# SAS – Smart Acoustic Sensor

## User Manual

SASK-00001, SASK-00002, SASK-00003
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# 1 Introduction

Congratulations for purchasing the SAS Smart Acoustic Sensor. The SAS smart acoustic sensor is a Precise, Rugged and Versatile Embedded Sound Level Meter.

Easy Field Deployment:

- Single sensor for Sound Level Meter (SLM) and Blast Overpressure (OPL)
- Seamless dynamic range automatic switching;
- Automatic Sensor Check with GRAS Syscheck2;
- Frequency compensation sound incidence and windscreen effect;
- Frequency compensation individually calibrated for each microphone;
- Rugged and Compact Form-Factor;
- Digital communication avoiding electrical interferences;
- Up-To 100m cable length.
- Embedded calibration certificate
- Embedded field-calibration record
- All-weather protection.

Sound Level Meter (SLM):

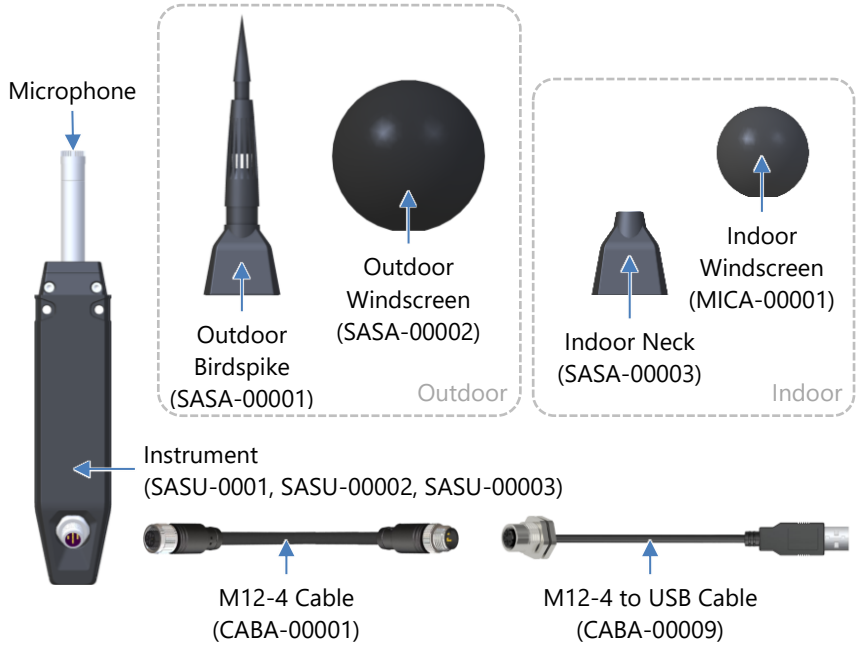
- Complies to IEC 61672/ANSI S1.4 Class 1
- 48kHz, 24-bit signal processing
- 117 dB total dynamic range
- Comprehensive data set
- Leq, Lmax, Lmin, Lpeak, and SEL in A, C, Z, and G weightings
- 10 Percentiles (LN%) for selected weighting (A, C, Z, or G)
- LAFtm5 (TaktMaximal) for impulsive content
- 1/3 Octave (6.3Hz to 20kHz)
- FFT spectrum (512 lines)
- Simultaneous recording of data and time signal
- Time signal with adaptative dynamic compression
- Infrasound 1/3 octave and G weighting for windfarm noise monitoring

Overpressure Level Meter (OPL):

- Complies to ISEE and AS 2187.2
- 1.5kHz, 24-bit signal processing
- Simultaneous recording of data and time signal
- Time signal with adaptative dynamic compression

# 2 Installation

## 2.1 Components

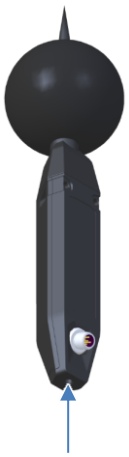



- Instrument (SASU-00001, SASU-00002, SASU-00003)
  - SASU-00001: Instrument with 378B02 microphone from PCB Piezotronics
  - SASU-00002: Instrument with 246AE microphone from GRAS with Syscheck2™
  - SASU-00003: Instrument with 378A06 microphone from PCB Piezotronics
  - The microphone is captive to the instrument body to protect the microphone analogue connection from environmental ingress.
  - The M12-4 connector is used to power and communicate with the instrument.
- The outdoor bidrspike (SASA-00001) and outdoor windscreen (SASA-00002) are required for outdoor use.
- The indoor neck (SASA-00003) and indoor windscreen (MICA-00001) are recommended for indoor use.
- The M12-4 cable (10m) (CABA-00001) and M12-4 to USB cable (CABA-00009) are used to connect the SAS to a computer or monitoring station.

## 2.2 Mounting

### 2.2.1 Tripod

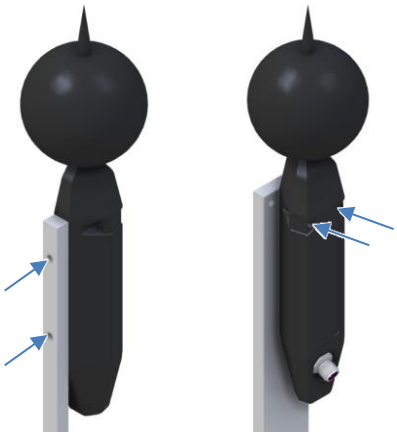
A ¼-20 mounting hole is present under the SAS to mount it on a standard tripod head. The tripod head should have a minimal apparent surface to minimize acoustical reflections that may affect the acoustical performance of the SAS.



### 2.2.2 Alternate mounting points

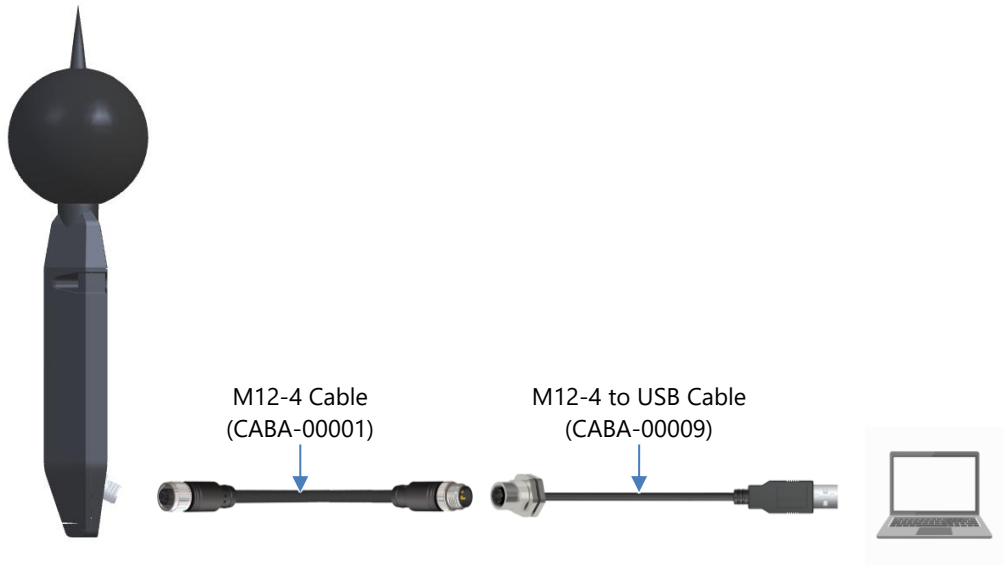
Alternate mounting points are available to secure the SAS on the side of a stick. Two ¼-20 mounting holes are present on the back and two 4.8mm ID (3/16") through holes are present on the front.

These mounting options are offered for convenience but are not recommended as they may affect the acoustical performance of the SAS.



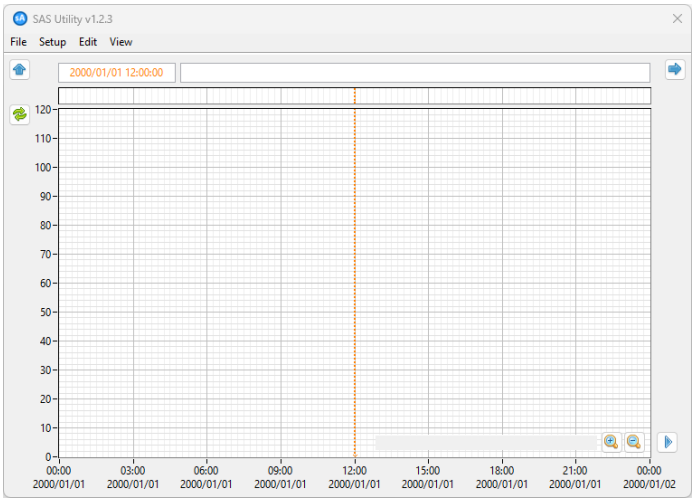
## 2.3 Connection

Connect the SAS to the computer using a M12-4 cable (CABA-00001) and a M12-4 to USB adapter cable (CABA-00009).




## 2.4 Utility Software

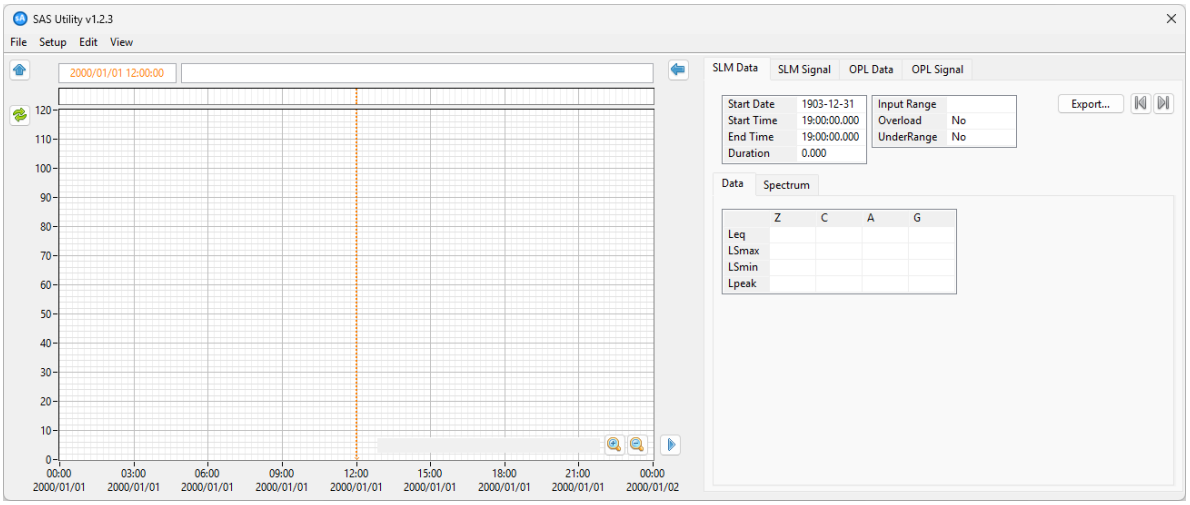
The SAS Utility software allows using the SAS on a computer.



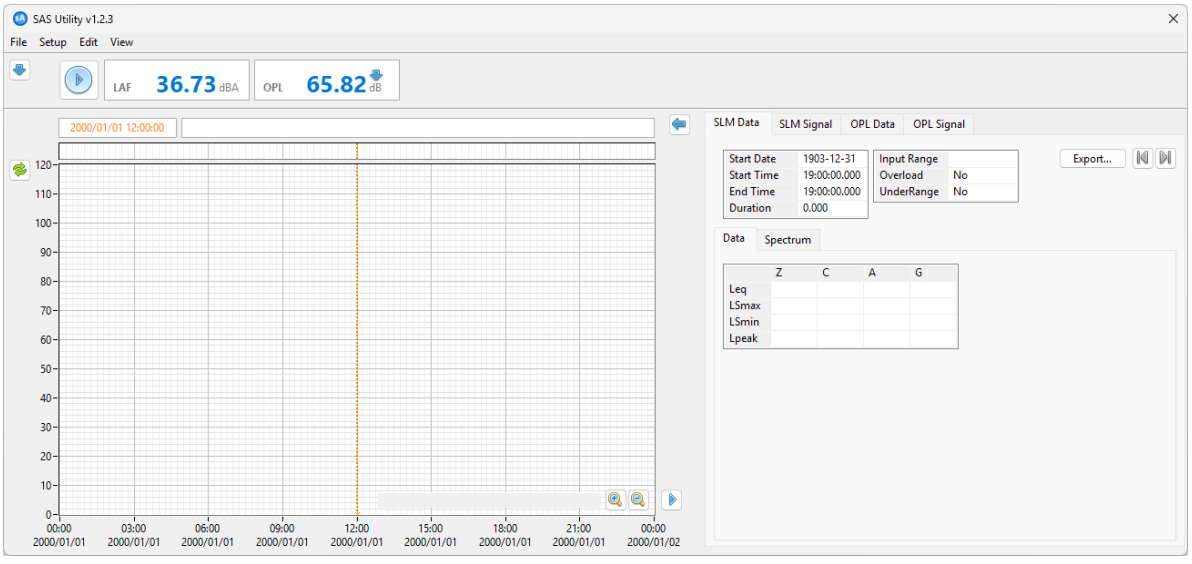

The version of the software is indicated on the window title bar.

The main interface shows a time history graph displaying data acquired by the SAS.

Selecting “Details Pane” from the “View” menu displays the details associated with the time history graph cursor time or the details of the current data acquired by the SAS.

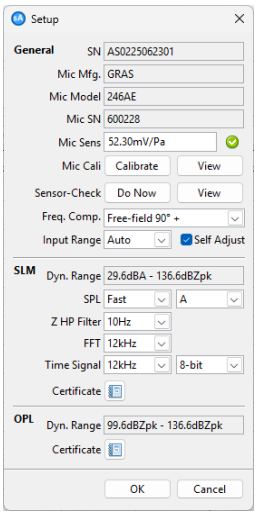



Selecting “Instrument Pane” from the “View” menu displays the live status of the SAS.



# 3 Instrument Setup

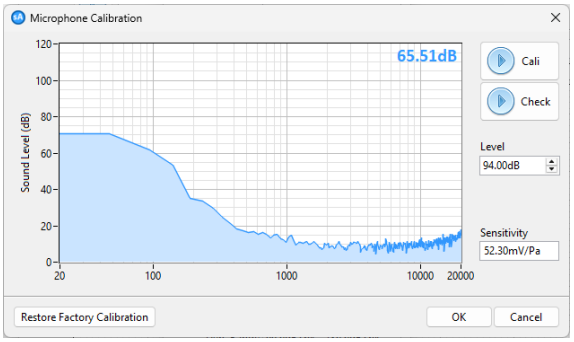
Using the SAS Utility software. Click on “Instrument Setup” from the “Setup” menu.



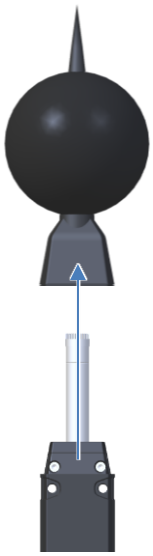

## 3.1 General

### 3.1.1 Microphone Calibration

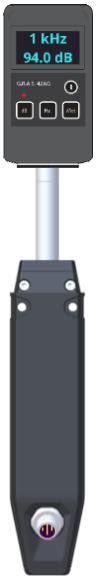
1) Click on the “Calibrate” button from the “Setup” interface to access the calibration interface.




2) Remove the birdspike and windscreen assembly to expose the microphone.

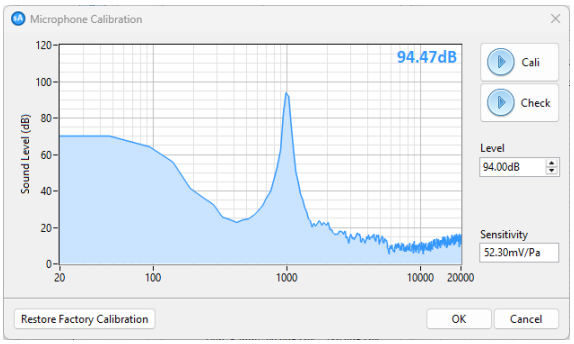


3) Insert the microphone inside the calibration chamber of the calibrator.




The recommended calibrator for the SAS is model 42AG from GRAS.

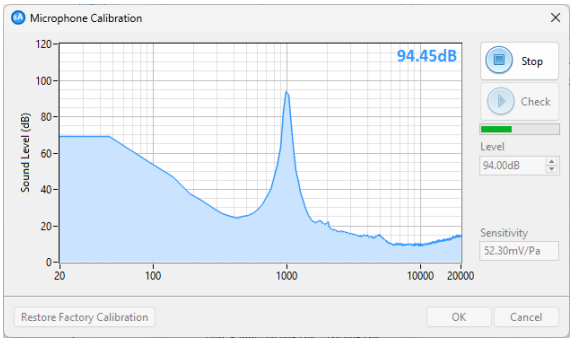
4) Activate the calibrator reference signal.



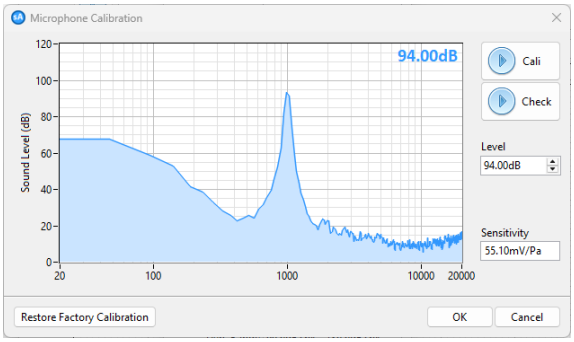

5) Make sure that the spectrum graph shows the tone of the reference signal.
6) Enter the reference signal in the "Level" numeric control.

The reference level should not include any pressure/free-field corrections as the SAS automatically selects the "Pressure" frequency compensation upon entering the calibration interface.

7) Click on the "Cali" button to initiate the calibration.




8) Wait for the calibration to complete. A progress bar indicates the averaging progress.




9) Click "OK" to accept the calibration or "Cancel" to revert to the initial sensitivity.

Once accepted, the SAS replaces the initial sensitivity value with the calibrated sensitivity.

The SAS also records the "Microphone Check" information for traceability purposes.

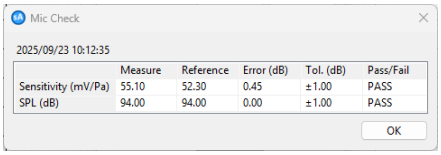
## Microphone Check

A microphone check is similar to a field calibration, but the sensitivity is not modified by the process. To perform a microphone check, follow the same procedure as described in 3.1.1 Microphone Calibration, but click on the "Check" button on step 7).

Note that the microphone check information is stored in non-volatile memory.

## Viewing the last microphone check

Click on the "View" button next to "Mic Cali" from the Setup interface to view the last microphone check.




- Date and time when the last microphone check was performed;
- Sensitivity:
  - Measure: Sensitivity used during the microphone check in mV/Pa.
  - Reference: Factory default sensitivity (as used on the certificate) in mV/Pa.
  - Error: Difference in dB between the measure and reference sensitivities.
  - Tolerance: Tolerance in dB for conformity.
  - Pass/Fail: Conformity statement.
- SPL:
  - Measure: Measured level during the microphone check in dB.
  - Reference: Calibrator reference signal level in dB.
  - Error: Difference in dB between the measure and reference levels.
  - Tolerance: Tolerance in dB for conformity.
  - Pass/Fail: Conformity statement.

When a Microphone Calibration is performed, the measure sensitivity is the adjusted sensitivity. The measure level and reference level are identical in this case since the sensitivity is adjusted for the measure level to match the reference level.

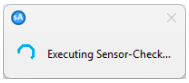
When a Microphone Check is performed, the measure sensitivity is the sensitivity used during the microphone check. Therefore, the measure level and reference level may not be identical.

### 3.1.2 Sensor-Check

The sensor-check feature implements the SysCheck2™ feature present on the 246AE microphone from GRAS, only available on the SASK-00002 model.

SysCheck2™ is a GRAS-patented technology for verifying measurement chain integrity. This verification tool enables a remote health check on microphone integrity. SysCheck2 can detect microphone sensitivity or channel gain changes greater than 0.3 dB. Additionally, SysCheck2 acquires data on local environmental conditions, including temperature, pressure and humidity for environmental compensation.

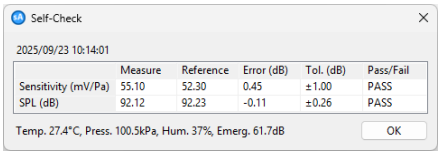
Click on the "Do Now" button next to "Sensor-Check" in the Setup interface.




The sensor-check takes about 30s to complete.

Viewing the last Sensor-check

Click on the "View" button next to "Sensor-Check" in the Setup Interface.




- Date and time when the last sensor check was performed;
- Environmental conditions prevailing when the last sensor check was performed.
- Sensitivity:
  - Measure: Sensitivity used during the sensor check in mV/Pa.
  - Reference: Factory default sensitivity (as used on the certificate) in mV/Pa.
  - Error: Difference in dB between the measure and reference sensitivities.
  - Tolerance: Tolerance in dB for conformity.
  - Pass/Fail: Conformity statement.
- SPL:
  - Measure: Measured level during the sensor-check in dB.
  - Reference: Sensor-check reference signal level in dB.
  - Error: Difference in dB between the measure and reference levels.
  - Tolerance: Tolerance in dB for conformity.
  - Pass/Fail: Conformity statement.

Executing a sensor-check is not equivalent as a microphone calibration using an acoustical calibrator and should not be considered as such.

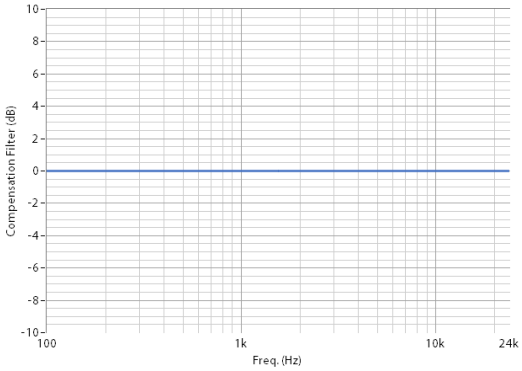
A sensor check is recommended for automated periodic (daily) check of the microphone chain during long unattended measurements.

### 3.1.3 Frequency Compensation

Click on the "Freq. Comp." drop-down menu from the Setup interface to select the appropriate frequency compensation for the measurement application.

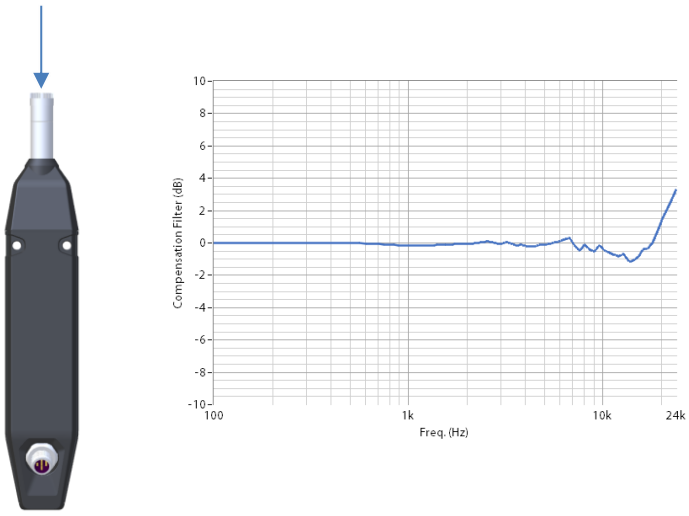
None

This selection uses no frequency compensation. It should be used only for the electrical tests from the certification procedure.




Free-field 0°

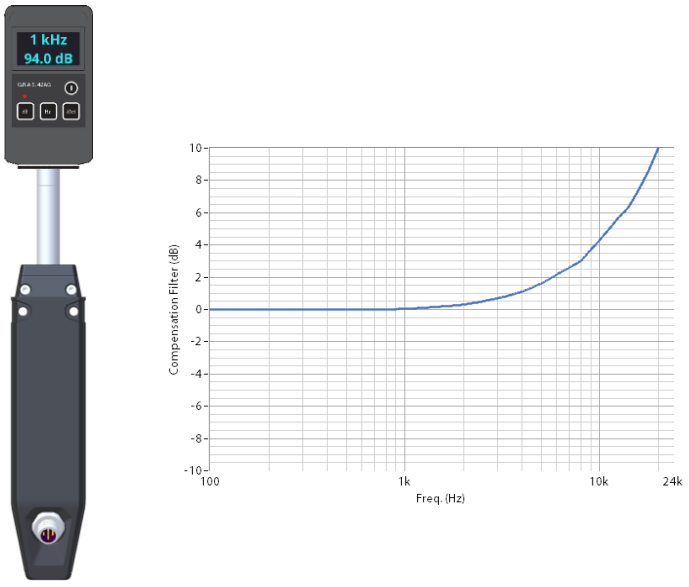
This selection uses a frequency compensation for a 0° incidence free-field. This application is to be used for indoors measurements without a windscreen.




Using this frequency compensation requires the use of the diffuser neck accessory (optional).

Pressure

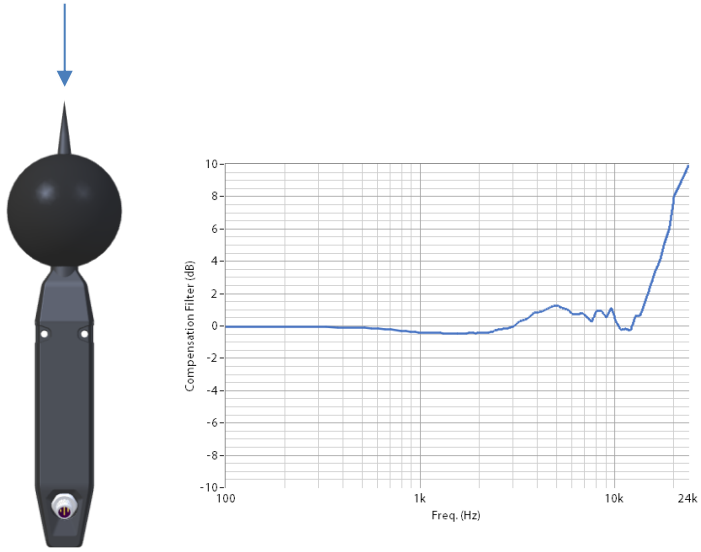
This selection uses a frequency compensation for a pressure sound field such as in the calibration chamber of a calibrator.




This frequency compensation is automatically selected when performing a microphone calibration.

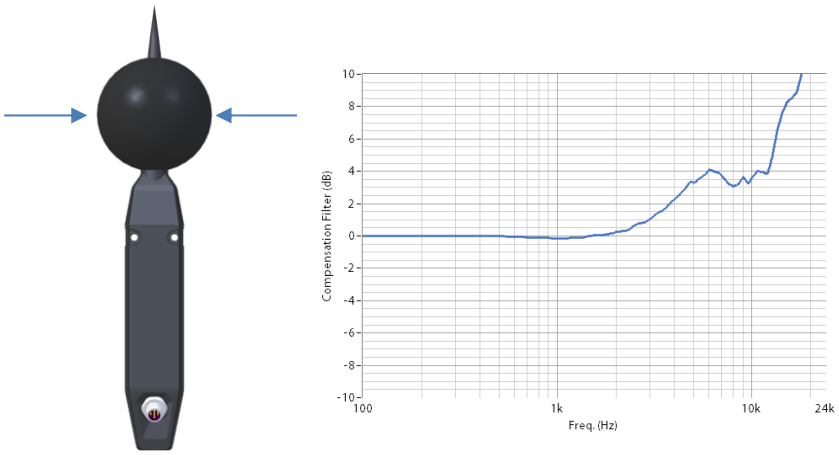
## Free-field 0° + Birdspike

This selection uses a frequency compensation for a 0° incidence free-field with the birdspike and windscreen assembly. This application is for outdoor measurements of overhead sources such as airplanes.



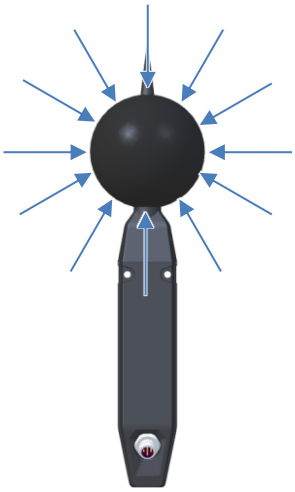

## Free-field 90° + Birdspike

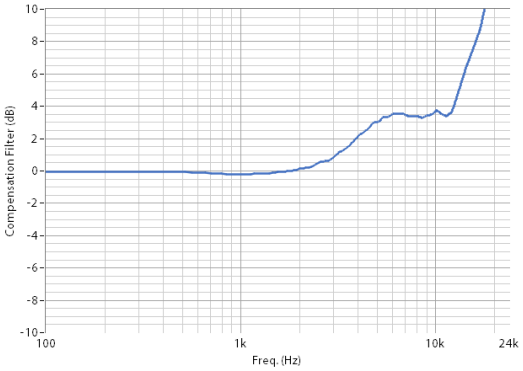
This selection uses a frequency compensation for a 90° incidence free-field with the birdspike and windscreen assembly. This application is for outdoor measurements of community noise sources such as construction equipment.



Random Incidence + Birdspike

This selection uses a frequency compensation for a random incidence sound field with the birdspike and windscreen assembly. This application is for reverberant indoor measurements such as inside a reverberant factory building.






### 3.1.4 Input Range

Click on the "Input Range" drop-down menu from the Setup interface to select the appropriate dynamic range for the measurement application.

Low

The low dynamic range selects the 2 Vpk input range which results in 20 dBA noise and 125 dBpk overload for a 50 mV/Pa microphone.

This input range is recommended for indoors sound measurements.

High

The high dynamic range selects the 8 Vpk input range which results in 32 dBA noise and 137 dBpk overload for a 50 mV/Pa microphone.

This input range is recommended for outdoors sound measurements.

Auto

The "auto" dynamic range sets the SAS to dynamically select the input range offering the best signal conditioning. In this case, both low and high range are acquired at the same time and

the signal coming from the low-range is selected if the signal is at least 10dB below its overload level. Otherwise, the signal from the high range is used.

This algorithm is performed at a rate of 10.7ms. If the high-range is selected during this process, the low-range will be selected only if it's 10dB below its overload level for 1s.

The result of this process is a click-free continuous dynamic range for the data and the audio recording.

This input range is recommended for any measurement application.

## 3.2 SLM

These settings are specific to the SLM processing.

### 3.2.1 Dynamic range

This indicator shows the under-range (dBA) and overload levels (dBZpk) for the selected dynamic range and current sensitivity.

### 3.2.2 SPL Time and Frequency Weightings

The time weighting for the SPL can be selected from the drop-down menu. The choices are "F" (Fast) or "S" (Slow).

The time weighting determines the time weighting used for all the SPL metrics (Live SPL, Lmax, Lmin and percentiles).

The frequency weighting for the SPL can be selected from the drop-down menu. The choices are "Z", "C", "A" or "G".

The frequency weighting determines the time weighting for selected SPL metrics (Live SPL and percentiles).

### 3.2.3 Low-Frequency Filter

The hardware low-frequency filter is set to 0.5Hz. However, this low-frequency roll-off can induce a significant contribution from infrasound on the "Z" (unweighted) global level.

Therefore, an optional high-pass filter can be enabled. This high-pass filter is a $2^{nd}$ order butterworth set at 10Hz. The effect of this filter is only applied on the "Z" global levels.

The low-frequency filter is not applied on the other frequency weightings (A, C, G), nor on the 1/3 octave, nor on the FFT, nor on the OPL.

### 3.2.4 FFT Bandwidth

The FFT spectrum is always 512 lines. That being said, these lines can be spread on different bandwidths for applications requiring a large bandwidth or a finer spectrum resolution.

| FFT Bandwidth (Hz) | FFT Resolution (Hz) |
|---|---|
| 24k | 46.88 |
| 12k | 23.44 |
| 6.0k | 11.72 |
| 3.0k | 5.859 |
| 1.5k | 2.930 |
| 750 | 1.465 |

### 3.2.5 Audio Sampling

The audio sampling is available with 3 sampling rates (48kHz, 24kHz, 12kHz) and 4 compression rates (24bit, 16bit, 8bit, 4bit).

These settings affect the duration of the SLM signal and data buffer.

| | 48kHz | 24kHz | 12kHz |
|---|---|---|---|
| **24-bit** | 2.47s | 4.52s | 7.85s |
| **16-bit** | 3.50s | 6.31s | 10.3s |
| **8-bit** | 6.31s | 10.3s | 15.2s |
| **4-bit** | 10.3s | 15.2s | 19.7s |

The recommended configuration for audio playback and source identification is 24kHz, 8-bit, offering a good compromise between fidelity, buffer length and file size.

The 12kHz, 4-bit configuration is recommended for critical applications where buffer length and small file size are important. On the other end, 48kHz, 24-bit is for applications where an uncompressed time-signal is required.

### 3.2.6 On-Board Certificate

This button allows viewing the on-board certificate for the SLM.

## 3.3 OPL

These settings are specific to the OPL processing.

### 3.3.1 Dynamic range

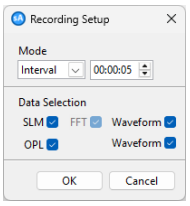
This indicator shows the under-range (dBZpk) and overload levels (dBZpk) for the selected dynamic range and current sensitivity.

### 3.3.2 On-Board Certificate

This button allows viewing the on-board certificate for the OPL.

# 4 Recording Setup

Using the SAS Utility software. Click on “Record Setup” from the “Setup” menu.




## 4.1 Record Mode

### 4.1.1 Live Record Mode

The Live record mode allows recording every Instant data block at a rate of 85.3ms.

The Instant Data block includes the SPL history (10.7ms intervals), but does not include the SEL, LN% or LAFtm5.

### 4.1.2 Interval Record Mode

The Interval record mode allows recording successive average data using a custom interval from 1s to 1h.

These intervals are aligned on clock, hence only intervals being a factor of one hour are supported. The first interval period may be shorter than the defined interval due to clock alignment.

The average data block includes SEL, LN% and LAFtm5, but does not include the SPL history.

### 4.1.3 Overall Record Mode

The Overall record mode allows recording a single average data.

The average data block includes SEL, LN% and LAFtm5, but does not include the SPL history.

## 4.2 Record Selection

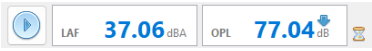
The record selection allows selecting which data is included in the record file.

- SLM: Records or not the SLM (Data, FFT, Signal)
  - FFT: Records or not the FFT

- Waveform: Records or not the SLM Waveform
- OPL: Records or not the OPL (Data, Signal)
  - Waveform: Records or not the OPL Waveform

# 5 Viewing Live Sound Levels

Click on “Instrument Pane” from the “View” menu to display the Live sound levels.




The left numeric indicator shows the SLM Live SPL for the selected time-weighting and frequency weighting while the right numeric indicator indicates the OPL Live Lpeak.

The refresh rate of the live sound levels is typically 40ms (25Hz) but should not exceed 100ms (10Hz).

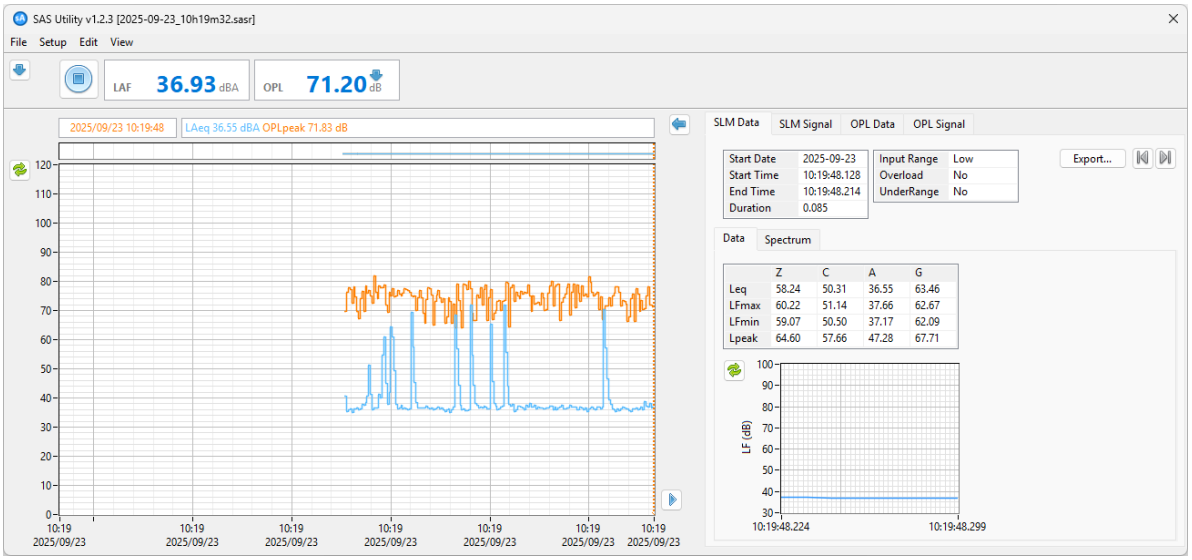
A icon is displayed when an overload occurs and a icon is displayed when an under-range occurs. These indicators are latched for as long as the condition exists or 1 s, whichever is the greater.

A icon is displayed during the warm-up period. This warm-up period occurs when the instrument is powered-on or whenever the instrument setup is changed.

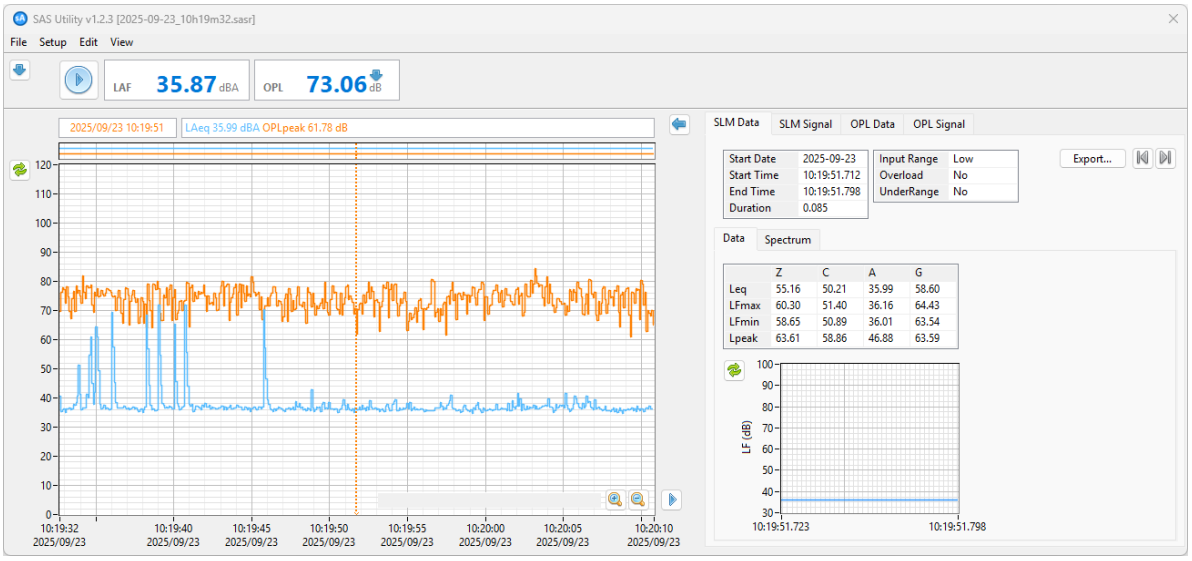
# 6 Perform a Measurement

With the SAS connected, click on the button, or click on “Run/Stop” from the “Setup” menu.

Once running, the interface shows a running history showing the data being recorded to the fileThe path of the file is shown on the window title. The default record directory is “C:\Users*USERNAME*\Documents”.




When the record is completed, click on the button or click on “Run/Stop” from the “Setup” menu.



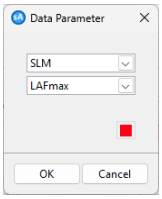
Once the record is completed, the Time history graph is rescaled to show the overall record period.

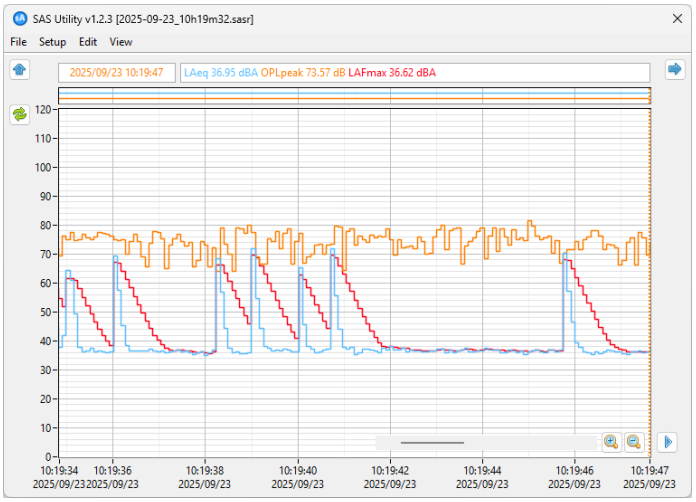
# 7 Analyze a Measurement

Once a measurement is completed, it can be analyzed in the same user interface. You may also recall a measurement file by clicking on “Open” from the “File” menu.

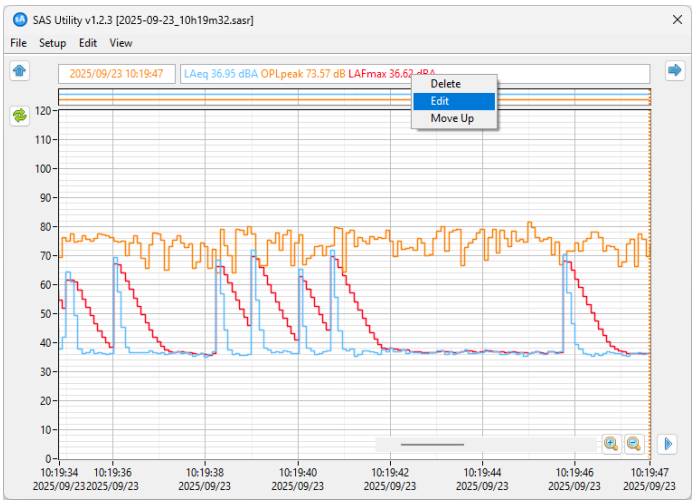
## 7.1 Time History Graph

The time history graph shows user-selected metrics. Select “Add Data” from the “Edit” menu to add a metric on the time history graph.




The displayed data can be edited or removed by right-clicking on the legend label.



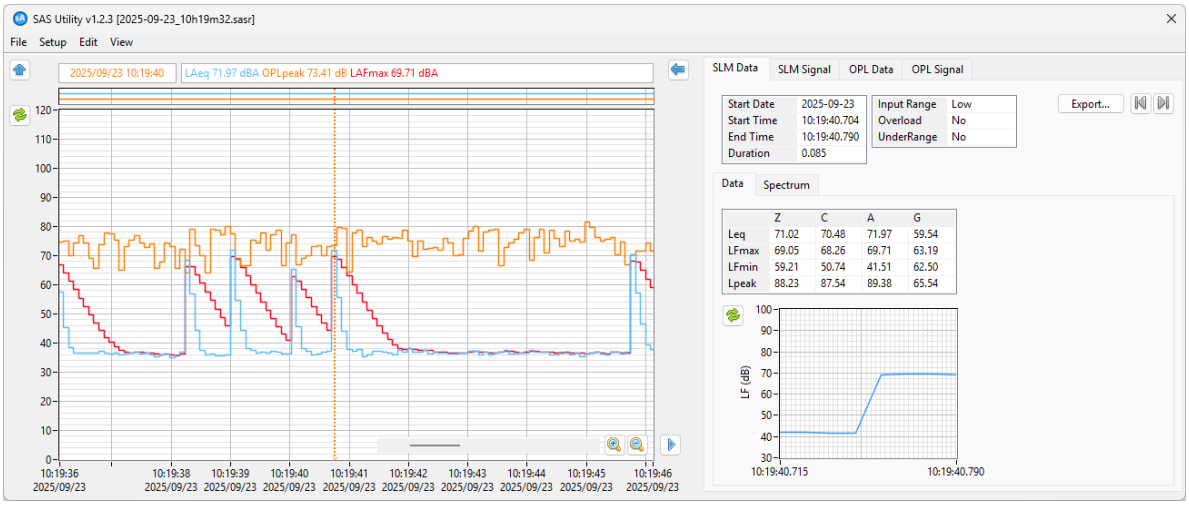

### 7.1.1 Time History Graph Cursor

Click on the time history graph to move the cursor at the desired time. The time history graph legend displays the cursor time and associated data values.

The ▶ button allows to move the cursor in real-time and update the cursor values accordingly. This button also activates the SLM Waveform playback.

## 7.2 Data Details

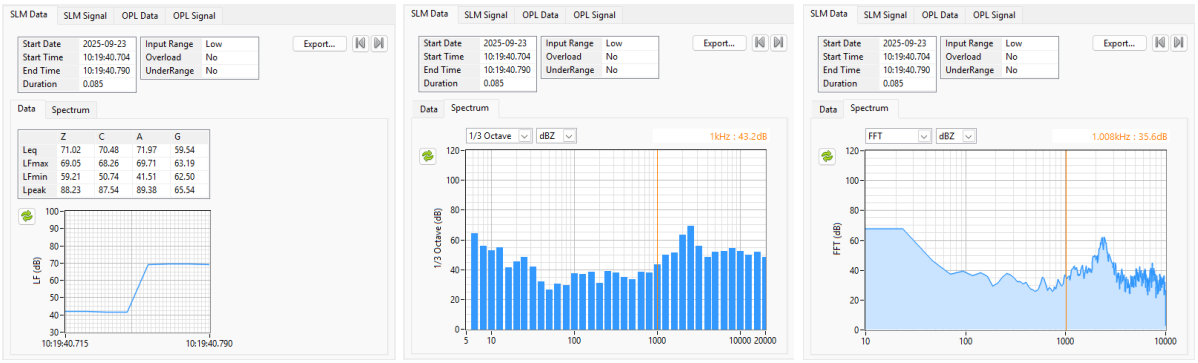
Selecting “Details Pane” from the “View” menu displays the details associated with the time history graph cursor time or the details of the current data acquired by the SAS.



### 7.2.1 SLM Data

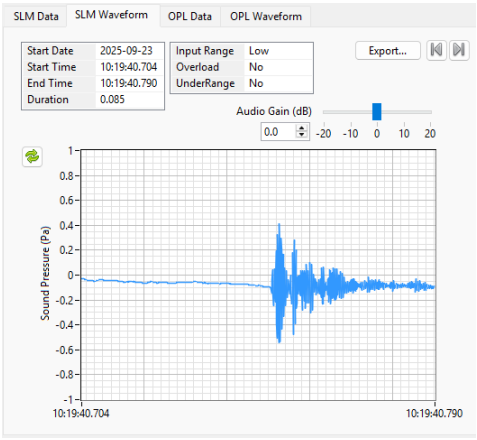
The “SLM Data” tab displays the SLM Data details associated with the time history graph cursor.

