About spider

Suspension stiffness, dynamic behavior and Kartesian spider technologies.

The short idea

The spider is often treated as a simple centering part.
In practice, its stiffness profile strongly affects low-frequency distortion, T&S stability, dynamic compression and large-excursion behavior.

DOCUMENT	DATE	AUTHOR	VERSION
About spider	**April 2nd 2024**	**Mr C. Lambert**	**1.1**

What the spider must do

Keep the coil centered

The spider helps keep the voice coil stable in the magnetic gap up to the largest useful excursion, avoiding rub & buzz.

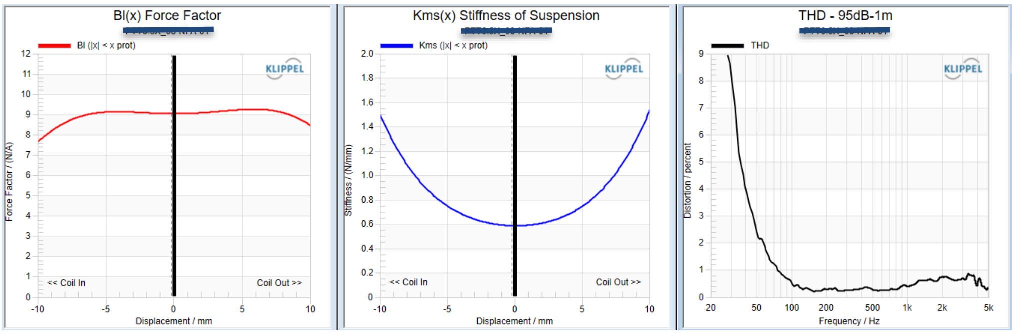
Set the resonance frequency

In most drivers the spider is stiffer than the surround, so it largely defines Fs and its behavior with excursion.

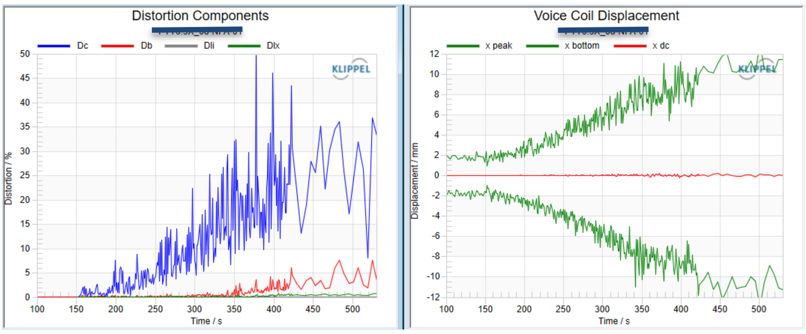
Suspension non-linearity is often the hidden limit

Low-frequency distortion

Even with a wide and stable Bl(x), and excellent inductance management, the main low-frequency THD source can be the suspension stiffness Kms(x).



Bl(x), Kms(x) and THD of a high quality – Low THD reputed woofer



Dominant distortion mechanism under increasing excursion

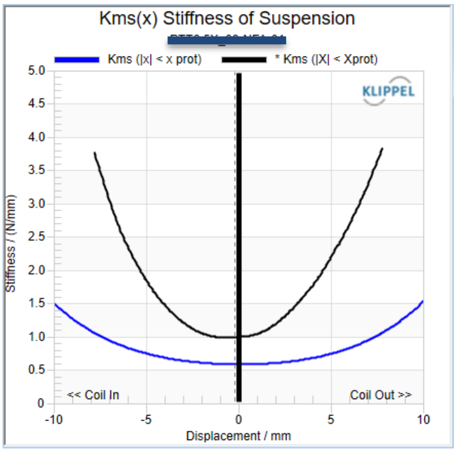
What to remember

- Stiffness asymmetry increases even-order harmonics such as H2 and H4.
- Stiffness variation with excursion increases low-frequency THD, even at moderate excursion.
- Current high-end drivers can already be excellent in the mid-band.
- The next meaningful improvement is often below 100 Hz, where suspension behavior dominates.

