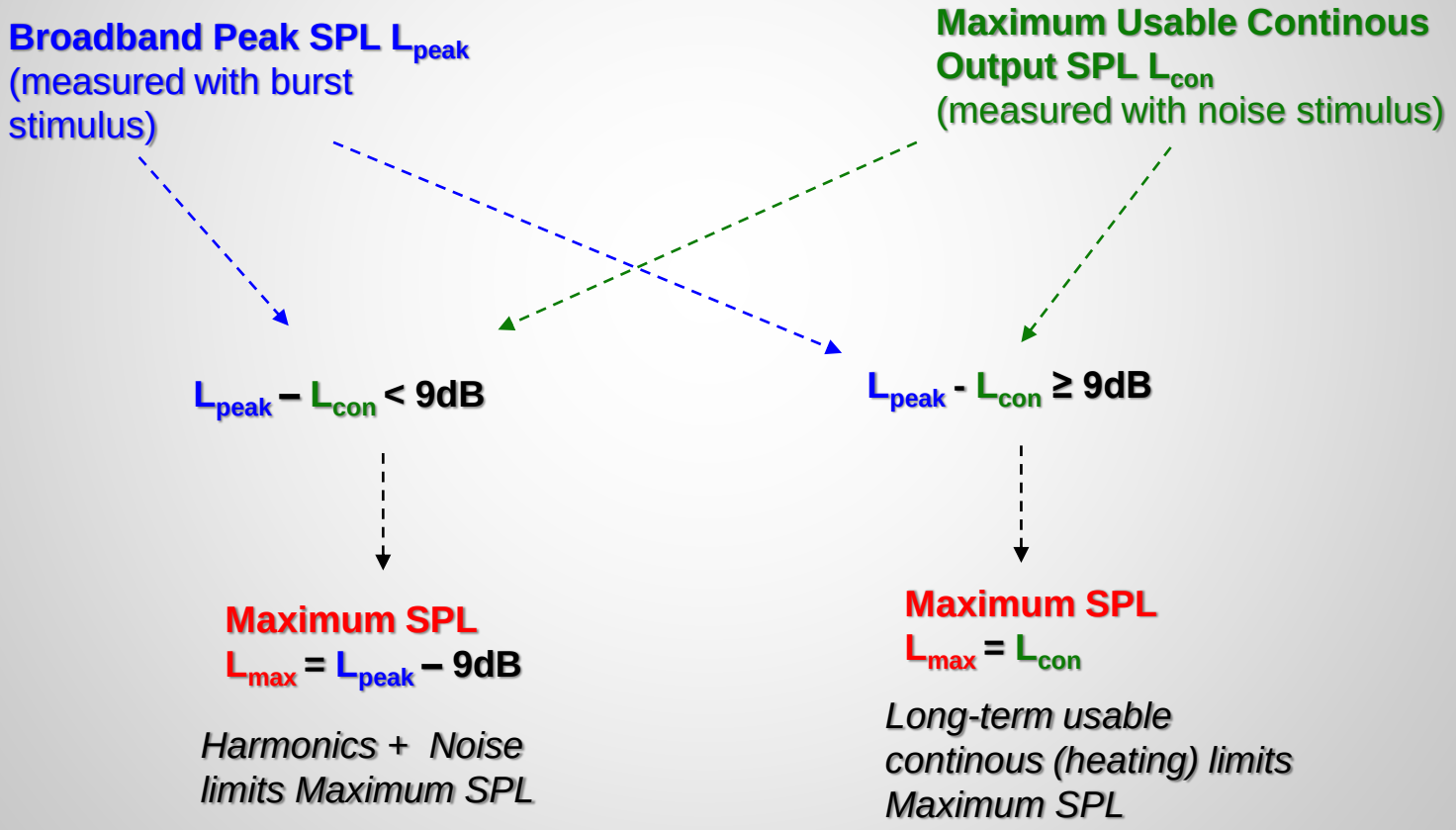
**6.2.3 Max Peak SPL Data Post-Processing**

1. The recorded peak SPL at each 1/3 octave band shall be weighted by the power spectrum given in Table 1 (6.1.1).
2. The Average Weighted SPL shall be calculated by averaging the weighted SPL values from 100 Hz to 5 kHz, inclusive.
3. The weighted SPL for any 1/3 octave band exceeding the Average Weighted SPL by 2 dB shall be reduced to a value of the Average Weighted SPL plus 2 dB.
4. The weighted & limited SPL in each 1/3 octave band shall be converted to its squared-pressure value ($p^2 = 10^{(SPL/10)}$)
5. The sum of all of the squared-pressure values for each 1/3 octave band shall be calculated.
6. The SPL of the summed squared-pressure shall be calculated (SPL = $10\log(\text{sum}(p^2))$).
7. The Broadband Peak SPL shall be the SPL of the summed squared-pressure minus 14 dB.

