Optimus Sound Level Meters
User Manual
Part B
Technical Information

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Produced by Cirrus Research plc, Acoustic House, Bridlington Road, Hunmanby, North Yorkshire, YO14 0PH, United Kingdom.

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This manual should be used in conjunction with the document titled "**User Manual for the optimus sound level meters**".

This manual refers to optimus sound level meters fitted with firmware version 2.9 or later.

The following table lists sections and tables in this manual where information required by specific sections of IEC 61672-1:2013 can be found. In certain instances the requested information is not applicable, as noted in the Comments column.

All tabular correction data in this manual is available in electronic spread sheet format on request from Cirrus Research plc. See Page 39 for contact details or visit **www.cirrusresearch.co.uk/library/user-manuals**

IEC 61672-1:2013 Section 5		
Section	**Reference**	**Comments**
5.1.3	See "User manual for the optimus sound level meters", page 31	
5.1.4	See "User manual for the optimus sound level meters", page 10	
5.1.6	See "User manual for the optimus sound level meters", pages 32 and 10	
5.1.7	See "User manual for the optimus sound level meters", page 10	
5.1.8		Computer software is not a part of the Sound Level Meter
5.1.10	See "User manual for the optimus sound level meters", page 32	
5.1.12		The optimus sound level meters have a single measurement range
5.1.13	See sections 9.3a and 9.3b – pages 19 and 19	
5.1.14	See section 5.1.14 – page 7	
5.1.15	See section 5.1.15 – page 7	
5.1.17	See section 5.1.16 – page 7	
5.1.18		The optimus sound level meters are single-channel instruments.
5.1.19	See section 5.1.19 – page 7	
5.2.1	See "User manual for the optimus sound level meters", page 42	
5.2.3	See "User manual for the optimus sound level meters", page 45, and for general guidance on calibration, page 42	The microphone should be checked if the calibration offset deviates by more than 1 dB from the previous calibration.
5.3.2.1	See Appendix 1 – Optimus correction data – page 22, and uncertainties on page 17	
5.3.3.1	See Appendix 1 – Optimus correction data – page 22	
5.3.5.1	See section 9.3d – page 19	
5.3.5.3	See section 9.3d – page 19	
5.5.8	See section 9.2.2c – page 15	There are no optional frequency responses.
5.6.10	See section 9.3f – page 19	
5.6.11	See section 9.3g – page 20	
5.7.2	See section 9.3i – page 20	
5.7.3	See section 9.3i – page 20	
5.7.5		No special procedures are required for measuring noise levels close to self-generated noise.
5.8.1	See "User manual for the optimus sound level	

	meters", page 32, and section 9.2.2d – page 16	
5.11.1	See "User manual for the optimus sound level meters", page 20	
5.12.1	See section 5.12.1 – page 8	
5.13.1	See section 9.2.2i – page 16	
5.16.1	See "User manual for the optimus sound level meters", page 27	
5.17.1	See section 5.17.1 – page 8	
5.18.1	See "User manual for the optimus sound level meters", page 19	
5.18.2	See "User manual for the optimus sound level meters", page 32	
5.18.3	See "User manual for the optimus sound level meters", page 19	
5.18.4	See section 5.18.4 – page 8	
5.18.5	See "User manual for the optimus sound level meters", page 17	
5.18.6		The optimus sound level meters use no alternative display devices
5.19.1	See section 5.19.1 – page 8	
5.20.1	See "User manual for the optimus sound level meters", page 13 for instructions to set the clock and page 22 to set timers, and section 5.20.1 – page 9 for the nominal drift	
5.20.2	See section 5.20.2 – page 9	
5.21.1	See "User manual for the optimus sound level meters", page 18	
5.21.2	See section 9.3n – page 21	
5.23.1	See "User manual for the optimus sound level meters", page 21	
5.23.2	See section 9.3k – page 21	
5.23.3	See "User manual for the optimus sound level meters", page 12	
5.23.4	See "User manual for the optimus sound level meters", page 18	
IEC 61672-1:2013 Section 6		
Section	Reference	Comments
6.1.2	See section 9.3l – page 21	
6.2.2	See section 6.2.2 – page 10, and "User manual for the optimus sound level meters", page 14	
6.5.2	See section 6.5.2 – page 10	
6.6.1	See section 9.3o – page 21	
6.6.3	See section 9.3o – page 21	
6.6.10	See section 9.3o – page 21	
6.7	See section 6.7 – page 10	
IEC 61672-1:2013 Section 7		
Section	**Reference**	**Comments**
7.1	See section 7.1 – page 10	
7.2	See Appendix 1 – Optimus correction data – page 22	The UA:237 90 mm diameter windshield is the only relevant accessory.
7.3		The optimus conforms to the specifications of IEC 61672-1:2013 of the same

		performance class when the UA:237 windshield is fitted.
7.4	See "User manual for the optimus sound level meters", page 34	
7.5		No auxiliary devices are provided with the optimus.
IEC 61672-1:2013 Section 9		
Section	**Reference**	**Comments**
9.2.1a	See "User manual for the optimus sound level meters", page 31	
9.2.1b	See "User manual for the optimus sound level meters", page 10	
9.2.1c	See "User manual for the optimus sound level meters", page 32	
9.2.1f	See section 6.7 – page 10	
9.2.2a	See "User manual for the optimus sound level meters", page 34	
9.2.2b	See section 9.2.2b – page 11 and Appendix 1 – Optimus correction data, page 22	
9.2.2c	See section 9.2.2c – page 15, and "User manual for the optimus sound level meters", page 32	A-, C- and Z-weightings are provided, and are measured simultaneously.
9.2.2d	See section 9.2.2d – page 16, and "User manual for the optimus sound level meters", page 32	Fast, Slow and Impulse are provided, and are measured simultaneously.
9.2.2e		The Optimus has no level range controls.
9.2.2g	See "User manual for the optimus sound level meters", page 19, Section 5.18.4 – page 8	
9.2.2h	See section 9.3f – page 19	
9.2.2i	See section 9.2.2i – page 16	
9.2.2j	See "User manual for the optimus sound level meters", page 24	
9.2.2k	See "User manual for the optimus sound level meters", page 31	
9.2.3a	See "User manual for the optimus sound level meters", pages 12 and 32	
9.2.3b	See "User manual for the optimus sound level meters", page 21	
9.2.3c	See "User manual for the optimus sound level meters", page 18	
9.2.4a	See "User manual for the optimus sound level meters", page 42	The following acoustic calibrators may be used with Optimus meters: Class 1: CR:515 Class 2: CR:514
9.2.4b	See "User manual for the optimus sound level meters", page 44	The calibration check frequency is 1 kHz.
9.2.4c	See "User manual for the optimus sound level meters", page 14	Optimus will accept a new acoustic calibration offset if the level is stable and the new offset is in the range ±1.5 dB (Class 1) or ±2 dB (Class 2).
9.2.5a	See section 9.2.5a – page 17	
9.2.5b	See section 9.2.5a – page 17	
9.2.5c	See section 9.2.5a – page 17	
9.2.5d	See section 9.3d – page 19	
9.2.6a	See section 9.2.6a – page 19	

9.2.6b	See section 9.2.6b – page 19	
9.2.6c		No special procedures are required for measuring noise levels close to the self-generated noise.
9.2.6d	See section 5.1.19 – page 7	
9.2.6e	See section 6.2.2 – page 10	
9.2.6f	See "User manual for the optimus sound level meters", page 13 for instructions to set the clock and page 22 to set timers	
9.2.6g	See section 5.20.2 – page 9	
9.2.6h	See section 5.1.14 – page 7	
9.2.6i	See section 5.1.14 – page 7	
9.2.6j	See section 5.1.14 – page 8, section 5.11.1 – page 8 and section 5.12.1 – page 8, and "User manual for the optimus sound level meters", page 20	
9.2.6k	See section 5.17.1 – page 8	
9.2.6l	See "User manual for the optimus sound level meters", page 17	
9.2.6m	See "User manual for the optimus sound level meters", page 18	
9.2.6n	See section 5.1.15 – page 7	
9.2.7a	See Appendix 1 – Optimus correction data – page 22	The optimus conforms to the specifications of IEC 61672-1:2013 of the same performance class when the UA:237 windshield is fitted.
9.2.7b		No correction is required for standard microphone extension cables.
9.2.7c	See "User manual for the optimus sound level meters", page 34	
9.2.7d		No auxiliary devices are provided with the optimus.
9.2.8a		No components of the optimus are intended to be operated only in an environmentally controlled enclosure.
9.2.8b	See section 6.5.2 – page 10	
9.2.8c	See "User manual for the optimus sound level meters", page 46, and section 9.2.8c – page 19	
9.3a	See section 9.3a – page 19	
9.3b	See section 9.3b – page 19	
9.3c	See section 9.3c – page 19	
9.3d	See section 9.3d – page 19	
9.3f	See section 9.3f – page 19	
9.3g	See section 9.3g – page 20	
9.3h	See section 5.1.15 – page 7	
9.3i	See section 9.3i – page 20	
9.3j	See section 5.1.17 – page 7	
9.3k	See section 9.3k – page 21	
9.3l	See section 9.3l – page 21	
9.3m	See section 9.3m – page 21	
9.3n	See section 9.3n – page 21	
9.3o	See section 9.3o – page 21	

Section 5

5.1.14 Description of Start, Stop and Restart functions

These functions control the measurement of LxyMax, LxyMin, Lxeq,t and LxPeak.

Start is on the left-hand softkey while the instrument is not yet running a measurement.

Stop is available while a measurement is in progress. If Pause Mode is enabled (via the Advanced Menu) hold the right-hand softkey for four seconds then release it, or press it briefly to enter Pause Mode then press it again to stop. The Stop function stores the measurement, suspends accumulation of data then clears the latching overload indicator.

Restart is available from the Main Menu: while a measurement is in progress press the centre 'Menu' softkey then select the upper left-hand **Restart** icon. The Restart function clears all accumulated data and clears the latching overload indicator.

Note that the term 'Hold' means the storage and display of the highest (or lowest) value of a given data type during a measurement period. LMax and LPeak hold the highest value; LMin holds the lowest.

5.1.15 Electrical testing method

Electrical testing is done by removing the microphone capsule by unscrewing it from the top of the preamplifier, and replacing it with a standard 1/2" 60UNS threaded dummy microphone of series capacitance 18 ± 2 pF fed from a signal source of impedance 50 Ω.

The Cirrus Research dummy microphone type KP:66 is recommended. The KP:66 has a standard BNC input socket and capacitance 18 pF.

Other types of dummy microphone may be used, but please take care that the device has a capacitance of 18 ± 2 pF.

The input sensitivity is nominally 50 mV/Pa (i.e. a signal of 50 mV_{RMS} at a suitable frequency produces a sound level reading of 94 dB).

Note that the exact sensitivity varies depending on the specific microphone capsule with which the instrument has been calibrated.

All microphone types fitted to the Optimus range share the same electrical substitution method and characteristics.

5.1.17 Highest sound pressure level

Maximum permissible sound pressure level for all microphone types fitted to the Optimus range is 160 dB.

Maximum input voltage at the input to the dummy microphone is 30 V_{pk-pk}.

5.1.19 Start-up period

The Optimus is ready to make measurements 40 seconds after switching on.

5.11.1 Overload indication

Overload is indicated by the word 'overload' (in the chosen language) on the display. On the Sound Level View and Leq View the overload indicator is situated beneath and to the left of the large number.

When a measurement is NOT in progress, the overload indicator is shown for at least 1 second, so that very short transient overload conditions are visible to the operator.

When a measurement IS in progress, the overload indicator stays on until the measurement is stopped or reset.

In some circumstances the overload and under-range indicators will be shown simultaneously. In this case the text will be abbreviated to save space.

The overload indicator is also shown when measurements are recalled from memory in Recall Mode.

5.12.1 Under-range indication

Under-range is indicated by the word 'under-range' (in the chosen language) on the display. On the Sound Level View and Leq View the overload indicator is situated beneath and to the left of the large number.

The under-range indicator is shown for at least 1 second, so that very short transient under-range conditions are visible to the operator.

Under-range is indicated on the Sound Level View and Leq View. The level below which under-range is displayed depends on the frequency weighting shown for the 'big number' on the selected display page:

A-weighting – less than 24.0 dB
C-weighting – less than 30.0 dB
Z-weighting – less than 45.0 dB

In some circumstances the overload and under-range indicators will be shown simultaneously. In this case the text will be abbreviated to save space.

Note that if any displayed decibel value on the Sound Level View or Leq View is below 14.0 dB, the value will be replaced by dashes ('---'). These levels are typically below the self-generated noise of the microphone capsule and so will only be encountered during electrical testing.

5.17.1 User adjustable thresholds

There are no user adjustable thresholds in the Optimus sound level meter, within the scope of IEC 61672-1:2013.

Note: some models include the Dose View, which features adjustable thresholds. These functions conform to IEC 61252 – Personal Sound Exposure Meters.

5.18.4 Display update rate

The display update rate for numerical values is 0.5 seconds for SPL functions and 1 second for Leq functions. The optimus sound level meters displays a valid integrated noise level 5 seconds after the start of a measurement.

5.19.1 Electrical output specifications

AC output is provided for testing purposes only. No electrical outputs are within the scope of IEC 61672-1:2013.

AC output is provided on Pin 4 of the 18-way utility connector (with Ground on Pin 1), and on the tip of the 2.5 mm stereo jack connector (with Ground on the outer ring).

The AC output is a buffered amplifier capable of driving loads down to 32 Ω.

The highest maximum output voltage before clipping is 1.7 $V_{pk\text{-}pk}$.

The maximum output power is 35 mW, and short circuit AC current will not exceed 100 mA.

The AC output is terminated internally with a series capacitor of 100 µF that is discharged to ground via 1 MΩ.

External equipment connected to the AC output should have a load resistance of 100 kΩ or greater, and must not have a significant capacitive component.

The AC output has four user-selectable gain settings available via the "Advanced, AC out" Menu: High/Low levels, and +20 dB amplifier On/Off.

Voltages and full scale levels are as follows:

High levels (70-140 dB)

0 dB gain:	1.3 V_{pk-pk} (450 mV_{RMS})	at full scale 140 dB
+20 dB gain:	1.7 V_{pk-pk} (600 mV_{RMS})	at full scale 132 dB

Low levels (20-90 dB)

0 dB gain:	400 mV_{pk-pk} (140 mV_{RMS})	at full scale 90 dB
+20 dB gain:	1.3 V_{pk-pk} (450 mV_{RMS})	at full scale 90 dB

The ring on the stereo jack socket is configured as a digital input. It is connected internally to +3.3 V via a 1 MΩ resistor. This input is not used on the Optimus.

5.20.1 Clock

Real-time clock drift is ±2 seconds per day at temperatures between 20 and 25 °C.

5.20.2 Minimum and maximum integration times

The minimum integration time for manual measurements is 5 seconds.

The integration time ranges from 1 minute up to 240 hours in "Timer" mode, and from 5 seconds up to 30 days in manual mode (depending on instrument capabilities and storage settings).

Section 6

6.2.2 Static pressure

The MK:224 microphone capsule has a typical static pressure linear coefficient of -0.0066 dB/kPa at 1 kHz (-0.0076 dB/kPa at 250 Hz). This corresponds to a change of -0.28 dB between 65 kPa and 108 kPa. Static pressure has no effect on the optimus without its microphone fitted.

The CR:515 acoustic calibrator uses internal static pressure compensation to keep its output sound level within specified tolerance limits between 108 kPa and 65 kPa static pressure with a design deviation 0.00 dB. Therefore no additional correction by the operator is necessary.

To measure sound levels at locations where the static pressure is lower than 85 kPa, calibrate the instrument with a CR:515 acoustic calibrator which produces a sound pressure that is compensated for the low pressure.

6.5.2 Electrostatic discharge

The instrument does not suffer permanent degradation or loss of functions after electrostatic discharges of up to ±4 kV by contact or ±8 kV by air discharge. Temporary loss of function may result: the instrument may restart.

6.7 Influence of mechanical vibrations

Mechanical vibrations with an acceleration of 1 m/s² perpendicular to the plane of the membrane of the microphone at frequencies of 31.5, 63, 125, 250, 500, 630, 800 and 1000 Hz will increase the lower limit of the linear operating range of the A-weighting to 75 dB.

Mechanical vibrations with an acceleration of 1 m/s² parallel to the plane of the membrane increases the lower limit of the linear working range of the A-weighting to 64 dB.

To minimize the influence of mechanical vibration on the indicated sound levels, try to position the optimus so the vibrations are perpendicular to the membrane of the microphone.

Section 7

7.1 Microphone extension cables

The ZL:205 is the standard microphone extension cable, with a length of 5 m.

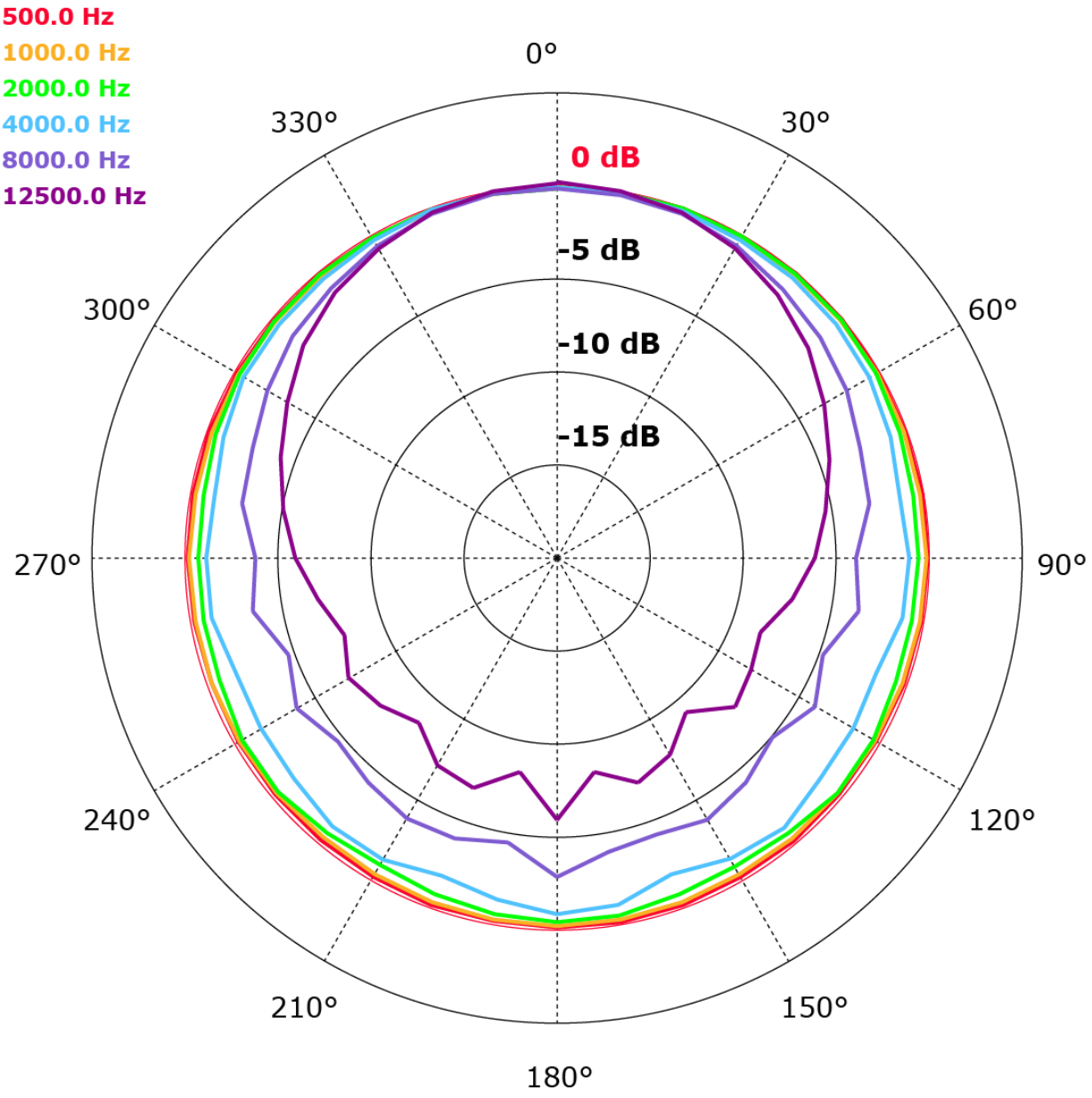
Section 9

9.2.2b – Directional response

The following polar charts are provided for illustrative purposes. For tabular data please see "Appendix 1 – Optimus correction data", page 22.