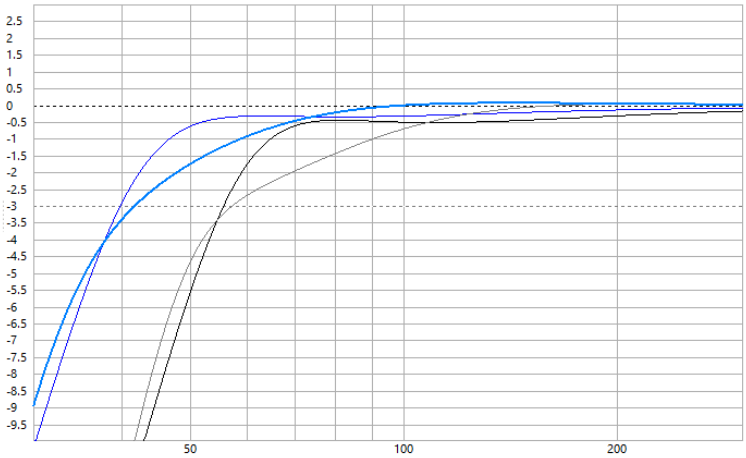
When stiffness changes, the driver no longer behaves the same

T&S variation

As Kms increases with excursion, Fs and Qts shift. The low-frequency response therefore changes with level, even before considering Bl(x) losses.

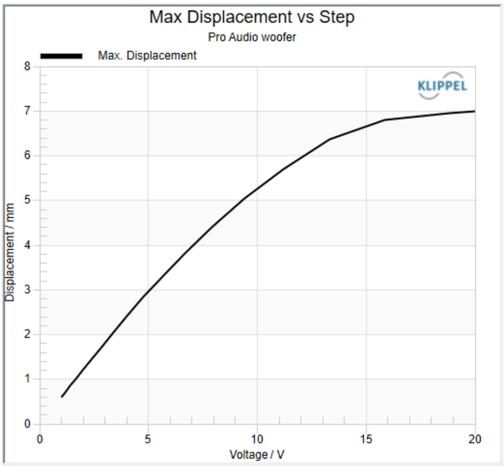


Kms(x) variation: pro-audio vs HiFi / monitoring woofer

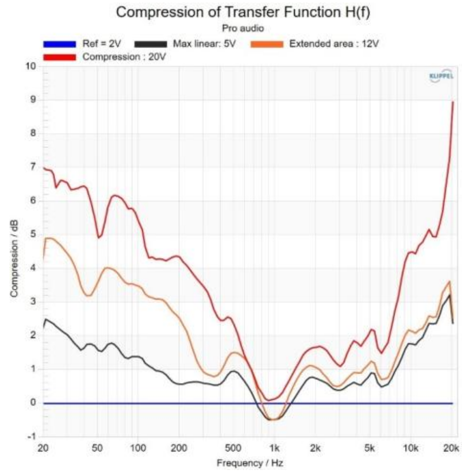


Simulated response changes at larger excursion

Dynamic compression



Above the linear zone, voltage no longer produces proportional displacement.



Compression can become visible in the transfer function.

Key point

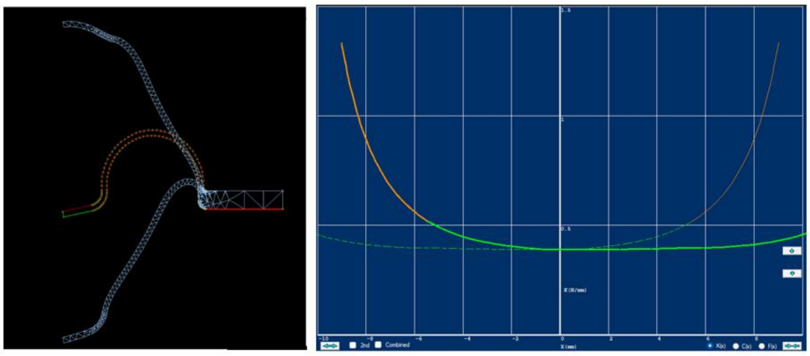
If motion forces change with excursion, cone movement is no longer proportional to the input signal.
Spider and surround stiffness can therefore become a direct cause of dynamic compression.