| Frequency [Hz] | Weigthed & limited Maximum SPL [dB] | CEA2034 - Broadband Peak SPL [dB] |
|---|---|---|
| 20 | 117 | |
| 25 | 119 | |
| 32 | 119 | |
| 40 | 120 | |
| 50 | 120 | |
| 63 | 120 | |
| 80 | 120 | |
| 100 | 120 | |
| 125 | 120 | |
| 160 | 120 | |
| 200 | 120 | |
| 250 | 120 | |
| 315 | 120 | 119.00 |
| 400 | 120 | |
| 500 | 120 | |
| 630 | 103 | |
| 800 | 120 | |
| 1000 | 120 | |
| 1250 | 120 | |
| 1600 | 119 | |
| 2000 | 119 | |
| 2500 | 119 | |
| 3150 | 118 | |
| 4000 | 117 | |
| 5000 | 115 | |

# Maximum SPL Calculation

## according CEA 2034

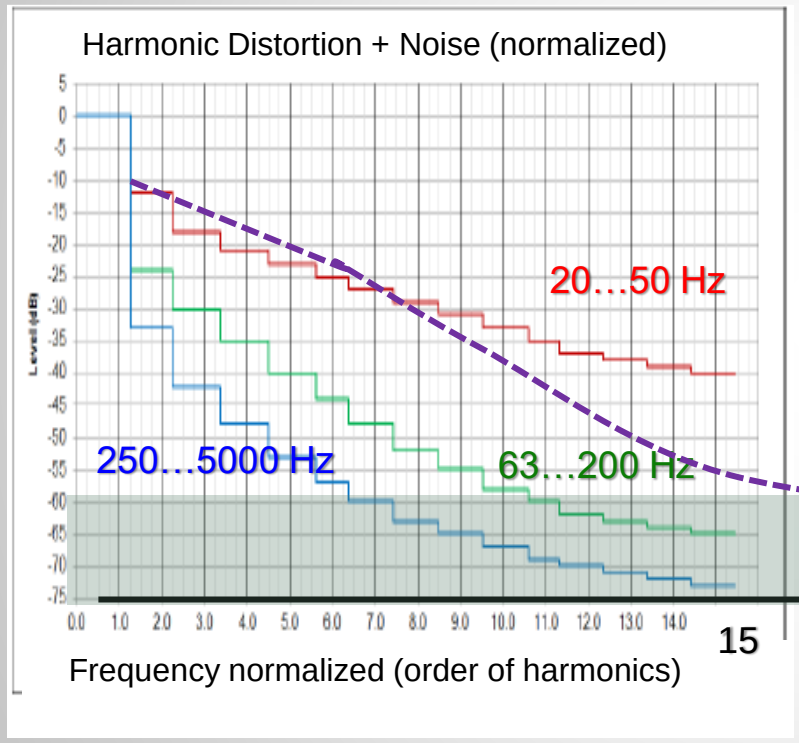


# CEA 2034中的问题
## Problems in CEA 2034

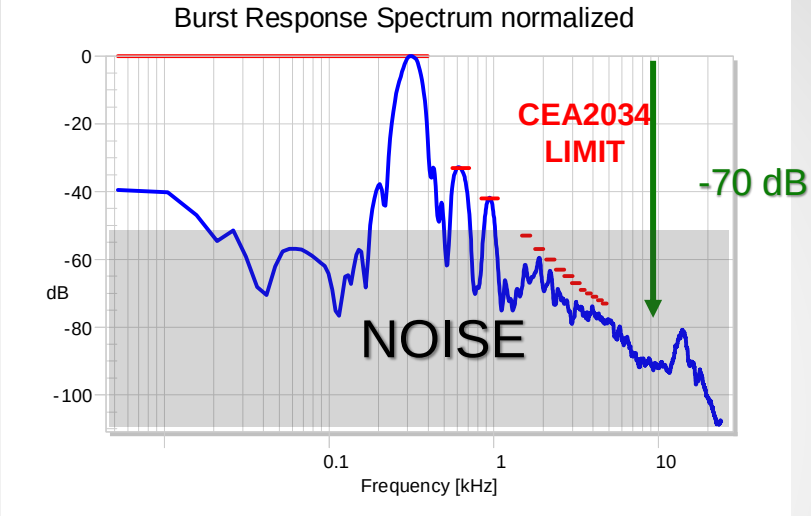
KLIPPEL LIVE series

- 未考虑互调失真(波动和粗糙感→ KLIPPEL live #14)
  Intermodulation distortion is not considered (fluctuation and roughness sensation → KLIPPEL live #14)
- 高猝发频率f>500Hz时，听音不再那么有意义(猝发太短<100ms) → #14
  Listening becomes less meaningful at higher burst frequencies f >500 Hz (burst too short < 100 ms) → #14
- 猝发激励太短而不能唤醒现代音频设备中的节能模式→ #7
  Burst stimulus is too short to wake up power saving mode in modern audio devices → #7
- 脉冲失真(异常音和其他缺陷)灵敏度低→ #10
  Poor sensitivity for impulsive distortion (rub&buzz and other defects) → #10
- 环境噪声(SNR较差)降低小扬声器的最大SPL Ambient noise (poor SNR) reduces max. SPL in small speakers
- CEA 2034提出的平均降低了所有常规失真(随机属性)的灵敏度→ #10
  Averaging proposed by CEA 2034 reduces sensitivity for all regular distortion (random properties) → #10
- 需要(模拟)远场/自由场条件→ #4 (simulated) far/free field condition required → #4

# 脉冲失真的低灵敏度 Poor Sensitivity for Impulsive Distortion a problem in CEA 2034



# 猝发测试中的环境噪声免疫
## Ambient Noise Immunity in Burst Test Problem in CEA 2010 & 2034




**问题 Problems:**

- 环境噪音降低最大SPL Ambient noise reduces max. SPL
- CEA 2034建议用平均来提高SNR，会降低具有随机特性的非常规失真的灵敏度
