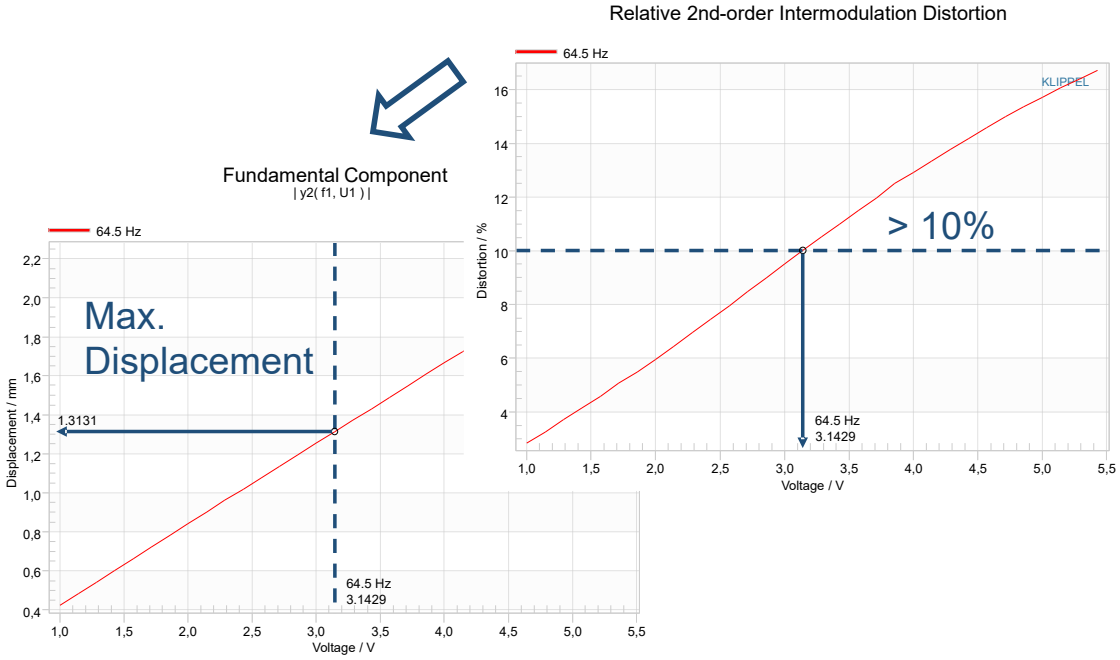
Measurement of peak displacement X_{max} AN 4 (Performance based method)

Application Note to the KLIPPEL R&D System (Document Revision 1.1)

DESCRIPTION

Using the 3D Distortion (DIS) measurement module of the KLIPPEL R&D SYSTEM the maximal peak displacement of a driver is determined by assessing the harmonic and intermodulation distortion in the radiated sound pressure (near field). The new performance-based method is an amendment of the technique AES 2 (1984) and subject of current discussion. It can be accomplished by straightforward techniques defined in the IEC 60268.