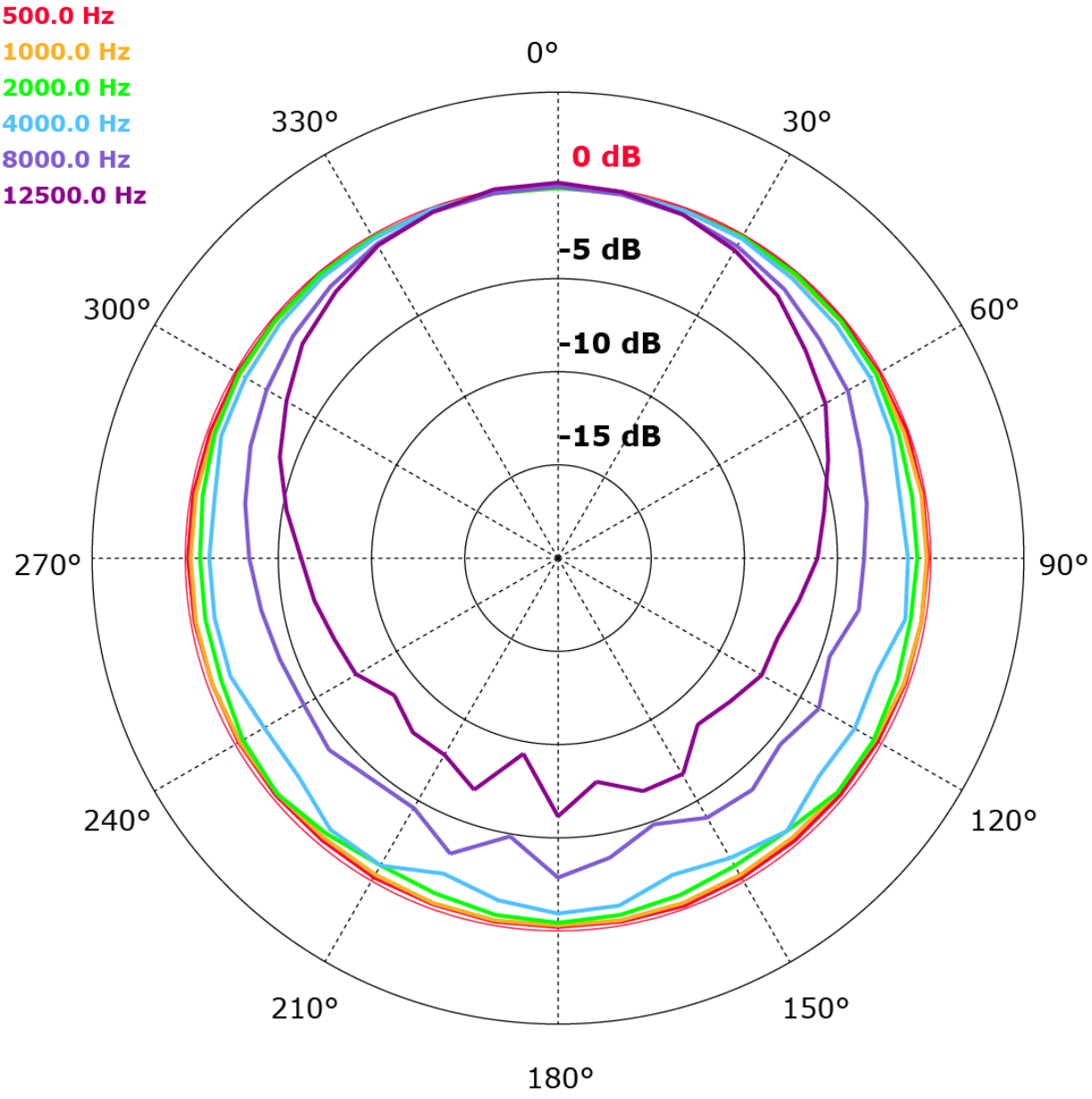
Responses of Optimus with typical MK:224 microphone capsule – influences of microphone frequency response, reflections and diffraction

Incidence direction – plane parallel to instrument display screen (horizontal)



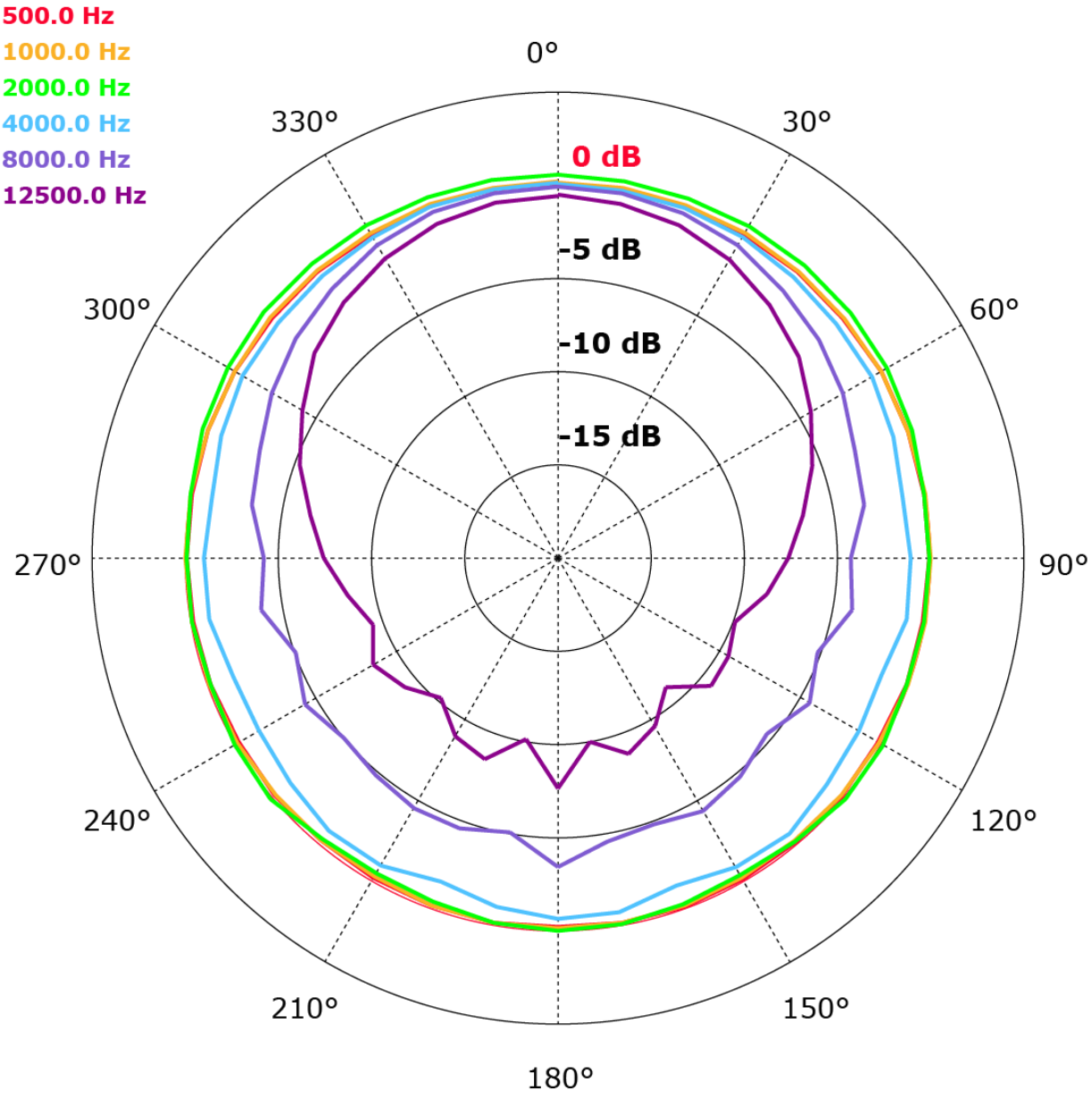
Responses of Optimus with typical MK:224 microphone capsule – influences of microphone frequency response, reflections and diffraction

Incidence direction – plane perpendicular to instrument display screen (vertical)



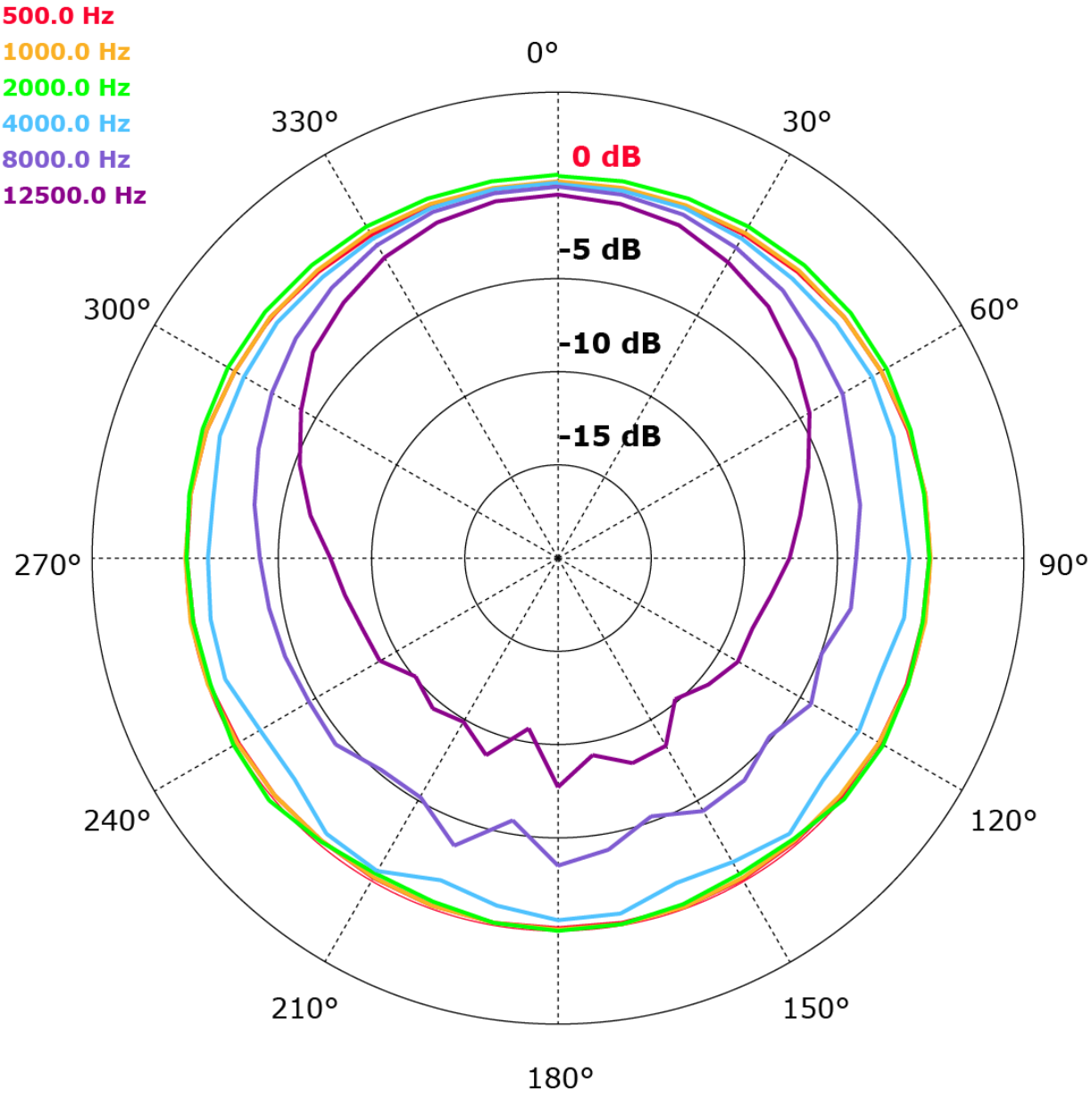
Responses of Optimus with typical MK:224 microphone capsule with UA-237 Windshield – influences of microphone frequency response, reflections and diffraction

Incidence direction – plane parallel to instrument display screen (horizontal)



Responses of Optimus with typical MK:224 microphone capsule with UA-237 Windshield – influences of microphone frequency response, reflections and diffraction

Incidence direction – plane perpendicular to instrument display screen (vertical)



9.2.2c – Frequency weightings

Nominal frequency (Hz)	Frequency weightings (dB)			Acceptance limits (dB)	
				Class	
	A	C	Z	1	2
10	-70.4	-14.3	0.0	+3.0 ; -∞	+5.0 ; -∞
12.5	-63.4	-11.2	0.0	+2.5 ; -∞	+5.0 ; -∞
16	-56.7	-8.5	0.0	+2.0 ; -4.0	+5.0 ; -∞
20	-50.5	-6.2	0.0	±2.0	±3.0
25	-44.7	-4.4	0.0	+2.0 ; -1.5	±3.0
31.5	-39.4	-3.0	0.0	±1.5	±3.0
40	-34.6	-2.0	0.0	±1.0	±2.0
50	-30.2	-1.3	0.0	±1.0	±2.0
63	-26.2	-0.8	0.0	±1.0	±2.0
80	-22.5	-0.5	0.0	±1.0	±2.0
100	-19.1	-0.3	0.0	±1.0	±1.5
125	-16.1	-0.2	0.0	±1.0	±1.5
160	-13.4	-0.1	0.0	±1.0	±1.5
200	-10.9	0.0	0.0	±1.0	±1.5
250	-8.6	0.0	0.0	±1.0	±1.5
315	-6.6	0.0	0.0	±1.0	±1.5
400	-4.8	0.0	0.0	±1.0	±1.5
500	-3.2	0.0	0.0	±1.0	±1.5
630	-1.9	0.0	0.0	±1.0	±1.5
800	-0.8	0.0	0.0	±1.0	±1.5
1 000	0	0	0	±0.7	±1.0
1 250	0.6	0.0	0.0	±1.0	±1.5
1 600	1.0	-0.1	0.0	±1.0	±2.0
2 000	1.2	-0.2	0.0	±1.0	±2.0
2 500	1.3	-0.3	0.0	±1.0	±2.5
3 150	1.2	-0.5	0.0	±1.0	±2.5
4 000	1.0	-0.8	0.0	±1.0	±3.0
5 000	0.5	-1.3	0.0	±1.5	±3.5
6 300	-0.1	-2.0	0.0	+1.5 ; -2.0	±4.5
8 000	-1.1	-3.0	0.0	+1.5 ; -2.5	±5.0
10 000	-2.5	-4.4	0.0	+2.0 ; -3.0	+5.0 ; -∞
12 500	-4.3	-6.2	0.0	+3.0 ; -5.0	+5.0 ; -∞
16 000	-6.6	-8.5	0.0	+2.5 ; -16.0	+5.0 ; -∞
20 000	-9.3	-11.2	0.0	+3.0 ; -∞	+5.0 ; -∞

9.2.2d – Time weightings

The time constants for the available time weightings are:

Fast: 0.125 s
Slow: 1 s
Impulse: 35 ms

9.2.2i – Peak measurement ranges

The Optimus measures L_{APeak}, L_{CPeak} and L_{ZPeak}. L_{CPeak} is mandated by the standard IEC 61672-1:2013 and its range is shown in **bold** in the table below.

Frequency	A-weighting	C-weighting	Z-weighting
31.5 Hz	40 – 102 dB	**50 – 139 dB**	55 – 142 dB
500 Hz	40 – 139 dB	**50 – 142 dB**	55 – 142 dB
1 kHz	40 – 142 dB	**50 – 142 dB**	55 – 142 dB
4 kHz	40 – 143 dB	**50 – 141 dB**	55 – 142 dB
8 kHz	40 – 140 dB	**50 – 138 dB**	55 – 141 dB
12.5 kHz	40 – 137 dB	**50 – 136 dB**	55 – 141 dB

Note that the upper limits of the A, C and Z-weighted Peak ranges are 3 dB above the corresponding Sound Level range upper limits as described in section 9.3f below (Page 19). The note in that section regarding the effect of calibration offset also applies to the upper limit of the Peak ranges.

9.2.5a – Frequency response corrections

The values in the table below should be subtracted from the measurement reading to correct for the corresponding effect at the reference direction, 0° angle of incidence for plane-progressive sound waves. See "Appendix 1 – Optimus correction data", page 22, for detailed correction tables at other angles of incidence.

