

KLIPPEL ANALYZER SYSTEM

Report

**Object: M10 D2**

Comment:

Operation: LPM T/S M10 D2 parallel

Comment: Measures linear parameters (Thiele & Small parameter) of Subwoofers.
 Driver connected to SPEAKER 2 channel.
 (SP2 = current sensitive channel at DA, High Current Sensitivity is default for SP2 at KA3)

Stimulus recommendation:

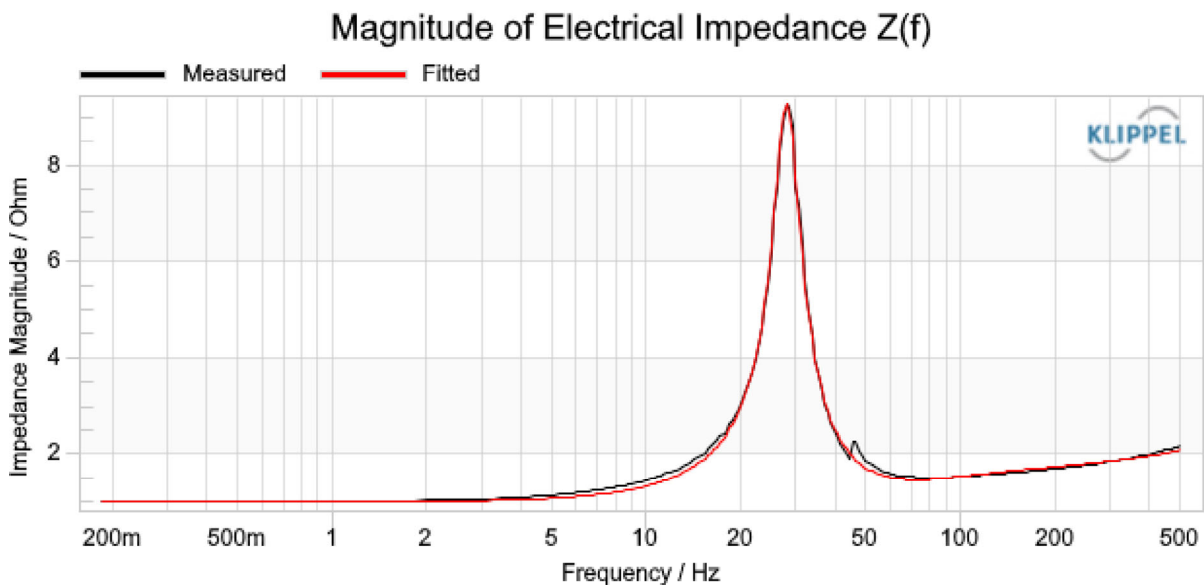
- for DUTs with resonance frequency $f_s \leq 32$ Hz
- LPM reference frequency should be $\leq 1/2 * f_s$
- A resolution of 1/30 octave is recommended for T/S parameter determination (1/31 oct. doubles the measurement time!)
- Fmax should be between $20 * f_s$ and $100 * f_s$
- Adjust voltage and averaging if a low SNR warning get displayed!

Database: M10 D2

Table Linear Parameters

Name	Value	Unit	Comment
Electrical Parameters			
Re	0.99	Ohm	electrical voice coil resistance at DC
Le	0.365	mH	frequency independent part of voice coil inductance
L2	1.686	mH	para-inductance of voice coil
R2	0.75	Ohm	electrical resistance due to eddy current losses
Cmes	3379.83	μ F	electrical capacitance representing moving mass
Lces	9.44	mH	electrical inductance representing driver compliance
Res	8.19	Ohm	resistance due to mechanical losses
fs	28.2	Hz	driver resonance frequency
Mechanical Parameters			
(using laser)			
Mms	254.134	g	mechanical mass of driver diaphragm assembly including air load and voice coil
Mmd (Sd)	246.850	g	mechanical mass of voice coil and diaphragm without air load
Rms	9.181	kg/s	mechanical resistance of total-driver losses
Cms	0.125	mm/N	mechanical compliance of driver suspension
Kms	7.97	N/mm	mechanical stiffness of driver suspension

