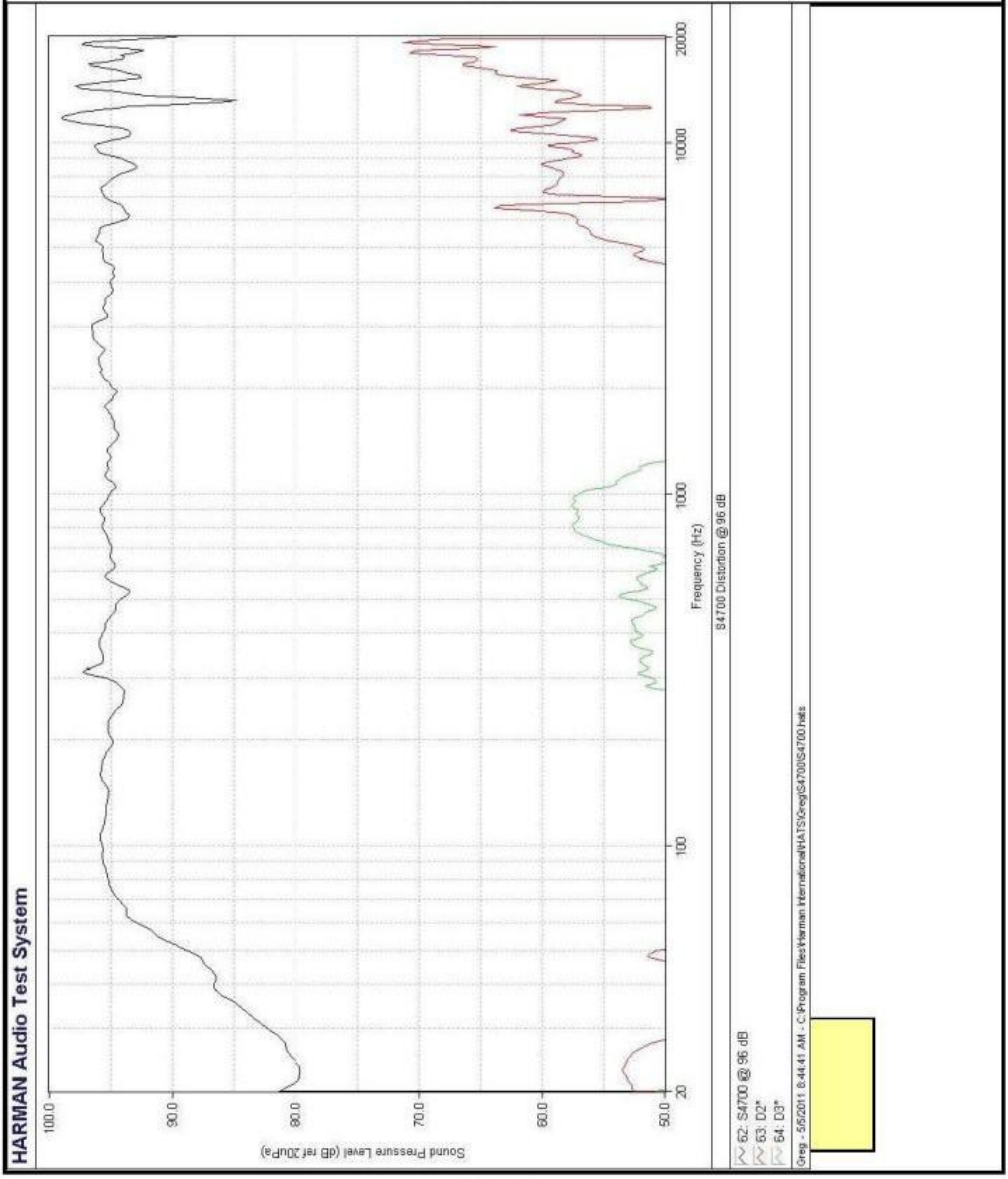
Engineering Standard Distortion	Date	Rev #	Document Number
	8/5/2011	X4	9900514

S4700



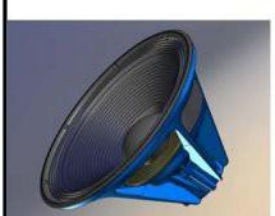
harman consumer group

Engineering Design Specification	Date	Rev #	Document Number
	8/12/2011	A	9990013

High Performance 15 inch woofer with low power compression

Model Number:	**2216Nd**
Part Number:	**320-0045-001**
Division:	**JBL (Harman Japan)**
Where Used:	**JBL S4700 System**
Approved Supplier(s)	**JBL Pro Manufacturing - HAdM (Mexico)**
Design Engineer:	**Jmoro**

Assembled View:



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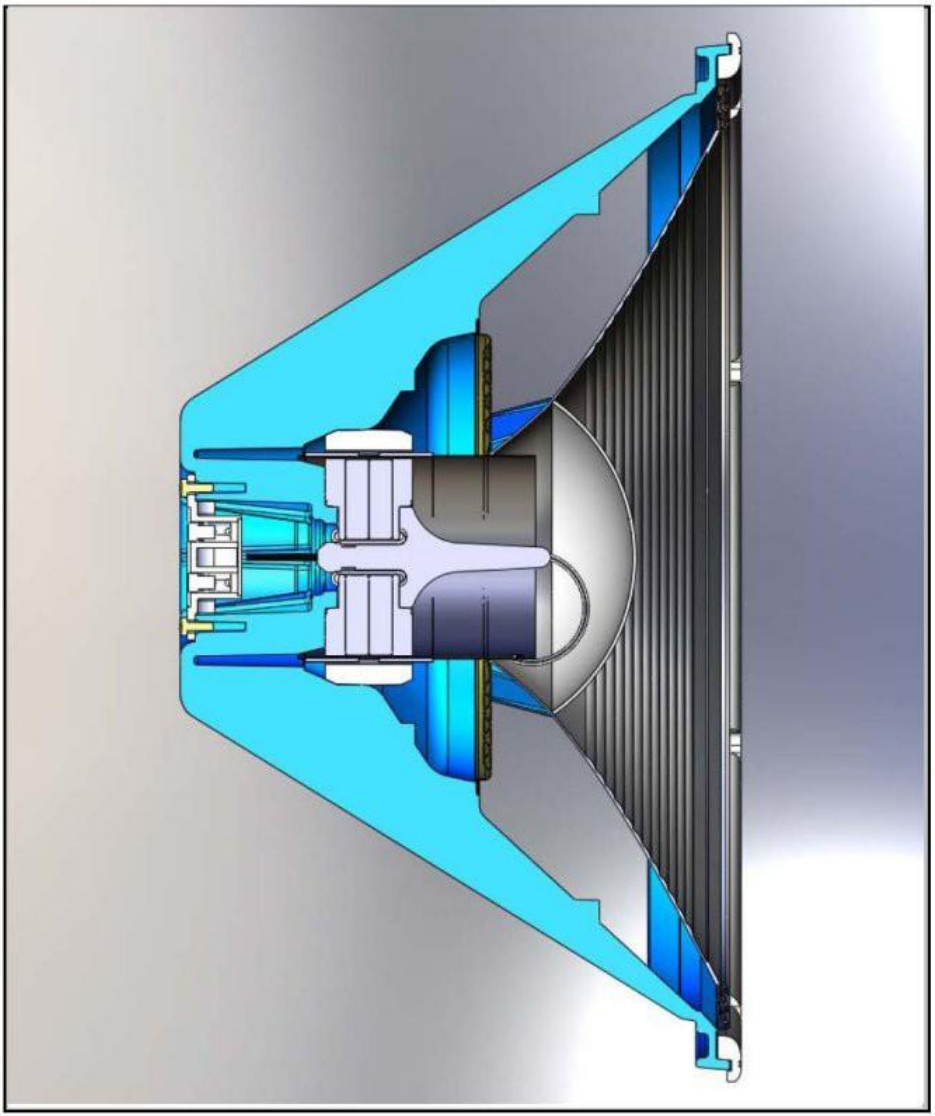
High Performance 15 inch woofer with low power compression

Section View

Model #	2216Nd	Part #	320-0045-001



Document Revision History

Rev #	Date	Description of Change	ECO#	Approval	
				M.E.	T.E.
X1	5/5/2011			n/a	JM
X2	5/5/2011	Update spec.		n/a	JM
X3	6/17/2011	Updated various items		n/a	JM
X4	7/28/2011	Updated ETS Power test spec and notes.		n/a	JM
A	8/12/2011	Release to production	5557	n/a	JM

Engineering Design Specification	Date	Rev #	Document Number
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High Performance 15 inch woofer with low power compression

Transducer Mechanical Characteristics

Model #	2216Nd	Part #	320-0045-001

Assembly

Mounting Diameter:	13.78 inches	Mounting Depth:	7.66 inches
Flange Diameter:	15.23 inch - 5 deg draft	Flange Depth:	0.500 inches
Mounting Detail:	8x 0.270" Thru on 14.560" B.C.	Overall Depth:	8.325 inches
Other:	Rubber front gasket sits outside frame flange, increasing Diameter to 15.578 inches		

Frame

Type:	Thin wall Cast Aluminum	Material:	380 Aluminum Alloy
Color:	Black	Finish:	Slight texture Powder Coat Paint
Other:			

Diaphragm

Type:	Curve-Linear cone	Material:	Mogami special Paper pulp formula
Color:	Black	Finish:	Ribbed cone surface - smooth back
Other:			

Surround

Type:	3 roll accordian edge - semi cup	Material:	Mogami special Nylon/cotton blend
Color:	Black	Finish:	Airflex 400 edge treat damping
Other:			

Spider

Type:	4.5 roll accordian - semi cup	Material:	Conex fiber (Aramid fiber)
Weave:	NX9046 / NW11	Color:	Natural (Yellow)
Other:	Deflection = 0.28 inches @ 50 grams		

Front Gasket

Material:	NBR rubber trim ring	Color:	Black

Rear Gasket

Material:	n/a	Color:	n/a

Voice Coil

I.D.:	3 inch - dual coil	Max. O.D.:	3.120 inches
Wire Type:	5056 Aluminum Ribbon (Edge) wound	Wire Size:	0.048 x 0.011989 inch (bare)
Wire Turns:	64 each coil	Wire D.C.R.:	5.00 Ohms (series connected total)
Winding Width:	0.800 inch each coil @ .30 inch apart	Winding layers:	1 layer
Former:	High-Temp 0.18mm FQG Fiberglass	Wrapper:	High-Temp 0.13mm NEC - 2 layers
Other:	Coils internally connected in Series, Perforations 10x @ 0.25 inch Dia.		