The “Data” tab shows the global metrics while the “Spectrum” tab shows the 1/3 octave and FFT spectra.




### 7.2.2 SLM Waveform

The “SLM Waveform” tab displays the SLM waveform associated with the time history graph cursor.

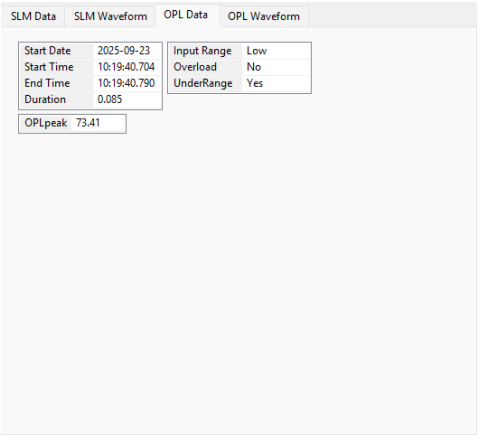



Click on the ▶ button to start the SLM Waveform playback.

Use the “Audio Gain” control to adjust the gain. The default (Gain = 0dB) playback dynamic range is 50 Pa peak (128 dB pk). This audio gain is also applied when exporting the waveform in a wav file.

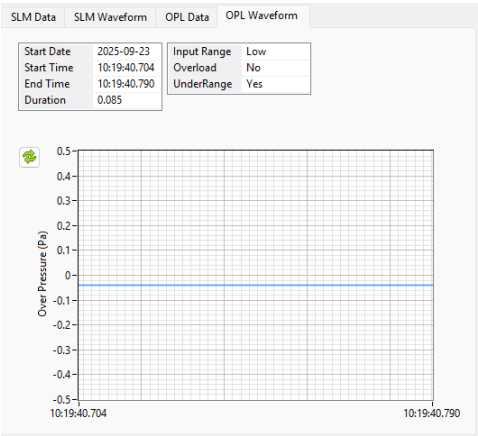
### 7.2.3 OPL Data

The “OPL Data” tab displays the OPL Data details associated with the time history graph cursor.



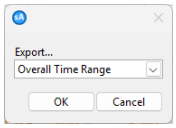

### 7.2.4 OPL Waveform

The “OPL Waveform” tab displays the OPL waveform associated with the time history graph cursor.




## 7.3 Export Data

Click on the “Export…” button from the Data details tabs to export the SLM Data, SLM Waveform, OPL Data or OPL Waveform.



- Overall Time Range: Exports all data from the beginning to the end of the measurement.
- Visible Time Range: Exports all data from the beginning to the end of the Time history graph visible time range.
- Cursor Time: Exports all data from single record associated with the cursor time.

The Data is exported in a tab delimited file while the Waveform is exported in a wav file format.

# 8 Detailed Specifications

## 8.1 General

The SAS is a sound level meter compliant with IEC 61672-1 (2013), Class 1, Group Z.

According to IEC 61672-1, "a sound level meter is a combination of a microphone, a preamplifier, a signal processor and a display device. [...] a display device provides a physical and visible display, or storage, of measurement results."

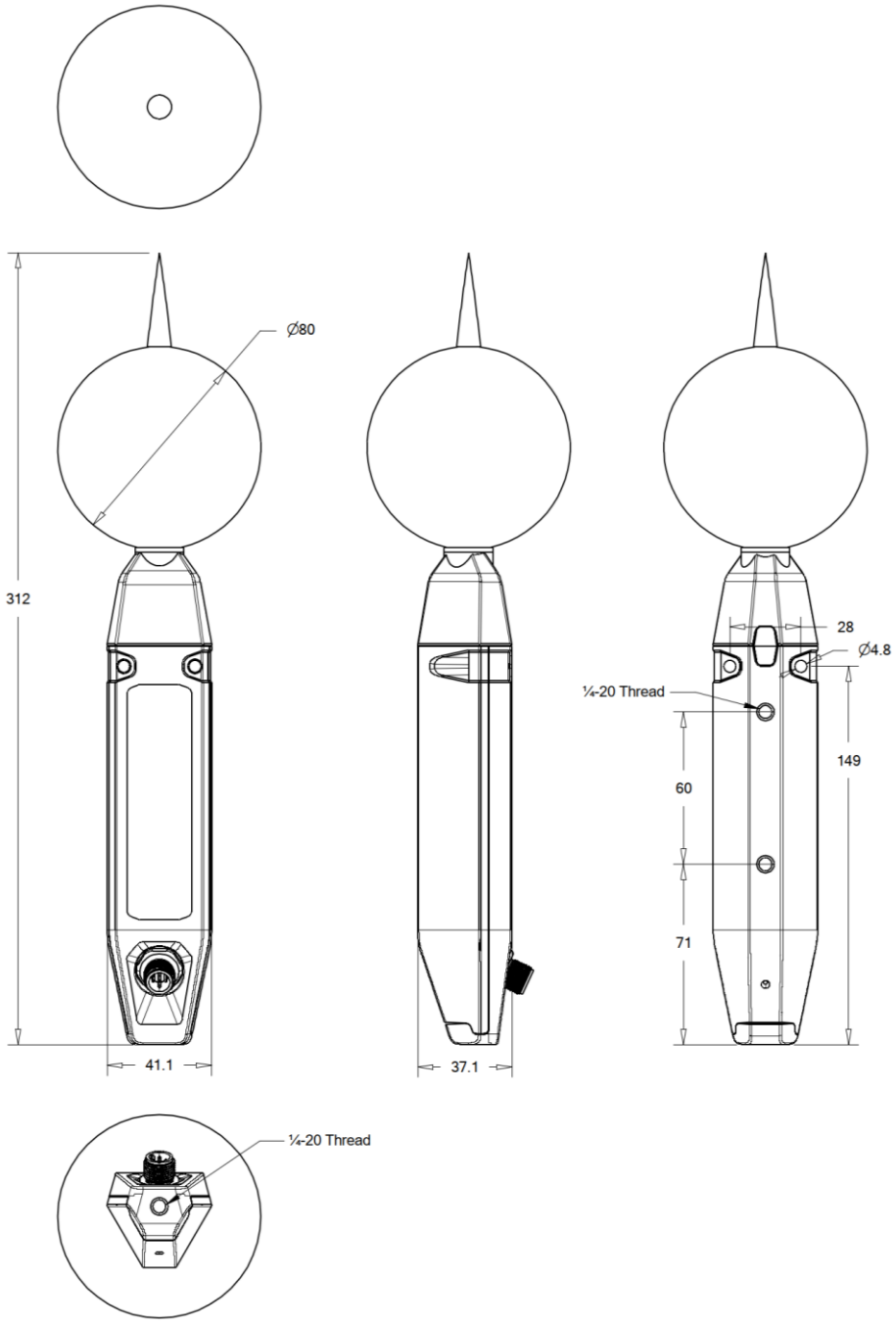
In this regard, the SAS combines a microphone, a preamplifier and a signal processor. The display/storage device is either a computer or a monitoring station controller. Therefore, the SAS is a "group Z" sound level meter as it requires a separate display/storage device.

The compliant configurations are:

1) Using the indoor neck (SASA-00003) and indoor windscreen (MICA-00001), in free-field with a 0° (vertical) reference direction;
2) Using the outdoor bidrspike (SASA-00001) and outdoor windscreen (SASA-00002), in free-field with a 0° (vertical) reference direction;
3) Using the outdoor bidrspike (SASA-00001) and outdoor windscreen (SASA-00002), in free-field with a 90° (horizontal) reference direction;

All the above configurations use the 378B02 microphone from PCB Piezotronics, a M12 cable (CABA-00001) and M12 to USB adapter cable (CABA-00009) connected to a computer running the SAS Utility software.

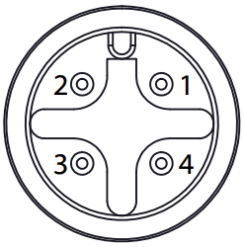
### 8.1.1 Dimensions




### 8.1.2 Communication Port

The SAS uses RS485 half-duplex serial communication. A shielded 4-pin M12 male connector is used for both digital communication and power-supply:

| Pin | Description |
|---|---|
| 1 | RS-485 Pos. |
| 2 | RS-485 Neg. |
| 3 | +5V |
| 4 | Ground |
| Shell | Ground |

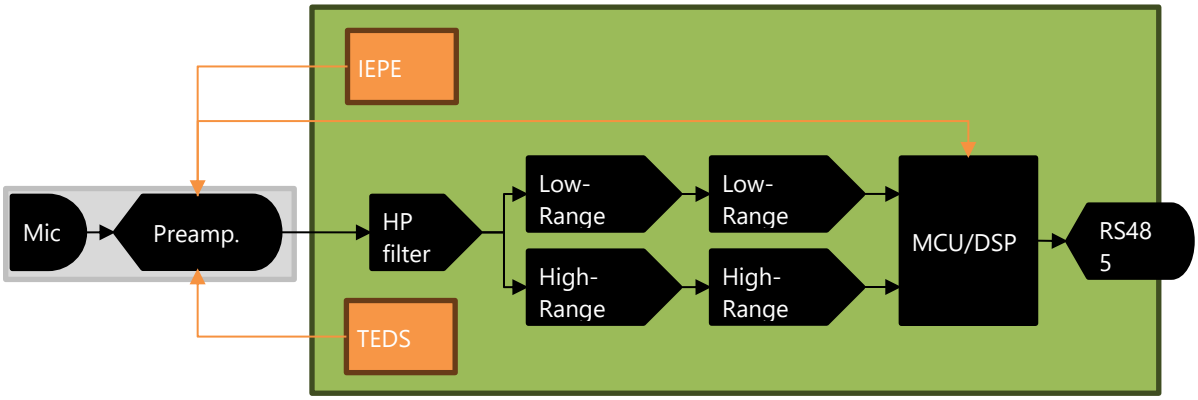



The power-supply must provide at least 0.7A at 5V. The SAS peak current is 400mA and average current consumption is 100mA.

The maximum cable length between the host and the sensor is 100 meters.

Only one SAS sensor is possible on a single serial port: the daisy-chain architecture, where many sensors are on the same port, is not supported.

### 8.1.3 Electrical Functional Description




Electrical Functional Diagram

Microphone Conditionning

The SAS supports an IEPE powered microphone preamp. The microphone bias voltage is read by the MCU as a basic microphone presence detection feature. A TEDS interface is available to read the microphone electronic data sheet, and also to implement GRAS SysCheck™ feature.

Analogue Front-end

The microphone signal is fed to a first-order high-pass filter with cut-off frequency of about 0.5Hz. the filtered signal is fed simultaneously to two analog front-end sub circuits. The low-range front-end has a dynamic range of 2Vpk while the high-range front-end has a dynamic

range of 8Vpk. The maximum voltage rating of the analogue front-end is 11.5Vpk (equivalent to 147dBpk @ 50mV/Pa).

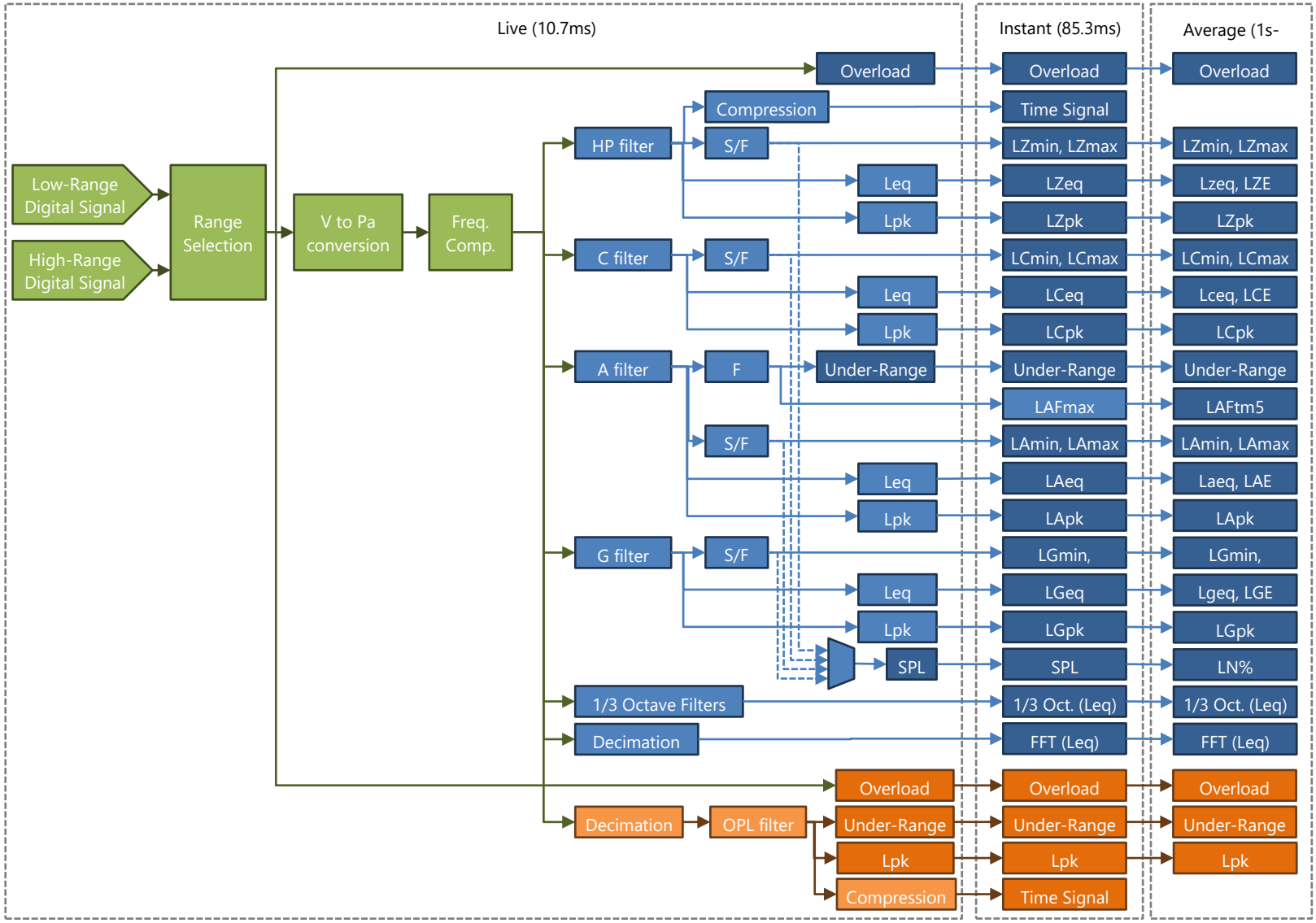
Analogue to Digital Conversion

The signals from each dynamic range front-ends are acquired by a dual channel ADC using a 24-bit, 48kHz sampling. The digital signals from each dynamic range ADC is fed to the DSP core of the MCU.

The DSP processes the digital signals from the two ADC and computes the SLM and OPL metrics which are transmitted over RS485.

### 8.1.4 Digital Signal Processing Functional Description

The digital signal processing is divided in 3 processing rates: Live, Instant Data, Average Data.




Digital Signal Processing Functional Diagram

Live Process

The Live process is executed every 10.7ms (512 samples @ 48kHz). This process performs the time-critical signal processing.

The live process also provides the Display information:

- Live SLM SPL;
- Live SLM Overload Indication;
- Live SLM Under-range Indication;
- Live OPL Lpeak;
- Live OPL Overload Indication;
- Live OPL Under-range Indication;

*Range Selection*

A range selection blocks selects the dynamic range, either manually selected (Low/high) or automatically. In this case, the signal coming from the low-range is selected if the signal is at least 10dB below its overload level. Otherwise, the signal from the high range is used. If the high-range is selected during this process, the low-range will be selected only if it's 10dB below its overload level for 1s. The result of this process is a click-free continuous dynamic range for the data and the audio recording.

*Overload Indication*

The Live overload indication is determined from the raw voltage signal using the predetermined overload limit set for each range. This overload indication is used for both SLM and OPL.

The display overload indication (see section 5) is latched from the live overload indication for as long as the overload condition exists or 1 s, whichever is the greater.

*Signal Conversion*

A conversion block converts the raw voltage signal to a Pascal signal using the microphone sensitivity. This block also implements a temperature compensation based on the microphone temperature (See section 8.5).

*Frequency Compensation*

The converted signal is fed through a frequency compensation filter providing a flat frequency response for selected applications. The resulting signal represents the true sound pressure signal, without the effects of the microphone response and environmental shielding. (see section 8.8)

*SLM Frequency Weighting*

Four frequency weight filters (Z, C, A and G) are applied on the sound pressure signal.

The Z weighting filter comprises of an optional high-pass filter (10Hz, 2nd order, Butterworth) (see section 3.2.3).

*SLM SPL Time Weighting*

The Z, C, A and G weighted signals are fed through an exponential detector set to Slow or Fast depending on user selection (see section 3.2.2).

A multiplexer selects the Live SPL values from the user-selected frequency weighting (Z, C, A or G) (see section 3.2.2).

The display SPL uses the live user-selected time/frequency-weighted SPL (see section 3.2.2).

*SLM Under-range Indication*

The A weighted signal is fed through a Fast exponential detector. The resulting LAF SPL is used for the Under-range Indication for the SLM using a predetermined under-range limit for each range.

The display under-range indication is latched for as long as the overload condition exists or 1 s, whichever is the greater (see section 5).

The resulting LAF SPL is also used for subsequent LAFtm5 processing from the Average process.

*SLM Leq*

The Live SLM Leq values are derived from the RMS integrated frequency weighted signals (Z, C, A and G).

*SLM Lpk*

The Live SLM Lpk values are derived from the frequency weighted signals (Z, C, A and G) peak value.

*SLM 1/3 Octave filters*

A 1/3 octave filter bank is applied on the sound pressure signal. The filter bank comprises of 31 bands from 6.3Hz to 20kHz. Refer to section 8.21.1 for more information.

The Live 1/3 octave Leq values are derived from the RMS integrated 1/3 octave signals.

*SLM FFT Decimation*

A decimation process is performed on the sound pressure signal for FFT processing. The decimation level is determined by the user-selected FFT bandwidth (see section 3.2.4).

*SLM Signal Compression*

The sound pressure signal is decimated according to the user-selected SLM signal bandwidth (see section 3.2.5).

The decimated time signal block (10.7ms) is normalized and compressed according to the user-defined SLM signal resolution (see-section 3.2.5).

The normalization factor used for compression is appended for post-processing signal decompression.

*OPL Decimation*

The sound pressure signal is decimated to 1.5kHz sampling rate.

*OPL Filter*

The OPL decimated time signal is fed to an OPL filter comprising A compensation filter to extend the frequency response from the working standard microphone down to a range appropriate for overpressure measurements, and A band-limiting filter. The resulting frequency response is a $2^{nd}$ order band-pass filter with 1.6Hz – 315Hz cut-off frequencies (-3dB).

*OPL Lpk*

The Live OPL Lpk values are derived from the OPL filtered signal peak value.

The display OPL Lpeak uses the Live OPL Lpeak values.

*OPL Under-range Indication*

The Live OPL Lpk is used for the Under-range Indicaiton for the OPL using a predetermined under-range limit for each range.

The display under-range Indication is latched for as long as the overload condition exists or 1 s, whichever is the greater (see section 5).

*OPL Signal Compression*

The OPL filtered time signal block (10.7ms) is normalized and compressed to an 8-bit resolution.

The normalization factor used for compression is appended for post-processing signal decompression.

Instant Data Process

The Instant Data process integrates 8 Live process blocks (85.3ms).

*Overload Indication*

The Instant Data overload indication is derived from the Live overload indications. This overload indication is used for both SLM and OPL.

*SLM Under-range Indicaiton*

The Instant Data SLM under-range Indication is derived from the Live SLM under-range Indication.

*SLM Lmax, Lmin*

The Instant Data Lmax and Lmin values for each frequency weightings (Z, C, A and G) and selected time-weighting (S or F) are derived from the Live SPL values.

*SLM Leq*

The Instant Data Leq values for each frequency weightings (Z, C, A and G) are derived from the Live Leq values.

*SLM Lpeak*

The Instant Data SLM Lpeak values for each frequency weightings (Z, C, A and G) are derived from the Live Lpeak values.

*SLM SPL History*

The Instant Data SPL History for the selected frequency weightings (Z, C, A or G) and selected time-weighting (S or F) are derived from the Live SPL values (8x).

*SLM 1/3 Octave*

The Instant Data 1/3 octave Leq values are derived from the Live 1/3 octave Leq values.

*SLM FFT*

The decimated FFT signal is processed in 1024 samples blocks, each overlapping the previous one by 66%. A Hanning window is applies on the 1024 samples block. A FFT is performed on the windowed time signal block.

The Instant Data FFT spectrum is derived from the RMS average of the resulting FFT spectra.

*SLM Time Signal*

The Instant Data SLM time signal is derived from the Live compressed SLM signal blocks (8x)

*OPL Under-range Indication*

The Instant Data OPL under-range indication is derived from the Live OPL under-range indication.

*OPL Lpeak*

The Instant Data OPL Lpeak value is derived from the Live OPL Lpeak values.

*OPL Time Signal*

The Instant Data OPL time signal is derived from the Live compressed OPL signal blocks (8x)

Average Data Process

The Average Data process integrates the Instant Data blocks (85.3ms) to longer periods, typically 1s to 3600s.

*Overload Indication*

The Average Data overload indication is derived from the overload indication from the Instant Data blocks overload indication.

*SLM Under-range Indication*

The Average Data SLM under-range Indication is derived from the Live SLM under-range Indication.

*SLM Lmax, Lmin*

The Average Data Lmax and Lmin values for each frequency weightings (Z, C, A and G) and selected time-weighting (S or F) (see section 3.2.2) are derived from the Instant Data Lmax and Lmin values.

*SLM Leq and SEL*

The Average Data Leq values for each frequency weightings (Z, C, A and G) are derived from the Instant Data Leq values. The Average Data SEL values are derived from the Average Data Leq and the Average duration.

*SLM Lpeak*

The Average Data Lpk values for each frequency weightings (Z, C, A and G) are derived from the Instant Data Lpk values.

*SLM SPL Percentiles*

The Average Data SPL percentiles values for the selected frequency weightings (Z, C, A or G) and selected time-weighting (S or F) (see section 3.2.2) are derived from the Instant Data SPL History.

*SLM LAFtm5*

The Average Data LAFtm5 value is the RMS average of the LAFmax,5s which is derived from the Instant Data LAFmax values.

*SLM 1/3 Octave*

The Average Data 1/3 octave Leq values are derived from the Instant Data 1/3 octave Leq values.

*SLM FFT*

The Average Data FFT Leq values are derived from the Instant Data FFT Leq values.

*OPL Under-range Indication*

The Average Data OPL under-range Indicaiton is derived from the Instant Data SLM under-range Indication.

*OPL Lpeak*

The Average Data OPL Lpk value is derived from the Instant Data OPL Lpk values.

## 8.2 Warm-Up

A warm-up period of 20s occurs when the IEPE microphone conditioning is enabled. This occurs when the instrument is powered-on and also after communicating with the TEDS interface, such as when performing a SysCheck2™.

A warm-up period of 5s occurs every time the Instrument Setup is modified (see section 5).

## 8.3 Timing

The Live Process (10.7ms) and Instant Data Process (85.3ms) are initiated at the instrument power-up.

Using any recording mode (Section 4.1), starting a measurement flushes the data buffer, but does not restart the processing. The first data block to be recorded will be the first "Instant Data" block that completes since the buffer was reset. Therefore, the true start time may be between 85.3ms in the past and now.

### 8.3.1 Live Record Mode

When using the Live Record Mode (Section 4.1.1), the Instant Data Blocks are recorded back-to-back with an 85.3ms resolution using the start time provided by the computer as the reference.

The accuracy of the real-world start and end times of the overall record is provided by the computer clock and the Instant Data Process timing resolution (85.3ms).

Additionally, the accuracy of the real-world end time is also affected by the on the on-board clock accuracy (±20ppm) which can lead to a real-world end-time error of up to ±1.7s per 24h.

### 8.3.2 Interval Record Mode

The Interval Record Mode (Section 4.1.24.1.1) allows recording successive average data using a custom interval from 1s to 1h.

These intervals are aligned on clock, hence only intervals being a factor of one hour are supported. The first interval period may be shorter than the defined interval due to clock alignment.

The intervals real-world start and end times are handled by the computer. At each interval, the on-board cumulated average is recorded and the Average Data Process is reset simultaneously.

The Average Data Process timing resolution being 85.3ms, successive intervals may have a real-world time duration difference of up to 85.3ms.

The accuracy of the real-world start and end times of each interval is provided by the computer clock and the Average Data Process timing resolution (85.3ms).

### 8.3.3 Overall Record Mode

The Overall Record Mode (Section 4.1.34.1.1) allows recording a single average data using a custom interval from 1s to 1h, or until the user stops the measurement.

The intervals real-world start and end times are handled by the computer. When the measurement ends, the on-board cumulated average is recorded and the Average Data Process is reset simultaneously.

The accuracy of the real-world start and end times of the overall record is provided by the computer clock and the Average Data Process timing resolution (85.3ms).

## 8.4 Injecting Electrical Signals

Electrical signals should be injected by replacing the microphone cartridge with a capacitive adapter having a similar capacity (±6dB) to the used microphone cartridge.

| | SAS with 378B02 microphone | SAS with 246AE microphone | SAS with 378A06 microphone |
|---|---|---|---|
| Microphone Capacitance | 12 pF | 14 pF | 14 pF |

## 8.5 Reference Values

- The reference sound pressure level is 94.0dB.
- The reference frequency is 1kHz.
- The reference level range is “Low”.
- The reference sensitivity is 50mV/Pa, unless otherwise specified.
- The reference orientation is 0° (vertical) or 90° (horizontal) against the microphone axis (Refer to section 8.7).
- The location of the microphone reference point is centered on the microphone protection grid.
- The reference ambiant temperature is 23 °C;
- The reference static pressure is 101.325 kPa;
- The reference relative humidity is 50 %.

## 8.6 Environmental Response

Typical stabilization time after change in environmental conditions is 10 minutes.

Longer stabilization times are expected if condensation occurs, such as when the environment changes from a warm environment with high humidity to a colder environment. In this

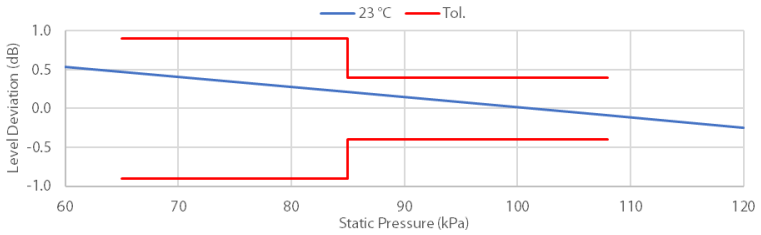
situation, the condensation must evaporate for the instrument to be in its operating range, thus leading longer stabilization time.

### 8.6.1 Static Pressure

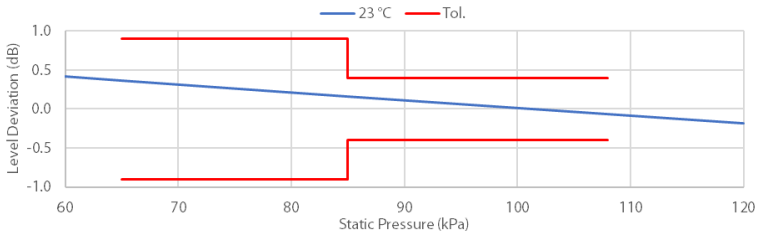
The static pressure operating range is from 85kPa to 108kPa.

The table below shows the static pressure response with respect to reference environmental conditions.

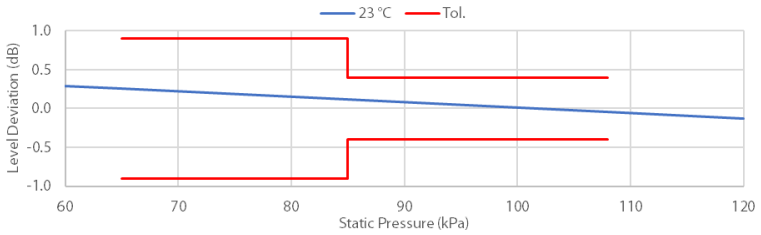
| | SAS with 378B02 microphone | SAS with 246AE microphone | SAS with 378A06 microphone |
|---|---|---|---|
| Static Pressure (dB/kPa) | -0.013 | -0.010 | -0.007 |




SAS with 378B02 microphone from PCB Piezotronics




SAS with 246AE microphone from GRAS



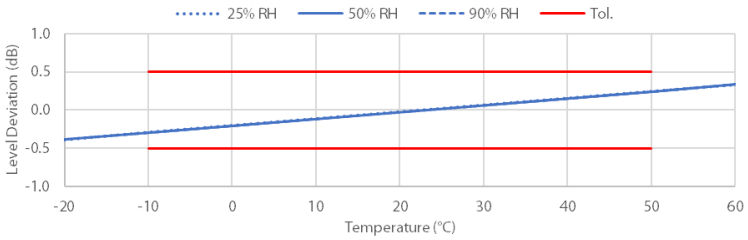

SAS with 378A06 microphone from PCB Piezotronics

### 8.6.2 Ambient Temperature

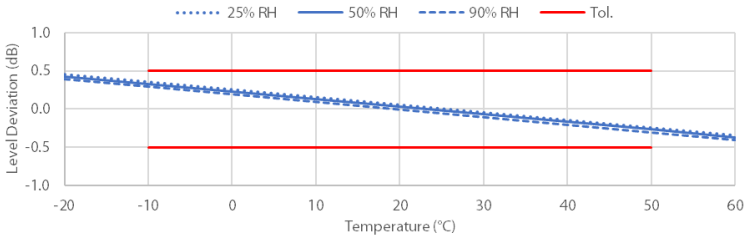
The ambiant temperature operating range is from -40°C to 50°C.

The table below shows the ambient temperature response with respect to reference environmental conditions.

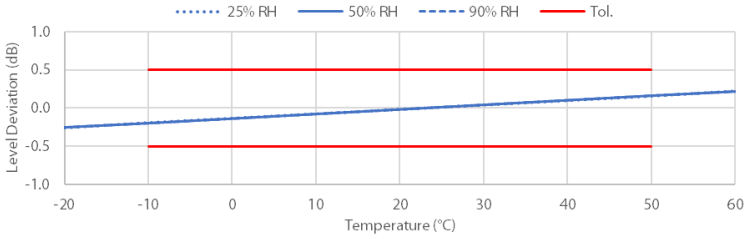
| | SAS with 378B02 microphone | SAS with 246AE microphone | SAS with 378A06 microphone |
|---|---|---|---|
| Temperature (dB/°C) | +0.009 | -0.010 | +0.006 |




SAS with 378B02 microphone from PCB Piezotronics




SAS with 246AE microphone from GRAS




SAS with 378A06 microphone from PCB Piezotronics

Temperature Compensation

The SAS features an on-board temperature sensor accurate to ±3°C from -10°C to 50°C. This allows the temperature response to be within ±0.03 dB for this range of temperature.

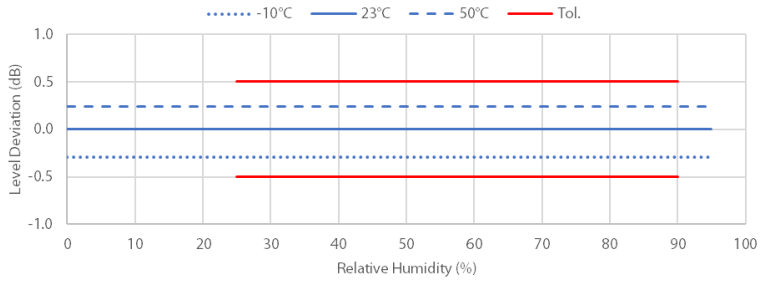
| | SAS with 378B02 microphone | SAS with 246AE microphone | SAS with 378A06 microphone |
|---|---|---|---|
| Temperature (dB/°C) | 0.000 | 0.000 | 0.000 |
| Uncertainty (dB) | ±0.027 | ±0.030 | ±0.018 |

### 8.6.3 Relative Humidity

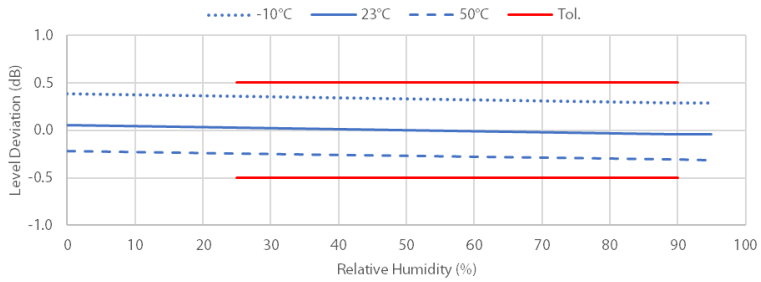
The relative humidity operating range is 0% to 95% without condensation.

The table below shows the relative humidity response with respect to reference environmental conditions.

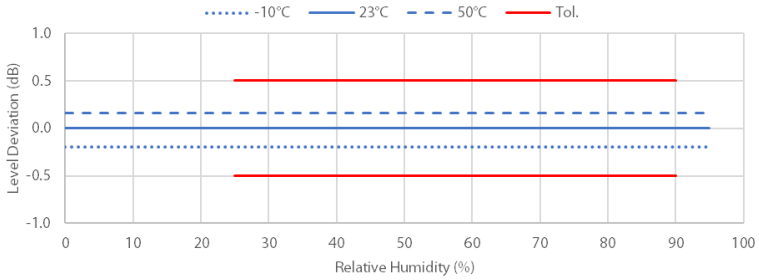
| | SAS with 378B02 microphone | SAS with 246AE microphone | SAS with 378A06 microphone |
|---|---|---|---|
| Humidity (dB/RH%) | 0.000 | -0.001 | 0.000 |




SAS with 378B02 microphone from PCB Piezotronics




SAS with 246AE microphone from GRAS

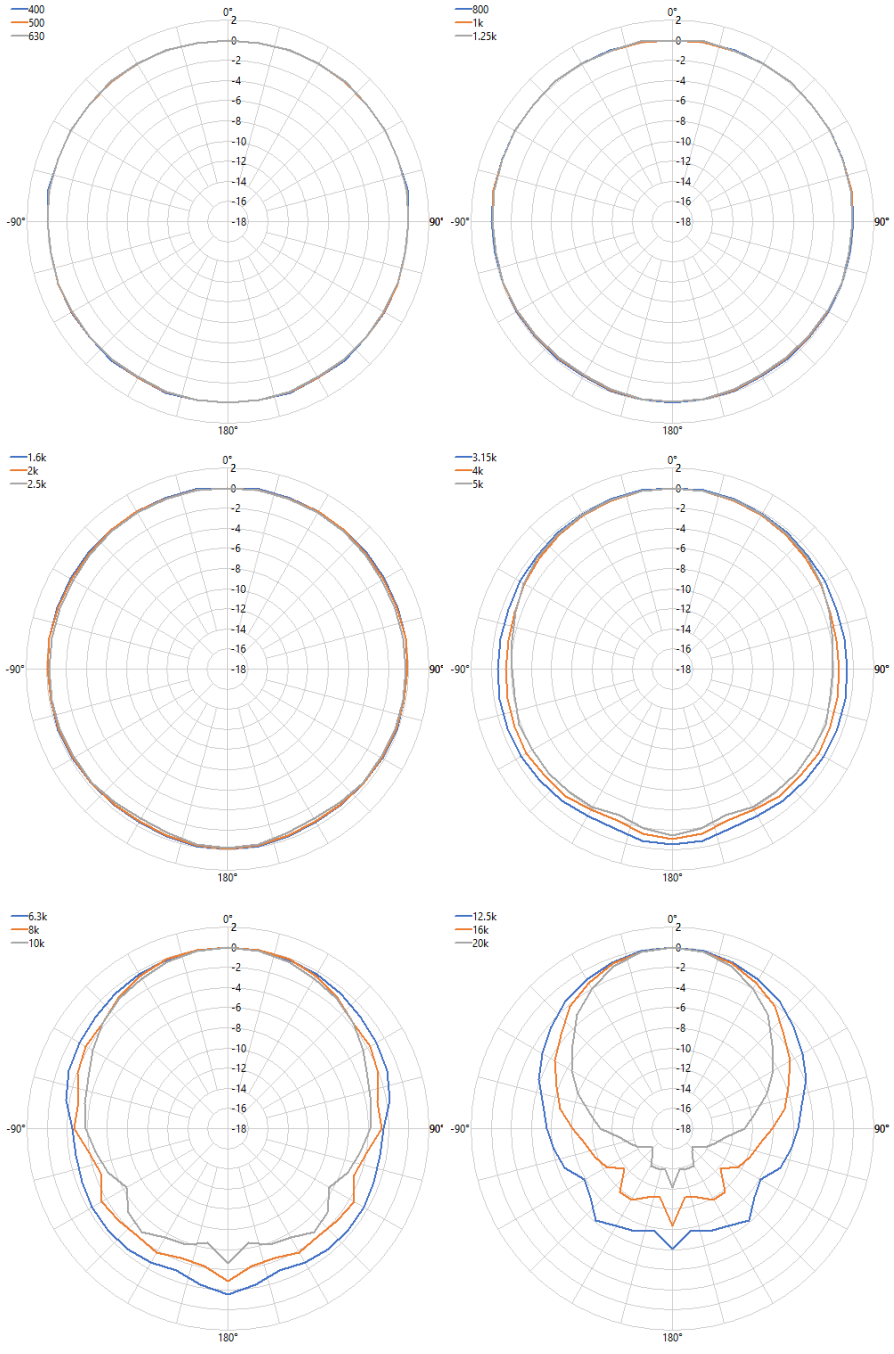


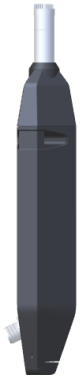

SAS with 378A06 microphone from PCB Piezotronics

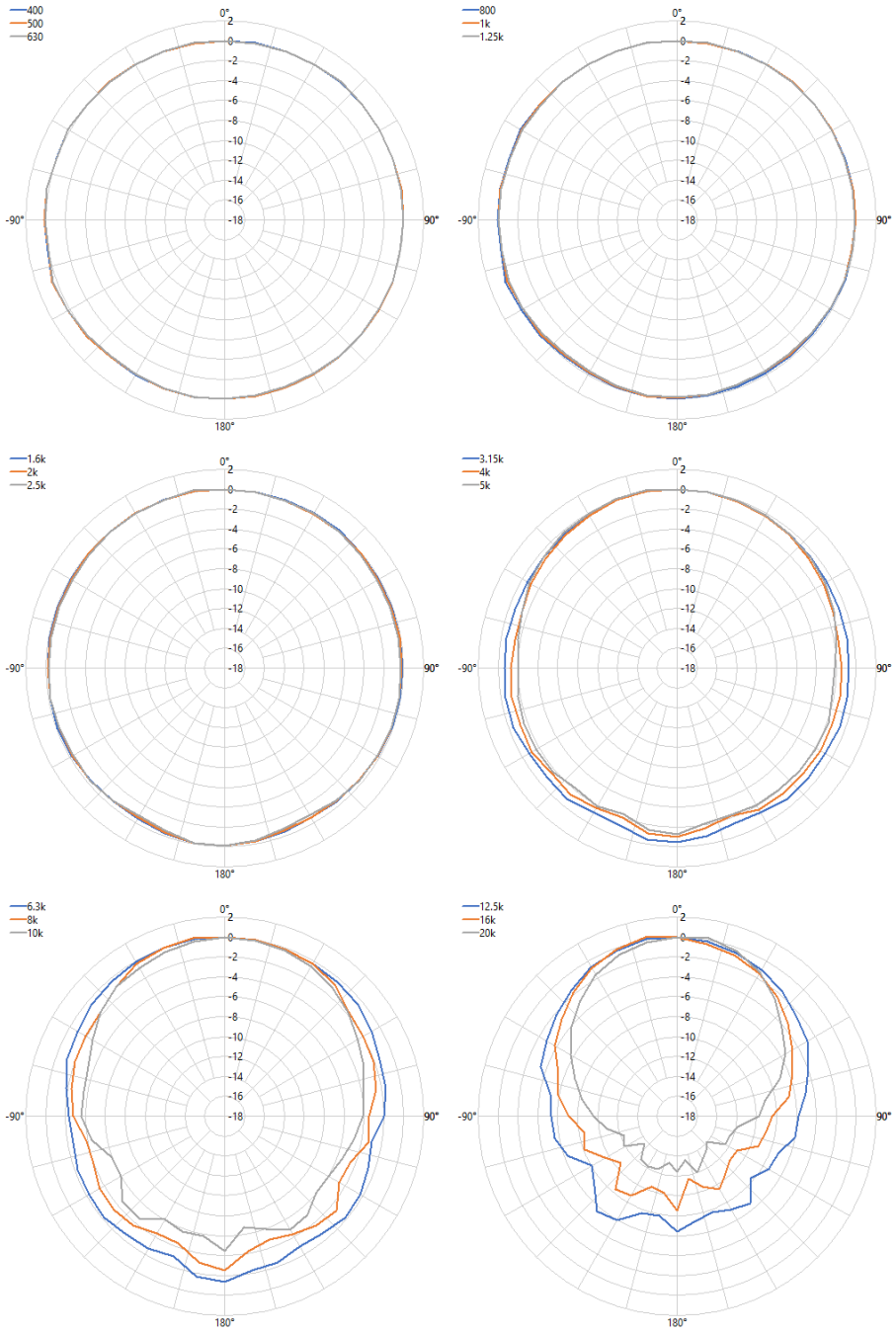
## 8.7 Free-Field Directional Response

### 8.7.1 Bare Mic

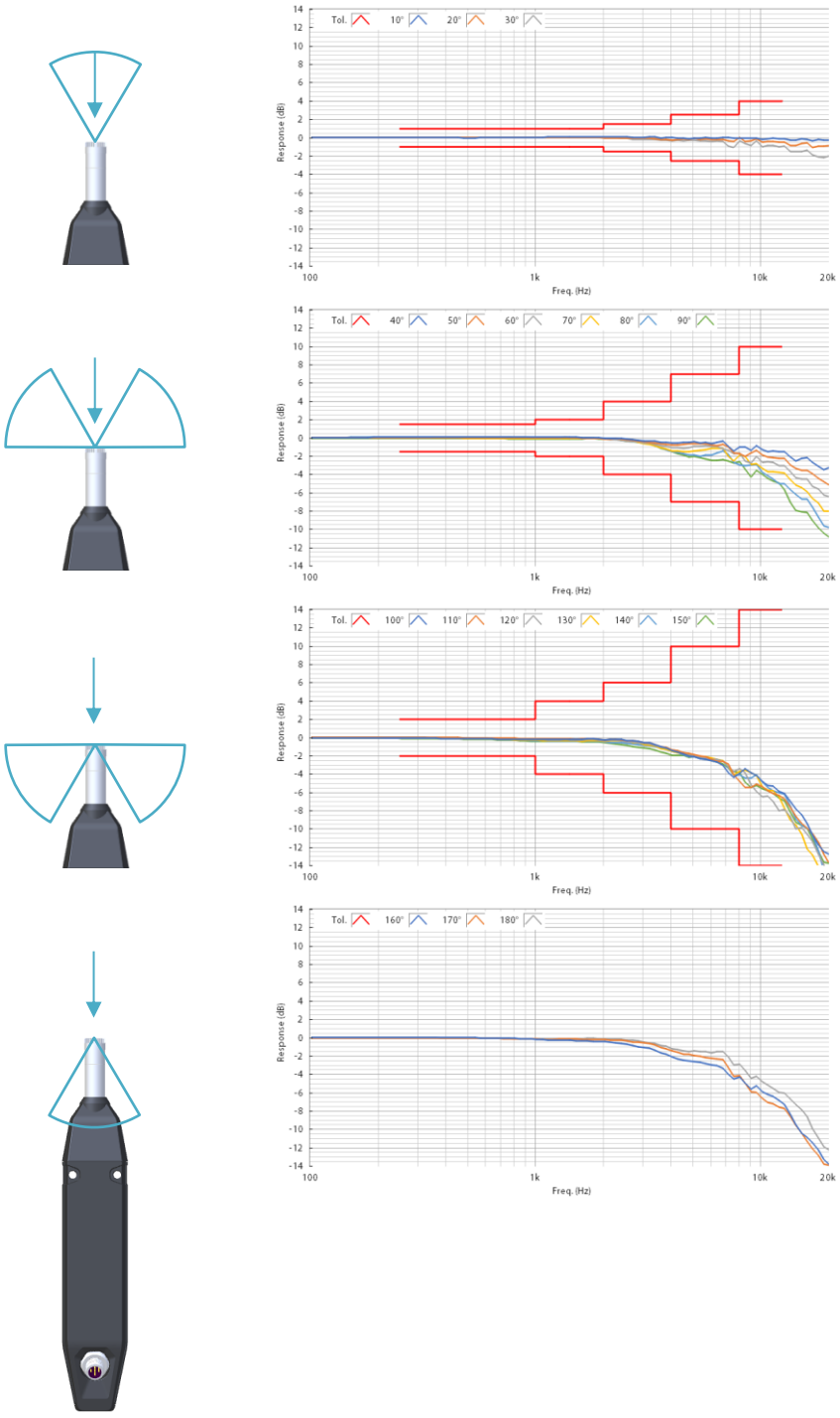
Polar Diagrams






400
500
630
800
1k
1.25k
1.6k
2k
2.5k
3.15k
4k
5k
6.3k
8k
10k
12.5k
16k
20k
0°
90°
-90°
180°
2
0
-2
-4
-6
-8
-10
-12
-14
-16
-18

## Frequency Response – Vertical Incidence Reference



## Frequency Response – Vertical Incidence Reference – Sides – 10° ~ 30°

| Freq. (Hz) | 10° (dB) | 20° (dB) | 30° (dB) | Tol. (dB) |
|---|---|---|---|---|
| 251.189 | 0.0 | 0.0 | 0.0 | ±1.0 |
| 316.228 | 0.0 | 0.0 | 0.0 | ±1.0 |
| 398.107 | 0.0 | 0.0 | 0.0 | ±1.0 |
| 501.187 | -0.0 | 0.0 | 0.0 | ±1.0 |
| 630.957 | 0.0 | 0.0 | 0.0 | ±1.0 |
| 794.328 | 0.0 | 0.0 | 0.0 | ±1.0 |
| 1000.00 | 0.1 | 0.0 | 0.0 | ±1.0 |
| 1258.93 | 0.1 | 0.0 | 0.0 | ±1.0 |
| 1584.89 | 0.1 | 0.0 | 0.1 | ±1.0 |
| 1995.26 | 0.1 | 0.0 | 0.0 | ±1.0 |
| 2238.72 | 0.1 | -0.0 | 0.0 | ±1.5 |
| 2511.89 | 0.1 | -0.0 | -0.1 | ±1.5 |
| 2818.38 | 0.0 | -0.0 | -0.2 | ±1.5 |
| 3162.28 | 0.1 | -0.0 | -0.2 | ±1.5 |
| 3548.13 | 0.0 | -0.2 | -0.2 | ±1.5 |
| 3981.07 | 0.0 | -0.2 | -0.3 | ±1.5 |
| 4466.84 | -0.1 | -0.1 | -0.3 | ±2.5 |
| 5011.87 | -0.0 | -0.1 | -0.3 | ±2.5 |
| 5623.41 | 0.0 | -0.1 | -0.3 | ±2.5 |
| 6309.57 | -0.0 | -0.2 | -0.3 | ±2.5 |
| 7079.46 | 0.1 | -0.3 | -0.8 | ±2.5 |
| 7943.28 | -0.0 | -0.1 | -0.5 | ±2.5 |
| 8413.95 | -0.1 | -0.3 | -0.5 | ±4.0 |
| 8912.51 | -0.1 | -0.4 | -0.8 | ±4.0 |
| 9440.61 | -0.1 | -0.2 | -0.4 | ±4.0 |
| 10000.0 | -0.1 | -0.4 | -0.8 | ±4.0 |
| 10592.5 | -0.1 | -0.4 | -0.9 | ±4.0 |
| 11220.2 | -0.1 | -0.4 | -0.8 | ±4.0 |
| 11885.0 | -0.1 | -0.4 | -1.0 | ±4.0 |
| 12589.3 | -0.1 | -0.5 | -0.9 | ±4.0 |

