IEC 60268-16 rev. 4

IEC 61672 Class 2 / ANSI S1.4 Type 2

CE

VOX

SPEECH INTELLIGIBILITY TESTER

Operating manual

VOX-01

Contact information and support

The VOX-01 is designed and manufactured in the Netherlands and supplied by SDi, USA.

You can contact SDi at the following address:

SDi,
3535 Route 66, Building 6
Neptune, NJ 07753
Tel: 732-751-9266
Fax: 732-751-9241
Email: sales@sdifire.com
Web: www.sdifire.com

Updates of the system's firmware and documentation are released online :

www.sdifire.com/support/#productsoftwareupdates

NOTE: Screenshots and product pictures shown in this manual correspond to the VOX-01 hardware platform 1.8 running firmware version 1.8. Once you update the firmware, the screenshots may not fully correspond to what is being displayed on your device's screen.

See page 46 for new features added in V2.0

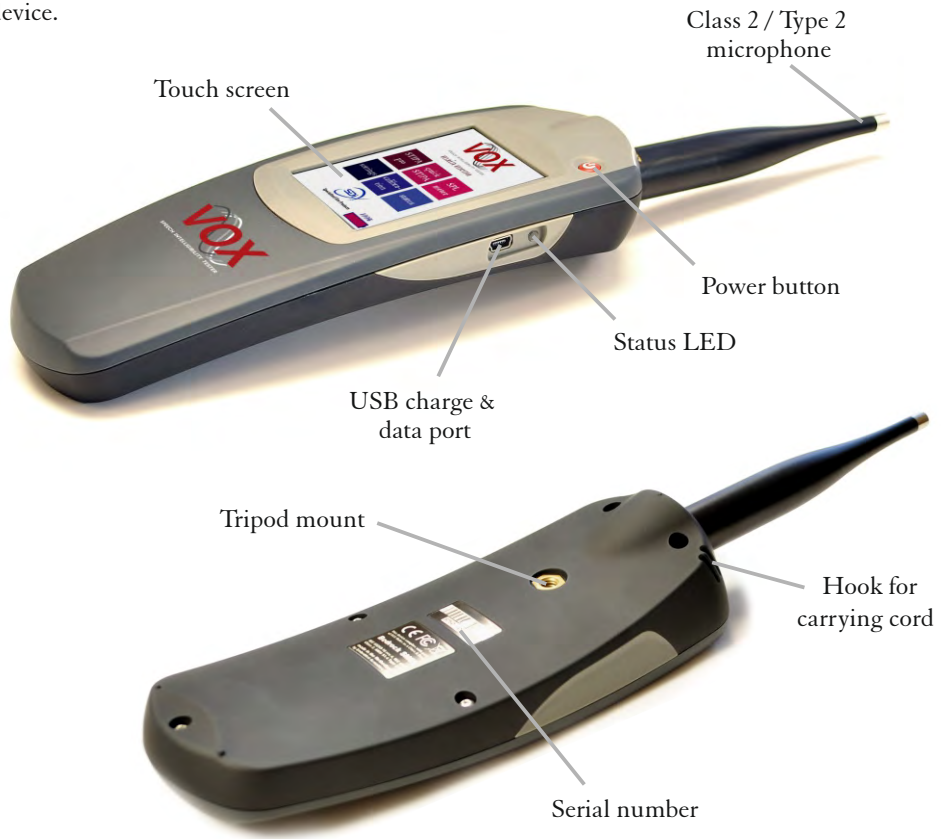
Document version 2.0, release date October 2017. Applies to model(s): VOX-01.

Contents

1. Introduction

Congratulations on purchasing the VOX-01 STIPA meter, the most advanced instrument for measuring the Speech Transmission Index ever built, designed and manufactured by the inventors of STIPA. The VOX-01 is also a fully compliant Class 2 / Type 2 Sound Pressure Level meter, a 1/1 and 1/3 octave Real-Time Analyzer, a Fast Fourier Transform Analyzer, a Reverberation Time Meter, an Oscilloscope, and much more. Its wide range of measurement options cater to a variety of different acoustic measuring needs.

Using the VOX-01 is quite easy, thanks to its touch-screen operation and intuitive menu structure. Most users will get the hang of doing measurements with the VOX-01 without spending much time with this manual. Nonetheless, we strongly recommend that you do read through this manual before starting to use your VOX-01, in order to get acquainted with the various features of the device and the procedures for charging and maintaining your device.



2. General use and safety precautions

The VOX-01 is a sophisticated electronic measuring instrument that should be used, maintained and stored with care:

- We recommend that you always use a lanyard to secure your device against dropping, by suspending it around your neck or wrist. If you use a tripod to mount the device during measurements, we recommend that you use a sturdy model with a sufficiently wide base.
- Do not expose the device itself, the measuring microphone or charger to rain, moisture or liquids of any kind. Take special care to prevent liquids to permeate into the device through the connectors or along the display bezel.
- Do not operate at ambient temperatures over 35°C/95°F
- Do not use close to flames or open fire.
- Do not use in environments where flammable or explosive materials are used.
- Do not keep the device powered on while unattended for prolonged periods of time.
- During transportation and storage, keep the device in a suitable casing or container – preferably its original case. The device needs to be protected from shocks and vibration (due to transportation or falling), excessive temperatures, liquids and moisture, and any other external conditions that could do damage to the device. Care should be taken that other objects cannot come into direct contact with the display during transportation.
- Make sure that the device is switched off before transportation and storage.

