
KLIPPEL
CONTROLLED SOUND

Overcome engineering constraints
with paradigm shifting technology.

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SOUND QUALITY


ROBUSTNESS


DYNAMICS


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CONTROLLED SOUND

NONLINEAR ADAPTIVE LOUDSPEAKER CONTROL

The KCS algorithm is a new paradigm that actively improves loudspeakers at their weak spots. Its adaptive nonlinear control system provides linear, protected and stabilized behavior over the entire working range and lifetime. **The result, without changing the original speaker footprint, is increased SPL, bass response and overall sound quality.** Reach new levels of product design with KCS:

Level 1: Enhance Existing Speakers

Unlock the speaker's full potential by

- Usage up to its physical limits
- Reduction of required safety margins
- Assurance of optimal alignment

Level 2: Enable New Speaker Design

Increase output with more efficient „green" speakers by

- Complementing the passive system with KCS
- Realizing previously impossible designs
- Using materials more economically (magnet, coil...)

KCS APPLICATIONS

... for Automotive

- **Reduced Speaker Footprint with Improved Performance:**
  Smaller speakers delivering the same or better output and quality.
- **Fewer Speaker Channels and Variants:**
  Simplified system designs with fewer components.
- **Enhanced Bass Performance:**
  Significant bass output in headrest speakers and entry-level systems, effective for ANC and RANC, even without a subwoofer.
- **Cost and Weight Reduction:**
  Reduce woofer and magnet size.
- **Safety-Critical Diagnostics:**
  Advanced diagnostics for safety-critical applications like AVAS & CA.
- **Speaker Health Monitoring:**
  Continuous surveillance to ensure optimal speaker performance.
- **Improved Audio Quality:**
  Overall enhancement of product quality and audio performance.
- **Advanced ANC Performance:**
  Superior Active Noise Cancellation capabilities with zero latency.

...for Multimedia / Telecommunication

- **Enhanced Output of Compact Speaker Systems:**
  Delivering higher SPL and more bass from smaller speakers.
- **Improved Sound Quality:**
  Overall enhancement of audio clarity and richness.
- **Better “Wake Word” Detection:**
  More accurate and responsive detection in smart speakers.
- **Clearer Communication:**
  Improved clarity in speaker phones for better communication.
- **Fewer Speaker Variants Required:**
  Simplified product lineup with fewer necessary variants.
- **Speaker Health Monitoring:**
  Continuous monitoring to ensure optimal performance.
- **Enhanced Product Quality:**
  Overall improvement of consistency and reliability of the product.

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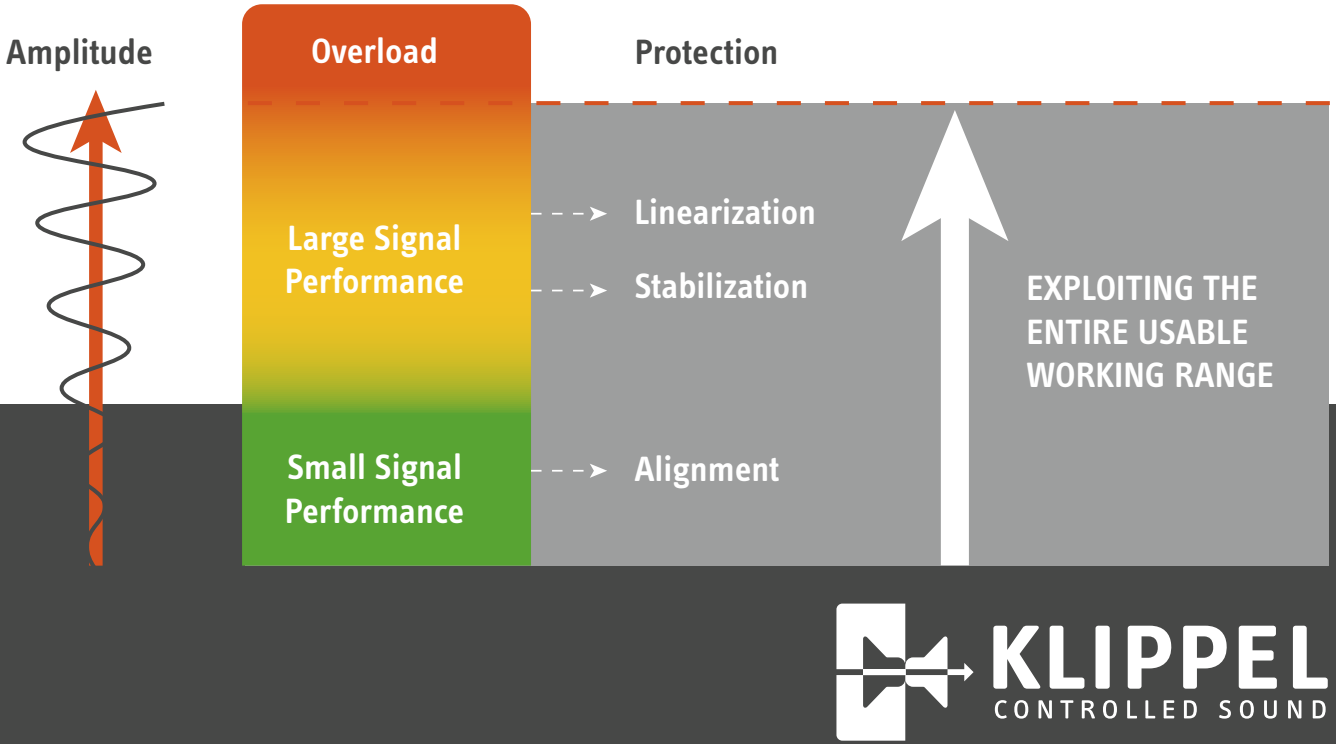
Technical Features