Nominal Frequency (Hz)	Exact Frequency (Hz)	Typical MK:224 free-field response at 0° (dB)	Free-field influence of optimus case at 0° (dB)	Expanded uncertainties at 95% coverage, k=2 (dB)
63	63	0.00	0.00	0.25
80	79	0.00	0.00	0.25
100	99	0.00	0.00	0.25
125	125	0.00	0.00	0.25
160	158	0.00	0.00	0.25
200	198	0.00	0.00	0.25
250	251	0.00	0.02	0.25
315	316	0.00	0.01	0.25
400	398	0.00	0.01	0.25
500	501	0.00	0.01	0.25
630	631	0.00	0.01	0.25
800	794	0.00	-0.01	0.25
1 000	1 000	0.00	-0.03	0.25
1 060	1 059	0.00	-0.03	0.25
1 120	1 122	0.00	-0.02	0.25
1 180	1 189	0.00	-0.01	0.25
1 250	1 259	0.00	0.00	0.25
1 320	1 334	0.00	0.02	0.25
1 400	1 413	0.00	0.05	0.25
1 500	1 496	0.00	0.07	0.25
1 600	1 585	0.00	0.09	0.25
1 700	1 679	0.00	0.10	0.25
1 800	1 778	0.00	0.09	0.25
1 900	1 884	0.00	0.05	0.25
2 000	1 995	0.00	-0.01	0.25
2 120	2 113	0.00	-0.06	0.25
2 240	2 239	0.00	-0.11	0.25
2 360	2 371	0.00	-0.11	0.25
2 500	2 512	0.00	-0.05	0.25
2 650	2 661	0.00	0.08	0.25
2 800	2 818	0.00	0.20	0.25
3 000	2 985	0.00	0.14	0.25
3 150	3 162	0.00	0.04	0.25
3 350	3 350	0.00	-0.03	0.25
3 550	3 548	0.00	-0.06	0.25
3 750	3 758	0.00	-0.05	0.25
4 000	3 981	0.00	-0.03	0.25
4 250	4 217	0.00	0.01	0.30
4 500	4 467	0.00	0.02	0.30
4 750	4 732	0.00	0.01	0.30
5 000	5 012	0.00	-0.07	0.30
5 300	5 309	0.00	-0.13	0.30
5 600	5 623	0.00	0.00	0.30
6 000	5 957	0.00	0.08	0.30
6 300	6 310	0.00	0.00	0.30
6 700	6 683	0.00	-0.09	0.30
7 100	7 079	0.00	-0.10	0.30
7 500	7 499	0.00	-0.03	0.30
8 000	7 943	0.00	-0.08	0.30
8 500	8 414	0.00	-0.21	0.30
9 000	8 913	0.00	-0.09	0.30
9 500	9 441	0.00	-0.05	0.30
10 000	10 000	0.10	-0.06	0.30
10 600	10 593	0.15	0.05	0.30
11 200	11 220	0.20	0.03	0.30
11 800	11 885	0.25	-0.07	0.30
12 500	12 589	0.30	-0.08	0.30
13 200	13 335	0.21	-0.02	0.30
14 000	14 125	0.12	-0.01	0.30
15 000	14 962	-0.19	-0.07	0.30
16 000	15 849	-0.51	-0.06	0.30

Nominal Frequency (Hz)	Exact Frequency (Hz)	Free-field influence of Windshield UA:237 at 0° (dB)	Expanded uncertainties at 95% coverage, k=2 (dB)
63	63	0.00	0.20
80	79	0.00	0.20
100	99	0.00	0.20
125	125	0.00	0.20
160	158	0.00	0.20
200	198	0.00	0.20
250	251	0.03	0.20
315	316	0.04	0.20
400	398	0.06	0.20
500	501	0.07	0.20
630	631	0.09	0.20
800	794	0.14	0.20
1 000	1 000	0.22	0.20
1 060	1 059	0.25	0.20
1 120	1 122	0.28	0.20
1 180	1 189	0.31	0.20
1 250	1 259	0.34	0.20
1 320	1 334	0.37	0.20
1 400	1 413	0.40	0.20
1 500	1 496	0.42	0.20
1 600	1 585	0.46	0.20
1 700	1 679	0.49	0.20
1 800	1 778	0.52	0.20
1 900	1 884	0.56	0.20
2 000	1 995	0.59	0.20
2 120	2 113	0.62	0.20
2 240	2 239	0.64	0.20
2 360	2 371	0.64	0.20
2 500	2 512	0.64	0.20
2 650	2 661	0.58	0.20
2 800	2 818	0.41	0.20
3 000	2 985	0.19	0.20
3 150	3 162	0.09	0.20
3 350	3 350	0.05	0.20
3 550	3 548	0.06	0.20
3 750	3 758	0.09	0.20
4 000	3 981	0.13	0.20
4 250	4 217	0.18	0.30
4 500	4 467	0.25	0.30
4 750	4 732	0.29	0.30
5 000	5 012	0.31	0.30
5 300	5 309	0.33	0.30
5 600	5 623	0.19	0.30
6 000	5 957	0.01	0.30
6 300	6 310	-0.01	0.30
6 700	6 683	0.01	0.30
7 100	7 079	0.03	0.30
7 500	7 499	0.06	0.30
8 000	7 943	0.04	0.30
8 500	8 414	0.07	0.30
9 000	8 913	-0.01	0.30
9 500	9 441	-0.19	0.30
10 000	10 000	-0.08	0.30
10 600	10 593	-0.10	0.30
11 200	11 220	-0.22	0.30
11 800	11 885	-0.23	0.30
12 500	12 589	-0.71	0.30
13 200	13 335	-0.64	0.30
14 000	14 125	-0.73	0.30
15 000	14 962	-0.79	0.30
16 000	15 849	-0.90	0.30

Note: These corrections have been determined in accordance with IEC 62585 by Cirrus Research.

9.2.6a – Reference direction

The reference direction, or "0°, head-on incidence", is perpendicular to the microphone diaphragm and parallel to the length of the preamplifier body.

9.2.6b – Observer position

The meter will be either mounted upon a tripod or held in the hand. In order to avoid the effect of sound reflections from the body of the operator interfering with the measurement, the meter should be located as far as possible from the body.

When taking a measurement, the operator should place themselves at a distance behind the tripod-mounted meter, or extend the hand-held meter as far from the body as is possible.

9.2.8c – Immunity to a.c. power-frequency and radio-frequency fields

The Optimus range conform to the specifications of IEC 61672-1:2013 for exposure to radio-frequency fields at sound levels less than 74 dB.

9.3a – Reference sound pressure level

The reference sound pressure level is 1 Pa (94.0 dB).

9.3b – Reference level range

The Optimus is a single-range instrument, so the only range is the reference range.

9.3c – Microphone reference point

The microphone reference point is the centre of the diaphragm of the MK:224 microphone.

9.3d – Periodic testing

It is recommended to use multi-frequency acoustic calibrator for Periodic Testing of frequency response. For the B&K Multifunction Acoustic Calibrator type 4226, use the function settings as follows:

Microphone – 'b'
Sound Field – 'Falcon, free-field'

These settings require no additional corrections to obtain A-weighted sound levels equivalent to the response to plane-progressive sound waves from the reference direction at the available frequencies.

9.3f – Linear operating range

Frequency	A-weighting	C-weighting	Z-weighting
31.5 Hz	24 – 99 dB	30 – 136 dB	45 – 139 dB
500 Hz	24 – 136 dB	30 – 139 dB	45 – 139 dB
1 kHz	24 – 139 dB	30 – 139 dB	45 – 139 dB
4 kHz	24 – 140 dB	30 – 138 dB	45 – 139 dB
8 kHz	24 – 137 dB	30 – 135 dB	45 – 138 dB
12.5 kHz	24 – 134 dB	30 – 133 dB	45 – 138 dB

(12.5 kHz applies to Class 1 Optimus models only)

Note that the upper limits on the linearity range are affected by the calibration offset. Optimus instruments are factory-adjusted to a zero calibration offset and will have the upper limits shown above. If a different microphone capsule is fitted or the microphone sensitivity changes, resulting in a negative calibration offset, the upper limits will be reduced by the value of the offset. For example: a calibration offset of -2.0 dB will result in an upper limit of 138 dB at 1 kHz.

9.3g – Linear measurement starting level

For testing of level linearity according to IEC 61672-2 and IEC 61672-3 the starting point is not critical and can be selected, within reasonable bounds, at the convenience of the testing laboratory.

Two options are presented in the table below:

Option 1 uses the same electrical signal (input) level at each test frequency;

Option 2 uses the same displayed (output) A-weighted level at each test frequency.

Decibel values in the table below represent the A-weighted Sound Level or Integrated Level shown on the Optimus display at each starting level.

Frequency	Option 1	Option 2
31.5 Hz	54.6 dB	94.0 dB
1 kHz	94.0 dB	94.0 dB
4 kHz	95.0 dB	94.0 dB
8 kHz	92.9 dB	94.0 dB
12.5 kHz	89.7 dB	94.0 dB

Note that decibel levels in Option 1 are stated to a tolerance of ±0.5 dB when a fixed electrical signal level is used.

9.3i – Self-generated noise

Highest anticipated self-generated noise in a low-level sound field with microphone capsule type MK:224 fitted:

A-weighted – 19 dB
C-weighted – 25 dB
Z-weighted – 40 dB

Highest anticipated self-generated noise in a low-level sound field with electrical input via 18pF dummy microphone terminated with a 50 Ω load (between signal pin and body):

A-weighted – 15 dB
C-weighted – 24 dB
Z-weighted – 40 dB

Note: the above decibel values are Leq,t measured over 30 seconds.

	Self-generated noise				
	L_{AF}	L_{CF}	L_{ZF}	L_{Aeq}	L_{AE} (t_{int} = 30 s)
Electric	<16 dB	<24 dB	<40 dB	<16 dB	<31 dB
Acoustic	<19 dB	<25 dB	<40 dB	<19 dB	<34 dB

The instrument's connections for data communication are non-reactive, which means that the displayed value is not affected by either the hardware or the software. Using the microphone extension cable does not require to apply any correction to the reading.

The averaging time for measuring the self-generated noise is at least 30 seconds. It is recommended that Integrated Level (Leq,t) is used.

9.3k – Battery voltage range

When powered by 4 x AA primary batteries: maximum 6.8 V, minimum 4.5 V. The instrument automatically shuts down when the battery voltage drops below 4.5 V.

When powered via USB: maximum 5.3 V, minimum 4.7 V.

9.3l – Typical stabilization time after changes in environmental conditions

Sudden changes in temperature will affect Optimus measurements. This is due to temperature differentials between parts of the analogic circuit and their stabilised power supply circuits. In particular, the self-generated noise will rise.

The instrument must be allowed to stabilize for at least 1 hour after a sudden change in temperature of more than 5 °C.

Sudden changes in barometric pressure will also affect measurements. (This is due to pressure equalization in the microphone capsule, which is vented via the preamplifier into the instrument body or cable back-shell. In particular the low frequency response and absolute sensitivity will be affected.)

The instrument must be allowed to stabilize for at least 10 minutes after a sudden change in barometric pressure of more than 5 kPa.

9.3m – Field strength >10 V/m

Not applicable. The Optimus conforms to the specifications of IEC 61672-1:2013 for electric field strengths up to and including 10 V/m.

9.3n – Radio-frequency emissions

No mode of operation or configuration produces radio-frequency emissions significantly greater than any other. However, for reference purposes the worst-case configuration for testing is with the plane of electric field perpendicular to the centre of the display.

9.3o – A.C. power-frequency and radio-frequency susceptibility

The operating mode of the meter (display mode, storage, settings, etc.) has no effect on susceptibility to radio frequency and a.c. power-frequency fields.

The configuration with the greatest susceptibility to radio-frequency fields is with ZL:205 microphone extension cable fitted, USB data cable fitted, the optimus case vertical with display facing the radio transmitter, and vertically polarised electrical field.

The configuration with the greatest susceptibility to a.c. power fields is with the axis of the field-generating coil passing through the centre of the meter's display and exiting through the centre of the back of the case.

Appendix 1 – Optimus correction data

The values in the tables below need to be subtracted from the measurement reading to correct for the corresponding effect.

Uncertainty figures for all tables below are as stated above in the table page 17.

Theses corrections have been determined in accordance with IEC 62585 by Cirrus Research.

Influence of reflections and diffraction on the frequency response of a typical MK:224 microphone (relative to 0°) - 0° to 110°

Nominal Frequency (Hz)	Exact Frequency (Hz)	Angle from reference direction											
		0°	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°	110°
63	63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
80	79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
100	99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
125	125	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
160	158	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
200	198	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
250	251	0.00	-0.02	-0.02	-0.02	0.01	0.00	-0.02	-0.03	-0.05	-0.05	-0.06	-0.07
315	316	0.00	-0.02	-0.02	-0.02	0.01	0.00	-0.02	-0.03	-0.05	-0.05	-0.07	-0.08
400	398	0.00	-0.03	-0.02	-0.02	0.00	-0.01	-0.02	-0.03	-0.05	-0.06	-0.08	-0.09
500	501	0.00	-0.02	-0.02	-0.02	0.00	-0.01	-0.03	-0.04	-0.06	-0.07	-0.09	-0.11
630	631	0.00	-0.02	-0.01	-0.02	-0.02	-0.03	-0.04	-0.06	-0.08	-0.09	-0.11	-0.12
800	794	0.00	-0.01	-0.01	-0.02	-0.03	-0.05	-0.06	-0.09	-0.11	-0.13	-0.14	-0.15
1 000	1 000	0.00	-0.01	-0.01	-0.02	-0.04	-0.07	-0.09	-0.12	-0.14	-0.17	-0.19	-0.20
1 060	1 059	0.00	-0.01	-0.02	-0.03	-0.04	-0.07	-0.10	-0.13	-0.15	-0.18	-0.21	-0.21
1 120	1 122	0.00	-0.01	-0.02	-0.03	-0.04	-0.07	-0.10	-0.13	-0.16	-0.19	-0.22	-0.22
1 180	1 189	0.00	-0.01	-0.03	-0.03	-0.04	-0.08	-0.10	-0.14	-0.16	-0.20	-0.23	-0.24
1 250	1 259	0.00	-0.01	-0.03	-0.04	-0.05	-0.08	-0.11	-0.14	-0.17	-0.21	-0.25	-0.25
1 320	1 334	0.00	-0.02	-0.03	-0.04	-0.05	-0.09	-0.12	-0.15	-0.19	-0.22	-0.26	-0.27
1 400	1 413	0.00	-0.02	-0.04	-0.05	-0.05	-0.09	-0.13	-0.16	-0.20	-0.24	-0.28	-0.29
1 500	1 496	0.00	-0.01	-0.04	-0.05	-0.06	-0.10	-0.14	-0.18	-0.22	-0.26	-0.30	-0.31
1 600	1 585	0.00	-0.01	-0.04	-0.05	-0.07	-0.12	-0.15	-0.19	-0.24	-0.28	-0.32	-0.33
1 700	1 679	0.00	-0.01	-0.04	-0.06	-0.09	-0.13	-0.17	-0.22	-0.26	-0.30	-0.35	-0.36
1 800	1 778	0.00	-0.01	-0.04	-0.06	-0.10	-0.15	-0.20	-0.24	-0.29	-0.33	-0.38	-0.40
1 900	1 884	0.00	-0.02	-0.04	-0.07	-0.11	-0.17	-0.22	-0.27	-0.32	-0.37	-0.41	-0.44
2 000	1 995	0.00	-0.02	-0.04	-0.08	-0.13	-0.19	-0.25	-0.30	-0.36	-0.40	-0.45	-0.48
2 120	2 113	0.00	-0.02	-0.05	-0.08	-0.14	-0.22	-0.28	-0.34	-0.39	-0.44	-0.49	-0.52
2 240	2 239	0.00	-0.02	-0.04	-0.09	-0.16	-0.24	-0.31	-0.37	-0.43	-0.48	-0.54	-0.57
2 360	2 371	0.00	-0.01	-0.04	-0.09	-0.17	-0.26	-0.34	-0.41	-0.47	-0.53	-0.58	-0.61
2 500	2 512	0.00	0.00	-0.03	-0.08	-0.18	-0.28	-0.37	-0.45	-0.51	-0.57	-0.62	-0.65
2 650	2 661	0.00	0.03	-0.02	-0.06	-0.19	-0.30	-0.41	-0.49	-0.55	-0.61	-0.68	-0.69
2 800	2 818	0.00	0.04	-0.01	-0.06	-0.21	-0.32	-0.45	-0.54	-0.63	-0.70	-0.79	-0.78
3 000	2 985	0.00	0.01	-0.05	-0.11	-0.23	-0.35	-0.48	-0.60	-0.72	-0.82	-0.92	-0.93
3 150	3 162	0.00	-0.03	-0.08	-0.16	-0.25	-0.37	-0.50	-0.64	-0.79	-0.92	-1.01	-1.06
3 350	3 350	0.00	-0.05	-0.09	-0.18	-0.27	-0.40	-0.53	-0.67	-0.84	-0.99	-1.09	-1.15
3 550	3 548	0.00	-0.06	-0.10	-0.20	-0.29	-0.43	-0.56	-0.71	-0.88	-1.05	-1.16	-1.23
3 750	3 758	0.00	-0.06	-0.11	-0.20	-0.30	-0.46	-0.61	-0.76	-0.92	-1.11	-1.23	-1.31
4 000	3 981	0.00	-0.05	-0.10	-0.21	-0.32	-0.50	-0.66	-0.81	-0.98	-1.18	-1.31	-1.39
4 250	4 217	0.00	-0.04	-0.10	-0.21	-0.33	-0.54	-0.73	-0.89	-1.06	-1.26	-1.42	-1.50
4 500	4 467	0.00	-0.03	-0.10	-0.22	-0.36	-0.57	-0.80	-1.00	-1.16	-1.36	-1.55	-1.63
4 750	4 732	0.00	-0.02	-0.11	-0.24	-0.40	-0.62	-0.87	-1.11	-1.30	-1.49	-1.70	-1.79
5 000	5 012	0.00	-0.02	-0.13	-0.27	-0.46	-0.69	-0.96	-1.23	-1.47	-1.65	-1.86	-1.98
5 300	5 309	0.00	-0.02	-0.15	-0.32	-0.55	-0.80	-1.06	-1.36	-1.64	-1.83	-2.04	-2.21
5 600	5 623	0.00	-0.01	-0.14	-0.34	-0.62	-0.91	-1.18	-1.49	-1.81	-2.05	-2.26	-2.46
6 000	5 957	0.00	-0.03	-0.14	-0.33	-0.61	-0.97	-1.27	-1.57	-1.90	-2.20	-2.43	-2.66
6 300	6 310	0.00	-0.05	-0.18	-0.36	-0.62	-1.01	-1.37	-1.68	-2.02	-2.37	-2.63	-2.85
6 700	6 683	0.00	-0.07	-0.23	-0.45	-0.72	-1.11	-1.51	-1.87	-2.21	-2.59	-2.89	-3.09
7 100	7 079	0.00	-0.07	-0.24	-0.52	-0.84	-1.23	-1.65	-2.07	-2.43	-2.82	-3.18	-3.36
7 500	7 499	0.00	-0.07	-0.24	-0.50	-0.90	-1.35	-1.76	-2.25	-2.64	-3.04	-3.45	-3.64
8 000	7 943	0.00	-0.08	-0.28	-0.53	-0.92	-1.48	-1.91	-2.42	-2.89	-3.30	-3.75	-3.95
8 500	8 414	0.00	-0.09	-0.33	-0.63	-1.00	-1.59	-2.11	-2.60	-3.15	-3.57	-4.05	-4.28
9 000	8 913	0.00	-0.07	-0.30	-0.67	-1.13	-1.68	-2.30	-2.81	-3.40	-3.87	-4.35	-4.64
9 500	9 441	0.00	-0.07	-0.29	-0.62	-1.14	-1.78	-2.36	-3.03	-3.58	-4.16	-4.64	-5.00
10 000	10 000	0.00	-0.10	-0.38	-0.73	-1.19	-1.96	-2.54	-3.30	-3.86	-4.53	-5.03	-5.44
10 600	10 593	0.00	-0.09	-0.39	-0.80	-1.34	-2.09	-2.81	-3.52	-4.20	-4.89	-5.43	-5.87
11 200	11 220	0.00	-0.08	-0.35	-0.75	-1.41	-2.19	-2.97	-3.70	-4.57	-5.19	-5.87	-6.33
11 800	11 885	0.00	-0.11	-0.44	-0.87	-1.56	-2.46	-3.22	-4.16	-4.95	-5.70	-6.43	-6.86
12 500	12 589	0.00	-0.12	-0.44	-0.95	-1.69	-2.60	-3.52	-4.48	-5.36	-6.28	-7.06	-7.52
13 200	13 335	0.00	-0.16	-0.54	-1.03	-1.83	-2.81	-3.81	-4.79	-5.86	-6.82	-7.61	-8.14
14 000	14 125	0.00	-0.17	-0.57	-1.18	-1.98	-3.10	-4.10	-5.25	-6.40	-7.35	-8.24	-8.89
15 000	14 962	0.00	-0.21	-0.66	-1.25	-2.22	-3.32	-4.46	-5.71	-6.87	-7.93	-8.94	-9.72
16 000	15 849	0.00	-0.23	-0.72	-1.41	-2.38	-3.65	-4.88	-6.10	-7.45	-8.70	-9.81	-10.63

