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

12th KLIPPEL LIVE:
Benchmarking of audio products under standard conditions

Topics today:

- Selecting essential physical characteristics at low and high amplitudes
- Benchmarking based on supplier specification
- Benchmarking at the same maxSPL defined by customer
- Simple benchmarking by rating maxSPL based on defined performance limits
- Practical application of the methods to two Bluetooth speakers

Poll:

How do you benchmark your audio products?

(multiple choices)

A. I have never done it 0%
B. Comparing technical specification provided by manufacturer 47%
C. Performing physical measurements on the device(s) and comparing the results 76%
D. Listening to the products reproducing my favorite audio samples 53%

Performance Metrics for Audio Devices

- cost
- size, volume, shape, weight
- maximum output (max. SPL, max. power $P_{a,max}$)
- efficiency (power consumption P_E, heating, mobile operation time in battery powered devices)
- perceptual audio quality (spectral and spatial properties, distortion)
- reliability (probability of failure)
- endurance of external stress (overload, environment)
- artistic product design and ergonomics
- technical story
- reputation of the brand, personal identification with the product
- enjoyment or hedonistic preference

Our topic today: Special physical Measurement (under standard condition)

Poll:

What is important for your bench marking ?
(multiple choices)

A. maximum output (max. SPL, max. power $P_{a,max}$) 61%
B. efficiency (power consumption P_E, heating, mobile operation time in battery powered devices) 39%
C. perceptual audio quality (spectral and spatial properties, distortion) 87%
D. reliability (probability of failure) 39%
E. endurance of external stress (overload, environment) 26%

Reduce complexity !

The benchmarking of audio products can be simplified in the following way:

- Comparing similar products (e.g. headphones)
- Designed for a clear defined group of end-users (e.g. teenager)
- Specify final application condition (e.g. in-ear)
- Select a minimum of metrics evaluating the important properties
- Use metrics which are clearly defined (e.g. standards)
- Define the evaluation condition (e.g. input level)

Important Standard Characteristics

Characteristics	output based testing
On-axis fundamental transfer response	*
3D output, directivity[3]	*
Electrical impedance[5]	-
Lumped parameters (linear, nonlinear,thermal)[5]	-
Amplitude compression[3]	*
DC-displacement X_{DC}[4]	(*)
Harmonic distortion (THD, 2nd, 3rd-order)[3]	*
Multi-tone distortion(HD +IMD)[3]	*
Distortion in reproduced audio signal	*
Modulated noise	*
Impulsive distortion (rub & buzz)[3]	*
Destructive test	*
Maximum displacement X_{MAX}[4]	(*)
Maximum SPL_{MAX} or input voltage U_{MAX}[3]	*
100h-long-term test[3]	*
Accelerated life test[5]	*
Environmental test[5]	*

[3]performed according **IEC 60268-21**
[4]measured according IEC 62458
[5]measured according IEC 60268-22 CDV

Parameters of a model (independent of the stimulus)

Symptoms measured with a defined test signal

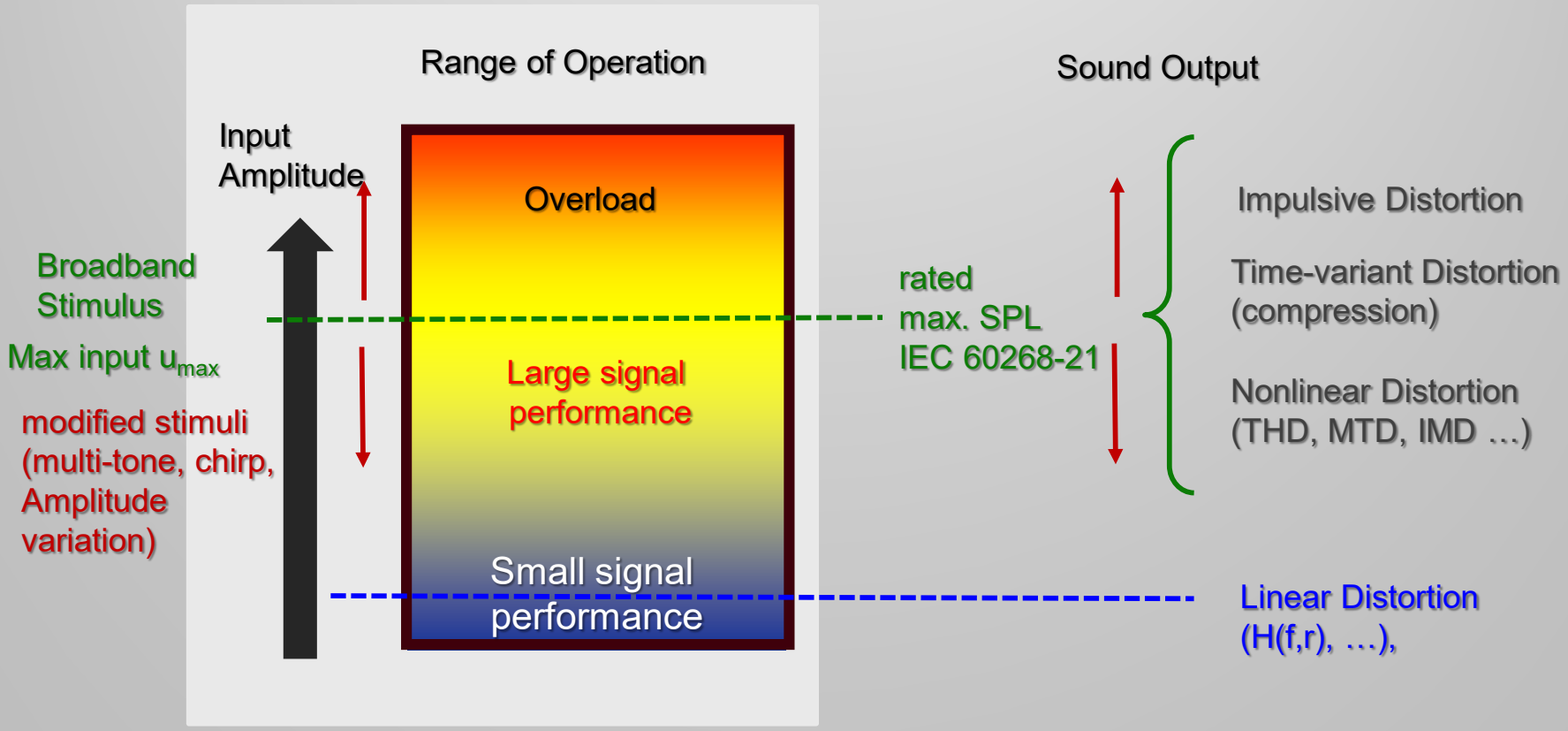
Rated characteristics considering the particular application

Long term testing with stimulus representing program material

Important for benchmarking

Evaluation Condition

The magnitude of the test stimulus has a high impact on performance of the audio system !



The rated maximum SPL (maximum input voltage u_{max}) according to IEC 60268-21 simplifies the benchmarking !