The spider cannot be designed alone

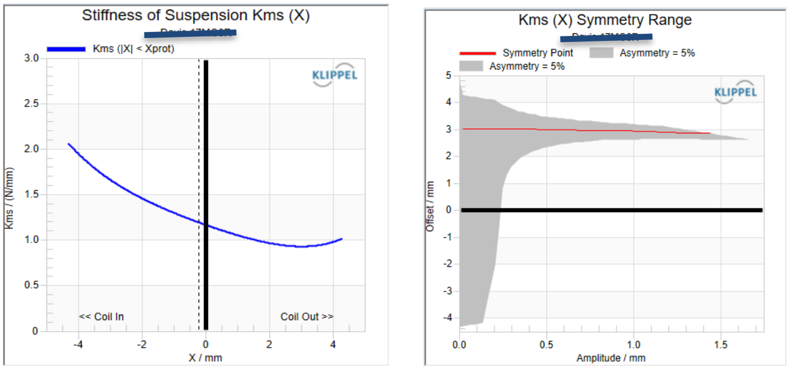
The surround is usually less stiff than the spider, but it is not perfectly linear.

At larger excursion, its stiffness can become comparable with spider stiffness and create offset or asymmetry.

Regular half-roll surround



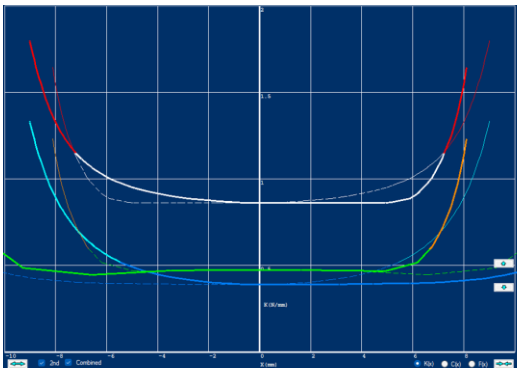
Asymmetric stiffness over the excursion



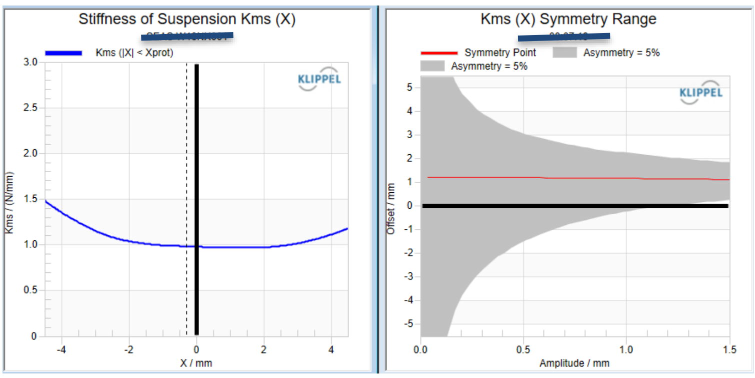
Stillness result with large offset

Compensation has a cost

A spider can be designed to compensate surround asymmetry, but the result is usually a limited useful linear excursion. A better solution is to engineer the whole suspension system.



