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VERIFIED WITH
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Operation Name	Date	Time
Xmax by 10% THD = 19.2mm	12/03/18	11:43:07
Xmax by IEC-62458 = 4.5mm	12/03/18	11:43:07
LPM auto	12/03/18	10:50:11
LSI auto	12/03/18	11:14:59
DIS auto DC Component	12/03/18	11:23:37
DIS auto Xmax (display state %)	12/03/18	11:17:31
DIS auto Xmax (display state mm)	12/03/18	11:17:26

Linear Parameter Measurement (LPM)

Linear Parameters Result Table (abridged)			
Name	Value	Unit	Comment
Electrical Parameters			
Re	6.60	Ohm	electrical voice coil resistance at DC
Le	5.034	mH	frequency independent part of voice coil inductance
fs	18.9	Hz	driver resonance frequency
Mechanical Parameters			
Mms	234.602	g	mechanical mass of diaphragm assembly with air load & voice coil
Mmd (Sd)	207.851	g	mechanical mass of voice coil and diaphragm without air load
Rms	2.139	kg/s	mechanical resistance of total-driver losses
Cms	0.304	mm/N	mechanical compliance of driver suspension
Kms	3.29	N/mm	mechanical stiffness of driver suspension
Bl	19.689	N/A	force factor (Bl product)
Loss factors			
Qms	12.995		mechanical Q-factor of driver in free air considering Rms only
Qes	0.473		electrical Q-factor of driver in free air considering Re only
Qts	0.456		total Q-factor considering Re and Rms only
Other Parameters			
Vas	292.0702	l	equivalent air volume of suspension
n0	0.398	%	reference efficiency (2 pi-radiation using Re)
Lm	88.20	dB	characteristic sound pressure level (SPL at 1m for 1W @ Re)
Lnom	89.04	dB	nominal sensitivity (SPL at 1m for 1W @ Zn)
rmse Z	4.83	%	root-mean-square fitting error of driver impedance Z(f)
rmse Hx	1.29	%	root-mean-square fitting error of transfer function Hx (f)
Sd	824.48	cm²	diaphragm area

Magnitude of electric impedance Z(f)

Measured —— Fitted ——

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Magnitude of transfer function Hx(f)= X(f)/U(f)

Measured —— Fitted without creep – – – Fitted ——

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Spectrum I(f) of current at speaker terminals