Influence of reflections and diffraction on the frequency response of a typical MK:224 microphone (relative to 0°) - 120° to 230°

Nominal Frequency (Hz)	Exact Frequency (Hz)	Angle from reference direction											
		120°	130°	140°	150°	160°	170°	180°	190°	200°	210°	220°	230°
63	63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
80	79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
100	99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
125	125	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
160	158	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
200	198	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
250	251	-0.10	-0.07	-0.06	-0.09	-0.08	-0.09	-0.09	-0.09	-0.10	-0.10	-0.14	-0.11
315	316	-0.12	-0.08	-0.06	-0.10	-0.07	-0.09	-0.10	-0.10	-0.11	-0.11	-0.16	-0.12
400	398	-0.13	-0.08	-0.06	-0.10	-0.08	-0.09	-0.10	-0.10	-0.12	-0.12	-0.17	-0.13
500	501	-0.13	-0.09	-0.08	-0.10	-0.08	-0.10	-0.11	-0.11	-0.12	-0.13	-0.17	-0.14
630	631	-0.13	-0.11	-0.10	-0.11	-0.10	-0.11	-0.11	-0.12	-0.13	-0.14	-0.16	-0.15
800	794	-0.14	-0.14	-0.14	-0.13	-0.13	-0.13	-0.12	-0.14	-0.15	-0.16	-0.17	-0.18
1 000	1 000	-0.21	-0.18	-0.18	-0.18	-0.16	-0.17	-0.15	-0.17	-0.19	-0.21	-0.21	-0.23
1 060	1 059	-0.24	-0.20	-0.19	-0.19	-0.17	-0.17	-0.16	-0.18	-0.20	-0.22	-0.23	-0.25
1 120	1 122	-0.26	-0.21	-0.20	-0.21	-0.18	-0.18	-0.18	-0.19	-0.21	-0.24	-0.25	-0.27
1 180	1 189	-0.29	-0.22	-0.21	-0.22	-0.19	-0.19	-0.19	-0.20	-0.23	-0.25	-0.27	-0.29
1 250	1 259	-0.31	-0.24	-0.22	-0.24	-0.20	-0.20	-0.20	-0.21	-0.24	-0.27	-0.29	-0.31
1 320	1 334	-0.33	-0.25	-0.23	-0.25	-0.21	-0.21	-0.21	-0.22	-0.25	-0.28	-0.31	-0.33
1 400	1 413	-0.35	-0.27	-0.25	-0.27	-0.22	-0.22	-0.22	-0.23	-0.27	-0.30	-0.32	-0.35
1 500	1 496	-0.37	-0.30	-0.27	-0.28	-0.24	-0.23	-0.23	-0.24	-0.28	-0.31	-0.34	-0.37
1 600	1 585	-0.39	-0.32	-0.30	-0.30	-0.25	-0.25	-0.23	-0.26	-0.29	-0.33	-0.36	-0.39
1 700	1 679	-0.41	-0.35	-0.33	-0.32	-0.28	-0.27	-0.24	-0.27	-0.31	-0.36	-0.39	-0.42
1 800	1 778	-0.44	-0.39	-0.36	-0.35	-0.30	-0.29	-0.26	-0.29	-0.34	-0.39	-0.42	-0.46
1 900	1 884	-0.48	-0.43	-0.40	-0.38	-0.33	-0.31	-0.29	-0.31	-0.37	-0.42	-0.45	-0.50
2 000	1 995	-0.52	-0.47	-0.44	-0.41	-0.36	-0.33	-0.33	-0.33	-0.40	-0.46	-0.49	-0.54
2 120	2 113	-0.56	-0.52	-0.49	-0.45	-0.39	-0.36	-0.36	-0.36	-0.43	-0.50	-0.54	-0.59
2 240	2 239	-0.61	-0.57	-0.54	-0.49	-0.43	-0.39	-0.38	-0.39	-0.47	-0.54	-0.58	-0.64
2 360	2 371	-0.65	-0.62	-0.59	-0.54	-0.47	-0.42	-0.40	-0.43	-0.51	-0.59	-0.62	-0.69
2 500	2 512	-0.70	-0.67	-0.64	-0.59	-0.51	-0.45	-0.43	-0.47	-0.55	-0.63	-0.66	-0.75
2 650	2 661	-0.75	-0.73	-0.72	-0.65	-0.56	-0.49	-0.48	-0.52	-0.59	-0.69	-0.68	-0.81
2 800	2 818	-0.85	-0.84	-0.84	-0.76	-0.65	-0.58	-0.58	-0.60	-0.68	-0.79	-0.77	-0.91
3 000	2 985	-0.98	-0.99	-0.97	-0.88	-0.76	-0.68	-0.68	-0.71	-0.80	-0.92	-0.95	-1.04
3 150	3 162	-1.09	-1.10	-1.05	-0.96	-0.83	-0.74	-0.75	-0.79	-0.90	-1.02	-1.11	-1.14
3 350	3 350	-1.17	-1.18	-1.11	-1.03	-0.89	-0.79	-0.80	-0.85	-0.97	-1.10	-1.23	-1.22
3 550	3 548	-1.25	-1.25	-1.16	-1.09	-0.93	-0.84	-0.86	-0.90	-1.05	-1.18	-1.33	-1.30
3 750	3 758	-1.33	-1.32	-1.23	-1.16	-0.99	-0.89	-0.91	-0.96	-1.12	-1.26	-1.41	-1.38
4 000	3 981	-1.42	-1.40	-1.31	-1.24	-1.06	-0.94	-0.96	-1.03	-1.19	-1.35	-1.50	-1.47
4 250	4 217	-1.52	-1.51	-1.43	-1.34	-1.15	-1.01	-1.02	-1.11	-1.29	-1.46	-1.60	-1.57
4 500	4 467	-1.65	-1.64	-1.58	-1.48	-1.27	-1.11	-1.12	-1.21	-1.41	-1.60	-1.73	-1.71
4 750	4 732	-1.80	-1.81	-1.77	-1.63	-1.42	-1.22	-1.23	-1.33	-1.54	-1.76	-1.88	-1.88
5 000	5 012	-1.99	-2.00	-1.98	-1.82	-1.60	-1.36	-1.36	-1.48	-1.72	-1.95	-2.07	-2.07
5 300	5 309	-2.21	-2.22	-2.21	-2.04	-1.80	-1.53	-1.55	-1.67	-1.92	-2.17	-2.27	-2.28
5 600	5 623	-2.47	-2.49	-2.49	-2.31	-2.04	-1.75	-1.74	-1.89	-2.17	-2.42	-2.51	-2.54
6 000	5 957	-2.73	-2.70	-2.67	-2.55	-2.23	-1.94	-1.97	-2.08	-2.40	-2.66	-2.75	-2.77
6 300	6 310	-2.99	-2.91	-2.86	-2.77	-2.41	-2.12	-2.14	-2.28	-2.63	-2.90	-2.99	-3.02
6 700	6 683	-3.30	-3.19	-3.12	-3.05	-2.67	-2.35	-2.37	-2.52	-2.91	-3.20	-3.28	-3.34
7 100	7 079	-3.60	-3.51	-3.41	-3.35	-2.95	-2.60	-2.60	-2.78	-3.22	-3.50	-3.58	-3.66
7 500	7 499	-3.91	-3.83	-3.70	-3.65	-3.23	-2.84	-2.84	-3.04	-3.52	-3.81	-3.88	-4.00
8 000	7 943	-4.22	-4.19	-4.02	-3.99	-3.54	-3.11	-3.08	-3.32	-3.85	-4.14	-4.20	-4.36
8 500	8 414	-4.51	-4.56	-4.37	-4.32	-3.86	-3.40	-3.35	-3.61	-4.17	-4.47	-4.53	-4.71
9 000	8 913	-4.86	-4.95	-4.72	-4.68	-4.21	-3.70	-3.69	-3.96	-4.57	-4.89	-4.95	-5.13
9 500	9 441	-5.22	-5.33	-5.06	-5.03	-4.55	-3.98	-4.02	-4.28	-4.94	-5.24	-5.32	-5.48
10 000	10 000	-5.69	-5.83	-5.52	-5.51	-5.02	-4.38	-4.38	-4.72	-5.41	-5.69	-5.81	-5.92
10 600	10 593	-6.10	-6.32	-6.00	-5.94	-5.48	-4.78	-4.72	-5.14	-5.88	-6.17	-6.30	-6.39
11 200	11 220	-6.58	-6.77	-6.51	-6.41	-5.95	-5.27	-5.19	-5.69	-6.46	-6.72	-6.91	-6.94
11 800	11 885	-7.16	-7.31	-7.08	-6.90	-6.48	-5.72	-5.78	-6.30	-7.18	-7.39	-7.65	-7.58
12 500	12 589	-7.90	-8.02	-7.82	-7.58	-7.16	-6.28	-6.33	-6.96	-7.86	-8.01	-8.33	-8.16
13 200	13 335	-8.58	-8.69	-8.54	-8.21	-7.76	-6.79	-6.76	-7.49	-8.39	-8.49	-8.85	-8.64
14 000	14 125	-9.39	-9.49	-9.43	-8.96	-8.53	-7.44	-7.37	-8.16	-9.04	-9.12	-9.54	-9.27
15 000	14 962	-10.14	-10.30	-10.32	-9.73	-9.32	-8.13	-8.08	-8.90	-9.75	-9.84	-10.32	-10.04
16 000	15 849	-10.96	-11.17	-11.22	-10.56	-10.14	-8.81	-8.75	-9.66	-10.47	-10.54	-11.06	-10.79

Influence of reflections and diffraction on the frequency response of a typical MK:224 microphone (relative to 0°) - 240° to 350°

Nominal Frequency (Hz)	Exact Frequency (Hz)	Angle from reference direction											
		240°	250°	260°	270°	280°	290°	300°	310°	320°	330°	340°	350°
63	63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
80	79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
100	99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
125	125	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
160	158	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
200	198	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
250	251	-0.14	-0.09	-0.12	-0.08	-0.06	-0.05	-0.06	-0.03	-0.01	-0.04	-0.03	-0.01
315	316	-0.16	-0.11	-0.13	-0.09	-0.06	-0.05	-0.07	-0.02	0.00	-0.04	-0.03	-0.01
400	398	-0.17	-0.12	-0.15	-0.10	-0.08	-0.06	-0.07	-0.02	-0.01	-0.05	-0.03	-0.01
500	501	-0.17	-0.14	-0.15	-0.12	-0.10	-0.08	-0.08	-0.04	-0.02	-0.05	-0.03	-0.02
630	631	-0.17	-0.16	-0.16	-0.14	-0.12	-0.11	-0.10	-0.06	-0.04	-0.05	-0.03	-0.03
800	794	-0.18	-0.19	-0.18	-0.18	-0.16	-0.14	-0.12	-0.09	-0.07	-0.05	-0.04	-0.04
1 000	1 000	-0.24	-0.24	-0.23	-0.22	-0.20	-0.17	-0.14	-0.11	-0.09	-0.06	-0.05	-0.05
1 060	1 059	-0.26	-0.26	-0.25	-0.23	-0.21	-0.17	-0.15	-0.11	-0.08	-0.07	-0.05	-0.05
1 120	1 122	-0.28	-0.28	-0.27	-0.24	-0.21	-0.18	-0.16	-0.11	-0.08	-0.07	-0.05	-0.05
1 180	1 189	-0.30	-0.29	-0.29	-0.25	-0.22	-0.18	-0.16	-0.11	-0.08	-0.07	-0.05	-0.05
1 250	1 259	-0.32	-0.31	-0.31	-0.26	-0.23	-0.19	-0.17	-0.11	-0.08	-0.07	-0.05	-0.04
1 320	1 334	-0.34	-0.32	-0.32	-0.27	-0.24	-0.19	-0.17	-0.12	-0.08	-0.07	-0.05	-0.04
1 400	1 413	-0.36	-0.34	-0.34	-0.28	-0.25	-0.20	-0.18	-0.12	-0.08	-0.08	-0.05	-0.04
1 500	1 496	-0.39	-0.36	-0.35	-0.30	-0.26	-0.22	-0.19	-0.13	-0.09	-0.08	-0.05	-0.04
1 600	1 585	-0.41	-0.38	-0.37	-0.32	-0.28	-0.24	-0.21	-0.15	-0.10	-0.09	-0.06	-0.05
1 700	1 679	-0.44	-0.41	-0.39	-0.35	-0.31	-0.26	-0.22	-0.17	-0.12	-0.09	-0.06	-0.05
1 800	1 778	-0.47	-0.45	-0.42	-0.38	-0.34	-0.29	-0.25	-0.19	-0.14	-0.10	-0.07	-0.06
1 900	1 884	-0.51	-0.48	-0.45	-0.41	-0.37	-0.32	-0.27	-0.21	-0.15	-0.11	-0.07	-0.06
2 000	1 995	-0.56	-0.52	-0.49	-0.45	-0.40	-0.35	-0.29	-0.22	-0.16	-0.11	-0.07	-0.06
2 120	2 113	-0.60	-0.56	-0.53	-0.49	-0.44	-0.38	-0.32	-0.24	-0.18	-0.11	-0.07	-0.06
2 240	2 239	-0.64	-0.60	-0.57	-0.53	-0.48	-0.42	-0.34	-0.26	-0.19	-0.12	-0.07	-0.05
2 360	2 371	-0.68	-0.65	-0.61	-0.57	-0.52	-0.46	-0.37	-0.29	-0.21	-0.12	-0.07	-0.05
2 500	2 512	-0.71	-0.71	-0.65	-0.61	-0.58	-0.50	-0.40	-0.32	-0.23	-0.11	-0.06	-0.05
2 650	2 661	-0.73	-0.78	-0.69	-0.67	-0.65	-0.56	-0.42	-0.36	-0.28	-0.11	-0.06	-0.06
2 800	2 818	-0.80	-0.88	-0.77	-0.77	-0.74	-0.62	-0.45	-0.41	-0.33	-0.12	-0.08	-0.07
3 000	2 985	-0.98	-0.98	-0.91	-0.88	-0.79	-0.65	-0.49	-0.40	-0.31	-0.15	-0.09	-0.07
3 150	3 162	-1.13	-1.07	-1.04	-0.96	-0.83	-0.67	-0.53	-0.39	-0.28	-0.18	-0.10	-0.05
3 350	3 350	-1.24	-1.15	-1.14	-1.02	-0.86	-0.69	-0.57	-0.38	-0.26	-0.19	-0.10	-0.04
3 550	3 548	-1.33	-1.24	-1.23	-1.07	-0.91	-0.73	-0.61	-0.39	-0.25	-0.20	-0.09	-0.02
3 750	3 758	-1.41	-1.33	-1.32	-1.12	-0.96	-0.78	-0.65	-0.41	-0.25	-0.20	-0.08	-0.01
4 000	3 981	-1.49	-1.43	-1.40	-1.18	-1.02	-0.83	-0.69	-0.44	-0.27	-0.19	-0.07	0.00
4 250	4 217	-1.59	-1.55	-1.48	-1.26	-1.10	-0.91	-0.75	-0.49	-0.30	-0.20	-0.07	-0.01
4 500	4 467	-1.72	-1.69	-1.59	-1.38	-1.21	-1.01	-0.81	-0.55	-0.36	-0.23	-0.11	-0.04
4 750	4 732	-1.89	-1.85	-1.71	-1.52	-1.35	-1.13	-0.89	-0.63	-0.44	-0.28	-0.16	-0.10
5 000	5 012	-2.09	-2.04	-1.85	-1.69	-1.50	-1.24	-0.97	-0.71	-0.52	-0.32	-0.19	-0.11
5 300	5 309	-2.31	-2.23	-2.01	-1.87	-1.65	-1.35	-1.05	-0.79	-0.59	-0.35	-0.19	-0.10
5 600	5 623	-2.57	-2.44	-2.21	-2.09	-1.81	-1.47	-1.16	-0.89	-0.64	-0.35	-0.16	-0.06
6 000	5 957	-2.81	-2.64	-2.43	-2.24	-1.92	-1.56	-1.25	-0.91	-0.60	-0.32	-0.13	-0.03
6 300	6 310	-3.05	-2.85	-2.66	-2.41	-2.06	-1.69	-1.37	-0.95	-0.61	-0.37	-0.18	-0.06
6 700	6 683	-3.35	-3.12	-2.94	-2.63	-2.26	-1.88	-1.51	-1.04	-0.72	-0.47	-0.25	-0.10
7 100	7 079	-3.63	-3.39	-3.21	-2.84	-2.47	-2.06	-1.62	-1.15	-0.83	-0.51	-0.24	-0.08
7 500	7 499	-3.92	-3.68	-3.46	-3.05	-2.68	-2.20	-1.72	-1.27	-0.86	-0.50	-0.23	-0.09
8 000	7 943	-4.23	-4.00	-3.73	-3.31	-2.93	-2.36	-1.90	-1.39	-0.90	-0.56	-0.32	-0.16
8 500	8 414	-4.54	-4.34	-4.01	-3.59	-3.19	-2.56	-2.11	-1.49	-1.02	-0.68	-0.39	-0.19
9 000	8 913	-4.93	-4.74	-4.33	-3.93	-3.43	-2.80	-2.26	-1.58	-1.15	-0.69	-0.33	-0.13
9 500	9 441	-5.28	-5.05	-4.59	-4.19	-3.54	-2.96	-2.25	-1.64	-1.07	-0.59	-0.27	-0.07
10 000	10 000	-5.73	-5.43	-4.96	-4.51	-3.81	-3.12	-2.44	-1.73	-1.08	-0.66	-0.30	-0.05
10 600	10 593	-6.20	-5.88	-5.39	-4.85	-4.21	-3.34	-2.72	-1.86	-1.27	-0.74	-0.31	-0.04
11 200	11 220	-6.76	-6.37	-5.92	-5.19	-4.61	-3.67	-2.88	-2.04	-1.35	-0.72	-0.29	-0.02
11 800	11 885	-7.43	-7.00	-6.51	-5.82	-5.01	-4.18	-3.21	-2.38	-1.60	-0.96	-0.49	-0.18
12 500	12 589	-8.04	-7.48	-6.86	-6.29	-5.32	-4.29	-3.45	-2.41	-1.65	-0.97	-0.47	-0.17
13 200	13 335	-8.51	-7.94	-7.19	-6.54	-5.64	-4.48	-3.52	-2.48	-1.62	-0.94	-0.44	-0.09
14 000	14 125	-9.17	-8.59	-7.80	-6.92	-6.00	-4.86	-3.76	-2.66	-1.75	-1.04	-0.45	-0.10
15 000	14 962	-9.86	-9.22	-8.50	-7.54	-6.39	-5.19	-4.10	-2.85	-1.91	-1.10	-0.52	-0.14
16 000	15 849	-10.46	-9.76	-8.97	-8.12	-6.86	-5.52	-4.30	-3.04	-1.98	-1.17	-0.51	-0.11