Benchmarking at Low Amplitudes

Measurement Condition:

- Small Signal Domain ($u=0.1\ u_{max}$)
- Any broadband stimulus
- Selected points (on-axis, listening zone) under far field /free field condition (CEA 2034 Standard)

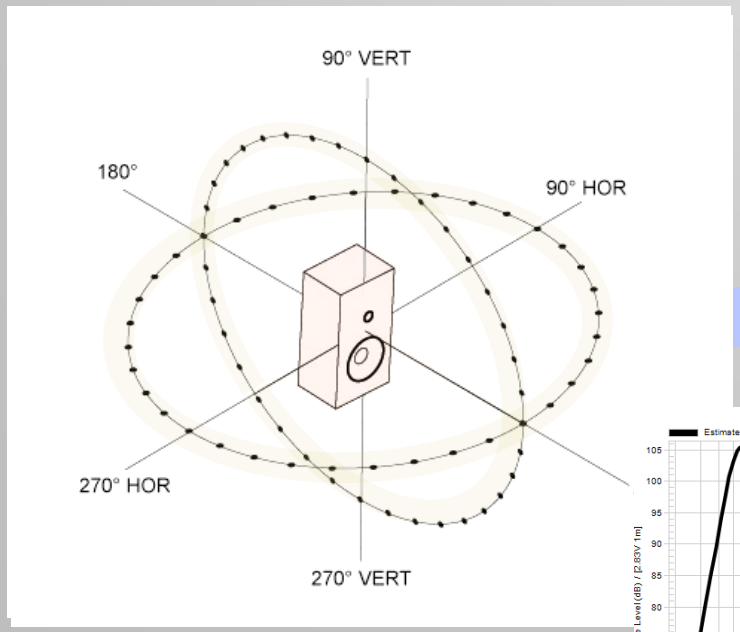
Important Metrics for Linear Distortion:

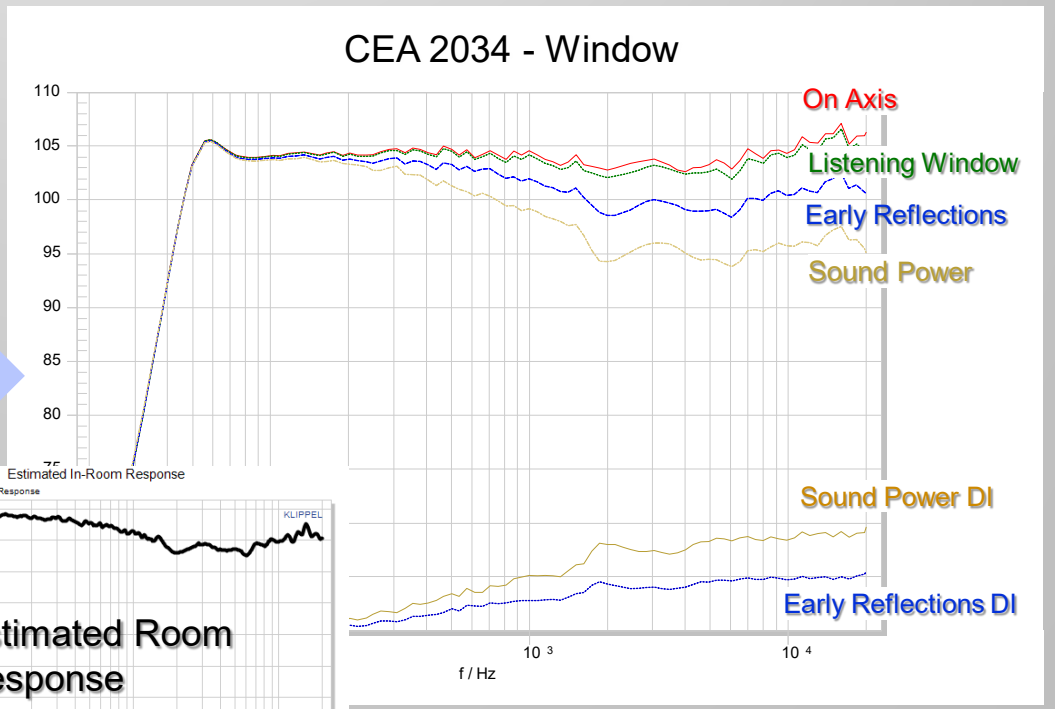
1. Upper and lower limits of the effective frequency range (IEC 60268-21)
2. SPL response (e.g. estimated room response CEA 2034 Standard) smoothed with 1/3rd octave
3. Mean deviation from a target response (new IEC project TV, monitor)

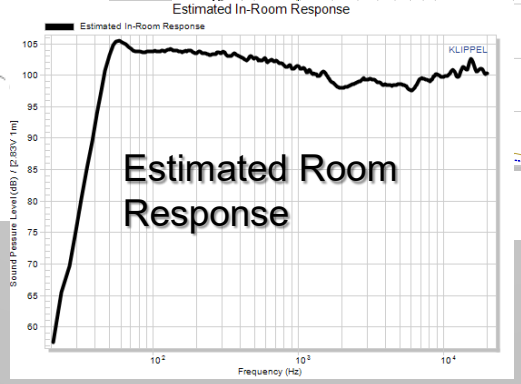
CEA 2034 Standard

using Spino-a-rama

Application : Home audio devices, Hifi-Loudspeaker



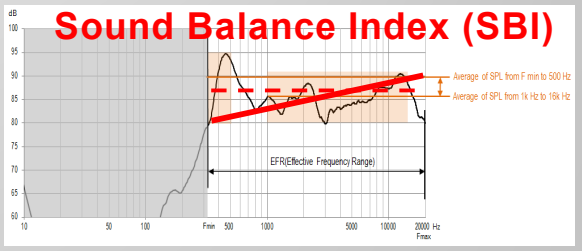


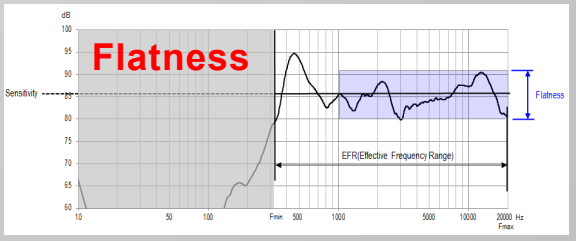


New Metrics for Linear Distortion

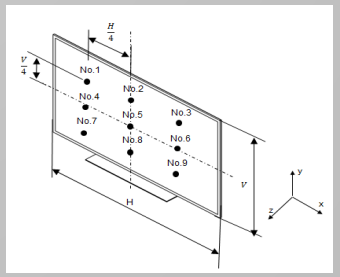
Measurement methods for TV and monitor audio systems
New IEC Project: PT 100-31

Measuring metric	Unit	Definition
Sound Balance Index (SBI)	**dB**	**The difference of SPL between different frequency band**
Flatness	**dB**	**Standard deviation of SPL in the and different frequency band**
SPL uniformity	%	Uniformity of SPL at screen 9 points and speaker on axis
Effective Frequency Range (EFR)	Hz	Frequency band which the speaker can play at each location
Sensitivity	dB	Average of SPL between EFR
Total Harmonic Distortion (THD)	%	Amount of output signal compared to input signal
Directivity index	dB	The ratio of the following two SPL values
Radiation angle	Degree	Angle of less than 10 dB below the SPL on the on axis
Coverage angle	Degree	Angle between direction 6 dB less than maximum SPL