Magnet

Material:	Neodymium 33MGOe - SH grade	Thickness:	0.350 inch
O.D.:	2.910 inch	I.D.:	0.535 inch
Other:	Finish: Zinc Electroplate with Electrolytically applied Epoxy paint		

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High Performance 15 inch woofer with low power compression

Transducer Mechanical Characteristics (Motor)

Model #	2216Nd	Part #	320-0045-001

Pole Plate(s)

Material:	Cold rolled Steel (< 0.15% carbon)	Thickness:	0.300 inch
O.D.:	2.930 inch	I.D.:	0.510 inch (for rivet)
Other:	Finish: Clear Zinc palting		

Pole-Mag-Pole Asy. (Burger)

O.D.:	n/a	Copper Cap:	n/a
Vent:	n/a		
Other:			

Gap Sleeve

Material:	Cold rolled Steel (< 0.15% carbon)	Thickness:	1.300 inch (Height)
O.D.:	3.788 inches (press area)	I.D.:	3.180 inches
Other:	Slight taper at ends but not "saturated tips".		

Bucking Magnet

Material:	n/a	Thickness:	n/a
O.D.:	n/a	I.D.:	n/a
Other:			

Shielding Can

Material:	n/a	Thickness:	n/a
Other:			

Misc

Terminal Size / Type:	Plastic Push-button (high pressure)	Polarity:	E.I.A.
SFG Configuration:	Differential Drive configuration with dual opposing magnetic gaps		
Flux Stabilizing Ring:	n/a		
Tinsel Lead Type:	Silicon Pigtail assembly (located under dome)		
Tinsel Lead Attach.:	Crimped at Terminal and crimped/soldered at voice coil		
Other:	Special voice coil wire is used with low TCR value to reduce increase of DCR as coil temp rises.		

Notes:

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High Performance 15 inch woofer with low power compression

Model #	2216Nd	Part #	320-0045-001

Transducer Electro-Mechanical Parameters

Fundamental Resonant Frequency (Hz):	Fs	36	+/-	10%
Transducer Direct Current Resistance (Ohms):	DCR	5	+/-	3%
Total Driver Q at Fs, Considering all driver Resistance:	Qts	0.44	+/-	5%
Moving Mass (g):	Mms	135	+/-	5%
Motor Strength (T*m):	Bl	18.9	+/-	5%
Voltage Sensitivity(2.83V@1 meter)	SPL	95 *	+/-	1dB
Radiation Area	Sd	907.92cm^2		

Method

Software:	MLSSA
Mass Loading:	200 grams
Misc.:	

Magnetic Flux Information (For Engineering Reference Only)

Total flux lines intercepted by coil windings [Maxwell Turns]:	291,500 (each coil)
Conversion to flux density [Tesla]:	0.587 (each coil)
Flux lines throughout gap thickness [Maxwell Turns]:	173,000 (each gap)
Conversion to flux density [Tesla]:	0.934 (each gap)

Notes

Parameters provided are nominal values which are closest to the Engineering Referance Standard

Voltage Sensitivity takes precedence over possible T/S combinations that would produce SPL

* SPL of 95dB measured at Min Impedance (200 - 300 Hz)

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High Performance 15 inch woofer with low power compression

Transducer Test Specifications

production testing quantities per HCG QA AQL

Model # **2216Nd** Part # **320-0045-001**

Polarity Test

Polarity: E.I.A standard (+ voltage at Pos terminal = Cone Out)

Dynamic Test

Sine Sweep Voltage:	17 vrms
Frequency Range:	20 Hz - 500 Hz
Sweep Duration:	6 seconds

Power Test

Signal	Pink Noise, 40-400 Hz, 38 Vrms, 6dB Crest Factor*
Duration:	8 + 92 hours(Qualification), 2 hrs (Production Audit)

Impedance

DC Resistance:	5 Ohms
Min. Impedance @ Frequency	5.8 Ohms at 240 Hz

Frequency Response

Freq. Response:

Window	***Averaging***	***Slope***
60 - 403 Hz +/- 1.0 dB	1/6 Octave	36 dB / Octave
403 - 905 Hz +/- 1.0 dB	1/3 Octave	36 dB / Octave
905 - 2K Hz +/- 2.0 dB	1/3 Octave	36 dB / Octave
	1/3 Octave	36 dB / Octave
	1/3 Octave	36 dB / Octave
	1/3 Octave	36 dB / Octave
	1/3 Octave	36 dB / Octave
	1/3 Octave	36 dB / Octave
	1/3 Octave	36 dB / Octave
	1/3 Octave	36 dB / Octave

Notes:

Units will pass 48 Vrms at 50Hrs and even higher voltages for much shorter duration.

2nd Harmonic Distortion level to be about +/- 5dB from 2nd Harmonic of authorized Line / QA Production Standard
This is to monitor LOW voice coils in the Magnetic gap.

High Performance 15 inch woofer with low power compression

Model # 2216Nd   Part # 320-0045-001

LL .1m32Wf!

MLSSA SPO 4WI #010227-3479-3488 for Harman Consumer Group

Measured Parameters   QC Limits

Line	Parameter	Value	Units
1	RMSE-free	0.55	Ohms
2	Fs	39.26	Hz
3	Re	5.27	Ohms
4	Res	51.36	Ohms
5	Qms	4.76	
6	Qes	0.49	
7	Qts	0.44	
8	L1	0.52	mH
9	L2	0.65	mH
10	R2	1.56	Ohms
11	RMSE-load	0.33	Ohms
12	Vas(Sd)	140.69	liters
13	Mms	135.21	grams
14	Cms	122	µM/Newton
15	Bl	18.96	Tesla-M
16	SPLref(Sd)	96.1	dB[8 ohms]
17	Rub-index	0.00	

$R_{me} = 68.21$

Method: Mass-loaded (200.000 grams)   Area (Sd): 907.92 sq cm

DCR mode: Fixed (5.84 - 0.57 ohms)   QC file: CLOSED

Analysis successful. Shift in Fs = -38.3% (-20% to -50% is recommended).