## Frequency Response – Vertical Incidence Reference – Sides – 40° ~ 90°

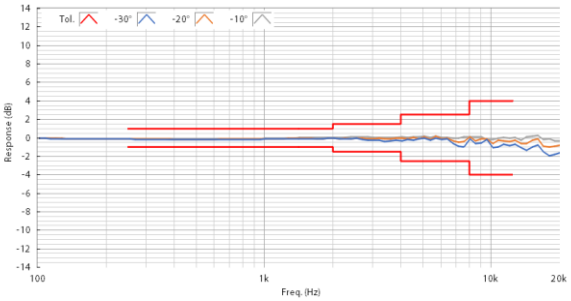
| Freq. (Hz) | 40° (dB) | 50° (dB) | 60° (dB) | 70° (dB) | 80° (dB) | 90° (dB) | Tol. (dB) |
|---|---|---|---|---|---|---|---|
| 251.189 | 0.1 | 0.0 | 0.1 | 0.0 | 0.1 | -0.0 | ±1.5 |
| 316.228 | 0.1 | 0.0 | 0.1 | 0.0 | 0.1 | -0.0 | ±1.5 |
| 398.107 | 0.1 | 0.0 | 0.1 | 0.0 | 0.1 | -0.0 | ±1.5 |
| 501.187 | 0.1 | 0.0 | 0.1 | -0.0 | 0.1 | -0.1 | ±1.5 |
| 630.957 | 0.1 | 0.0 | 0.1 | -0.0 | 0.1 | -0.1 | ±1.5 |
| 794.328 | 0.1 | 0.0 | 0.1 | -0.0 | 0.1 | -0.1 | ±1.5 |
| 1000.00 | 0.1 | 0.0 | 0.1 | -0.0 | 0.0 | -0.1 | ±2.0 |
| 1258.93 | 0.1 | 0.0 | 0.1 | -0.1 | -0.0 | -0.1 | ±2.0 |
| 1584.89 | 0.1 | 0.0 | 0.0 | -0.0 | -0.0 | -0.1 | ±2.0 |
| 1995.26 | -0.0 | -0.1 | -0.1 | -0.1 | -0.0 | -0.1 | ±2.0 |
| 2238.72 | -0.0 | -0.1 | -0.2 | -0.1 | -0.0 | -0.1 | ±4.0 |
| 2511.89 | -0.1 | -0.2 | -0.3 | -0.3 | -0.3 | -0.3 | ±4.0 |
| 2818.38 | -0.2 | -0.3 | -0.4 | -0.4 | -0.4 | -0.5 | ±4.0 |
| 3162.28 | -0.3 | -0.5 | -0.5 | -0.6 | -0.6 | -0.6 | ±4.0 |
| 3548.13 | -0.4 | -0.6 | -0.8 | -1.0 | -1.0 | -1.0 | ±4.0 |
| 3981.07 | -0.6 | -0.8 | -1.0 | -1.3 | -1.5 | -1.4 | ±4.0 |
| 4466.84 | -0.5 | -0.7 | -1.1 | -1.5 | -1.7 | -1.8 | ±7.0 |
| 5011.87 | -0.4 | -0.6 | -1.0 | -1.5 | -1.9 | -2.0 | ±7.0 |
| 5623.41 | -0.5 | -0.6 | -0.9 | -1.3 | -1.9 | -2.3 | ±7.0 |
| 6309.57 | -0.5 | -0.8 | -0.9 | -1.1 | -1.7 | -2.5 | ±7.0 |
| 7079.46 | -0.8 | -0.9 | -1.3 | -1.8 | -1.7 | -2.5 | ±7.0 |
| 7943.28 | -1.1 | -1.7 | -1.7 | -2.0 | -2.9 | -2.7 | ±7.0 |
| 8413.95 | -1.0 | -1.9 | -2.3 | -2.0 | -3.0 | -3.2 | ±10.0 |
| 8912.51 | -1.2 | -1.8 | -2.7 | -2.7 | -3.0 | -4.1 | ±10.0 |
| 9440.61 | -1.0 | -1.5 | -2.2 | -2.9 | -2.9 | -3.7 | ±10.0 |
| 10000.0 | -1.2 | -1.7 | -2.5 | -3.2 | -3.6 | -3.9 | ±10.0 |
| 10592.5 | -1.4 | -2.0 | -2.6 | -3.6 | -4.0 | -4.3 | ±10.0 |
| 11220.2 | -1.5 | -2.1 | -2.7 | -3.7 | -4.4 | -4.7 | ±10.0 |
| 11885.0 | -1.5 | -2.2 | -3.0 | -3.8 | -4.9 | -4.9 | ±10.0 |
| 12589.3 | -1.5 | -2.2 | -3.1 | -3.8 | -5.0 | -5.5 | ±10.0 |

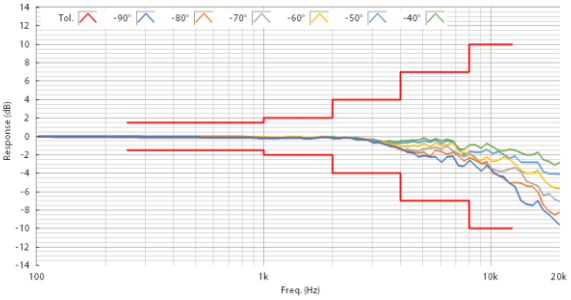
## Frequency Response – Vertical Incidence Reference – Sides – 100° ~ 150°

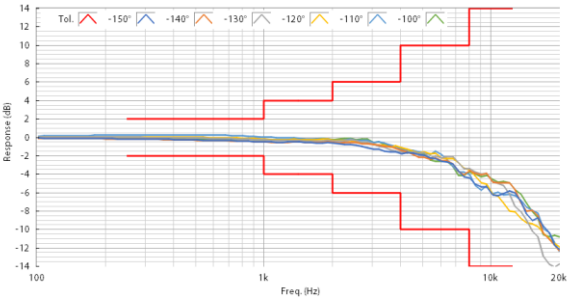
| Freq. (Hz) | 100° (dB) | 110° (dB) | 120° (dB) | 130° (dB) | 140° (dB) | 150° (dB) | Tol. (dB) |
|---|---|---|---|---|---|---|---|
| 251.189 | -0.0 | 0.0 | -0.0 | -0.0 | 0.0 | -0.1 | ±2.0 |
| 316.228 | -0.1 | 0.0 | -0.0 | -0.0 | 0.0 | -0.1 | ±2.0 |
| 398.107 | -0.1 | 0.0 | -0.0 | -0.1 | -0.0 | -0.1 | ±2.0 |
| 501.187 | -0.1 | -0.0 | -0.0 | -0.1 | -0.1 | -0.2 | ±2.0 |
| 630.957 | -0.1 | -0.0 | -0.1 | -0.1 | -0.1 | -0.2 | ±2.0 |
| 794.328 | -0.2 | -0.1 | -0.1 | -0.2 | -0.2 | -0.3 | ±2.0 |
| 1000.00 | -0.2 | -0.1 | -0.2 | -0.3 | -0.3 | -0.4 | ±4.0 |
| 1258.93 | -0.2 | -0.1 | -0.2 | -0.3 | -0.4 | -0.4 | ±4.0 |
| 1584.89 | -0.2 | -0.1 | -0.2 | -0.4 | -0.4 | -0.5 | ±4.0 |
| 1995.26 | -0.2 | -0.2 | -0.3 | -0.4 | -0.5 | -0.5 | ±4.0 |
| 2238.72 | -0.2 | -0.2 | -0.3 | -0.3 | -0.5 | -0.6 | ±6.0 |
| 2511.89 | -0.3 | -0.3 | -0.4 | -0.4 | -0.6 | -0.8 | ±6.0 |
| 2818.38 | -0.4 | -0.4 | -0.5 | -0.6 | -0.8 | -1.0 | ±6.0 |
| 3162.28 | -0.6 | -0.5 | -0.7 | -0.8 | -0.9 | -1.2 | ±6.0 |
| 3548.13 | -0.9 | -0.9 | -1.0 | -1.1 | -1.1 | -1.5 | ±6.0 |
| 3981.07 | -1.3 | -1.3 | -1.3 | -1.4 | -1.4 | -1.8 | ±6.0 |
| 4466.84 | -1.7 | -1.6 | -1.6 | -1.7 | -1.8 | -1.9 | ±10.0 |
| 5011.87 | -2.1 | -1.8 | -1.9 | -1.9 | -2.1 | -2.1 | ±10.0 |
| 5623.41 | -2.4 | -2.1 | -2.2 | -2.1 | -2.4 | -2.3 | ±10.0 |
| 6309.57 | -2.7 | -2.6 | -2.4 | -2.3 | -2.4 | -2.6 | ±10.0 |
| 7079.46 | -3.6 | -2.8 | -3.0 | -3.0 | -3.1 | -3.2 | ±10.0 |
| 7943.28 | -4.0 | -4.6 | -3.5 | -3.8 | -4.1 | -3.8 | ±10.0 |
| 8413.95 | -3.5 | -5.3 | -3.8 | -3.6 | -4.3 | -4.6 | ±14.0 |
| 8912.51 | -3.7 | -5.4 | -4.8 | -3.8 | -4.4 | -5.3 | ±14.0 |
| 9440.61 | -4.0 | -5.2 | -5.7 | -4.1 | -4.1 | -5.3 | ±14.0 |
| 10000.0 | -4.6 | -5.3 | -6.3 | -5.1 | -4.6 | -5.5 | ±14.0 |
| 10592.5 | -5.1 | -5.7 | -6.4 | -5.6 | -5.3 | -5.8 | ±14.0 |
| 11220.2 | -5.3 | -6.0 | -6.8 | -5.8 | -5.7 | -6.1 | ±14.0 |
| 11885.0 | -5.7 | -6.2 | -7.7 | -6.3 | -6.0 | -6.5 | ±14.0 |
| 12589.3 | -6.1 | -6.6 | -7.9 | -7.4 | -6.1 | -6.8 | ±14.0 |

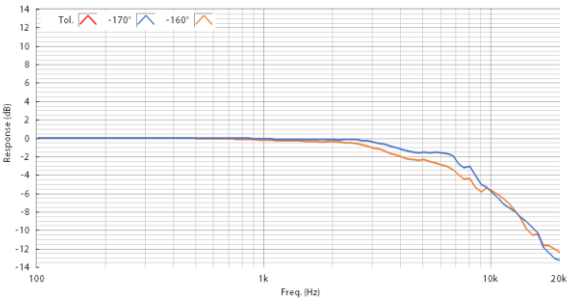
Frequency Response – Vertical Incidence Reference – Sides – 160° ~ 180°

| Freq. (Hz) | 160° (dB) | 170° (dB) | 180° (dB) |
|---|---|---|---|
| 251.189 | 0.1 | -0.0 | 0.0 |
| 316.228 | 0.1 | -0.0 | 0.0 |
| 398.107 | 0.0 | -0.0 | -0.0 |
| 501.187 | 0.0 | -0.0 | -0.0 |
| 630.957 | -0.0 | -0.0 | -0.0 |
| 794.328 | -0.1 | -0.1 | -0.1 |
| 1000.00 | -0.2 | -0.1 | -0.1 |
| 1258.93 | -0.3 | -0.1 | -0.1 |
| 1584.89 | -0.3 | -0.1 | -0.1 |
| 1995.26 | -0.4 | -0.2 | -0.1 |
| 2238.72 | -0.5 | -0.2 | -0.1 |
| 2511.89 | -0.7 | -0.3 | -0.2 |
| 2818.38 | -0.9 | -0.5 | -0.3 |
| 3162.28 | -1.1 | -0.6 | -0.5 |
| 3548.13 | -1.6 | -1.0 | -0.8 |
| 3981.07 | -2.0 | -1.4 | -1.1 |
| 4466.84 | -2.4 | -1.7 | -1.4 |
| 5011.87 | -2.6 | -1.9 | -1.5 |
| 5623.41 | -2.8 | -2.1 | -1.5 |
| 6309.57 | -3.0 | -2.3 | -1.5 |
| 7079.46 | -3.8 | -3.1 | -1.9 |
| 7943.28 | -4.3 | -4.2 | -2.9 |
| 8413.95 | -4.8 | -4.7 | -3.4 |
| 8912.51 | -5.5 | -5.6 | -4.2 |
| 9440.61 | -5.3 | -6.0 | -4.2 |
| 10000.0 | -5.7 | -6.5 | -4.6 |
| 10592.5 | -6.1 | -6.9 | -5.0 |
| 11220.2 | -6.3 | -7.2 | -5.4 |
| 11885.0 | -6.7 | -7.5 | -5.9 |
| 12589.3 | -7.2 | -7.7 | -6.0 |


Tol.
-30°
-20°
-10°
Response (dB)
Freq. (Hz)
100
1k
10k
20k


Tol.
-90°
-80°
-70°
-60°
-50°
-40°
Response (dB)
Freq. (Hz)
100
1k
10k
20k


Tol.
-150°
-140°
-130°
-120°
-110°
-100°
Response (dB)
Freq. (Hz)
100
1k
10k
20k


Tol.
-170°
-160°
Response (dB)
Freq. (Hz)
100
1k
10k
20k

## Frequency Response – Vertical Incidence Reference – Front – -30° ~ -10°

| Freq. (Hz) | -30° (dB) | -20° (dB) | -10° (dB) | Tol. (dB) |
|---|---|---|---|---|
| 251.189 | -0.0 | 0.0 | 0.0 | ±1.0 |
| 316.228 | -0.0 | 0.0 | 0.0 | ±1.0 |
| 398.107 | -0.0 | 0.0 | 0.0 | ±1.0 |
| 501.187 | -0.0 | 0.0 | 0.0 | ±1.0 |
| 630.957 | -0.0 | 0.0 | 0.0 | ±1.0 |
| 794.328 | -0.0 | 0.0 | 0.1 | ±1.0 |
| 1000.00 | -0.0 | 0.0 | 0.1 | ±1.0 |
| 1258.93 | -0.0 | 0.0 | 0.1 | ±1.0 |
| 1584.89 | -0.0 | -0.0 | 0.1 | ±1.0 |
| 1995.26 | -0.0 | -0.0 | 0.1 | ±1.0 |
| 2238.72 | -0.1 | -0.1 | 0.1 | ±1.5 |
| 2511.89 | -0.0 | -0.0 | 0.1 | ±1.5 |
| 2818.38 | -0.2 | -0.1 | 0.1 | ±1.5 |
| 3162.28 | -0.2 | -0.1 | 0.0 | ±1.5 |
| 3548.13 | -0.3 | -0.1 | 0.0 | ±1.5 |
| 3981.07 | -0.3 | -0.1 | 0.1 | ±1.5 |
| 4466.84 | -0.2 | -0.0 | 0.1 | ±2.5 |
| 5011.87 | -0.1 | 0.1 | 0.2 | ±2.5 |
| 5623.41 | -0.1 | 0.1 | 0.1 | ±2.5 |
| 6309.57 | -0.1 | -0.0 | 0.0 | ±2.5 |
| 7079.46 | -0.9 | -0.4 | -0.0 | ±2.5 |
| 7943.28 | -0.3 | -0.0 | 0.1 | ±2.5 |
| 8413.95 | -0.5 | -0.2 | 0.1 | ±4.0 |
| 8912.51 | -0.6 | -0.2 | 0.1 | ±4.0 |
| 9440.61 | -0.3 | -0.1 | -0.1 | ±4.0 |
| 10000.0 | -0.8 | -0.5 | -0.2 | ±4.0 |
| 10592.5 | -1.0 | -0.3 | -0.1 | ±4.0 |
| 11220.2 | -0.8 | -0.3 | 0.0 | ±4.0 |
| 11885.0 | -0.8 | -0.4 | 0.0 | ±4.0 |
| 12589.3 | -0.7 | -0.3 | 0.0 | ±4.0 |

## Frequency Response – Vertical Incidence Reference – Front – -90° ~ -40°

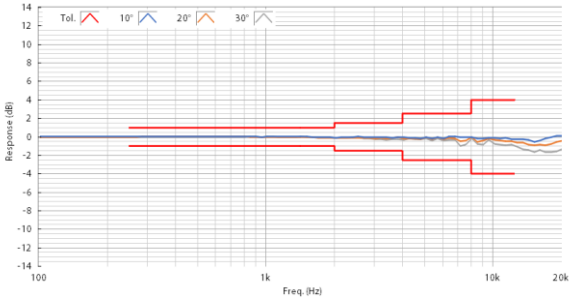
| Freq. (Hz) | -90° (dB) | -80° (dB) | -70° (dB) | -60° (dB) | -50° (dB) | -40° (dB) | Tol. (dB) |
|---|---|---|---|---|---|---|---|
| 251.189 | 0.1 | 0.1 | 0.0 | 0.2 | 0.1 | 0.1 | ±1.5 |
| 316.228 | 0.1 | 0.2 | -0.0 | 0.2 | 0.1 | 0.1 | ±1.5 |
| 398.107 | 0.1 | 0.1 | -0.0 | 0.2 | 0.1 | 0.1 | ±1.5 |
| 501.187 | 0.1 | 0.1 | -0.0 | 0.2 | 0.1 | 0.1 | ±1.5 |
| 630.957 | 0.1 | 0.1 | -0.0 | 0.2 | 0.0 | 0.1 | ±1.5 |
| 794.328 | 0.1 | 0.1 | -0.0 | 0.2 | 0.0 | 0.1 | ±1.5 |
| 1000.00 | -0.0 | 0.0 | -0.1 | 0.1 | -0.0 | 0.0 | ±2.0 |
| 1258.93 | -0.1 | -0.0 | -0.1 | 0.0 | -0.1 | 0.0 | ±2.0 |
| 1584.89 | -0.2 | -0.1 | -0.1 | -0.1 | -0.1 | -0.1 | ±2.0 |
| 1995.26 | -0.2 | -0.2 | -0.2 | -0.2 | -0.1 | -0.0 | ±2.0 |
| 2238.72 | -0.1 | -0.1 | -0.1 | -0.2 | -0.2 | -0.1 | ±4.0 |
| 2511.89 | -0.3 | -0.3 | -0.3 | -0.3 | -0.2 | -0.1 | ±4.0 |
| 2818.38 | -0.4 | -0.3 | -0.3 | -0.4 | -0.3 | -0.3 | ±4.0 |
| 3162.28 | -0.6 | -0.6 | -0.7 | -0.6 | -0.5 | -0.4 | ±4.0 |
| 3548.13 | -0.9 | -1.0 | -1.0 | -0.8 | -0.7 | -0.5 | ±4.0 |
| 3981.07 | -1.3 | -1.4 | -1.4 | -1.0 | -0.7 | -0.5 | ±4.0 |
| 4466.84 | -1.8 | -1.7 | -1.5 | -1.0 | -0.6 | -0.4 | ±7.0 |
| 5011.87 | -2.1 | -1.7 | -1.4 | -0.9 | -0.5 | -0.3 | ±7.0 |
| 5623.41 | -2.2 | -1.7 | -1.2 | -0.8 | -0.5 | -0.3 | ±7.0 |
| 6309.57 | -2.4 | -1.9 | -1.2 | -0.9 | -0.5 | -0.4 | ±7.0 |
| 7079.46 | -2.9 | -2.0 | -1.8 | -1.3 | -1.1 | -1.1 | ±7.0 |
| 7943.28 | -2.7 | -2.4 | -2.0 | -1.8 | -1.7 | -1.0 | ±7.0 |
| 8413.95 | -3.0 | -2.5 | -2.2 | -2.3 | -1.7 | -0.9 | ±10.0 |
| 8912.51 | -3.6 | -2.9 | -2.8 | -2.6 | -1.7 | -1.2 | ±10.0 |
| 9440.61 | -3.3 | -2.8 | -3.0 | -2.3 | -1.5 | -0.9 | ±10.0 |
| 10000.0 | -3.6 | -3.6 | -3.4 | -2.6 | -1.7 | -1.0 | ±10.0 |
| 10592.5 | -4.1 | -4.1 | -3.7 | -2.6 | -1.7 | -1.4 | ±10.0 |
| 11220.2 | -4.3 | -4.5 | -3.8 | -2.3 | -1.8 | -1.6 | ±10.0 |
| 11885.0 | -4.9 | -4.9 | -3.6 | -2.4 | -2.2 | -1.5 | ±10.0 |
| 12589.3 | -5.4 | -5.0 | -3.4 | -2.9 | -2.2 | -1.5 | ±10.0 |

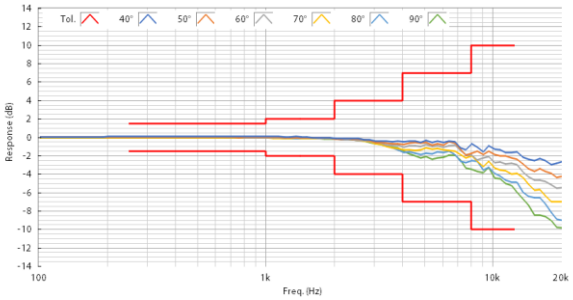
## Frequency Response – Vertical Incidence Reference – Front – -150° ~ -100°

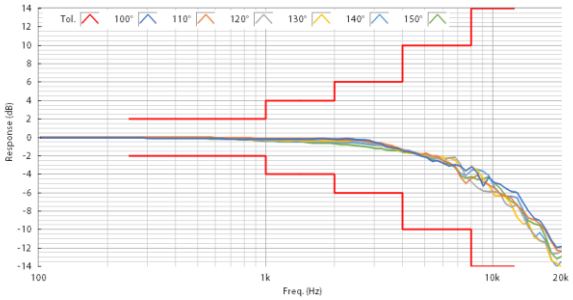
| Freq. (Hz) | -150° (dB) | -140° (dB) | -130° (dB) | -120° (dB) | -110° (dB) | -100° (dB) | Tol. (dB) |
|---|---|---|---|---|---|---|---|
| 251.189 | -0.0 | -0.0 | 0.1 | 0.2 | 0.4 | 0.0 | ±2.0 |
| 316.228 | -0.0 | -0.1 | 0.1 | 0.2 | 0.4 | 0.0 | ±2.0 |
| 398.107 | -0.1 | -0.1 | 0.1 | 0.2 | 0.4 | 0.0 | ±2.0 |
| 501.187 | -0.1 | -0.1 | 0.1 | 0.2 | 0.4 | 0.0 | ±2.0 |
| 630.957 | -0.2 | -0.2 | 0.1 | 0.1 | 0.4 | -0.0 | ±2.0 |
| 794.328 | -0.2 | -0.2 | -0.0 | 0.1 | 0.3 | -0.0 | ±2.0 |
| 1000.00 | -0.4 | -0.4 | -0.1 | -0.1 | 0.2 | -0.1 | ±4.0 |
| 1258.93 | -0.4 | -0.5 | -0.3 | -0.1 | 0.0 | -0.1 | ±4.0 |
| 1584.89 | -0.5 | -0.5 | -0.4 | -0.2 | -0.2 | -0.2 | ±4.0 |
| 1995.26 | -0.6 | -0.5 | -0.4 | -0.3 | -0.3 | -0.2 | ±4.0 |
| 2238.72 | -0.8 | -0.6 | -0.4 | -0.3 | -0.3 | -0.1 | ±6.0 |
| 2511.89 | -0.8 | -0.5 | -0.3 | -0.4 | -0.3 | -0.2 | ±6.0 |
| 2818.38 | -1.1 | -0.7 | -0.5 | -0.5 | -0.3 | -0.2 | ±6.0 |
| 3162.28 | -1.3 | -0.8 | -0.9 | -0.8 | -0.5 | -0.5 | ±6.0 |
| 3548.13 | -1.5 | -1.0 | -1.3 | -1.0 | -0.8 | -0.9 | ±6.0 |
| 3981.07 | -1.7 | -1.4 | -1.5 | -1.1 | -1.2 | -1.1 | ±6.0 |
| 4466.84 | -1.7 | -1.8 | -1.6 | -1.5 | -1.4 | -1.5 | ±10.0 |
| 5011.87 | -1.9 | -2.1 | -1.7 | -1.6 | -1.6 | -1.8 | ±10.0 |
| 5623.41 | -2.3 | -2.3 | -2.0 | -1.8 | -1.6 | -2.5 | ±10.0 |
| 6309.57 | -2.6 | -2.5 | -2.1 | -2.3 | -2.3 | -2.6 | ±10.0 |
| 7079.46 | -3.4 | -3.5 | -2.5 | -2.6 | -3.6 | -3.9 | ±10.0 |
| 7943.28 | -4.4 | -3.7 | -3.4 | -3.5 | -4.0 | -3.9 | ±10.0 |
| 8413.95 | -4.9 | -3.9 | -3.6 | -4.0 | -4.9 | -3.9 | ±14.0 |
| 8912.51 | -5.3 | -4.0 | -3.9 | -4.8 | -5.6 | -4.2 | ±14.0 |
| 9440.61 | -5.4 | -4.0 | -3.9 | -5.0 | -5.4 | -4.1 | ±14.0 |
| 10000.0 | -6.0 | -4.6 | -4.6 | -5.9 | -5.9 | -4.5 | ±14.0 |
| 10592.5 | -6.3 | -4.9 | -4.9 | -6.4 | -6.0 | -4.8 | ±14.0 |
| 11220.2 | -6.2 | -4.9 | -5.2 | -7.0 | -6.2 | -4.8 | ±14.0 |
| 11885.0 | -5.9 | -4.9 | -5.9 | -7.8 | -6.2 | -4.9 | ±14.0 |
| 12589.3 | -6.0 | -5.5 | -7.2 | -8.1 | -6.3 | -5.5 | ±14.0 |

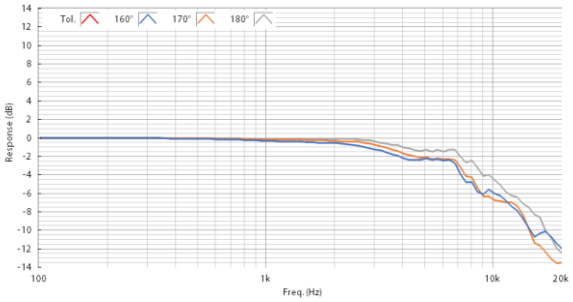
## Frequency Response – Vertical Incidence Reference – Front – -170° ~ -160°

| Freq. (Hz) | -170° (dB) | -160° (dB) |
|---|---|---|
| 251.189 | 0.1 | 0.0 |
| 316.228 | 0.1 | 0.0 |
| 398.107 | 0.1 | 0.0 |
| 501.187 | 0.1 | -0.0 |
| 630.957 | 0.0 | -0.0 |
| 794.328 | 0.0 | -0.1 |
| 1000.00 | -0.0 | -0.2 |
| 1258.93 | -0.1 | -0.3 |
| 1584.89 | -0.1 | -0.3 |
| 1995.26 | -0.1 | -0.4 |
| 2238.72 | -0.1 | -0.5 |
| 2511.89 | -0.1 | -0.5 |
| 2818.38 | -0.3 | -0.8 |
| 3162.28 | -0.5 | -1.1 |
| 3548.13 | -0.8 | -1.5 |
| 3981.07 | -1.1 | -2.0 |
| 4466.84 | -1.4 | -2.3 |
| 5011.87 | -1.5 | -2.3 |
| 5623.41 | -1.5 | -2.6 |
| 6309.57 | -1.6 | -3.0 |
| 7079.46 | -2.5 | -3.8 |
| 7943.28 | -3.1 | -4.4 |
| 8413.95 | -3.7 | -5.1 |
| 8912.51 | -4.7 | -5.7 |
| 9440.61 | -5.2 | -5.5 |
| 10000.0 | -5.8 | -5.6 |
| 10592.5 | -6.3 | -6.0 |
| 11220.2 | -7.0 | -6.4 |
| 11885.0 | -7.4 | -7.0 |
| 12589.3 | -7.9 | -7.7 |


Tol.
10°
20°
30°
Response (dB)
Freq. (Hz)
100
1k
10k
20k


Tol.
40°
50°
60°
70°
80°
90°
Response (dB)
Freq. (Hz)
100
1k
10k
20k


Tol.
100°
110°
120°
130°
140°
150°
Response (dB)
Freq. (Hz)
100
1k
10k
20k


Tol.
160°
170°
180°
Response (dB)
Freq. (Hz)
100
1k
10k
20k

## Frequency Response – Vertical Incidence Reference – Back – 10° ~ 30°

| Freq. (Hz) | 10° (dB) | 20° (dB) | 30° (dB) | Tol. (dB) |
|---|---|---|---|---|
| 251.189 | 0.0 | -0.0 | -0.0 | ±1.0 |
| 316.228 | 0.0 | 0.0 | -0.0 | ±1.0 |
| 398.107 | 0.0 | 0.0 | -0.0 | ±1.0 |
| 501.187 | 0.0 | 0.0 | -0.0 | ±1.0 |
| 630.957 | 0.0 | 0.0 | -0.0 | ±1.0 |
| 794.328 | 0.0 | 0.0 | -0.0 | ±1.0 |
| 1000.00 | 0.0 | -0.0 | -0.0 | ±1.0 |
| 1258.93 | 0.0 | -0.0 | -0.0 | ±1.0 |
| 1584.89 | -0.0 | -0.1 | -0.0 | ±1.0 |
| 1995.26 | -0.1 | -0.1 | -0.1 | ±1.0 |
| 2238.72 | -0.1 | -0.1 | -0.1 | ±1.5 |
| 2511.89 | 0.0 | -0.1 | -0.1 | ±1.5 |
| 2818.38 | -0.0 | -0.1 | -0.2 | ±1.5 |
| 3162.28 | -0.0 | -0.1 | -0.3 | ±1.5 |
| 3548.13 | -0.1 | -0.1 | -0.3 | ±1.5 |
| 3981.07 | -0.1 | -0.2 | -0.3 | ±1.5 |
| 4466.84 | -0.1 | -0.2 | -0.2 | ±2.5 |
| 5011.87 | -0.0 | -0.1 | -0.2 | ±2.5 |
| 5623.41 | -0.0 | -0.1 | -0.3 | ±2.5 |
| 6309.57 | -0.0 | -0.2 | -0.3 | ±2.5 |
| 7079.46 | -0.0 | -0.4 | -0.8 | ±2.5 |
| 7943.28 | -0.0 | -0.2 | -0.4 | ±2.5 |
| 8413.95 | -0.1 | -0.4 | -0.6 | ±4.0 |
| 8912.51 | -0.1 | -0.5 | -0.8 | ±4.0 |
| 9440.61 | -0.1 | -0.3 | -0.5 | ±4.0 |
| 10000.0 | -0.1 | -0.3 | -0.6 | ±4.0 |
| 10592.5 | -0.2 | -0.4 | -0.8 | ±4.0 |
| 11220.2 | -0.1 | -0.4 | -0.9 | ±4.0 |
| 11885.0 | -0.2 | -0.5 | -0.9 | ±4.0 |
| 12589.3 | -0.2 | -0.6 | -1.0 | ±4.0 |

## Frequency Response – Vertical Incidence Reference – Back – 40° ~ 90°

| Freq. (Hz) | 40° (dB) | 50° (dB) | 60° (dB) | 70° (dB) | 80° (dB) | 90° (dB) | Tol. (dB) |
|---|---|---|---|---|---|---|---|
| 251.189 | 0.1 | 0.0 | 0.0 | -0.0 | 0.0 | -0.0 | ±1.5 |
| 316.228 | 0.1 | 0.0 | 0.0 | -0.0 | 0.0 | -0.0 | ±1.5 |
| 398.107 | 0.1 | 0.0 | 0.0 | -0.0 | 0.0 | -0.0 | ±1.5 |
| 501.187 | 0.1 | 0.0 | 0.0 | -0.0 | 0.0 | -0.0 | ±1.5 |
| 630.957 | 0.1 | 0.0 | 0.0 | -0.0 | 0.0 | -0.0 | ±1.5 |
| 794.328 | 0.1 | -0.0 | 0.0 | -0.0 | -0.0 | -0.0 | ±1.5 |
| 1000.00 | 0.1 | 0.0 | -0.0 | -0.1 | -0.1 | -0.1 | ±2.0 |
| 1258.93 | 0.1 | -0.0 | -0.0 | -0.1 | -0.1 | -0.1 | ±2.0 |
| 1584.89 | -0.0 | -0.0 | -0.1 | -0.1 | -0.1 | -0.1 | ±2.0 |
| 1995.26 | -0.1 | -0.1 | -0.2 | -0.2 | -0.1 | -0.2 | ±2.0 |
| 2238.72 | -0.1 | -0.1 | -0.2 | -0.2 | -0.1 | -0.2 | ±4.0 |
| 2511.89 | -0.1 | -0.2 | -0.3 | -0.3 | -0.3 | -0.3 | ±4.0 |
| 2818.38 | -0.3 | -0.3 | -0.4 | -0.5 | -0.4 | -0.5 | ±4.0 |
| 3162.28 | -0.4 | -0.5 | -0.6 | -0.7 | -0.7 | -0.7 | ±4.0 |
| 3548.13 | -0.5 | -0.7 | -0.8 | -1.1 | -1.1 | -1.0 | ±4.0 |
| 3981.07 | -0.5 | -0.8 | -1.0 | -1.3 | -1.6 | -1.4 | ±4.0 |
| 4466.84 | -0.4 | -0.6 | -0.9 | -1.4 | -1.7 | -1.9 | ±7.0 |
| 5011.87 | -0.4 | -0.6 | -0.8 | -1.2 | -1.7 | -2.1 | ±7.0 |
| 5623.41 | -0.4 | -0.7 | -0.9 | -1.2 | -1.6 | -2.3 | ±7.0 |
| 6309.57 | -0.4 | -0.6 | -1.0 | -1.4 | -1.6 | -2.0 | ±7.0 |
| 7079.46 | -1.0 | -1.1 | -1.3 | -1.7 | -2.4 | -2.3 | ±7.0 |
| 7943.28 | -0.8 | -1.7 | -1.9 | -2.0 | -2.6 | -3.4 | ±7.0 |
| 8413.95 | -1.0 | -1.6 | -2.3 | -2.5 | -2.6 | -3.7 | ±10.0 |
| 8912.51 | -1.4 | -1.8 | -2.3 | -3.1 | -3.3 | -3.8 | ±10.0 |
| 9440.61 | -1.1 | -1.6 | -2.1 | -2.8 | -3.3 | -3.4 | ±10.0 |
| 10000.0 | -1.2 | -1.8 | -2.6 | -3.1 | -3.8 | -4.1 | ±10.0 |
| 10592.5 | -1.3 | -2.0 | -2.7 | -3.5 | -4.1 | -4.5 | ±10.0 |
| 11220.2 | -1.6 | -2.0 | -2.8 | -3.6 | -4.5 | -4.9 | ±10.0 |
| 11885.0 | -1.6 | -2.2 | -2.8 | -3.9 | -4.8 | -5.2 | ±10.0 |
| 12589.3 | -1.6 | -2.4 | -2.9 | -4.0 | -4.9 | -5.8 | ±10.0 |

## Frequency Response – Vertical Incidence Reference – Back – 100° ~ 150°

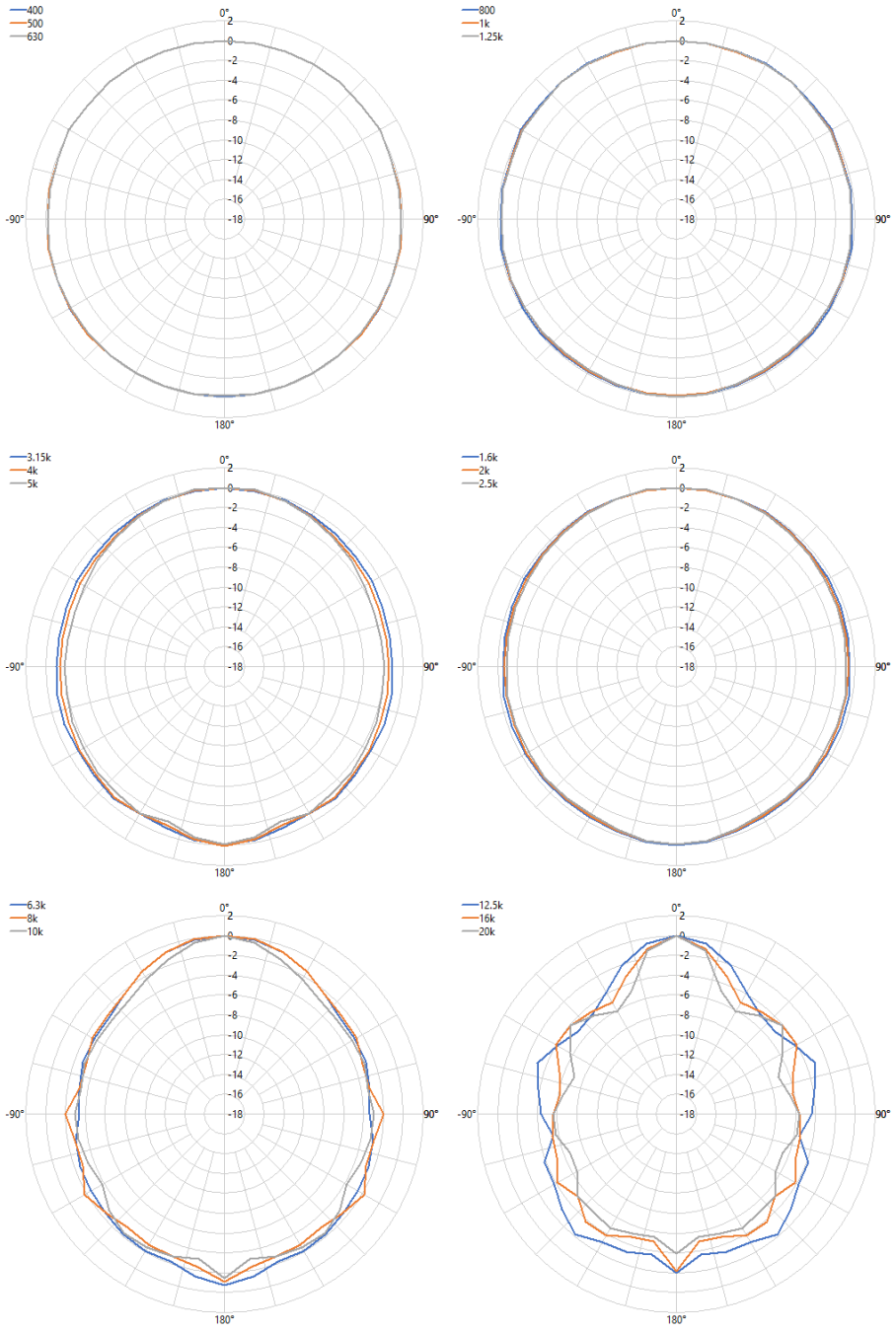
| Freq. (Hz) | 100° (dB) | 110° (dB) | 120° (dB) | 130° (dB) | 140° (dB) | 150° (dB) | Tol. (dB) |
|---|---|---|---|---|---|---|---|
| 251.189 | -0.1 | 0.0 | -0.0 | -0.0 | -0.0 | -0.1 | ±2.0 |
| 316.228 | -0.1 | 0.0 | -0.0 | -0.0 | -0.0 | -0.1 | ±2.0 |
| 398.107 | -0.1 | 0.0 | -0.0 | -0.1 | -0.0 | -0.1 | ±2.0 |
| 501.187 | -0.1 | 0.0 | -0.1 | -0.1 | -0.1 | -0.1 | ±2.0 |
| 630.957 | -0.1 | -0.0 | -0.1 | -0.1 | -0.1 | -0.2 | ±2.0 |
| 794.328 | -0.2 | -0.0 | -0.2 | -0.2 | -0.2 | -0.3 | ±2.0 |
| 1000.00 | -0.2 | -0.1 | -0.3 | -0.3 | -0.4 | -0.4 | ±4.0 |
| 1258.93 | -0.2 | -0.1 | -0.3 | -0.4 | -0.5 | -0.5 | ±4.0 |
| 1584.89 | -0.2 | -0.1 | -0.2 | -0.4 | -0.5 | -0.6 | ±4.0 |
| 1995.26 | -0.2 | -0.2 | -0.3 | -0.4 | -0.6 | -0.7 | ±4.0 |
| 2238.72 | -0.2 | -0.2 | -0.3 | -0.4 | -0.6 | -0.8 | ±6.0 |
| 2511.89 | -0.2 | -0.2 | -0.4 | -0.4 | -0.6 | -0.9 | ±6.0 |
| 2818.38 | -0.3 | -0.4 | -0.5 | -0.5 | -0.7 | -1.1 | ±6.0 |
| 3162.28 | -0.6 | -0.6 | -0.8 | -0.8 | -0.8 | -1.2 | ±6.0 |
| 3548.13 | -1.1 | -0.9 | -1.1 | -1.2 | -1.1 | -1.4 | ±6.0 |
| 3981.07 | -1.4 | -1.4 | -1.3 | -1.5 | -1.5 | -1.6 | ±6.0 |
| 4466.84 | -1.7 | -1.7 | -1.6 | -1.7 | -1.8 | -1.7 | ±10.0 |
| 5011.87 | -2.2 | -1.8 | -1.8 | -1.9 | -2.0 | -2.1 | ±10.0 |
| 5623.41 | -2.5 | -2.0 | -2.2 | -2.1 | -2.2 | -2.5 | ±10.0 |
| 6309.57 | -3.0 | -2.7 | -2.3 | -2.2 | -2.7 | -2.9 | ±10.0 |
| 7079.46 | -3.1 | -4.0 | -2.7 | -3.0 | -3.7 | -3.9 | ±10.0 |
| 7943.28 | -3.3 | -4.6 | -4.7 | -3.3 | -3.7 | -4.3 | ±10.0 |
| 8413.95 | -3.7 | -4.2 | -5.3 | -3.4 | -3.5 | -4.5 | ±14.0 |
| 8912.51 | -4.9 | -4.6 | -5.7 | -4.3 | -3.7 | -4.5 | ±14.0 |
| 9440.61 | -4.6 | -5.0 | -5.9 | -5.0 | -4.0 | -4.4 | ±14.0 |
| 10000.0 | -4.8 | -5.4 | -5.9 | -6.0 | -5.1 | -4.8 | ±14.0 |
| 10592.5 | -5.1 | -6.0 | -6.1 | -6.4 | -5.9 | -5.4 | ±14.0 |
| 11220.2 | -5.4 | -6.3 | -6.9 | -6.4 | -6.3 | -6.1 | ±14.0 |
| 11885.0 | -5.8 | -6.5 | -7.5 | -7.1 | -6.4 | -6.8 | ±14.0 |
| 12589.3 | -6.0 | -7.2 | -7.4 | -8.3 | -6.5 | -7.2 | ±14.0 |

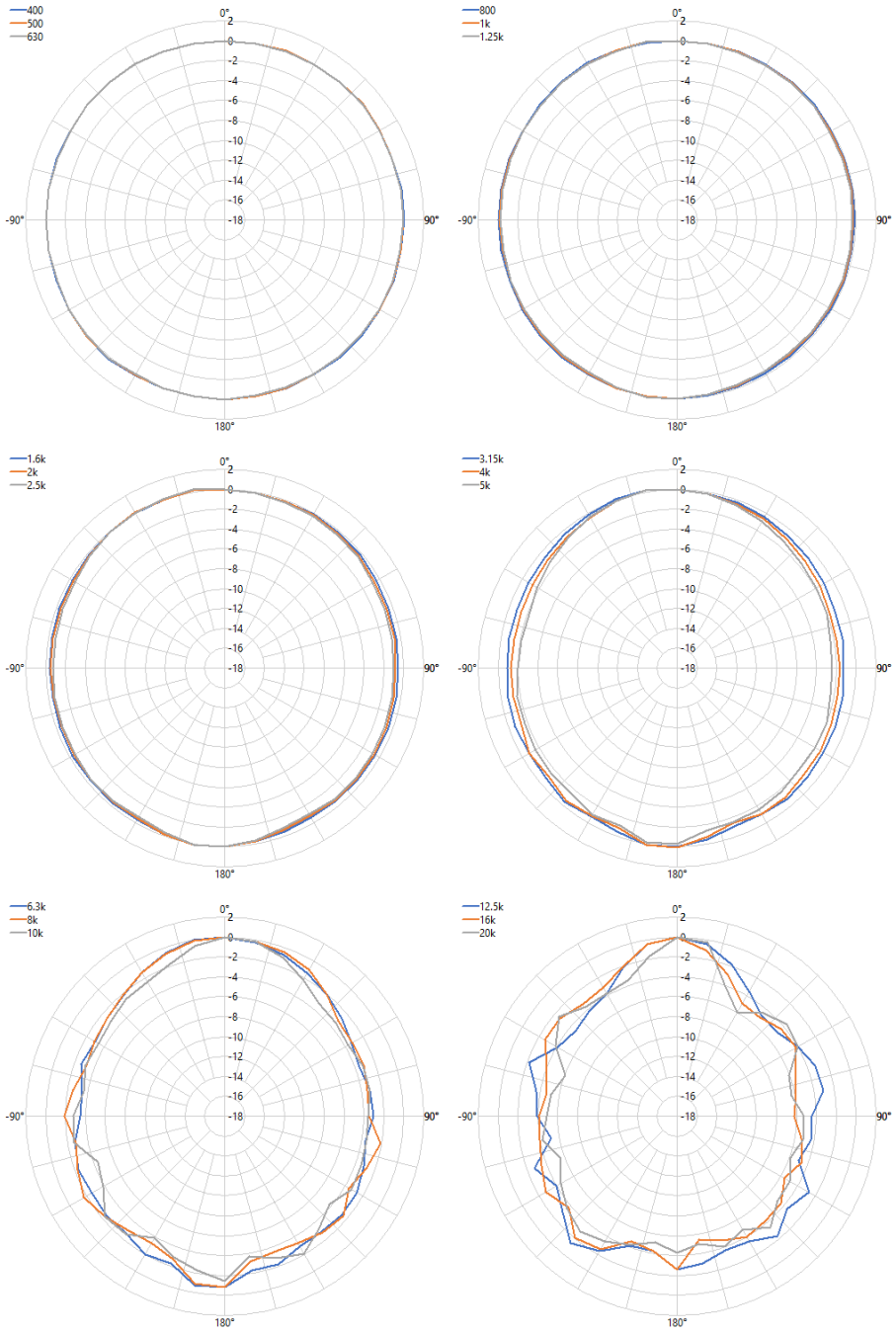
Frequency Response – Vertical Incidence Reference – Back – 160° ~ 180°

| Freq. (Hz) | 160° (dB) | 170° (dB) | 180° (dB) |
|---|---|---|---|
| 251.189 | -0.0 | -0.0 | 0.0 |
| 316.228 | -0.1 | -0.0 | 0.0 |
| 398.107 | -0.1 | -0.0 | -0.0 |
| 501.187 | -0.1 | -0.1 | -0.0 |
| 630.957 | -0.2 | -0.1 | -0.0 |
| 794.328 | -0.2 | -0.1 | -0.1 |
| 1000.00 | -0.3 | -0.2 | -0.1 |
| 1258.93 | -0.4 | -0.2 | -0.2 |
| 1584.89 | -0.5 | -0.3 | -0.1 |
| 1995.26 | -0.6 | -0.3 | -0.1 |
| 2238.72 | -0.7 | -0.4 | -0.1 |
| 2511.89 | -0.8 | -0.4 | -0.2 |
| 2818.38 | -1.1 | -0.6 | -0.3 |
| 3162.28 | -1.3 | -0.9 | -0.5 |
| 3548.13 | -1.7 | -1.2 | -0.7 |
| 3981.07 | -2.1 | -1.6 | -1.0 |
| 4466.84 | -2.4 | -2.0 | -1.3 |
| 5011.87 | -2.3 | -2.1 | -1.3 |
| 5623.41 | -2.3 | -2.2 | -1.3 |
| 6309.57 | -2.4 | -2.3 | -1.3 |
| 7079.46 | -3.6 | -3.0 | -1.8 |
| 7943.28 | -4.8 | -4.2 | -2.5 |
| 8413.95 | -5.5 | -5.1 | -3.0 |
| 8912.51 | -6.0 | -6.1 | -3.9 |
| 9440.61 | -5.7 | -6.3 | -4.0 |
| 10000.0 | -5.9 | -6.6 | -4.5 |
| 10592.5 | -6.2 | -6.8 | -5.0 |
| 11220.2 | -6.6 | -6.9 | -5.7 |
| 11885.0 | -7.2 | -7.0 | -6.1 |
| 12589.3 | -7.7 | -7.3 | -6.4 |