Safety precautions when charging

The VOX-01 is a battery-powered rechargeable device, with an internal low self-discharge NiMH battery pack. This battery pack is designed for many years of operation, and therefore cannot be swapped out by the user. Recharging takes place through the mini USB connector found on the left side of the device.

The VOX-01 is charged through the USB connector using high currents of up to 1500 mA. While being charged, the device will heat up. DO NOT CHARGE THE DEVICE WHILE IT IS INSIDE A CLOSED CONTAINER (BOX, BRIEFCASE, ETC.). Please make sure that the device can shed excess heat while charging.

The supplied charger includes adapters for use worldwide, and operates on a wide AC-voltage range of 100 – 240V. Do not use the charger if the casing appears cracked or broken, or if it has been exposed to fluids or moisture. Contact with components inside the charger while this is plugged in may result in serious injury or death.

Safety precautions related to connectors

The VOX-01 features a USB connector and an XLR connector (to which the microphone is attached). If you connect external devices to these connectors, please ensure that these connections are protected against over-voltage and power surges. The voltage supplied to the USB port should not exceed 5.5V. As the USB power circuitry is connected to the battery pack, excessive voltage applied to the USB port may cause the battery pack to catch fire or explode.

The XLR connector supplies 48V phantom power to the microphone. This phantom voltage can be switched on and off through the hardware settings menu. IMPORTANT: connecting equipment not designed for 48V phantom power to the VOX-01 connector (with phantom power switched on) will permanently damage the connected device. The manufacturer explicitly denounces responsibility for any damages to third-party hardware resulting from exposure to the VOX-01's phantom power.

3. Getting started

You should receive your VOX-01 with sufficiently charged batteries to start the device and get acquainted with its features. We do recommend that you fully charge the device using the supplied charger before starting your first real measurement session.

The device is powered on by pressing the red power button once.

Note: the power button can also be used to power the device off. If you press the button while the device is in operation, you will see a dialog window asking confirmation before powering off. If the power button is kept pressed for 10 seconds in the "power on" state, the device will be forced into the "off" condition. This can be used to reset the device if it becomes unresponsive (keep pressed to 10 seconds to switch off, then press again to restart).

The VOX-01 will boot into the main menu. You can launch its different modules from this menu.

STIPA pro: module that gives you access to all STI measurement details
Quick STIPA: simple module to quickly do STIPA measurements
SPL meter: Sound Pressure Level meter module
Settings: change the system's hardware configuration
Calibration: calibrate the VOX-01 and its microphone
Status: general information on the measurement system

All modules will be explained in detail in the following sections of this manual. Apart from these modules, the VOX-01 has two specific operating modes: charging via USB, and data transfer via USB. These modes will also be explained further on in this manual.

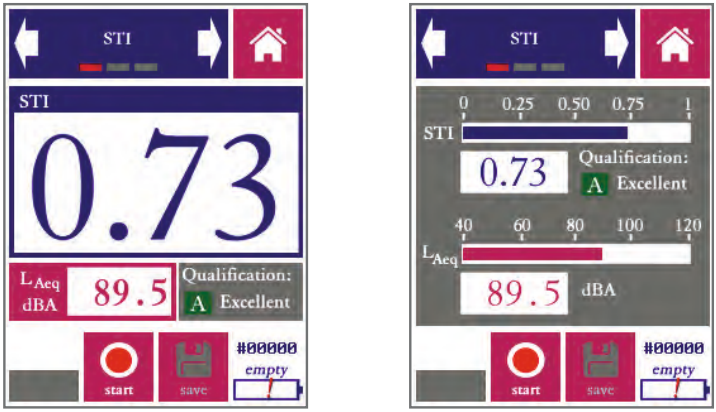
4. Using the VOX-01

Quick STIPA

The Quick STIPA module is intended to do simple and straightforward STI measurements using the STIPA test signal. A comprehensive explanation of the STI method is beyond the scope of this device manual; there are several online and offline resources that provide guidance and information on doing STI measurements. In this manual, we will briefly explain how to set up your equipment for measuring the STI. The Quick STIPA module makes the process as simple as possible.

For any STI measurement, you need a source of the STIPA test signal as well as an STI analyzer. In your case, the analyzer is your VOX-01. What the signal source is, depends on what kind of measurement you aim to carry out.

The Embedded Acoustics reference STIPA test signal is included with the VOX-01 (on a USB flash drive) and can also be downloaded from the SDi website, free of charge. This is a fully IEC-60268-16 rev.4 compliant test signal, compatible with all STIPA meters that conform with the standard.



STI measurement screen of the Quick STIPA module, in digit mode (left) and bar mode (right)

In order to carry out an STI measurement, complete the following steps:

- Power on your VOX-01 and go to Quick STIPA
- Now start playback of the STIPA test signal through the channel or system which you intend to test. Note that the STI that you will now measure, will characterize all parts of your transmission path, from playback device up to the microphone of your VOX-01.