Range of Loudspeaker Operation



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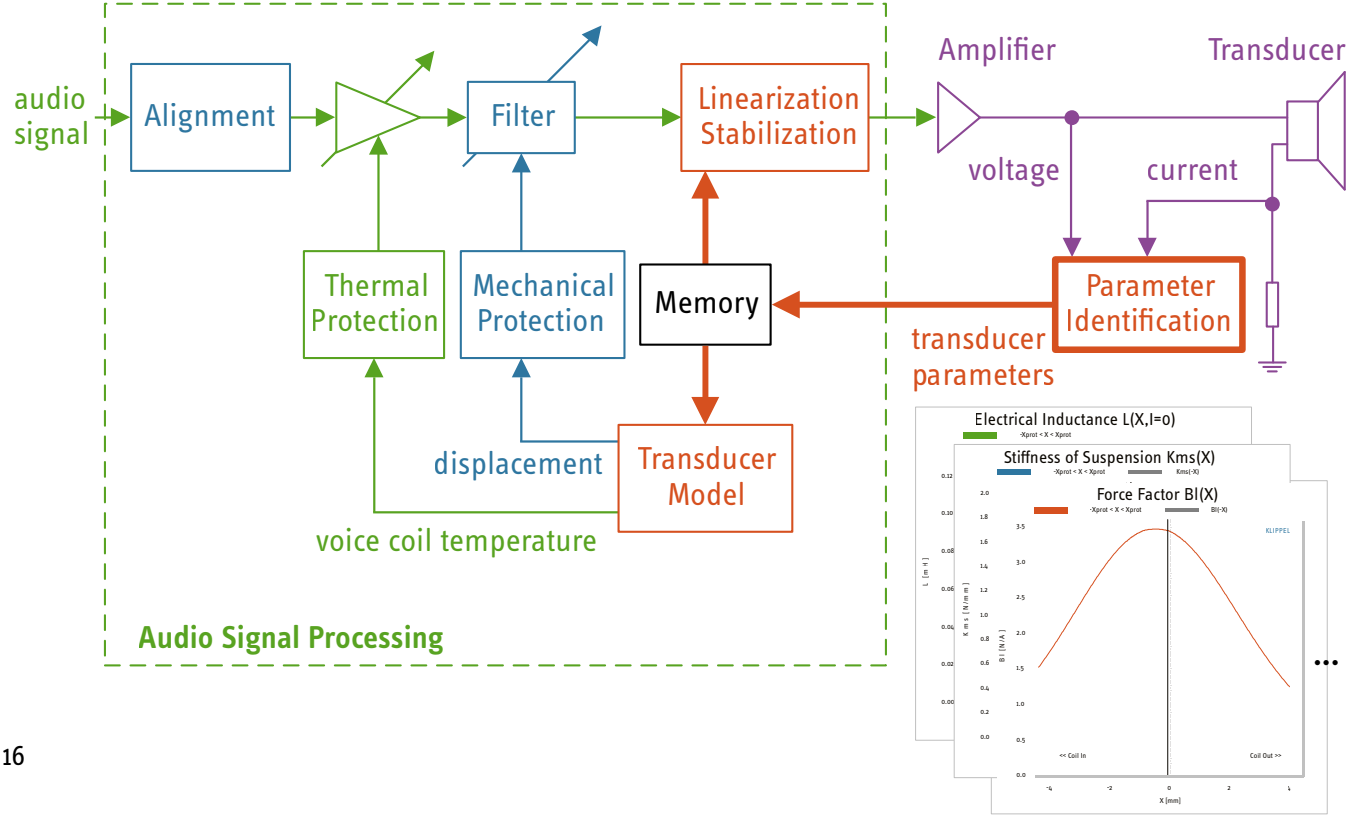
KLIPPEL CONTROLLED SOUND (KCS)