SPL uniformity



Essential Metrics according IEC Standards

for Assesing Small Signal Performance

affects the „Low bass performance“

Lower limit of effective frequency range

Upper limit of effective frequency range

variance of SPL response versus frequency (contra flatness)

Contributes to the „sharpness“

→ Perceived as „sound coloration“

Sound Balance Index

There are other important metrics defined in various standards:

- *Sound Power Directional Index IEC 60268-21*
- *Latency IEC 60268-21*

Benchmarking at High Amplitudes

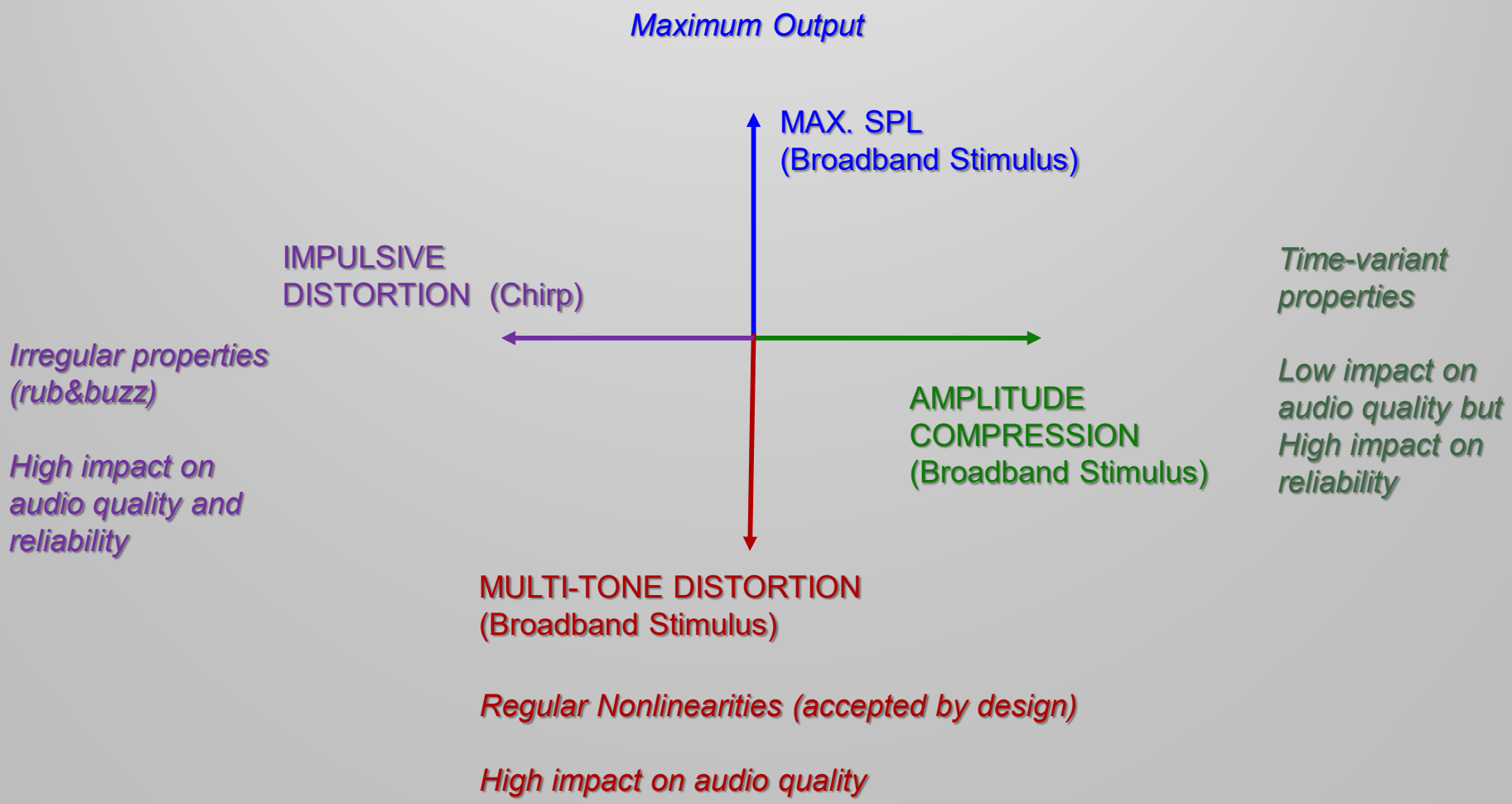
IDEA: Using Rated MAXIMUM SPL as the basis for the Large Signal Measurement

There are three interesting ways:

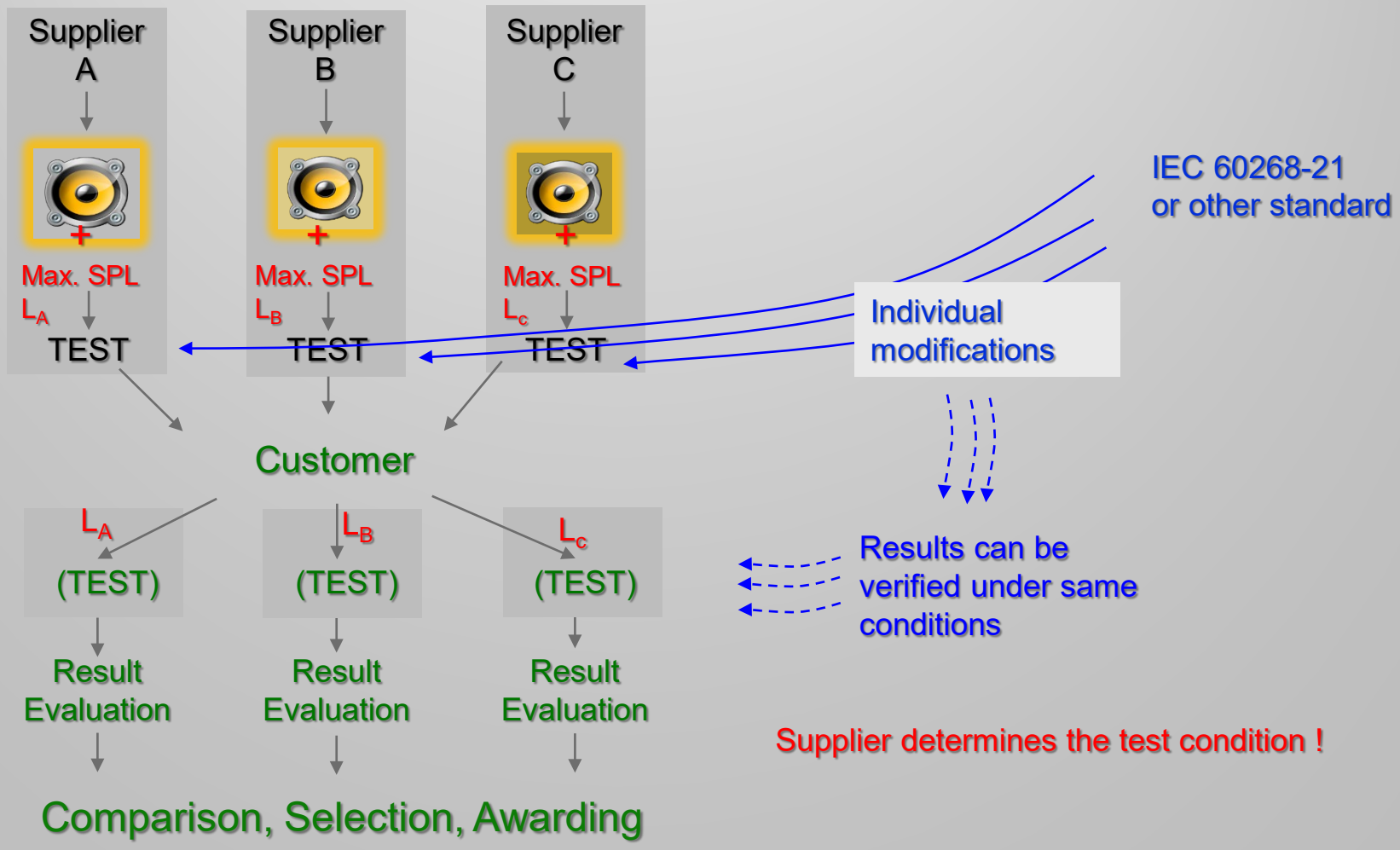
1. Testing using individual maxSPL values for each DUTs rated by supplier
2. Testing at maxSPL target value defined by customer (product requirement)
3. Comparing maxSPL rated by customer