Bl	8.671	N/A	force factor (Bl product)
Lambda s	0.000		suspension creep factor
Loss factors			
Qtp	0.579		total Q-factor considering all losses
Qms	4.902		mechanical Q-factor of driver in free air considering Rms only
Qes	0.595		electrical Q-factor of driver in free air considering Re only
Qts	0.531		total Q-factor considering Re and Rms only
Other Parameters			
Vas	21.3058	l	equivalent air volume of suspension
n0	0.077	%	reference efficiency (2 pi-radiation using Re)
Lm	80.88	dB	characteristic sound pressure level (at 1 m for 1 W @ Re)
Lnom	80.91	dB	nominal sensitivity (SPL at 1 m for 1 W @ Zn)
rmse Z			
rmse Z	4.85	%	root-mean-square fitting error of driver impedance Z(f)
rmse Hx			
rmse Hx	4.04	%	root-mean-square fitting error of transfer function Hx(f)
Series resistor			
Series resistor	0.00	Ohm	resistance of series resistor
Sd			
Sd	346.36	cm2	diaphragm area



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KLIPPEL ANALYZER SYSTEM

Report



Object: M10 D2

Comment:

Operation: LPM T/S M10 D2 series

Comment: Measures linear parameters (Thiele & Small parameter) of Subwoofers.
 Driver connected to SPEAKER 2 channel.
 (SP2 = current sensitive channel at DA, High Current Sensitivity is default for SP2 at KA3)

Stimulus recommendation:

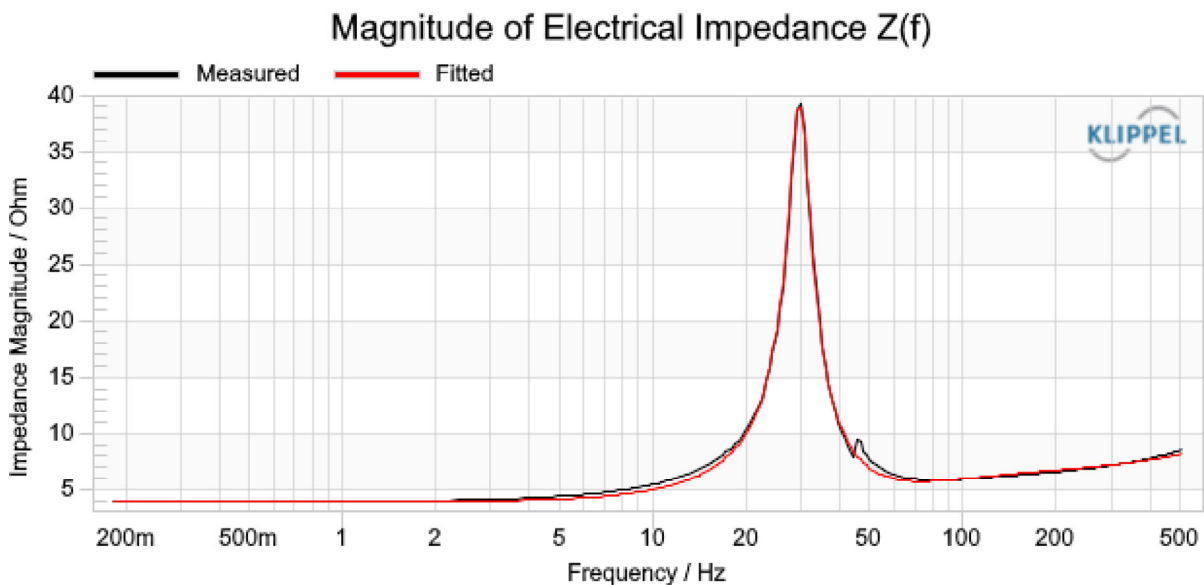
- for DUTs with resonance frequency $f_s \leq 32$ Hz
- LPM reference frequency should be $\leq 1/2 * f_s$
- A resolution of 1/30 octave is recommended for T/S parameter determination (1/31 oct. doubles the measurement time!)
- Fmax should be between $20 * f_s$ and $100 * f_s$
- Adjust voltage and averaging if a low SNR warning get displayed!