Combined spider + surround stiffness

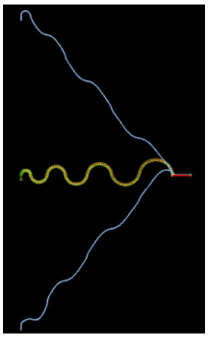
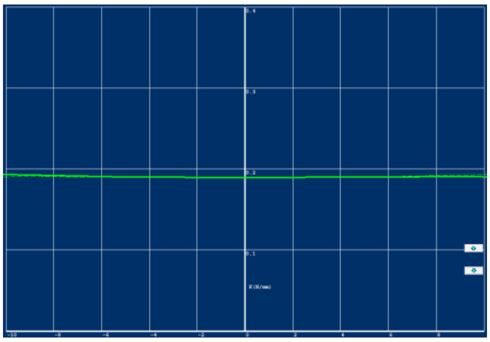
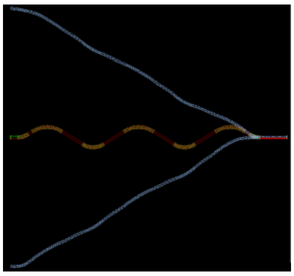
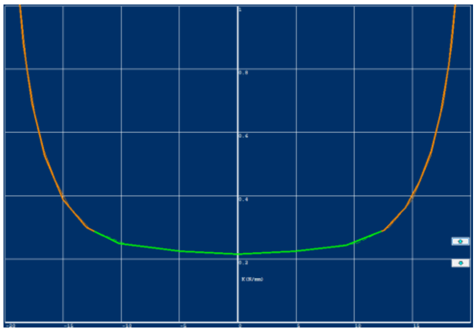
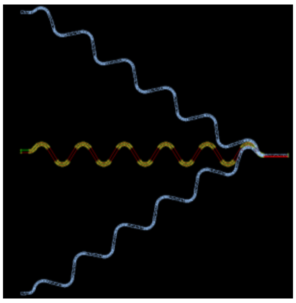
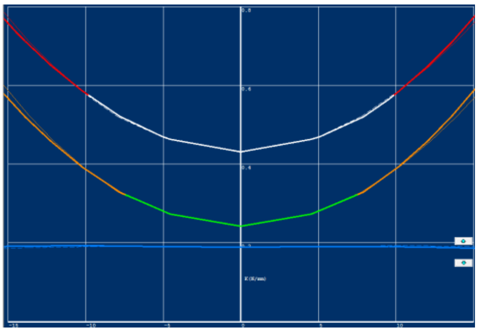


Offset reduction, but limited linear range

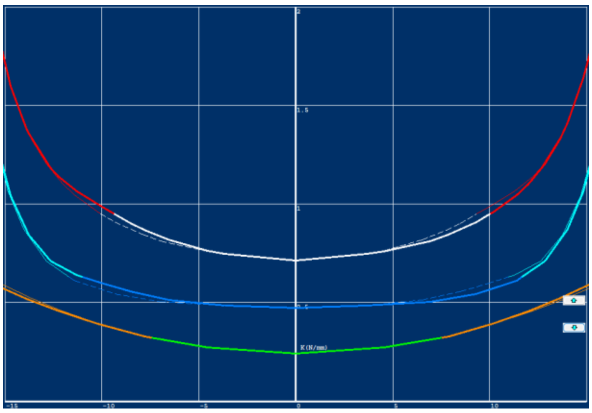
Different spider profiles for different performance targets

Design objective

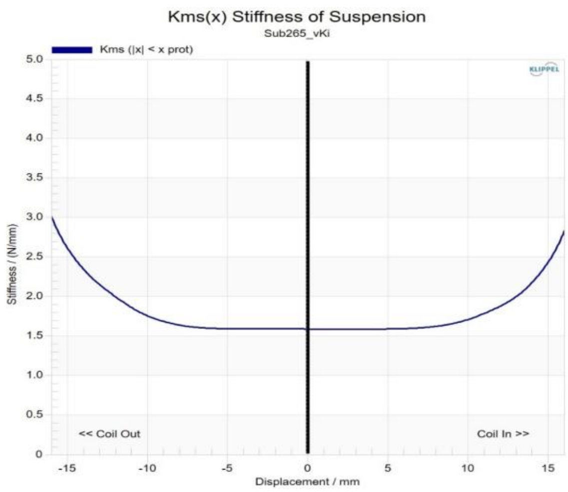
The right spider is not universal.
Kartesian uses different spider technologies to balance linearity, protection, guidance and product application.

dynamiK	Nearly constant stiffness over the useful range. Best linearity and no compression, but requires controlled excursion (DSP, Limiter, …).		
pumaX	Wide linear zone with a stronger protection area at larger excursion. Good balance between performance and safety.		
progressiF	Used alone or with dynamiK / pumaX to tune the smooth transition area before protection and improve voice-coil guidance.		