2216Nd Rev.G#1 (w/12 coil Perfs)   MLSSA: Parameter

Engineering Standard Frequency Response	Date	Rev #	Document Number
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High Performance 15 inch woofer with low power compression

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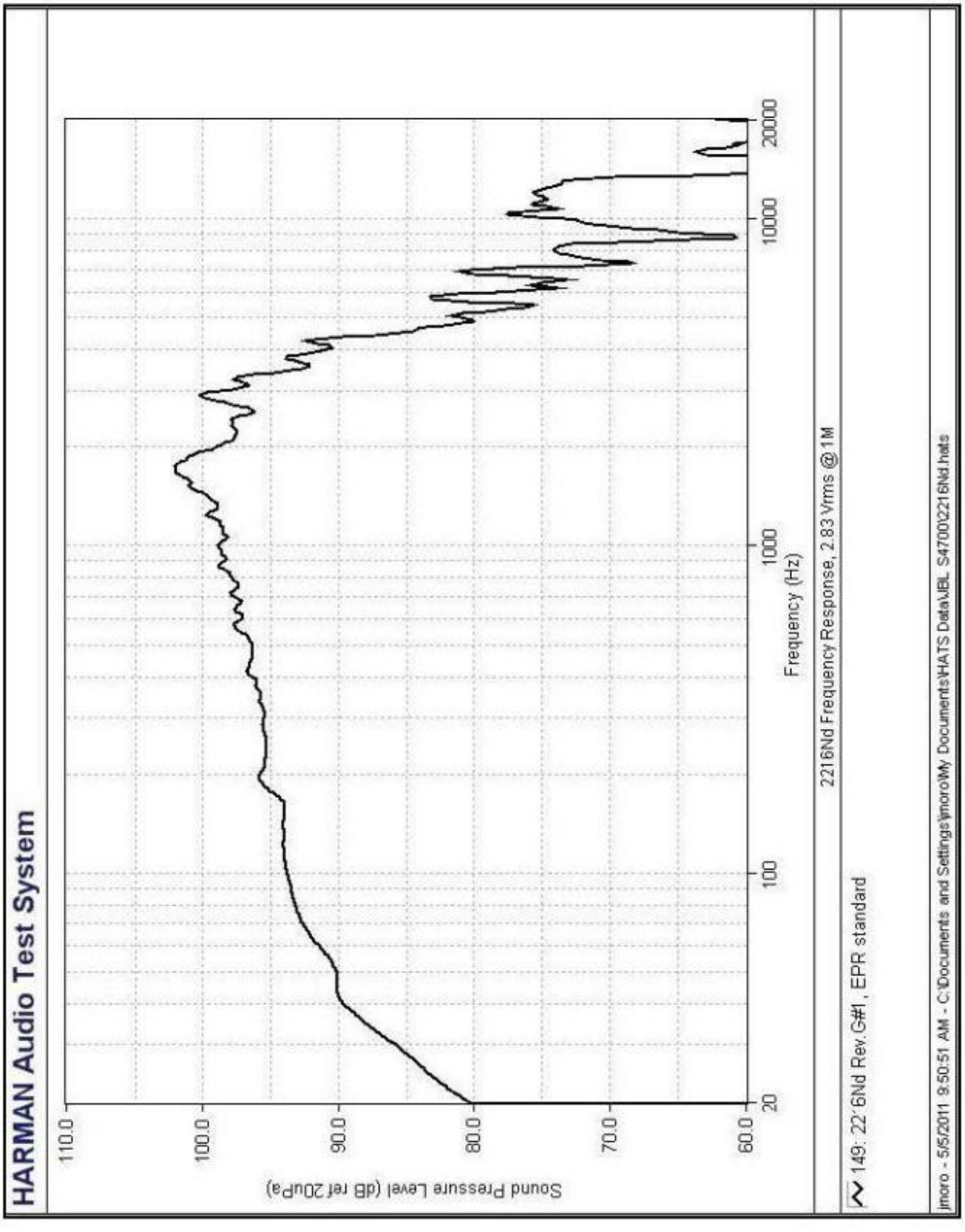