Database: M10 D2

Table Linear Parameters

Name	Value	Unit	Comment
Electrical Parameters			
Re	3.86	Ohm	electrical voice coil resistance at DC
Le	1.438	mH	frequency independent part of voice coil inductance
L2	6.620	mH	para-inductance of voice coil
R2	2.93	Ohm	electrical resistance due to eddy current losses
Cmes	854.67	μ F	electrical capacitance representing moving mass
Lces	33.37	mH	electrical inductance representing driver compliance
Res	34.80	Ohm	resistance due to mechanical losses
fs	29.8	Hz	driver resonance frequency
Mechanical Parameters			
(using laser)			
Mms	255.425	g	mechanical mass of driver diaphragm assembly including air load and voice coil
Mmd (Sd)	248.141	g	mechanical mass of voice coil and diaphragm without air load
Rms	8.589	kg/s	mechanical resistance of total-driver losses
Cms	0.112	mm/N	mechanical compliance of driver suspension
Kms	8.96	N/mm	mechanical stiffness of driver suspension

Bl	17.287	N/A	force factor (Bl product)
Lambda s	0.000		suspension creep factor
Loss factors			
Qtp	0.613		total Q-factor considering all losses
Qms	5.569		mechanical Q-factor of driver in free air considering Rms only
Qes	0.618		electrical Q-factor of driver in free air considering Re only
Qts	0.556		total Q-factor considering Re and Rms only
Other Parameters			
Vas	18.9562	l	equivalent air volume of suspension
n0	0.078	%	reference efficiency (2 pi-radiation using Re)
Lm	80.95	dB	characteristic sound pressure level (at 1 m for 1 W @ Re)
Lnom	81.10	dB	nominal sensitivity (SPL at 1 m for 1 W @ Zn)
rmse Z			
rmse Z	4.69	%	root-mean-square fitting error of driver impedance Z(f)
rmse Hx			
rmse Hx	3.60	%	root-mean-square fitting error of transfer function Hx(f)
Series resistor			
Series resistor	0.00	Ohm	resistance of series resistor
Sd			
Sd	346.36	cm2	diaphragm area