Essential Metrics according IEC 60268-21

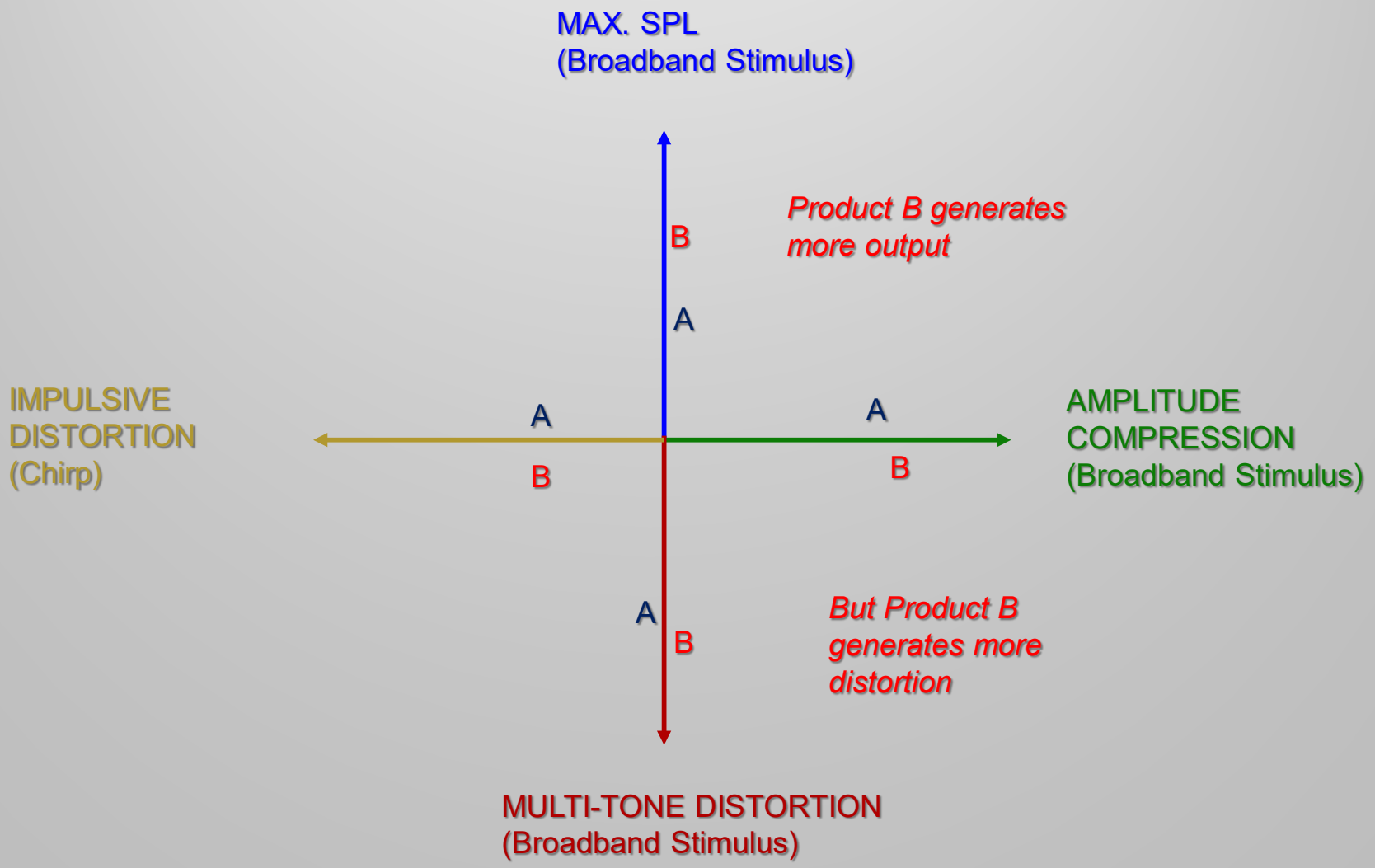
for Assesing Large Signal Performance



1st Method: Benchmarking at Individual Max. SPL



Benchmarking of Two Products (A,B) at Individual Max. SPL



Benchmarking at Individual Max. SPL

IDEA: Best matching of Max. SPL and Audio Performance

Benefits:

- Supplier rates Max. SPL based on background information
- Benchmarking based on existing products
- No communication with supplier required
- Minimum test effort for customer

Drawbacks:

- Comparison of DUTs with different Max. SPL values and distortion values is more complicated

Application:

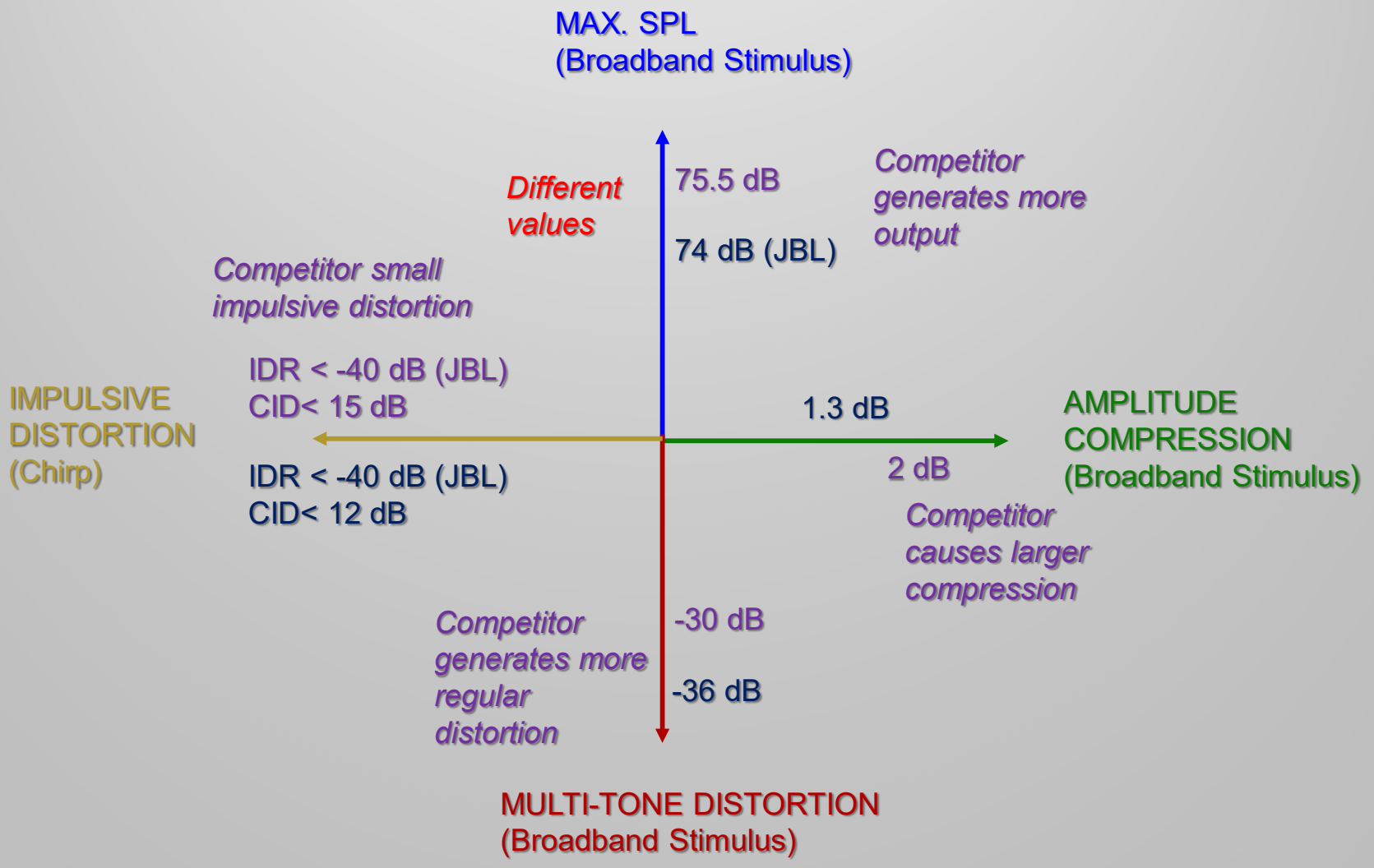
- Benchmarking based on datasheet published by supplier

Demo: Benchmarking at Individual Max. SPL

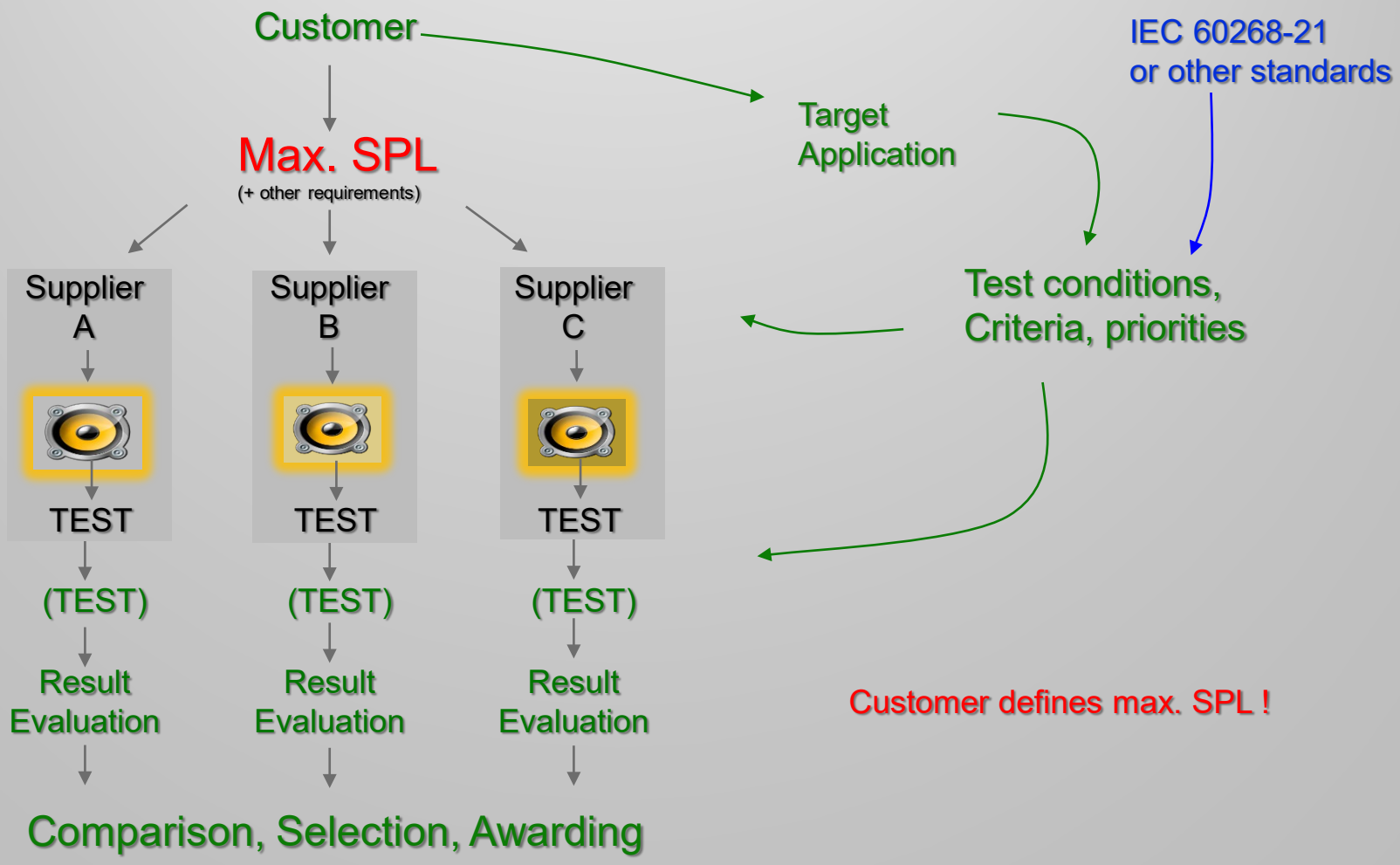
Tools: Using dedicated software modules of the KLIPPEL Analyzer

- Near Field Scanner (NFS)
- In-Situ Room Compensation (ISC)
- Transfer Function Measurement Pro (TRF-Pro)
- Transfer Function Measurement Stepping (TRF)
- Multi-Tone Measurement (MTON)