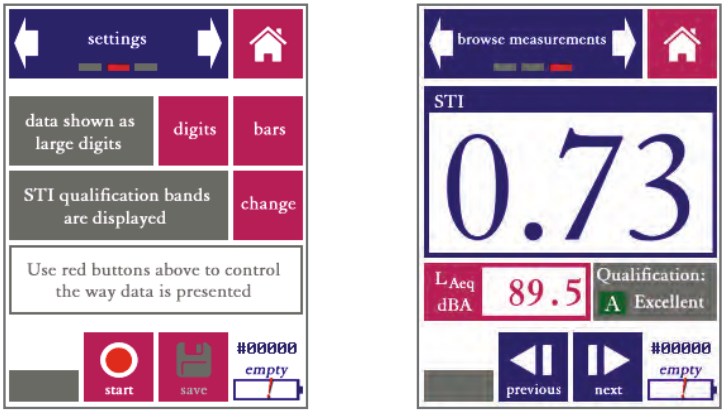
- Tap “Start” on the VOX-01
- Wait for 25 seconds while the measurement takes place. Make sure that signal playback is not interrupted, and that the acoustic environment is stable and free from impulsive sounds (such as door slams).
- You will see that the STI on your screen stabilizing towards its end value.
- Optionally, you can press “save” once the measurement is finished to store the data, to be browsed or downloaded to PC later. A measurement number is assigned to each saved measurement. This number is displayed at the bottom right of the screen (preceded by a “#” character), above the battery indicator.

That is really the entire procedure. If you are new to STIPA measurements, please consult tutorials and standards to make informed decisions about the STIPA signal playback level, measuring positions, number of repeated measurements, etc.

The Quick STIPA module also shows some additional measurement information:

- The A-weighted sound pressure level
- The qualification band (a letter between A and U) that is used in some standards and defined in IEC 60268-16 rev. 4.
- A label (“bad”-”excellent”) the characterizes intelligibility based on the STI

The arrows in the blue bar on the top of the display van be used to navigate through the different screens for each module. The Quick STIPA app has three screens: “STI”, “settings”, and “browse measurements”.



“Settings” screen and “browse measurements” screen. The latter screen is nearly identical to the STI measurement screen, but with previous/back buttons instead of start/stop and save buttons.

The “settings” screen give you some options to control the appearance of your measure ment results:

- Choose between presentation of the STI in large digits or as a bar plot
- Choose whether or not you want to see the qualification bands displayed

The “browse measurements” screen allows you to review earlier (saved) measurements without having to download your data to a PC first.

- Use to blue buttons at the bottom of the screen to scroll back and forth through your saved measurements.
- Note that the measurement number displayed above the battery indicator corresponds to the measurement currently shown on the screen.

Interpreting larger numbers of STIPA measurements by using the “browse measurements” screen will be inefficient; we recommend downloading the data to a PC for this.

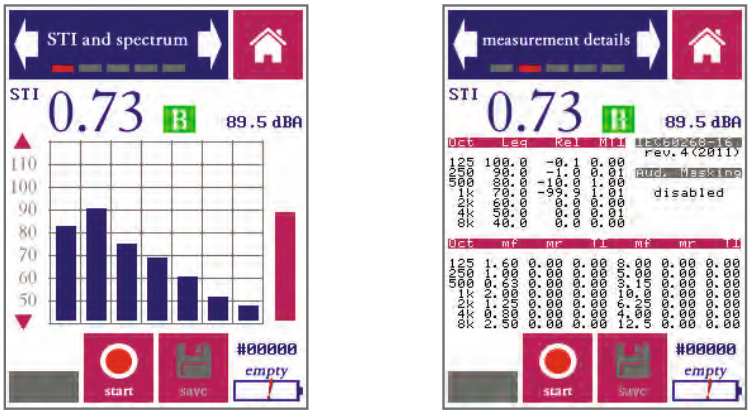
Please take note of the following features of the Quick STIPA module:

- On the bottom left of the screen, a red “recording dot” is displayed whenever a measurement is running. Below this red dot, the progress of the current measurement is indicated by a progress bar.
- The “save” button is only operational when new (unsaved) measurement data is available from a finished measurement. If this is not the case, the save icon is colored gray.
- The VOX-01 calculates a heuristic reliability metric for each STI measure ment. If the measurement is found to be unreliable (e.g. due to disturbance by impulsive sounds), then a red cross is displayed across the STI value. Crossed-out STI values are often seen at the beginning of measurements, when the calculation has not ran long enough to compute a reliable STI. As soon as the cross disappears, the STI value can be trusted to be within the usual STI measurement error of 0.03.

A crossed-out STI value means that the measurement is not (yet) sufficiently reliable

STIPA pro

The STIPA pro module is also used to measure the Speech Transmission Index, but unlike the quick STIPA module, it also comprises features that allow you to analyze and manipulate your measurement data in greater detail.