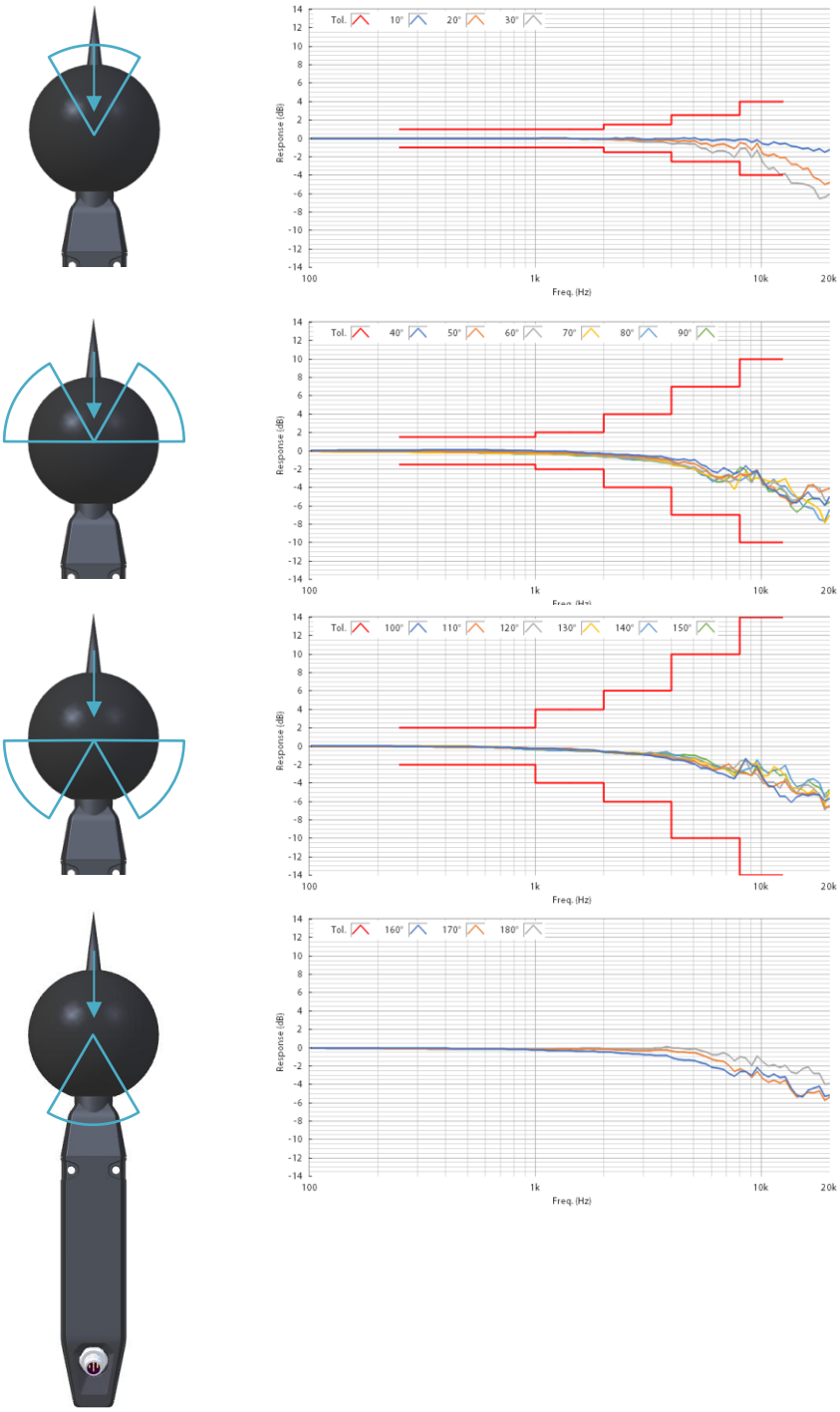
### 8.7.2 BirdSpike and Windscreen

Polar Diagrams




400
500
630
800
1k
1.25k
1.6k
2k
2.5k
3.15k
4k
5k
6.3k
8k
10k
12.5k
16k
20k
0°
90°
-90°
180°
2
0
-2
-4
-6
-8
-10
-12
-14
-16
-18

## Frequency Response – Vertical Incidence Reference



## Frequency Response – Vertical Incidence Reference – Sides – 10° ~ 30°

| Freq. (Hz) | 10° (dB) | 20° (dB) | 30° (dB) | Tol. (dB) |
|---|---|---|---|---|
| 251.189 | -0.1 | -0.0 | 0.0 | ±1.0 |
| 316.228 | -0.1 | -0.0 | 0.0 | ±1.0 |
| 398.107 | -0.1 | -0.1 | 0.0 | ±1.0 |
| 501.187 | -0.1 | -0.1 | 0.0 | ±1.0 |
| 630.957 | -0.0 | -0.0 | 0.0 | ±1.0 |
| 794.328 | -0.0 | -0.0 | 0.0 | ±1.0 |
| 1000.00 | -0.0 | -0.1 | 0.0 | ±1.0 |
| 1258.93 | 0.0 | -0.0 | -0.0 | ±1.0 |
| 1584.89 | -0.0 | -0.1 | -0.1 | ±1.0 |
| 1995.26 | -0.0 | -0.1 | -0.1 | ±1.0 |
| 2238.72 | 0.0 | -0.1 | -0.2 | ±1.5 |
| 2511.89 | 0.0 | -0.1 | -0.2 | ±1.5 |
| 2818.38 | 0.0 | -0.2 | -0.3 | ±1.5 |
| 3162.28 | -0.1 | -0.2 | -0.4 | ±1.5 |
| 3548.13 | -0.1 | -0.2 | -0.4 | ±1.5 |
| 3981.07 | -0.0 | -0.3 | -0.6 | ±1.5 |
| 4466.84 | 0.0 | -0.3 | -0.5 | ±2.5 |
| 5011.87 | 0.0 | -0.3 | -0.6 | ±2.5 |
| 5623.41 | -0.1 | -0.6 | -1.1 | ±2.5 |
| 6309.57 | -0.2 | -0.7 | -1.4 | ±2.5 |
| 7079.46 | -0.2 | -0.8 | -1.5 | ±2.5 |
| 7943.28 | -0.1 | -0.6 | -1.4 | ±2.5 |
| 8413.95 | -0.1 | -0.6 | -1.1 | ±4.0 |
| 8912.51 | -0.3 | -1.1 | -1.8 | ±4.0 |
| 9440.61 | -0.2 | -0.7 | -1.5 | ±4.0 |
| 10000.0 | -0.5 | -1.4 | -2.3 | ±4.0 |
| 10592.5 | -0.6 | -1.8 | -3.2 | ±4.0 |
| 11220.2 | -0.5 | -1.8 | -3.2 | ±4.0 |
| 11885.0 | -0.6 | -2.0 | -3.7 | ±4.0 |
| 12589.3 | -0.6 | -2.1 | -3.9 | ±4.0 |

## Frequency Response – Vertical Incidence Reference – Sides – 40° ~ 90°

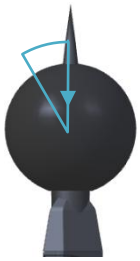
| Freq. (Hz) | 40° (dB) | 50° (dB) | 60° (dB) | 70° (dB) | 80° (dB) | 90° (dB) | Tol. (dB) |
|---|---|---|---|---|---|---|---|
| 251.189 | 0.1 | -0.1 | 0.1 | -0.1 | -0.1 | -0.1 | ±1.5 |
| 316.228 | 0.1 | -0.1 | 0.1 | -0.2 | -0.1 | -0.2 | ±1.5 |
| 398.107 | 0.1 | -0.1 | 0.1 | -0.2 | -0.1 | -0.2 | ±1.5 |
| 501.187 | 0.1 | -0.1 | 0.1 | -0.2 | -0.1 | -0.2 | ±1.5 |
| 630.957 | 0.1 | -0.1 | 0.1 | -0.2 | -0.2 | -0.2 | ±1.5 |
| 794.328 | 0.0 | -0.1 | 0.0 | -0.2 | -0.2 | -0.3 | ±1.5 |
| 1000.00 | 0.0 | -0.2 | -0.0 | -0.3 | -0.3 | -0.4 | ±2.0 |
| 1258.93 | -0.0 | -0.2 | -0.1 | -0.4 | -0.3 | -0.4 | ±2.0 |
| 1584.89 | -0.2 | -0.3 | -0.3 | -0.4 | -0.5 | -0.5 | ±2.0 |
| 1995.26 | -0.3 | -0.4 | -0.6 | -0.6 | -0.6 | -0.7 | ±2.0 |
| 2238.72 | -0.4 | -0.5 | -0.6 | -0.6 | -0.7 | -0.7 | ±4.0 |
| 2511.89 | -0.4 | -0.5 | -0.7 | -0.8 | -0.9 | -0.9 | ±4.0 |
| 2818.38 | -0.4 | -0.6 | -0.8 | -0.8 | -0.9 | -1.0 | ±4.0 |
| 3162.28 | -0.6 | -0.8 | -0.9 | -1.0 | -1.1 | -1.1 | ±4.0 |
| 3548.13 | -0.6 | -0.9 | -1.0 | -1.2 | -1.2 | -1.2 | ±4.0 |
| 3981.07 | -0.9 | -1.1 | -1.2 | -1.5 | -1.5 | -1.4 | ±4.0 |
| 4466.84 | -0.9 | -1.2 | -1.6 | -1.7 | -1.7 | -1.7 | ±7.0 |
| 5011.87 | -1.0 | -1.4 | -1.8 | -2.0 | -2.0 | -1.9 | ±7.0 |
| 5623.41 | -1.6 | -2.0 | -2.2 | -2.6 | -2.7 | -2.6 | ±7.0 |
| 6309.57 | -2.3 | -2.9 | -2.8 | -2.8 | -3.2 | -3.4 | ±7.0 |
| 7079.46 | -2.1 | -2.7 | -3.4 | -3.2 | -2.6 | -3.0 | ±7.0 |
| 7943.28 | -2.3 | -2.6 | -2.6 | -3.2 | -3.2 | -2.0 | ±7.0 |
| 8413.95 | -1.8 | -2.6 | -2.8 | -2.5 | -3.0 | -2.0 | ±10.0 |
| 8912.51 | -2.2 | -2.5 | -3.3 | -2.9 | -2.7 | -3.0 | ±10.0 |
| 9440.61 | -2.3 | -2.2 | -2.5 | -3.0 | -2.3 | -2.4 | ±10.0 |
| 10000.0 | -3.0 | -3.2 | -3.1 | -3.1 | -3.4 | -3.0 | ±10.0 |
| 10592.5 | -3.9 | -3.8 | -3.9 | -3.3 | -3.6 | -4.1 | ±10.0 |
| 11220.2 | -4.3 | -4.0 | -3.6 | -3.4 | -3.2 | -4.4 | ±10.0 |
| 11885.0 | -4.7 | -4.7 | -3.7 | -3.4 | -3.6 | -4.2 | ±10.0 |
| 12589.3 | -4.9 | -5.1 | -4.3 | -3.1 | -3.8 | -4.3 | ±10.0 |

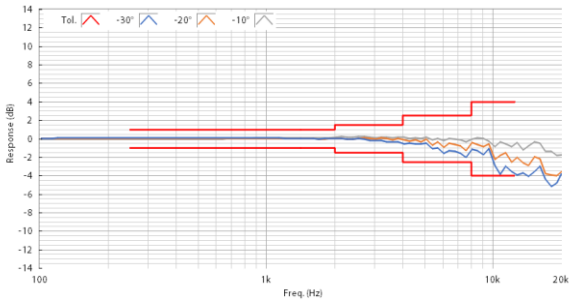
## Frequency Response – Vertical Incidence Reference – Sides – 100° ~ 150°

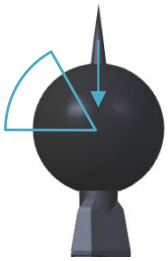
| Freq. (Hz) | 100° (dB) | 110° (dB) | 120° (dB) | 130° (dB) | 140° (dB) | 150° (dB) | Tol. (dB) |
|---|---|---|---|---|---|---|---|
| 251.189 | -0.0 | -0.1 | 0.0 | 0.0 | -0.0 | -0.0 | ±2.0 |
| 316.228 | -0.0 | -0.1 | -0.0 | 0.0 | -0.0 | -0.1 | ±2.0 |
| 398.107 | -0.0 | -0.1 | -0.0 | 0.0 | -0.0 | -0.1 | ±2.0 |
| 501.187 | -0.1 | -0.1 | -0.0 | 0.0 | -0.1 | -0.1 | ±2.0 |
| 630.957 | -0.1 | -0.1 | -0.1 | -0.0 | -0.1 | -0.1 | ±2.0 |
| 794.328 | -0.2 | -0.2 | -0.1 | -0.1 | -0.2 | -0.2 | ±2.0 |
| 1000.00 | -0.3 | -0.2 | -0.3 | -0.3 | -0.4 | -0.4 | ±4.0 |
| 1258.93 | -0.3 | -0.3 | -0.3 | -0.4 | -0.5 | -0.4 | ±4.0 |
| 1584.89 | -0.4 | -0.4 | -0.4 | -0.5 | -0.5 | -0.5 | ±4.0 |
| 1995.26 | -0.6 | -0.6 | -0.6 | -0.6 | -0.6 | -0.6 | ±4.0 |
| 2238.72 | -0.6 | -0.7 | -0.6 | -0.6 | -0.7 | -0.7 | ±6.0 |
| 2511.89 | -0.8 | -0.8 | -0.8 | -0.7 | -0.7 | -0.8 | ±6.0 |
| 2818.38 | -0.8 | -0.8 | -0.9 | -0.7 | -0.7 | -0.9 | ±6.0 |
| 3162.28 | -1.0 | -0.9 | -1.0 | -0.9 | -0.7 | -0.9 | ±6.0 |
| 3548.13 | -1.2 | -1.1 | -1.0 | -0.9 | -0.7 | -0.9 | ±6.0 |
| 3981.07 | -1.4 | -1.4 | -1.1 | -1.1 | -0.8 | -0.9 | ±6.0 |
| 4466.84 | -1.6 | -1.5 | -1.4 | -1.3 | -1.1 | -0.9 | ±10.0 |
| 5011.87 | -1.9 | -1.7 | -1.6 | -1.4 | -1.3 | -1.0 | ±10.0 |
| 5623.41 | -2.4 | -2.1 | -2.2 | -1.8 | -1.7 | -1.4 | ±10.0 |
| 6309.57 | -2.8 | -2.5 | -2.5 | -2.4 | -2.2 | -2.1 | ±10.0 |
| 7079.46 | -3.3 | -2.0 | -2.3 | -2.7 | -2.6 | -2.5 | ±10.0 |
| 7943.28 | -2.7 | -2.8 | -1.8 | -2.5 | -3.0 | -2.7 | ±10.0 |
| 8413.95 | -1.7 | -2.9 | -1.5 | -1.7 | -2.6 | -2.8 | ±14.0 |
| 8912.51 | -1.9 | -3.1 | -2.5 | -1.8 | -2.4 | -3.1 | ±14.0 |
| 9440.61 | -2.2 | -2.6 | -3.0 | -1.9 | -1.7 | -2.3 | ±14.0 |
| 10000.0 | -3.1 | -3.4 | -3.8 | -2.9 | -2.3 | -2.5 | ±14.0 |
| 10592.5 | -4.1 | -4.3 | -3.9 | -3.2 | -2.8 | -2.8 | ±14.0 |
| 11220.2 | -4.4 | -4.4 | -3.9 | -2.4 | -2.7 | -2.7 | ±14.0 |
| 11885.0 | -5.2 | -4.1 | -4.4 | -2.5 | -2.6 | -3.0 | ±14.0 |
| 12589.3 | -5.4 | -3.9 | -3.8 | -3.0 | -2.2 | -3.0 | ±14.0 |

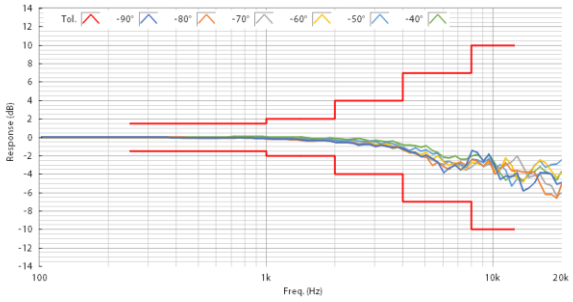
## Frequency Response – Vertical Incidence Reference – Sides – 160° ~ 180°

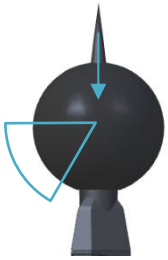
| Freq. (Hz) | 160° (dB) | 170° (dB) | 180° (dB) |
|---|---|---|---|
| 251.189 | -0.0 | -0.1 | -0.1 |
| 316.228 | -0.0 | -0.1 | -0.1 |
| 398.107 | -0.1 | -0.1 | -0.2 |
| 501.187 | -0.1 | -0.1 | -0.2 |
| 630.957 | -0.1 | -0.1 | -0.2 |
| 794.328 | -0.2 | -0.1 | -0.2 |
| 1000.00 | -0.3 | -0.2 | -0.2 |
| 1258.93 | -0.3 | -0.1 | -0.1 |
| 1584.89 | -0.4 | -0.2 | -0.1 |
| 1995.26 | -0.5 | -0.2 | -0.1 |
| 2238.72 | -0.5 | -0.2 | -0.1 |
| 2511.89 | -0.6 | -0.2 | -0.1 |
| 2818.38 | -0.7 | -0.3 | -0.1 |
| 3162.28 | -0.7 | -0.3 | -0.1 |
| 3548.13 | -0.8 | -0.3 | -0.0 |
| 3981.07 | -1.0 | -0.3 | 0.0 |
| 4466.84 | -1.3 | -0.5 | -0.1 |
| 5011.87 | -1.4 | -0.5 | -0.1 |
| 5623.41 | -1.8 | -0.9 | -0.4 |
| 6309.57 | -2.2 | -1.4 | -0.7 |
| 7079.46 | -2.7 | -1.8 | -0.8 |
| 7943.28 | -2.7 | -2.4 | -1.1 |
| 8413.95 | -2.6 | -2.5 | -1.1 |
| 8912.51 | -2.9 | -3.1 | -1.7 |
| 9440.61 | -2.4 | -2.8 | -1.2 |
| 10000.0 | -2.7 | -3.2 | -1.4 |
| 10592.5 | -3.1 | -3.7 | -1.9 |
| 11220.2 | -2.9 | -3.6 | -1.9 |
| 11885.0 | -3.1 | -3.7 | -2.1 |
| 12589.3 | -3.2 | -3.6 | -2.0 |

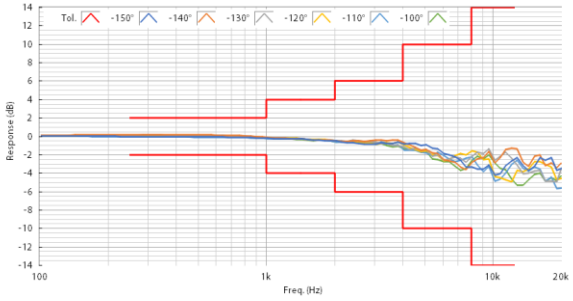


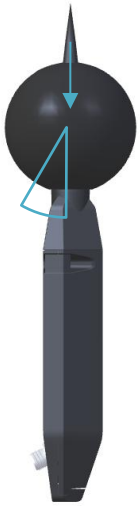

Tol.
-30°
-20°
-10°
Response (dB)
Freq. (Hz)
100
1k
10k
20k

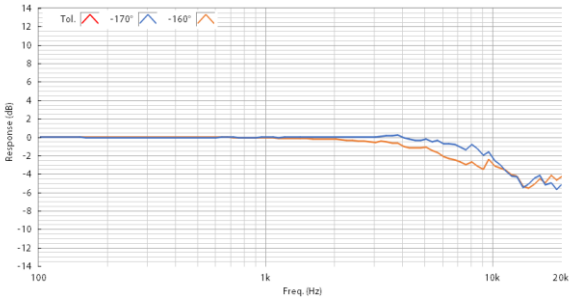



Tol.
-90°
-80°
-70°
-60°
-50°
-40°
Response (dB)
Freq. (Hz)
100
1k
10k
20k




Tol.
-150°
-140°
-130°
-120°
-110°
-100°
Response (dB)
Freq. (Hz)
100
1k
10k
20k




Tol.
-170°
-160°
Response (dB)
Freq. (Hz)
100
1k
10k
20k

## Frequency Response – Vertical Incidence Reference – Front – -30° ~ -10°

| Freq. (Hz) | -30° (dB) | -20° (dB) | -10° (dB) | Tol. (dB) |
|---|---|---|---|---|
| 251.189 | 0.1 | 0.0 | -0.0 | ±1.0 |
| 316.228 | 0.1 | 0.0 | -0.0 | ±1.0 |
| 398.107 | 0.1 | 0.0 | -0.0 | ±1.0 |
| 501.187 | 0.1 | 0.0 | -0.0 | ±1.0 |
| 630.957 | 0.1 | 0.0 | -0.0 | ±1.0 |
| 794.328 | 0.1 | 0.1 | 0.1 | ±1.0 |
| 1000.00 | 0.1 | 0.1 | 0.1 | ±1.0 |
| 1258.93 | 0.1 | 0.0 | 0.1 | ±1.0 |
| 1584.89 | 0.0 | 0.0 | 0.1 | ±1.0 |
| 1995.26 | 0.1 | 0.0 | 0.2 | ±1.0 |
| 2238.72 | -0.0 | -0.0 | 0.2 | ±1.5 |
| 2511.89 | 0.0 | 0.0 | 0.2 | ±1.5 |
| 2818.38 | -0.1 | 0.0 | 0.2 | ±1.5 |
| 3162.28 | -0.2 | 0.1 | 0.2 | ±1.5 |
| 3548.13 | -0.3 | -0.1 | 0.1 | ±1.5 |
| 3981.07 | -0.5 | -0.1 | 0.2 | ±1.5 |
| 4466.84 | -0.5 | -0.1 | 0.1 | ±2.5 |
| 5011.87 | -0.5 | -0.1 | 0.1 | ±2.5 |
| 5623.41 | -1.0 | -0.4 | 0.0 | ±2.5 |
| 6309.57 | -1.4 | -0.6 | -0.0 | ±2.5 |
| 7079.46 | -1.5 | -0.8 | -0.1 | ±2.5 |
| 7943.28 | -1.3 | -0.6 | -0.1 | ±2.5 |
| 8413.95 | -1.2 | -0.6 | 0.1 | ±4.0 |
| 8912.51 | -1.6 | -0.8 | 0.0 | ±4.0 |
| 9440.61 | -1.2 | -0.6 | -0.2 | ±4.0 |
| 10000.0 | -2.4 | -1.8 | -0.7 | ±4.0 |
| 10592.5 | -3.6 | -1.9 | -0.4 | ±4.0 |
| 11220.2 | -3.2 | -1.6 | -0.5 | ±4.0 |
| 11885.0 | -3.4 | -2.2 | -0.8 | ±4.0 |
| 12589.3 | -3.8 | -2.1 | -0.5 | ±4.0 |

## Frequency Response – Vertical Incidence Reference – Front – -90° ~ -40°

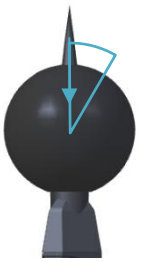
| Freq. (Hz) | -90° (dB) | -80° (dB) | -70° (dB) | -60° (dB) | -50° (dB) | -40° (dB) | Tol. (dB) |
|---|---|---|---|---|---|---|---|
| 251.189 | 0.0 | 0.0 | -0.0 | -0.0 | 0.0 | 0.1 | ±1.5 |
| 316.228 | 0.0 | 0.0 | -0.0 | -0.1 | -0.0 | 0.1 | ±1.5 |
| 398.107 | -0.0 | 0.0 | -0.1 | -0.1 | -0.0 | 0.0 | ±1.5 |
| 501.187 | -0.0 | -0.0 | -0.1 | -0.1 | -0.0 | 0.0 | ±1.5 |
| 630.957 | -0.0 | -0.0 | -0.1 | -0.1 | -0.0 | 0.1 | ±1.5 |
| 794.328 | -0.0 | -0.0 | -0.1 | -0.1 | -0.0 | 0.1 | ±1.5 |
| 1000.00 | -0.1 | -0.1 | -0.1 | -0.1 | -0.0 | 0.1 | ±2.0 |
| 1258.93 | -0.2 | -0.2 | -0.2 | -0.2 | -0.1 | 0.0 | ±2.0 |
| 1584.89 | -0.4 | -0.4 | -0.3 | -0.3 | -0.2 | -0.1 | ±2.0 |
| 1995.26 | -0.5 | -0.5 | -0.5 | -0.5 | -0.3 | -0.1 | ±2.0 |
| 2238.72 | -0.5 | -0.5 | -0.5 | -0.5 | -0.4 | -0.2 | ±4.0 |
| 2511.89 | -0.8 | -0.7 | -0.6 | -0.6 | -0.4 | -0.1 | ±4.0 |
| 2818.38 | -0.8 | -0.7 | -0.6 | -0.6 | -0.4 | -0.4 | ±4.0 |
| 3162.28 | -0.9 | -0.9 | -0.8 | -0.8 | -0.6 | -0.4 | ±4.0 |
| 3548.13 | -1.0 | -1.1 | -1.1 | -0.9 | -0.7 | -0.4 | ±4.0 |
| 3981.07 | -1.2 | -1.3 | -1.4 | -1.2 | -1.0 | -0.8 | ±4.0 |
| 4466.84 | -1.6 | -1.7 | -1.8 | -1.7 | -1.2 | -0.9 | ±7.0 |
| 5011.87 | -2.0 | -2.1 | -2.2 | -1.7 | -1.4 | -1.0 | ±7.0 |
| 5623.41 | -2.6 | -2.8 | -2.6 | -2.1 | -1.7 | -1.6 | ±7.0 |
| 6309.57 | -3.5 | -3.4 | -2.7 | -2.9 | -2.6 | -2.2 | ±7.0 |
| 7079.46 | -3.4 | -2.7 | -3.0 | -3.3 | -2.9 | -2.3 | ±7.0 |
| 7943.28 | -1.9 | -2.5 | -3.3 | -2.9 | -2.6 | -2.1 | ±7.0 |
| 8413.95 | -1.6 | -2.5 | -2.8 | -2.8 | -2.4 | -1.9 | ±10.0 |
| 8912.51 | -2.4 | -3.0 | -3.1 | -3.0 | -2.7 | -2.3 | ±10.0 |
| 9440.61 | -2.1 | -2.6 | -3.0 | -2.8 | -2.4 | -2.0 | ±10.0 |
| 10000.0 | -2.8 | -3.6 | -3.1 | -3.4 | -3.1 | -2.6 | ±10.0 |
| 10592.5 | -4.2 | -3.6 | -3.3 | -3.5 | -3.1 | -3.7 | ±10.0 |
| 11220.2 | -4.3 | -2.9 | -3.1 | -2.6 | -3.4 | -4.5 | ±10.0 |
| 11885.0 | -4.3 | -3.4 | -2.7 | -2.8 | -4.9 | -4.3 | ±10.0 |
| 12589.3 | -4.0 | -3.6 | -2.2 | -4.1 | -4.7 | -4.2 | ±10.0 |

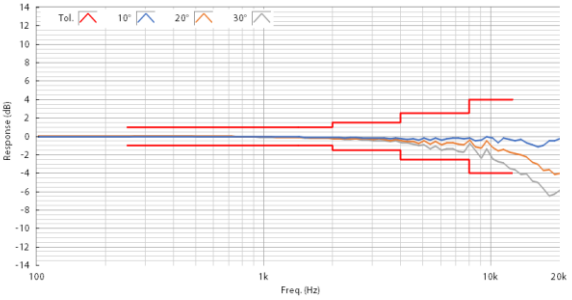
## Frequency Response – Vertical Incidence Reference – Front – -150° ~ -100°

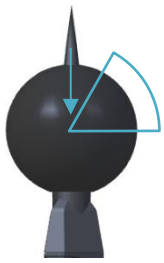
| Freq. (Hz) | -150° (dB) | -140° (dB) | -130° (dB) | -120° (dB) | -110° (dB) | -100° (dB) | Tol. (dB) |
|---|---|---|---|---|---|---|---|
| 251.189 | -0.0 | 0.2 | 0.1 | 0.1 | -0.0 | 0.0 | ±2.0 |
| 316.228 | -0.0 | 0.2 | 0.1 | 0.1 | -0.0 | 0.0 | ±2.0 |
| 398.107 | -0.0 | 0.2 | 0.1 | 0.1 | -0.0 | 0.0 | ±2.0 |
| 501.187 | -0.0 | 0.2 | 0.1 | 0.1 | -0.1 | -0.0 | ±2.0 |
| 630.957 | -0.1 | 0.1 | 0.1 | 0.0 | -0.1 | -0.0 | ±2.0 |
| 794.328 | -0.1 | 0.1 | 0.0 | -0.0 | -0.1 | -0.1 | ±2.0 |
| 1000.00 | -0.2 | -0.1 | -0.1 | -0.1 | -0.2 | -0.2 | ±4.0 |
| 1258.93 | -0.3 | -0.2 | -0.3 | -0.2 | -0.2 | -0.3 | ±4.0 |
| 1584.89 | -0.4 | -0.4 | -0.4 | -0.3 | -0.4 | -0.4 | ±4.0 |
| 1995.26 | -0.5 | -0.5 | -0.5 | -0.5 | -0.6 | -0.6 | ±4.0 |
| 2238.72 | -0.7 | -0.5 | -0.5 | -0.5 | -0.6 | -0.5 | ±6.0 |
| 2511.89 | -0.7 | -0.5 | -0.5 | -0.6 | -0.7 | -0.7 | ±6.0 |
| 2818.38 | -0.9 | -0.5 | -0.5 | -0.7 | -0.6 | -0.6 | ±6.0 |
| 3162.28 | -0.8 | -0.4 | -0.8 | -0.8 | -0.7 | -0.8 | ±6.0 |
| 3548.13 | -0.8 | -0.4 | -0.9 | -0.8 | -0.9 | -1.1 | ±6.0 |
| 3981.07 | -0.8 | -0.6 | -1.1 | -0.9 | -1.3 | -1.3 | ±6.0 |
| 4466.84 | -0.8 | -1.1 | -1.3 | -1.4 | -1.5 | -1.5 | ±10.0 |
| 5011.87 | -0.9 | -1.5 | -1.5 | -1.6 | -1.7 | -1.7 | ±10.0 |
| 5623.41 | -1.3 | -1.8 | -2.1 | -2.1 | -1.8 | -2.5 | ±10.0 |
| 6309.57 | -2.0 | -2.6 | -2.5 | -2.6 | -2.3 | -2.7 | ±10.0 |
| 7079.46 | -2.5 | -3.2 | -2.4 | -1.9 | -2.6 | -3.6 | ±10.0 |
| 7943.28 | -3.3 | -3.0 | -2.3 | -1.7 | -2.3 | -2.8 | ±10.0 |
| 8413.95 | -3.5 | -2.5 | -1.8 | -1.7 | -2.9 | -2.3 | ±14.0 |
| 8912.51 | -3.5 | -2.3 | -1.8 | -2.3 | -3.7 | -2.3 | ±14.0 |
| 9440.61 | -3.2 | -1.8 | -1.5 | -2.5 | -3.4 | -2.1 | ±14.0 |
| 10000.0 | -3.9 | -2.6 | -2.3 | -3.9 | -4.4 | -2.7 | ±14.0 |
| 10592.5 | -4.1 | -2.4 | -2.3 | -4.5 | -4.7 | -3.3 | ±14.0 |
| 11220.2 | -3.4 | -1.6 | -1.8 | -4.7 | -4.2 | -3.6 | ±14.0 |
| 11885.0 | -2.8 | -1.3 | -2.2 | -4.9 | -3.3 | -4.4 | ±14.0 |
| 12589.3 | -2.4 | -1.3 | -2.9 | -4.0 | -2.7 | -5.1 | ±14.0 |

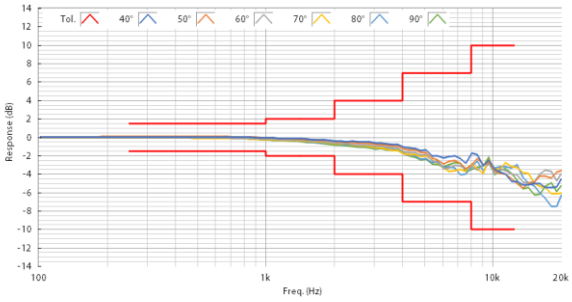
## Frequency Response – Vertical Incidence Reference – Front – -170° ~ -160°

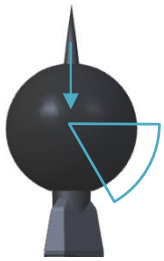
| Freq. (Hz) | -170° (dB) | -160° (dB) |
|---|---|---|
| 251.189 | -0.0 | 0.0 |
| 316.228 | -0.0 | 0.0 |
| 398.107 | -0.0 | 0.0 |
| 501.187 | -0.0 | 0.0 |
| 630.957 | -0.0 | 0.0 |
| 794.328 | -0.0 | -0.0 |
| 1000.00 | 0.0 | -0.1 |
| 1258.93 | 0.0 | -0.1 |
| 1584.89 | 0.0 | -0.2 |
| 1995.26 | 0.0 | -0.2 |
| 2238.72 | 0.0 | -0.3 |
| 2511.89 | 0.1 | -0.4 |
| 2818.38 | 0.0 | -0.4 |
| 3162.28 | 0.1 | -0.4 |
| 3548.13 | 0.2 | -0.6 |
| 3981.07 | 0.0 | -0.9 |
| 4466.84 | -0.3 | -1.1 |
| 5011.87 | -0.2 | -1.1 |
| 5623.41 | -0.4 | -1.6 |
| 6309.57 | -0.7 | -2.3 |
| 7079.46 | -1.0 | -2.6 |
| 7943.28 | -0.9 | -2.7 |
| 8413.95 | -1.1 | -3.0 |
| 8912.51 | -1.8 | -3.4 |
| 9440.61 | -1.7 | -2.7 |
| 10000.0 | -2.3 | -2.9 |
| 10592.5 | -2.9 | -3.3 |
| 11220.2 | -3.4 | -3.5 |
| 11885.0 | -4.0 | -3.9 |
| 12589.3 | -4.2 | -4.2 |

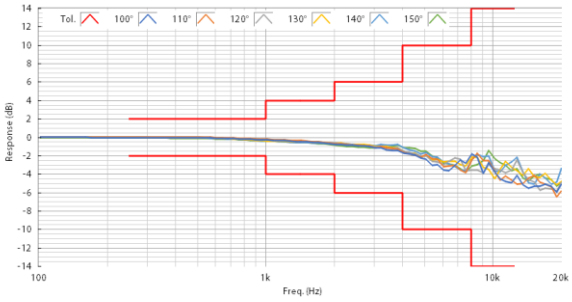


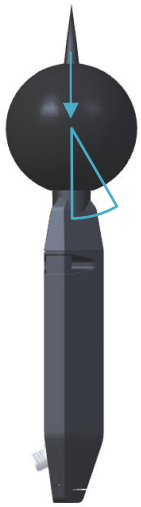

Tol.
10°
20°
30°
Response (dB)
Freq. (Hz)

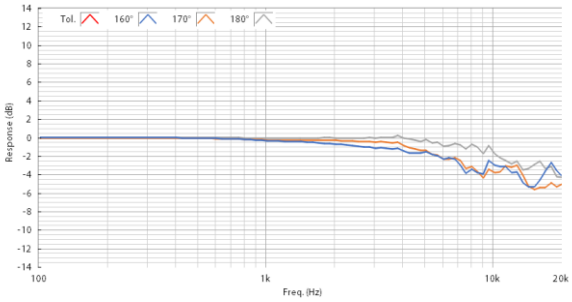



Tol.
40°
50°
60°
70°
80°
90°
Response (dB)
Freq. (Hz)




Tol.
100°
110°
120°
130°
140°
150°
Response (dB)
Freq. (Hz)




Tol.
160°
170°
180°
Response (dB)
Freq. (Hz)

## Frequency Response – Vertical Incidence Reference – Back – 10° ~ 30°

| Freq. (Hz) | 10° (dB) | 20° (dB) | 30° (dB) | Tol. (dB) |
|---|---|---|---|---|
| 251.189 | -0.0 | 0.0 | -0.0 | ±1.0 |
| 316.228 | -0.0 | 0.0 | 0.0 | ±1.0 |
| 398.107 | -0.0 | 0.0 | 0.0 | ±1.0 |
| 501.187 | -0.0 | 0.0 | -0.0 | ±1.0 |
| 630.957 | -0.0 | 0.0 | -0.0 | ±1.0 |
| 794.328 | -0.0 | -0.0 | -0.0 | ±1.0 |
| 1000.00 | -0.0 | -0.1 | -0.1 | ±1.0 |
| 1258.93 | -0.0 | -0.1 | -0.1 | ±1.0 |
| 1584.89 | -0.1 | -0.2 | -0.1 | ±1.0 |
| 1995.26 | -0.1 | -0.2 | -0.2 | ±1.0 |
| 2238.72 | -0.2 | -0.3 | -0.3 | ±1.5 |
| 2511.89 | -0.1 | -0.2 | -0.3 | ±1.5 |
| 2818.38 | -0.2 | -0.3 | -0.4 | ±1.5 |
| 3162.28 | -0.2 | -0.3 | -0.5 | ±1.5 |
| 3548.13 | -0.2 | -0.4 | -0.5 | ±1.5 |
| 3981.07 | -0.2 | -0.4 | -0.6 | ±1.5 |
| 4466.84 | -0.3 | -0.5 | -0.8 | ±2.5 |
| 5011.87 | -0.2 | -0.5 | -0.9 | ±2.5 |
| 5623.41 | -0.2 | -0.6 | -1.2 | ±2.5 |
| 6309.57 | -0.3 | -0.8 | -1.4 | ±2.5 |
| 7079.46 | -0.2 | -0.8 | -1.6 | ±2.5 |
| 7943.28 | -0.2 | -0.5 | -1.0 | ±2.5 |
| 8413.95 | -0.4 | -0.9 | -1.3 | ±4.0 |
| 8912.51 | -0.4 | -1.2 | -2.2 | ±4.0 |
| 9440.61 | -0.1 | -0.7 | -1.6 | ±4.0 |
| 10000.0 | -0.2 | -1.0 | -2.2 | ±4.0 |
| 10592.5 | -0.5 | -1.5 | -2.7 | ±4.0 |
| 11220.2 | -0.3 | -1.5 | -2.9 | ±4.0 |
| 11885.0 | -0.3 | -1.7 | -3.3 | ±4.0 |
| 12589.3 | -0.4 | -1.8 | -3.6 | ±4.0 |

## Frequency Response – Vertical Incidence Reference – Back – 40° ~ 90°

| Freq. (Hz) | 40° (dB) | 50° (dB) | 60° (dB) | 70° (dB) | 80° (dB) | 90° (dB) | Tol. (dB) |
|---|---|---|---|---|---|---|---|
| 251.189 | 0.1 | 0.1 | -0.0 | -0.1 | 0.0 | 0.0 | ±1.5 |
| 316.228 | 0.1 | 0.1 | -0.0 | -0.1 | 0.0 | 0.0 | ±1.5 |
| 398.107 | 0.1 | 0.1 | -0.0 | -0.1 | 0.0 | 0.0 | ±1.5 |
| 501.187 | 0.1 | 0.1 | -0.0 | -0.1 | 0.0 | 0.0 | ±1.5 |
| 630.957 | 0.1 | 0.1 | -0.0 | -0.1 | -0.0 | -0.0 | ±1.5 |
| 794.328 | 0.0 | 0.0 | -0.1 | -0.1 | -0.1 | -0.1 | ±1.5 |
| 1000.00 | -0.0 | -0.0 | -0.2 | -0.2 | -0.2 | -0.3 | ±2.0 |
| 1258.93 | -0.1 | -0.1 | -0.3 | -0.3 | -0.3 | -0.4 | ±2.0 |
| 1584.89 | -0.2 | -0.3 | -0.4 | -0.4 | -0.5 | -0.6 | ±2.0 |
| 1995.26 | -0.4 | -0.4 | -0.6 | -0.6 | -0.7 | -0.8 | ±2.0 |
| 2238.72 | -0.4 | -0.5 | -0.7 | -0.7 | -0.8 | -0.9 | ±4.0 |
| 2511.89 | -0.4 | -0.6 | -0.8 | -0.9 | -0.9 | -1.0 | ±4.0 |
| 2818.38 | -0.5 | -0.6 | -0.8 | -1.0 | -1.0 | -1.1 | ±4.0 |
| 3162.28 | -0.6 | -0.8 | -0.9 | -1.1 | -1.2 | -1.3 | ±4.0 |
| 3548.13 | -0.7 | -0.9 | -1.1 | -1.4 | -1.3 | -1.4 | ±4.0 |
| 3981.07 | -1.0 | -1.2 | -1.4 | -1.7 | -1.7 | -1.6 | ±4.0 |
| 4466.84 | -1.2 | -1.3 | -1.6 | -1.9 | -2.0 | -2.1 | ±7.0 |
| 5011.87 | -1.4 | -1.7 | -1.9 | -2.0 | -2.3 | -2.4 | ±7.0 |
| 5623.41 | -2.0 | -2.4 | -2.7 | -2.7 | -2.6 | -3.0 | ±7.0 |
| 6309.57 | -2.1 | -2.7 | -3.3 | -3.6 | -3.2 | -3.0 | ±7.0 |
| 7079.46 | -2.2 | -2.7 | -3.1 | -3.5 | -3.9 | -2.8 | ±7.0 |
| 7943.28 | -2.0 | -3.1 | -3.2 | -3.1 | -3.4 | -3.5 | ±7.0 |
| 8413.95 | -1.8 | -2.5 | -3.5 | -3.2 | -2.8 | -3.3 | ±10.0 |
| 8912.51 | -2.8 | -2.8 | -3.2 | -3.8 | -3.4 | -3.1 | ±10.0 |
| 9440.61 | -2.6 | -2.8 | -2.9 | -2.8 | -3.0 | -2.4 | ±10.0 |
| 10000.0 | -3.2 | -3.4 | -3.7 | -3.2 | -3.2 | -3.6 | ±10.0 |
| 10592.5 | -3.7 | -3.9 | -3.6 | -3.4 | -3.2 | -3.7 | ±10.0 |
| 11220.2 | -3.9 | -3.9 | -3.6 | -2.9 | -3.2 | -3.5 | ±10.0 |
| 11885.0 | -4.6 | -4.3 | -3.9 | -3.1 | -3.3 | -3.8 | ±10.0 |
| 12589.3 | -4.8 | -4.9 | -4.0 | -3.2 | -3.1 | -4.5 | ±10.0 |

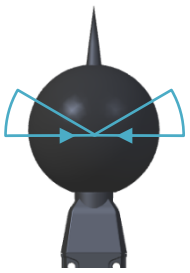
## Frequency Response – Vertical Incidence Reference – Back – 100° ~ 150°