  CEA 2034 recommends averaging to improve SNR which reduces sensitivity for irregular distortion with random properties

**解决SNR问题 Solution for SNR problem:**

1. 根据近场(5cm) (SNR高于20dB !)的失真限制确定$u_{max,burst}$ (f)
   determine $u_{max,burst}$ (f) based on distortion limits in near field (5cm) (20dB more SNR !)
2. 使用$u_{max,burst}$ (f)在(模拟)远场中测量最大峰值$SPL_{burst}$(f) Measure maximum peak $SPL_{burst}$(f) in (simulated) far field using $u_{max,burst}$ (f)

# 最大SPL的KLIPPEL测试方案 KLIPPEL Test Solution for maxSPL

## 符合CEA 2010A和CEA 2034 according to CEA 2010A and CEA 2034

KLIPPEL Analyzer

**0 准备(如果声学条件还不充分) 0 Preparation (if acoustical conditions are not sufficient)**

a) 确保固定的修正曲线对音频设备有效(→ ISC模组) Ensure fixed room correction curve is valid for the audio device (→ ISC module)

b) 通过为麦克风位置r>0.3m创建现场补偿函数来生产模拟自由场/远场条件(→ TRF, NFS, ISC模组)
Generate simulated far/free field condition by creating an in-situ compensation function for microphone position r>0.3m (→ TRF, NFS, ISC modules)

**1 远场/自由场测量(连续、多音) 1 Far/Free Field Measurement (continuous, multi-tone)**

a) 放置麦克风到评估距离(r=1m)或者现场测试距离(r=0.3m)
Place microphone at evaluation distance (r=1m) or in-situ test position (r=0.3m)

b) 增加整形多音激励的电压 shaped multi-tone stimulus with increasing voltage

c) 自动搜索压缩或失真达到极限的最大测试电压$u_{con}$和$SPL_{con}$ (→新模组MTON)
Automatic search for maximum test voltage $u_{con}$ and $SPL_{con}$ where either compression or distortion hit the limits (→ new MTON module)

**2 近场测量(猝发) 2 Near Field Measurement (burst)**

a) 放置麦克风靠近振膜r<5cm(最佳SNR) Place microphone close to the diaphragm r < 5 cm (best SNR)

b) 自动搜索**归一化**谐波失真超过极限的最大测试电压$u_{burst}(f)$ (→新模组TBM) Automatic search for maximum test voltage $u_{burst}(f)$ where **normalized** harmonic distortion exceeds the limits (→new TBM module)