"STI and spectrum" and "measurement details" screen in the STIPA pro module

The STIPA pro module has five screens:

STI and spectrum: display measured STI, octave spectrum and dBA level
Measurement details: display all measurement details including the MTF
Settings: configure the STIPA pro module
Additive noise: enter and enable/disable a noise spectrum to add to data
Browse measurements: review saved measurements

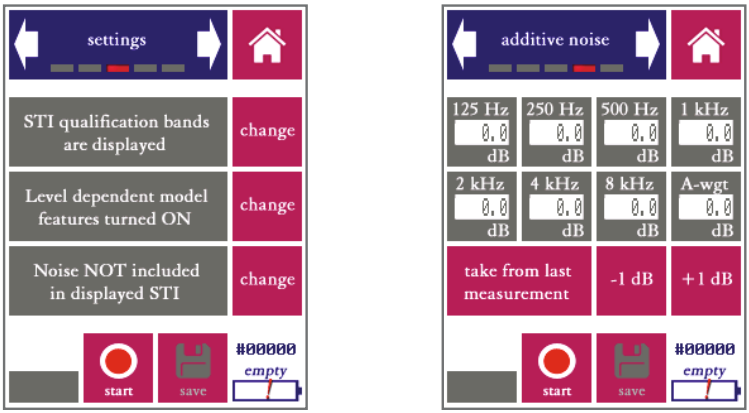
Measurements are usually started from the "STI and spectrum" or the "measurement details" screen. STI measurements are set up and started in the same way as when using the Quick STIPA module (see above). However, in the STIPA pro module, more details about the measurement are shown, and the user has more elaborate options to configure the measurement. Measurements are started, stopped and saved in the same way as with the Quick STIPA module (by using the buttons at the bottom of the screen).

The "STI and spectrum" screen shows not only the current STI value and the A-weighted sound pressure level, but it also shows an octave band spectrum of the measured signal in the 7 octave bands from 125 Hz to 8 kHz. The STI analysis is carried out in these octave bands. The scale of the octave band spectrum plot can be modified by tapping on the triangualar arrows to the left of the plot.

The “measurement details” screen shows all the diagnostic details of an individual STI measurement:

- OCT: The octave center frequency (Hz)
- REL: The octave band levels relative to the STIPA signal spectrum (this is effectively the frequency transfer function of the tested channel in octaves).
- MTI: Modulation Transfer Index. This quantifies the contribution to the overall STI from each octave band.
- mr: the m-values (modulation transfer function in octave band OCT for modulation frequency mf). These m-values are uncorrected, not adjusted for masking effects and additive noise. Since the STIPA signal features two modulation frequencies per octave band, there are also two m-values per octave band. The modulation frequencies are also shown (mf)
- TI: the Transmission Index per octave band for each modulation frequency

These measurement details will enable more experienced operators to determine not only the speech intelligibility of the tested channel, but also the *causes* of intelligibility reduction induced by the channel.



Settings screen (left) and additive noise screen (right)

The settings screen gives the user three options:

- Choose whether or not to display STI qualification bands (A-U) as standardized in IEC-60268-16. These bands are used in certain applications.
- Choose to enable or disable the level dependent model features: level dependent masking and the speech reception threshold. *For standard measure ments, these features should be turned ON.* Only when all-electric transmission chains are tested (without any acoustics involved) should these features be turned off, since there is no acoustic level reference in those cases.
- Choose whether or not to (computationally) add noise to the measurement.

There are two ways to include the influence of background noise in your STI measurement:

- Simply do your measurement in the actual noise environment. The STI method is designed to incorporate the effects of any noise present during the measurement representatively in the measured STI. This approach works well if the noise field is stable and free from fluctuating and impulsive-components.
- If you have the option to physically “turn the noise off,” then it is often more accurate to add the noise computationally in a so-called post-hoc calculation The VOX-01 does this for you, if you enter the noise spectrum in the “additive noise” screen and change the setting to “Noise included in displayed STI

If you wish to add noise computationally, the screen “additive noise” should be used to enter the noise spectrum. Note that the noise spectrum that you enter is only used if you also select the corresponding option in the settings menu.

You can browse through all measurements saved earlier in the “browse measurements” screen.

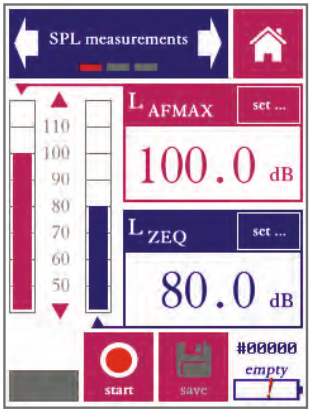
The following tips and pointers may be useful to remember when browsing STI measurements with Quick STIPA and STIPA Pro:

- Measurements saved in Quick STIPA can be browsed in STIPA pro, and vice versa. The measurement numbering range is shared between these modules. This means that you can use STIPA pro to investigate measurements done with Quick STIPA in more detail using the browsing screen in STIPA pro.
- The settings you choose in STIPA pro (additive noise, level dependent masking) affect the current measurement, but also affect which data is shown in the measurement browser. This means that you can always enter a noise spectrum and see how this affects measurements you did earlier on. Similarly, you can go back later on and see what affect level dependent masking has for a certain measurement.
- This implies that all data for each measurement is always saved - including any data not actually shown during the measurement itself.
- Measurements can also be retrieved over USB; please refer to the section “accessing saved measurements on a PC” for further instructions. For larger numbers of measurements, processing of these saved data files (e.g. through worksheet software) may be more efficient than inspection through the measurement browser.