Signal lines —— Noise + Distortions —— Noise floor ——

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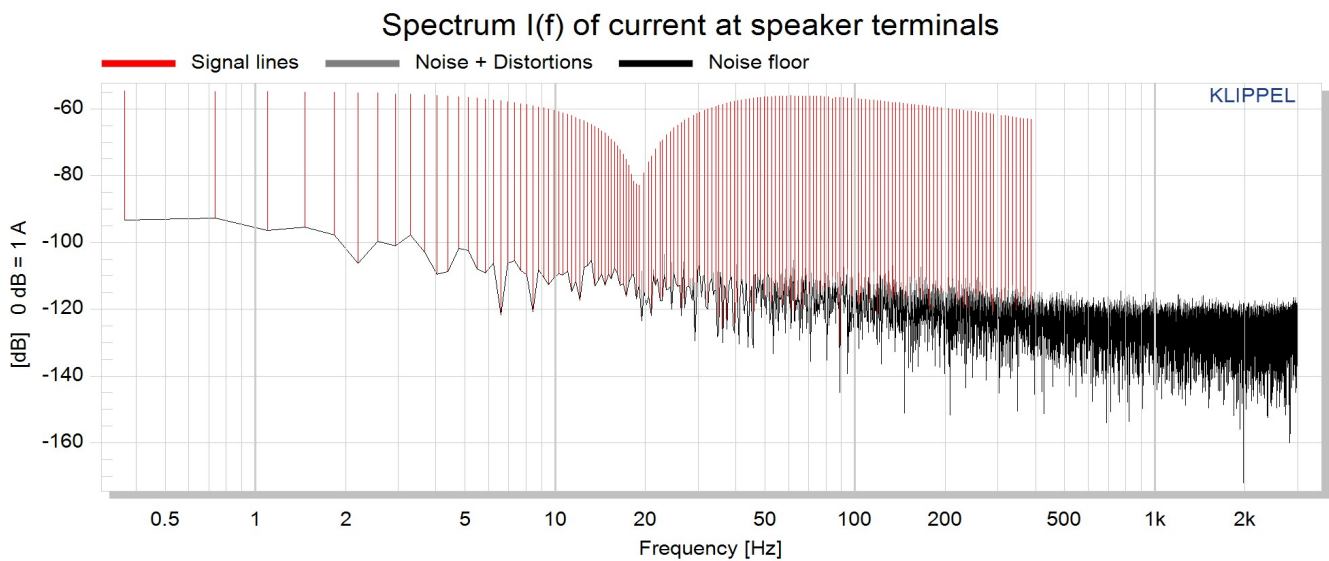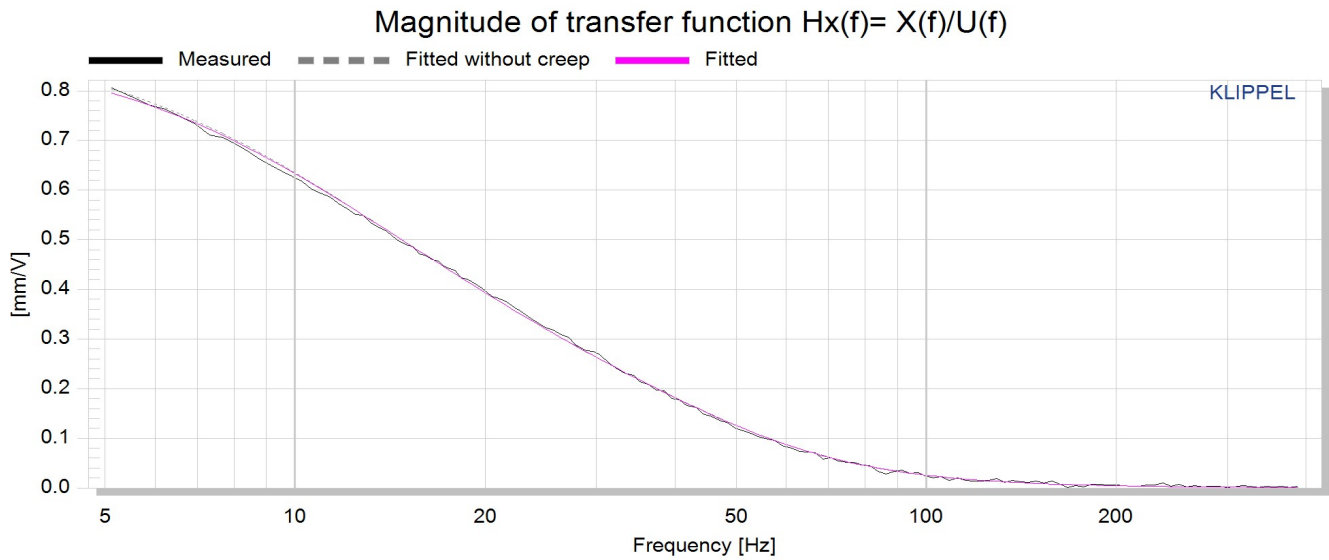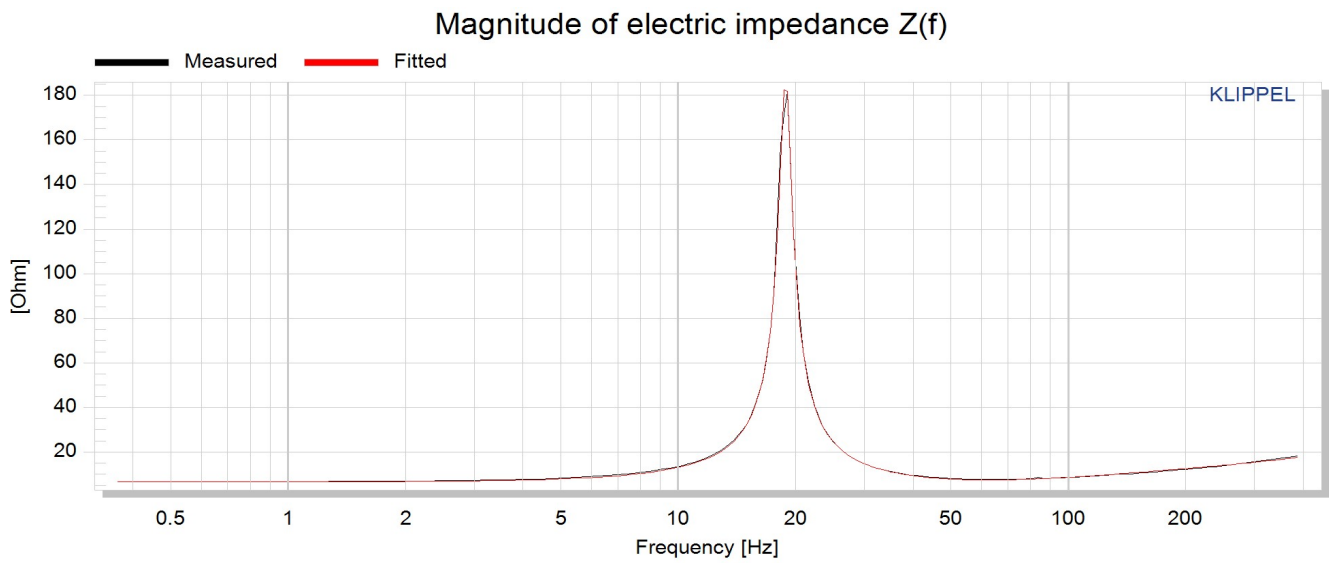
Xmax Measurements