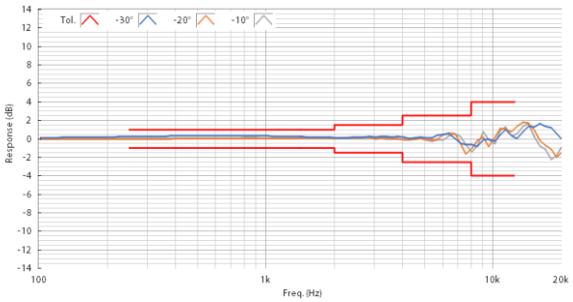
| Freq. (Hz) | 100° (dB) | 110° (dB) | 120° (dB) | 130° (dB) | 140° (dB) | 150° (dB) | Tol. (dB) |
|---|---|---|---|---|---|---|---|
| 251.189 | -0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -0.1 | ±2.0 |
| 316.228 | -0.0 | 0.0 | 0.0 | -0.0 | 0.0 | -0.1 | ±2.0 |
| 398.107 | -0.0 | 0.0 | 0.0 | -0.0 | -0.0 | -0.1 | ±2.0 |
| 501.187 | -0.0 | 0.0 | 0.0 | -0.0 | -0.0 | -0.1 | ±2.0 |
| 630.957 | -0.1 | -0.0 | -0.1 | -0.1 | -0.1 | -0.2 | ±2.0 |
| 794.328 | -0.2 | -0.1 | -0.1 | -0.2 | -0.2 | -0.3 | ±2.0 |
| 1000.00 | -0.3 | -0.2 | -0.3 | -0.4 | -0.4 | -0.4 | ±4.0 |
| 1258.93 | -0.4 | -0.3 | -0.4 | -0.4 | -0.5 | -0.5 | ±4.0 |
| 1584.89 | -0.5 | -0.4 | -0.5 | -0.5 | -0.6 | -0.6 | ±4.0 |
| 1995.26 | -0.8 | -0.6 | -0.6 | -0.6 | -0.7 | -0.8 | ±4.0 |
| 2238.72 | -0.8 | -0.8 | -0.7 | -0.7 | -0.8 | -1.0 | ±6.0 |
| 2511.89 | -0.9 | -0.9 | -0.8 | -0.7 | -0.8 | -1.0 | ±6.0 |
| 2818.38 | -0.9 | -0.9 | -0.9 | -0.8 | -0.8 | -1.1 | ±6.0 |
| 3162.28 | -1.1 | -1.0 | -1.0 | -1.0 | -0.8 | -1.0 | ±6.0 |
| 3548.13 | -1.4 | -1.2 | -1.2 | -1.1 | -0.9 | -1.0 | ±6.0 |
| 3981.07 | -1.7 | -1.6 | -1.4 | -1.4 | -1.1 | -1.0 | ±6.0 |
| 4466.84 | -1.9 | -1.9 | -1.7 | -1.7 | -1.5 | -1.2 | ±10.0 |
| 5011.87 | -2.4 | -2.0 | -2.0 | -2.0 | -1.7 | -1.5 | ±10.0 |
| 5623.41 | -3.0 | -2.4 | -2.7 | -2.4 | -2.1 | -2.2 | ±10.0 |
| 6309.57 | -3.6 | -3.1 | -2.7 | -2.6 | -2.8 | -2.9 | ±10.0 |
| 7079.46 | -2.6 | -3.4 | -2.4 | -2.9 | -3.5 | -3.3 | ±10.0 |
| 7943.28 | -2.1 | -2.8 | -3.5 | -2.4 | -2.7 | -3.3 | ±10.0 |
| 8413.95 | -2.1 | -1.9 | -3.5 | -2.1 | -2.0 | -3.0 | ±14.0 |
| 8912.51 | -3.4 | -2.3 | -3.8 | -3.0 | -2.0 | -2.6 | ±14.0 |
| 9440.61 | -3.0 | -2.5 | -3.2 | -3.4 | -2.1 | -1.7 | ±14.0 |
| 10000.0 | -3.5 | -3.4 | -3.3 | -4.2 | -3.2 | -2.1 | ±14.0 |
| 10592.5 | -4.3 | -4.4 | -3.5 | -3.7 | -3.7 | -2.6 | ±14.0 |
| 11220.2 | -4.7 | -4.3 | -3.8 | -2.8 | -3.2 | -2.9 | ±14.0 |
| 11885.0 | -4.9 | -4.5 | -3.6 | -3.1 | -2.8 | -3.4 | ±14.0 |
| 12589.3 | -4.4 | -5.0 | -2.7 | -3.5 | -2.3 | -3.4 | ±14.0 |

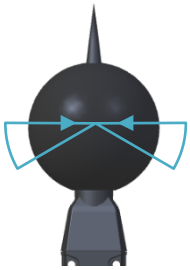
## Frequency Response – Vertical Incidence Reference – Back – 160° ~ 180°

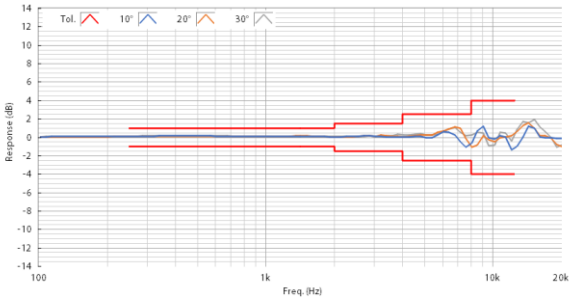
| Freq. (Hz) | 160° (dB) | 170° (dB) | 180° (dB) |
|---|---|---|---|
| 251.189 | 0.0 | -0.0 | 0.0 |
| 316.228 | 0.0 | -0.0 | 0.0 |
| 398.107 | 0.0 | -0.0 | 0.0 |
| 501.187 | -0.0 | -0.0 | 0.0 |
| 630.957 | -0.1 | -0.1 | 0.0 |
| 794.328 | -0.2 | -0.2 | -0.0 |
| 1000.00 | -0.3 | -0.2 | -0.0 |
| 1258.93 | -0.4 | -0.2 | -0.1 |
| 1584.89 | -0.5 | -0.3 | -0.0 |
| 1995.26 | -0.7 | -0.3 | -0.0 |
| 2238.72 | -0.8 | -0.4 | -0.1 |
| 2511.89 | -0.9 | -0.4 | -0.0 |
| 2818.38 | -1.0 | -0.4 | 0.0 |
| 3162.28 | -1.1 | -0.4 | 0.0 |
| 3548.13 | -1.2 | -0.5 | 0.1 |
| 3981.07 | -1.4 | -0.8 | 0.0 |
| 4466.84 | -1.6 | -1.2 | -0.2 |
| 5011.87 | -1.5 | -1.3 | -0.3 |
| 5623.41 | -1.9 | -1.8 | -0.5 |
| 6309.57 | -2.2 | -2.3 | -0.8 |
| 7079.46 | -2.8 | -2.4 | -0.7 |
| 7943.28 | -3.5 | -3.2 | -0.8 |
| 8413.95 | -3.7 | -3.5 | -0.9 |
| 8912.51 | -3.9 | -4.2 | -1.5 |
| 9440.61 | -2.9 | -3.6 | -1.1 |
| 10000.0 | -2.9 | -3.7 | -1.5 |
| 10592.5 | -3.1 | -3.7 | -2.0 |
| 11220.2 | -3.1 | -3.2 | -2.4 |
| 11885.0 | -3.6 | -3.1 | -2.7 |
| 12589.3 | -3.7 | -3.0 | -2.6 |

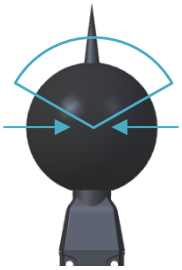
## Frequency Response – Horizontal Incidence Reference

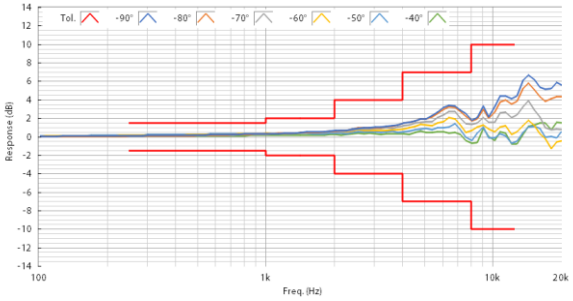


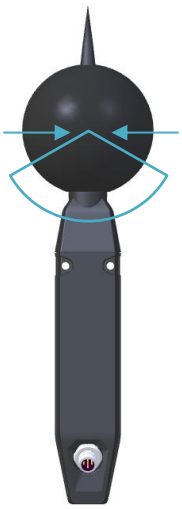


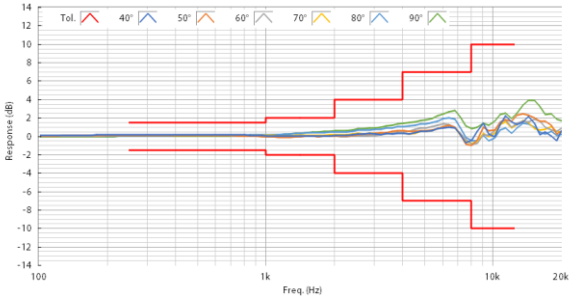









## Frequency Response – Horizontal Incidence Reference – Sides – -30° ~ 30°

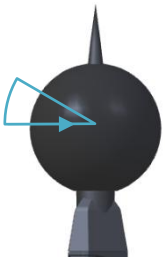
| Freq. (Hz) | -30° (dB) | -20° (dB) | -10° (dB) | 10° (dB) | 20° (dB) | 30° (dB) | Tol. (dB) |
|---|---|---|---|---|---|---|---|
| 251.189 | 0.2 | -0.0 | 0.0 | 0.1 | 0.1 | 0.1 | ±1.0 |
| 316.228 | 0.3 | -0.0 | 0.1 | 0.1 | 0.1 | 0.2 | ±1.0 |
| 398.107 | 0.3 | -0.0 | 0.1 | 0.2 | 0.1 | 0.2 | ±1.0 |
| 501.187 | 0.3 | 0.0 | 0.1 | 0.2 | 0.1 | 0.2 | ±1.0 |
| 630.957 | 0.3 | 0.0 | 0.0 | 0.1 | 0.1 | 0.2 | ±1.0 |
| 794.328 | 0.3 | 0.0 | 0.1 | 0.1 | 0.1 | 0.1 | ±1.0 |
| 1000.00 | 0.3 | 0.0 | 0.1 | 0.1 | 0.1 | 0.1 | ±1.0 |
| 1258.93 | 0.2 | 0.0 | 0.1 | 0.1 | 0.1 | 0.1 | ±1.0 |
| 1584.89 | 0.2 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | ±1.0 |
| 1995.26 | 0.1 | 0.1 | 0.0 | 0.1 | 0.1 | 0.1 | ±1.0 |
| 2238.72 | 0.1 | 0.1 | 0.1 | 0.1 | 0.0 | 0.1 | ±1.5 |
| 2511.89 | 0.2 | 0.1 | 0.0 | 0.1 | 0.1 | 0.1 | ±1.5 |
| 2818.38 | 0.2 | 0.2 | 0.1 | 0.2 | 0.2 | 0.2 | ±1.5 |
| 3162.28 | 0.2 | 0.1 | 0.0 | 0.1 | 0.2 | 0.1 | ±1.5 |
| 3548.13 | 0.2 | 0.0 | -0.0 | 0.0 | 0.1 | 0.2 | ±1.5 |
| 3981.07 | 0.2 | -0.1 | -0.0 | 0.0 | 0.0 | 0.3 | ±1.5 |
| 4466.84 | 0.1 | -0.0 | -0.0 | 0.1 | 0.2 | 0.3 | ±2.5 |
| 5011.87 | 0.1 | -0.1 | -0.1 | 0.0 | 0.2 | 0.3 | ±2.5 |
| 5623.41 | 0.3 | -0.0 | -0.1 | 0.2 | 0.5 | 0.3 | ±2.5 |
| 6309.57 | 0.5 | 0.6 | 0.2 | 0.6 | 0.9 | 0.9 | ±2.5 |
| 7079.46 | -0.4 | -0.2 | 0.4 | -0.3 | 1.0 | 0.7 | ±2.5 |
| 7943.28 | -0.6 | -1.2 | -1.2 | -0.7 | -0.8 | 0.2 | ±2.5 |
| 8413.95 | -0.8 | -0.4 | -1.0 | 0.4 | -0.9 | 0.5 | ±4.0 |
| 8912.51 | -0.3 | 0.1 | 0.4 | 1.1 | -0.1 | 0.5 | ±4.0 |
| 9440.61 | -0.0 | -0.6 | 0.1 | 0.3 | -0.2 | -0.5 | ±4.0 |
| 10000.0 | -0.2 | -0.1 | -0.4 | -0.2 | -0.4 | -0.8 | ±4.0 |
| 10592.5 | 0.2 | 0.9 | 0.5 | 0.1 | -0.1 | 0.2 | ±4.0 |
| 11220.2 | 0.8 | 1.1 | 1.2 | 0.1 | 0.0 | 0.5 | ±4.0 |
| 11885.0 | 0.5 | 0.8 | 0.6 | -1.0 | 0.1 | -0.2 | ±4.0 |
| 12589.3 | 0.1 | 1.2 | 0.5 | -1.1 | 0.5 | 0.5 | ±4.0 |

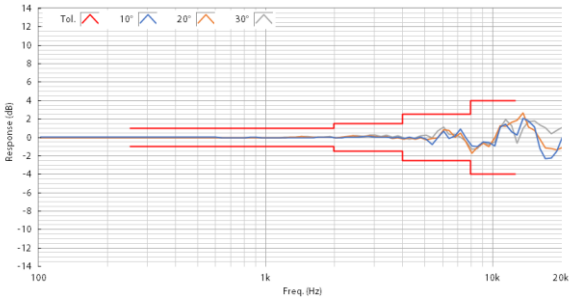
## Frequency Response – Horizontal Incidence Reference – Sides – -90° ~ -40°

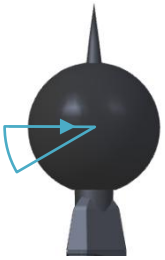
| Freq. (Hz) | -90° (dB) | -80° (dB) | -70° (dB) | -60° (dB) | -50° (dB) | -40° (dB) | Tol. (dB) |
|---|---|---|---|---|---|---|---|
| 251.189 | 0.1 | 0.1 | 0.1 | 0.2 | 0.2 | 0.1 | ±1.5 |
| 316.228 | 0.2 | 0.1 | 0.1 | 0.2 | 0.2 | 0.1 | ±1.5 |
| 398.107 | 0.2 | 0.1 | 0.1 | 0.2 | 0.3 | 0.1 | ±1.5 |
| 501.187 | 0.2 | 0.1 | 0.2 | 0.2 | 0.3 | 0.1 | ±1.5 |
| 630.957 | 0.2 | 0.2 | 0.2 | 0.3 | 0.3 | 0.1 | ±1.5 |
| 794.328 | 0.3 | 0.3 | 0.2 | 0.3 | 0.3 | 0.1 | ±1.5 |
| 1000.00 | 0.4 | 0.3 | 0.3 | 0.4 | 0.4 | 0.2 | ±2.0 |
| 1258.93 | 0.4 | 0.4 | 0.3 | 0.4 | 0.4 | 0.2 | ±2.0 |
| 1584.89 | 0.5 | 0.5 | 0.5 | 0.5 | 0.3 | 0.2 | ±2.0 |
| 1995.26 | 0.7 | 0.6 | 0.6 | 0.6 | 0.4 | 0.2 | ±2.0 |
| 2238.72 | 0.7 | 0.7 | 0.6 | 0.6 | 0.4 | 0.2 | ±4.0 |
| 2511.89 | 0.9 | 0.9 | 0.8 | 0.7 | 0.5 | 0.4 | ±4.0 |
| 2818.38 | 1.0 | 1.0 | 0.8 | 0.7 | 0.6 | 0.4 | ±4.0 |
| 3162.28 | 1.1 | 1.0 | 0.9 | 0.7 | 0.5 | 0.3 | ±4.0 |
| 3548.13 | 1.2 | 1.1 | 0.9 | 0.8 | 0.6 | 0.3 | ±4.0 |
| 3981.07 | 1.4 | 1.4 | 1.1 | 0.8 | 0.5 | 0.3 | ±4.0 |
| 4466.84 | 1.7 | 1.7 | 1.4 | 1.1 | 0.7 | 0.4 | ±7.0 |
| 5011.87 | 1.9 | 2.0 | 1.7 | 1.3 | 0.9 | 0.5 | ±7.0 |
| 5623.41 | 2.6 | 2.4 | 2.0 | 1.4 | 0.9 | 0.6 | ±7.0 |
| 6309.57 | 3.4 | 3.2 | 2.7 | 1.9 | 1.1 | 0.5 | ±7.0 |
| 7079.46 | 3.0 | 2.8 | 2.2 | 1.5 | 0.9 | 0.3 | ±7.0 |
| 7943.28 | 2.0 | 1.9 | 1.4 | 0.6 | -0.3 | -0.6 | ±7.0 |
| 8413.95 | 2.0 | 1.9 | 1.4 | 0.9 | 0.2 | -0.6 | ±10.0 |
| 8912.51 | 3.0 | 2.7 | 1.9 | 1.2 | 0.9 | 0.5 | ±10.0 |
| 9440.61 | 2.4 | 2.2 | 1.7 | 0.9 | 0.2 | 0.2 | ±10.0 |
| 10000.0 | 3.0 | 2.5 | 1.6 | 0.6 | -0.1 | -0.3 | ±10.0 |
| 10592.5 | 4.1 | 3.5 | 2.3 | 1.0 | 0.2 | 0.3 | ±10.0 |
| 11220.2 | 4.4 | 3.9 | 2.7 | 1.2 | 0.2 | 0.4 | ±10.0 |
| 11885.0 | 4.2 | 3.6 | 2.2 | 0.5 | -0.5 | -0.5 | ±10.0 |
| 12589.3 | 4.3 | 3.8 | 2.3 | 0.5 | -0.5 | -0.8 | ±10.0 |

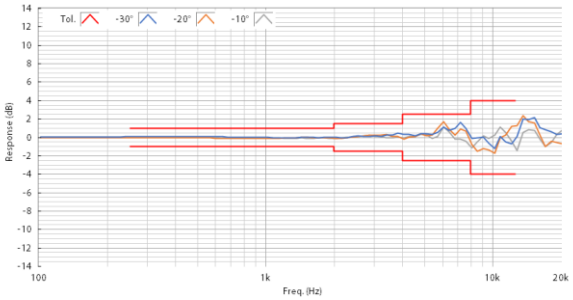
## Frequency Response – Horizontal Incidence Reference – Sides – 40° ~ 90°

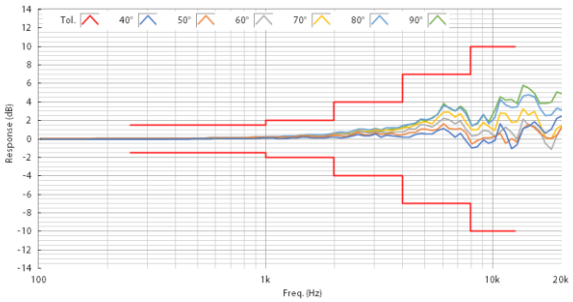
| Freq. (Hz) | 40° (dB) | 50° (dB) | 60° (dB) | 70° (dB) | 80° (dB) | 90° (dB) | Tol. (dB) |
|---|---|---|---|---|---|---|---|
| 251.189 | 0.2 | 0.1 | 0.1 | 0.1 | 0.1 | 0.0 | ±1.5 |
| 316.228 | 0.2 | 0.1 | 0.1 | 0.1 | 0.1 | 0.0 | ±1.5 |
| 398.107 | 0.2 | 0.1 | 0.1 | 0.1 | 0.1 | 0.0 | ±1.5 |
| 501.187 | 0.2 | 0.1 | 0.1 | 0.1 | 0.1 | 0.0 | ±1.5 |
| 630.957 | 0.2 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | ±1.5 |
| 794.328 | 0.2 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | ±1.5 |
| 1000.00 | 0.1 | -0.0 | -0.0 | 0.1 | 0.2 | 0.1 | ±2.0 |
| 1258.93 | 0.0 | -0.1 | -0.0 | 0.1 | 0.3 | 0.2 | ±2.0 |
| 1584.89 | 0.1 | 0.0 | 0.0 | 0.1 | 0.4 | 0.5 | ±2.0 |
| 1995.26 | 0.1 | 0.1 | 0.0 | 0.2 | 0.5 | 0.6 | ±2.0 |
| 2238.72 | 0.1 | 0.0 | -0.0 | 0.2 | 0.5 | 0.6 | ±4.0 |
| 2511.89 | 0.2 | 0.2 | 0.1 | 0.3 | 0.7 | 0.8 | ±4.0 |
| 2818.38 | 0.3 | 0.3 | 0.1 | 0.3 | 0.7 | 0.9 | ±4.0 |
| 3162.28 | 0.2 | 0.4 | 0.2 | 0.3 | 0.8 | 1.0 | ±4.0 |
| 3548.13 | 0.3 | 0.5 | 0.3 | 0.4 | 0.9 | 1.2 | ±4.0 |
| 3981.07 | 0.3 | 0.6 | 0.5 | 0.4 | 1.1 | 1.4 | ±4.0 |
| 4466.84 | 0.4 | 0.6 | 0.7 | 0.3 | 1.2 | 1.6 | ±7.0 |
| 5011.87 | 0.6 | 0.6 | 0.9 | 0.5 | 1.4 | 1.8 | ±7.0 |
| 5623.41 | 0.8 | 0.8 | 1.2 | 0.8 | 1.6 | 2.1 | ±7.0 |
| 6309.57 | 1.0 | 1.2 | 1.3 | 1.2 | 2.0 | 2.6 | ±7.0 |
| 7079.46 | 0.3 | 0.4 | 0.5 | 0.3 | 1.2 | 2.2 | ±7.0 |
| 7943.28 | -0.5 | -1.0 | -0.7 | -0.7 | -0.4 | 0.9 | ±7.0 |
| 8413.95 | 0.3 | -0.6 | -0.8 | -0.6 | -0.5 | 1.0 | ±10.0 |
| 8912.51 | 1.2 | 0.6 | -0.1 | 0.1 | -0.0 | 1.3 | ±10.0 |
| 9440.61 | 0.6 | 0.7 | 0.1 | 0.1 | -0.3 | 1.3 | ±10.0 |
| 10000.0 | 0.0 | 0.7 | 0.5 | 0.2 | -0.3 | 1.5 | ±10.0 |
| 10592.5 | 0.9 | 1.3 | 1.3 | 1.0 | 0.5 | 2.2 | ±10.0 |
| 11220.2 | 2.0 | 1.7 | 1.7 | 1.5 | 0.8 | 2.5 | ±10.0 |
| 11885.0 | 1.7 | 1.7 | 1.2 | 1.1 | 0.5 | 2.1 | ±10.0 |
| 12589.3 | 1.4 | 2.1 | 1.3 | 1.2 | 0.7 | 2.4 | ±10.0 |

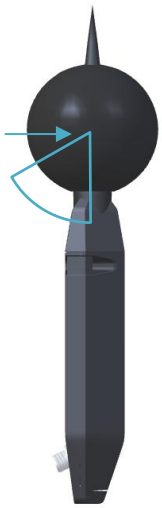


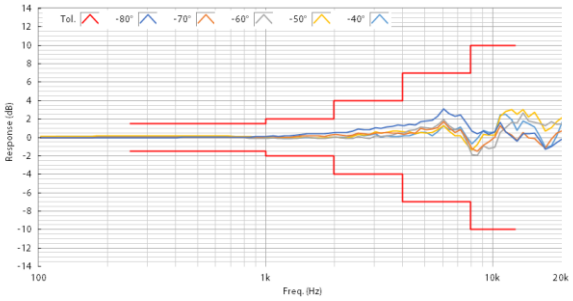

Tol.
10°
20°
30°
Response (dB)
Freq. (Hz)
100
1k
10k
20k




Tol.
-30°
-20°
-10°
Response (dB)
Freq. (Hz)
100
1k
10k
20k


Tol.
40°
50°
60°
70°
80°
90°
Response (dB)
Freq. (Hz)
100
1k
10k
20k




Tol.
-80°
-70°
-60°
-50°
-40°
Response (dB)
Freq. (Hz)
100
1k
10k
20k

## Frequency Response – Horizontal Incidence Reference – Front – -30° ~ 30°

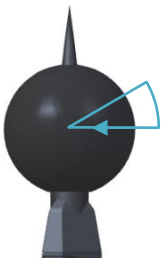
| Freq. (Hz) | -30° (dB) | -20° (dB) | -10° (dB) | 10° (dB) | 20° (dB) | 30° (dB) | Tol. (dB) |
|---|---|---|---|---|---|---|---|
| 251.189 | 0.1 | -0.0 | 0.0 | 0.0 | -0.0 | -0.1 | ±1.0 |
| 316.228 | 0.1 | -0.0 | 0.0 | 0.0 | -0.1 | -0.1 | ±1.0 |
| 398.107 | 0.1 | -0.0 | 0.0 | 0.0 | -0.0 | -0.1 | ±1.0 |
| 501.187 | 0.1 | -0.1 | 0.0 | 0.0 | -0.0 | -0.1 | ±1.0 |
| 630.957 | 0.1 | -0.1 | -0.0 | -0.0 | -0.0 | -0.1 | ±1.0 |
| 794.328 | 0.0 | -0.1 | -0.0 | -0.0 | -0.0 | -0.0 | ±1.0 |
| 1000.00 | 0.0 | -0.1 | -0.1 | -0.0 | -0.0 | -0.0 | ±1.0 |
| 1258.93 | -0.0 | -0.1 | -0.1 | -0.0 | 0.0 | 0.0 | ±1.0 |
| 1584.89 | 0.0 | -0.0 | -0.1 | -0.0 | 0.1 | 0.1 | ±1.0 |
| 1995.26 | 0.0 | -0.1 | -0.1 | -0.0 | -0.0 | 0.0 | ±1.0 |
| 2238.72 | -0.0 | -0.1 | -0.0 | 0.0 | 0.1 | 0.0 | ±1.5 |
| 2511.89 | 0.1 | 0.1 | 0.1 | 0.0 | 0.1 | 0.2 | ±1.5 |
| 2818.38 | 0.1 | 0.2 | 0.2 | 0.1 | 0.2 | 0.2 | ±1.5 |
| 3162.28 | 0.1 | 0.2 | 0.1 | 0.0 | 0.1 | 0.1 | ±1.5 |
| 3548.13 | 0.3 | 0.2 | -0.0 | -0.0 | -0.1 | 0.1 | ±1.5 |
| 3981.07 | 0.4 | -0.1 | -0.0 | -0.1 | -0.1 | 0.0 | ±1.5 |
| 4466.84 | 0.2 | 0.1 | 0.1 | -0.1 | -0.2 | -0.1 | ±2.5 |
| 5011.87 | 0.4 | 0.2 | 0.3 | -0.1 | -0.2 | 0.2 | ±2.5 |
| 5623.41 | 0.5 | 0.8 | 0.1 | -0.2 | -0.1 | 0.5 | ±2.5 |
| 6309.57 | 0.9 | 1.1 | 0.7 | 0.1 | 0.8 | 0.5 | ±2.5 |
| 7079.46 | 1.5 | 0.8 | -0.2 | 0.7 | 0.3 | 0.1 | ±2.5 |
| 7943.28 | 0.2 | -0.4 | -0.9 | -0.7 | -1.4 | -1.0 | ±2.5 |
| 8413.95 | -0.1 | -1.3 | -0.7 | -0.9 | -1.2 | -1.2 | ±4.0 |
| 8912.51 | 0.0 | -1.3 | 0.0 | -0.6 | -0.7 | -0.7 | ±4.0 |
| 9440.61 | -0.4 | -1.3 | -0.0 | -0.6 | -0.9 | -0.7 | ±4.0 |
| 10000.0 | -1.1 | -1.6 | 0.2 | -0.8 | -0.3 | -0.5 | ±4.0 |
| 10592.5 | -0.2 | -0.5 | 0.9 | 0.6 | 0.9 | 0.7 | ±4.0 |
| 11220.2 | -0.3 | 0.2 | 0.7 | 1.4 | 1.2 | 1.7 | ±4.0 |
| 11885.0 | -0.6 | 1.0 | -0.1 | 0.9 | 1.5 | 1.4 | ±4.0 |
| 12589.3 | -0.1 | 1.2 | -1.1 | 0.4 | 1.8 | -0.1 | ±4.0 |

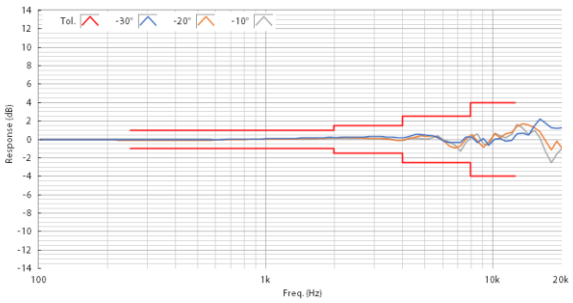
## Frequency Response – Horizontal Incidence Reference – Front – 40° ~ 90°

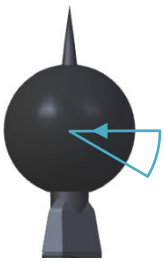
| Freq. (Hz) | 40° (dB) | 50° (dB) | 60° (dB) | 70° (dB) | 80° (dB) | 90° (dB) | Tol. (dB) |
|---|---|---|---|---|---|---|---|
| 251.189 | -0.0 | 0.0 | 0.1 | 0.0 | -0.0 | -0.0 | ±1.5 |
| 316.228 | -0.0 | 0.0 | 0.1 | 0.0 | -0.0 | -0.0 | ±1.5 |
| 398.107 | -0.0 | 0.1 | 0.1 | 0.0 | -0.0 | 0.0 | ±1.5 |
| 501.187 | 0.0 | 0.1 | 0.1 | 0.0 | -0.0 | 0.0 | ±1.5 |
| 630.957 | 0.0 | 0.1 | 0.2 | 0.1 | 0.0 | 0.0 | ±1.5 |
| 794.328 | 0.0 | 0.1 | 0.2 | 0.1 | 0.1 | 0.0 | ±1.5 |
| 1000.00 | 0.1 | 0.2 | 0.3 | 0.2 | 0.2 | 0.1 | ±2.0 |
| 1258.93 | 0.1 | 0.2 | 0.2 | 0.2 | 0.3 | 0.2 | ±2.0 |
| 1584.89 | 0.1 | 0.3 | 0.4 | 0.4 | 0.5 | 0.4 | ±2.0 |
| 1995.26 | 0.2 | 0.4 | 0.6 | 0.5 | 0.7 | 0.5 | ±2.0 |
| 2238.72 | 0.2 | 0.3 | 0.5 | 0.5 | 0.7 | 0.5 | ±4.0 |
| 2511.89 | 0.4 | 0.6 | 0.8 | 0.8 | 1.0 | 0.8 | ±4.0 |
| 2818.38 | 0.3 | 0.4 | 0.6 | 0.8 | 1.0 | 0.8 | ±4.0 |
| 3162.28 | 0.3 | 0.5 | 0.7 | 1.0 | 1.0 | 0.9 | ±4.0 |
| 3548.13 | 0.4 | 0.6 | 0.7 | 1.0 | 1.2 | 1.0 | ±4.0 |
| 3981.07 | 0.2 | 0.5 | 0.8 | 1.2 | 1.4 | 1.2 | ±4.0 |
| 4466.84 | 0.4 | 0.7 | 1.1 | 1.5 | 1.7 | 1.6 | ±7.0 |
| 5011.87 | 0.6 | 1.0 | 1.5 | 1.9 | 2.1 | 2.0 | ±7.0 |
| 5623.41 | 0.8 | 1.0 | 1.6 | 2.2 | 2.6 | 2.6 | ±7.0 |
| 6309.57 | 0.9 | 1.2 | 2.1 | 2.9 | 3.5 | 3.5 | ±7.0 |
| 7079.46 | 0.5 | 1.1 | 1.9 | 2.6 | 3.3 | 3.4 | ±7.0 |
| 7943.28 | -0.8 | -0.2 | 0.5 | 1.2 | 1.8 | 1.9 | ±7.0 |
| 8413.95 | -0.8 | -0.3 | 0.4 | 1.0 | 1.7 | 1.6 | ±10.0 |
| 8912.51 | -0.3 | 0.0 | 0.8 | 1.6 | 2.4 | 2.4 | ±10.0 |
| 9440.61 | -0.4 | 0.1 | 0.9 | 1.5 | 1.9 | 2.1 | ±10.0 |
| 10000.0 | -0.3 | 0.2 | 0.4 | 1.0 | 2.1 | 2.8 | ±10.0 |
| 10592.5 | 1.2 | 0.6 | 0.6 | 2.3 | 3.8 | 4.2 | ±10.0 |
| 11220.2 | 0.9 | -0.2 | 1.2 | 2.7 | 3.8 | 4.3 | ±10.0 |
| 11885.0 | -0.6 | -0.1 | 0.9 | 2.0 | 3.5 | 4.3 | ±10.0 |
| 12589.3 | -0.7 | -0.2 | 0.1 | 1.8 | 3.5 | 4.0 | ±10.0 |

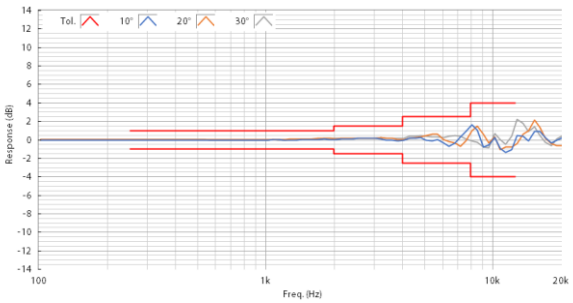
## Frequency Response – Horizontal Incidence Reference – Front – -80° ~ -40°

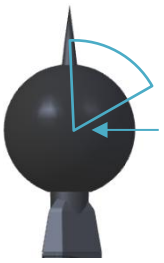
| Freq. (Hz) | -80° (dB) | -70° (dB) | -60° (dB) | -50° (dB) | -40° (dB) | Tol. (dB) |
|---|---|---|---|---|---|---|
| 251.189 | -0.0 | 0.0 | -0.0 | 0.2 | 0.1 | ±1.5 |
| 316.228 | -0.0 | 0.0 | -0.0 | 0.2 | 0.1 | ±1.5 |
| 398.107 | -0.0 | 0.0 | -0.0 | 0.2 | 0.1 | ±1.5 |
| 501.187 | 0.0 | 0.0 | -0.0 | 0.2 | 0.1 | ±1.5 |
| 630.957 | 0.0 | 0.0 | -0.0 | 0.2 | 0.1 | ±1.5 |
| 794.328 | 0.0 | 0.0 | -0.1 | 0.1 | 0.1 | ±1.5 |
| 1000.00 | 0.1 | 0.1 | -0.1 | 0.0 | 0.0 | ±2.0 |
| 1258.93 | 0.2 | 0.1 | -0.1 | -0.0 | -0.1 | ±2.0 |
| 1584.89 | 0.4 | 0.2 | -0.0 | 0.0 | -0.0 | ±2.0 |
| 1995.26 | 0.5 | 0.3 | 0.0 | 0.0 | 0.0 | ±2.0 |
| 2238.72 | 0.6 | 0.2 | -0.1 | -0.0 | 0.0 | ±4.0 |
| 2511.89 | 0.8 | 0.4 | 0.0 | 0.3 | 0.3 | ±4.0 |
| 2818.38 | 0.8 | 0.3 | -0.1 | 0.3 | 0.3 | ±4.0 |
| 3162.28 | 1.0 | 0.5 | 0.1 | 0.5 | 0.1 | ±4.0 |
| 3548.13 | 1.2 | 0.5 | 0.3 | 0.6 | 0.1 | ±4.0 |
| 3981.07 | 1.3 | 0.4 | 0.5 | 0.6 | 0.1 | ±4.0 |
| 4466.84 | 1.3 | 0.5 | 0.8 | 0.5 | 0.3 | ±7.0 |
| 5011.87 | 1.8 | 0.9 | 1.1 | 0.5 | 0.5 | ±7.0 |
| 5623.41 | 2.2 | 1.0 | 1.3 | 0.7 | 0.5 | ±7.0 |
| 6309.57 | 2.7 | 1.2 | 1.5 | 0.9 | 1.0 | ±7.0 |
| 7079.46 | 2.4 | 0.8 | 0.9 | 0.2 | 1.0 | ±7.0 |
| 7943.28 | 1.0 | -0.9 | -1.5 | -1.2 | -0.4 | ±7.0 |
| 8413.95 | 0.5 | -1.4 | -1.9 | -0.9 | -0.2 | ±10.0 |
| 8912.51 | 0.6 | -1.0 | -1.2 | 0.0 | 0.5 | ±10.0 |
| 9440.61 | 0.4 | -0.6 | -1.1 | 0.2 | 0.6 | ±10.0 |
| 10000.0 | 0.5 | -0.1 | -1.1 | 0.3 | 0.5 | ±10.0 |
| 10592.5 | 1.4 | 1.0 | 0.1 | 1.8 | 2.0 | ±10.0 |
| 11220.2 | 0.9 | 0.8 | 0.9 | 2.7 | 2.5 | ±10.0 |
| 11885.0 | 0.2 | 0.3 | 1.5 | 3.0 | 2.1 | ±10.0 |
| 12589.3 | -0.3 | -0.2 | 1.6 | 2.6 | 1.0 | ±10.0 |

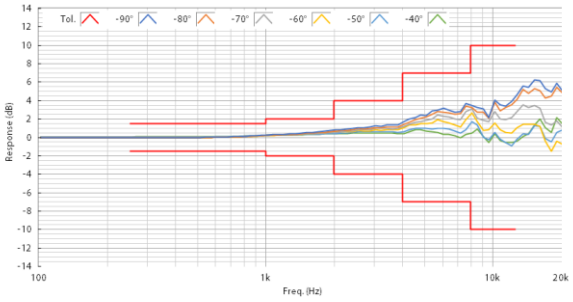


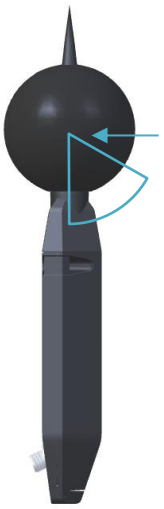

Tol.
-30°
-20°
-10°
Response (dB)
Freq. (Hz)
100
1k
10k
20k

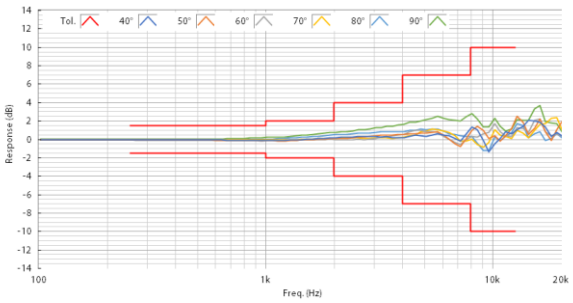



Tol.
10°
20°
30°
Response (dB)
Freq. (Hz)
100
1k
10k
20k




Tol.
-90°
-80°
-70°
-60°
-50°
-40°
Response (dB)
Freq. (Hz)
100
1k
10k
20k




Tol.
40°
50°
60°
70°
80°
90°
Response (dB)
Freq. (Hz)
100
1k
10k
20k

## Frequency Response – Horizontal Incidence Reference – Back – -30° ~ 30°

| Freq. (Hz) | -30° (dB) | -20° (dB) | -10° (dB) | 10° (dB) | 20° (dB) | 30° (dB) | Tol. (dB) |
|---|---|---|---|---|---|---|---|
| 251.189 | -0.0 | -0.1 | 0.0 | -0.0 | 0.0 | 0.0 | ±1.0 |
| 316.228 | -0.0 | -0.1 | 0.0 | -0.0 | 0.0 | 0.0 | ±1.0 |
| 398.107 | -0.0 | -0.1 | 0.0 | -0.0 | 0.0 | 0.0 | ±1.0 |
| 501.187 | -0.0 | -0.1 | 0.0 | -0.0 | 0.0 | 0.0 | ±1.0 |
| 630.957 | -0.0 | -0.1 | 0.0 | -0.1 | 0.0 | -0.0 | ±1.0 |
| 794.328 | 0.0 | -0.0 | 0.0 | -0.0 | 0.0 | -0.0 | ±1.0 |
| 1000.00 | 0.1 | 0.0 | 0.1 | -0.0 | 0.1 | -0.0 | ±1.0 |
| 1258.93 | 0.1 | 0.0 | 0.0 | -0.0 | 0.1 | -0.0 | ±1.0 |
| 1584.89 | 0.2 | 0.1 | 0.0 | 0.0 | 0.1 | 0.1 | ±1.0 |
| 1995.26 | 0.2 | 0.2 | 0.1 | 0.0 | 0.1 | 0.2 | ±1.0 |
| 2238.72 | 0.2 | 0.2 | 0.1 | 0.1 | 0.2 | 0.2 | ±1.5 |
| 2511.89 | 0.2 | 0.2 | 0.1 | 0.1 | 0.2 | 0.2 | ±1.5 |
| 2818.38 | 0.3 | 0.1 | 0.1 | 0.2 | 0.2 | 0.2 | ±1.5 |
| 3162.28 | 0.3 | 0.1 | 0.1 | 0.1 | 0.2 | 0.2 | ±1.5 |
| 3548.13 | 0.2 | -0.0 | 0.0 | -0.1 | 0.2 | 0.2 | ±1.5 |
| 3981.07 | 0.2 | -0.1 | -0.1 | -0.1 | 0.0 | 0.2 | ±1.5 |
| 4466.84 | 0.5 | 0.2 | 0.1 | 0.2 | 0.2 | 0.4 | ±2.5 |
| 5011.87 | 0.5 | 0.4 | 0.1 | 0.0 | 0.4 | 0.4 | ±2.5 |
| 5623.41 | 0.3 | 0.3 | 0.3 | -0.0 | 0.6 | 0.3 | ±2.5 |
| 6309.57 | -0.3 | -0.6 | -0.2 | -0.6 | -0.1 | 0.4 | ±2.5 |
| 7079.46 | -0.3 | -0.7 | -1.1 | 0.2 | -0.6 | 0.4 | ±2.5 |
| 7943.28 | 0.3 | 0.4 | 0.1 | 1.4 | 0.7 | -0.0 | ±2.5 |
| 8413.95 | -0.2 | 0.0 | 0.5 | 1.2 | 1.4 | -0.2 | ±4.0 |
| 8912.51 | -0.0 | -0.6 | -0.2 | -0.3 | 0.8 | -0.6 | ±4.0 |
| 9440.61 | -0.5 | -0.4 | -0.6 | -0.6 | -0.1 | -0.8 | ±4.0 |
| 10000.0 | -0.1 | 0.4 | 0.3 | 0.1 | 0.2 | 0.3 | ±4.0 |
| 10592.5 | 0.1 | 0.3 | 0.5 | -0.6 | -0.7 | 0.2 | ±4.0 |
| 11220.2 | -0.1 | 0.5 | 0.3 | -1.3 | -0.8 | -0.3 | ±4.0 |
| 11885.0 | -0.1 | 0.7 | 0.5 | -1.1 | -0.8 | 0.2 | ±4.0 |
| 12589.3 | 0.4 | 1.3 | 1.4 | 0.1 | -0.5 | 1.7 | ±4.0 |

## Frequency Response – Horizontal Incidence Reference – Back – -90° ~ -40°

| Freq. (Hz) | -90° (dB) | -80° (dB) | -70° (dB) | -60° (dB) | -50° (dB) | -40° (dB) | Tol. (dB) |
|---|---|---|---|---|---|---|---|
| 251.189 | -0.0 | -0.0 | 0.0 | -0.0 | 0.0 | 0.1 | ±1.5 |
| 316.228 | -0.0 | -0.0 | 0.0 | -0.0 | 0.0 | 0.1 | ±1.5 |
| 398.107 | -0.0 | -0.0 | 0.0 | -0.0 | 0.0 | 0.1 | ±1.5 |
| 501.187 | -0.0 | -0.0 | 0.0 | -0.0 | 0.1 | 0.1 | ±1.5 |
| 630.957 | 0.0 | 0.0 | 0.1 | 0.0 | 0.1 | 0.1 | ±1.5 |
| 794.328 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.2 | ±1.5 |
| 1000.00 | 0.3 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | ±2.0 |
| 1258.93 | 0.4 | 0.3 | 0.3 | 0.3 | 0.3 | 0.2 | ±2.0 |
| 1584.89 | 0.6 | 0.5 | 0.4 | 0.4 | 0.3 | 0.3 | ±2.0 |
| 1995.26 | 0.8 | 0.7 | 0.6 | 0.6 | 0.4 | 0.4 | ±2.0 |
| 2238.72 | 0.9 | 0.7 | 0.7 | 0.6 | 0.5 | 0.4 | ±4.0 |
| 2511.89 | 1.0 | 0.9 | 0.8 | 0.7 | 0.6 | 0.5 | ±4.0 |
| 2818.38 | 1.1 | 1.0 | 0.9 | 0.7 | 0.6 | 0.5 | ±4.0 |
| 3162.28 | 1.3 | 1.1 | 1.0 | 0.8 | 0.6 | 0.5 | ±4.0 |
| 3548.13 | 1.4 | 1.1 | 0.9 | 0.8 | 0.6 | 0.5 | ±4.0 |
| 3981.07 | 1.6 | 1.4 | 1.2 | 1.0 | 0.6 | 0.4 | ±4.0 |
| 4466.84 | 2.1 | 1.9 | 1.6 | 1.3 | 0.9 | 0.8 | ±7.0 |
| 5011.87 | 2.4 | 2.2 | 1.9 | 1.5 | 1.0 | 0.7 | ±7.0 |
| 5623.41 | 3.0 | 2.7 | 2.4 | 1.8 | 1.0 | 0.6 | ±7.0 |
| 6309.57 | 3.0 | 2.7 | 2.3 | 1.6 | 0.9 | 0.3 | ±7.0 |
| 7079.46 | 2.8 | 2.6 | 2.0 | 1.2 | 0.5 | 0.0 | ±7.0 |
| 7943.28 | 3.5 | 3.3 | 3.0 | 2.5 | 1.5 | 0.4 | ±7.0 |
| 8413.95 | 3.3 | 2.9 | 2.3 | 1.9 | 1.4 | 0.8 | ±10.0 |
| 8912.51 | 3.1 | 2.7 | 1.9 | 1.0 | 0.4 | 0.3 | ±10.0 |
| 9440.61 | 2.4 | 2.3 | 1.7 | 0.8 | -0.2 | -0.4 | ±10.0 |
| 10000.0 | 3.6 | 3.4 | 2.5 | 1.4 | 0.3 | 0.1 | ±10.0 |
| 10592.5 | 3.7 | 3.1 | 2.2 | 1.0 | -0.0 | -0.2 | ±10.0 |
| 11220.2 | 3.5 | 3.2 | 2.0 | 0.6 | -0.5 | -0.5 | ±10.0 |
| 11885.0 | 3.8 | 3.5 | 2.1 | 0.5 | -0.8 | -0.6 | ±10.0 |
| 12589.3 | 4.5 | 4.0 | 2.6 | 0.9 | -0.4 | -0.4 | ±10.0 |

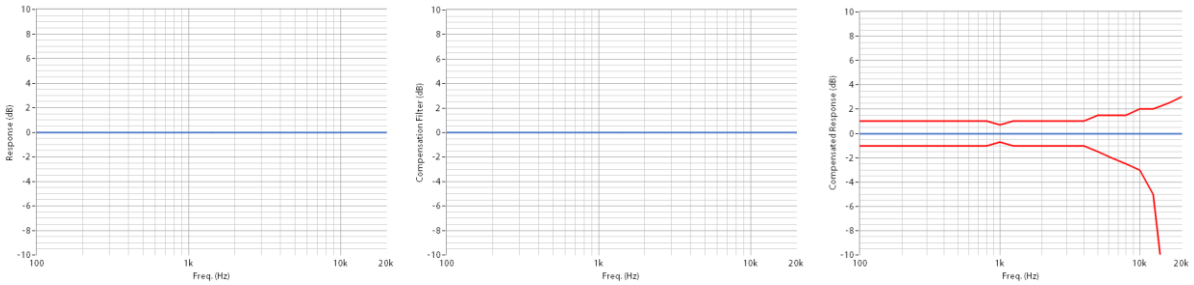
## Frequency Response – Horizontal Incidence Reference – Back – 40° ~ -90°

| Freq. (Hz) | 40° (dB) | 50° (dB) | 60° (dB) | 70° (dB) | 80° (dB) | 90° (dB) | Tol. (dB) |
|---|---|---|---|---|---|---|---|
| 251.189 | -0.0 | -0.0 | -0.1 | -0.0 | -0.0 | 0.0 | ±1.5 |
| 316.228 | -0.0 | -0.0 | -0.1 | -0.0 | -0.1 | 0.0 | ±1.5 |
| 398.107 | -0.0 | -0.0 | -0.1 | -0.0 | -0.1 | 0.0 | ±1.5 |
| 501.187 | -0.0 | -0.0 | -0.1 | -0.0 | -0.1 | 0.0 | ±1.5 |
| 630.957 | -0.1 | -0.1 | -0.1 | -0.0 | -0.0 | 0.1 | ±1.5 |
| 794.328 | -0.1 | -0.1 | -0.1 | -0.0 | -0.0 | 0.1 | ±1.5 |
| 1000.00 | -0.1 | -0.1 | -0.1 | -0.0 | 0.0 | 0.2 | ±2.0 |
| 1258.93 | -0.1 | -0.1 | -0.1 | -0.0 | 0.1 | 0.3 | ±2.0 |
| 1584.89 | 0.0 | -0.0 | -0.1 | 0.1 | 0.3 | 0.5 | ±2.0 |
| 1995.26 | 0.2 | 0.1 | -0.0 | 0.1 | 0.5 | 0.8 | ±2.0 |
| 2238.72 | 0.2 | 0.1 | -0.0 | 0.1 | 0.6 | 0.9 | ±4.0 |
| 2511.89 | 0.3 | 0.2 | 0.0 | 0.2 | 0.7 | 1.0 | ±4.0 |
| 2818.38 | 0.3 | 0.3 | 0.0 | 0.1 | 0.7 | 1.1 | ±4.0 |
| 3162.28 | 0.3 | 0.4 | 0.2 | 0.2 | 0.8 | 1.3 | ±4.0 |
| 3548.13 | 0.2 | 0.5 | 0.4 | 0.1 | 0.8 | 1.4 | ±4.0 |
| 3981.07 | 0.2 | 0.5 | 0.6 | 0.2 | 0.8 | 1.6 | ±4.0 |
| 4466.84 | 0.4 | 0.6 | 0.9 | 0.5 | 1.0 | 1.9 | ±7.0 |
| 5011.87 | 0.4 | 0.7 | 0.9 | 0.9 | 1.1 | 2.1 | ±7.0 |
| 5623.41 | 0.6 | 0.8 | 0.8 | 1.1 | 1.2 | 2.5 | ±7.0 |
| 6309.57 | 0.4 | 0.2 | 0.1 | 0.8 | 0.7 | 2.2 | ±7.0 |
| 7079.46 | -0.1 | -0.7 | -0.5 | -0.0 | 0.4 | 2.0 | ±7.0 |
| 7943.28 | 1.1 | 0.8 | 0.2 | 0.0 | 0.3 | 2.7 | ±7.0 |
| 8413.95 | 1.2 | 1.3 | 0.3 | -0.4 | -0.2 | 2.4 | ±10.0 |
| 8912.51 | 0.2 | 1.1 | 0.5 | -0.7 | -1.0 | 1.6 | ±10.0 |
| 9440.61 | -1.0 | 0.4 | 0.7 | -0.4 | -1.2 | 1.3 | ±10.0 |
| 10000.0 | -0.7 | 0.3 | 1.5 | 0.7 | -0.1 | 2.1 | ±10.0 |
| 10592.5 | -0.1 | -0.0 | 1.1 | 0.6 | -0.0 | 1.7 | ±10.0 |
| 11220.2 | 0.6 | 0.2 | 0.5 | 0.3 | 0.2 | 1.1 | ±10.0 |
| 11885.0 | 0.7 | 1.0 | 0.3 | 0.2 | 0.6 | 1.1 | ±10.0 |
| 12589.3 | 0.9 | 2.2 | 1.0 | 0.8 | 1.4 | 1.9 | ±10.0 |

## 8.8 Frequency Response Compensation

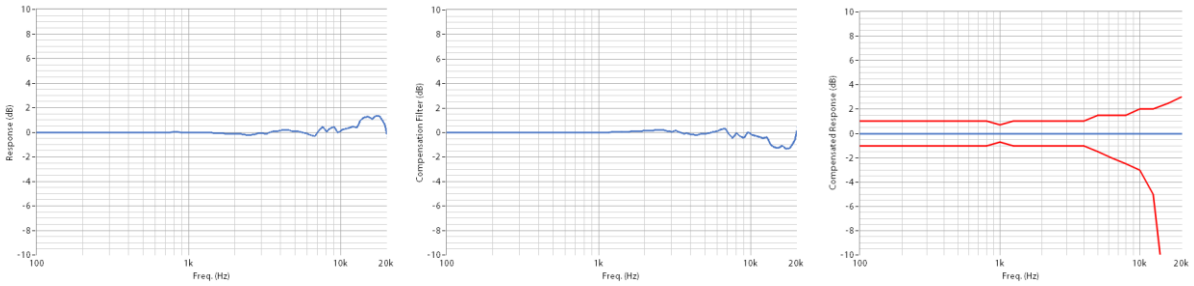
### 8.8.1 None

This frequency response compensation is to be used when injecting electrical signals in place of the microphone cartridge.