SPL meter

The VOX-01 is also Sound Pressure Level meter (also known as SPL meter or SLM) that complies with IEC 61672 Class 2 and ANSI S1.4 Type 2. In fact, the VOX-01 electronics far exceed the requirements for a Class 2/Type 2 device.

The layout and buttons of the SPL meter app are similar to the STIPA module, featuring three screens: SPL measurements, settings and browse measurements.



SPL measurements screen

The following sound pressure level measurement settings are supported:

- Time weighting: Fast (F) and Slow (F)
- Frequency weighting: Z (linear, unweighted), A-weighted, C-weighted
- Max hold (holds and displays the maximum level during the measurement interval; used with either Fast or Slow time weighting)
- Equivalent continuous (EQ): computes the time-integrated level over the measurement interval; the level shown corresponds to the level of a contin -uous signal containing the same amount of energy as the measured signal.
- Peak values (PK): the highest instantaneous value within a measurement interval.

Once a measurement has started, each combination of the above settings is measured simultaneously. However, not all of these combinations are displayed: only two level measurements are displayed at the same time.

Each of these two levels is shown in its own bar graph and its own digit field. The red graph corresponds to the red field, the blue bar graph to the blue field. You are free to select which level to display in each of the two fields. Tap the “set” button in the level field to choose time weighting, frequency weighting, max hold and time integration settings for the corresponding field.

The settings screen in the SPL module allows you to set the measurement time. Once you press start, the measurement will run for as many seconds as you choose here. You may also choose to let measurements run continuously; you then determine the measurement time manually, by choosing the moment you press "stop."

The SPL meter module also features are measurement browser, that lets you review previously saved sound pressure level measurements.

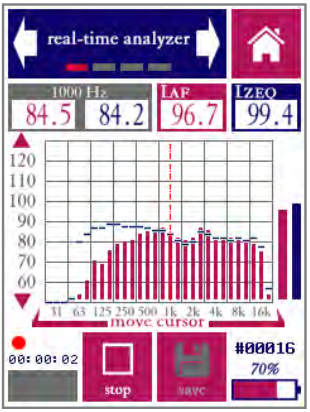
A few things to note about SPL measurements and the SPL meter module:

- By definition, "max hold", "EQ" and "PK" are mutually exclusive settings.
- The elapsed measurement time is shown above the progress bar. If the measurement interval is set to "continuous," the measurement will run until it is manually stopped. Note that, in practice, the maximum measuring time is limited by:
    - The battery. When measuring continuously, the battery is drained relatively quickly (within 3-4). For longer measurements, we recommend using the charger or an external power bank.
    - Internal data storage, especially if you are recording all measurement audio (per the option in the "Settings" module). When recording audio, the internal storage fills up in about 5 hours.
- When you press "save," data from the current measurement is stored. Results based on all time and frequency weightings are saved; not just the results that are currently displayed. However, as remarked above, since the instantaneous levels fluctuate throughout the measurement, these cannot be saved as a single number representing the entire measurement interval. So for each saved measurement, just the maximum level (max hold) and equivalent continuous level (EQ) and Peak level (PK) are saved.
- As a logical consequence, the measurement browser can only display Max Hold, EQ and PK results from earlier measurements. If you set a display field to show instantaneous values, the measurement browser will leave this display field blank.
- You can use the measurement browser to go back to earlier measurements, and see what the level is with different time- and frequency weightings applied.
- The measurement numbers form a separate consecutive series for each module. That means that the same measurement number might occur multiple times (once for each module; e.g. number #0002 might exist for SPL as well as RTA, STIPA, etc.)

Real-Time Analyzer (RTA)

The RTA module has two main modes of operation: as a 1/1 octave band analyzer (spanning the octave bands from 31 Hz to 16 kHz) and as a 1/3 octave band analyzer (25 Hz through 20 kHz).

The operation is generally similar to the SPL module, but instead of just the overall signal level, a frequency analysis (into 1/1 or 1/3 octave bands) is also shown.



RTA main measurement screen (1/3 octave band mode)

The RTA module has the ability to present two different spectral views at the same time, differing in frequency weighting (A, C or Z) and time averaging and integration (FAST, SLOW, MAX, or EQ). The main spectrum is presented in red bars, while a second (auxiliary) spectrum is shown in blue lines. The corresponding broadband levels are also shown, to the right of the spectrum.

While the spectrum graph already gives a first impression of the spectral content of the measured signal, you may wish to read the exact value in each band. This is done by placing the cursor (dashed line) over the band of interest. The cursor can be moved left and right by pressing on the left or right side of the frequency axis (or the area of the graph above the axis). The values for the selected band are shown in the grey field on the top left of the screen (main weighting shown in read, aux weighting in blue - same color as the spectrum bars).