Value	Method	Measured
Xmax	(by IEC-62458)	4.5mm
X10	(by 10% THD)	19.2mm
XVAR	(by 50% BL or C)	>17.2mm

There are many methods to calculate the linear excursion range of a driver (commonly called Xmax). Some methods are more suitable to some applications, so multiple methods are offered here.

Standard IEC-62458 is an acoustic-based measurement where displacement is determined by both total harmonic distortion and intermodulation distortion. This test is better suited for wide-bandwitdh drivers, not bass drivers. This test is based on Klippel's Application Note 4 available at: http://www.klippel.de/know-how/literature/application-notes.html

X10 is the measurement listed above as "10% THD". X10 shows an excursion limit is when the driver reaches 10% total harmonic distortion, as measured with a microphone, while playing a sine wave at resonant frequency (fs). This test is more suitable for bass drivers that play low frequencies.
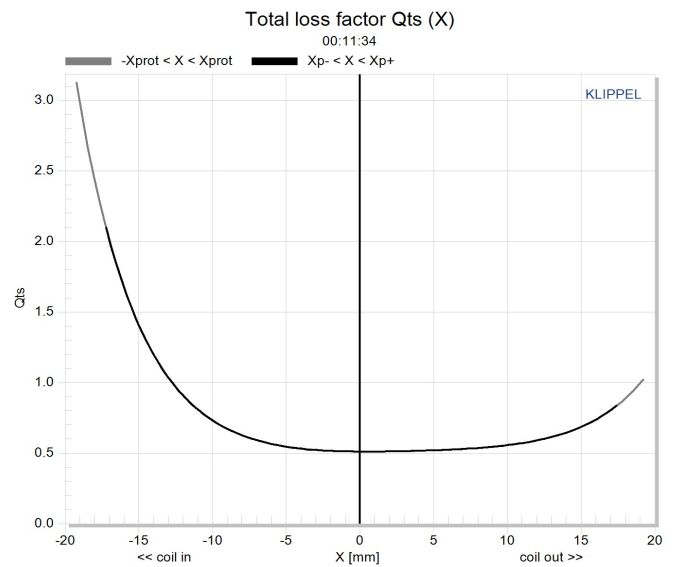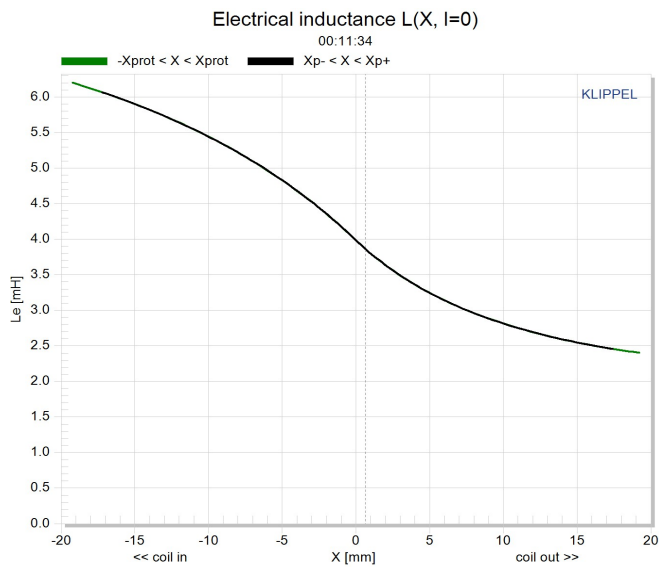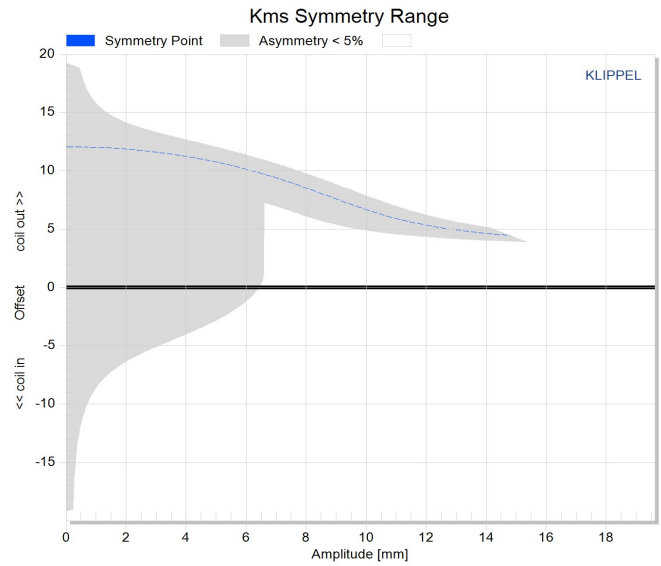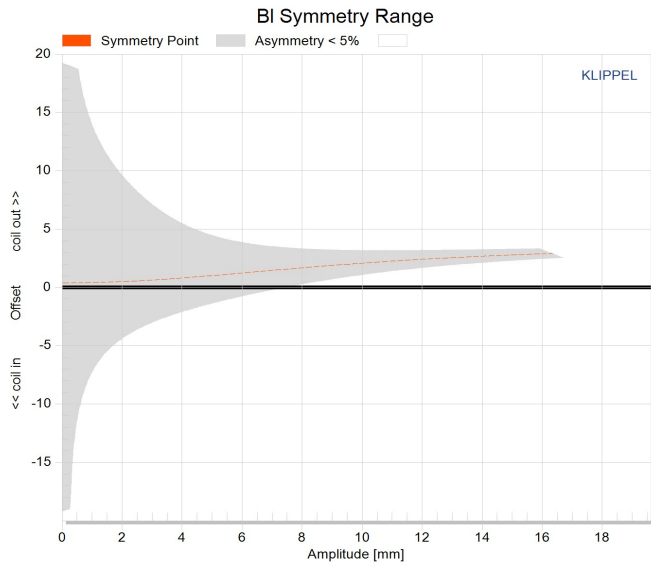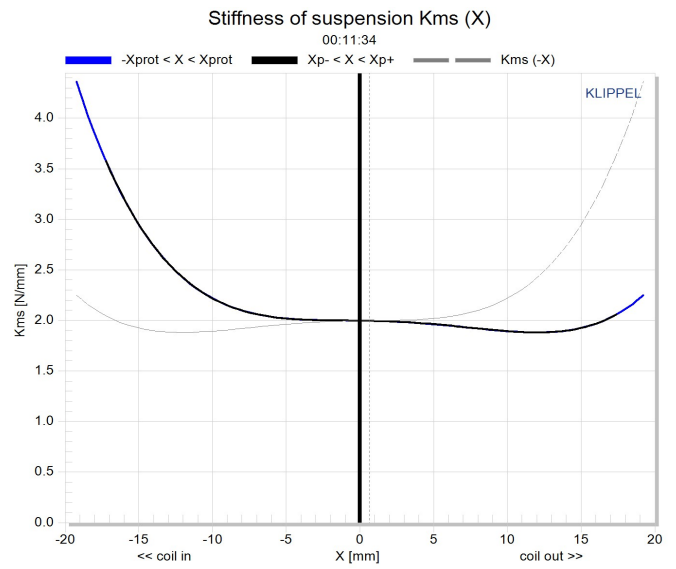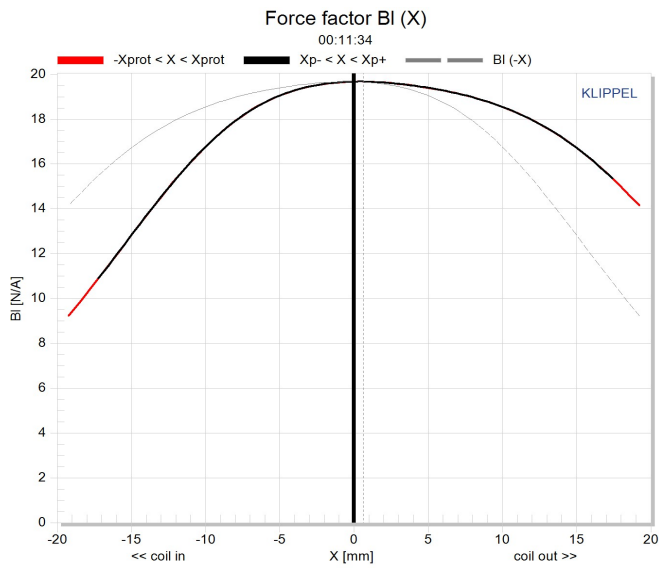
Xvar is the displacement when either motor strength BL or compliance C decay by 50%. The value for Xvar can be found in the *LSI Nonlinear Parameters Result Table* below; it is the lesser of the first two listed values (*BL@min=50%* and also *C@min=50%*). Xvar is sometimes reported as ">x.x" (greater than some displacement) when displacement was limited by a high voice coil temperature.