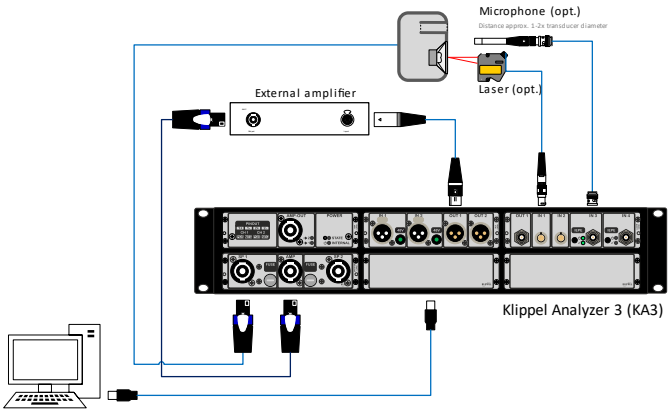


CONTENT

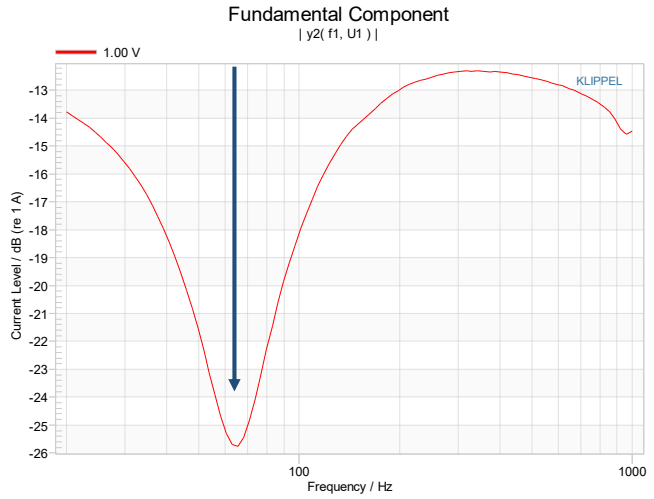
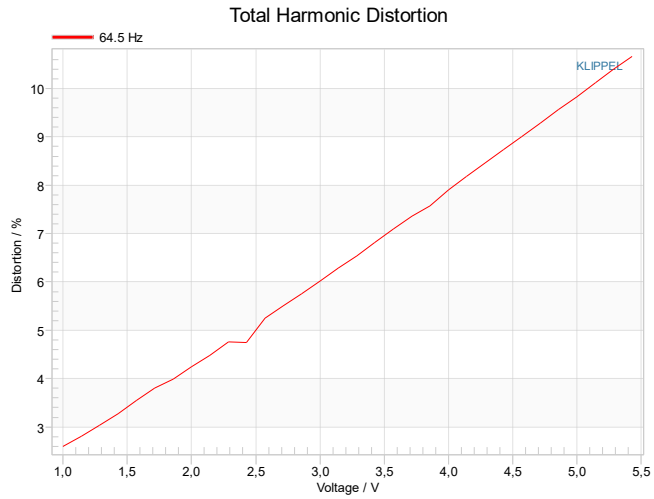
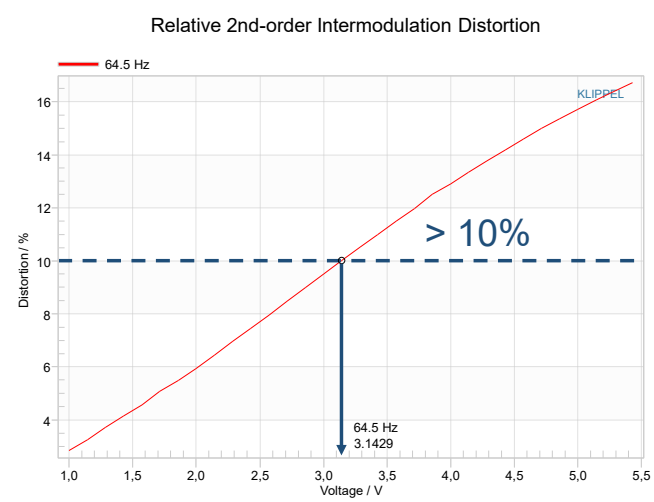
1 Definition of maximum voice-coil displacement