The “measuring time” screen can be used to set the duration of a measurement to a fixed value. The measurement can also be set to run until stopped manually. The “settings” screen allows you to switch between 1/1 and 1/3 octave band resolution, and to change the weightings for the main and auxiliary spectrum views.

By pressing the “save” () button in the main measurement screen, you store the current measurement on the devices internal storage, using the measurement number indicated above the battery indicator.

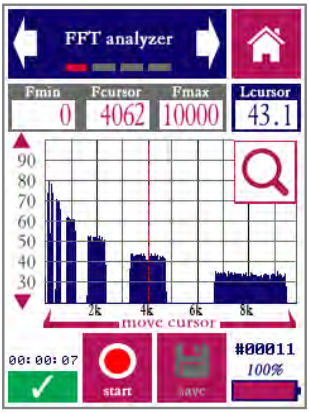
Some remarks about the RTA module:

- By definition, “max hold” and “EQ” are mutually exclusive settings.
- The elapsed measurement time is shown above the progress bar. If the measurement interval is set to “continuous,” the measurement will run until it is manually stopped. The progress bar itself is not used when measuring continuously.
- Measurements saved as 1/1 octave cannot be retrieved as 1/3 or vice versa. However, data recalled through the measurement browser are shown with the frequency weightings selected at the time the measurement is recalled - even if these are different from the settings that were in effect during the measurement. This allows you to inspect the effect of frequency weightings on all measurements saved previously
- Note that the spectrum and its corresponding broadband level are affected by the same time- and frequency weightings. In other words, if the main spectrum is A-weighted, then the level shown in the red field is also A-weighed (and vice versa). If you wish to display a Z-weighted spectrum and an A-weighted level at the same time, you need to display these in different channels (main and aux).
- The measurement numbers form a separate consecutive series for each module. That means that the same measurement number might occur multiple times (once for each module; e.g. number #0002 might exist for SPL as well as RTA, STIPA, etc.)

Fast Fourier Transform Analyzer

The FFT module allows you to perform spectral analyses with a much higher frequency resolution that the RTA module. This is very useful if you are looking to identify the exact frequency and level of certain signal components, or if you want to study the harmonic structure of sounds.

The maximum frequency resolution of the FFT analysis, with supported window sizes of up to 32768 samples, approaches 1 Hz. This means that the analysis contains more data and more detail than can be shown on the display at once. In order to deal with this, the FFT module features a zoom function to zoom in on part of the spectrum. Also, the full details of every measurement can be retrieved through USB by saving measurements.



FFT measurement screen

The general "look and feel" of the measurement screen is similar to the RTA module, but with a few differences. First of all, in line with the normal conventions, frequency weightings are not supported by the FFT module. Secondly, a button at the top right-hand side of the graph can be tapped to reveal a small keyboard with zooming options:

These controls are used to zoom in or zoom out along the frequency axis, and to center the display around the current cursor position. By pressing "hide" the zoom controls are collapsed again. The zoom controls are used together with the cursor to focus on any region of interest in the spectrum.. The cursor, shown as a vertical red line, can be moved by tapping the arrows below the frequency axis or by tapping directly on the graph.

The minimum and maximum frequency that can currently be displayed are indicated at the top of the screen, as well as the exact frequency at the cursor position and the level at the cursor position.

The second screen of the FFT module allows you to set an integration time for the FFT analysis. If the integration time is set to “infinite,” then the instantaneous spectrum is shown. The graph on the display will show rapid fluctuations. In general, the longer the integration time that is chosen, the more accurate the spectrum.

The third screen of the FFT module (“settings”) is where the parameters of the FFT algorithm are controlled.

The window size determines the frequency resolution of the FFT analysis. The number of spectral lines is exactly half the window size. At the maximum window size (32768), the audible frequency range is analyzed in16384 spectral lines. Shorter windows offer less detail, but the analysis runs quicker allowing for shorter integration times to arrive at the same accuracy.

The type of window to be applied can also be set in the graphics screen. Each type of window (blackman, hamming, rectangular, etc) is associated with a specific set of advantages and disadvantages relating to the FFT analysis. We recommend studying the literature on spectral analysis, or one of the many available online resources, to choose the window that best suits your application.

For most non-critical applications, the settings selected by default (hamming window with a window size of 8192 samples) are a suitable choice.

Some remarks about the FFT module:

- The elapsed measurement time is shown above the progress bar. If the integration time is set to “continuous,” the instantaneous spectrum will be shown.
- The FFT module is recommended whenever a high frequency resolution is needed. To obtain standardized spectral measurements, where the exact levels at standardized frequencies are of prime interest, 1/3 or 1/1 octave band measurements through the RTA module are the best choice.
- Saved data can be retrieved over USB and imported in MS Excel or any other program capable of dealing with .csv formatted data. This is the same as all other modules. However, the FFT module is capable of producing much more data (up to 32768 data points and frequencies for a single measurement). Not all spreadsheet programs may be able to import that many columns, which is why the data is organized in rows rather than columns.

Reverberation Time Meter (RT60) RT60

The reverberation time (or RT60) is among the most commonly specified acoustic measures. Unfortunately, reverberation time measurements are also among the most complex to carry out accurately. RT60 measurements are prone to errors, which cannot always be detected by the measuring device.