**3 远场/自由场测量(猝发) 3 Far/Free Field Measurement (burst)**

a) 放置麦克风到评估距离(r=1m)或者现场测试距离(r=0.3m) Place microphone at evaluation distance (r=1m) or in-situ test position (r=0.3m)

b) 在**归一化**谐波失真超过极限的最大测试电压$u_{burst}(f)$ 下测量最大SPL (→新模组TBM) SPLMeasure maximum SPL at maximum test voltage $u_{burst}(f)$ where **normalized** harmonic distortion exceeds the limits (→new TBM module)

**4 指定最大SPL 4 Assignment of maxSPL**

a) 基于$SPL_{con}$和$SPL_{burst}$计算最大SPL Calculate maxSPL based on $SPL_{con}$ and $SPL_{burst}$

b) 执行100h测试以符合IEC 60268-21(可选但强烈推荐) Perform 100h test to comply with IEC 60268-21 (optional but strongly recommended)

# 最后：什么是重要的?
## At the end: What is important ?

IEC 60268-21的讯息 Message of IEC 60268-21:

- 使用IEC 60268-21提供的**自由度** Use the **freedom** provided by IEC 60268-21
- 明确定义和记录**测试条件** Clearly define and document the **test conditions**
- 考虑**可靠性**和**耐久性**并用$u_{max}$处的100h功率测试检查 Consider **reliability** and **endurance** and check it with a 100 h power test at $u_{max}$
- 把最大SPL值连带记录的测量条件提供给同事、供应商和客户(标准简化工作量！) Provide maxSPL value together with **documented** measurement conditions to your coworkers, suppliers and customers (standard simplifies the effort !)

然后 THEN

KLIPPEL LIVE series

以下方面maxSPL将是一个有意义的数值 MaxSPL becomes a **meaningful** number for

- 校准有源系统的输入→ #5 Calibrating the input of active systems → #5
- 音频产品的基准测试→ #12 Benchmarking of audio products → #12
- 制作终端用户眼里的好产品→#14 Making better products as seen by the end user →#14

# Discussion

# 结论 Conclusions

- 基于输出的测量可以确保对音频设备进行全面评估
  OUTPUT based measurements can ensure comprehensive evaluation of audio devices
- DSP算法、无线传输、智能放大器需要现代测量技术
  DSP algorithms, wireless transmission, smart amplifiers need modern measurement techniques
- IEC标准60268-21是一个很好的基础，已经可以服务于您的应用 IEC Standard 60268-21 is a good basis and is ready for your application
- 向IEC或AES标准委员会提供任何反馈(错误、新想法)
  Provide any feedback (errors, new ideas) to IEC or AES standard committees
- 感知建模和可听化技术可以进一步缩小聆听和测量之间的差距(未来标准项目？) Perceptual modeling and auralization techniques can further reduce the gap between listening and measurement (future standard project ?)

# 分享和使用资料 Share and Use the Material

KLIPPEL LIVE**“符合IEC 60268-21音响系统设备的声学测量”**?
KLIPPEL LIVE “**Acoustical Measurement of Sound System Equipment according IEC 60268-21**” ?

1. 在www.klippel.net.cn免费访问录制的网络研讨会
   Free access to the recorded webinars on www.klippel.net.cn

2. 联系 rnd-support@klippel.de 或者 china@klippel.de ，
   Contact rnd-support@klippel.de if you
   - 需要更多详细信息 need more detailed information,
   - 发现错误，有些建议或新想法 found errors, have some suggestions or new ideas,
   - 需要软件和模板以及免费demo授权进行实际评估 need software and templates for practical evaluation with free demo license,
   - 其他 other things

# 展望 OUTLOOK

新KLIPPEL Live网络研讨会系列主题 A new KLIPPEL Live webinar series entitled
**“符合IEC 60268-22的换能单元和系统的电学和机械测量”**
**“Electrical and Mechanical Measurement of Transducers and Systems according IEC 60268-22”**

将讨论 will address the points:

- 考虑基本物理关系 Considering fundamental physical relationships
- 利用扬声器建模能力(集总、模态、有限元、面向系统等)
  Exploiting the power of loudspeaker modeling (lumped, modal, finite element, system oriented…)
- 识别模型参数 Identification of free model parameters
- 优化设计和产品开发 Optimal design and product development
- DSP开发的结论 Consequences for DSP development
- 以及更多 and much more