Large Signal Identification (LSI)

LSI Setup Parameter Table (abridged)			
Name	**Value**	**Unit**	**Comment**
Protection (Property Page)			
Delta Tlim	100	K	increase of voice coil temp (limit)
Bllim	30.0	%	minimal force factor ratio (limit)
Clim	30.0	%	minimal compliance ratio (limit)
Plim	200.000	W	electrical input power (limit)
Gsmall	-10.0	dB	small-signal gain

LSI Nonlinear Parameters Result Table (abridged)			
Name	**Value**	**Unit**	**Comment**
Displacement Limits			
X Bl @ Bl min=50%	>17.2	mm	limit due to force factor variation (used to calculate XVAR)
X C @ C min=50%	>17.2	mm	limit due to compliance variation (used to calculate XVAR)
X L @ Z max=10 %	3.1	mm	limit due to inductance variation
X d @ d2=10%	61.7	mm	limit due to IM distortion (Doppler)
Asymmetry (IEC 62458)			
Ak	63.83	%	Stiffness asymmetry Ak(Xpeak)
Xsym	2.73	mm	Symmetry point of Bl(x) at maximal excursion
Xpse	19.2	mm	-Xpse < X < Xpse, range where power series is fitted

State Result Table (abridged)			
Name	**Value**	**Unit**	**Comment**
t		h:min:s	measurement time
Glarge (Gmax)	21.2 (26.0)	dB	excitation amplitude gain in large signal domain (max)
Xprot	19.2	mm	max voice coil excursion allowed by protection system

Force factor Bl (X)

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Legend: ■ -Xprot < X < Xprot   ■ Xp- < X < Xp+   ┄ Bl (-X)

Y-axis: Bl [N/A]
X-axis: X [mm] — << coil in ... coil out >>

Stiffness of suspension Kms (X)

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Legend: ■ -Xprot < X < Xprot   ■ Xp- < X < Xp+   ┄ Kms (-X)

Y-axis: Kms [N/mm]
X-axis: X [mm] — << coil in ... coil out >>

Bl Symmetry Range

Legend: ■ Symmetry Point   ▨ Asymmetry < 5%   ☐

Y-axis: coil out >> / Offset / << coil in
X-axis: Amplitude [mm]

Kms Symmetry Range

Legend: ■ Symmetry Point   ▨ Asymmetry < 5%   ☐

Y-axis: coil out >> / Offset / << coil in
X-axis: Amplitude [mm]