The adaptive control structure is based on electro-acoustical modeling and combines real-time monitoring of the transducer parameters with active protection against thermal and mechanical overload, nonlinear distortion cancellation, system alignment and stabilization of the voice coil position.

These features lead to an extension of the usable working range to increase bass and sound pressure level or allow transducers to be made smaller, lighter and more cost effective. Additionally, transducer designs can focus on efficiency by reducing parameter linearity to create a new generation of Green Speakers, producing more acoustical output and less heat by requiring less energy.

- **Higher sound pressure output**
- **Active protection against overload**
- **Cancellation of nonlinear distortion**
- **Desired linear target performance**
- **Coping with aging, climate, production variance**
- **Lower cost, weight and size**

SELF-LEARNING SYSTEM



KCS uses the transducer itself as the sensor to identify the instantaneous transducer parameters by monitoring voltage and current at the speaker terminals. The nonlinearities indicate the usable working range of the transducer, eliminating time-consuming tuning by a human expert.

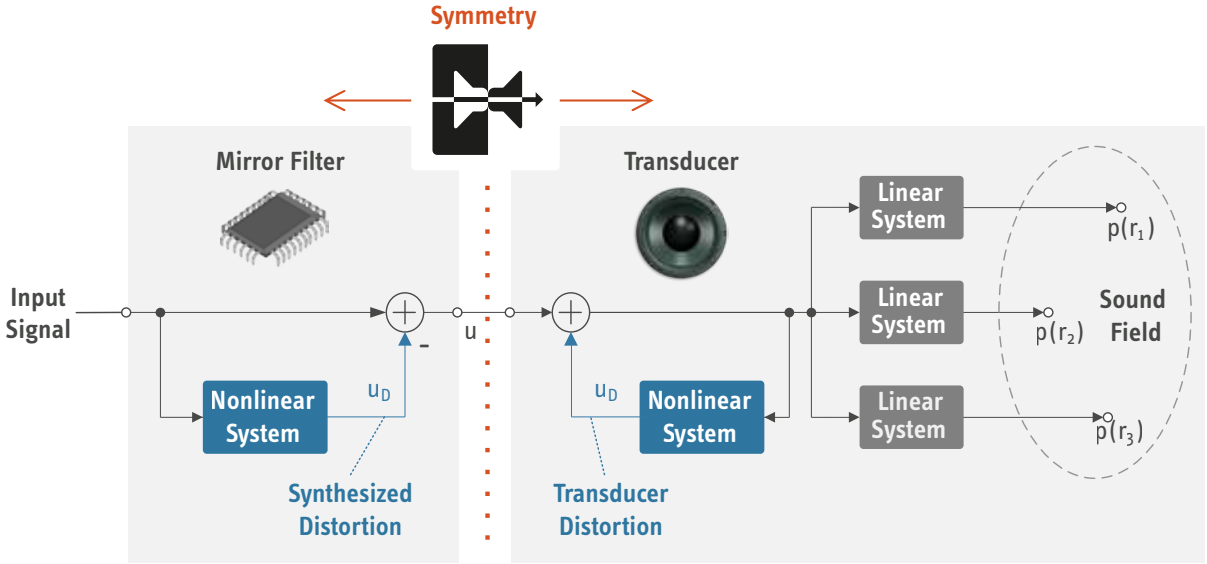
While playing music in online mode, KCS constantly monitors voltage and current at the speaker terminals continuously adapting the internal model with time varying transducer properties, such as variances of mechanical stiffness, voice coil temperature and voice coil position.