Benchmarking of the two Bluetooth Speakers at Individual Max. SPL

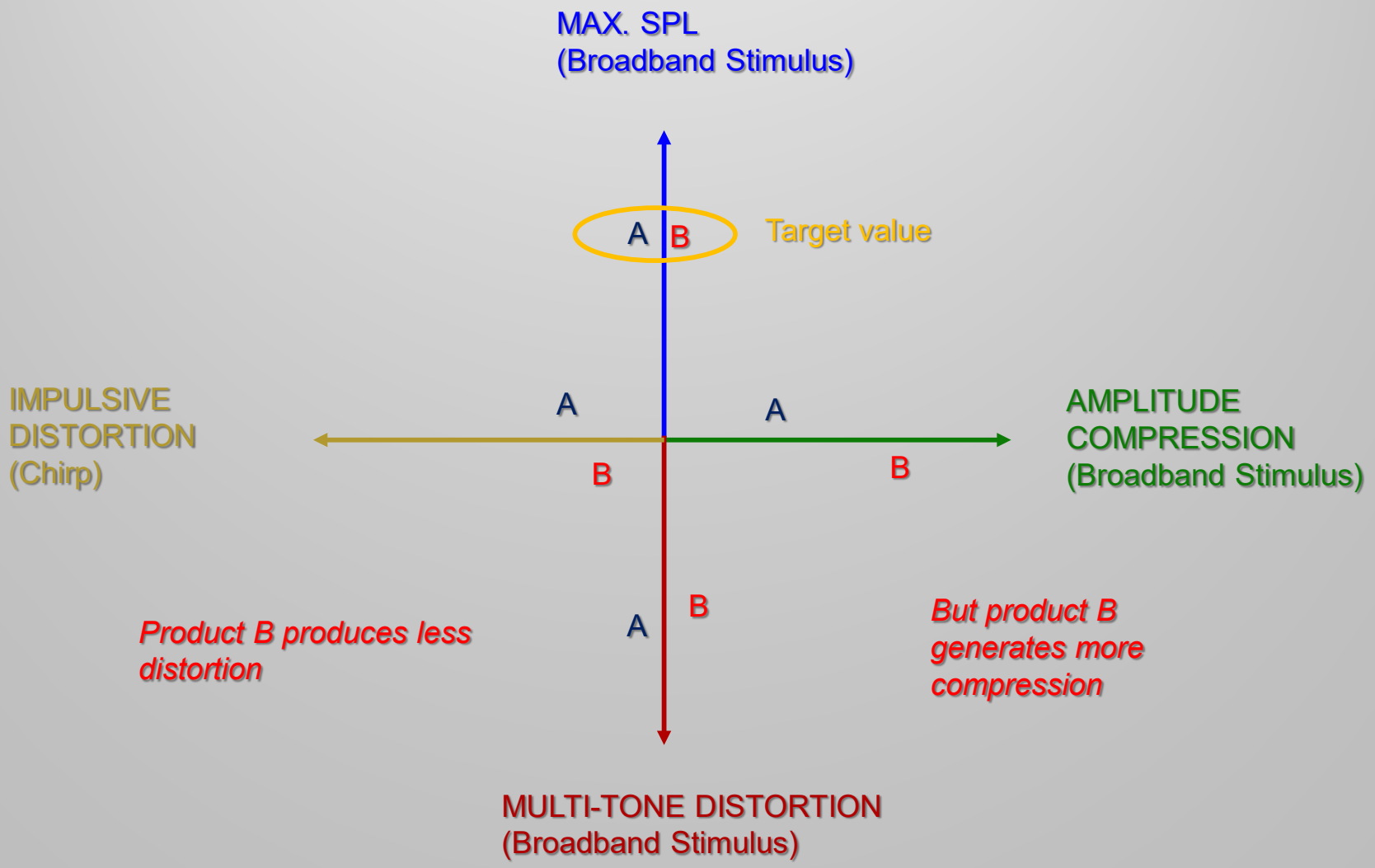


2nd Method: Benchmarking at Target Max. SPL



Benchmarking at Target Value

Essential Metrics according IEC 60268-21



Benchmarking at Target Value

IDEA: Best Audio Performance for given Max. SPL

Benefits:

- Customer defines Max. SPL value (target requirement)
- Customer and supplier define measurement condition
- Simplifies communication between customer and supplier
- Supplier can provide all test results to customer
- Minimum test effort for customer
- Test results of the DUTs are comparable

Drawbacks:

- Max. SPL is defined before product development begins

Application:

- Transducer Manufacturer – System Integrator (OEM business)