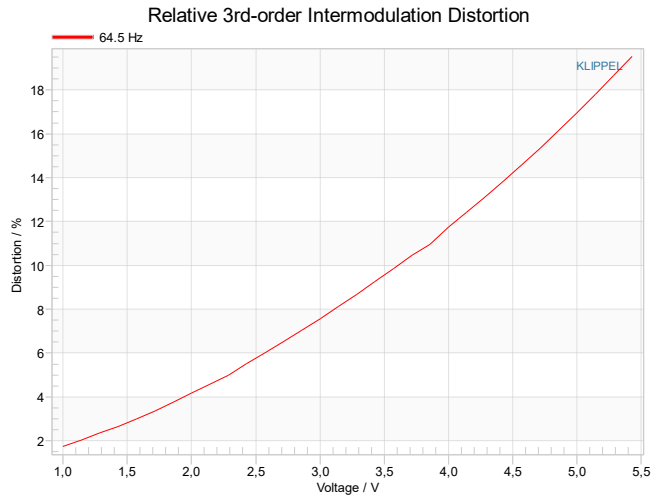
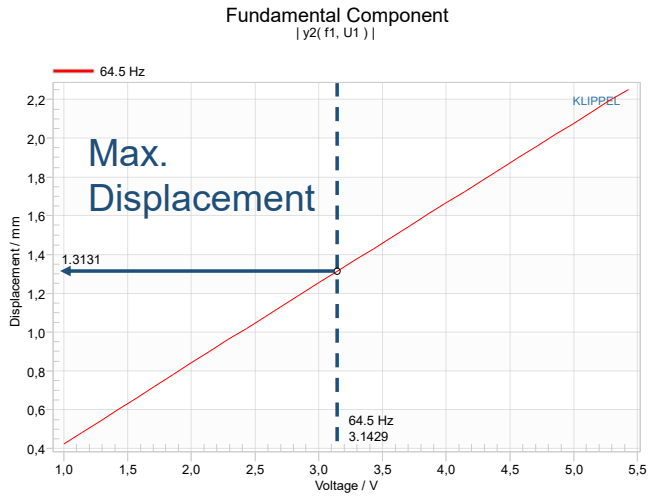
Definition (AES 2-1984)	This standard defines "*the voice-coil peak displacement X_{max} at which the linearity of the motor deviates by 10%. Linearity may be measured by percent distortion of the input current or by percent deviation of displacement versus input current. The manufacturer shall state the method used. The measurement shall be made in free air at f_s.*"
What is wrong with AES 2-1984?	This method of defining the peak displacement X_{max} : • Gives no clear definition of X_{max} • Gives multiple or infinite values of X_{max} • Considers suspension nonlinearity only • Fails in assessing motor linearity
Definition (IEC 62458)	This standard define*s "the voice-coil peak displacement X_{max} at which either the total harmonic distortion d_t or the n^{th}-order modulation distortion (where n=2 or 3) exceeds 10% in the sound pressure radiated by the driver in free air excited by the linear superposition of a first tone at the resonance frequency $f_1=f_s$ and a second tone $f_2=8.5\cdot f_s$ with an amplitude ratio of 4:1. The total harmonic distortion d_t assesses the harmonics of f_1 and the modulation distortion are measured by the modulation components $f_2 \pm n\cdot f_1$ according to IEC 60268.*
Practical Usage	1) Measure resonance frequency f_s of the driver 2) Operate driver under free-field condition and excite driver with a two-tone signal $f_1= f_s$ and $f_2=8.5\cdot f_s$ and amplitude ratio $U_1=4\cdot U_2$ and perform a series of measurements with varied amplitudes $U_{start} < U_1 < U_{end}$. 3) Measure sound pressure in the near-field and perform a spectral analysis to measure the amplitude of the fundamental $P(f_1)$ and $P(f_2)$, of harmonic components $P(k\cdot f_1)$ with k= 2, 3, ...,K and of summed-tone component $P(f_2+(n-1)\cdot f_1)$ and difference-tone components $P(f_2-(n-1)\cdot f_1)$ with n=2, 3 versus amplitude U_1. Measure the peak displacement $X(f_1)$ versus amplitude U_1. 4) Calculate the total harmonic distortion $$d_t = \frac{\sqrt{P(2f_1)^2 + P(3f_1)^2 + .. + P(Kf_1)^2}}{P_t} \cdot 100\%$$ the second-order intermodulation distortion $$d_2 = \frac{P(f_2 - f_1) + P(f_2 + f_1)}{P(f_2)} \cdot 100\%$$ and the third-order intermodulation distortion $$d_3 = \frac{P(f_2 - 2 * f_1) + P(f_2 + 2 * f_1)}{P(f_2)} \cdot 100\%$$ according to IEC 60268 as a function of U_1. 5) Search for minimal value $U_{10\%}$ in the range $U_{start} < U_{10\%} < U_{end}$ where the harmonic distortion d_t, the second- or third-order intermodulation distortion d_2 or d_3, respectively, reach 10%. Search for the peak displacement X_{max} corresponding to the amplitude $U_{10\%}$.