Based on the identified parameters, the nonlinear transducer model estimates precise state information such as voice coil displacement, which enables a highly accurate protection.

- **Adaptive software solution**
- **Based on a nonlinear physical model**
- **Automatic parameter identification**
- **On-line learning with any audio signal**
- **Using the transducer itself as sensor**

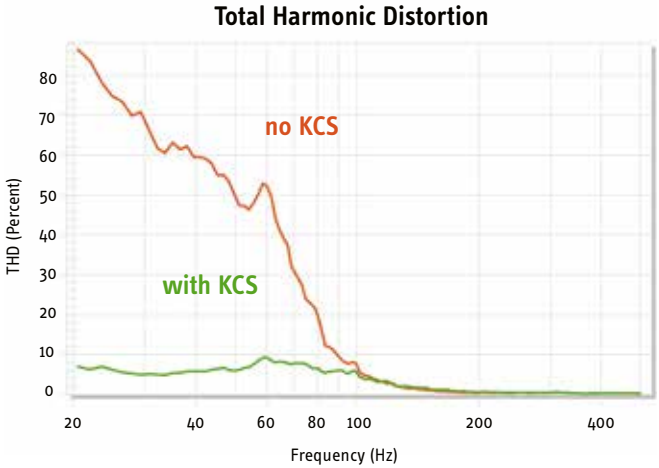
DISTORTION COMPENSATION

Nonlinear and time-variant transducer parameters will cause nonlinear and linear distortion in the output signal of the transducer. KCS uses a nonlinear filter structure, which is a mirror image of the determined transducer model, for eliminating these undesired effects.



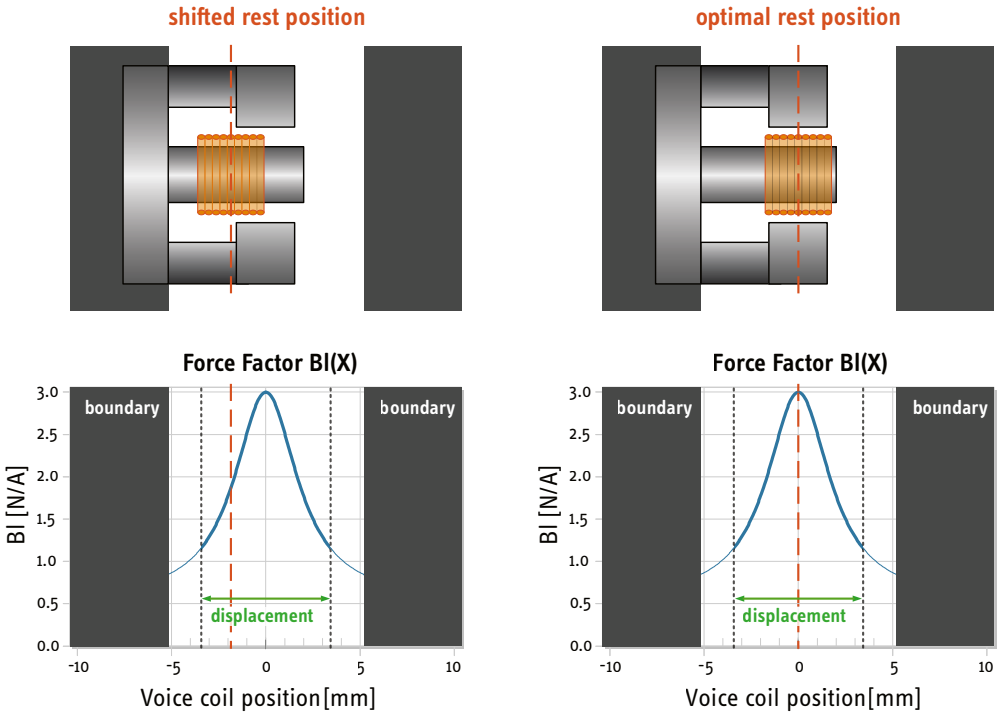
The harmonic and intermodulation distortions synthesized in the mirror filter are subtracted from the input signal before it is fed to the transducer. Thus, the distortions generated by the transducer are compensated, and a linear relationship between the input signal and sound pressure output at any point in the sound field is established.