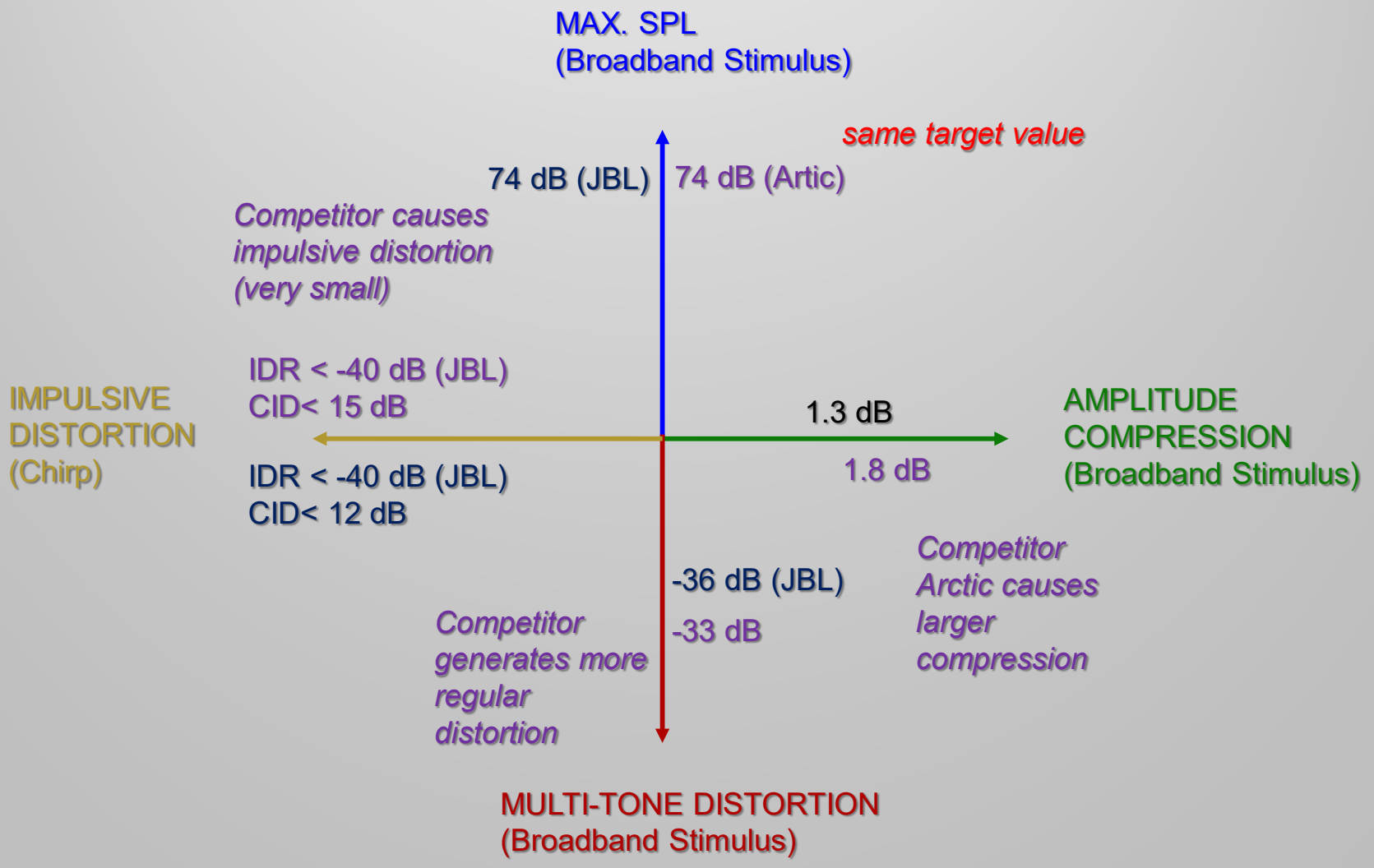
Demo

Benchmarking at Target Value

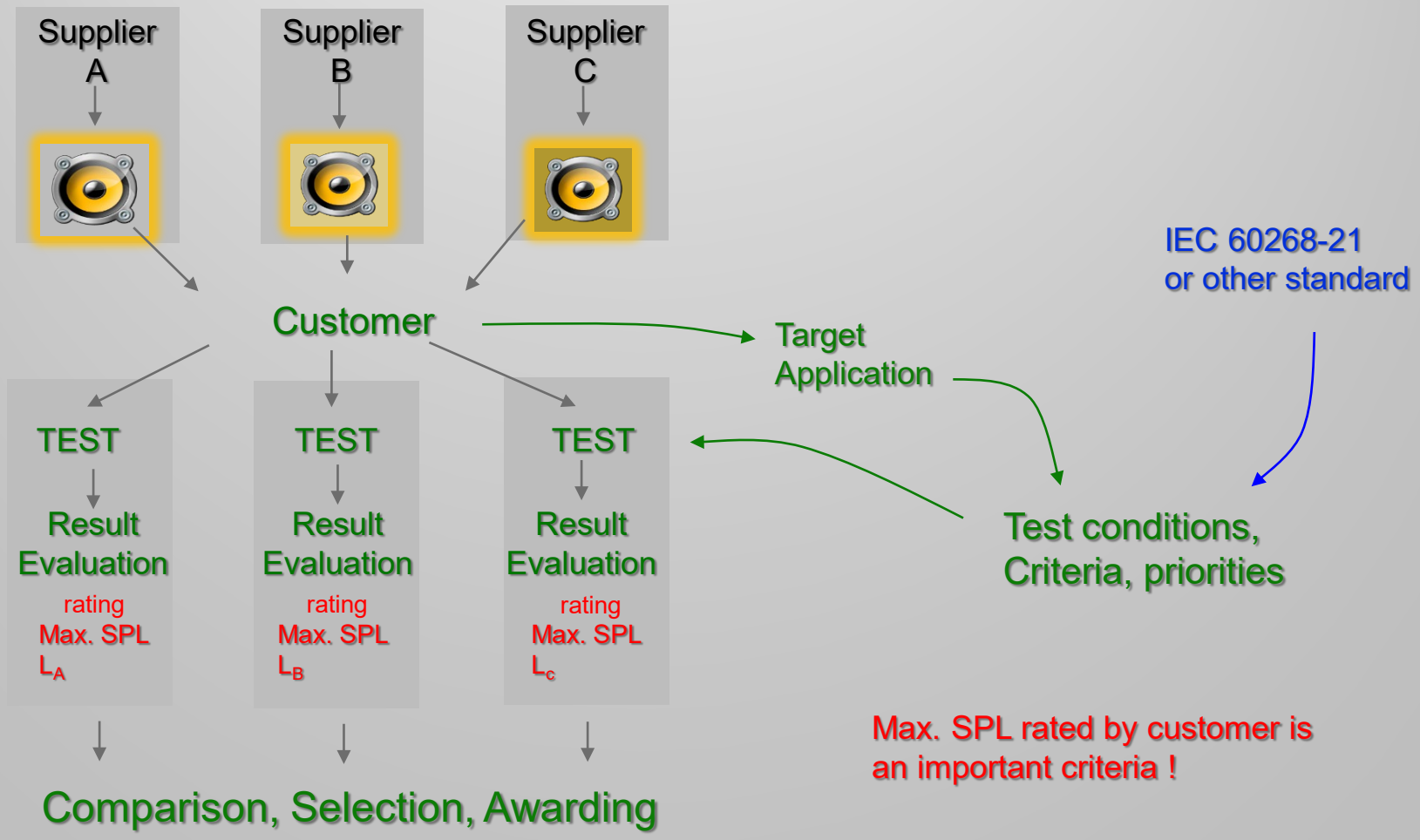
Tools: Using dedicated software modules of the KLIPPEL Analyzer

- Near Field Scanner (NFS)
- In-Situ Room Compensation (ISC)
- Transfer Function Measurement Pro (TRF-Pro)
- Transfer Function Measurement Stepping (TRF)
- Multi-Tone Measurement (MTON)