Engineering Standard Distortion (Low Level)	Date	Rev #	Document Number
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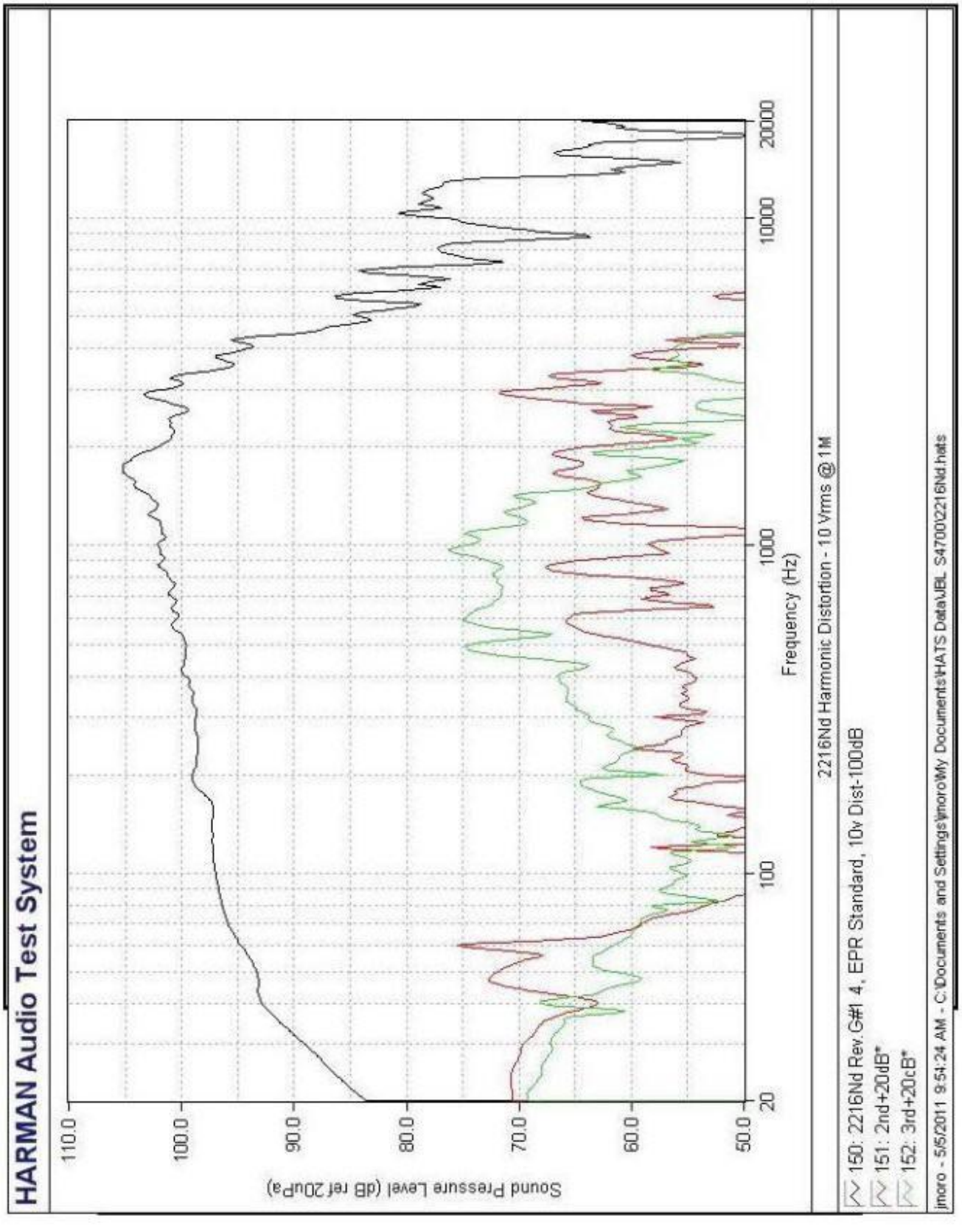
High Performance 15 inch woofer with low power compression

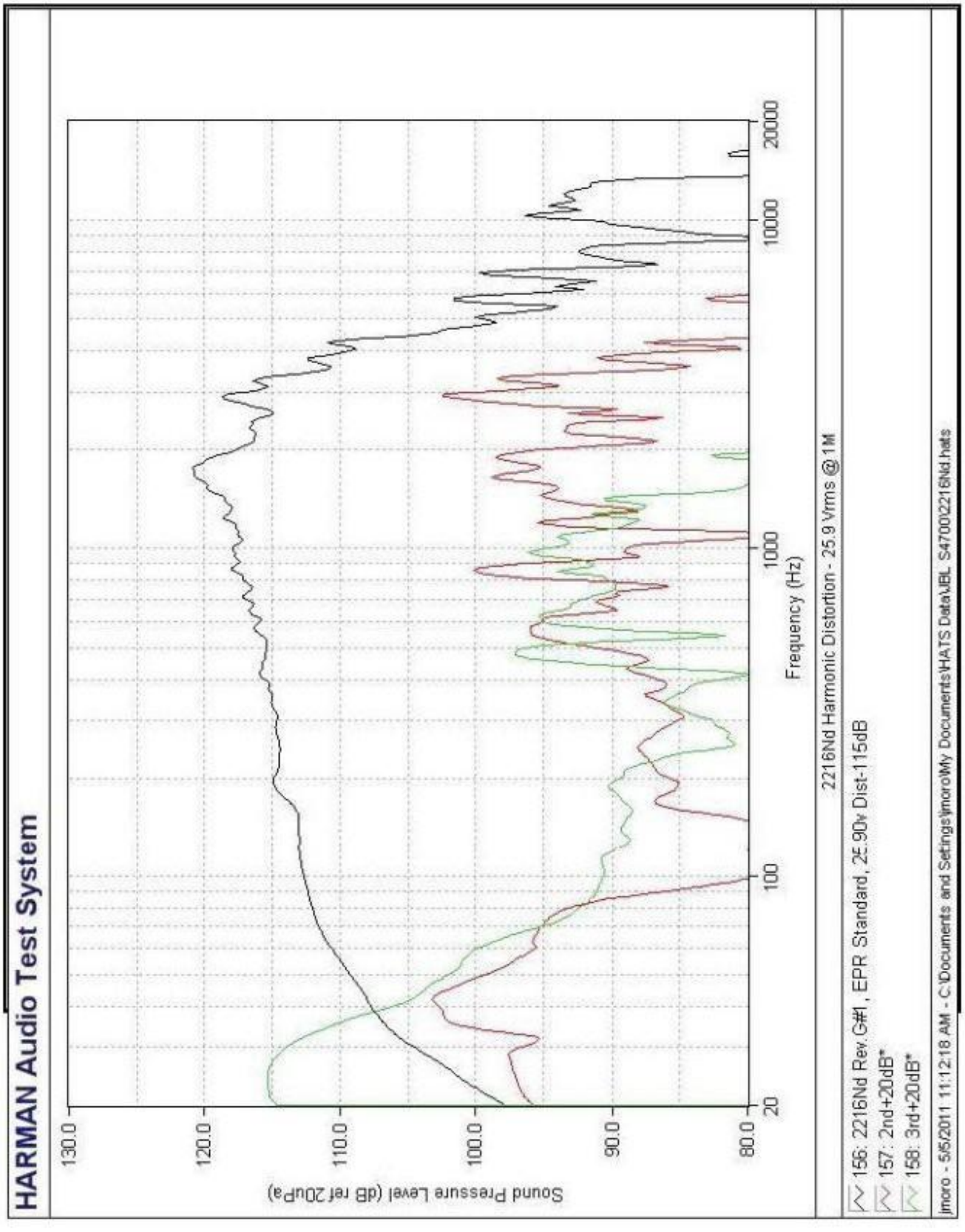
Model # **2216Nd** Part # **320-0045-001**