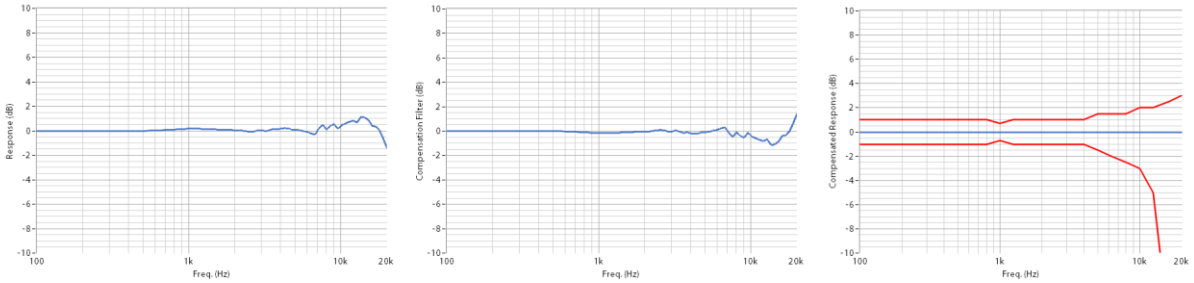



### 8.8.2 Free-field 0°

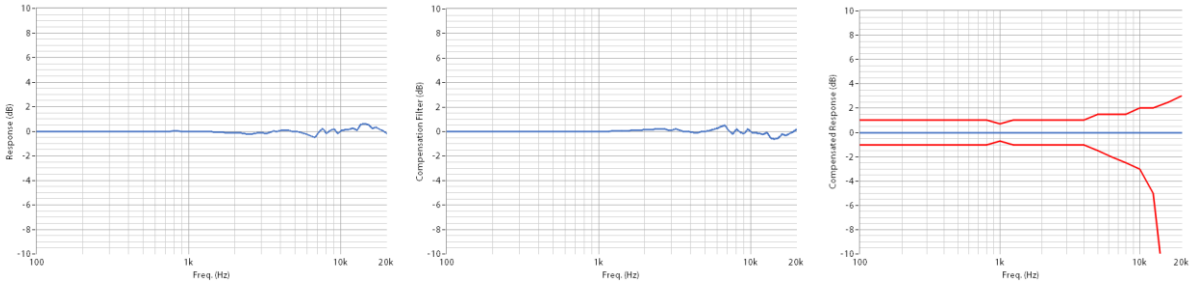
This frequency response is to be used in a 0° incidence free-field. This application is to be used for indoors measurements using the diffusor neck without a windscreen.




SAS with 378B02 microphone from PCB Piezotronics



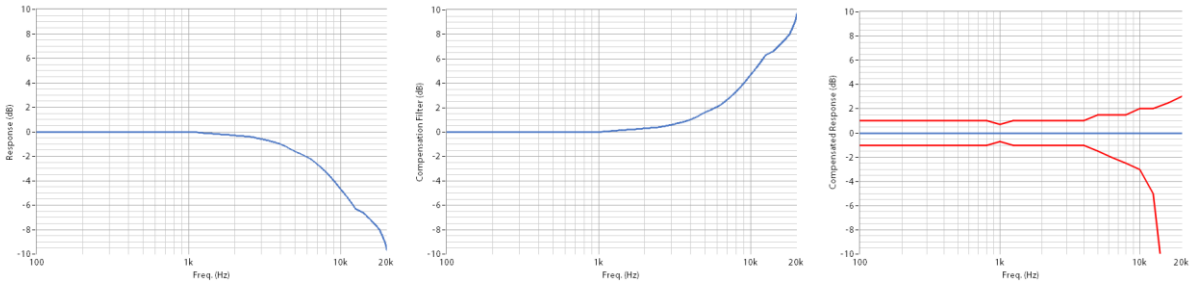

SAS with 246AE microphone from GRAS



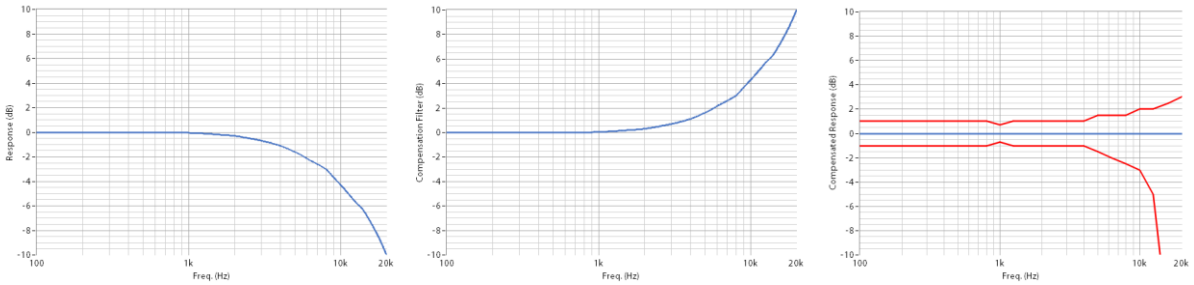

SAS with 378A06 microphone from PCB Piezotronics

### 8.8.3 Pressure

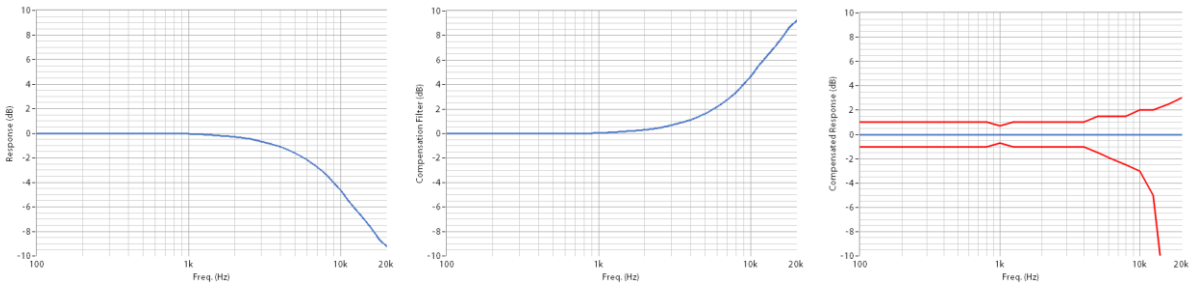
This frequency response is to be used when exposing the microphone diaphragm to a pressure field such as in the calibration chamber of an acoustical calibrator.




SAS with 378B02 microphone from PCB Piezotronics



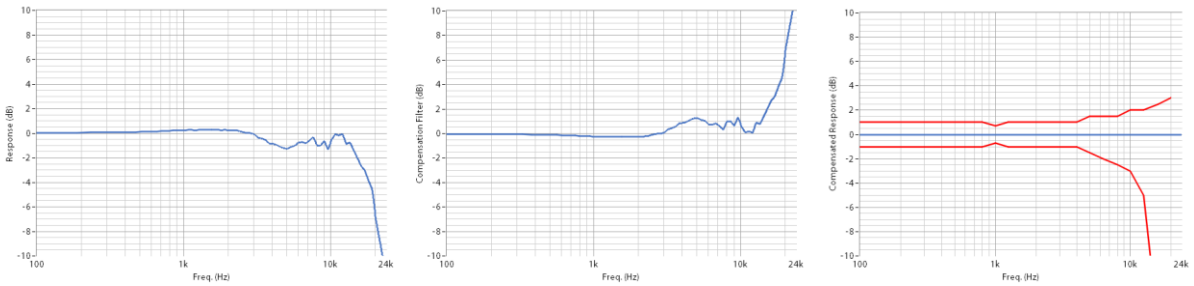

SAS with 246AE microphone from GRAS



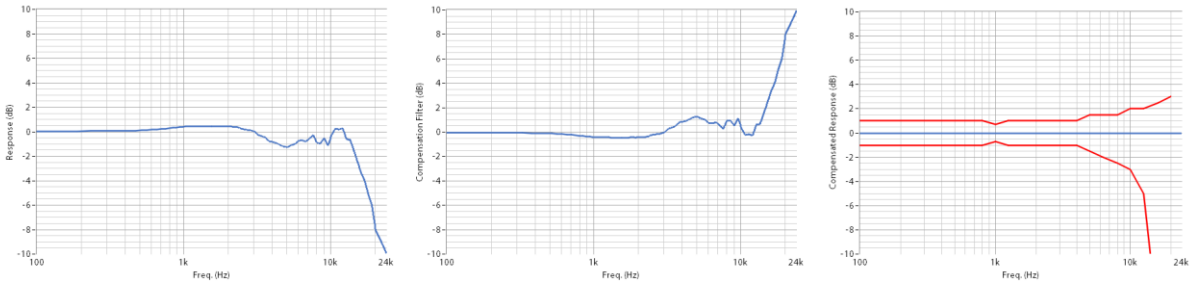

SAS with 378A06 microphone from PCB Piezotronics

### 8.8.4 Free-field 0° + Birdspike

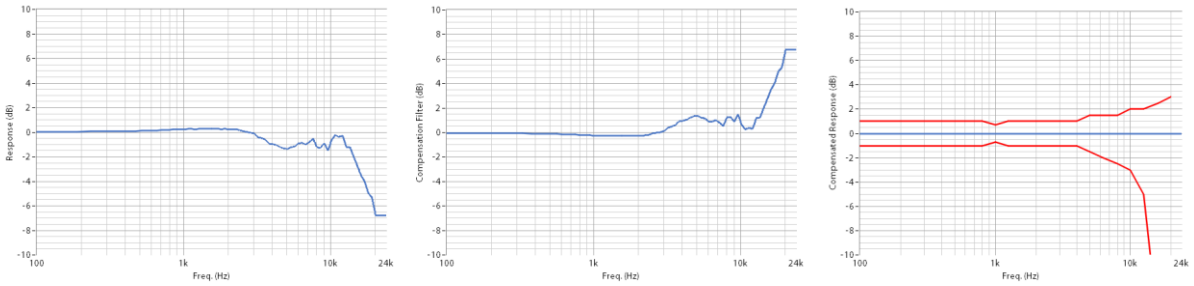
This selection uses a frequency compensation for a 0° incidence free-field with the birdspike and windscreen assembly. This application is for outdoor measurements of overhead sources such as airplanes.




SAS with 378B02 microphone from PCB Piezotronics



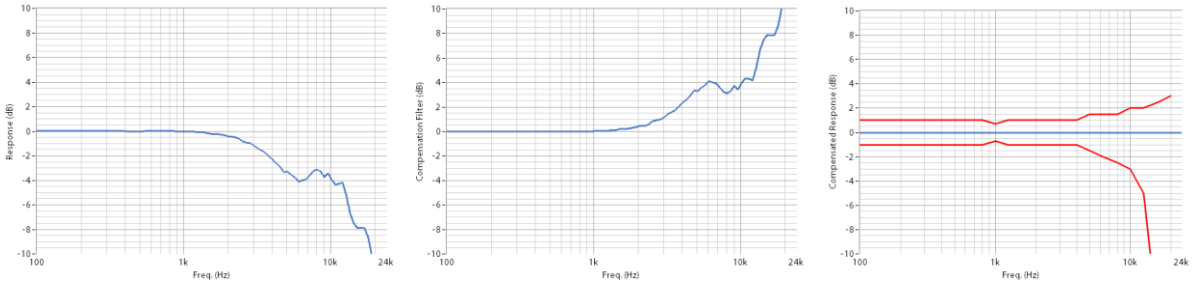

SAS with 246AE microphone from GRAS



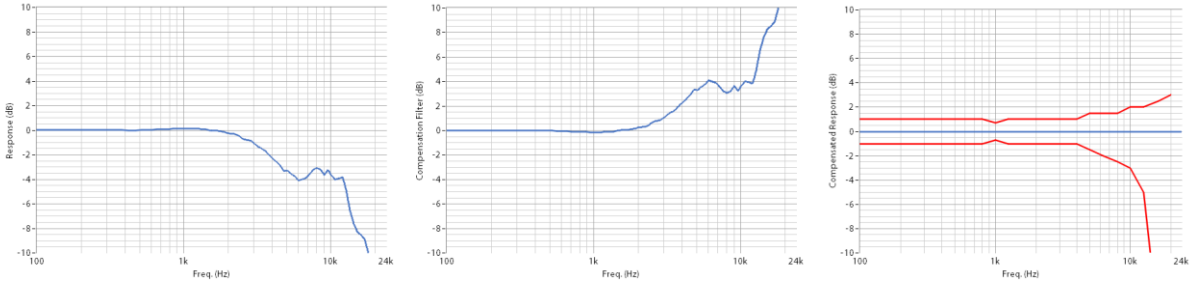

SAS with 378A06 microphone from PCB Piezotronics

### 8.8.5 Free-field 90° + Birdspike

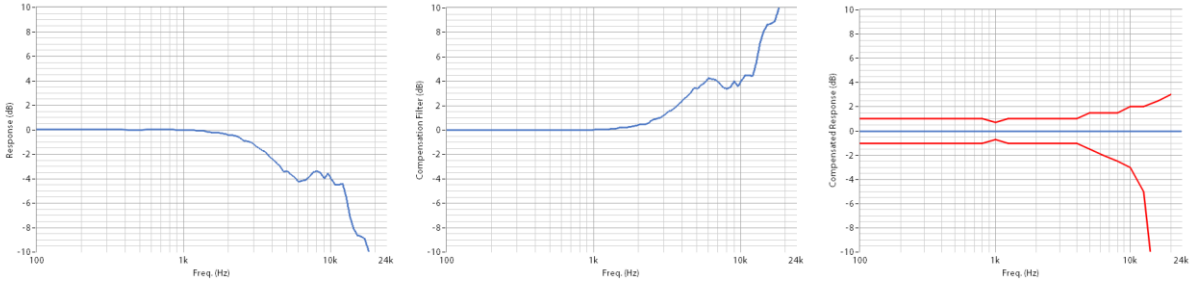
This selection uses a frequency compensation for a 90° incidence free-field with the birdspike and windscreen assembly. This application is for outdoor measurements of community noise sources such as construction equipment.




SAS with 378B02 microphone from PCB Piezotronics



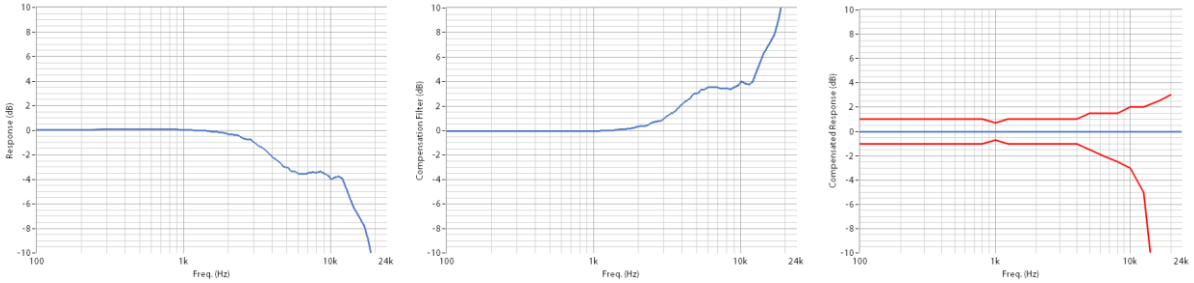

SAS with 246AE microphone from GRAS



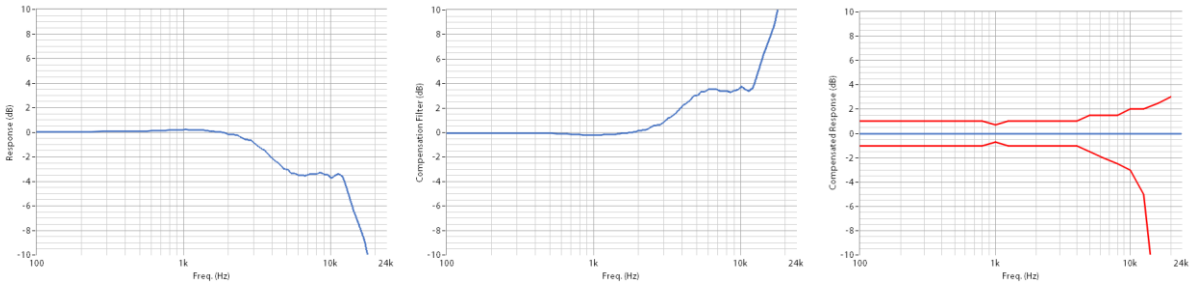

SAS with 378A06 microphone from PCB Piezotronics

### 8.8.6 Random Incidence + Birdspike

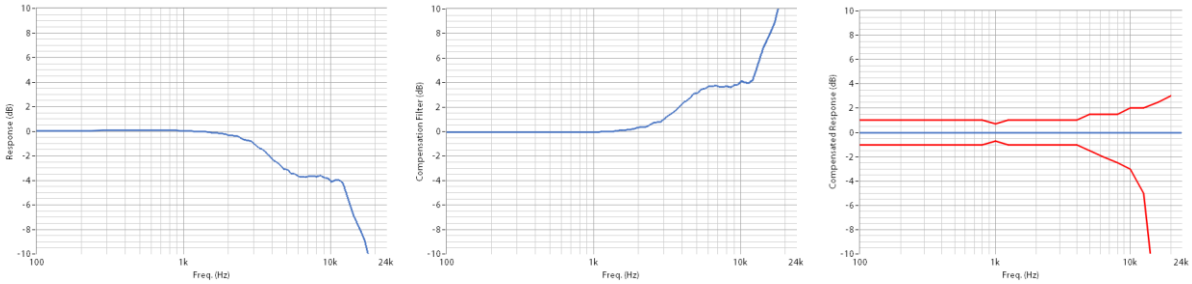
This selection uses a frequency compensation for a random incidence sound field with the birdspike and windscreen assembly. This application is for reverberant indoor measurements such as inside a reverberant factory building.



SAS with 378B02 microphone from PCB Piezotronics



SAS with 246AE microphone from GRAS



SAS with 378A06 microphone from PCB Piezotronics

## 8.9 Acoustical Frequency Response

The acoustical frequency response is measured using a multi-tone acoustical calibrator such as model 4226 from Brüel & Kjær or equivalent and selecting the "Pressure" frequency compensation (refer to section 8.8.3) and 94.0dB reference amplitude.

The resulting frequency response should be flat (0dB) from 20Hz to 20kHz (±0.5dB uncertainty).

## 8.10 Electrical Frequency Response

The electrical frequency response is measured by injecting an electrical signal from a tone generator and selecting the "None" frequency compensation.

The resulting frequency response should be flat (0dB) from 10Hz to 20kHz against the frequency weighting target response (±0.2dB uncertainty).

| Frequency (Hz) | dBA | dBC | dBZ (LF Filter OFF) | dBZ (LF Filter ON) |
|---|---|---|---|---|
| 5 | -93.1 | -25.0 | 0.0 | -12.3 |
| 6.3 | -85.4 | -21.3 | 0.0 | -8.7 |

| | | | | |
|---|---|---|---|---|
| 8 | -77.8 | -17.7 | 0.0 | -5.4 |
| 10 | -70.4 | -14.3 | 0.0 | -3.0 |
| 12.5 | -63.4 | -11.2 | 0.0 | -1.5 |
| 16 | -56.7 | -8.5 | 0.0 | -0.6 |
| 20 | -50.5 | -6.2 | 0.0 | -0.3 |
| 25 | -44.7 | -4.4 | 0.0 | -0.1 |
| 31.5 | -39.4 | -3.0 | 0.0 | -0.0 |
| 40 | -34.6 | -2.0 | 0.0 | -0.0 |
| 50 | -30.2 | -1.3 | 0.0 | 0.0 |
| 63 | -26.2 | -0.8 | 0.0 | 0.0 |
| 80 | -22.5 | -0.5 | 0.0 | 0.0 |
| 100 | -19.1 | -0.3 | 0.0 | 0.0 |
| 125 | -16.1 | -0.2 | 0.0 | 0.0 |
| 160 | -13.4 | -0.1 | 0.0 | 0.0 |
| 200 | -10.9 | 0.0 | 0.0 | 0.0 |
| 250 | -8.6 | 0.0 | 0.0 | 0.0 |
| 315 | -6.6 | 0.0 | 0.0 | 0.0 |
| 400 | -4.8 | 0.0 | 0.0 | 0.0 |
| 500 | -3.2 | 0.0 | 0.0 | 0.0 |
| 630 | -1.9 | 0.0 | 0.0 | 0.0 |
| 800 | -0.8 | 0.0 | 0.0 | 0.0 |
| 1k | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.25k | 0.6 | 0.0 | 0.0 | 0.0 |
| 1.6k | 1.0 | -0.1 | 0.0 | 0.0 |
| 2k | 1.2 | -0.2 | 0.0 | 0.0 |
| 2.5k | 1.3 | -0.3 | 0.0 | 0.0 |
| 3.15k | 1.2 | -0.5 | 0.0 | 0.0 |
| 4k | 1.0 | -0.8 | 0.0 | 0.0 |
| 5k | 0.5 | -1.3 | 0.0 | 0.0 |
| 6.3k | -0.1 | -2.0 | 0.0 | 0.0 |
| 8k | -1.1 | -3.0 | 0.0 | 0.0 |
| 10k | -2.5 | -4.4 | 0.0 | 0.0 |
| 12.5k | -4.3 | -6.2 | 0.0 | 0.0 |
| 16k | -6.6 | -8.5 | 0.0 | 0.0 |
| 20k | -9.3 | -11.2 | 0.0 | 0.0 |

## 8.11 Level Linearity

### 8.11.1 Minimum

Low Range

| Frequency (Hz) | Lower Bound (dBA) | Upper Bound (dBA) | Dynamic (dB) |
|---|---|---|---|
| 31.5 | 30.0 | 82.5 | 52.5 |
| 63 | 30.0 | 95.8 | 65.8 |
| 125 | 30.0 | 105.8 | 75.8 |
| 250 | 30.0 | 113.3 | 83.3 |
| 500 | 30.0 | 118.7 | 88.7 |
| 1k | 30.0 | 122.0 | 92.0 |
| 2k | 30.0 | 123.2 | 93.2 |
| 4k | 30.0 | 123.0 | 93.0 |
| 8k | 30.0 | 120.8 | 90.8 |
| 10k | 30.0 | 119.5 | 89.5 |
| 12.5k | 30.0 | 117.7 | 87.7 |
| 16k | 30.0 | 115.3 | 85.3 |

High Range

| Frequency (Hz) | Lower Bound (dBA) | Upper Bound (dBA) | Dynamic (dB) |
|---|---|---|---|
| 31.5 | 42.0 | 94.5 | 52.5 |
| 63 | 42.0 | 107.8 | 65.8 |
| 125 | 42.0 | 117.8 | 75.8 |
| 250 | 42.0 | 125.3 | 83.3 |
| 500 | 42.0 | 130.7 | 88.7 |
| 1k | 42.0 | 134.0 | 92.0 |
| 2k | 42.0 | 135.2 | 93.2 |
| 4k | 42.0 | 135.0 | 93.0 |
| 8k | 42.0 | 132.8 | 90.8 |
| 10k | 42.0 | 131.5 | 89.5 |
| 12.5k | 42.0 | 129.7 | 87.7 |
| 16k | 42.0 | 127.3 | 85.3 |

### 8.11.2 Typical

Low Range

| Frequency (Hz) | Lower Bound (dBA) | Upper Bound (dBA) | Dynamic (dB) |
|---|---|---|---|

| | | | |
|---|---|---|---|
| 31.5 | 28.0 | 84.0 | 56.0 |
| 63 | 27.0 | 99.0 | 72.0 |
| 125 | 27.0 | 109.0 | 82.0 |
| 250 | 27.0 | 116.0 | 89.0 |
| 500 | 27.0 | 122.0 | 95.0 |
| 1k | 26.0 | 125.0 | 99.0 |
| 2k | 27.0 | 126.0 | 99.0 |
| 4k | 27.0 | 126.0 | 99.0 |
| 8k | 27.0 | 124.0 | 97.0 |
| 10k | 27.0 | 122.0 | 95.0 |
| 12.5k | 27.0 | 120.0 | 93.0 |
| 16k | 28.0 | 118.0 | 90.0 |

High Range

| Frequency (Hz) | Lower Bound (dBA) | Upper Bound (dBA) | Dynamic (dB) |
|---|---|---|---|
| 31.5 | 38.0 | 96.0 | 58.0 |
| 63 | 38.0 | 111.0 | 73.0 |
| 125 | 38.0 | 121.0 | 83.0 |
| 250 | 38.0 | 128.0 | 90.0 |
| 500 | 37.0 | 134.0 | 97.0 |
| 1k | 37.0 | 137.0 | 100.0 |
| 2k | 37.0 | 138.0 | 101.0 |
| 4k | 37.0 | 138.0 | 101.0 |
| 8k | 38.0 | 136.0 | 98.0 |
| 10k | 38.0 | 134.0 | 96.0 |
| 12.5k | 38.0 | 132.0 | 94.0 |
| 16k | 38.0 | 130.0 | 92.0 |

### 8.11.3 Dynamic Range Reference Starting point

| Frequency (Hz) | Reference Starting Point (dBA) |
|---|---|
| 31.5 | 54.6 |
| 63 | 67.8 |
| 125 | 77.9 |
| 250 | 85.4 |
| 500 | 90.8 |
| 1k | 94.0 |

| | |
|---|---|
| 2k | 95.2 |
| 4k | 95.0 |
| 8k | 92.9 |
| 10k | 91.5 |
| 12.5k | 89.7 |
| 16k | 87.4 |

## 8.12 Self-Generated Noise

Electrical self-generated noise is measured using a short-circuit on the capacitive adapter replacing the microphone. The frequency response compensation is set to "None".

Acoustical self-generated noise is measured using the SAS in a low-level sound field that does not add significantly to the self-generated noise. The frequency response compensation is set to "Free-Field 0°".

### 8.12.1 Maximum

Low Range

| Condition | dBA | dBC | dBZ (LF Filter OFF) | dBZ (LF Filter ON) |
|---|---|---|---|---|
| Electrical | 20.0 | 24.0 | 35.0 | 30.0 |
| Acoustical (Total) | 22.0 | 50.0 | 70.0 | 55.0 |

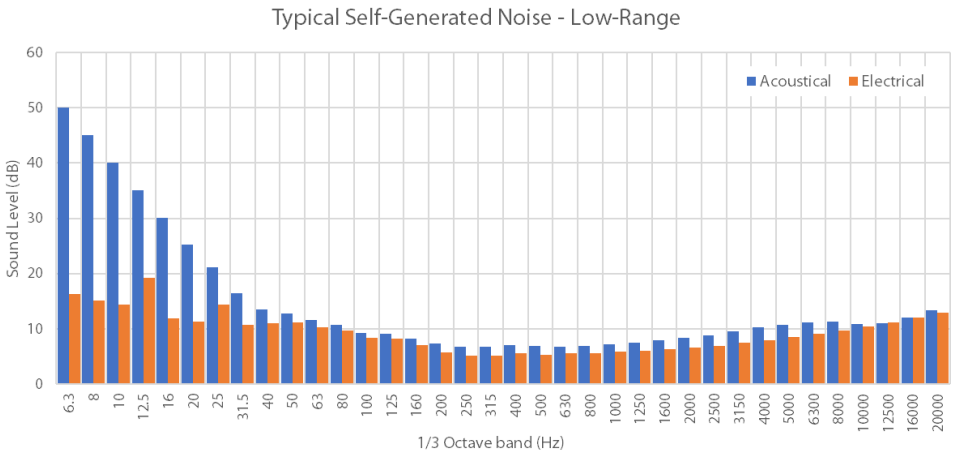
High Range

| Condition | dBA | dBC | dBZ (LF Filter OFF) | dBZ (LF Filter ON) |
|---|---|---|---|---|
| Electrical | 32.0 | 35.0 | 40.0 | 35.0 |
| Acoustical (Total) | 32.0 | 50.0 | 70.0 | 55.0 |

### 8.12.2 Typical

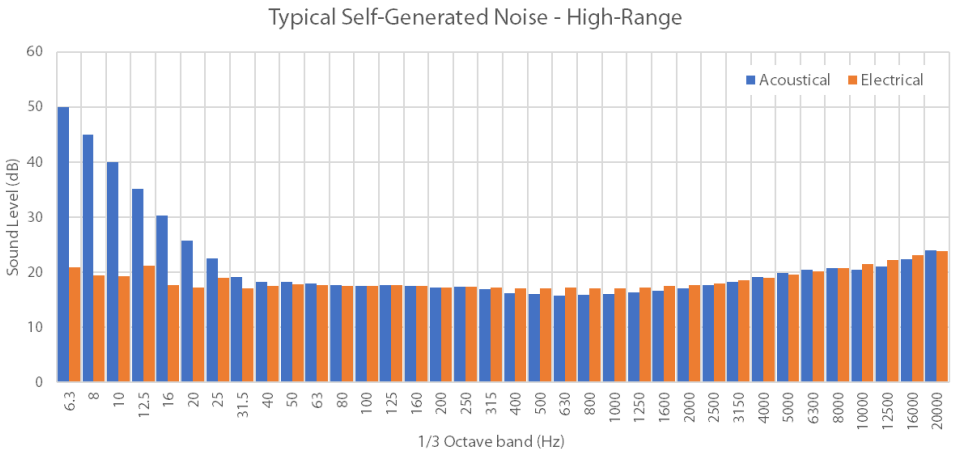
Low Range

| Condition | dBA | dBC | dBZ (LF Filter OFF) | dBZ (LF Filter ON) |
|---|---|---|---|---|
| Electrical | 19.5 | 22.0 | 32.0 | 26.0 |
| Acoustical (Total) | 21.0 | 38.0 | 67.0 | 50.0 |




## High Range

| Condition | dBA | dBC | dBZ (LF Filter OFF) | dBZ (LF Filter ON) |
|---|---|---|---|---|
| Electrical | 30.2 | 31.2 | 38.0 | 34.5 |
| Acoustical (Total) | 30.2 | 38.2 | 67.0 | 50.0 |




# 8.13 Time Weightings

## 8.13.1 Decay Rate

| Time Weighting | Meas. Decay Rate (dB/s) | Target Decay Rate (dB/s) | Error (dB/s) | Tolerance (dB/s) |
|---|---|---|---|---|
| Fast | -34.79 | -34.7 | -0.09 | +3.8; -3.7 |
| Slow | -4.35 | -4.3 | -0.05 | +0.8; -0.7 |

### 8.13.2 Continuous Response at 1kHz

"Fast" Time Weighting as a Reference

| Freq. Weighting | LF Measure (dB) | LS Response (dB) | Leq Response (dB) | Tolerance (dB) |
|---|---|---|---|---|
| A | 94.0 | 0.0 | 0.0 | ±0.1 |
| C | 94.0 | 0.0 | 0.0 | ±0.1 |
| Z | 94.0 | 0.0 | 0.0 | ±0.1 |

"A" Frequency Weighting as a Reference

| Time Weighting | LA Measure (dBA) | LC Response (dB) | LZ Response (dB) | Tolerance (dB) |
|---|---|---|---|---|
| Fast | 94.0 | 0.0 | 0.0 | ±0.2 |
| Slow | 94.0 | 0.0 | 0.0 | ±0.2 |
| Eq. | 94.0 | 0.0 | 0.0 | ±0.2 |

## 8.14 Toneburst Response

### 8.14.1 Slow Time Weighting

Z Frequency Weighting

| Toneburst duration (ms) | LZ (dBZ) | LZSmax (dBZ) | Response (dB) | Target Resp. (dB) | Error (dB) | Tolerance (dB) |
|---|---|---|---|---|---|---|
| 1000 | 131.0 | 128.9 | -2.0 | -2.0 | 0.0 | ±0.5 |
| 500 | 131.0 | 126.9 | -4.1 | -4.1 | 0.0 | ±0.5 |
| 200 | 131.0 | 123.5 | -7.5 | -7.4 | -0.1 | ±0.5 |
| 100 | 131.0 | 120.7 | -10.3 | -10.2 | -0.1 | ±1.0 |
| 50 | 131.0 | 117.8 | -13.2 | -13.1 | -0.1 | ±1.0 |
| 20 | 131.0 | 113.9 | -17.1 | -17.0 | -0.1 | 1.0; -1.5 |
| 10 | 131.0 | 110.9 | -20.1 | -20.0 | -0.1 | 1.0; -2.0 |
| 5 | 131.0 | 107.9 | -23.1 | -23.0 | -0.1 | 1.0; -2.5 |
| 2 | 131.0 | 103.9 | -27.0 | -27.0 | 0.0 | 1.0; -3.0 |

C Frequency Weighting

| Toneburst duration (ms) | LC (dBC) | LCSmax (dBC) | Response (dB) | Target Resp. (dB) | Error (dB) | Tolerance (dB) |
|---|---|---|---|---|---|---|
| 1000 | 130.2 | 128.1 | -2.0 | -2.0 | 0.0 | ±0.5 |
| 500 | 130.2 | 126.1 | -4.1 | -4.1 | 0.0 | ±0.5 |
| 200 | 130.2 | 122.7 | -7.5 | -7.4 | -0.1 | ±0.5 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 100 | 130.2 | 119.9 | -10.3 | -10.2 | -0.1 | ±1.0 |
| 50 | 130.2 | 117.0 | -13.2 | -13.1 | -0.1 | ±1.0 |
| 20 | 130.2 | 113.1 | -17.1 | -17.0 | -0.1 | 1.0; -1.5 |
| 10 | 130.2 | 110.1 | -20.1 | -20.0 | -0.1 | 1.0; -2.0 |
| 5 | 130.2 | 107.1 | -23.1 | -23.0 | -0.1 | 1.0; -2.5 |
| 2 | 130.2 | 103.1 | -27.1 | -27.0 | -0.1 | 1.0; -3.0 |

### A Frequency Weighting

| Toneburst duration (ms) | LA (dBA) | LASmax (dBA) | Response (dB) | Target Resp. (dB) | Error (dB) | Tolerance (dB) |
|---|---|---|---|---|---|---|
| 1000 | 132.0 | 129.9 | -2.0 | -2.0 | 0.0 | ±0.5 |
| 500 | 132.0 | 127.8 | -4.1 | -4.1 | 0.0 | ±0.5 |
| 200 | 132.0 | 124.5 | -7.5 | -7.4 | -0.1 | ±0.5 |
| 100 | 132.0 | 121.7 | -10.3 | -10.2 | -0.1 | ±1.0 |
| 50 | 132.0 | 118.8 | -13.2 | -13.1 | -0.1 | ±1.0 |
| 20 | 132.0 | 114.9 | -17.1 | -17.0 | -0.1 | 1.0; -1.5 |
| 10 | 132.0 | 111.9 | -20.1 | -20.0 | -0.1 | 1.0; -2.0 |
| 5 | 132.0 | 108.9 | -23.1 | -23.0 | -0.1 | 1.0; -2.5 |
| 2 | 132.0 | 104.9 | -27.1 | -27.0 | -0.1 | 1.0; -3.0 |

## 8.14.2 Fast Time Weighting

### Z Frequency Weighting

| Toneburst duration (ms) | LZ (dBZ) | LZFmax (dBZ) | Response (dB) | Target Resp. (dB) | Error (dB) | Tolerance (dB) |
|---|---|---|---|---|---|---|
| 1000 | 131.0 | 131.0 | 0.0 | 0.0 | 0.0 | ±0.5 |
| 500 | 131.0 | 130.9 | -0.1 | -0.1 | 0.0 | ±0.5 |
| 200 | 131.0 | 129.9 | -1.1 | -1.0 | -0.1 | ±0.5 |
| 100 | 131.0 | 128.3 | -2.7 | -2.6 | -0.1 | ±1.0 |
| 50 | 131.0 | 126.0 | -5.0 | -4.8 | -0.2 | ±1.0 |
| 20 | 131.0 | 122.5 | -8.5 | -8.3 | -0.2 | ±1.0 |
| 10 | 131.0 | 119.7 | -11.3 | -11.1 | -0.2 | ±1.0 |
| 5 | 131.0 | 116.7 | -14.3 | -14.1 | -0.2 | ±1.0 |
| 2 | 131.0 | 112.6 | -18.4 | -18.0 | -0.4 | 1.0; -1.5 |
| 1 | 131.0 | 109.8 | -21.2 | -21.0 | -0.2 | 1.0; -2.0 |
| 0.5 | 131.0 | 106.8 | -24.2 | -24.0 | -0.2 | 1.0; -2.5 |
| 0.25 | 131.0 | 103.8 | -27.2 | -27.0 | -0.2 | 1.0; -3.0 |

C Frequency Weighting

| Toneburst duration (ms) | LC (dBC) | LCFmax (dBC) | Response (dB) | Target Resp. (dB) | Error (dB) | Tolerance (dB) |
|---|---|---|---|---|---|---|
| 1000 | 130.2 | 130.1 | 0.0 | 0.0 | 0.0 | ±0.5 |
| 500 | 130.2 | 130.1 | -0.1 | -0.1 | 0.0 | ±0.5 |
| 200 | 130.2 | 129.1 | -1.1 | -1.0 | -0.1 | ±0.5 |
| 100 | 130.2 | 127.5 | -2.6 | -2.6 | 0.0 | ±1.0 |
| 50 | 130.2 | 125.1 | -5.0 | -4.8 | -0.2 | ±1.0 |
| 20 | 130.2 | 121.7 | -8.5 | -8.3 | -0.2 | ±1.0 |
| 10 | 130.2 | 119.0 | -11.2 | -11.1 | -0.1 | ±1.0 |
| 5 | 130.2 | 115.7 | -14.4 | -14.1 | -0.3 | ±1.0 |
| 2 | 130.2 | 112.0 | -18.2 | -18.0 | -0.2 | 1.0; -1.5 |
| 1 | 130.2 | 109.0 | -21.2 | -21.0 | -0.2 | 1.0; -2.0 |
| 0.5 | 130.2 | 106.0 | -24.1 | -24.0 | -0.1 | 1.0; -2.5 |
| 0.25 | 130.2 | 103.1 | -27.1 | -27.0 | -0.1 | 1.0; -3.0 |

| Toneburst duration (ms) | LA (dBA) | LAFmax (dBA) | Response (dB) | Target Resp. (dB) | Error (dB) | Tolerance (dB) |
|---|---|---|---|---|---|---|
| 1000 | 132.0 | 131.9 | 0.0 | 0.0 | 0.0 | ±0.5 |
| 500 | 132.0 | 131.8 | -0.1 | -0.1 | 0.0 | ±0.5 |
| 200 | 132.0 | 130.9 | -1.1 | -1.0 | -0.1 | ±0.5 |
| 100 | 132.0 | 129.3 | -2.7 | -2.6 | -0.1 | ±1.0 |
| 50 | 132.0 | 127.0 | -5.0 | -4.8 | -0.2 | ±1.0 |
| 20 | 132.0 | 123.5 | -8.5 | -8.3 | -0.2 | ±1.0 |
| 10 | 132.0 | 120.6 | -11.3 | -11.1 | -0.2 | ±1.0 |
| 5 | 132.0 | 117.6 | -14.4 | -14.1 | -0.3 | ±1.0 |
| 2 | 132.0 | 113.8 | -18.2 | -18.0 | -0.2 | 1.0; -1.5 |
| 1 | 132.0 | 110.7 | -21.2 | -21.0 | -0.2 | 1.0; -2.0 |
| 0.5 | 132.0 | 107.7 | -24.3 | -24.0 | -0.3 | 1.0; -2.5 |
| 0.25 | 132.0 | 104.6 | -27.3 | -27.0 | -0.3 | 1.0; -3.0 |

### 8.14.3 Sound Exposure Level (SEL)

Z Frequency Weighting

| Toneburst duration (ms) | LZ (dBZ) | LZE (dBZ) | Response (dB) | Target Resp. (dB) | Error (dB) | Tolerance (dB) |
|---|---|---|---|---|---|---|
| 1000 | 131.0 | 131.0 | 0.0 | 0.0 | 0.0 | ±0.5 |
| 500 | 131.0 | 127.9 | -3.0 | -3.0 | 0.0 | ±0.5 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 200 | 131.0 | 124.0 | -7.0 | -7.0 | 0.0 | ±0.5 |
| 100 | 131.0 | 121.0 | -10.0 | -10.0 | 0.0 | ±1.0 |
| 50 | 131.0 | 117.9 | -13.0 | -13.0 | 0.0 | ±1.0 |
| 20 | 131.0 | 114.0 | -17.0 | -17.0 | 0.0 | ±1.0 |
| 10 | 131.0 | 111.0 | -20.0 | -20.0 | 0.0 | ±1.0 |
| 5 | 131.0 | 107.9 | -23.0 | -23.0 | 0.0 | ±1.0 |
| 2 | 131.0 | 104.0 | -27.0 | -27.0 | 0.0 | 1.0; -1.5 |
| 1 | 131.0 | 101.0 | -30.0 | -30.0 | 0.0 | 1.0; -2.0 |
| 0.5 | 131.0 | 98.0 | -33.0 | -33.0 | 0.0 | 1.0; -2.5 |
| 0.25 | 131.0 | 95.0 | -36.0 | -36.0 | 0.0 | 1.0; -3.0 |

## C Frequency Weighting

| Toneburst duration (ms) | LC (dBC) | LCE (dBC) | Response (dB) | Target Resp. (dB) | Error (dB) | Tolerance (dB) |
|---|---|---|---|---|---|---|
| 1000 | 130.2 | 130.1 | 0.0 | 0.0 | 0.0 | ±0.5 |
| 500 | 130.2 | 127.1 | -3.0 | -3.0 | 0.0 | ±0.5 |
| 200 | 130.2 | 123.1 | -7.0 | -7.0 | 0.0 | ±0.5 |
| 100 | 130.2 | 120.1 | -10.0 | -10.0 | 0.0 | ±1.0 |
| 50 | 130.2 | 117.1 | -13.0 | -13.0 | 0.0 | ±1.0 |
| 20 | 130.2 | 113.1 | -17.0 | -17.0 | 0.0 | ±1.0 |
| 10 | 130.2 | 110.1 | -20.0 | -20.0 | 0.0 | ±1.0 |
| 5 | 130.2 | 107.1 | -23.0 | -23.0 | 0.0 | ±1.0 |
| 2 | 130.2 | 103.2 | -27.0 | -27.0 | 0.0 | 1.0; -1.5 |
| 1 | 130.2 | 100.2 | -30.0 | -30.0 | 0.0 | 1.0; -2.0 |
| 0.5 | 130.2 | 97.2 | -33.0 | -33.0 | 0.0 | 1.0; -2.5 |
| 0.25 | 130.2 | 94.3 | -35.9 | -36.0 | 0.1 | 1.0; -3.0 |

## A Frequency Weighting

| Toneburst duration (ms) | LA (dBA) | LAE (dBA) | Response (dB) | Target Resp. (dB) | Error (dB) | Tolerance (dB) |
|---|---|---|---|---|---|---|
| 1000 | 132.0 | 131.9 | 0.0 | 0.0 | 0.0 | ±0.5 |
| 500 | 132.0 | 128.9 | -3.0 | -3.0 | 0.0 | ±0.5 |
| 200 | 132.0 | 124.9 | -7.0 | -7.0 | 0.0 | ±0.5 |
| 100 | 132.0 | 121.9 | -10.0 | -10.0 | 0.0 | ±1.0 |
| 50 | 132.0 | 118.9 | -13.0 | -13.0 | 0.0 | ±1.0 |
| 20 | 132.0 | 114.9 | -17.0 | -17.0 | 0.0 | ±1.0 |
| 10 | 132.0 | 111.9 | -20.0 | -20.0 | 0.0 | ±1.0 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 5 | 132.0 | 108.9 | -23.1 | -23.0 | -0.1 | ±1.0 |
| 2 | 132.0 | 104.9 | -27.1 | -27.0 | -0.1 | 1.0; -1.5 |
| 1 | 132.0 | 101.9 | -30.1 | -30.0 | -0.1 | 1.0; -2.0 |
| 0.5 | 132.0 | 98.9 | -33.1 | -33.0 | -0.1 | 1.0; -2.5 |
| 0.25 | 132.0 | 95.8 | -36.1 | -36.0 | -0.1 | 1.0; -3.0 |

## 8.15 Repeated Toneburst Response

The numbers given in the tables below are for 3 repeated tonebusts.