Influence of the Optimus case on frequency response – plane parallel to the display screen (Horizontal) 0° to 110°

Nominal Frequency (Hz)	Exact Frequency (Hz)	Angle from reference direction											
		0°	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°	110°
63	63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
80	79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
100	99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
125	125	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
160	158	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
200	198	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
250	251	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.00	-0.03
315	316	0.01	0.03	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.00	-0.04
400	398	0.01	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.02	0.00	-0.04
500	501	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01	-0.04
630	631	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.03	0.03	0.03	0.01	-0.04
800	794	-0.01	-0.01	-0.01	-0.01	-0.01	0.00	0.00	0.02	0.03	0.04	0.03	-0.02
1 000	1 000	-0.03	-0.03	-0.03	-0.03	-0.04	-0.03	-0.03	-0.01	0.01	0.04	0.06	0.02
1 060	1 059	-0.03	-0.03	-0.03	-0.04	-0.04	-0.04	-0.04	-0.02	-0.01	0.03	0.07	0.03
1 120	1 122	-0.02	-0.02	-0.02	-0.03	-0.04	-0.05	-0.05	-0.03	-0.03	0.02	0.07	0.04
1 180	1 189	-0.01	-0.01	-0.01	-0.03	-0.04	-0.05	-0.06	-0.04	-0.04	0.01	0.06	0.04
1 250	1 259	0.00	0.01	0.00	-0.02	-0.04	-0.06	-0.06	-0.05	-0.06	-0.01	0.05	0.05
1 320	1 334	0.02	0.03	0.02	0.00	-0.03	-0.06	-0.07	-0.06	-0.07	-0.02	0.04	0.06
1 400	1 413	0.05	0.05	0.05	0.02	-0.01	-0.05	-0.07	-0.07	-0.08	-0.04	0.03	0.06
1 500	1 496	0.07	0.07	0.08	0.05	0.01	-0.04	-0.08	-0.09	-0.09	-0.06	0.00	0.06
1 600	1 585	0.09	0.10	0.10	0.08	0.05	-0.02	-0.07	-0.10	-0.11	-0.07	-0.02	0.05
1 700	1 679	0.10	0.10	0.12	0.11	0.08	0.02	-0.06	-0.11	-0.13	-0.09	-0.05	0.03
1 800	1 778	0.09	0.09	0.12	0.12	0.12	0.07	-0.02	-0.11	-0.15	-0.11	-0.08	0.00
1 900	1 884	0.05	0.06	0.09	0.11	0.14	0.12	0.04	-0.08	-0.18	-0.13	-0.10	-0.04
2 000	1 995	-0.01	0.01	0.04	0.08	0.13	0.16	0.11	-0.03	-0.20	-0.16	-0.12	-0.08
2 120	2 113	-0.06	-0.05	-0.02	0.02	0.09	0.16	0.16	0.06	-0.17	-0.19	-0.12	-0.12
2 240	2 239	-0.11	-0.10	-0.08	-0.05	0.03	0.13	0.19	0.14	-0.12	-0.23	-0.12	-0.14
2 360	2 371	-0.11	-0.13	-0.12	-0.11	-0.05	0.07	0.18	0.21	-0.03	-0.26	-0.14	-0.14
2 500	2 512	-0.05	-0.10	-0.12	-0.15	-0.13	-0.01	0.14	0.25	0.08	-0.29	-0.20	-0.13
2 650	2 661	0.08	-0.01	-0.04	-0.13	-0.20	-0.14	0.07	0.24	0.21	-0.26	-0.32	-0.10
2 800	2 818	0.20	0.10	0.11	0.02	-0.14	-0.27	-0.09	0.14	0.25	-0.09	-0.45	-0.10
3 000	2 985	0.14	0.10	0.14	0.12	0.03	-0.17	-0.22	-0.01	0.17	0.12	-0.34	-0.18
3 150	3 162	0.04	0.05	0.08	0.11	0.10	-0.02	-0.20	-0.13	0.09	0.20	-0.15	-0.28
3 350	3 350	-0.03	0.01	0.03	0.06	0.11	0.08	-0.12	-0.20	0.02	0.22	-0.01	-0.35
3 550	3 548	-0.06	-0.01	-0.01	0.02	0.09	0.13	-0.04	-0.20	-0.06	0.22	0.09	-0.38
3 750	3 758	-0.05	-0.01	-0.02	-0.02	0.04	0.15	0.05	-0.16	-0.16	0.21	0.17	-0.39
4 000	3 981	-0.03	0.00	-0.01	-0.03	-0.01	0.13	0.12	-0.07	-0.24	0.17	0.22	-0.35
4 250	4 217	0.01	0.01	0.00	-0.03	-0.06	0.03	0.15	0.04	-0.30	0.07	0.25	-0.27
4 500	4 467	0.02	0.01	0.01	-0.03	-0.09	-0.10	0.07	0.14	-0.29	-0.14	0.25	-0.17
4 750	4 732	0.01	-0.01	0.01	-0.02	-0.09	-0.19	-0.12	0.18	-0.19	-0.38	0.20	-0.07
5 000	5 012	-0.07	-0.10	-0.03	0.00	0.00	-0.15	-0.25	0.06	0.02	-0.51	0.08	0.04
5 300	5 309	-0.13	-0.18	-0.13	-0.08	0.03	0.02	-0.22	-0.15	0.21	-0.44	-0.15	0.17
5 600	5 623	0.00	-0.07	-0.08	-0.11	-0.08	0.09	0.02	-0.25	0.18	-0.16	-0.37	0.33
6 000	5 957	0.08	0.05	0.04	0.00	-0.06	-0.05	0.14	-0.13	-0.10	0.14	-0.46	0.31
6 300	6 310	0.00	-0.01	0.02	0.01	-0.03	-0.09	-0.02	0.01	-0.33	0.19	-0.49	0.16
6 700	6 683	-0.09	-0.09	-0.04	-0.01	-0.03	-0.07	-0.13	0.05	-0.41	0.11	-0.37	-0.01
7 100	7 079	-0.10	-0.11	-0.06	-0.02	0.01	-0.03	-0.10	-0.01	-0.26	-0.05	-0.09	-0.16
7 500	7 499	-0.03	-0.06	-0.07	-0.09	-0.02	0.00	-0.08	-0.11	-0.06	-0.32	0.14	-0.44
8 000	7 943	-0.08	-0.07	-0.01	-0.08	-0.16	-0.04	-0.08	-0.21	0.00	-0.56	0.26	-0.79
8 500	8 414	-0.21	-0.22	-0.12	-0.02	-0.12	-0.13	-0.04	-0.18	-0.07	-0.51	0.27	-0.88
9 000	8 913	-0.09	-0.14	-0.15	-0.16	0.00	-0.11	-0.07	-0.06	-0.33	-0.14	-0.12	-0.61
9 500	9 441	-0.05	-0.06	0.00	-0.06	-0.13	0.04	-0.15	-0.04	-0.38	0.14	-0.55	-0.37
10 000	10 000	-0.06	-0.09	-0.03	0.02	-0.03	-0.05	-0.05	-0.12	-0.23	-0.03	-0.68	0.03
10 600	10 593	0.05	-0.02	-0.02	-0.07	0.02	-0.08	0.01	-0.17	-0.08	-0.42	-0.57	0.38
11 200	11 220	0.03	-0.03	0.03	-0.01	-0.08	0.04	-0.18	-0.12	-0.28	-0.60	0.14	0.15
11 800	11 885	-0.07	-0.14	-0.13	-0.19	-0.12	-0.17	-0.15	-0.18	-0.38	-0.29	0.05	-0.54
12 500	12 589	-0.08	-0.12	-0.10	-0.11	-0.10	-0.06	-0.14	-0.19	-0.28	-0.16	-0.34	-1.08
13 200	13 335	-0.02	-0.01	0.06	0.02	0.09	0.09	0.09	0.09	0.06	-0.03	-0.39	-0.91
14 000	14 125	-0.01	0.01	0.06	0.08	0.16	0.21	0.18	0.22	0.16	0.02	0.02	-0.07
15 000	14 962	-0.07	-0.02	0.09	0.08	0.20	0.21	0.28	0.26	0.14	0.17	0.55	0.92
16 000	15 849	-0.06	0.01	0.10	0.12	0.24	0.33	0.31	0.31	0.25	0.43	0.74	1.14

Influence of the Optimus case on frequency response – plane parallel to the display screen (Horizontal) 120° to 230°

Nominal Frequency (Hz)	Exact Frequency (Hz)	Angle from reference direction											
		120°	130°	140°	150°	160°	170°	180°	190°	200°	210°	220°	230°
63	63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
80	79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
100	99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
125	125	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
160	158	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
200	198	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
250	251	0.00	-0.03	-0.03	-0.03	-0.04	-0.01	-0.02	-0.03	-0.03	-0.03	-0.03	-0.04
315	316	-0.01	-0.04	-0.04	-0.03	-0.05	-0.01	-0.02	-0.04	-0.03	-0.03	-0.03	-0.04
400	398	-0.01	-0.04	-0.04	-0.03	-0.05	-0.02	-0.02	-0.04	-0.03	-0.03	-0.03	-0.04
500	501	-0.02	-0.05	-0.05	-0.04	-0.05	-0.02	-0.02	-0.04	-0.03	-0.04	-0.05	-0.05
630	631	-0.04	-0.07	-0.06	-0.05	-0.05	-0.03	-0.03	-0.04	-0.04	-0.05	-0.07	-0.07
800	794	-0.04	-0.08	-0.08	-0.08	-0.06	-0.04	-0.04	-0.05	-0.06	-0.08	-0.10	-0.09
1 000	1 000	0.00	-0.09	-0.12	-0.12	-0.09	-0.05	-0.04	-0.06	-0.09	-0.12	-0.14	-0.09
1 060	1 059	0.01	-0.09	-0.14	-0.13	-0.10	-0.05	-0.04	-0.06	-0.10	-0.13	-0.15	-0.08
1 120	1 122	0.03	-0.08	-0.15	-0.14	-0.11	-0.05	-0.04	-0.07	-0.11	-0.14	-0.15	-0.07
1 180	1 189	0.05	-0.08	-0.16	-0.15	-0.12	-0.05	-0.04	-0.07	-0.11	-0.15	-0.16	-0.06
1 250	1 259	0.08	-0.07	-0.17	-0.16	-0.14	-0.05	-0.04	-0.07	-0.12	-0.17	-0.17	-0.04
1 320	1 334	0.10	-0.06	-0.18	-0.18	-0.15	-0.05	-0.03	-0.08	-0.13	-0.18	-0.17	-0.02
1 400	1 413	0.12	-0.04	-0.19	-0.20	-0.16	-0.05	-0.03	-0.08	-0.15	-0.20	-0.18	-0.01
1 500	1 496	0.15	-0.02	-0.20	-0.22	-0.18	-0.05	-0.03	-0.09	-0.16	-0.22	-0.19	0.01
1 600	1 585	0.16	0.00	-0.20	-0.25	-0.19	-0.06	-0.03	-0.09	-0.19	-0.25	-0.20	0.04
1 700	1 679	0.18	0.03	-0.21	-0.28	-0.22	-0.07	-0.03	-0.10	-0.22	-0.28	-0.20	0.07
1 800	1 778	0.19	0.07	-0.21	-0.32	-0.25	-0.08	-0.03	-0.12	-0.26	-0.32	-0.20	0.11
1 900	1 884	0.19	0.12	-0.21	-0.37	-0.29	-0.09	-0.03	-0.14	-0.30	-0.37	-0.20	0.15
2 000	1 995	0.18	0.18	-0.19	-0.42	-0.34	-0.11	-0.04	-0.16	-0.35	-0.41	-0.17	0.20
2 120	2 113	0.15	0.22	-0.14	-0.43	-0.36	-0.11	-0.04	-0.16	-0.37	-0.42	-0.12	0.23
2 240	2 239	0.10	0.26	-0.09	-0.43	-0.37	-0.11	-0.04	-0.16	-0.39	-0.42	-0.06	0.25
2 360	2 371	0.03	0.29	-0.03	-0.43	-0.38	-0.11	-0.02	-0.15	-0.41	-0.42	0.00	0.26
2 500	2 512	-0.05	0.31	0.03	-0.42	-0.37	-0.11	-0.01	-0.13	-0.44	-0.43	0.06	0.25
2 650	2 661	-0.15	0.30	0.10	-0.42	-0.37	-0.12	0.01	-0.10	-0.49	-0.44	0.13	0.20
2 800	2 818	-0.19	0.22	0.22	-0.41	-0.41	-0.15	0.01	-0.10	-0.57	-0.44	0.21	0.07
3 000	2 985	-0.12	0.09	0.33	-0.35	-0.53	-0.15	0.02	-0.16	-0.61	-0.34	0.28	-0.05
3 150	3 162	-0.05	0.01	0.37	-0.28	-0.63	-0.14	0.05	-0.21	-0.61	-0.23	0.33	-0.08
3 350	3 350	-0.03	-0.03	0.38	-0.22	-0.70	-0.13	0.07	-0.24	-0.61	-0.14	0.36	-0.08
3 550	3 548	-0.05	-0.06	0.37	-0.16	-0.75	-0.12	0.09	-0.26	-0.60	-0.06	0.37	-0.06
3 750	3 758	-0.09	-0.06	0.35	-0.10	-0.78	-0.12	0.10	-0.27	-0.60	0.02	0.37	-0.04
4 000	3 981	-0.16	-0.05	0.33	-0.04	-0.79	-0.13	0.11	-0.28	-0.61	0.10	0.35	0.00
4 250	4 217	-0.26	-0.03	0.29	0.01	-0.80	-0.14	0.12	-0.30	-0.64	0.17	0.30	0.03
4 500	4 467	-0.42	-0.02	0.21	0.05	-0.85	-0.19	0.11	-0.35	-0.70	0.22	0.21	0.03
4 750	4 732	-0.56	-0.03	0.10	0.07	-0.92	-0.26	0.07	-0.42	-0.77	0.25	0.08	-0.02
5 000	5 012	-0.58	-0.05	-0.01	0.13	-0.96	-0.32	0.10	-0.46	-0.81	0.30	-0.02	-0.13
5 300	5 309	-0.46	-0.13	-0.06	0.21	-0.97	-0.37	0.14	-0.49	-0.80	0.36	-0.03	-0.29
5 600	5 623	-0.29	-0.26	-0.01	0.30	-0.92	-0.42	0.19	-0.53	-0.74	0.41	0.07	-0.48
6 000	5 957	-0.14	-0.41	0.10	0.36	-0.86	-0.45	0.22	-0.62	-0.59	0.46	0.22	-0.53
6 300	6 310	-0.03	-0.54	0.12	0.34	-0.85	-0.51	0.18	-0.72	-0.46	0.45	0.28	-0.53
6 700	6 683	0.13	-0.62	0.09	0.29	-0.81	-0.57	0.19	-0.80	-0.36	0.41	0.26	-0.52
7 100	7 079	0.29	-0.64	0.07	0.30	-0.70	-0.59	0.26	-0.84	-0.22	0.40	0.22	-0.47
7 500	7 499	0.33	-0.67	-0.02	0.30	-0.65	-0.65	0.29	-0.93	-0.12	0.38	0.12	-0.37
8 000	7 943	0.28	-0.70	-0.15	0.25	-0.63	-0.83	0.30	-1.09	-0.07	0.32	0.00	-0.20
8 500	8 414	0.28	-0.56	-0.20	0.17	-0.51	-1.01	0.34	-1.26	0.04	0.25	-0.06	0.01
9 000	8 913	0.25	-0.25	-0.30	0.09	-0.32	-1.12	0.39	-1.47	0.26	0.20	-0.20	0.27
9 500	9 441	-0.10	-0.09	-0.44	0.12	-0.24	-1.21	0.34	-1.56	0.37	0.32	-0.31	0.45
10 000	10 000	-0.55	0.06	-0.52	0.19	-0.13	-1.36	0.37	-1.51	0.45	0.45	-0.24	0.63
10 600	10 593	-0.94	0.17	-0.60	0.24	-0.01	-1.56	0.38	-1.61	0.54	0.60	-0.26	0.84
11 200	11 220	-1.23	0.41	-1.04	0.14	0.00	-1.85	0.39	-1.75	0.66	0.71	-0.52	1.18
11 800	11 885	-1.19	0.43	-1.65	-0.29	-0.17	-2.13	0.23	-1.84	0.63	0.63	-0.64	0.86
12 500	12 589	-0.29	0.22	-1.59	-0.49	-0.26	-2.31	0.15	-1.62	0.74	0.58	-0.33	0.28
13 200	13 335	0.54	0.15	-1.14	-0.35	-0.14	-2.42	0.26	-1.56	0.81	0.52	-0.19	-0.22
14 000	14 125	1.08	-0.05	-0.60	-0.18	-0.02	-2.56	0.32	-1.67	0.66	0.35	-0.18	-0.98
15 000	14 962	0.97	-0.52	-0.20	0.04	0.16	-2.67	0.35	-1.66	0.52	0.27	-0.09	-1.54
16 000	15 849	0.48	-0.85	0.21	0.22	0.40	-2.76	0.38	-1.58	0.47	-0.09	0.30	-1.18

Influence of the Optimus case on frequency response – plane parallel to the display screen (Horizontal) 240° to 350°