Due to the continuous identification of transducer variances, the behavior is kept constant over the speaker lifetime because the time-variance of parameters is compensated.



- Linear and nonlinear distortions are reduced
- Constant transducer behavior over its lifetime
- Based on a nonlinear physical speaker model
- Always stable

ACTIVE STABILIZATION OF VOICE COIL POSITION



For achieving maximum bass level, the peak-to-peak displacement must be maximized. This requires the voice coil being centered between the boundaries.

However, the voice coil position is not stable. It depends on soft parts, which show high production variances and will change over time due to temperature, aging and other external influences like air pressure. In addition, transducer nonlinearities can cause dynamic voice coil position shifts due to instable behavior.

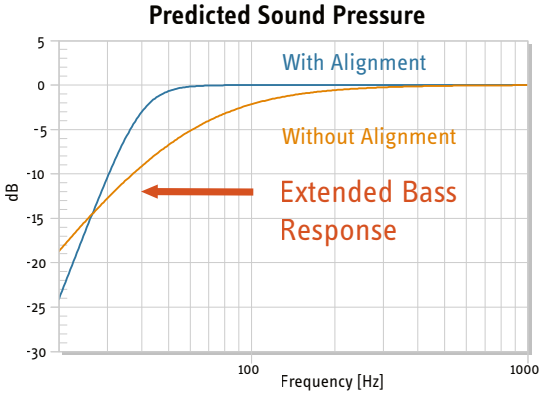
KCS detects the absolute position of the coil without a mechanical sensor by monitoring the input current and identifying an offset in the nonlinear curves. The detected coil position offset can be actively compensated by supplying an appropriate DC voltage to the transducer via a DC-coupled amplifier. This ensures maximum positive and negative voice coil swing, giving maximum bass generated at high efficiency over the lifetime of the speaker.

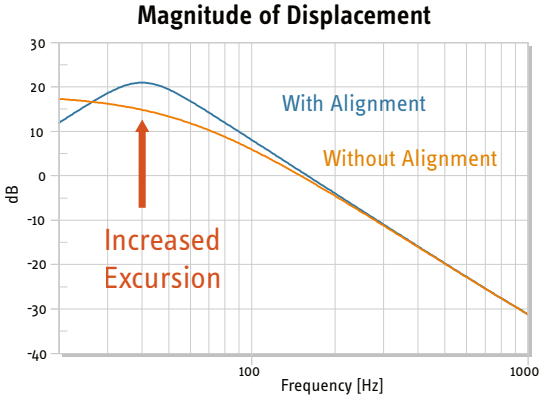
- **Voice Coil shift to the optimal position**
- **Maximum peak-to-peak displacement**
- **No additional sensor required**

SYSTEM ALIGNMENT

KCS ensures a constant linear transfer behavior between audio input and sound pressure output. KCS exploits the information about the transducer and the coupled mechanical and acoustical system (box, vent, passive radiator). Based on this, it automatically equalizes the overall transfer function to a desired alignment (e.g. Butterworth) by applying a pre-filter to the input signal.

Matching the transducer to a given enclosure is no longer required as cutoff frequency, Q-factor and other alignment parameters can be adjusted in the software.