2 Measurement Process

Requirements	• Klippel Analyzer (KA3 or DA2) + PC • 3D Distortion Measurement (DIS) + dB-Lab • Laser sensor head for displacement measurement • Microphone for near field measurement
Setup	• Connect external power amplifier or use internal AMP-Card of KA3 • Mount DUT and connect terminals with speaker output of Klippel Analyzer • Connect microphone to the microphone input of Klippel Analyzer • Adjust laser head to the diaphragm • Place microphone in the near field of the driver 
Preparation	Create new object based on the object template “Xmax10% distortion - AN4” provided in the dB-Lab object templates.
1st Measurement	If you know the resonance frequency of the driver (from LPM or FLSI/LSI) you may skip the first measurement. Alternatively, you may use the DIS measurement 1st measurement for measuring the frequency response of the input current. 1) Start the measurement "1 DIS Find resonance fs" 2) Search for the frequency f_s in window “Fundamental” where the amplitude is minimal.
2nd Measurement	1) Make sure signal level is appropriate for loudspeaker in property page “Stimulus” 2) Start measurement "2 DIS Distortion Measurement" 3) On property page “DISPLAY” make sure “Signal at IN 1” is selected as state signal. 4) Window “2nd Intermodulation Distortion”: Read $U_{d2}=U_1$ where d_2=10% by using the cross cursor (may be activated by using the right-mouse button). 5) Window “3nd Intermodulation Distortion”: Read $U_{d3}=U_1$ where d_3=10% by using the cross cursor 6) Window “THD Total Harmonic Distortion”: Read $U_{dt}=U_1$ where d_t=10% by using the cross cursor 7) If d_2 < 10 % and d_3 < 10% and d_t < 10 % increase U_{end} of the measurement 8) Search for U_{min}= min(U_{dt}, U_{d2}, U_{d3}) 9) Open property page “DISPLAY” and select “Displacement X” 10) Window “FUNDAMENTAL”: Read X_{rms} for U_{min} by using the cross cursor 11) Calculate peak value $X_{max}=1.4 \cdot X_{rms}$

3 Results

Resonance frequency f_s		The fundamental of the input current versus frequency f_1. The minimum of the current shows the resonance frequency f_s of the driver. The minimum of the input current indicates that the resonance frequency is here f_s = 65 Hz.
Total harmonic distortion d_t		The total harmonic distortion d_t of sound pressure of the tone f_1=f_s in percent versus amplitude U_1. For U_1 = 5.2 V_{rms} the driver produces 10 % total harmonic distortion.
Second-order modulation distortion d_2		The second-order inter-modulation distortion d_2 of the radiated two-tone signal in percent versus amplitude U_1. For U_{d2} = 3.15 V_{rms} the driver produces 10 % second-order intermodulation distortion.

Third-order modulation distortion d_3		The third-order inter-modulation distortion d_3 of the radiated two-tone signal in percent versus amplitude U_1. For U_{d3} = 3.65 V_{rms} the driver produces 10 % third-order intermodulation distortion.
Voice Coil displacement		The minimal voltage $U_{min} = U_{d2}$ is determined by the second-order inter-modulation distortion. For U_{min} = 3.15 V_{rms} a displacement X_{RMS} = 1.3 mm is read. As a result, the peak displacement of the driver is **$X_{max} = 1.4 \cdot X_{RMS} = 1.82$ mm**.

4 More Information

Related Specification	3D Distortion Measurement (DIS), Specification S4 Linear Parameter measurement (LPM), Specification S2 Large Signal Identification (FLSI or LSI), Specification S75 or Specification S52 Klippel Analyzer 3 (KA3), Specification H3 Laser displacement sensor, Specification A2 Microphones, Specification A4
Online Manual	DIS - Distortion

Find explanations for symbols at:

http://www.klippel.de/know-how/literature.html

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