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KLIPPEL ANALYZER SYSTEM

Report



Object: M10 D2
 Comment:
Operation: LS13 M10 D2
 Comment:
Database: M10 D2

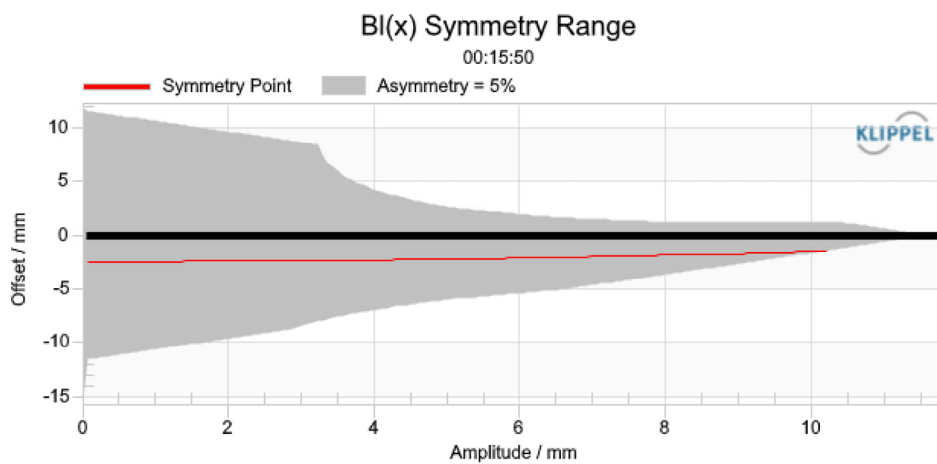
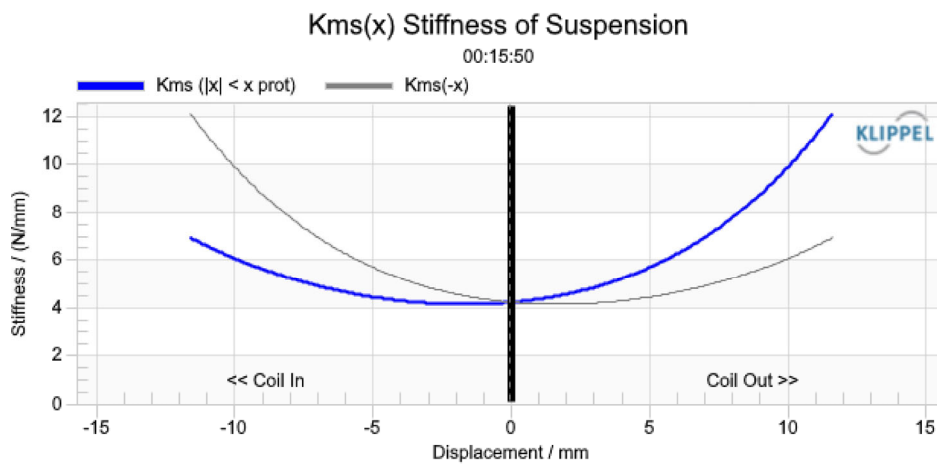
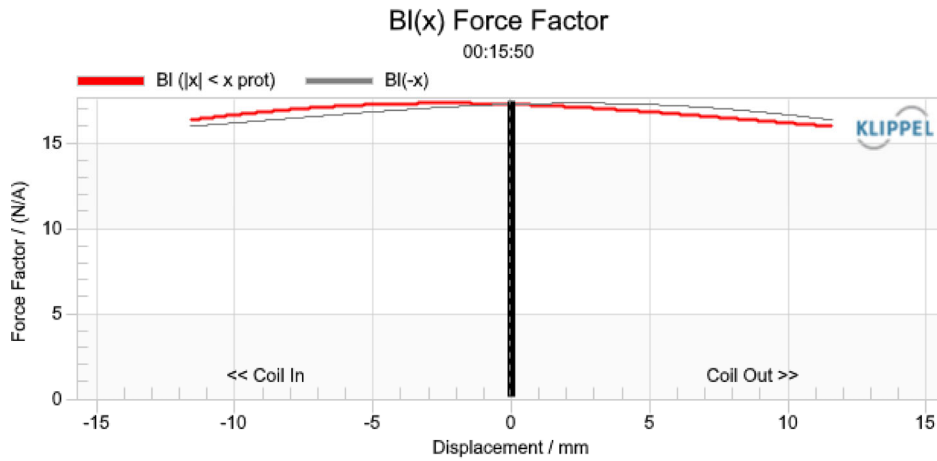


Table Parameters at x=0

Symbol	Large + Warm	Large + Cold	Small Signal	Unit	Comment
ΔT_v	25.24	0.00	0.00	K	Increase of voice coil temperature
x_{prot}	11.64	11.64	0.17	mm	Maximum voice coil excursion allowed by protection system
$R_e(T_v)$	4.34	3.96	3.96	Ω	Voice coil resistance considering the voice coil temperature ΔT_v
$L_e(x=0)$	0.80	0.80	0.66	mH	Voice coil inductance at the coil's rest position
$L_2(x=0)$	4.15	4.15	3.66	mH	Electrical inductance model parameter
$R_2(x=0)$	5.15	5.15	5.08	Ω	Electrical resistance due to magnetic losses
$f_s(x=0)$	20.00	20.00	27.01	Hz	Driver resonance frequency
$Q_{ts}(x=0, T_v)$	0.43	0.39	0.54		Total Q-factor considering $R_e(T_v)$ and R_{ms} at f_s
$Q_{es}(x=0, T_v)$	0.49	0.45	0.58		Electrical Q-factor at f_s , considering $R_e(T_v)$ only
$Q_{ms}(x=0)$	3.45	3.45	8.13		Mechanical Q-factor at f_s , considering R_{ms} only
$Bl(x=0)$	17.287	17.287	-	N/A	(IMPORTED) Force factor at the rest position (Bl product)
M_{ms}	267.706	267.706	-	g	Moving mass including air load
$K_{ms}(x=0)$	4.23	4.23	7.38	N/mm	Mechanical stiffness of the driver suspension at f_s
$C_{ms}(x=0)$	0.24	0.24	0.14	mm/N	Mechanical compliance of the driver suspension at f_s
$R_{ms}(x=0)$	9.742	9.742	5.350	kg/s	Mechanical resistance of total driver losses at f_s
$C_{mes}(x=0)$	895.82	895.82	857.49	μF	Electrical capacitance representing moving mass
$L_{ces}(x=0)$	70.70	70.70	40.48	mH	Electrical inductance representing driver compliance at f_s
$R_{es}(x=0)$	30.67	30.67	55.86	Ω	Electrical resistance representing non-electrical losses at f_s
S_d	346.36	346.36	346.36	cm^2	(IMPORTED) effective sound radiation area. Used to display V_{as} , η_0 and L_m
V_{as}	39.8613	39.8613	22.8231	l	Equivalent air volume of suspension
η_0	0.0628	0.0688	0.0751	%	Reference efficiency (2π -sr radiation using $R_e(T_v)$)
L_m	80.00	80.39	80.77	dB	Characteristic sound pressure level