Nominal Frequency (Hz)	Exact Frequency (Hz)	Angle from reference direction											
		240°	250°	260°	270°	280°	290°	300°	310°	320°	330°	340°	350°
63	63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
80	79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
100	99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
125	125	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
160	158	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
200	198	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
250	251	-0.02	-0.03	-0.02	-0.02	-0.01	-0.01	0.01	-0.01	-0.01	0.01	0.01	0.00
315	316	-0.01	-0.03	-0.02	-0.02	-0.01	-0.01	0.01	-0.01	-0.01	0.01	0.01	0.00
400	398	-0.02	-0.03	-0.01	-0.02	-0.01	-0.01	0.02	-0.01	-0.01	0.01	0.01	0.00
500	501	-0.02	-0.03	-0.01	-0.01	0.00	0.00	0.01	-0.01	-0.01	0.01	0.01	-0.01
630	631	-0.04	-0.03	0.00	0.00	0.01	0.00	0.01	-0.01	-0.02	-0.01	-0.01	-0.01
800	794	-0.05	-0.01	0.02	0.02	0.01	0.00	-0.02	-0.03	-0.03	-0.04	-0.04	-0.03
1 000	1 000	-0.02	0.03	0.03	0.01	-0.02	-0.04	-0.05	-0.06	-0.07	-0.07	-0.06	-0.04
1 060	1 059	-0.01	0.04	0.04	0.00	-0.03	-0.06	-0.06	-0.07	-0.08	-0.07	-0.06	-0.05
1 120	1 122	0.01	0.05	0.03	-0.02	-0.04	-0.07	-0.07	-0.08	-0.08	-0.07	-0.05	-0.04
1 180	1 189	0.03	0.06	0.03	-0.03	-0.06	-0.09	-0.08	-0.09	-0.09	-0.06	-0.04	-0.03
1 250	1 259	0.05	0.07	0.02	-0.05	-0.07	-0.10	-0.09	-0.10	-0.09	-0.05	-0.03	-0.02
1 320	1 334	0.07	0.07	0.00	-0.07	-0.09	-0.12	-0.10	-0.10	-0.08	-0.04	-0.01	0.00
1 400	1 413	0.10	0.07	-0.02	-0.09	-0.10	-0.13	-0.10	-0.10	-0.06	-0.01	0.02	0.02
1 500	1 496	0.12	0.06	-0.05	-0.11	-0.12	-0.15	-0.11	-0.08	-0.04	0.01	0.04	0.05
1 600	1 585	0.13	0.04	-0.07	-0.12	-0.14	-0.16	-0.11	-0.05	0.00	0.04	0.07	0.07
1 700	1 679	0.15	0.02	-0.10	-0.14	-0.17	-0.17	-0.10	-0.01	0.04	0.06	0.08	0.08
1 800	1 778	0.16	-0.02	-0.13	-0.16	-0.20	-0.17	-0.06	0.04	0.07	0.07	0.08	0.07
1 900	1 884	0.15	-0.07	-0.16	-0.19	-0.23	-0.15	0.00	0.08	0.08	0.06	0.05	0.04
2 000	1 995	0.14	-0.12	-0.18	-0.23	-0.25	-0.09	0.07	0.11	0.07	0.02	0.00	-0.02
2 120	2 113	0.09	-0.15	-0.18	-0.26	-0.23	0.00	0.12	0.10	0.02	-0.04	-0.07	-0.08
2 240	2 239	0.03	-0.16	-0.20	-0.29	-0.17	0.09	0.13	0.07	-0.04	-0.12	-0.14	-0.12
2 360	2 371	-0.04	-0.15	-0.23	-0.31	-0.06	0.16	0.10	0.02	-0.10	-0.19	-0.18	-0.14
2 500	2 512	-0.14	-0.13	-0.29	-0.29	0.07	0.20	0.03	-0.04	-0.16	-0.24	-0.20	-0.09
2 650	2 661	-0.27	-0.11	-0.39	-0.18	0.19	0.20	-0.10	-0.11	-0.18	-0.25	-0.14	0.03
2 800	2 818	-0.33	-0.18	-0.43	0.04	0.21	0.09	-0.30	-0.16	-0.07	-0.13	-0.03	0.16
3 000	2 985	-0.19	-0.33	-0.27	0.16	0.11	-0.09	-0.34	-0.11	0.04	0.00	0.04	0.11
3 150	3 162	-0.06	-0.40	-0.09	0.16	0.04	-0.21	-0.23	-0.05	0.05	0.05	0.03	0.00
3 350	3 350	0.01	-0.40	0.04	0.15	-0.01	-0.26	-0.10	-0.01	0.03	0.04	0.01	-0.06
3 550	3 548	0.02	-0.36	0.14	0.14	-0.08	-0.24	0.02	0.02	-0.01	0.02	-0.01	-0.09
3 750	3 758	-0.01	-0.29	0.21	0.12	-0.15	-0.18	0.11	0.03	-0.05	-0.01	-0.01	-0.08
4 000	3 981	-0.10	-0.19	0.26	0.08	-0.22	-0.08	0.17	0.01	-0.09	-0.03	0.00	-0.05
4 250	4 217	-0.24	-0.07	0.28	-0.02	-0.25	0.04	0.18	-0.05	-0.10	-0.03	0.01	-0.01
4 500	4 467	-0.40	0.06	0.27	-0.20	-0.20	0.15	0.08	-0.12	-0.08	-0.01	0.04	0.05
4 750	4 732	-0.51	0.14	0.18	-0.37	-0.07	0.18	-0.11	-0.13	-0.01	0.03	0.06	0.09
5 000	5 012	-0.47	0.23	-0.02	-0.41	0.12	0.06	-0.23	-0.05	0.09	0.04	0.02	0.02
5 300	5 309	-0.29	0.32	-0.26	-0.26	0.27	-0.16	-0.19	0.12	0.09	-0.07	-0.10	-0.07
5 600	5 623	-0.11	0.36	-0.44	0.03	0.18	-0.27	0.02	0.11	-0.05	-0.15	-0.11	-0.02
6 000	5 957	0.08	0.27	-0.41	0.26	-0.08	-0.11	0.13	-0.07	-0.05	-0.05	0.00	0.04
6 300	6 310	0.24	0.12	-0.26	0.27	-0.25	0.07	0.00	-0.08	-0.01	0.00	0.03	0.02
6 700	6 683	0.39	-0.06	-0.04	0.16	-0.27	0.11	-0.09	-0.06	0.00	0.00	0.00	-0.03
7 100	7 079	0.49	-0.26	0.20	-0.03	-0.11	0.00	-0.08	-0.03	0.03	-0.02	-0.05	-0.05
7 500	7 499	0.47	-0.51	0.34	-0.31	0.08	-0.13	-0.06	0.00	-0.02	-0.10	-0.04	0.02
8 000	7 943	0.41	-0.61	0.35	-0.42	0.13	-0.19	-0.05	-0.04	-0.12	-0.05	0.05	0.04
8 500	8 414	0.41	-0.46	0.19	-0.30	0.01	-0.14	-0.02	-0.14	-0.03	0.01	-0.07	-0.09
9 000	8 913	0.20	-0.14	-0.34	0.12	-0.27	-0.02	-0.11	-0.10	0.04	-0.15	-0.10	-0.01
9 500	9 441	-0.30	0.36	-0.47	0.32	-0.18	0.01	-0.14	0.08	-0.07	-0.02	0.08	0.06
10 000	10 000	-0.40	0.67	-0.23	0.09	0.09	-0.05	0.11	-0.03	0.08	0.10	0.06	0.01
10 600	10 593	-0.41	0.69	0.27	-0.12	0.29	-0.01	0.20	0.05	0.18	0.03	0.06	0.09
11 200	11 220	-0.39	0.34	0.77	-0.03	0.14	0.20	0.01	0.20	0.12	0.09	0.09	0.04
11 800	11 885	0.07	-0.30	0.32	0.36	0.04	0.15	0.09	0.07	0.18	-0.01	-0.03	0.05
12 500	12 589	0.70	-0.63	-0.33	0.09	-0.01	-0.14	-0.04	-0.03	0.01	-0.05	-0.04	-0.04
13 200	13 335	0.89	-0.25	-0.40	-0.19	-0.05	-0.10	-0.08	-0.09	-0.01	-0.05	-0.01	-0.01
14 000	14 125	0.81	0.34	-0.08	-0.41	-0.28	-0.25	-0.21	-0.20	-0.09	-0.12	-0.07	-0.01
15 000	14 962	0.11	0.18	-0.16	-0.43	-0.55	-0.43	-0.35	-0.34	-0.22	-0.23	-0.16	-0.10
16 000	15 849	-1.11	-0.64	-0.76	-0.50	-0.46	-0.56	-0.43	-0.39	-0.24	-0.27	-0.16	-0.11

Influence of the Optimus case on frequency response – plane perpendicular to the display screen (Vertical) 0° to 110°

Nominal Frequency (Hz)	Exact Frequency (Hz)	Angle from reference direction											
		0°	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°	110°
63	63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
80	79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
100	99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
125	125	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
160	158	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
200	198	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
250	251	-0.01	0.00	-0.01	0.00	-0.01	-0.02	-0.02	-0.03	-0.03	-0.04	-0.05	-0.05
315	316	-0.01	0.00	-0.01	0.01	-0.02	-0.02	-0.02	-0.03	-0.04	-0.04	-0.05	-0.05
400	398	-0.01	0.00	-0.01	0.01	-0.02	-0.02	-0.02	-0.03	-0.04	-0.04	-0.05	-0.05
500	501	-0.02	-0.01	-0.02	0.00	-0.02	-0.03	-0.02	-0.03	-0.04	-0.03	-0.05	-0.05
630	631	-0.03	-0.03	-0.03	-0.02	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.04	-0.06
800	794	-0.06	-0.06	-0.06	-0.06	-0.06	-0.05	-0.05	-0.03	-0.03	-0.02	-0.03	-0.06
1 000	1 000	-0.08	-0.08	-0.08	-0.09	-0.10	-0.09	-0.09	-0.07	-0.06	-0.02	-0.01	-0.03
1 060	1 059	-0.08	-0.09	-0.09	-0.10	-0.11	-0.11	-0.10	-0.09	-0.07	-0.03	-0.01	-0.02
1 120	1 122	-0.08	-0.08	-0.08	-0.09	-0.12	-0.12	-0.12	-0.10	-0.09	-0.04	-0.01	0.00
1 180	1 189	-0.07	-0.07	-0.07	-0.08	-0.13	-0.13	-0.13	-0.11	-0.11	-0.06	-0.01	0.01
1 250	1 259	-0.05	-0.06	-0.06	-0.07	-0.13	-0.14	-0.14	-0.13	-0.13	-0.08	-0.02	0.02
1 320	1 334	-0.03	-0.04	-0.04	-0.06	-0.12	-0.15	-0.15	-0.14	-0.15	-0.10	-0.03	0.03
1 400	1 413	-0.01	-0.02	-0.02	-0.03	-0.11	-0.15	-0.16	-0.16	-0.16	-0.12	-0.05	0.04
1 500	1 496	0.01	0.00	0.00	-0.01	-0.09	-0.14	-0.17	-0.18	-0.18	-0.15	-0.07	0.04
1 600	1 585	0.02	0.02	0.02	0.02	-0.06	-0.12	-0.18	-0.21	-0.20	-0.18	-0.10	0.03
1 700	1 679	0.02	0.03	0.04	0.04	-0.03	-0.09	-0.17	-0.23	-0.23	-0.20	-0.14	0.01
1 800	1 778	0.00	0.01	0.03	0.05	0.01	-0.04	-0.14	-0.24	-0.27	-0.23	-0.18	-0.03
1 900	1 884	-0.04	-0.03	0.01	0.04	0.03	0.01	-0.09	-0.23	-0.31	-0.26	-0.22	-0.07
2 000	1 995	-0.10	-0.08	-0.05	0.00	0.03	0.06	-0.02	-0.19	-0.34	-0.30	-0.25	-0.13
2 120	2 113	-0.16	-0.14	-0.11	-0.06	-0.01	0.08	0.06	-0.09	-0.33	-0.33	-0.25	-0.18
2 240	2 239	-0.20	-0.19	-0.17	-0.14	-0.07	0.06	0.11	0.02	-0.28	-0.36	-0.25	-0.21
2 360	2 371	-0.20	-0.21	-0.21	-0.23	-0.15	0.00	0.11	0.12	-0.18	-0.40	-0.25	-0.24
2 500	2 512	-0.16	-0.19	-0.21	-0.30	-0.25	-0.09	0.07	0.19	-0.04	-0.42	-0.29	-0.25
2 650	2 661	-0.05	-0.11	-0.12	-0.32	-0.34	-0.25	-0.05	0.19	0.14	-0.37	-0.40	-0.26
2 800	2 818	0.04	-0.02	0.00	-0.21	-0.27	-0.39	-0.30	0.03	0.23	-0.14	-0.59	-0.29
3 000	2 985	0.01	-0.02	0.02	-0.06	-0.09	-0.27	-0.43	-0.21	0.11	0.09	-0.57	-0.35
3 150	3 162	-0.06	-0.05	-0.03	0.00	-0.02	-0.12	-0.34	-0.35	-0.03	0.16	-0.38	-0.40
3 350	3 350	-0.09	-0.07	-0.07	0.02	-0.01	-0.04	-0.20	-0.38	-0.13	0.15	-0.17	-0.44
3 550	3 548	-0.09	-0.06	-0.09	0.01	-0.03	0.00	-0.09	-0.34	-0.23	0.12	0.00	-0.47
3 750	3 758	-0.06	-0.03	-0.07	0.01	-0.05	0.02	0.00	-0.24	-0.32	0.09	0.15	-0.46
4 000	3 981	-0.02	0.00	-0.03	0.02	-0.08	0.00	0.06	-0.10	-0.38	0.03	0.25	-0.41
4 250	4 217	0.02	0.02	0.00	0.04	-0.09	-0.06	0.07	0.02	-0.36	-0.08	0.29	-0.28
4 500	4 467	0.03	0.01	-0.02	-0.01	-0.08	-0.14	-0.03	0.07	-0.24	-0.31	0.25	-0.08
4 750	4 732	-0.01	-0.02	-0.03	-0.08	-0.13	-0.13	-0.22	0.05	-0.09	-0.56	0.15	0.12
5 000	5 012	-0.10	-0.09	-0.02	-0.03	-0.14	-0.12	-0.22	-0.10	0.01	-0.51	0.04	0.26
5 300	5 309	-0.17	-0.20	-0.14	-0.05	-0.02	-0.15	-0.11	-0.31	0.11	-0.21	-0.25	0.24
5 600	5 623	-0.05	-0.12	-0.17	-0.21	-0.02	0.00	-0.17	-0.15	0.00	-0.04	-0.64	0.21
6 000	5 957	0.07	0.03	-0.01	-0.09	-0.18	0.06	-0.10	-0.08	-0.33	0.09	-0.51	0.27
6 300	6 310	0.01	0.00	0.02	0.02	-0.16	-0.14	0.02	-0.20	-0.28	0.12	-0.27	0.11
6 700	6 683	-0.07	-0.09	-0.08	0.01	-0.07	-0.21	-0.05	-0.17	-0.19	-0.14	-0.21	-0.27
7 100	7 079	-0.06	-0.07	-0.07	-0.05	-0.02	-0.06	-0.21	0.03	-0.21	-0.31	-0.07	-0.55
7 500	7 499	0.02	-0.04	-0.08	-0.04	-0.15	0.03	-0.19	-0.02	-0.28	-0.23	0.17	-0.56
8 000	7 943	-0.06	-0.06	-0.05	-0.12	-0.18	-0.17	-0.09	-0.31	-0.22	-0.22	0.16	-0.49
8 500	8 414	-0.20	-0.22	-0.14	-0.07	-0.24	-0.21	-0.06	-0.34	-0.05	-0.27	-0.13	-0.47
9 000	8 913	-0.04	-0.10	-0.17	-0.14	-0.07	-0.11	-0.22	-0.09	-0.19	-0.33	-0.38	-0.29
9 500	9 441	0.03	0.01	0.02	-0.03	-0.15	-0.07	-0.09	0.03	-0.35	-0.11	-0.29	0.24
10 000	10 000	0.02	-0.03	-0.02	0.10	-0.16	0.00	-0.15	-0.19	-0.34	0.07	-0.14	0.47
10 600	10 593	0.13	0.03	0.00	-0.03	0.00	-0.11	-0.02	-0.06	-0.02	-0.09	-0.05	0.10
11 200	11 220	0.09	0.03	-0.01	-0.07	-0.16	0.00	-0.13	-0.27	-0.23	-0.42	-0.37	-0.45
11 800	11 885	-0.03	-0.14	-0.18	-0.17	-0.22	-0.19	-0.32	-0.10	-0.40	-0.35	-0.08	-0.44
12 500	12 589	-0.10	-0.17	-0.19	-0.25	-0.24	-0.26	-0.17	-0.32	-0.39	-0.04	-0.07	-0.19
13 200	13 335	0.03	-0.02	-0.04	-0.01	-0.14	-0.06	-0.14	-0.14	-0.15	-0.15	0.00	0.02
14 000	14 125	0.03	-0.01	-0.05	-0.01	-0.07	-0.04	-0.06	0.07	-0.02	-0.08	-0.22	-0.15
15 000	14 962	-0.06	-0.09	-0.09	-0.08	-0.12	-0.09	-0.13	-0.05	-0.16	0.00	-0.01	0.04
16 000	15 849	-0.03	-0.05	-0.06	0.00	-0.09	-0.07	-0.03	-0.09	0.03	0.06	0.56	0.67

Influence of the Optimus case on frequency response – plane perpendicular to the display screen (Vertical) 120° to 230°