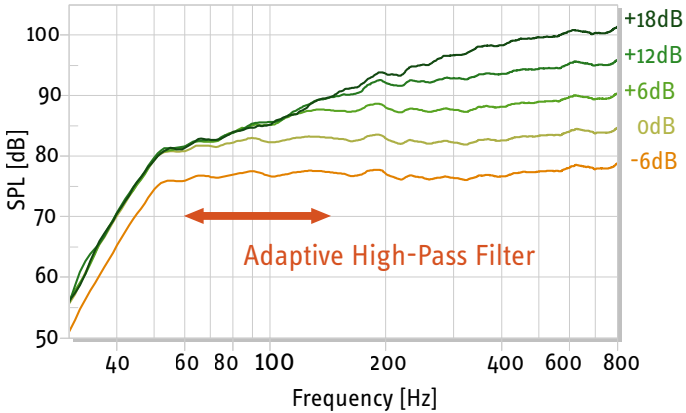
- Extended bass response
- Optimal transducer-enclosure alignment
- Decoupled enclosure and transducer design

RELIABLE PROTECTION

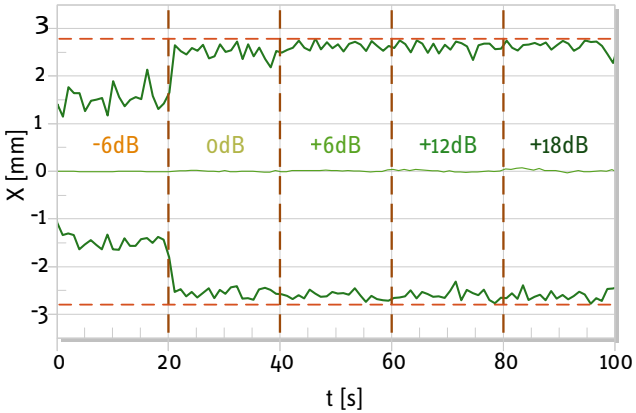
Electro-mechanical transducers need active protection against mechanical overload at high excursion and against thermal overload at high input power to avoid excessive audible distortion or even destruction. The nonlinear and thermal modeling combined with continuous parameter identification of KCS provide a highly accurate displacement and voice coil temperature estimation. Thus, the protection system can anticipate critical situations and attenuate signal components to prevent overload.

While the thermal protection adjusts the level of the entire input signal to reduce the electrical power, the mechanical protection system only attenuates low frequencies where the voice coil excursion is high. Hence the maximum allowed excursion is fully utilized because the audio level can still be increased while only the excursion is restrained. This method reliably protects the transducer without latency and without compressors and limiters introducing artefacts that degrade the perceived sound quality.

Sound Pressure Level



Voice Coil Displacement



- Reliable mechanical and thermal protection
- Exploiting the entire voice coil swing
- Minimal artifacts
- Zero delay can be achieved

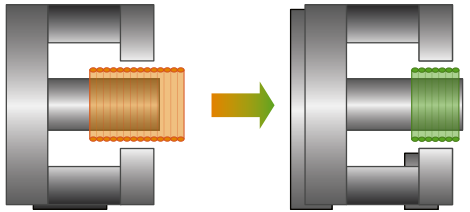
GREEN SPEAKER DESIGN

The unique features provided by KCS allow a change of paradigm in passive transducer and system design. Increasing efficiency and voltage sensitivity of the transducer are given the highest priority for using available resources such as energy, size, weight, material, manufacturing effort and budget. This leads to the concept of Green Speaker design, aiming for more output while requiring less power.

Many design choices dedicated to improving efficiency, such as using very soft suspensions or very nonlinear motors, were not applicable in the past due to the high risk of destruction and increased distortion.

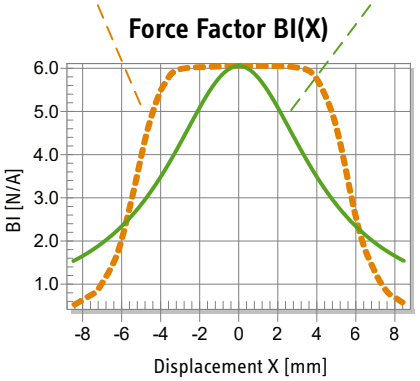
Adaptive nonlinear control solves these problems by compensating for the increased signal distortion and by preventing overload.

For example, the voice coil height can be reduced while maintaining the same pole plate, magnet and other transducer components. This significantly increases efficiency and voltage sensitivity by reducing electrical resistance R_e and moving mass M_{ms}.