Benchmarking of the two Bluetooth Speakers at Target Max. SPL

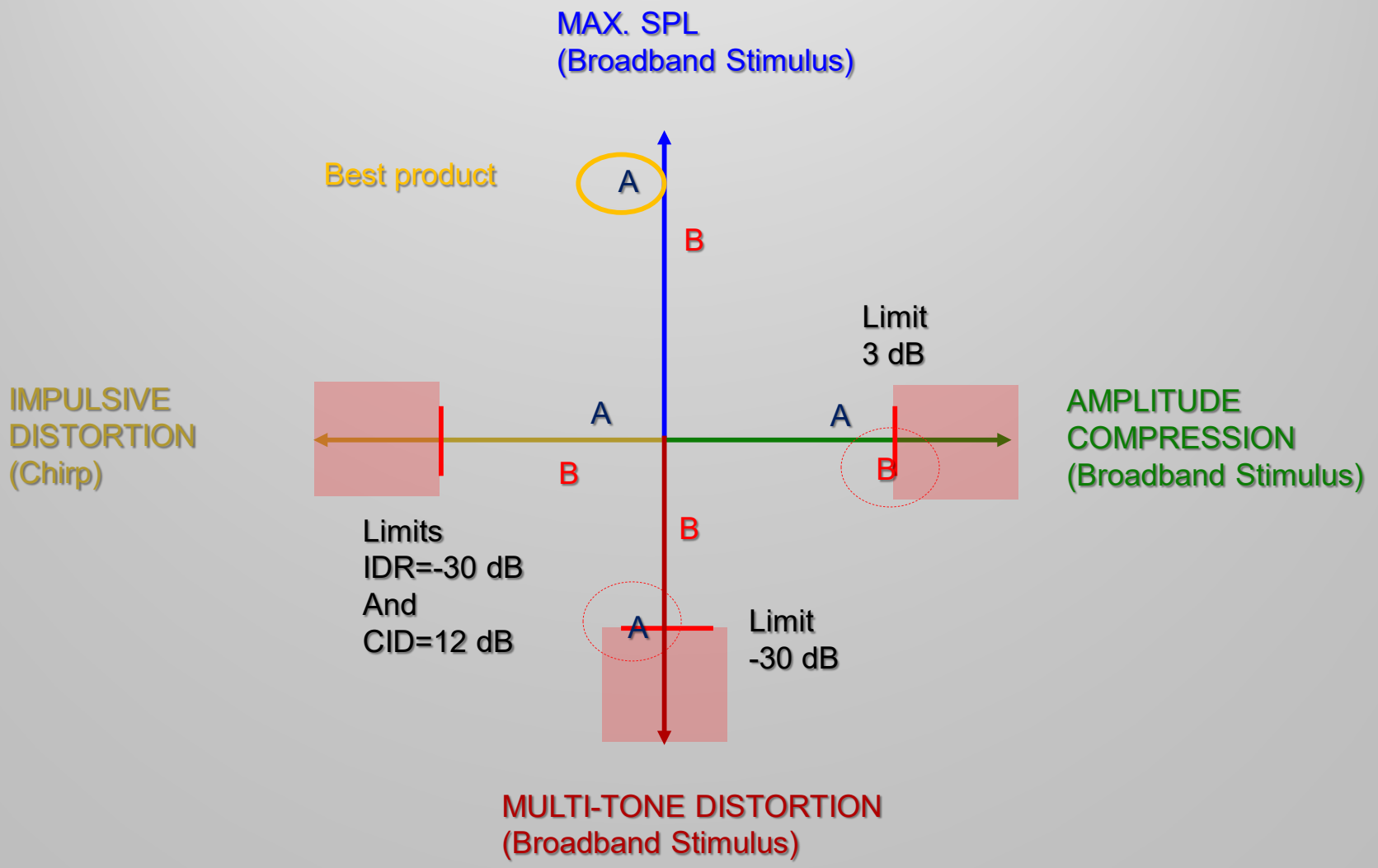


3rd Method: Benchmarking by maxSPL rated by customer under same condition



Benchmarking by maxSPL rated by customer

Essential Metrics according IEC 60268-21



Benchmarking by maxSPL rated by customer

IDEA: Highest Max. SPL for given Audio Performance

Benefits:

- Can be applied to any product
- Customer defines test condition (IEC 60268-21)
- Sufficient Audio Performance
- Simplified decision in benchmarking

Drawbacks:

- Test effort on customer side
- Less useful for applications where audio performance is more important than Max. SPL

Application:

- Professional equipment, small portable-personal audio equipment where larger Max. SPL is desired

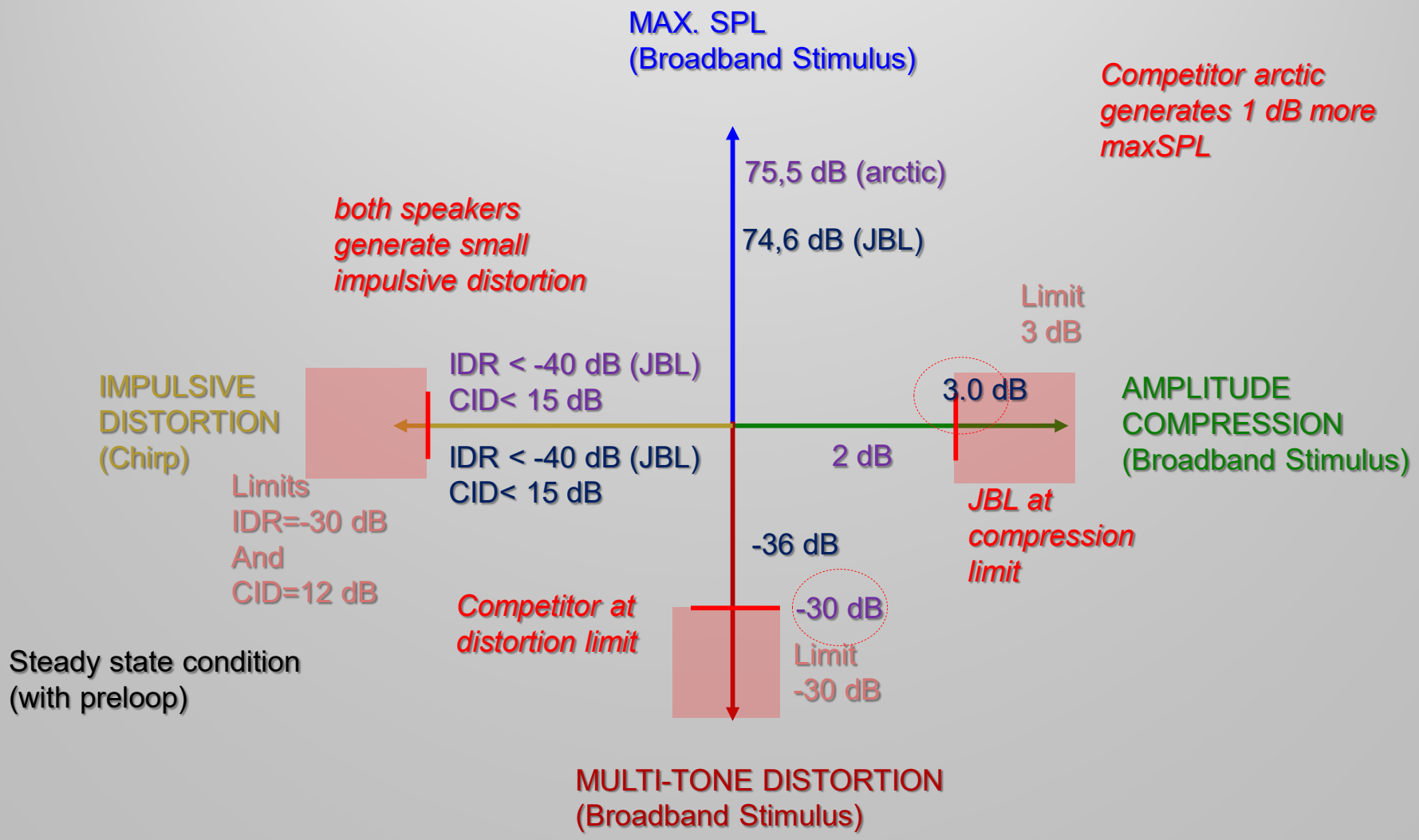
Demo

Benchmarking: Rating maxSPL by customer

Tools: Using dedicated software modules of the KLIPPEL Analyzer

- Near Field Scanner (NFS)
- In-Situ Room Compensation (ISC)
- Transfer Function Measurement Pro (TRF-Pro)
- Transfer Function Measurement Stepping (TRF)
- Multi-Tone Measurement (MTON)

Benchmarking of the two Bluetooth Speakers by customer using same limits



Summary

- IEC 60268-21 provides useful methods and meaningful characteristics for benchmarking audio products
- Rated maxSPL is an important characteristic for testing and benchmarking
- Effective frequency range and the mean deviation from target response are important small signal characteristics
- Amplitude compression, multi-tone distortion and impulsive distortion give essential information of assessing the large signal performance
- Limits and permissible tolerance have to be defined for each metric considering the particular target application

Open Questions

The scope of IEC 60268-21 is limited to physical measurements. How can standard tests be linked to perceptual evaluation ?

The next 13th KLIPPEL live webinar entitled
Auralization of signal distortion – perceptual evaluation
will address the points:

- How to test audio systems with ordinary audio stimuli (music, speech)
- How to separate linear, time-variant and nonlinear distortion in stimuli with a dense spectrum
- How to combine physical and perceptual testing
- How to evaluate the masking of signal distortion

Next Section

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