If you are new to measuring reverberation times, we recommend that you read this section of the manual carefully, and preferably also consult external literature and training materials on reverberation time measurements.

Standardized procedures for measuring the reverberation time of a room are specified in ISO-3382-2. Generally speaking, there are two different ways to measure RT60: the impulse response method and the interrupted noise method. Both methods are standardized through ISO-3382-2.

The impulse response method uses a carefully controlled, known test stimulus of short duration (sweeps, chirps, pseudo-noise sequences or gunshot-like impulsive sounds). By normalizing the recorded sound in a room relative to the source signal, the impulse response of the room is obtained. From this impulse response, the RT60 is calculated. The impulse response method is currently not supported by the VOX-01. Of the two available methods, it is more likely to produce invalid results for the following reasons:

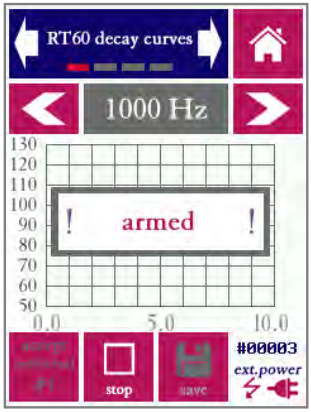
- The impulse response method requires that very specific, known test signals are used. Any difference between the test signal that was really used on the one hand, and that test signal that the measuring instrument expects on the other hand, may produce greatly distorted results.
- Depending on the type of test signal, even the slightest movement of the microphone during the test may render the measurement inaccurate. The use of a tripod is absolutely necessary.

The interrupted noise method, as supported by the VOX-01, measures the decay of the sound field if a sound source is suddenly switched off. This method is more robust against slight inaccuracies or inconsistencies in the placement of sound source and microphone. In small rooms, no other tools than the VOXBOX talkbox and the VOX-01 may be needed. In larger rooms, a larger (spherical) loudspeaker and amplifier will be needed. Either way, the procedure requires the following steps to be taken in preparation:

- Place a source of continuous sound (preferably pink noise) in the room for which the RT60 needs to be measured.
- Place the VOX-01 at some distance from the source (stay clear from walls and other flat surfaces)

- Start the RT60 module and press “arm”
- To trigger the measurement, shut off the noise source.

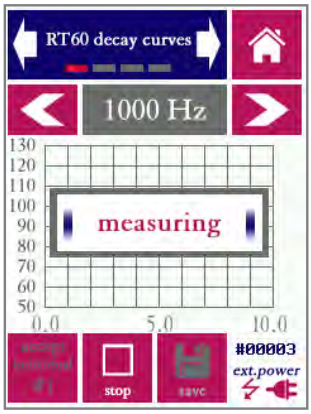
Once the device has been armed, it will start measuring the ambient noise field. At this stage the device is continuously sampling the audio, but the RT60 measurement itself has not yet been started. The device is merely detecting the moment the noise source has been shut off - which is the beginning of the energy decay curve.



RT60 measurement screen, armed for measurement, but before a measurement has started

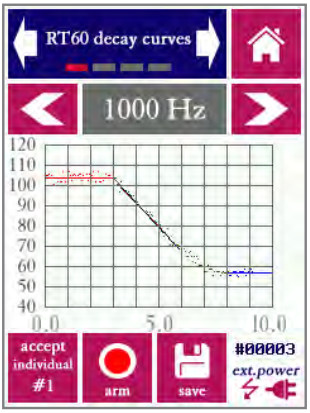
Make sure that the external sound source is always switched on BEFORE you arm the VOX-01 for a measurement by pressing “arm”

Once the beginning of the energy decay curve has been detected, the device starts measuring. By definition, no RT60 results can be calculated until the measurement and analysis are completely finished. While the device is acquiring measuring data, the following screen is displayed:



RT60 measurement screen, while the measurement is running and data is being acquired

Once the measurement is completed, the energy decay curves are plotted. Use the arrows to cycle through the frequency bands (note that you can choose whether to measure in 1/1 or 1/3 octave bands through the “settings” screen).



RT60 decay curves plotted once the measurement is completed

Inspect the decay curves to visually verify that the measurement is correct. An incorrect measurement (which should be rejected) may become apparent in any of the following ways:

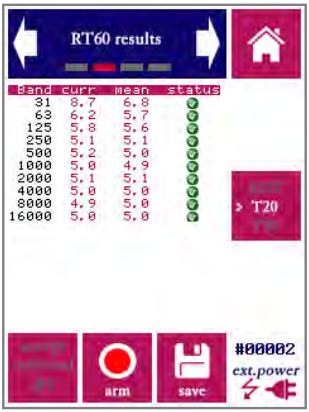
- The plotted data points do not reflect the expected linear decay of energy: the level does not decrease linearly over time. If this happens, the triggering process may have been disrupted.
- The linear decay curve that is fitted (drawn line) does not match the displayed data points. E.g., the starting point of the decay curve may be off.
- The signal-to-noise ratio (difference between the steady-state noise signal and the system noise floor) is insufficient.