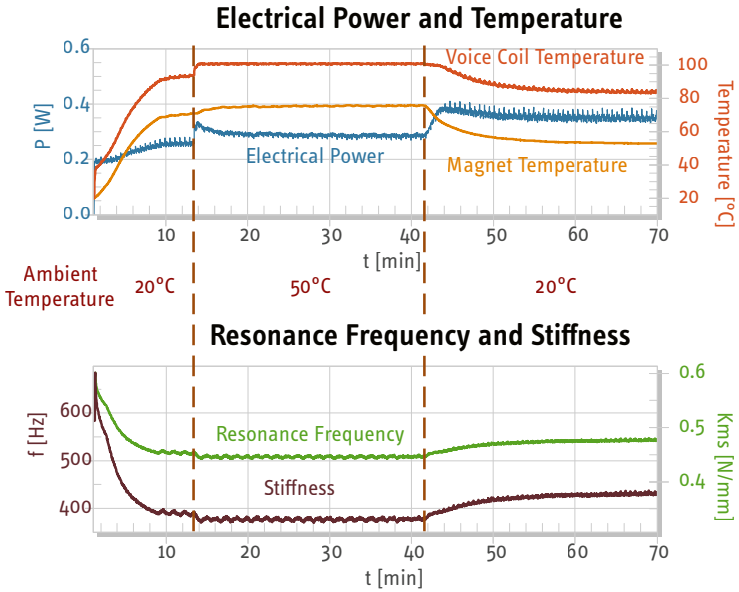
Pass-band Efficiency:

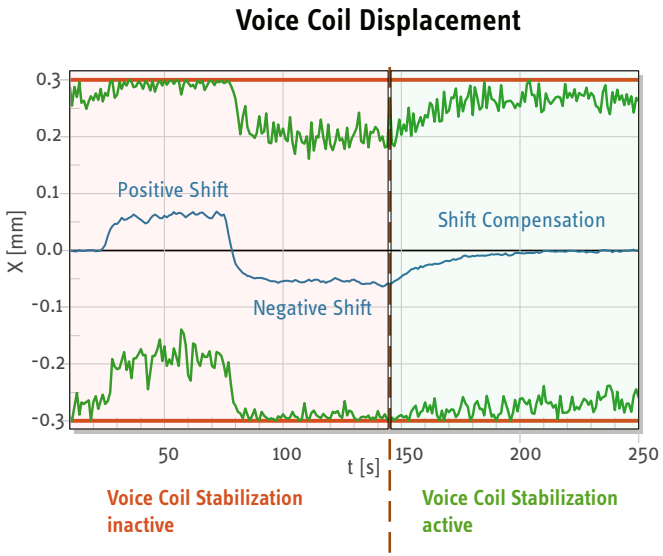
$$\eta_0 = \frac{P_a}{P_e} = \frac{(Bl)^2}{R_e M_{ms}^2} \frac{\rho_0 S_d^2}{2\pi c}$$



- Increased efficiency and voltage sensitivity
- Higher bass output of smaller speakers
- Higher SPL output, generating less heat build-up
- Extended battery life