Engineering Standard Distortion (High Level)	Date	Rev #	Document Number
	8/12/2011	A	9990013

High Performance 15 inch woofer with low power compression

Model # **2216Nd** Part # **320-0045-001**



Engineering Standard Impedance	Date	Rev #	Document Number
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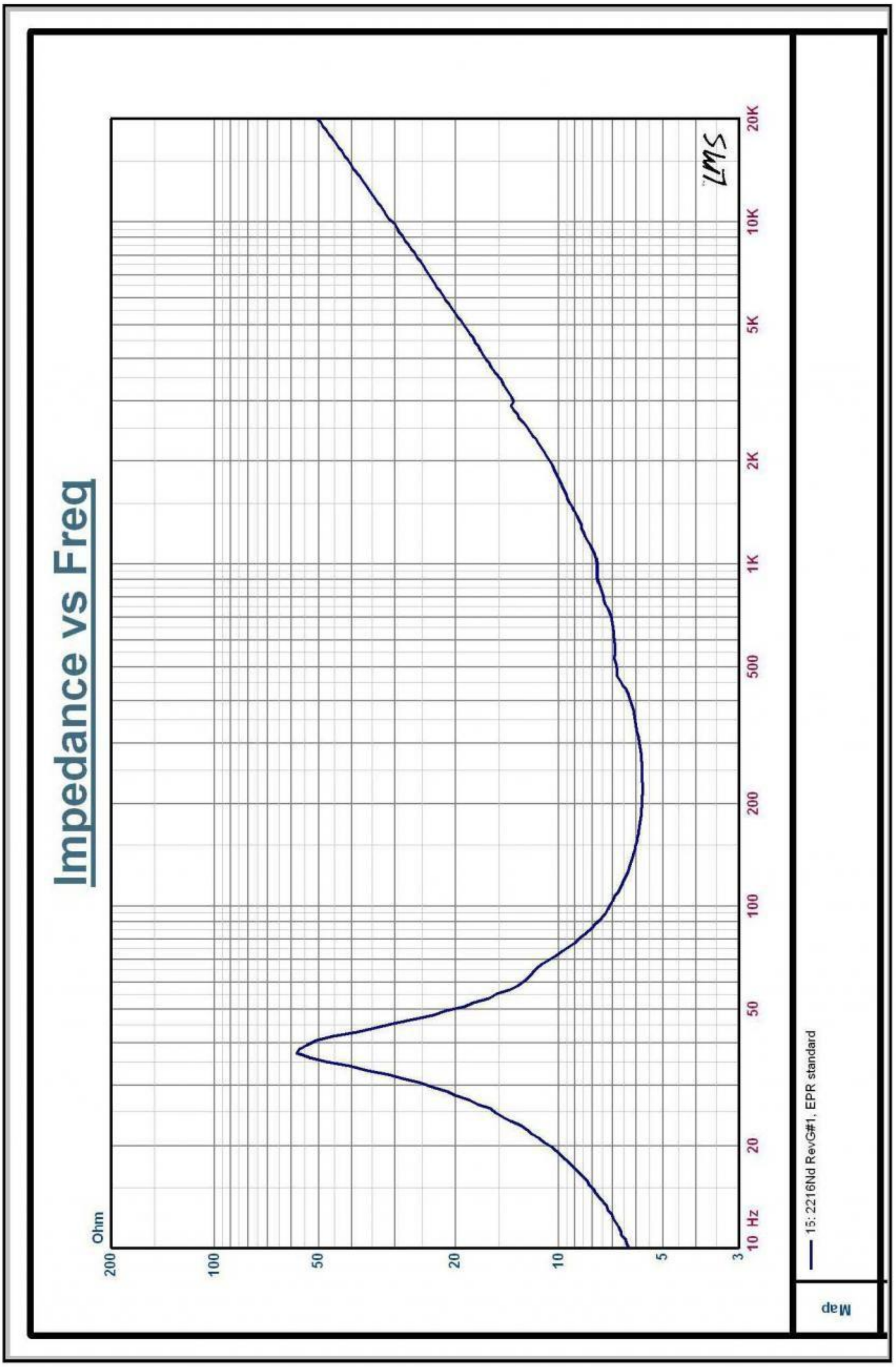
High Performance 15 inch woofer with low power compression