Electrical inductance L(X, I=0)

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Legend: ■ -Xprot < X < Xprot   ■ Xp- < X < Xp+

Y-axis: Le [mH]
X-axis: X [mm] — << coil in ... coil out >>

Total loss factor Qts (X)

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Legend: ■ -Xprot < X < Xprot   ■ Xp- < X < Xp+

Y-axis: Qts
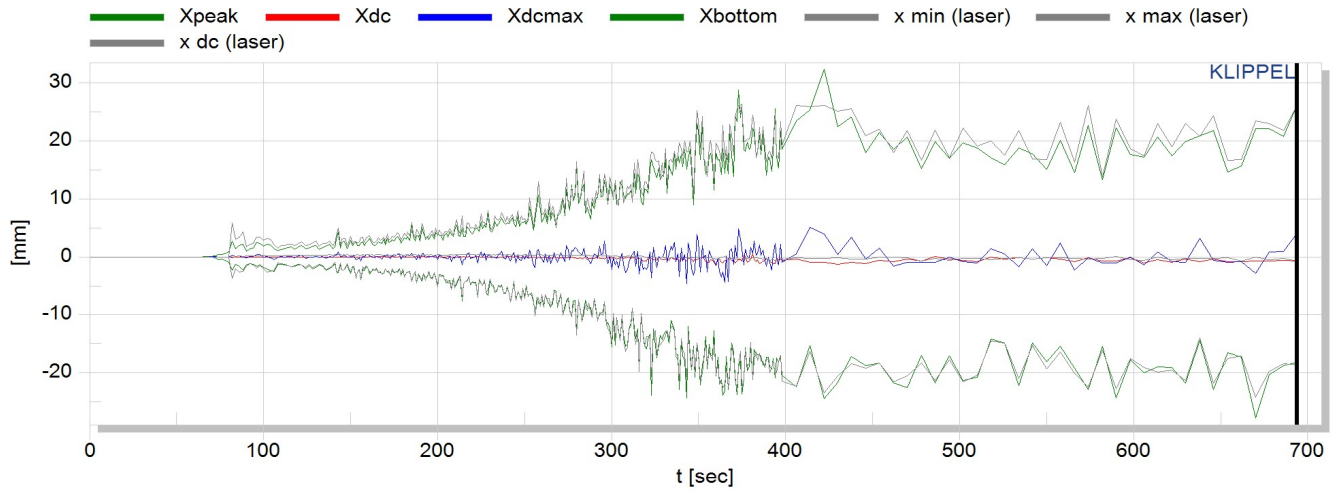X-axis: X [mm] — << coil in ... coil out >>