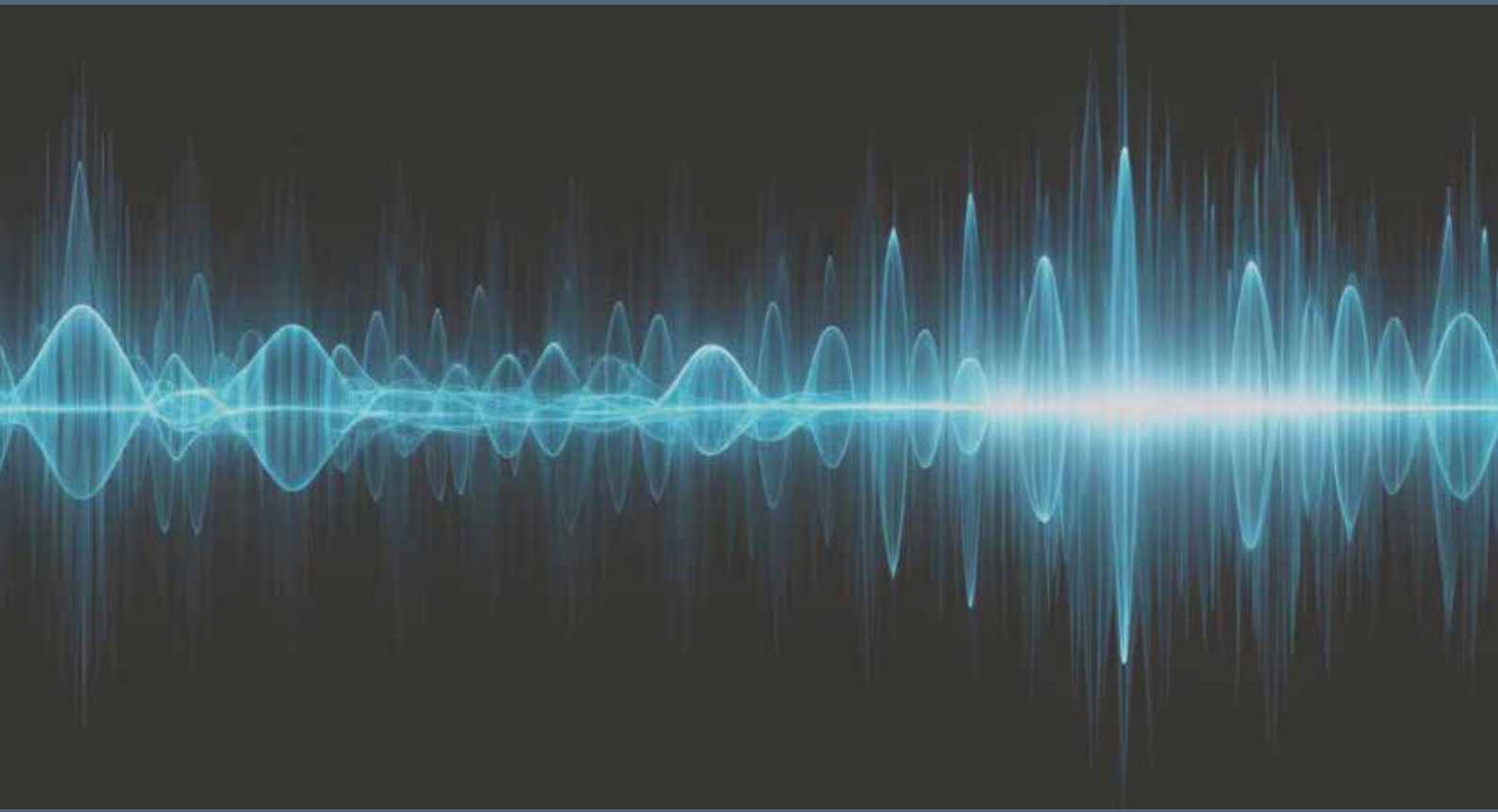
ON-LINE DIAGNOSTICS





KCS extracts valuable information from the voltage and current signals about the instantaneous properties of the transducer in the target application. The influence of climate, acoustic load and the progress of the natural ageing process can be identified from the parameter and state information. In addition, the parameters can give an early indication of defects that may eventually lead to complete failure. The diagnostic information provided by KCS can be used to safely operate the transducer at reduced amplitudes until the defective transducer is replaced.

- **Measurement with any audio signal**
- **In-situ monitoring over speaker lifetime**
- **Comprehensive information**
- **Providing valuable feedback to design**



KCS IN COMBINATION WITH ACTIVE SOUND CONTROL ALGORITHMS

Most active sound control algorithms assume that loudspeakers are linear and identical, with little or no change in properties over time. This is not true in reality. KCS actively corrects for these deficiencies, resulting in improved performance and convergence of many algorithms. Its very low latency makes it ideal for time-critical applications such as Active Noise Control (ANC).

Active Noise Control

- Consistent frequency response enhances performance
- Zero Latency processing available with dedicated protection system for ANC signal
- Powerful low frequency performance of small speakers, e.g. woofers, headrest-speakers
- Significantly reduced distortion

Active Echo Cancellation (handsfree, speaker phone)

- Improved cancellation performance
- Faster convergence
- Linearized AEC reference signal
- Improved wake word detection
- Clear audio quality

Interested? Contact us directly:

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Videos and demo kit info:
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