Table Nonlinear Parameters

Symbol	Value	Unit	Comment
Displacement Limits			
$x_{Bl} @ Bl_{\min}=70\%$	> 11.64	mm	Displacement limit due to force factor variation
$x_C @ C_{\min}=75\%$	4.97	mm	Displacement limit due to compliance variation
$x_L @ Z_{\max}=10\%$	> 11.64	mm	Displacement limit due to inductance variation
$x_d @ d_2=10\%$	45.30	mm	Displacement limit due Doppler IM distortion
Asymmetry (IEC 62458)			
x_{sym}	-1.42	mm	Symmetry point of $Bl(x)$ at x_{prot}
a_{bl}	2.28	%	$Bl(x)$ asymmetry $A_{bl}(x_{\text{prot}})$
a_{kms}	-54.96	%	Stiffness asymmetry $A_{kms}(x_{\text{prot}})$
Power Series			
$Bl0 = Bl(x=0)$	17.2870000	N/A	Constant part in force factor
$Bl1$	-0.0483589	N/Amm	1st order coefficient in force factor expansion
$Bl2$	-0.0093492	N/Amm ²	2nd order coefficient in force factor expansion
$Bl3$	0.0002481	N/Amm ³	3rd order coefficient in force factor expansion
$Bl4$	0.0000091	N/Amm ⁴	4th order coefficient in force factor expansion
$K0 = K_{ms}(x=0)$	4.2269430	N/mm	Constant part in stiffness
$K1$	0.1013776	N/mm ²	1st order coefficient in stiffness expansion
$K2$	0.0322088	N/mm ³	2nd order coefficient in stiffness expansion
$K3$	0.0009071	N/mm ⁴	3rd order coefficient in stiffness expansion

K4	0.0000532	N/mm ⁵	4th order coefficient in stiffness expansion
<hr/>			
$C_0 = C_{ms}(X=0)$	0.2365776	mm/N	Constant part in compliance
C1	-0.0053488	1/N	1st order coefficient in compliance expansion
C2	-0.0014994	1/Nmm	2nd order coefficient in compliance expansion
C3	0.0000210	1/Nmm ²	3rd order coefficient in compliance expansion
C4	0.0000045	1/Nmm ³	4th order coefficient in compliance expansion
<hr/>			
$L_0 = L_e(X=0)$	0.7994957	mH	Constant part in inductance
Lx1	-0.0030640	mH/mm	1st order coefficient in inductance expansion
Lx2	-0.0009571	mH/mm ²	2nd order coefficient in inductance expansion
Lx3	0.0000058	mH/mm ³	3rd order coefficient in inductance expansion
Lx4	0.0000009	mH/mm ⁴	4th order coefficient in inductance expansion
<hr/>			
f1	0.0021236	1/A	1st coefficient of L(I) Inductance over current (flux modulation)
f2	0.0000762	1/A ²	2nd coefficient of L(I) Inductance over current (flux modulation)

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