### 8.15.1 Sound Exposure Level (SEL)

Z Frequency Weighting

| Toneburst duration (ms) | LZ (dBZ) | LZE (dBZ) | Response (dB) | Target Resp. (dB) | Error (dB) | Tolerance (dB) |
|---|---|---|---|---|---|---|
| 1000 | 131.0 | 135.7 | 4.7 | 4.8 | -0.1 | ±0.5 |
| 500 | 131.0 | 132.7 | 1.7 | 1.8 | -0.1 | ±0.5 |
| 200 | 131.0 | 128.7 | -2.2 | -2.2 | 0.0 | ±0.5 |
| 100 | 131.0 | 125.7 | -5.3 | -5.2 | -0.1 | ±1.0 |
| 50 | 131.0 | 122.7 | -8.3 | -8.2 | -0.1 | ±1.0 |
| 20 | 131.0 | 118.7 | -12.2 | -12.2 | 0.0 | ±1.0 |
| 10 | 131.0 | 115.7 | -15.3 | -15.2 | -0.1 | ±1.0 |
| 5 | 131.0 | 112.7 | -18.3 | -18.2 | -0.1 | ±1.0 |
| 2 | 131.0 | 108.7 | -22.2 | -22.2 | 0.0 | 1.0; -1.5 |
| 1 | 131.0 | 105.7 | -25.2 | -25.2 | 0.0 | 1.0; -2.0 |
| 0.5 | 131.0 | 102.7 | -28.2 | -28.2 | 0.0 | 1.0; -2.5 |
| 0.25 | 131.0 | 99.8 | -31.2 | -31.2 | 0.0 | 1.0; -3.0 |

C Frequency Weighting

| Toneburst duration (ms) | LC (dBC) | LCE (dBC) | Response (dB) | Target Resp. (dB) | Error (dB) | Tolerance (dB) |
|---|---|---|---|---|---|---|
| 1000 | 130.2 | 134.9 | 4.7 | 4.8 | -0.1 | ±0.5 |
| 500 | 130.2 | 131.9 | 1.7 | 1.8 | -0.1 | ±0.5 |
| 200 | 130.2 | 127.9 | -2.3 | -2.2 | -0.1 | ±0.5 |
| 100 | 130.2 | 124.9 | -5.3 | -5.2 | -0.1 | ±1.0 |
| 50 | 130.2 | 121.9 | -8.3 | -8.2 | -0.1 | ±1.0 |
| 20 | 130.2 | 117.9 | -12.3 | -12.2 | -0.1 | ±1.0 |
| 10 | 130.2 | 114.9 | -15.3 | -15.2 | -0.1 | ±1.0 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 5 | 130.2 | 111.9 | -18.3 | -18.2 | -0.1 | ±1.0 |
| 2 | 130.2 | 107.9 | -22.2 | -22.2 | 0.0 | 1.0; -1.5 |
| 1 | 130.2 | 104.9 | -25.2 | -25.2 | 0.0 | 1.0; -2.0 |
| 0.5 | 130.2 | 102.0 | -28.2 | -28.2 | 0.0 | 1.0; -2.5 |
| 0.25 | 130.2 | 99.0 | -31.1 | -31.2 | 0.1 | 1.0; -3.0 |

### A Frequency Weighting

| Toneburst duration (ms) | LA (dBA) | LAE (dBA) | Response (dB) | Target Resp. (dB) | Error (dB) | Tolerance (dB) |
|---|---|---|---|---|---|---|
| 1000 | 132.0 | 136.7 | 4.7 | 4.8 | -0.1 | ±0.5 |
| 500 | 132.0 | 133.7 | 1.7 | 1.8 | -0.1 | ±0.5 |
| 200 | 132.0 | 129.7 | -2.3 | -2.2 | -0.1 | ±0.5 |
| 100 | 132.0 | 126.7 | -5.3 | -5.2 | -0.1 | ±1.0 |
| 50 | 132.0 | 123.7 | -8.3 | -8.2 | -0.1 | ±1.0 |
| 20 | 132.0 | 119.7 | -12.3 | -12.2 | -0.1 | ±1.0 |
| 10 | 132.0 | 116.7 | -15.3 | -15.2 | -0.1 | ±1.0 |
| 5 | 132.0 | 113.7 | -18.3 | -18.2 | -0.1 | ±1.0 |
| 2 | 132.0 | 109.7 | -22.3 | -22.2 | -0.1 | 1.0; -1.5 |
| 1 | 132.0 | 106.6 | -25.3 | -25.2 | -0.1 | 1.0; -2.0 |
| 0.5 | 132.0 | 103.6 | -28.3 | -28.2 | -0.1 | 1.0; -2.5 |
| 0.25 | 132.0 | 100.6 | -31.3 | -31.2 | -0.1 | 1.0; -3.0 |

## 8.16 Overload Indication

The overload indication is determined from the raw voltage signal absolute peak level using the predetermined overload limit set for each range.

The predetermined overload limit is determined from the linearity range upper limit expressed in peak level.

| Dynamic Range | Overload Limit (LZpk, dBZpk) |
|---|---|
| Low | 125.0 |
| High | 137.0 |

The live display overload indication (see section 5) is latched from the live overload indication for as long as the overload condition exists or 1 s, whichever is the greater.

The record under-range indication is latched as soon as the overload condition exists during the record duration.

The following tables provide the continuous sound level (RMS) at which the overload condition occurs.

### Low Range

| Frequency (Hz) | Overload Indication (dBZ) | Overload Indication (dBC) | Overload Indication (dBA) |
|---|---|---|---|
| 31.5 | 122.0 | 119.0 | 82.6 |
| 63 | 122.0 | 121.2 | 95.8 |
| 125 | 122.0 | 121.8 | 105.9 |
| 250 | 122.0 | 122.0 | 113.4 |
| 500 | 122.0 | 122.0 | 118.8 |
| 1k | 122.0 | 122.0 | 122.0 |
| 2k | 122.0 | 122.0 | 123.2 |
| 4k | 122.0 | 121.2 | 123.0 |
| 8k | 122.0 | 119.0 | 120.9 |
| 10k | 122.0 | 117.6 | 119.5 |
| 12.5k | 122.0 | 115.8 | 117.7 |
| 16k | 122.0 | 113.5 | 115.4 |

### High Range

| Frequency (Hz) | Overload Indication (dBZ) | Overload Indication (dBC) | Overload Indication (dBA) |
|---|---|---|---|
| 31.5 | 134.0 | 131.0 | 94.6 |
| 63 | 134.0 | 133.2 | 107.8 |
| 125 | 134.0 | 133.8 | 117.9 |
| 250 | 134.0 | 134.0 | 125.4 |
| 500 | 134.0 | 134.0 | 130.8 |
| 1k | 134.0 | 134.0 | 134.0 |
| 2k | 134.0 | 134.0 | 135.2 |
| 4k | 134.0 | 133.2 | 135.0 |
| 8k | 134.0 | 131.0 | 132.9 |
| 10k | 134.0 | 129.6 | 131.5 |
| 12.5k | 134.0 | 127.8 | 129.7 |
| 16k | 134.0 | 125.5 | 127.4 |

### 8.16.1 Overload Indication Symmetry

He Overload Indication is determined from absolute peak level, meaning that both positive-going and negative-going peak signals should indicate the same overload indication with an uncertainty of ±0.2dB.

The tables below show the level at which the overload condition occurred for positive and negative one-half-cycle signal of the given frequency.

#### Low Range

| Metric | Freq. (Hz) | Pos. Ovld. (dB) | Neg. Ovld. (dB) | Error (dB) | Tolerance (dB) |
|---|---|---|---|---|---|
| LZpk | 31.5 | 125.1 | 125.1 | 0.0 | ±1.5 |
| LZpk | 1k | 125.0 | 125.1 | 0.1 | ±1.5 |
| LZpk | 4k | 125.1 | 125.1 | 0.0 | ±1.5 |
| LCpk | 31.5 | 121.2 | 121.2 | 0.0 | ±1.5 |
| LCpk | 1k | 124.7 | 124.7 | 0.0 | ±1.5 |
| LCpk | 4k | 124.2 | 124.2 | 0.0 | ±1.5 |
| LApk | 31.5 | 98.2 | 98.2 | 0.0 | ±1.5 |
| LApk | 1k | 122.1 | 122.0 | 0.1 | ±1.5 |
| LApk | 4k | 124.3 | 124.3 | 0.0 | ±1.5 |
| LZE | 31.5 | 104.3 | 104.3 | 0.0 | ±1.5 |
| LZE | 1k | 89.0 | 89.1 | 0.1 | ±1.5 |
| LZE | 4k | 83.2 | 83.2 | 0.0 | ±1.5 |
| LCE | 31.5 | 99.4 | 99.4 | 0.0 | ±1.5 |
| LCE | 1k | 88.9 | 88.9 | 0.0 | ±1.5 |
| LCE | 4k | 82.5 | 82.6 | 0.1 | ±1.5 |
| LAE | 31.5 | 71.5 | 71.5 | 0.0 | ±1.5 |
| LAE | 1k | 87.2 | 87.2 | 0.0 | ±1.5 |
| LAE | 4k | 83.4 | 83.4 | 0.0 | ±1.5 |

#### High Range

| Metric | Freq. (Hz) | Pos. Ovld. (dB) | Neg. Ovld. (dB) | Error (dB) | Tolerance (dB) |
|---|---|---|---|---|---|
| LZpk | 31.5 | 137.1 | 137.1 | 0.0 | 137.1 |
| LZpk | 1k | 137.0 | 137.0 | 0.0 | 137.0 |
| LZpk | 4k | 137.1 | 137.1 | 0.0 | 137.1 |
| LCpk | 31.5 | 133.2 | 133.2 | 0.0 | 133.2 |
| LCpk | 1k | 136.7 | 136.7 | 0.0 | 136.7 |
| LCpk | 4k | 136.2 | 136.2 | 0.0 | 136.2 |

| | | | | | |
|---|---|---|---|---|---|
| LApk | 31.5 | 110.2 | 110.2 | 0.0 | 110.2 |
| LApk | 1k | 134.0 | 134.1 | 0.1 | 134.0 |
| LApk | 4k | 136.1 | 136.0 | 0.1 | 136.1 |
| LZE | 31.5 | 116.3 | 116.3 | 0.0 | 116.3 |
| LZE | 1k | 101.0 | 101.1 | 0.0 | 101.0 |
| LZE | 4k | 95.2 | 95.1 | 0.1 | 95.2 |
| LCE | 31.5 | 111.4 | 111.4 | 0.0 | 111.4 |
| LCE | 1k | 100.9 | 100.9 | 0.0 | 100.9 |
| LCE | 4k | 94.5 | 94.5 | 0.0 | 94.5 |
| LAE | 31.5 | 83.5 | 83.5 | 0.0 | 83.5 |
| LAE | 1k | 99.2 | 99.2 | 0.0 | 99.2 |
| LAE | 4k | 95.4 | 95.3 | 0.1 | 95.4 |

## 8.17 Under-Range Indication

The Under-Range Indication is derived from the Live LAF SPL using a predetermined under-range limit for each range.

The predetermined under-range limit is determined from the linearity range lower limit.

| Dynamic Range | Under-Range Limit (LAF, dBA) |
|---|---|
| Low | 30.0 |
| High | 42.0 |

The live display under-range indication is latched for as long as the under-range condition exists or 1 s, whichever is the greater (see section 5).

The record under-range indication is latched as soon aa the under-range condition exists during the record duration.

## 8.18 C-Weighted Peak Sound Level

The specifications for indications of C-weighted peak sound levels are given in terms of the response to one-cycle, and positive-going and negative-going half-cycle electrical signals.

### Low Range

| Nb Cycles | Freq. (Hz) | LC (dB) | LCpeak (dB) | Response (dB) | Target Resp. (dB) | Error (dB) | Tolerance (dB) |
|---|---|---|---|---|---|---|---|
| 1 | 31.5 | 111.0 | 113.6 | 2.6 | 2.5 | 0.1 | ±2.0 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | 500 | 114.0 | 117.5 | 3.5 | 3.5 | 0.0 | ±1.0 |
| 1 | 8k | 110.9 | 113.7 | 2.8 | 3.4 | -0.6 | ±2.0 |
| Pos. ½ | 500 | 114.0 | 116.3 | 2.2 | 2.4 | -0.2 | ±1.0 |
| Neg. ½ | 500 | 114.0 | 116.3 | 2.2 | 2.4 | -0.2 | ±1.0 |

High Range

| Nb Cycles | Freq. (Hz) | LC (dB) | LCpeak (dB) | Response (dB) | Target Resp. (dB) | Error (dB) | Tolerance (dB) |
|---|---|---|---|---|---|---|---|
| 1 | 31.5 | 123.0 | 125.6 | 2.6 | 2.5 | 0.1 | ±2.0 |
| 1 | 500 | 126.0 | 129.5 | 3.5 | 3.5 | 0.0 | ±1.0 |
| 1 | 8k | 122.9 | 125.5 | 2.5 | 3.4 | -0.9 | ±2.0 |
| Pos. ½ | 500 | 126.0 | 128.3 | 2.2 | 2.4 | -0.2 | ±1.0 |
| Neg. ½ | 500 | 126.0 | 128.3 | 2.3 | 2.4 | -0.1 | ±1.0 |

## 8.19 Stability During Continuous Operation

The A-weighted sound level indicated in response to a steady 1 kHz electrical signal at reference amplitude (94.0 dB) should not deviate by more than ±0.1 dB at the beginning and end of a 30-minute period.

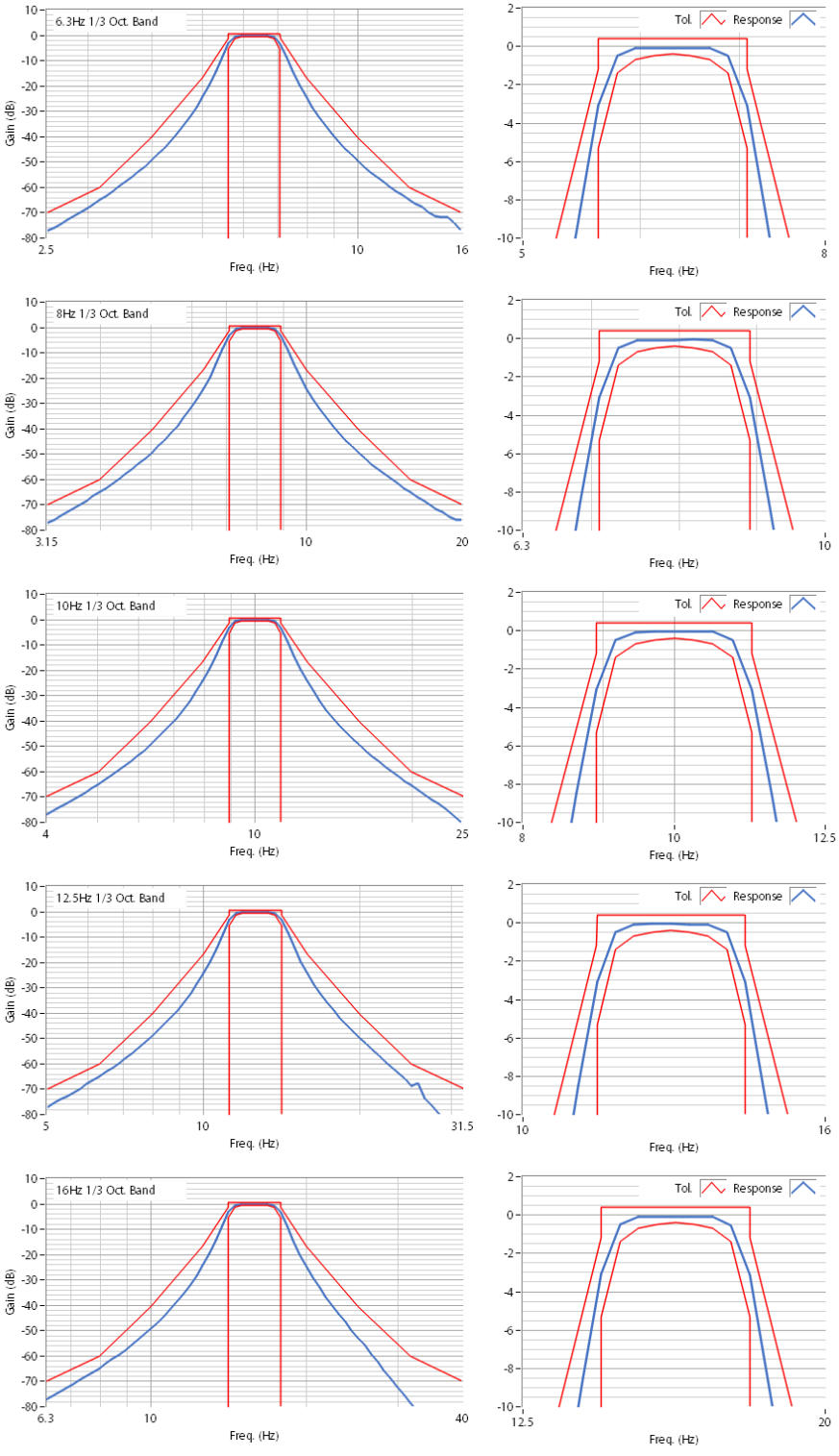
## 8.20 High-Level Stability

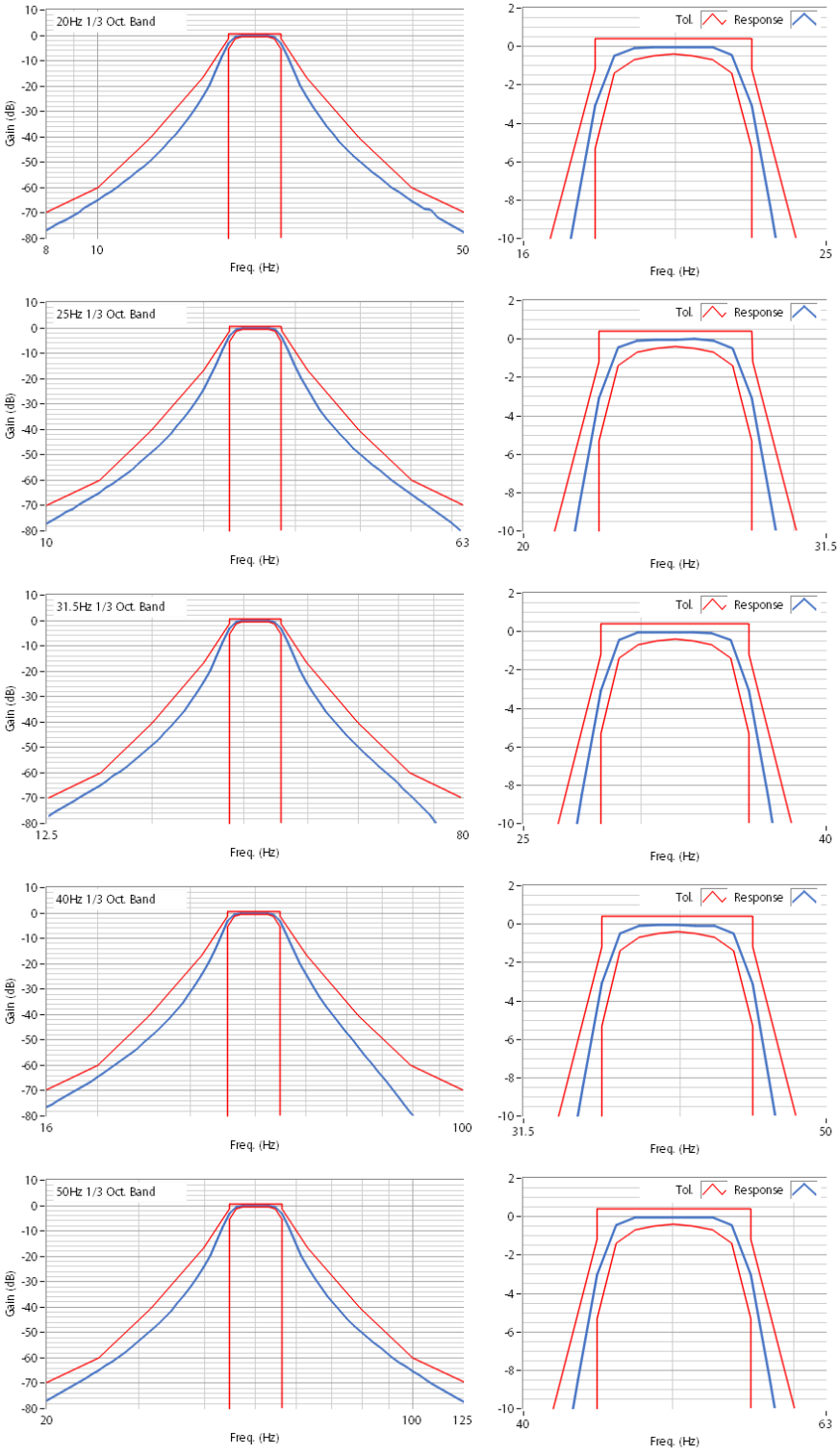
The A-weighted sound level indicated in response to a steady 1 kHz electrical signal with an amplitude of 1 dB below the linearity upper limit should not deviate by more than ±0.1 dB at the beginning and end of a 5-minute period.

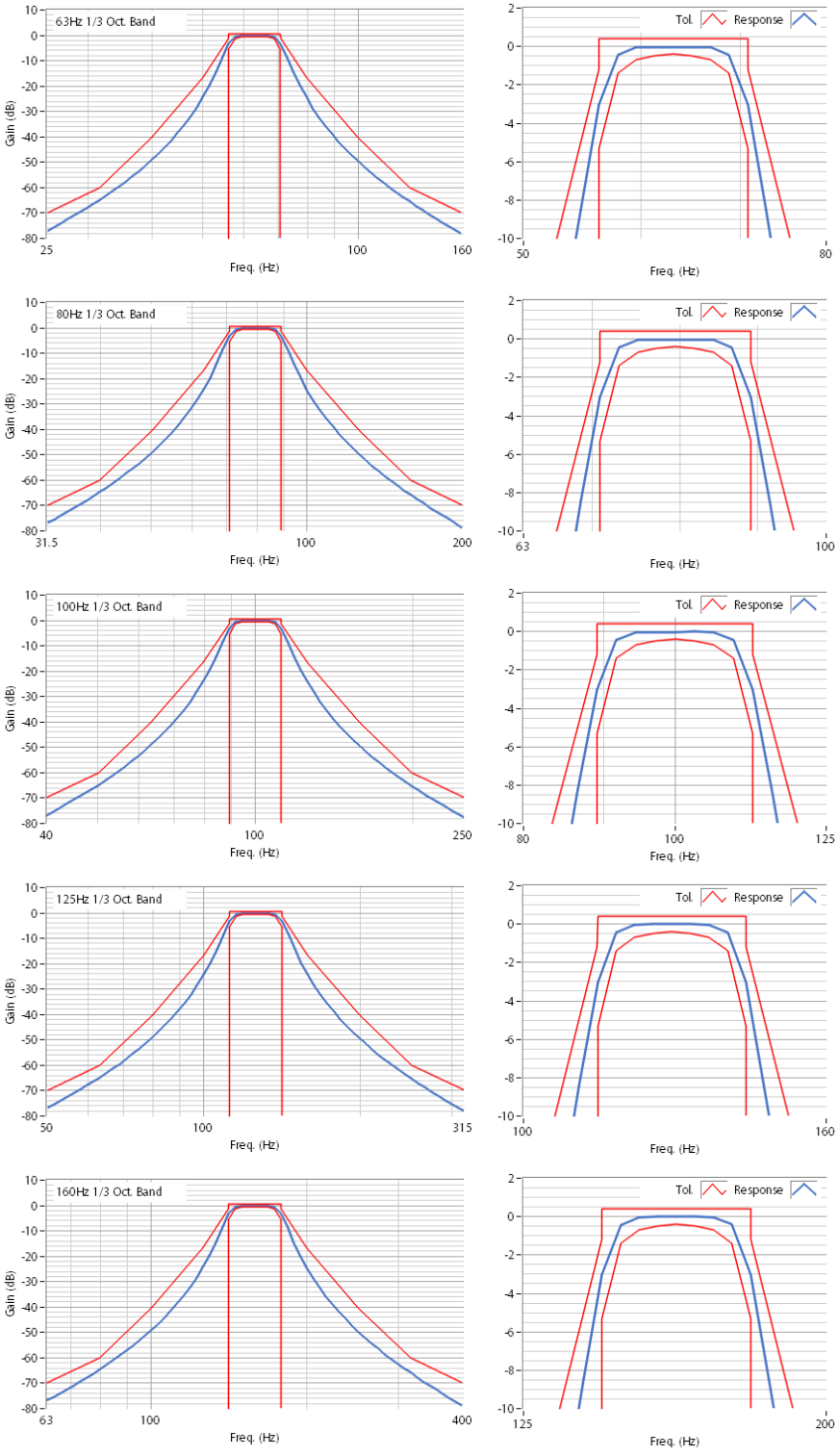
## 8.21 Frequency Analysis

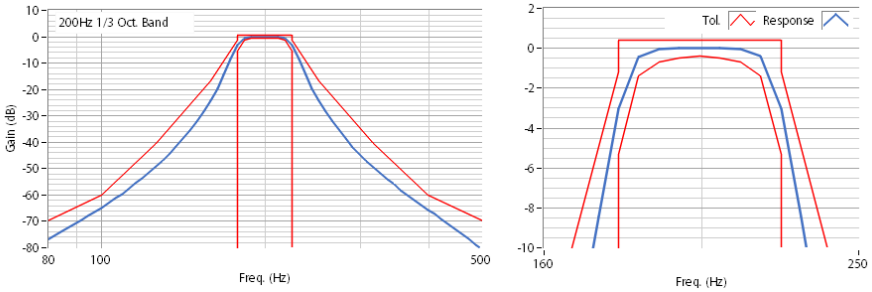
### 8.21.1 1/3 Octave Spectrum

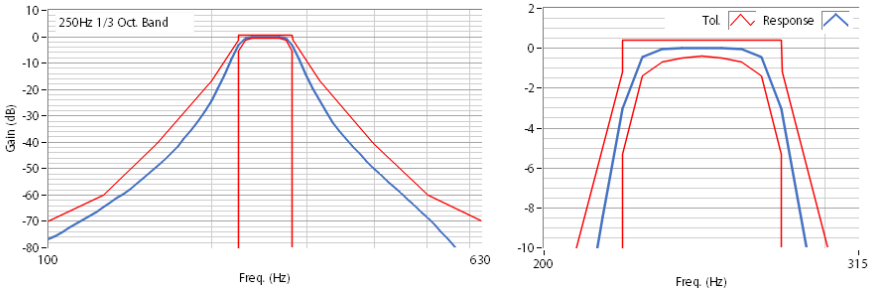
The figures below show the 1/3 octave band spectrum filters amplitude response against IEC 61260 class 1 tolerances.

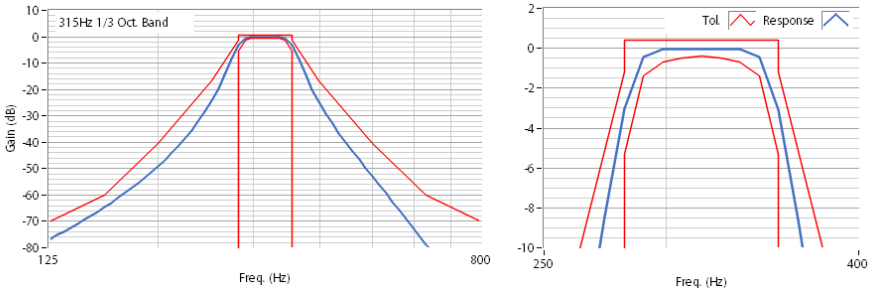

6.3Hz 1/3 Oct. Band
Gain (dB)
Freq. (Hz)
Tol.
Response
8Hz 1/3 Oct. Band
10Hz 1/3 Oct. Band
12.5Hz 1/3 Oct. Band
16Hz 1/3 Oct. Band

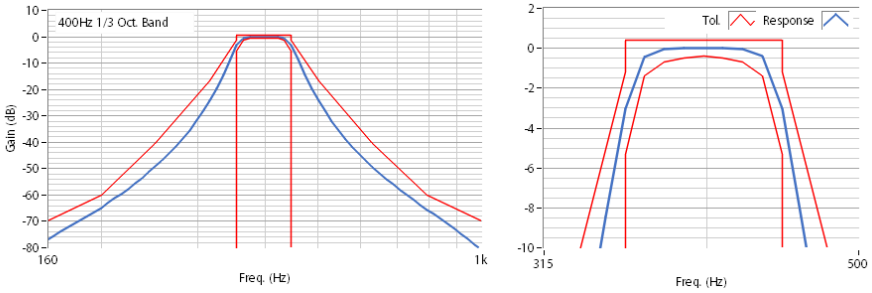

20Hz 1/3 Oct. Band
Gain (dB)
Freq. (Hz)
Tol.
Response
25Hz 1/3 Oct. Band
31.5Hz 1/3 Oct. Band
40Hz 1/3 Oct. Band
50Hz 1/3 Oct. Band

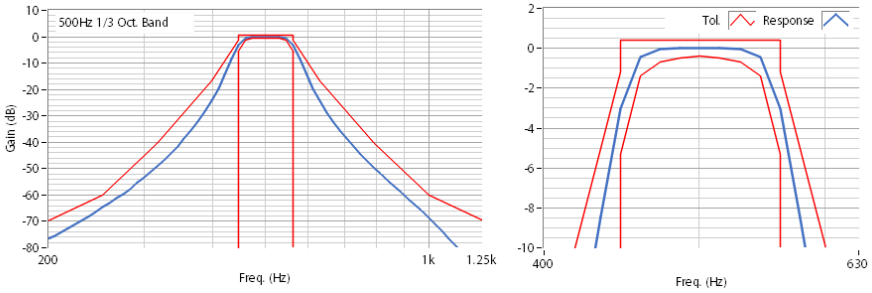

63Hz 1/3 Oct. Band
Gain (dB)
Freq. (Hz)
Tol.
Response
80Hz 1/3 Oct. Band
100Hz 1/3 Oct. Band
125Hz 1/3 Oct. Band
160Hz 1/3 Oct. Band

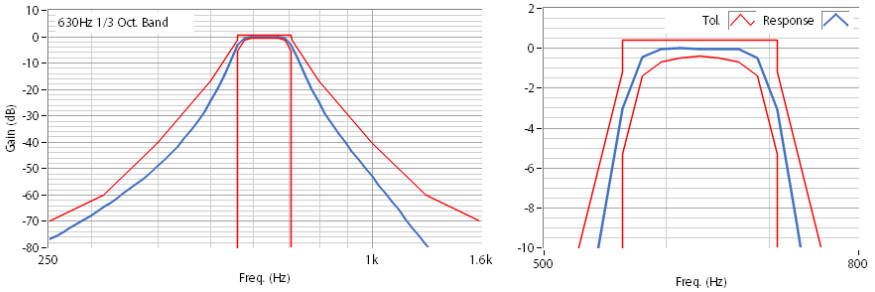

200Hz 1/3 Oct. Band
Gain (dB)
Freq. (Hz)
80
100
500
Tol.
Response
160
250

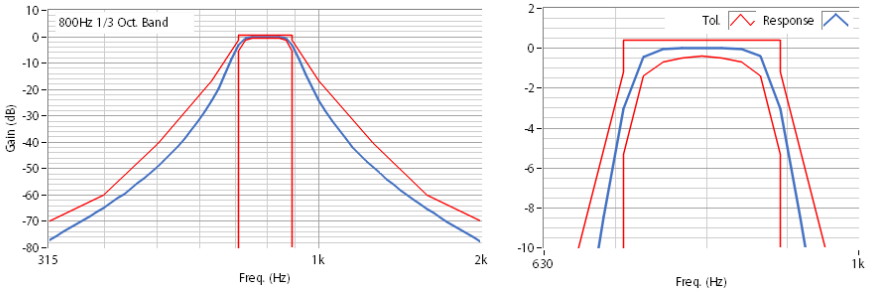

250Hz 1/3 Oct. Band
Gain (dB)
Freq. (Hz)
100
630
Tol.
Response
200
315

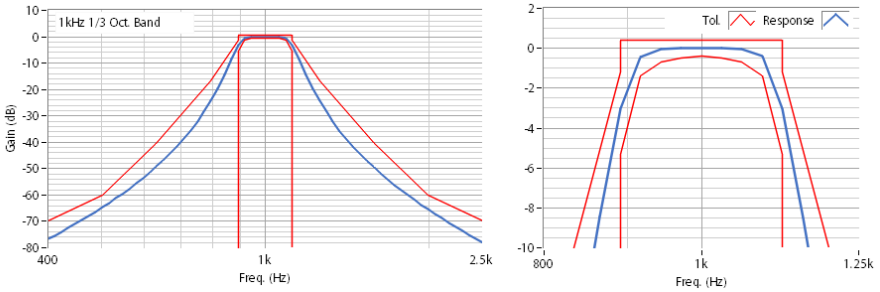

315Hz 1/3 Oct. Band
Gain (dB)
Freq. (Hz)
125
800
Tol.
Response
250
400

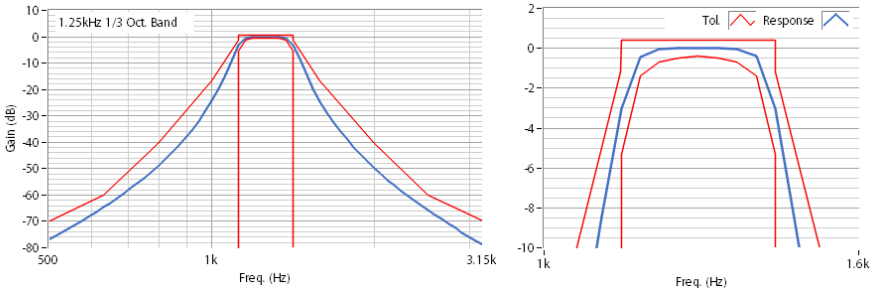

400Hz 1/3 Oct. Band
Gain (dB)
Freq. (Hz)
160
1k
Tol.
Response
315
500

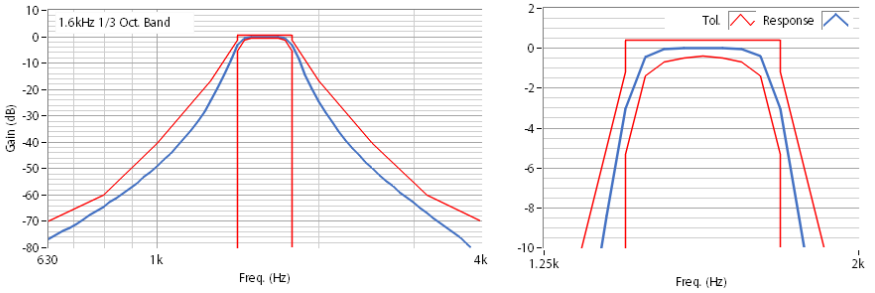

500Hz 1/3 Oct. Band
Gain (dB)
Freq. (Hz)
200
1k
1.25k
Tol.
Response
400
630

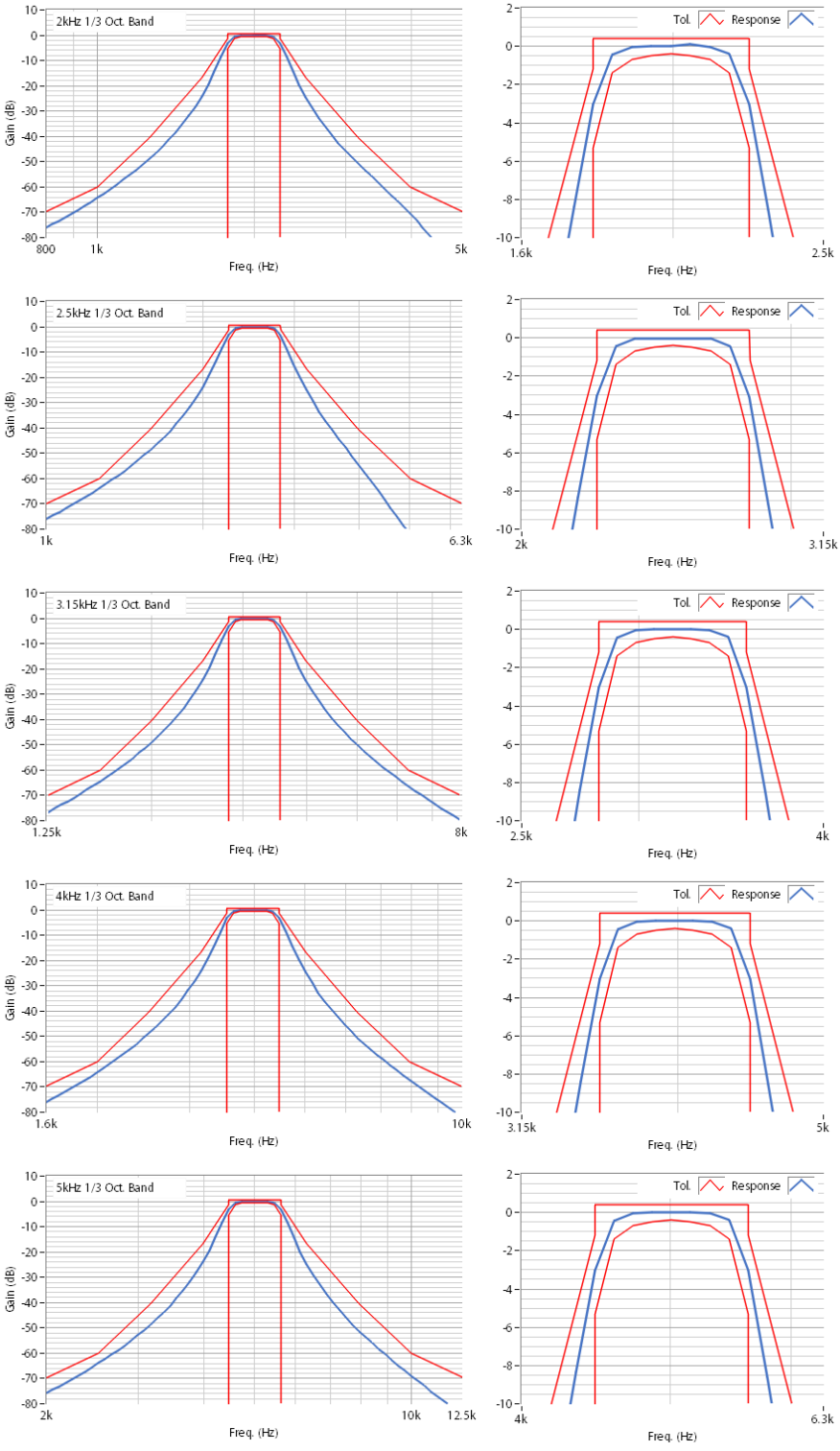

630Hz 1/3 Oct. Band
Gain (dB)
Freq. (Hz)
250
1k
1.6k
Tol.
Response
500
800

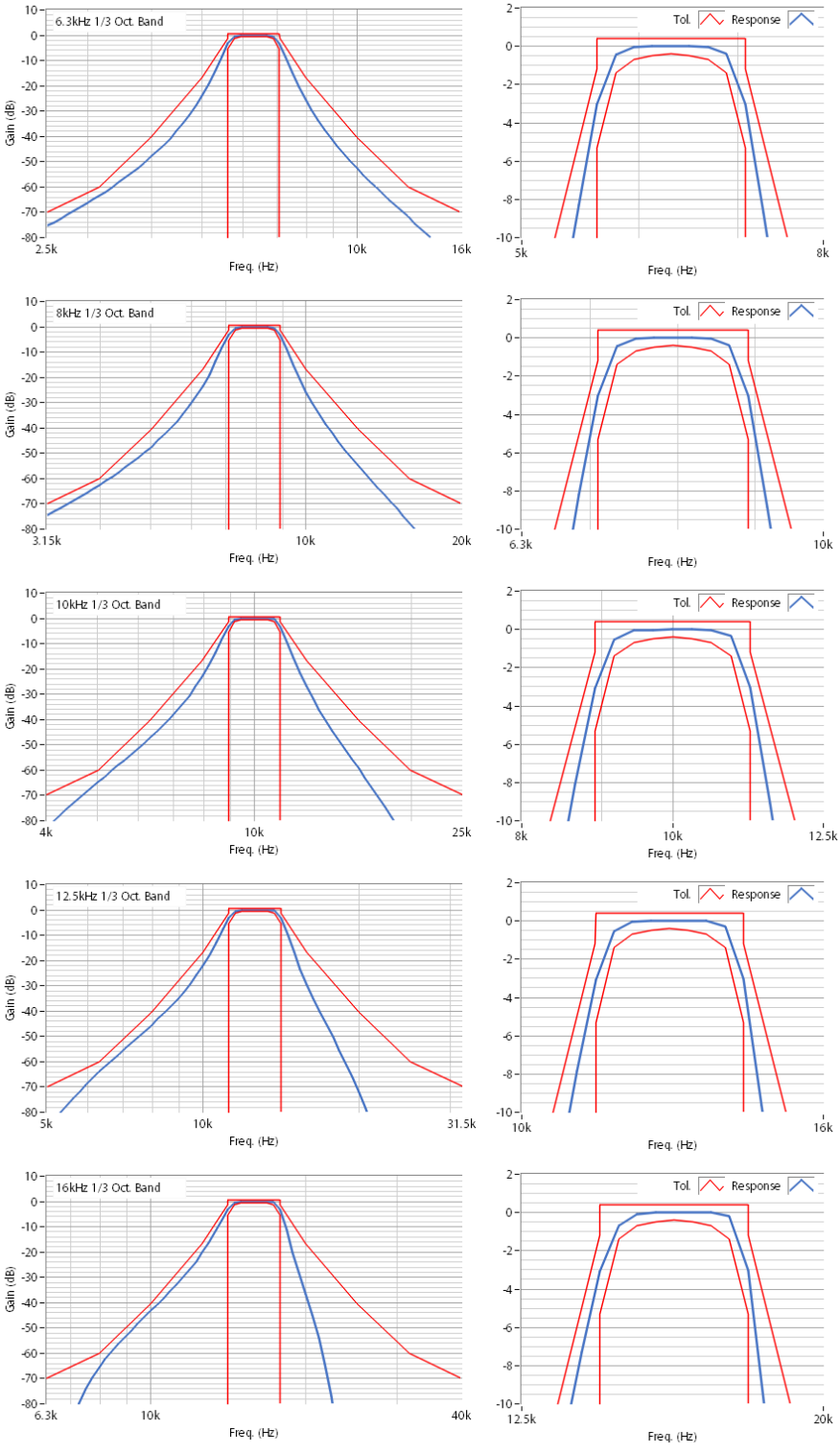

800Hz 1/3 Oct. Band
Gain (dB)
Freq. (Hz)
315
1k
2k
Tol.
Response
630
1k

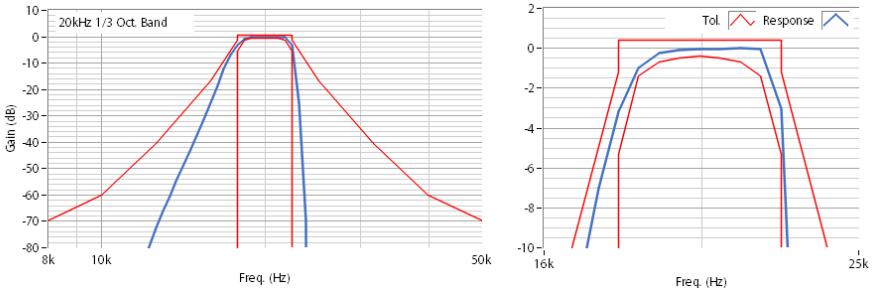

1kHz 1/3 Oct. Band
Gain (dB)
Freq. (Hz)
400
1k
2.5k
Tol.
Response
800
1k
1.25k


1.25kHz 1/3 Oct. Band
Gain (dB)
Freq. (Hz)
500
1k
3.15k
Tol.
Response
1k
1.6k


1.6kHz 1/3 Oct. Band
Gain (dB)
Freq. (Hz)
630
1k
4k
Tol.
Response
1.25k
2k


2kHz 1/3 Oct. Band
Gain (dB)
Freq. (Hz)
800
1k
5k
Tol.
Response
1.6k
2.5k
2.5kHz 1/3 Oct. Band
1k
6.3k
2k
3.15k
3.15kHz 1/3 Oct. Band
1.25k
8k
2.5k
4k
4kHz 1/3 Oct. Band
1.6k
10k
3.15k
5k
5kHz 1/3 Oct. Band
2k
10k
12.5k
4k
6.3k

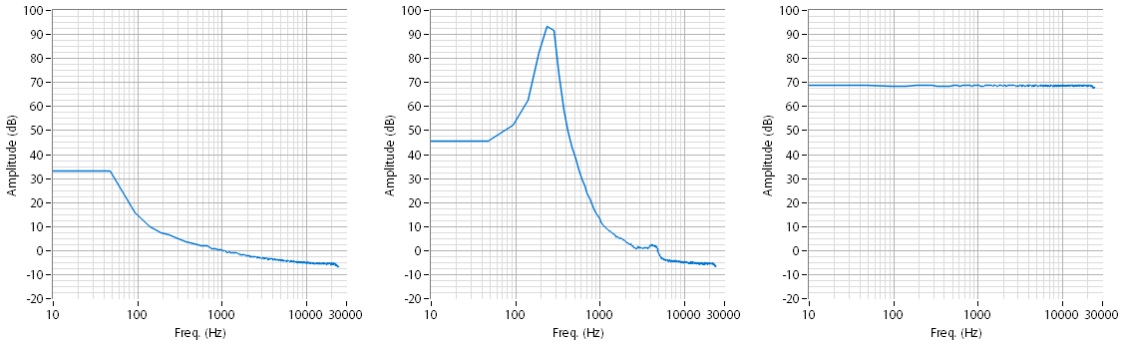

6.3kHz 1/3 Oct. Band
Gain (dB)
Freq. (Hz)
2.5k
10k
16k
Tol.
Response
5k
8k
8kHz 1/3 Oct. Band
3.15k
20k
6.3k
10kHz 1/3 Oct. Band
4k
25k
8k
12.5k
12.5kHz 1/3 Oct. Band
31.5k
16kHz 1/3 Oct. Band
40k
12.5k
20k



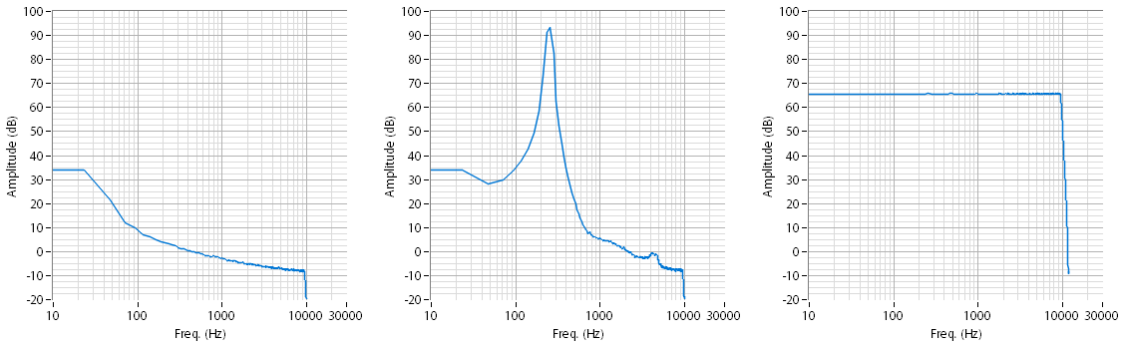

## 8.21.2 Fast Fourrier Transform (FFT)

The figures below show the FFT for: background noise (left) 250Hz sine at 94dB amplitude (center), and white noise at 94dB broadband amplitude (right).