Nominal Frequency (Hz)	Exact Frequency (Hz)	Angle from reference direction											
		120°	130°	140°	150°	160°	170°	180°	190°	200°	210°	220°	230°
63	63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
80	79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
100	99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
125	125	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
160	158	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
200	198	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
250	251	-0.04	-0.06	-0.04	-0.04	-0.05	-0.04	-0.04	-0.03	-0.04	-0.03	-0.04	-0.04
315	316	-0.04	-0.07	-0.05	-0.04	-0.06	-0.05	-0.05	-0.03	-0.04	-0.03	-0.04	-0.04
400	398	-0.05	-0.08	-0.06	-0.04	-0.07	-0.05	-0.05	-0.03	-0.05	-0.03	-0.05	-0.05
500	501	-0.06	-0.09	-0.07	-0.05	-0.07	-0.06	-0.05	-0.04	-0.05	-0.04	-0.06	-0.06
630	631	-0.08	-0.11	-0.08	-0.07	-0.07	-0.06	-0.05	-0.05	-0.06	-0.06	-0.08	-0.08
800	794	-0.10	-0.13	-0.12	-0.10	-0.08	-0.08	-0.06	-0.06	-0.08	-0.09	-0.11	-0.09
1 000	1 000	-0.09	-0.16	-0.17	-0.15	-0.11	-0.09	-0.07	-0.08	-0.11	-0.13	-0.15	-0.08
1 060	1 059	-0.07	-0.17	-0.19	-0.16	-0.13	-0.10	-0.07	-0.08	-0.12	-0.14	-0.16	-0.07
1 120	1 122	-0.05	-0.17	-0.20	-0.17	-0.14	-0.10	-0.07	-0.08	-0.13	-0.15	-0.16	-0.06
1 180	1 189	-0.03	-0.18	-0.22	-0.18	-0.15	-0.10	-0.07	-0.09	-0.14	-0.16	-0.17	-0.04
1 250	1 259	-0.01	-0.18	-0.23	-0.19	-0.17	-0.10	-0.07	-0.09	-0.14	-0.17	-0.17	-0.03
1 320	1 334	0.02	-0.17	-0.25	-0.21	-0.18	-0.10	-0.07	-0.09	-0.16	-0.18	-0.18	-0.01
1 400	1 413	0.04	-0.16	-0.26	-0.23	-0.19	-0.10	-0.07	-0.09	-0.17	-0.20	-0.19	0.01
1 500	1 496	0.07	-0.14	-0.28	-0.25	-0.21	-0.11	-0.07	-0.10	-0.19	-0.23	-0.19	0.04
1 600	1 585	0.09	-0.12	-0.30	-0.29	-0.22	-0.11	-0.07	-0.10	-0.21	-0.26	-0.20	0.07
1 700	1 679	0.11	-0.09	-0.32	-0.33	-0.25	-0.12	-0.07	-0.12	-0.24	-0.29	-0.21	0.10
1 800	1 778	0.13	-0.05	-0.34	-0.38	-0.28	-0.13	-0.07	-0.13	-0.28	-0.34	-0.21	0.14
1 900	1 884	0.14	0.00	-0.35	-0.44	-0.32	-0.15	-0.08	-0.15	-0.33	-0.38	-0.20	0.20
2 000	1 995	0.15	0.06	-0.35	-0.50	-0.36	-0.16	-0.09	-0.18	-0.38	-0.43	-0.17	0.26
2 120	2 113	0.13	0.13	-0.31	-0.51	-0.37	-0.16	-0.08	-0.19	-0.41	-0.43	-0.11	0.30
2 240	2 239	0.09	0.19	-0.26	-0.53	-0.38	-0.16	-0.08	-0.19	-0.43	-0.44	-0.04	0.34
2 360	2 371	0.04	0.25	-0.21	-0.54	-0.39	-0.14	-0.06	-0.19	-0.45	-0.44	0.04	0.36
2 500	2 512	-0.03	0.31	-0.16	-0.57	-0.38	-0.13	-0.02	-0.20	-0.48	-0.46	0.12	0.36
2 650	2 661	-0.13	0.36	-0.10	-0.62	-0.38	-0.12	0.02	-0.22	-0.54	-0.50	0.21	0.33
2 800	2 818	-0.25	0.31	0.00	-0.66	-0.43	-0.14	0.03	-0.27	-0.64	-0.50	0.34	0.16
3 000	2 985	-0.30	0.12	0.17	-0.60	-0.56	-0.16	0.00	-0.30	-0.72	-0.33	0.47	-0.10
3 150	3 162	-0.27	-0.04	0.28	-0.50	-0.66	-0.16	-0.02	-0.29	-0.75	-0.14	0.56	-0.25
3 350	3 350	-0.24	-0.16	0.35	-0.41	-0.71	-0.15	-0.02	-0.28	-0.75	0.02	0.61	-0.33
3 550	3 548	-0.20	-0.25	0.39	-0.33	-0.76	-0.14	-0.01	-0.28	-0.75	0.16	0.64	-0.36
3 750	3 758	-0.18	-0.29	0.43	-0.26	-0.78	-0.12	0.01	-0.29	-0.75	0.30	0.64	-0.35
4 000	3 981	-0.17	-0.30	0.45	-0.18	-0.80	-0.10	0.04	-0.30	-0.75	0.44	0.61	-0.30
4 250	4 217	-0.23	-0.27	0.47	-0.10	-0.81	-0.09	0.07	-0.34	-0.75	0.57	0.52	-0.23
4 500	4 467	-0.40	-0.24	0.42	-0.02	-0.88	-0.11	0.08	-0.42	-0.78	0.68	0.34	-0.15
4 750	4 732	-0.67	-0.16	0.30	0.05	-0.98	-0.17	0.06	-0.52	-0.83	0.76	0.07	-0.12
5 000	5 012	-0.87	-0.04	0.12	0.19	-1.08	-0.20	0.10	-0.60	-0.83	0.88	-0.26	-0.17
5 300	5 309	-0.75	0.02	-0.12	0.36	-1.18	-0.23	0.14	-0.67	-0.77	0.98	-0.56	-0.37
5 600	5 623	-0.27	-0.13	-0.36	0.56	-1.26	-0.29	0.16	-0.77	-0.63	1.00	-0.71	-0.71
6 000	5 957	0.16	-0.56	-0.40	0.69	-1.30	-0.32	0.15	-0.88	-0.37	0.91	-0.46	-0.77
6 300	6 310	0.22	-0.90	-0.35	0.69	-1.32	-0.34	0.11	-1.01	-0.11	0.75	-0.17	-0.44
6 700	6 683	0.16	-1.01	-0.22	0.63	-1.33	-0.37	0.13	-1.13	0.15	0.52	0.04	0.07
7 100	7 079	0.24	-0.80	0.02	0.54	-1.27	-0.36	0.20	-1.21	0.43	0.25	0.15	0.53
7 500	7 499	0.40	-0.48	0.19	0.37	-1.22	-0.41	0.22	-1.33	0.67	-0.05	0.05	0.67
8 000	7 943	0.46	-0.23	0.28	0.13	-1.24	-0.54	0.22	-1.50	0.78	-0.31	-0.22	0.46
8 500	8 414	0.32	-0.04	0.28	-0.12	-1.16	-0.66	0.27	-1.73	0.93	-0.51	-0.50	0.19
9 000	8 913	-0.18	-0.03	0.03	-0.37	-0.97	-0.70	0.28	-2.11	1.36	-0.75	-0.90	0.11
9 500	9 441	-0.56	-0.07	-0.38	-0.51	-0.79	-0.69	0.24	-2.21	1.63	-0.44	-0.91	0.41
10 000	10 000	-0.52	0.23	-0.80	-0.50	-0.58	-0.75	0.28	-2.08	1.70	-0.04	-0.47	0.57
10 600	10 593	-0.55	0.82	-1.31	-0.40	-0.30	-0.90	0.30	-2.27	1.85	0.34	-0.03	0.52
11 200	11 220	-0.96	0.90	-1.30	0.30	0.14	-1.25	0.28	-2.61	1.84	0.84	0.63	0.22
11 800	11 885	-0.25	0.00	-0.70	0.68	0.36	-1.65	0.07	-2.90	1.38	0.65	0.58	-0.15
12 500	12 589	0.29	-0.18	-0.77	0.71	0.23	-1.78	-0.09	-2.62	0.82	-0.07	0.26	-0.59
13 200	13 335	0.44	-0.24	-0.77	0.95	0.40	-1.91	0.06	-2.39	0.65	-0.40	0.34	-0.56
14 000	14 125	0.24	-0.68	-0.74	0.76	0.54	-2.18	0.08	-2.44	0.19	-0.92	0.40	-0.26
15 000	14 962	-0.22	-1.04	-0.39	0.24	0.42	-2.39	0.00	-2.32	-0.54	-1.37	0.43	-0.19
16 000	15 849	-0.12	-0.41	0.38	-0.23	0.26	-2.57	-0.04	-1.79	-0.75	-1.08	0.23	-0.13

Influence of the Optimus case on frequency response – plane perpendicular to the display screen (Vertical) 240° to 350°

Nominal Frequency (Hz)	Exact Frequency (Hz)	Angle from reference direction											
		240°	250°	260°	270°	280°	290°	300°	310°	320°	330°	340°	350°
63	63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
80	79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
100	99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
125	125	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
160	158	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
200	198	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
250	251	-0.03	-0.04	-0.03	-0.03	-0.04	-0.03	-0.01	-0.01	-0.01	0.01	0.00	-0.01
315	316	-0.02	-0.03	-0.04	-0.03	-0.04	-0.03	-0.01	-0.01	-0.01	0.01	0.01	-0.01
400	398	-0.02	-0.03	-0.03	-0.03	-0.03	-0.02	-0.01	-0.01	-0.01	0.01	0.01	-0.01
500	501	-0.03	-0.03	-0.03	-0.01	-0.02	-0.02	-0.01	-0.01	-0.01	0.00	0.00	-0.02
630	631	-0.04	-0.03	-0.02	0.00	-0.01	-0.02	-0.01	-0.02	-0.02	-0.01	-0.02	-0.03
800	794	-0.05	-0.01	0.00	0.02	-0.01	-0.04	-0.03	-0.04	-0.04	-0.04	-0.05	-0.05
1 000	1 000	-0.02	0.03	0.01	0.00	-0.04	-0.08	-0.07	-0.07	-0.07	-0.07	-0.07	-0.06
1 060	1 059	0.00	0.04	0.01	-0.02	-0.06	-0.09	-0.08	-0.08	-0.08	-0.07	-0.07	-0.06
1 120	1 122	0.02	0.05	0.00	-0.04	-0.08	-0.11	-0.09	-0.09	-0.08	-0.07	-0.07	-0.06
1 180	1 189	0.04	0.06	-0.02	-0.06	-0.09	-0.12	-0.10	-0.09	-0.08	-0.06	-0.05	-0.05
1 250	1 259	0.06	0.06	-0.04	-0.09	-0.11	-0.13	-0.11	-0.09	-0.08	-0.04	-0.04	-0.03
1 320	1 334	0.08	0.06	-0.06	-0.11	-0.13	-0.14	-0.11	-0.09	-0.06	-0.03	-0.02	-0.01
1 400	1 413	0.10	0.05	-0.08	-0.13	-0.14	-0.15	-0.12	-0.08	-0.05	0.00	0.01	0.01
1 500	1 496	0.11	0.03	-0.11	-0.15	-0.16	-0.16	-0.12	-0.06	-0.02	0.02	0.03	0.04
1 600	1 585	0.13	0.00	-0.14	-0.17	-0.17	-0.17	-0.10	-0.03	0.01	0.05	0.05	0.06
1 700	1 679	0.14	-0.03	-0.18	-0.19	-0.19	-0.17	-0.07	0.01	0.05	0.07	0.06	0.06
1 800	1 778	0.14	-0.08	-0.21	-0.21	-0.21	-0.16	-0.03	0.06	0.07	0.07	0.05	0.05
1 900	1 884	0.14	-0.14	-0.24	-0.24	-0.22	-0.11	0.04	0.10	0.08	0.06	0.02	0.02
2 000	1 995	0.12	-0.21	-0.26	-0.27	-0.22	-0.04	0.10	0.11	0.06	0.01	-0.03	-0.03
2 120	2 113	0.07	-0.25	-0.26	-0.28	-0.16	0.05	0.14	0.08	0.01	-0.05	-0.09	-0.09
2 240	2 239	-0.01	-0.28	-0.27	-0.28	-0.05	0.13	0.13	0.03	-0.05	-0.11	-0.14	-0.13
2 360	2 371	-0.11	-0.29	-0.28	-0.24	0.08	0.17	0.09	-0.03	-0.10	-0.17	-0.18	-0.14
2 500	2 512	-0.24	-0.27	-0.30	-0.14	0.24	0.15	0.03	-0.08	-0.14	-0.21	-0.19	-0.10
2 650	2 661	-0.42	-0.26	-0.35	0.07	0.37	0.07	-0.03	-0.13	-0.15	-0.21	-0.14	0.01
2 800	2 818	-0.55	-0.35	-0.30	0.32	0.30	-0.08	-0.15	-0.17	-0.06	-0.11	-0.05	0.10
3 000	2 985	-0.45	-0.46	-0.07	0.30	0.04	-0.20	-0.26	-0.11	0.04	0.00	-0.01	0.05
3 150	3 162	-0.29	-0.45	0.12	0.14	-0.10	-0.27	-0.22	-0.04	0.04	0.03	-0.01	-0.03
3 350	3 350	-0.19	-0.36	0.22	0.02	-0.17	-0.26	-0.11	-0.01	0.01	0.03	-0.02	-0.07
3 550	3 548	-0.15	-0.21	0.25	-0.05	-0.22	-0.18	-0.02	0.00	-0.02	0.03	-0.01	-0.08
3 750	3 758	-0.16	-0.03	0.23	-0.06	-0.26	-0.06	0.05	0.01	-0.03	0.03	0.00	-0.06
4 000	3 981	-0.23	0.19	0.17	-0.07	-0.27	0.07	0.10	0.01	-0.05	0.02	0.02	-0.01
4 250	4 217	-0.38	0.41	0.10	-0.13	-0.17	0.16	0.12	-0.03	-0.05	0.04	0.06	0.05
4 500	4 467	-0.51	0.52	0.05	-0.29	0.03	0.17	0.06	-0.10	-0.01	0.09	0.11	0.12
4 750	4 732	-0.52	0.38	-0.01	-0.37	0.18	0.13	-0.10	-0.09	0.08	0.14	0.13	0.14
5 000	5 012	-0.19	0.08	-0.20	-0.12	0.20	-0.04	-0.15	0.04	0.15	0.09	0.04	0.06
5 300	5 309	0.32	-0.11	-0.46	0.18	0.18	-0.23	0.00	0.11	0.08	-0.03	-0.07	-0.03
5 600	5 623	0.65	-0.05	-0.33	0.21	0.01	-0.15	0.11	0.02	-0.04	-0.09	-0.07	-0.01
6 000	5 957	0.48	-0.05	0.08	0.15	-0.18	0.03	0.08	-0.08	-0.03	0.02	0.02	0.04
6 300	6 310	0.13	-0.31	0.15	0.09	-0.14	0.10	0.01	-0.07	0.06	0.06	0.05	0.04
6 700	6 683	-0.03	-0.47	0.10	-0.07	-0.05	0.08	-0.07	0.01	0.06	0.07	0.04	0.02
7 100	7 079	0.11	-0.27	0.20	-0.18	0.06	0.02	-0.02	0.05	0.08	0.06	0.02	0.00
7 500	7 499	0.23	-0.04	0.18	-0.19	0.12	-0.09	0.05	0.03	0.05	0.04	0.05	0.08
8 000	7 943	0.05	-0.04	-0.04	-0.11	0.04	-0.04	0.01	-0.03	0.01	0.05	0.08	0.08
8 500	8 414	-0.31	-0.02	-0.20	0.03	-0.08	0.02	-0.02	-0.04	0.01	0.07	0.00	-0.04
9 000	8 913	-0.54	0.27	-0.23	0.15	-0.08	0.03	0.04	-0.03	0.16	0.04	0.00	0.08
9 500	9 441	-0.29	0.29	0.02	0.10	0.11	0.10	0.05	0.16	0.11	0.15	0.21	0.18
10 000	10 000	-0.09	0.24	0.25	0.01	0.17	0.18	0.16	0.15	0.22	0.29	0.16	0.10
10 600	10 593	0.12	0.03	0.45	0.13	0.23	0.17	0.31	0.14	0.36	0.17	0.19	0.22
11 200	11 220	0.43	-0.09	0.24	0.30	0.17	0.17	0.19	0.28	0.19	0.28	0.17	0.08
11 800	11 885	0.27	0.05	0.02	0.17	0.18	0.20	0.18	0.11	0.32	0.12	0.14	0.16
12 500	12 589	0.30	-0.05	-0.13	-0.17	-0.13	-0.12	0.01	0.03	0.02	0.08	0.00	-0.03
13 200	13 335	0.08	0.05	-0.11	-0.04	-0.01	0.00	-0.04	0.02	0.19	0.12	0.13	0.08
14 000	14 125	-0.43	-0.13	-0.14	-0.27	-0.11	-0.02	0.05	0.01	0.09	0.14	0.09	0.09
15 000	14 962	-0.37	-0.57	-0.34	-0.40	-0.39	-0.22	-0.14	-0.11	0.05	0.03	0.04	0.01
16 000	15 849	-0.75	-0.58	-0.36	-0.23	-0.19	-0.06	-0.16	-0.13	-0.01	0.02	0.01	0.00