Minimal parameter values
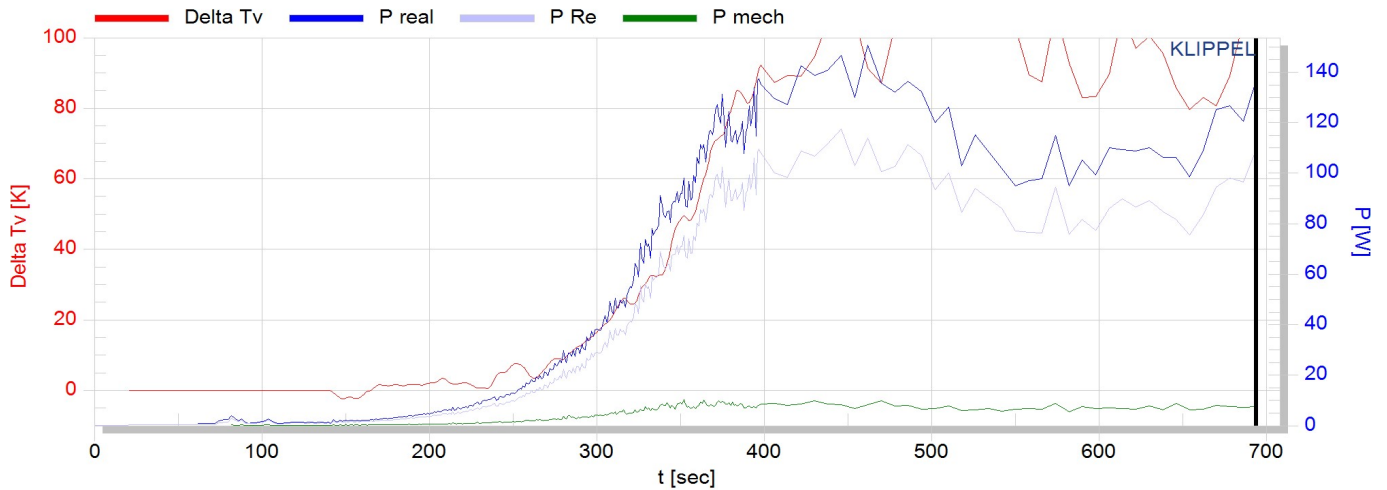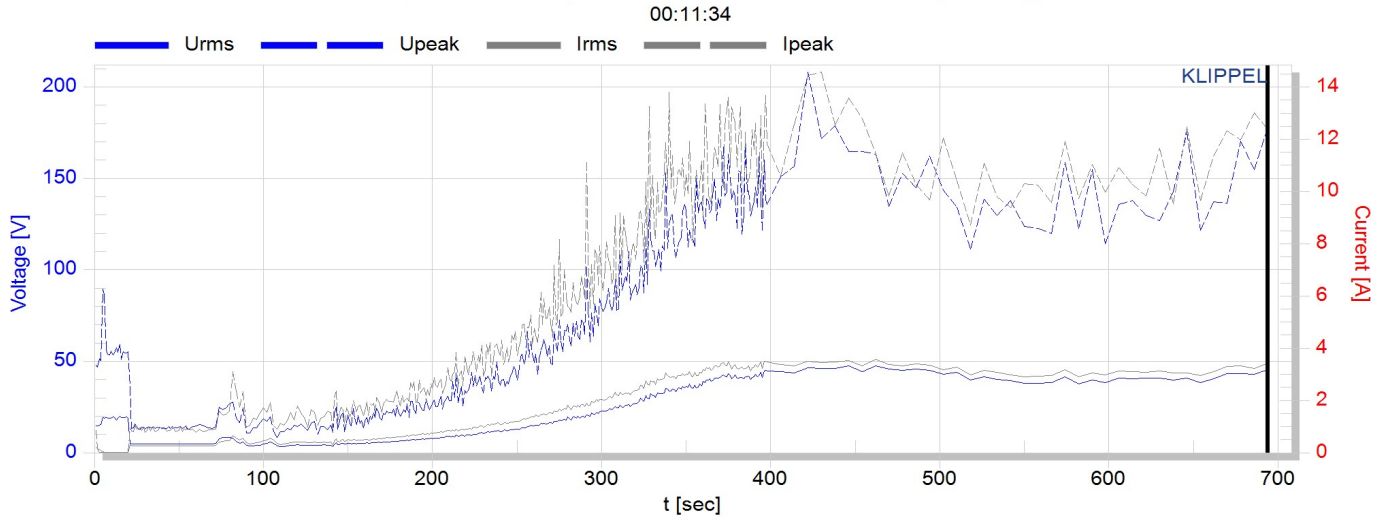
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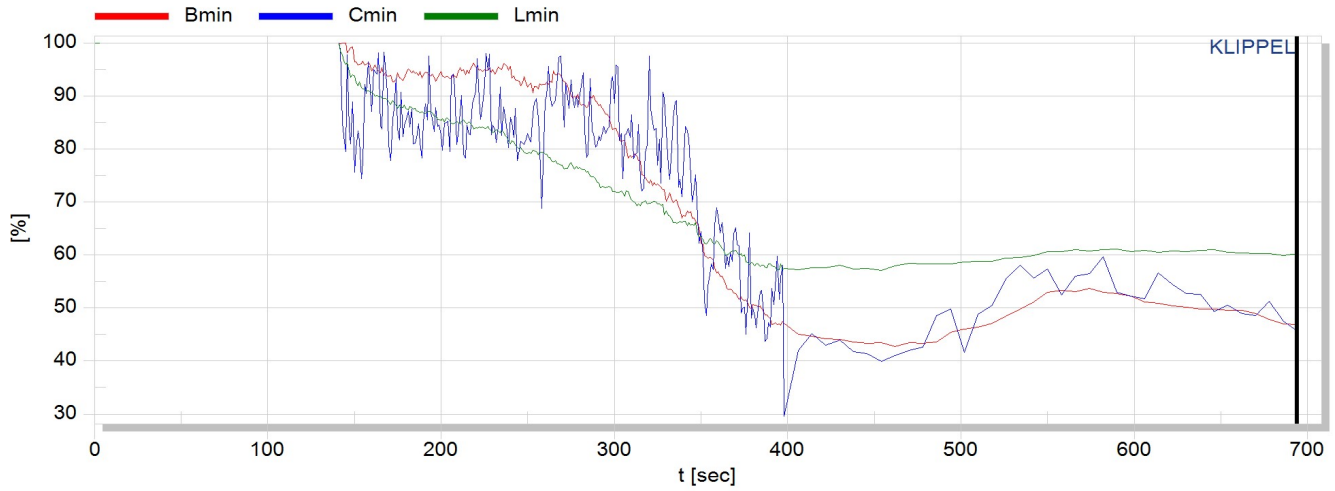
Voice coil displacement