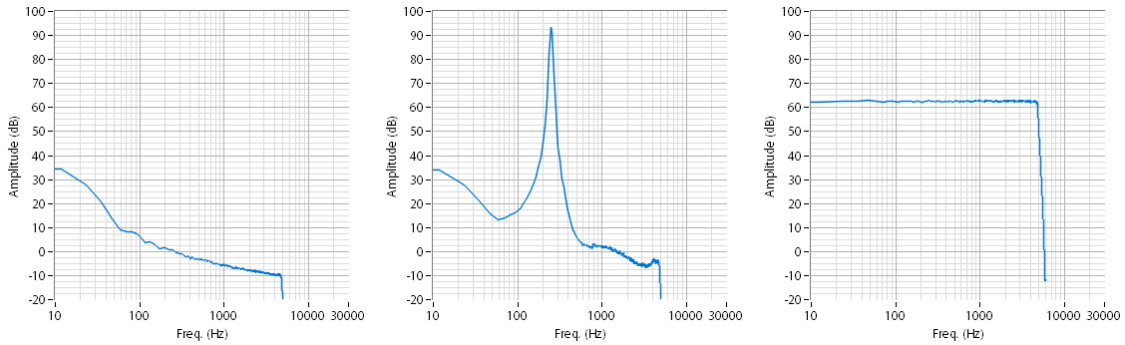
24 kHz Bandwidth



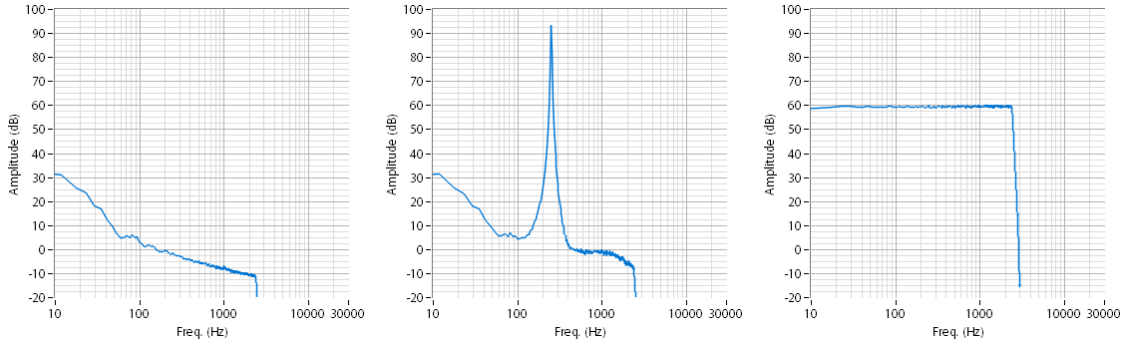

12 kHz Bandwidth



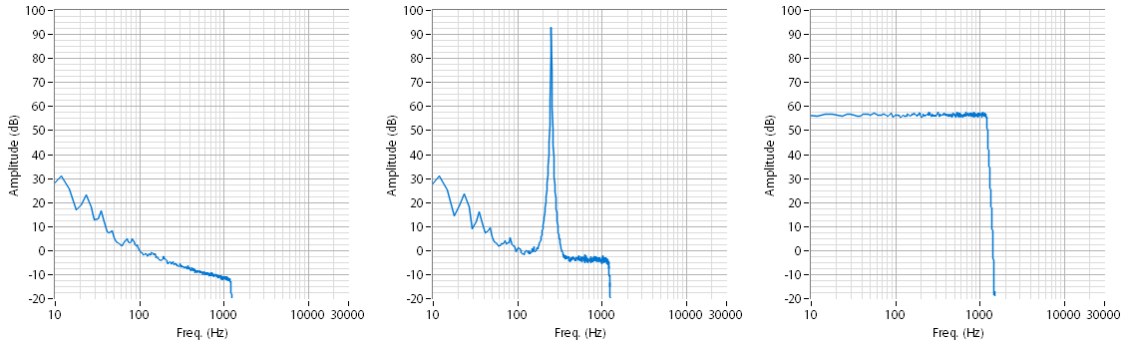
## 6 kHz Bandwidth



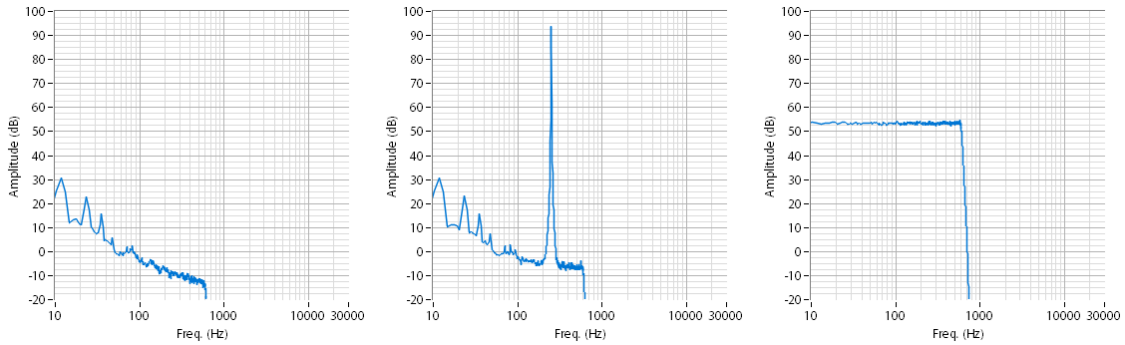

## 3 kHz Bandwidth




## 1.5 kHz Bandwidth



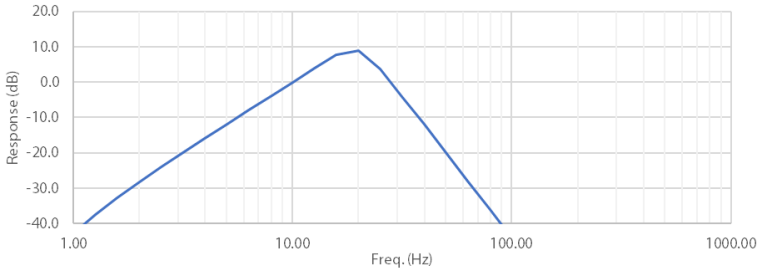
750 Hz Bandwidth




## 8.22 Infrasound Level

The SAS provides a "G" frequency weighting for infrasound measurement. This frequency weighting is described in ISO 7196 (1995).

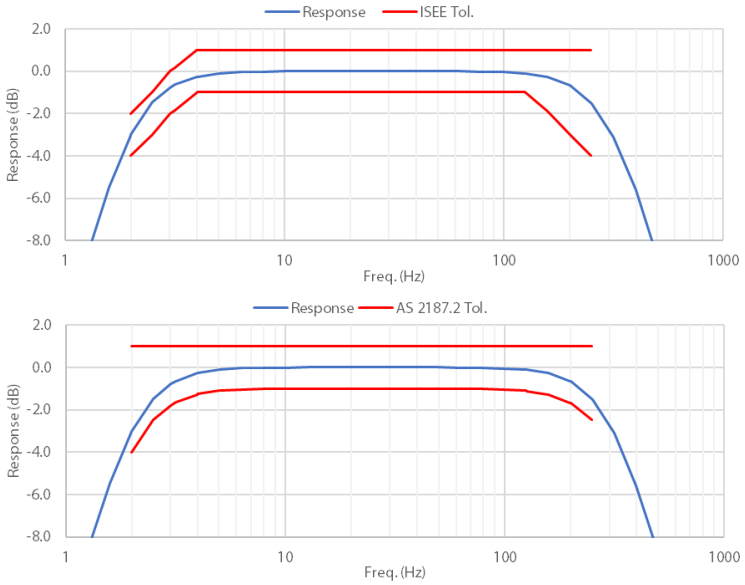
### 8.22.1 Frequency Response




## 8.23 Over-Pressure Level

### 8.23.1 Frequency Response

The frequency response follows a 2.0Hz-250Hz (-3dB) bandpass response with 2nd order Butterworth roll-off. This response is compliant with ISEE PSBS (2022) and AS 2187.2 (2006), section J3.3.1.




### 8.23.2 Overload Indication

The overload indication is determined from the raw voltage signal absolute peak level using the predetermined overload limit set for each range.

This overload indication is the same as the SLM overload indication (see section 8.16) since the Over-Pressure level is calculated from the SLM sub-sampled signal.

The display overload indication (see section 5) is latched from the live overload indication for as long as the overload condition exists or 1 s, whichever is the greater.

### 8.23.3 Self-Generated Noise

The peak instrument total noise is determined using RMS noise plus 10dB which is equivalent to 99% confidence in peak level.

#### Maximum Peak Noise

| Condition | Low-Range | High Range |
|---|---|---|
| Electrical | 55.0 | |
| Acoustical (Total) | 90.0 | |

#### Typical Peak Noise

| Condition | Low-Range | High Range |
|---|---|---|
| Electrical | 50.0 | |
| Acoustical (Total) | 85.0 | |

### 8.23.4 Detection Limit

The detection limit or “Under Range” is set at 10 dB above the instrument total noise (electrical and acoustical) expressed in peak.

| | Low-Range | High Range |
|---|---|---|
| Detection Limit | 100.0 | |

# 9 Programming

## 9.1 Serial Port Configuration

The SAS uses RS485 half-duplex serial communication with the following specifications:

- BaudRate: 3 MBPS
- WordLength: 8 bits
- StopBit: one bit
- Parity: No
- Control flow: No

## 9.2 Protocol Description

The SAS communication protocol is based on a set of commands and responses:

1) The host sends a command of 12 bytes to the SAS;
2) The SAS replies with the requested data and/or with an acknowledge.

The host must wait at least 5ms after receiving data from the SAS for the sensor to be ready to receive another command.

Whenever 16-bit integers, 32-bit integers or 32-bit floating point numbers are present in the command or payload, it must be represented with LSB-First topology (Least significant byte first).

## 9.3 Checksum

The protocol uses a simple checksum to validate the host commands and SAS data. Below is a code example to compute the checksum for a buffer of bytes:

```
unsigned char CheckSum = 0; // 8-bit unsigned
for (int i = 0; i < BytesBufferSize; i++)
{
      CheckSum = CheckSum ^ BytesBuffer[i];      // ^ operator is XOR
}
```

## 9.4 Initialization and Configuration

1) Configure the Host serial port (Serial Port Configuration);
2) Open the serial port socket;

3) The Host sends the Get Board Info command to validate that the connected sensor is an SAS.
4) The Host sends the Get Sensor Info command to determine the serial number of the SAS and validate the firmware version and model ID.
5) Set Sensor Configuration for your application. If the SAS is not configured, it will use the last configuration from its non-volatile memory.

## 9.5 Hardware and Firmware Compatibility

The Get Sensor Info command returns the SAS serial number and firmware version.

The SAS Model can be determined from the SAS serial number. Below is an example for serial number "AS0126032207":

| | |
|---|---|
| "AS" | SAS |
| "01" | Model ID "1" |
| "260322" | Manufacture batch ID |
| "07" | Specific ID in batch. |

The table below indicates the hardware and firmware compatibility:

| Model ID | 1 | 2 | 3 |
|---|---|---|---|
| Product Code | SASK-00001 | SASK-00002 | SASK-00003 |
| Sensitivity | 50 mV/Pa | 50 mV/Pa | 12.6 mV/Pa |
| Syscheck2 | No | Yes | No |
| Firmware Compatibility | 6 | | |

## 9.6 Typical Applications

The SAS may be used for real-time data acquisition or for average data acquisition. These two typical applications are detailed below.

It's also possible to combine these two modes of operation by performing real-time acquisition and average data acquisition in the same process.

### 9.6.1 Real-Time Data

For this application, the Host reads every data block and/or waveform block in real-time.

While the most common application is to read every data and waveform block, it's also possible to read every data block, but read only specific waveform blocks when a threshold is exceeded

for example. Thanks to the SAS buffer, the host may read blocks in the past in the buffer up to 8.5s for the SLM signal and 320s for the OPL signal.

Reset Buffers

1) Reset Buffer Status to initialize the buffers (This step resets the block counter to zero for both SLM and OPL buffers);
2) Set a "Block ID" variable to zero.

Query Buffer Status

3) Periodically Get Buffer Status and compare the returned "Buffer Last Block ID" to the "Block ID" variable.

If the "Buffer Last Block ID" is greater than the "Block ID" variable, it means that blocks are ready to be read from the buffer.

The host may read any Block ID in the buffer. The available Block IDs are determined from the "Buffer Last Block ID" and the "Buffer Number of Blocks". Below is an example:

- Buffer Last Block ID = 842576
- Buffer Number of Blocks = 100
- Any Block ID from 842477 to 842576 can be read.

Read Blocks

4) Increment the "Block ID" variable;
5) Read the Block ID Data and/or Waveform using the following set of functions:
    - Get Data and Signal SLM;
    - Get Data and Signal OPL

The host may read several blocks one after the other for as long as the "Buffer Last Block ID" is greater than the "Buffer Last Block ID".

### 9.6.2 Average Data

For this application, the Host performs Get/Reset Average Data (SLM and OPL) at fixed intervals.

Reset Average

1) The Host resets the SAS running average by sending the Get/Reset Average Data (SLM and OPL) command;

Wait for Interval

2) The Host waits for the average to complete using its own time reference.

Read Data and Reset Average

3) The Host reads the SAS running average data by sending the Get/Reset Average Data (SLM and OPL) command;

The Get/Reset Average Data (SLM and OPL) command also resets the average. The Host may proceed directly to Wait for Interval for the next interval.

## 9.7 Commands Description

### 9.7.1 Get Board Info

This command is the first command used to determine the presence of the sensor. The Vendor ID value must be 0x1612 and the Product ID must be 0x0108. The protocol sequence is:

*The host sends the following 12-bytes command:*

| | |
|---|---|
| [0] | 0x42 |
| [1] | 0x6F |
| [2] | 0x61 |
| [3] | 0x72 |
| [4] | 0x64 |
| [5] | 0x49 |
| [6] | 0x6E |
| [7] | 0x66 |
| [8] | 0x6F |
| [9] | 0x2D |
| [10] | 0x2D |
| [11] | Checksum (computed on byte 0 to 10) |

*The SAS replies with 8 bytes:*

| | |
|---|---|
| [0-1] | Vendor ID (Unsigned 16-bit) (0x1612) |
| [2-3] | Product ID (Unsigned 16-bit) (0x0108) |
| [4-5] | Reserved |
| [6] | Checksum (computed on byte 0 to 5) |
| [7] | Acknowledge (0x32) |

### 9.7.2 Get Sensor Info

This command is used to read the serial number and firmware. This information is important to determine the Hardware and Firmware Compatibility.

*The host sends the following 12-bytes command:*

| | |
|---|---|
| [0] | 0x41 |
| [1] | 0x50 |
| [2] | 0x50 |
| [3] | 0x30 |
| [4] | 0x31 |
| [5-10] | 0x00 |
| [11] | Checksum (computed on byte 0 to 10) |

*The SAS replies with 18-bytes:*

| | |
|---|---|
| [0-1] | Magic Number (Unsigned 16-bit) (0x8178) |
| [2-13] | Serial Number (ASCII characters) |
| [14-15] | Firmware Version (Unsigned 16-bit) |
| [16] | Checksum (computed on byte 0 to 15) |
| [17] | Acknowledge (0x32) |

### 9.7.3 Get Sensor Configuration

This command allows to read the SAS configuration.

*The host sends the following 12-bytes command:*

| | |
|---|---|
| [0] | 0x41 |
| [1] | 0x50 |
| [2] | 0x50 |
| [3] | 0x30 |
| [4] | 0x36 |
| [5-10] | 0x00 |
| [11] | Checksum (computed on byte 0 to 10) |

*The SAS responds with 21 bytes:*

| | |
|---|---|
| [0-1] | Magic Number (Unsigned 16-bit) (0x8178) |
| [2] | SAS config format version (1) |
| [3] | Range (0x00: Low, 0x01: High, 0x02: Auto) |
| [4-7] | Sensitivity in Pa/V (Float 32-bit) |
| [8-11] | Sensitivity in dB (20log(Pa/V)) (Float 32-bit) |
| [12] | Frequency Compensation (0x00: None, 0x01: Mic, 0x02: MicRI, 0x03: MicWs, 0x04: MicRiWs) |
| [13] | Frequency Weighting (0x00: Z, 0x01: C, 0x02: A, 0x03: G) |
| [14] | Time Averaging (0x00: Slow, 0x01: Fast) |

| | |
|---|---|
| [15] | FFT Bandwidth (0x00: 24kHz, 0x01: 12kHz, 0x02: 6kHz, 0x03: 3kHz, 0x04: 1.5kHz, 0x05: 750Hz) |
| [16] | Time Signal Recording Set-Up: (0x00: 48kHz/24bit, 0x01: 48kHz/16bit, 0x02: 48kHz/8bit, 0x03: 48kHz/4bit, 0x04: 24kHz/24bit, 0x05: 24kHz/16bit, 0x06: 24kHz/8bit, 0x07: 24kHz/4bit, 0x08: 12kHz/24bit, 0x09: 12kHz/16bit, 0x0A: 12kHz/8bit, 0x0B: 12kHz/4bit) |
| [17] | Low/High gain match (0x00: Off, 0x01: On) |
| [18] | Z High-Pass Filter (0x00: Off, 0x01: On) |
| [19] | Checksum (computed on byte 0 to 18) |
| [20] | Acknowledge (0x32) |

### 9.7.4 Set Sensor Configuration

This command allows to configured SAS.

*The host sends the following 12-bytes command:*

| | |
|---|---|
| [0] | 0x41 |
| [1] | 0x50 |
| [2] | 0x50 |
| [3] | 0x30 |
| [4] | 0x37 |
| [5-10] | 0x00 |
| [11] | Checksum (computed on byte 0 to 10) |

*The SAS responds with 1 byte:*

| | |
|---|---|
| [0] | Acknowledge (0x32) |

*The host waits 5ms*

*The host sends the following 20-bytes configuration:*

| | |
|---|---|
| [0-1] | Magic Number (Unsigned 16-bit) (0x8178) |
| [2] | SAS config format version (1) |
| [3] | Range (0x00: Low, 0x01: High, 0x02: Auto) |
| [4-7] | Sensitivity in Pa/V (Float 32-bit) |
| [8-11] | Sensitivity in dB (20log(Pa/V)) (Float 32-bit) |
| [12] | Frequency Compensation (0x00: None, 0x01: Mic, 0x02: MicRI, 0x03: MicWs, 0x04: MicRiWs) |
| [13] | Frequency Weighting (0x00: Z, 0x01: C, 0x02: A, 0x03: G) |
| [14] | Time Averaging (0x00: Slow, 0x01: Fast) |

[15] FFT Bandwidth (0x00: 24kHz, 0x01: 12kHz, 0x02: 6kHz, 0x03: 3kHz, 0x04: 1.5kHz, 0x05: 750Hz)
[16] Time Signal Recording Set-Up: (0x00: 48kHz/24bit, 0x01: 48kHz/16bit, 0x02: 48kHz/8bit, 0x03: 48kHz/4bit, 0x04: 24kHz/24bit, 0x05: 24kHz/16bit, 0x06: 24kHz/8bit, 0x07: 24kHz/4bit, 0x08: 12kHz/24bit, 0x09: 12kHz/16bit, 0x0A: 12kHz/8bit, 0x0B: 12kHz/4bit)
[17] Low/High gain match (0x00: Off, 0x01: On)
[18] Z High-Pass Filter (0x00: Off, 0x01: On)
[19] Checksum (computed on byte 0 to 18)

*The SAS responds with 1 byte:*

[0] Acknowledge (0x32)

### 9.7.5 Reset Buffer Status

This command is used at the beginning of the acquisition session or when desired to empty the acquisition buffers (both SLM and OPL): all blocks of 85ms for both the data and the time signal are erased.

*The host sends the following 12-bytes command:*

[0] 0x41
[1] 0x50
[2] 0x50
[3] 0x30
[4] 0x33
[5-10] 0x00
[11] Checksum (computed on byte 0 to 10)

*The SAS replies with 1 byte:*

[0] Acknowledge (0x32)

### 9.7.6 Get Buffer Status

This command is used to determine the number of blocks in the buffer for both the Data and Time Signal. The byte 3 of the command allows selecting the SLM or the OPL buffer. Each block has a duration of 85ms. For the SLM, the number of blocks varies depending on the Time Signal Recording Mode:

| Time Signal Recording Mode | Sampling Rate (kHz) | Resolution (Bit) | Number of Blocks | Buffer duration (s) |
|---|---|---|---|---|

| | | | | |
|---|---|---|---|---|
| 0x00 | 48 | 24 | 22 | 1.87 |
| 0x01 | 48 | 16 | 33 | 2.81 |
| 0x02 | 48 | 8 | 67 | 5.70 |
| 0x03 | 48 | 4 | 100 | 8.50 |
| 0x04 | 24 | 24 | 44 | 3.74 |
| 0x05 | 24 | 16 | 67 | 5.70 |
| 0x06 | 24 | 8 | 100 | 8.50 |
| 0x07 | 24 | 4 | 100 | 8.50 |
| 0x08 | 12 | 24 | 89 | 7.57 |
| 0x09 | 12 | 16 | 100 | 8.50 |
| 0x0A | 12 | 8 | 100 | 8.50 |
| 0x0B | 12 | 4 | 100 | 8.50 |

For the OPL, the number of blocks is always 3770 for a duration of 320s.

The buffer status indicates the quantity of blocks available in the buffer as well as the ID of the last block in the buffer.

*The host sends the following 12-bytes command:*

| | |
|---|---|
| [0] | 0x41 |
| [1] | 0x50 |
| [2] | 0x50 |
| [3] | 0x30 (SLM buffer) 0x32 (OPL buffer) |
| [4] | 0x32 |
| [5-10] | 0x00 |
| [11] | Checksum (computed on byte 0 to 10) |

*The SAS replies with 18-bytes:*

| | |
|---|---|
| [0-3] | Buffer Number of Blocks (Unsigned 32-bit) |
| [4-11] | Reserved |
| [12-15] | Buffer Last Block ID (Unsigned 32-bit) |
| [16] | Checksum (computed on byte 0 to 15) |
| [17] | Acknowledge (0x32) |

### 9.7.7 Get SLM Data and Waveform

This command allows to get a specific instant data and or waveform block of 85ms in the sensor SLM buffer.

*The host sends the following 12-bytes command:*

| | |
|---|---|
| [0] | 0x41 |
| [1] | 0x50 |
| [2] | 0x50 |
| [3] | 0x30 |
| [4] | 0x34 |
| [5-8] | Block ID (Unsigned 32-bit) |
| [9] | Acquisition Mode (0x01: Data without FFT, 0x03: Data with FFT, 0x04: Waveform, 0x05: Data and Waveform, 0x07: Data with FFT and Waveform) |
| [10] | 0x00 |
| [11] | Checksum (computed on byte 0 to 10) |

Acquisition Mode 0x01: Data Without FFT

*The SAS replies with 127 bytes:*

| | |
|---|---|
| [0-3] | Block ID (Unsigned 32-bit) |
| [4] | Status (Unsigned 8-bit) (bit 0: Reserved, bit 1: Reserved, bit 2: Overload, bit 3: Underrange, bit 4: Low Range Selected, bit 5: High Range Selected) |
| [5-6] | Lmin (dBZ x 100, Slow or Fast) (Signed 16-bit) |
| [7-8] | Lmin (dBC x 100, Slow or Fast) (Signed 16-bit) |
| [9-10] | Lmin (dBA x 100, Slow or Fast) (Signed 16-bit) |
| [11-12] | Lmin (dBG x 100, Slow or Fast) (Signed 16-bit) |
| [13-14] | Lmax (dBZ x 100, Slow or Fast) (Signed 16-bit) |
| [15-16] | Lmax (dBC x 100, Slow or Fast) (Signed 16-bit) |
| [17-18] | Lmax (dBA x 100, Slow or Fast) (Signed 16-bit) |
| [19-20] | Lmax (dBG x 100, Slow or Fast) (Signed 16-bit) |
| [21-36] | SPL (dB[Z, C, A, or G] x 100, Slow or Fast) (8 x Signed 16-bit) |
| [37-38] | Lpk (dBZ x 100, Slow or Fast) (Signed 16-bit) |
| [39-40] | Lpk (dBC x 100, Slow or Fast) (Signed 16-bit) |
| [41-42] | Lpk (dBA x 100, Slow or Fast) (Signed 16-bit) |
| [43-44] | Lpk (dBG x 100, Slow or Fast) (Signed 16-bit) |
| [45-46] | Leq (dBZ x 100, Slow or Fast) (Signed 16-bit) |
| [47-48] | Leq (dBC x 100, Slow or Fast) (Signed 16-bit) |
| [49-50] | Leq (dBA x 100, Slow or Fast) (Signed 16-bit) |
| [51-52] | Leq (dBG x 100, Slow or Fast) (Signed 16-bit) |
| [53-124] | 1/3 Octave Leq (dBZ x100) (36 x Signed 16-bit) |
| [125] | Checksum (computed on byte 0 to 124) |
| [126] | Acknowledge (0x32) |

Acquisition Mode 0x03: Data With FFT

*The SAS replies with 1151 bytes:*

| | |
|---|---|
| [0-3] | Block ID (Unsigned 32-bit) |
| [4] | Status (Unsigned 8-bit) (bit 0: Reserved, bit 1: Reserved, bit 2: Overload, bit 3: Underrange, bit 4: Low Range Selected, bit 5: High Range Selected) |
| [5-6] | Lmin (dBZ x 100, Slow or Fast) (Signed 16-bit) |
| [7-8] | Lmin (dBC x 100, Slow or Fast) (Signed 16-bit) |
| [9-10] | Lmin (dBA x 100, Slow or Fast) (Signed 16-bit) |
| [11-12] | Lmin (dBG x 100, Slow or Fast) (Signed 16-bit) |
| [13-14] | Lmax (dBZ x 100, Slow or Fast) (Signed 16-bit) |
| [15-16] | Lmax (dBC x 100, Slow or Fast) (Signed 16-bit) |
| [17-18] | Lmax (dBA x 100, Slow or Fast) (Signed 16-bit) |
| [19-20] | Lmax (dBG x 100, Slow or Fast) (Signed 16-bit) |
| [21-36] | SPL (dB[Z, C, A, or G] x 100, Slow or Fast) (8 x Signed 16-bit) |
| [37-38] | Lpk (dBZ x 100, Slow or Fast) (Signed 16-bit) |
| [39-40] | Lpk (dBC x 100, Slow or Fast) (Signed 16-bit) |
| [41-42] | Lpk (dBA x 100, Slow or Fast) (Signed 16-bit) |
| [43-44] | Lpk (dBG x 100, Slow or Fast) (Signed 16-bit) |
| [45-46] | Leq (dBZ x 100, Slow or Fast) (Signed 16-bit) |
| [47-48] | Leq (dBC x 100, Slow or Fast) (Signed 16-bit) |
| [49-50] | Leq (dBA x 100, Slow or Fast) (Signed 16-bit) |
| [51-52] | Leq (dBG x 100, Slow or Fast) (Signed 16-bit) |
| [53-124] | 1/3 Octave Leq (dBZ x 100) (36 x Signed 16-bit) |
| [125-1148] | FFT Leq (dBZ x 100) (512 x Signed 16-bit) |
| [1149] | Checksum (computed on byte 0 to 1148) |
| [1150] | Acknowledge (0x32) |

### Acquisition Mode 0x04: Waveform

*The SAS replies with 559 to 12335 bytes depending on waveform sampling configuration:*

| Waveform Sampling Mode | Sampling Rate (kHz) | Resolution (Bit) | Block Samples | Waveform Block (Bytes) | Payload (Bytes) |
|---|---|---|---|---|---|
| 0x00 | 48 | 24 | 512 | 1536 | 12335 |
| 0x01 | 48 | 16 | 512 | 1024 | 8239 |
| 0x02 | 48 | 8 | 512 | 512 | 4143 |
| 0x03 | 48 | 4 | 512 | 256 | 2095 |
| 0x04 | 24 | 24 | 256 | 768 | 6191 |
| 0x05 | 24 | 16 | 256 | 512 | 4143 |
| 0x06 | 24 | 8 | 256 | 256 | 2095 |
| 0x07 | 24 | 4 | 256 | 128 | 1071 |
| 0x08 | 12 | 24 | 128 | 384 | 3119 |
| 0x09 | 12 | 16 | 128 | 256 | 2095 |

| | | | | | |
|---|---|---|---|---|---|
| 0x0A | 12 | 8 | 128 | 128 | 1071 |
| 0x0B | 12 | 4 | 128 | 64 | 559 |

*The payload consists of 8 waveform blocks, each having a status byte and conversion factor.*

*The payload description below is shown for Waveform Sampling Config 0x01 (48kHz, 16-bit):*

| | |
|---|---|
| [0-3] | Block ID (Unsigned 32-bit) |
| [4] | Status (Unsigned 8-bit) (bit 0: Reserved, bit 1: Reserved, bit 2: Overload, bit 3: Underrange, bit 4: Low Range Selected, bit 5: High Range Selected) |
| [5] | Block 1 Status (Unsigned 8-bit) (bit 0: Reserved, bit 1: Reserved, bit 2: Overload, bit 3: Underrange, bit 4: Low Range Selected, bit 5: High Range Selected) |
| [6-9] | Block 1 Conversion Factor (Signed *16-bit* to Pa) (Float 32-bit) |
| [10-1033] | Block 1 Waveform (*512* x Signed *16-bit*) |
| [1034-2062] | Block 2 (use format from bytes [5-1033]) |
| [2063-3091] | Block 3 (use format from bytes [5-1033]) |
| [3092-4120] | Block 4 (use format from bytes [5-1033]) |
| [4121-5149] | Block 5 (use format from bytes [5-1033]) |
| [5150-6178] | Block 6 (use format from bytes [5-1033]) |
| [6179-7207] | Block 7 (use format from bytes [5-1033]) |
| [7208-8236] | Block 8 (use format from bytes [5-1033]) |
| [8237] | Checksum (computed on byte 0 to 8236) |
| [8238] | Acknowledge (0x32) |

Acquisition Mode 0x05: Data and Waveform

*The SAS replies with 679 to 12455 bytes depending on Waveform Sampling Configuration.*

| Waveform Sampling Mode | Sampling Rate (kHz) | Resolution (Bit) | Block Samples | Waveform Block (Bytes) | Payload (Bytes) |
|---|---|---|---|---|---|
| 0x00 | 48 | 24 | 512 | 1536 | 12455 |
| 0x01 | 48 | 16 | 512 | 1024 | 8359 |
| 0x02 | 48 | 8 | 512 | 512 | 4263 |
| 0x03 | 48 | 4 | 512 | 256 | 2215 |
| 0x04 | 24 | 24 | 256 | 768 | 6311 |
| 0x05 | 24 | 16 | 256 | 512 | 4263 |
| 0x06 | 24 | 8 | 256 | 256 | 2215 |
| 0x07 | 24 | 4 | 256 | 128 | 1191 |
| 0x08 | 12 | 24 | 128 | 384 | 3239 |
| 0x09 | 12 | 16 | 128 | 256 | 2215 |

| | | | | | |
|---|---|---|---|---|---|
| 0x0A | 12 | 8 | 128 | 128 | 1191 |
| 0x0B | 12 | 4 | 128 | 64 | 679 |

*The payload description below is shown for Waveform Sampling Config 0x01 (48kHz, 16-bit):*

| | |
|---|---|
| [0-124] | Use format from bytes [0-124] from Acquisition Mode 0x01: Data Without FFT |
| [125-8356] | Use format from bytes [5-8236] from Acquisition Mode 0x04: Waveform |
| [8357] | Checksum (computed on byte 0 to 8356) |
| [8358] | Acknowledge (0x32) |

Acquisition Mode 0x07: Data with FFT and Waveform

*The SAS replies with 1703 to 13479 bytes depending on Waveform Sampling Configuration.*

| Waveform Sampling Mode | Sampling Rate (kHz) | Resolution (Bit) | Block Samples | Waveform Block (Bytes) | Payload (Bytes) |
|---|---|---|---|---|---|
| 0x00 | 48 | 24 | 512 | 1536 | 13479 |
| 0x01 | 48 | 16 | 512 | 1024 | 9383 |
| 0x02 | 48 | 8 | 512 | 512 | 5287 |
| 0x03 | 48 | 4 | 512 | 256 | 3239 |
| 0x04 | 24 | 24 | 256 | 768 | 7335 |
| 0x05 | 24 | 16 | 256 | 512 | 5287 |
| 0x06 | 24 | 8 | 256 | 256 | 3239 |
| 0x07 | 24 | 4 | 256 | 128 | 2215 |
| 0x08 | 12 | 24 | 128 | 384 | 4263 |
| 0x09 | 12 | 16 | 128 | 256 | 3239 |
| 0x0A | 12 | 8 | 128 | 128 | 2215 |
| 0x0B | 12 | 4 | 128 | 64 | 1703 |

*The payload description below is shown for Waveform Sampling Config 0x01 (48kHz, 16-bit):*

| | |
|---|---|
| [0-1148] | Use format from bytes [0-1148] from Acquisition Mode 0x03: Data With FFT |
| [1149-9380] | Use format from bytes [5-8236] from Acquisition Mode 0x04: Waveform |
| [9381] | Checksum (computed on byte 0 to 9380) |
| [9382] | Acknowledge (0x32) |

### 9.7.8 Get OPL Data and Waveform

This command allows to get a specific instant data and or waveform block of 85ms in the sensor OPL buffer.

*The host sends the following 12-bytes command:*

| | |
|---|---|
| [0] | 0x41 |
| [1] | 0x50 |
| [2] | 0x50 |
| [3] | 0x32 |
| [4] | 0x31 |
| [5-8] | Block ID (Unsigned 32-bit) |
| [9] | Acquisition Mode (0x01: Data, 0x04: Waveform, 0x05: Data and Waveform) |
| [10] | 0x00 |
| [11] | Checksum (computed on byte 0 to 10) |

Acquisition Mode 0x01: Data

*The SAS replies with 9 bytes:*

| | |
|---|---|
| [0-3] | Block ID (Unsigned 32-bit) |
| [4] | Status (Unsigned 8-bit) (bit 0: Reserved, bit 1: Reserved, bit 2: Overload, bit 3: Underrange, bit 4: Low Range Selected, bit 5: High Range Selected) |
| [5-6] | OPL Peak (dB x100) (Signed 16-bit) |
| [7] | Checksum (computed on byte 0 to 6) |
| [8] | Acknowledge (0x32) |

Acquisition Mode 0x04: Waveform

*The SAS replies with 139 bytes:*

| | |
|---|---|
| [0-3] | Block ID (Unsigned 32-bit) |
| [4] | Status (Unsigned 8-bit) (bit 0: Reserved, bit 1: Reserved, bit 2: Overload, bit 3: Underrange, bit 4: Low Range Selected, bit 5: High Range Selected) |
| [5-8] | Waveform Conversion Factor (Signed 8-bit to Pa) (Float 32-bit) |
| [9-136] | Waveform (128 x Signed 8-bit) |
| [137] | Checksum (computed on byte 0 to 136) |
| [138] | Acknowledge (0x32) |

Acquisition Mode 0x05: Data and Waveform

*The SAS replies with 141 bytes:*

| | |
|---|---|
| [0-3] | Block ID (Unsigned 32-bit) |
| [4] | Status (Unsigned 8-bit) (bit 0: Reserved, bit 1: Reserved, bit 2: Overload, bit 3: Underrange, bit 4: Low Range Selected, bit 5: High Range Selected) |
| [5-8] | Waveform Conversion Factor (Signed 8-bit to Pa) (Float 32-bit) |

| | |
|---|---|
| [9-136] | Waveform (128 x Signed 8-bit) |
| [137-138] | OPL Peak (dB x100) (Signed 16-bit) |
| [139] | Checksum (computed on byte 0 to 138) |
| [140] | Acknowledge (0x32) |

### 9.7.9 Get/Reset Average Data (SLM and OPL)

The SAS automatically computes an average for the SLM and OPL data. The same function is used to read the accumulated data and reset the average.

*The host sends the following 12-bytes command:*

| | |
|---|---|
| [0] | 0x41 |
| [1] | 0x50 |
| [2] | 0x50 |
| [3] | 0x31 |
| [4] | 0x39 |
| [5-10] | 0x00 |
| [11] | Checksum (computed on byte 0 to 10) |

*The SAS replies with 1164 bytes and resets the average:*

| | |
|---|---|
| [0-3] | Number of Instant SLM blocks in the average (Unsigned 32-bit) |
| [4] | Status (Unsigned 8-bit) (bit 0: Reserved, bit 1: Reserved, bit 2: Overload, bit 3: Underrange, bit 4: Low Range Selected, bit 5: High Range Selected) |
| [5-24] | LN% (dB[Z, C, A, or G] x 100, Slow or Fast) (10 x Signed 16-bit) |
| [25-26] | Lmin (dBZ x 100, Slow or Fast) (Signed 16-bit) |
| [27-28] | Lmin (dBC x 100, Slow or Fast) (Signed 16-bit) |
| [29-30] | Lmin (dBA x 100, Slow or Fast) (Signed 16-bit) |
| [31-32] | Lmin (dBG x 100, Slow or Fast) (Signed 16-bit) |
| [33-34] | Lmax (dBZ x 100, Slow or Fast) (Signed 16-bit) |
| [35-36] | Lmax (dBC x 100, Slow or Fast) (Signed 16-bit) |
| [37-38] | Lmax (dBA x 100, Slow or Fast) (Signed 16-bit) |
| [39-40] | Lmax (dBG x 100, Slow or Fast) (Signed 16-bit) |
| [41-42] | Leq (dBZ x 100, Slow or Fast) (Signed 16-bit) |
| [43-44] | Leq (dBC x 100, Slow or Fast) (Signed 16-bit) |
| [45-46] | Leq (dBA x 100, Slow or Fast) (Signed 16-bit) |
| [47-48] | Leq (dBG x 100, Slow or Fast) (Signed 16-bit) |
| [49-50] | Lpk (dBZ x 100, Slow or Fast) (Signed 16-bit) |
| [51-52] | Lpk (dBC x 100, Slow or Fast) (Signed 16-bit) |
| [53-54] | Lpk (dBA x 100, Slow or Fast) (Signed 16-bit) |
| [55-56] | Lpk (dBG x 100, Slow or Fast) (Signed 16-bit) |
| [59-130] | 1/3 Octave Leq (dBZ x 100) (36 x Signed 16-bit) |

| | |
|---|---|
| [131-1154] | FFT Leq (dBZ x 100) (512 x Signed 16-bit) |
| [1155-1158] | Number of Instant OPL blocks in the average (Unsigned 32-bit) |
| [1159] | Status (Unsigned 8-bit) (bit 0: Reserved, bit 1: Reserved, bit 2: Overload, bit 3: Underrange, bit 4: Low Range Selected, bit 5: High Range Selected) |
| [1160-1161] | OPL Peak (dB x100) (Signed 16-bit) |
| [1162] | Checksum (computed on byte 0 to 1161) |
| [1163] | Acknowledge (0x32) |

### 9.7.10 Exec Sensor-Check

This command executes a sensor-check on the SAS (valid on Model ID 2 only: SASK-00002) and saves the result in its non-volatile memory.

The host must provide the current Unix time reference in the command payload for the SAS to add the time reference to the sensor-check.

When the Exec Sensor-Check command is launched, the host must periodically perform Get Sensor-Check Status to confirm the end of the Sensor-Check (~30s) and then perform Get Sensor-Check to read the result.

*The host sends the following 12-bytes command:*

| | |
|---|---|
| [0] | 0x41 |
| [1] | 0x50 |
| [2] | 0x50 |
| [3] | 0x31 |
| [4] | 0x30 |
| [5-10] | Unix Time Reference (Unsigned 64-bit, least significant 6 bytes) |
| [11] | Checksum (computed on byte 0 to 10) |

*The SAS replies with 1 byte:*

| | |
|---|---|
| [0] | Acknowledge (0x32) |

### 9.7.11 Get Sensor-Check Status

This command should be executed by the host to determine if the ongoing sensor-check procedure is done. When the sensor-check procedure is done, the host can execute the Get Sensor-Check command (see section 3.7.12)

*The host sends the following 12-bytes command:*

| | |
|---|---|
| [0] | 0x41 |
| [1] | 0x50 |

| | |
|---|---|
| [2] | 0x50 |
| [3] | 0x31 |
| [4] | 0x30 |
| [5-10] | 0x2D |
| [11] | Checksum (computed on byte 0 to 10) |

*The SAS replies with 3 bytes:*

| | |
|---|---|
| [0] | Sensor-Check Status (0x00: Completed without error, 0x03: In progress, 0x06: Completed with error) |
| [1] | Checksum (computed on byte 0) |
| [2] | Acknowledge (0x32) |

### 9.7.12 Get Sensor-Check

This command reads the last sensor-check result from the SAS non-volatile memory. The host can either read the last sensor-check performed by the host, or the factory reference.

*The host sends the following 12-bytes command:*

| | |
|---|---|
| [0] | 0x41 |
| [1] | 0x50 |
| [2] | 0x50 |
| [3] | 0x31 |
| [4] | 0x31 |
| [5] | 0x01: read last sensor-check, 0x00: read reference sensor-check |
| [6-10] | 0x00 |
| [11 | Checksum (computed on byte 0 to 10) |

*The SAS replies with 75 bytes:*

| | |
|---|---|
| [0-1] | Magic Number (Unsigned 16-bit) (0x8178) |
| [2-9] | Unix Time Reference (Unsigned 64-bit) |
| [10] | Error Code (Unsigned 8-bit) (0x00: Success, 0x01: TEDS ROM error, 0x02: ROM SN mismatch, 0x03: Memory error, 0x04: Syscheck2 error, 0x05: Memory Error 2, 0x06: Environment info error, 0x07: Environment out of range; 0x08: Invalid reference) |
| [11-18] | TEDS ROM Serial Number (Unsigned 64-bit) |
| [19-22] | Ambient Temperature (°C) (Float 32-bit) |
| [23-26] | Atmospheric Pressure (hPa) (Float 32-bit) |
| [27-30] | Relative Humidity (%) (Float 32-bit) |
| [31-34] | Temperature correction factor 1 (Tc1) (Float 32-bit) |
| [35-38] | Temperature correction factor 2 (Tc2) (Float 32-bit) |

| | |
|---|---|
| [39-42] | Background SPL (250Hz 1/3 Octave band, dB) (Float 32-bit) |
| [43-46] | Syscheck2 Level (250Hz 1/3 Octave band, dB) (Float 32-bit) |
| [47-50] | Reference Sensitivity (Pa/V) (Float 32-bit) |
| [51-54] | User Sensitivity (Pa/V) (Float 32-bit) |
| [55-58] | Sensitivity Tolerance (dB) (Float 32-bit) |
| [59] | Sensitivity in Tolerance (0x00: No, 0x01: Yes) (Unsigned 8-bit) |
| [60-63] | Reference SPL (dB) (Float 32-bit) |
| [64-67] | Measure SPL (dB) (Float 32-bit) |
| [68-71] | SPL Tolerance (dB) (Float 32-bit) |
| [72] | SPL in Tolerance (0x00: No, 0x01: Yes) (unsigned 8-bit) |
| [73] | Checksum (computed on byte 0 to 72) |
| [74] | Acknowledge (0x32) |

### 9.7.13 Get Temperature

This command allows to obtain the current SAS processor temperature and estimated ambiant temperature.

*The host sends the following 12-bytes command:*

| | |
|---|---|
| [0] | 0x41 |
| [1] | 0x50 |
| [2] | 0x50 |
| [3] | 0x30 |
| [4] | 0x39 |
| [5-11] | 0x00 |
| [11] | Checksum (computed on byte 0 to 10) |

*The SAS replies with 10 bytes:*

| | |
|---|---|
| [0-3] | Processor Temperature (°C) (Float 32-bit) |
| [4-7] | Ambient Temperature (°C) (Float 32-bit) |
| [8] | Checksum (computed on byte 0 to 7) |
| [9] | Acknowledge (0x32) |

### 9.7.14 Reset Device

This command can be used to make a software reset of the SAS.

*The host sends the following 12-bytes command:*

| | |
|---|---|
| [0] | 0x42 |
| [1] | 0x6F |

| | |
|---|---|
| [2] | 0x61 |
| [3] | 0x72 |
| [4] | 0x64 |
| [5] | 0x52 |
| [6] | 0x65 |
| [7] | 0x73 |
| [8] | 0x65 |
| [9] | 0x74 |
| [10] | 0x2D |
| [11] | Checksum (computed on byte 0 to 10) |

*The SAS does not reply to this command and will be ready for a new command after about 2s.*