Tunable combinations



Progressive + pumaX: smoother transition

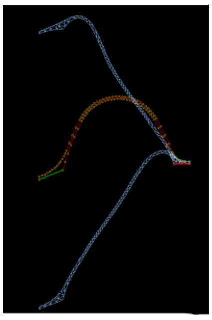


progressive + pumaX used in Sub265_vKi-S

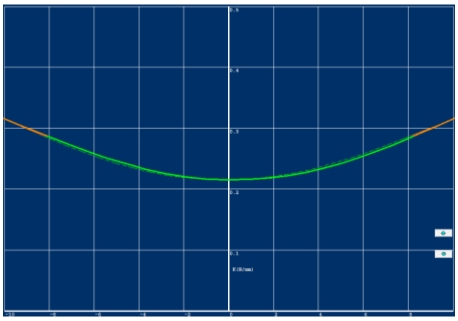
Lower distortion where it matters most

Symmetric and linear suspension

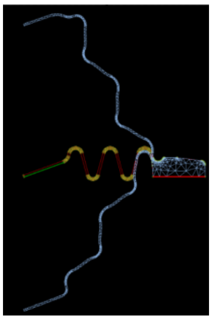
Kartesian surrounds and spiders are engineered together to keep stiffness symmetric and controlled over large excursion, while leaving room for application-specific tuning.



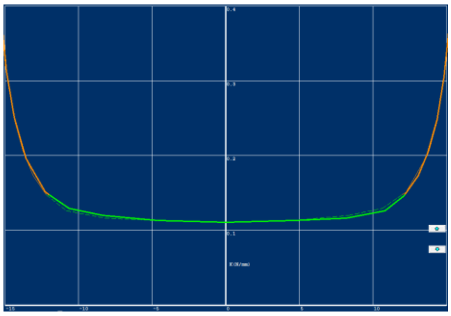
Wom185_vKi



Stiffness profile

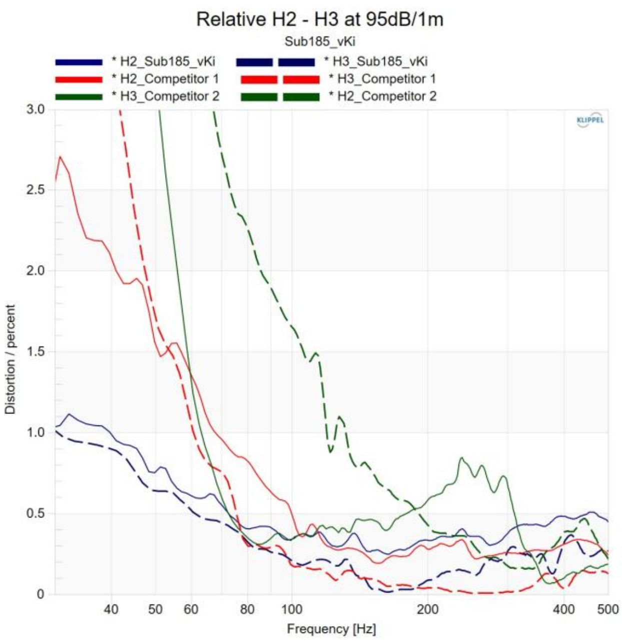


Bom155_vKi



Protection profile

Low-frequency THD improvement



Relative H2 / H3 at 95 dB / 1 m

By controlling suspension stiffness, it is possible to significantly reduce low-frequency THD.

The graph below compares H2 and H3 distortion of the Sub185_vKi with two high-quality competitors in a similar price range.

Both competitors are very good drivers:

- Competitor 1 shows extremely low THD from ~150Hz to 1000Hz, even lower than some 185_vKi references,
- Competitor 2 uses advanced cone material and also performs very well in the midband.

The purpose here is not to discredit these drivers, but to show where the suspension design brings a significant improvement: **below ~100Hz**, where excursion becomes critical.

At 40 Hz, the difference is typically between **1.5% and 5% THD** compared with regular high-quality woofers.

To put this into perspective:

- 1.5% H3 at 50 Hz generates 150Hz at about **–36dB** below the reference level.
  Reducing it to 0.7% places the same harmonic around **–43dB**.
  That means roughly **9dB lower distortion** in low frequency.

- By comparison, reducing H2 at 400Hz from 0.5% to 0.3% represents about **4dB improvement**.

Kartesian focuses its R&D efforts on low-frequency THD below 100 Hz, because this issue remains largely unaddressed while midband distortion is already well controlled by many manufacturers.

Final message

The spider is a performance component.
While it isn’t the best component for marketing purpose, its geometry and stiffness profile directly influence distortion, T&S stability, dynamic compression and driver reliability.