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Increase of voice coil temperature Delta Tv (t) and electrical input power P (t)

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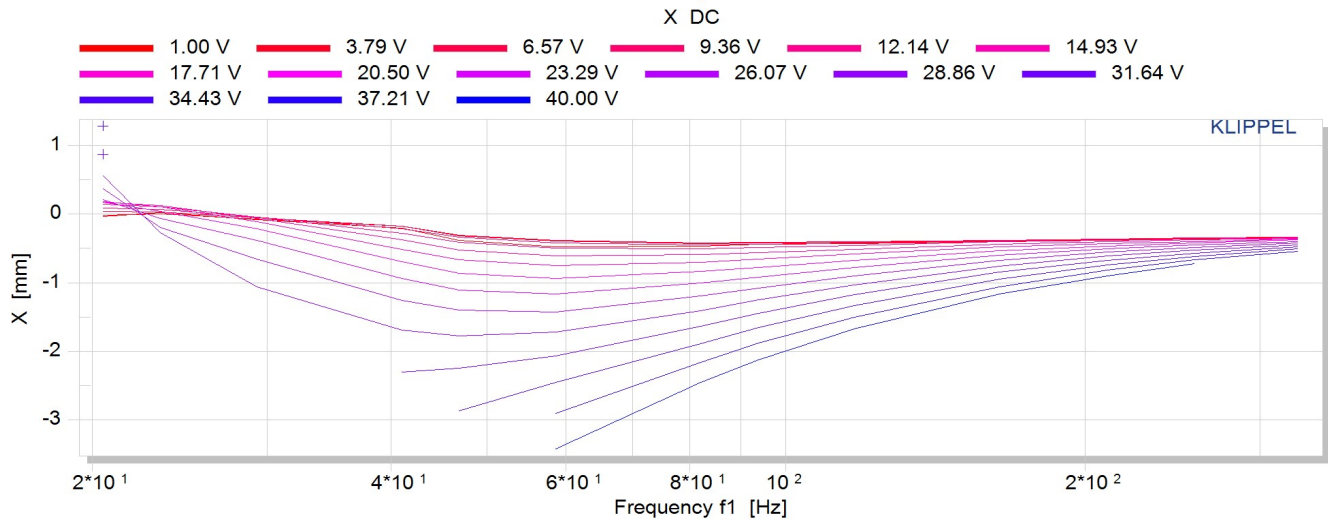
Voltage Urms, Upeak (t) and current Irms, Ipeak (t)

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DC Component (DIS)

DIS Table Signal Characteristics (abridged) - (these are the limits of the test)			
Name	Value	Unit	Comment
Delta Tv lim	50.000	K	allowed increase of voice coil temperature
dht 1 lim	10.000	percent	allowed total harmonic distortion in signal Y1

DC component

X DC

Xmax measurement graphs

Relative total harmonic distortion (dht)
Signal at IN1

Fundamental component
| X (f1, U1) |

Relative second-order harmonic distortion (dh2)
Signal at IN1

Relative third-order harmonic distortion (dh3)
Signal at IN1

Relative second-order intermodulation distortion (d2)
Signal at IN1

Relative third-order intermodulation distortion (d3)
Signal at IN1