Influence of the UA:237 windshield on frequency response
0° to 110°

Nominal Frequency (Hz)	Exact Frequency (Hz)	Angle from reference direction											
		0°	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°	110°
63	63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
80	79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
100	99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
125	125	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
160	158	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
200	198	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
250	251	0.03	0.04	0.07	0.07	0.02	0.01	0.04	0.04	-0.02	-0.01	-0.04	0.04
315	316	0.04	0.05	0.09	0.09	0.04	0.01	0.05	0.04	0.01	-0.01	-0.03	0.07
400	398	0.06	0.06	0.09	0.10	0.06	0.02	0.06	0.05	0.03	-0.01	-0.02	0.09
500	501	0.07	0.08	0.10	0.10	0.07	0.03	0.06	0.05	0.05	0.01	0.01	0.11
630	631	0.09	0.10	0.11	0.11	0.10	0.06	0.08	0.06	0.08	0.04	0.04	0.12
800	794	0.14	0.15	0.14	0.14	0.13	0.12	0.12	0.10	0.11	0.09	0.10	0.14
1 000	1 000	0.22	0.23	0.23	0.22	0.21	0.20	0.19	0.17	0.17	0.16	0.16	0.20
1 060	1 059	0.25	0.26	0.26	0.25	0.23	0.22	0.22	0.19	0.19	0.18	0.17	0.22
1 120	1 122	0.28	0.29	0.29	0.27	0.25	0.24	0.24	0.22	0.21	0.20	0.19	0.24
1 180	1 189	0.31	0.32	0.32	0.30	0.28	0.27	0.27	0.24	0.23	0.22	0.20	0.26
1 250	1 259	0.34	0.34	0.35	0.34	0.30	0.30	0.29	0.27	0.26	0.25	0.22	0.27
1 320	1 334	0.37	0.37	0.38	0.37	0.33	0.32	0.32	0.29	0.28	0.27	0.25	0.29
1 400	1 413	0.40	0.40	0.41	0.40	0.35	0.36	0.35	0.33	0.31	0.30	0.27	0.31
1 500	1 496	0.42	0.43	0.44	0.43	0.38	0.39	0.38	0.36	0.34	0.34	0.31	0.34
1 600	1 585	0.46	0.46	0.46	0.46	0.41	0.43	0.42	0.39	0.37	0.38	0.35	0.37
1 700	1 679	0.49	0.50	0.49	0.49	0.45	0.47	0.46	0.44	0.41	0.42	0.39	0.41
1 800	1 778	0.52	0.53	0.53	0.52	0.49	0.50	0.50	0.48	0.46	0.47	0.44	0.45
1 900	1 884	0.56	0.57	0.56	0.55	0.52	0.54	0.54	0.53	0.51	0.51	0.49	0.50
2 000	1 995	0.59	0.60	0.59	0.59	0.56	0.57	0.58	0.57	0.55	0.56	0.54	0.55
2 120	2 113	0.62	0.63	0.62	0.61	0.59	0.60	0.61	0.61	0.60	0.61	0.59	0.59
2 240	2 239	0.64	0.65	0.63	0.62	0.61	0.62	0.63	0.63	0.64	0.65	0.64	0.64
2 360	2 371	0.64	0.66	0.63	0.63	0.62	0.64	0.64	0.64	0.67	0.70	0.68	0.68
2 500	2 512	0.64	0.66	0.61	0.61	0.63	0.66	0.64	0.63	0.70	0.75	0.74	0.72
2 650	2 661	0.58	0.62	0.53	0.53	0.59	0.68	0.62	0.60	0.71	0.81	0.79	0.74
2 800	2 818	0.41	0.45	0.35	0.35	0.43	0.59	0.50	0.48	0.61	0.75	0.75	0.68
3 000	2 985	0.19	0.22	0.18	0.19	0.23	0.35	0.31	0.31	0.41	0.53	0.55	0.55
3 150	3 162	0.09	0.10	0.11	0.13	0.12	0.17	0.21	0.21	0.28	0.35	0.40	0.47
3 350	3 350	0.05	0.05	0.09	0.11	0.07	0.06	0.14	0.16	0.20	0.23	0.31	0.43
3 550	3 548	0.06	0.05	0.09	0.11	0.05	0.00	0.10	0.12	0.15	0.14	0.24	0.39
3 750	3 758	0.09	0.08	0.11	0.12	0.04	-0.04	0.06	0.08	0.10	0.06	0.19	0.35
4 000	3 981	0.13	0.12	0.14	0.14	0.05	-0.05	0.02	0.04	0.06	-0.01	0.13	0.28
4 250	4 217	0.18	0.18	0.17	0.16	0.06	-0.03	-0.02	0.00	0.01	-0.09	0.04	0.16
4 500	4 467	0.25	0.24	0.23	0.21	0.11	0.03	-0.04	-0.04	-0.02	-0.17	-0.07	0.01
4 750	4 732	0.29	0.29	0.27	0.25	0.17	0.13	-0.01	-0.08	-0.05	-0.20	-0.19	-0.16
5 000	5 012	0.31	0.31	0.28	0.26	0.19	0.21	0.08	-0.10	-0.09	-0.19	-0.32	-0.35
5 300	5 309	0.33	0.33	0.29	0.25	0.17	0.20	0.14	-0.06	-0.17	-0.16	-0.42	-0.52
5 600	5 623	0.19	0.20	0.17	0.17	0.09	0.09	0.06	-0.02	-0.29	-0.20	-0.50	-0.72
6 000	5 957	0.01	0.02	0.02	0.04	0.01	0.04	-0.03	-0.01	-0.20	-0.26	-0.45	-0.69
6 300	6 310	-0.01	-0.01	-0.01	0.00	-0.02	0.04	0.00	0.00	-0.03	-0.21	-0.30	-0.51
6 700	6 683	0.01	0.01	-0.01	-0.03	-0.08	-0.03	-0.02	-0.05	0.06	-0.17	-0.21	-0.36
7 100	7 079	0.03	0.03	-0.01	-0.05	-0.15	-0.13	-0.12	-0.15	-0.01	-0.21	-0.22	-0.29
7 500	7 499	0.06	0.06	0.03	-0.01	-0.16	-0.19	-0.23	-0.27	-0.17	-0.29	-0.30	-0.27
8 000	7 943	0.04	0.04	0.03	0.03	-0.11	-0.18	-0.29	-0.36	-0.37	-0.37	-0.42	-0.36
8 500	8 414	0.07	0.07	0.03	0.00	-0.10	-0.15	-0.31	-0.42	-0.55	-0.49	-0.59	-0.58
9 000	8 913	-0.01	0.02	0.01	0.00	-0.12	-0.10	-0.28	-0.42	-0.59	-0.64	-0.86	-0.87
9 500	9 441	-0.19	-0.16	-0.14	-0.08	-0.16	-0.15	-0.20	-0.38	-0.45	-0.79	-1.03	-1.02
10 000	10 000	-0.08	-0.07	-0.15	-0.21	-0.28	-0.25	-0.23	-0.34	-0.40	-0.85	-1.00	-1.10
10 600	10 593	-0.10	-0.07	-0.12	-0.16	-0.34	-0.27	-0.34	-0.31	-0.42	-0.64	-0.82	-1.13
11 200	11 220	-0.22	-0.22	-0.29	-0.30	-0.44	-0.54	-0.57	-0.62	-0.64	-0.59	-0.94	-1.19
11 800	11 885	-0.23	-0.23	-0.29	-0.29	-0.39	-0.41	-0.60	-0.76	-0.76	-0.80	-0.92	-1.00
12 500	12 589	-0.71	-0.70	-0.73	-0.70	-0.79	-0.76	-0.90	-1.07	-1.27	-1.48	-1.51	-1.54
13 200	13 335	-0.64	-0.63	-0.70	-0.71	-0.85	-0.78	-0.83	-0.98	-1.22	-1.45	-1.68	-1.71
14 000	14 125	-0.73	-0.69	-0.71	-0.73	-0.97	-0.95	-1.01	-1.06	-1.21	-1.35	-1.81	-1.96
15 000	14 962	-0.79	-0.76	-0.81	-0.81	-1.00	-1.07	-1.18	-1.22	-1.29	-1.44	-1.87	-2.18
16 000	15 849	-0.90	-0.88	-0.88	-0.85	-1.07	-1.09	-1.21	-1.37	-1.53	-1.62	-1.88	-2.09

Influence of the UA:237 windshield on frequency response

120° to 180°

Note: the UA:237 is spherically symmetrical, angles 350°-190° are respectively equivalent to angles 10°-170°.

Nominal Frequency (Hz)	Exact Frequency (Hz)	Angle from reference direction						
		120°	130°	140°	150°	160°	170°	180°
63	63	0.00	0.00	0.00	0.00	0.00	0.00	0.00
80	79	0.00	0.00	0.00	0.00	0.00	0.00	0.00
100	99	0.00	0.00	0.00	0.00	0.00	0.00	0.00
125	125	0.00	0.00	0.00	0.00	0.00	0.00	0.00
160	158	0.00	0.00	0.00	0.00	0.00	0.00	0.00
200	198	0.00	0.00	0.00	0.00	0.00	0.00	0.00
250	251	-0.02	0.05	0.00	0.03	0.06	-0.02	-0.06
315	316	-0.01	0.07	0.01	0.03	0.09	-0.01	-0.07
400	398	0.00	0.08	0.02	0.03	0.10	0.00	-0.06
500	501	0.02	0.08	0.03	0.03	0.10	0.01	-0.04
630	631	0.04	0.08	0.05	0.04	0.08	0.03	0.00
800	794	0.08	0.09	0.08	0.08	0.08	0.06	0.06
1 000	1 000	0.14	0.15	0.14	0.13	0.14	0.11	0.11
1 060	1 059	0.16	0.17	0.16	0.15	0.17	0.13	0.12
1 120	1 122	0.18	0.20	0.18	0.17	0.20	0.15	0.12
1 180	1 189	0.20	0.22	0.20	0.19	0.23	0.17	0.13
1 250	1 259	0.22	0.24	0.22	0.21	0.25	0.19	0.15
1 320	1 334	0.25	0.27	0.25	0.23	0.28	0.20	0.16
1 400	1 413	0.27	0.29	0.27	0.26	0.30	0.22	0.18
1 500	1 496	0.30	0.32	0.29	0.29	0.32	0.25	0.21
1 600	1 585	0.33	0.35	0.32	0.32	0.34	0.28	0.24
1 700	1 679	0.37	0.39	0.36	0.36	0.37	0.31	0.27
1 800	1 778	0.42	0.43	0.40	0.40	0.40	0.35	0.31
1 900	1 884	0.47	0.47	0.45	0.45	0.45	0.39	0.36
2 000	1 995	0.51	0.52	0.50	0.50	0.49	0.43	0.40
2 120	2 113	0.56	0.57	0.54	0.55	0.54	0.48	0.44
2 240	2 239	0.61	0.61	0.59	0.59	0.57	0.52	0.49
2 360	2 371	0.66	0.64	0.64	0.63	0.60	0.56	0.54
2 500	2 512	0.72	0.66	0.69	0.67	0.60	0.61	0.61
2 650	2 661	0.77	0.66	0.75	0.69	0.58	0.67	0.71
2 800	2 818	0.75	0.62	0.75	0.69	0.54	0.68	0.77
3 000	2 985	0.61	0.56	0.64	0.65	0.57	0.62	0.64
3 150	3 162	0.49	0.54	0.54	0.61	0.62	0.55	0.49
3 350	3 350	0.42	0.52	0.48	0.57	0.65	0.51	0.40
3 550	3 548	0.36	0.49	0.43	0.54	0.66	0.47	0.34
3 750	3 758	0.31	0.45	0.39	0.49	0.64	0.44	0.30
4 000	3 981	0.24	0.37	0.34	0.43	0.57	0.39	0.27
4 250	4 217	0.13	0.25	0.25	0.34	0.45	0.31	0.22
4 500	4 467	-0.01	0.08	0.12	0.21	0.29	0.19	0.13
4 750	4 732	-0.18	-0.12	-0.06	0.04	0.07	0.02	0.00
5 000	5 012	-0.38	-0.38	-0.31	-0.21	-0.22	-0.22	-0.22
5 300	5 309	-0.56	-0.65	-0.59	-0.50	-0.55	-0.52	-0.50
5 600	5 623	-0.76	-0.94	-0.93	-0.85	-0.96	-0.89	-0.86
6 000	5 957	-0.79	-1.00	-1.07	-1.08	-1.13	-1.11	-1.13
6 300	6 310	-0.66	-0.87	-0.99	-1.08	-1.10	-1.10	-1.16
6 700	6 683	-0.53	-0.70	-0.86	-0.98	-1.01	-1.03	-1.10
7 100	7 079	-0.45	-0.57	-0.72	-0.84	-0.89	-0.91	-0.98
7 500	7 499	-0.40	-0.47	-0.58	-0.70	-0.71	-0.74	-0.80
8 000	7 943	-0.43	-0.44	-0.50	-0.59	-0.60	-0.55	-0.61
8 500	8 414	-0.57	-0.55	-0.57	-0.60	-0.60	-0.47	-0.53
9 000	8 913	-0.88	-0.81	-0.81	-0.76	-0.70	-0.53	-0.64
9 500	9 441	-1.19	-1.08	-1.13	-1.02	-0.93	-0.81	-0.90
10 000	10 000	-1.40	-1.31	-1.45	-1.39	-1.29	-1.24	-1.32
10 600	10 593	-1.37	-1.44	-1.66	-1.69	-1.65	-1.60	-1.68
11 200	11 220	-1.29	-1.57	-1.84	-2.00	-2.00	-2.00	-2.09
11 800	11 885	-1.07	-1.46	-1.59	-1.81	-1.83	-1.73	-1.86
12 500	12 589	-1.50	-1.73	-1.82	-1.80	-1.71	-1.65	-1.74
13 200	13 335	-1.71	-1.86	-1.85	-1.75	-1.59	-1.52	-1.59
14 000	14 125	-2.16	-2.35	-2.19	-2.14	-2.01	-1.92	-2.00
15 000	14 962	-2.54	-2.72	-2.64	-2.76	-2.83	-2.70	-2.88
16 000	15 849	-2.36	-2.48	-2.82	-3.03	-3.05	-3.05	-3.41

Appendix 2 – Instructions for legal applications

Only calibrated instruments should be used when measurements are made for legal purposes. The Optimus sound level meter has been designed according to the IEC 61672-1 standard and can therefore be approved.

Information for performing electrical tests

The Cirrus Research dummy microphone type KP:66 is recommended. The KP:66 has a capacitance 18 pF and an input sensitivity is nominally 50 mV/Pa (see section 5.1.15 – page 7). The maximum input voltage at the input to the dummy microphone is 30 $V_{pk\text{-}pk}$ (see section 5.1.17 – page 7).

	L_A (dB)	L_C (dB)	L_Z (dB)	$L_{Aeq,T}$ (dB)	L_{AE} (dB) (t_{int} = 30 s)	L_{Cpeak} (dB)
31.5 Hz	from 24 to 99 start 94	from 30 to 136 start 94	from 45 to 139 start 94	from 24 to 99 start 94	from 39 to 114 start 109	
1 kHz	from 24 to 139 start 94	from 30 to 139 start 94	from 45 to 139 start 94	from 24 to 139 start 94	from 39 to 154 start 109	from 50 to 142
12.5 kHz	from 24 to 134 start 94	from 30 to 133 start 94	from 45 to 138 start 94	from 24 to 134 start 94	from 39 to 149 start 109	

Appendix 3 – Octave and third-octave band filters

This appendix contains information about the octave and third-octave band filters required by the IEC 61260:1995 standard. The following table lists the required information.

Statement of conformity	All the available filters comply with all the performance requirements of IEC 61260:1995 for the instrument's performance class.
Design method	Butterworth for the 12.5 kHz, 16 kHz and 20 kHz third-octave-band filters and the 16 kHz octave-band filter Elliptic for the other octave and third-octave-bands filters
Sampling frequency	96 kHz
Mid-band frequencies	See table page 36
Frequency ratio	G = 2
Reference level range	N/A (the optimus sound level meters have a single measurement range)
Reference input signal level	1 µV
Reference attenuation	0 dB
Linear range	See tables page 37
Recommendation to operate the instrument within the linear range	N/A (the optimus sound level meters have a single measurement range)
Real-time operation frequency range	Octave-band filters: 31.5 Hz to 16 kHz Third-octave band filters: 6.3 Hz to 20 kHz
Flat frequency response	6.3 Hz to 20 kHz
Maximum input signal	10.6 V_{rms}
Terminating impedance	N/A
Temperature	Operating: -10 to +50 °C Storage: -20 to +60 °C No permanent damage to the instrument when kept within those temperature ranges.
Limitations on operation in proximity to sources of alternating magnetic fields	None (see section 9.3o – A.C. power-frequency and radio-frequency susceptibility – page 21) The optimus electromagnetic performances comply with IEC 61672-1:2013
Limitation on operation in proximity to sources of electrostatic discharge	None (see section 6.5.2 Electrostatic discharge – page 10)
Limitation on operation in proximity to sources of radio-frequency electromagnetic fields	None (see section 9.3o – A.C. power-frequency and radio-frequency susceptibility – page 21) The optimus electromagnetic performances comply with IEC 61672-1:2013
Battery indicator	See "User manual for the optimus sound level meters", page 21
Model of associated sound level meter	N/A (the filters are an integral part of the optimus sound level meters)
Stabilization time	See section 9.3l – Typical stabilization time after changes in environmental conditions – page 21

Mid-band frequencies

Nominal mid-band frequency (Hz)	Exact mid-band frequency (Hz)	Octave	Third-octave
6.3	6.2008		•
8	7.8125		•
10	9.8431		•
12.5	12.402		•
16	15.625		•
20	19.686		•
25	24.803		•
31.5	31.250	•	•
40	39.373		•
50	49.606		•
63	62.500	•	•
80	78.745		•
100	99.213		•
125	125.000	•	•
160	157.490		•
200	198.43		•
250	250.00	•	•
315	314.98		•
400	396.85		•
500	500.00	•	•
630	629.96		•
800	793.70		•
1 000	1 000.0	•	•
1 250	1 259.9		•
1 600	1 587.4		•
2 000	2 000.0	•	•
2 500	2 519.8		•
3 150	3 174.8		•
4 000	4 000.0	•	•
5 000	5 039.7		•
6 300	6 349.6		•
8 000	8 000.0	•	•
10 000	10 079		•
12 500	12 699		•
16 000	16 000	•	•
20 000	20 159		•

Linear operating range

Octave band filters

Nominal mid-band frequency (Hz)	Range (dB)
31.5	25 – 139
63	23 – 139
125	21 – 139
250	18 – 139
500	18 – 139
1 000	20 – 139
2 000	22 – 139
4 000	25 – 139
8 000	28 – 139
16 000	33 – 139

Third-octave band filters

Nominal mid-band frequency (Hz)	Range (dB)	Nominal mid-band frequency (Hz)	Range (dB)
6.3	28 – 139	400	16 – 139
8	28 – 139	500	16 – 139
10	28 – 139	630	16 – 139
12.5	25 – 139	800	16 – 139
16	25 – 139	1 000	16 – 139
20	25 – 139	1 250	16 – 139
25	22 – 139	1 600	16 – 139
31.5	22 – 139	2 000	16 – 139
40	22 – 139	2 500	17 – 139
50	19 – 139	3 150	19 – 139
63	19 – 139	4 000	20 – 139
80	19 – 139	5 000	21 – 139
100	16 – 139	6 300	23 – 139
125	16 – 139	8 000	24 – 139
160	16 – 139	10 000	25 – 139
200	16 – 139	12 500	27 – 139
250	16 – 139	16 000	29 – 139
315	16 – 139	20 000	32 – 139

Note that the upper limits on the linearity range are affected by the calibration offset. Optimus instruments are factory-adjusted to a zero calibration offset and will have the upper limits shown above. If a different microphone capsule is fitted or the microphone sensitivity changes, resulting in a negative calibration offset, the upper limits will be reduced by the value of the offset. For example: a calibration offset of -2.0 dB will result in an upper limit of 137 dB at 1 kHz.

Self-generated noise

Octave band filters

Nominal mid-band frequency (Hz)	Self-generated noise level (dB)
31.5	<17
63	<16
125	<13
250	<11
500	<11
1 000	<14
2 000	<15
4 000	<18
8 000	<22
16 000	<28

Third-octave band filters

Nominal mid-band frequency (Hz)	Self-generated noise level (dB)	Nominal mid-band frequency (Hz)	Self-generated noise level (dB)
6.3	<17	400	<12
8	<16	500	<12
10	<15	630	<12
12.5	<14	800	<12
16	<14	1 000	<12
20	<13	1 250	<12
25	<13	1 600	<12
31.5	<12	2 000	<12
40	<12	2 500	<12
50	<12	3 150	<12
63	<12	4 000	<13
80	<12	5 000	<15
100	<12	6 300	<16
125	<12	8 000	<17
160	<12	10 000	<18
200	<12	12 500	<20
250	<12	16 000	<23
315	<12	20 000	<26

Cirrus Research offices

The addresses given below are the Cirrus Research plc offices. Cirrus Research plc also have approved distributors and agents is many countries worldwide. For details of your local representative, please contact Cirrus Research plc at the address below. Contact details for Cirrus Research authorised distributors and agents are also available from the Internet Web site at the address shown below.

Main Office

Cirrus Research plc
Acoustic House
Bridlington Road
Hunmanby
North Yorkshire
United Kingdom
YO14 0PH

Telephone: +44 (0)1723 891655
Fax: +44 (0)1723 891742
E-mail: sales@cirrusresearch.co.uk
Web Site: www.cirrusresearch.co.uk

Germany

Cirrus Research plc Deutschland
Arabella Center
Lyoner Strasse 44 – 48
D-60528 Frankfurt
Germany

Telefon: +49 (0) 69 95932047
Fax: +49 (0) 69 95932049
E-Mail: vertrieb@cirrusresearch.de
Website: www.cirrusresearch.de

France

Email: sales@cirrusresearch.fr
Web: www.cirrusresearch.fr

Cirrus Environmental

Unit 2 Bridlington Road Industrial Estate
Hunmanby
North Yorkshire
YO14 0PH
United Kingdom

Tel: +44 (0) 1723 891722
Email: sales@cirrus-environmental.com
Web: www.cirrus-environmental.com