Model # **2216Nd** Part # **320-0045-001**



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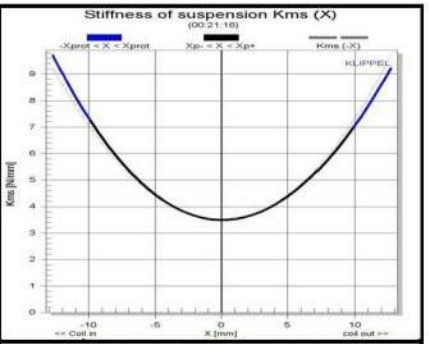
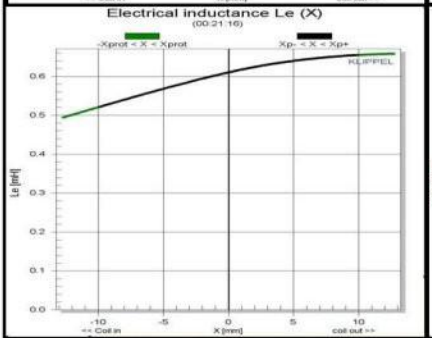
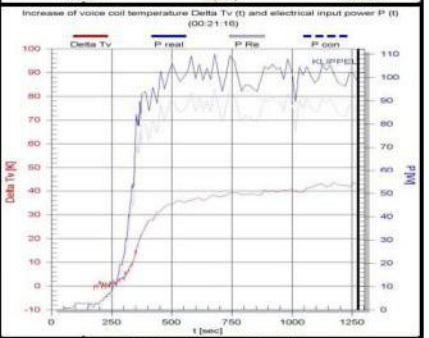
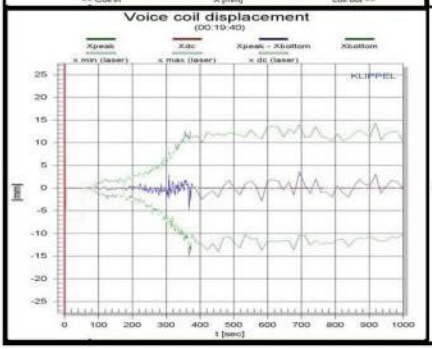
High Performance 15 inch woofer with low power compression

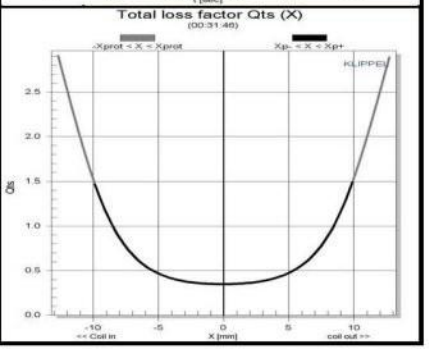
Model # 2216Nd Part # 320-0045-001











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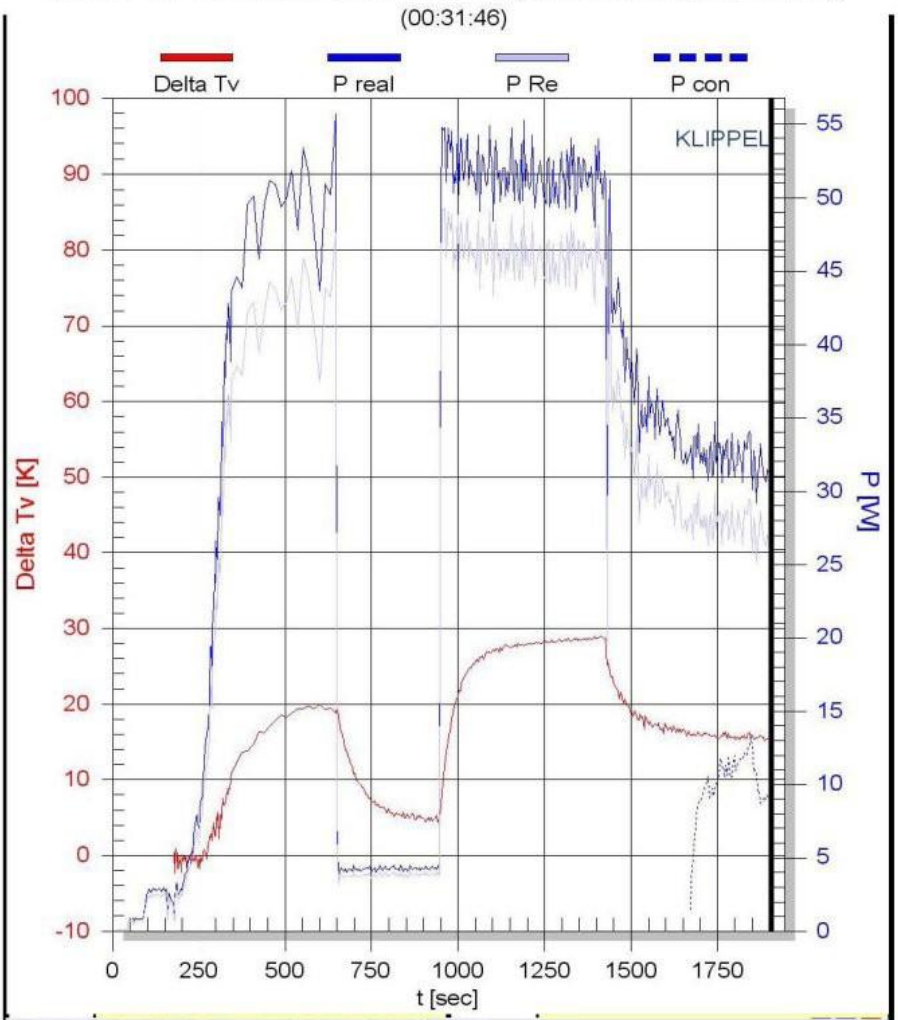
High Performance 15 inch woofer with low power compression

Model #	2216Nd	Part #	320-0045-001

Increase of voice coil temperature Delta Tv (t) and electrical input power P (t)
(00:31:46)



Symbol	Large + Warm	Large + Cold	Small Signal	Unit	Comment
Delta Tv = Tv-Ta	15	0	-0	K	increase of voice coil temperature during the measurement
Xprot	9.5	9.5	1.7	mm	maximal voice coil excursion (limited by protection system)
Re (Tv)	5.58	5.27	5.27	Ohm	(imported) voice coil resistance considering increase of voice coil temperature Tv
Le (X=0)	0.61	0.61	0.58	mH	voice coil inductance at the rest position of the voice coil
L2 (X=0)	0.32	0.32	0.30	mH	para-inductance at the rest position due to the effect of eddy current
R2 (X=0)	2.60	2.60	2.48	Ohm	resistance at the rest position due to eddy currents
Cmes (X=0)	456	456	432	µF	electrical capacitance representing moving mass
Lces (X=0)	58.63	58.63	45.15	mH	electrical inductance at the rest position representing driver compliance
Res (X=0)	39.72	39.72	41.75	Ohm	resistance at the rest position due to mechanical losses
Qms (X=0, Tv)	3.50	3.50	4.08		mechanical Q-factor considering Rms only
Qes (Tv)	0.43	0.41	0.48		electrical Q-factor considering Re (Tv) only
Qts (X=0, Tv)	0.39	0.37	0.43		total Q-factor considering Re (Tv) and Rms only
fs	30.8	30.8	36.0	Hz	driver resonance frequency
Rtv	0.695	0.695		K/W	thermal resistance of path from coil to magnet structure
Rtm	0.148	0.148		K/W	thermal resistance of magnet structure to ambient air
Ctv	83.081	83.081		J/K	thermal capacitance of voice coil and nearby surroundings
rc	1.4265	1.4265		Ws/Km	thermal resistance due to convection
Mms	135.900	135.900	135.900	g	(imported) mechanical mass of driver diaphragm assembly including voice-coil and air load
Rms (X=0)	7.508	7.508	7.533	kg/s	mechanical resistance of total-driver losses
Cms (X=0)	0.20	0.20	0.14	mm/N	mechanical compliance of driver suspension at the rest position
Bl (X=0)	18.39	18.39	18.39	N/A	(imported) force factor at the rest position (Bl product)
Vas	228.4737	228.4737	166.8286	l	equivalent air volume of suspension
N0	1.473	1.560	1.560	%	reference efficiency (2Pi-sr radiation using Re)
Lm	93.8	94.1	94.1	dB	characteristic sound pressure level
Sd	907.92	907.92	907.92	cm²	diaphragm area

Symbol	Value	Unit	Comment
Mode	Thermal Mode 6(7)		
Record	484/484		
Laser	signal reliable		
t	00:31:46	h:min:s	measurement time
Ei (t)	4.0	%	error current measurement
Ex (t)	3.4	%	error laser measurement
Eu (t)	13.2	%	error amplifier check
Delta Tv (Delta Tlim)	15.2 (100.0)	K	increase of voice coil temperature (limit)
Blmin (Blim)	54.6 (25.0)	%	minimal force factor ratio (limit)
Cmin (Clim)	59.0 (20.0)	%	minimal compliance ratio (limit)
P (Plim)	31.59 (50.00)	W	real electrical input power (limit)
Lmin	83.3	%	minimal inductance ratio
Pn	46.88	W	nominal electrical input power
P Re	27.15	W	Power heating voice coil
P con	8.81	W	deducted power due to convection cooling
Glarge (Gmax)	16.5 (26.0)	dB	gain of the excitation amplitude increased in the large signal domain (maximum)
Mech. system		abs.	import used to identify mechanical system in absolute quantities
Xdc	0.1	mm	dc component of voice coil excursion measured in the last update intervall
Xpeak	8.9	mm	positive peak value of voice coil excursion measured in the last update intervall
Xbottom	-7.5	mm	negative peak value (bottom) of voice coil excursion measured in the last update intervall
Xp+	6.3	mm	upper limit of displacement range (99% probability)
Xp-	-6.1	mm	lower limit of displacement range (99% probability)
Xprot	9.5	mm	maximal voice coil excursion allowed by protection system
v rms	0.41	m/s	voice coil velocity
Irms	2.205	A	rms value of the electrical input current
Urms	16.489	V	rms value of the electrical voltage at the transducer terminals
Ipeak	7.523	A	peak value of the electrical input current
Upeak	53.967	V	peak value of the electrical voltage at the transducer terminals
PC	0.50	dB	thermal power compression factor
Db	21.3	%	distortion factors representing contribution of nonlinear force factor
Dl	1.2	%	distortion factor representing contribution of nonlinear inductance
Dc	11.6	%	distortion factor representing contribution of nonlinear compliance
R tc (v)	1.73	K/W	
R th total	0.56	K/W	Delta Tv / P Re