From the decay curves, three different reverberation time metrics are calculated:

- The EDT (Early Decay Time), based on the first 10 dB of decay
- The T20, based on the section of the decay curve between -5 dB and -25 dB
- The T30, based on the section of the decay curve between -5 dB and -35 dB

Each of these three metrics has its own linear decay curve fit through the data points. The values of the EDT, T20 and T30 can be seen on the second screen of the RT60 module. Note that the reverberation time usually differs significantly between different frequency bands. Also note that (although respectively measured over 10, 20 and 30 dB of decay) the values of EDT, T20 and T30 are always extrapolated to 60 dB of decay; hence the name T60: the time it takes for the energy to decay to a level 60 dB below the starting level.

Cycle through EDT, T20 and T30 using the button on the right. Note that each of these three metrics is always calculated and saved for each measurement, even if only one metric at a time is displayed on the screen at a time.



RT60 measurement results.

Quite often, a single RT60 measurement is insufficient to obtain a stable result. Many application standards require that data from multiple measurements are averaged. Sometimes the position of the noise source and/or measurement microphone must be changed in between measurements.

The averaging of multiple measurements is supported in the following way:

- On the bottom left of the screen you will find an “accept individual” button, which is not usually present in other measurement modules. Use this to commit a measurement to memory, if you are satisfied (upon inspection of the decay curves) that the measurement is valid.
- Once your first (valid) measurement is finished, press “accept individual”
- The letters and the numeral “#1” are now greyed out on the accept button.
- Now repeat the test procedure as many times as required, pressing “accept” after each measurement. The serial number is incremented after each individual measurement.
- Data from up to 20 individual measurements can be kept in the device memory at the same time.
- In the “RT60 measurement details” screen, you can inspect the latest individual measurement as well as the mean across all measurements.
- Once you are satisfied with the overall (mean) results, press the “Save” button (to the right of the “arm” button). Mean data from all measurements are now permanently saved and the temporary memory is reset.
- When browsing through save measurements (in the “browse measurements” screen), you will see the mean data from each measurement series.

The capability of averaging measurement data adds complexity to the user interface, but averaging is sometimes essential to arrive at valid end results. Note that averaging takes place on the level of the individualy measured data points along the decay curve (so not just across individually measured reverberation times).

In the table on the measurement details screen, a column is shown that indicates the status (reliability) of the current average measurement for the corresponding frequency:

- A green checkmark indicates a healthy, reliable measurement. The RT60 measurement data may be presumed accurate with a margin of error of at most 0.1 seconds.
- A yellow exclamation point indicates that the measurement accuracy cannot be guaranteed. This may have various causes. For example, the signal-to-noise ratio may be insufficient (not enough dynamic range between the steady-state noise signal and the noise floor with the noise source switched off). This may also happen if the signal fluctuates more than expected for a given frequency band and the resulting linear decay fit is poor.
- A red cross indicates that the result is statistically deemed unreliable. In order to obtain a reliable result in the corresponding frequency band, averaging across more individual measurements (adding to the overall measurement time) is needed. If the red cross persists upon averaging across multiple measurements, disregard the corresponding frequency band or repeat the entire measurement series.

It is good practice (and a formal requirement for many applications) to average across as many measurements as needed to obtain a green cross next to all relevant frequency bands.

Never rely on results from RT60 measurements until you have checked the reported status per individual frequency band. Note that in some rooms it may be difficult, if not impossible, to obtain reliable results for the lowest frequency bands.

Please take note of the following practical tips and pointers for RT60 measurements:

- Do not place the measurement microphone and noise source too close to each other; if possible, estimate the reverberation radius in the room, and make sure that the microphone is as far outside the speaker's reverberation radius as possible.
- Make sure that your noise source is capable of producing levels far above the ambient noise floor in the room, and above the electronic noise floor of the device. Ambient levels of 90 dB(A) and higher are often needed. The SNR must be at least 50 dB in all relevant frequency bands.

- A spherical loudspeaker configuration playing pink or white noise is the preferred source of measurement noise.
- If you are using a single, non-spherical loudspeaker, avoid placement of the microphone on the loudspeaker axis. Even though the microphone is omnidirectional, avoid pointing the microphone straight at the loudspeaker.
- Eliminate sources of background noise.
- The state of all doors, windows and other separations should be fixed (open or closed) throughout the measurements. The opening of doors and windows changes the reverberation time.
- Do not walk around when the measurement is running, especially not in the immediate surroundings of the noise source.
- The signal-to-noise ratio requirements for RT60 measurements are sometimes difficult to meet. Especially for T30 measurements, it may be necessary to play back the test stimulus (interrupted noise) at high sound pressure levels.
- If your signal-to-noise ratio is insufficient for reliably measuring the higher frequency bands, consider switching over to white noise (instead of the commonly used pink noise) as a source stimulus.

If you are having trouble getting acceptable measurement data (green balls with check marks next to your measurement data), it may help to study the exact reasons why your measurement data is marked for rejection.

Along with each measurement value, the reliabily status is display (acceptable, warning, error). The stored data for each measurement (downloadable via USB) contains more details on the exact motivation for the indicated reliability status. This is indicated with the following letter codes:

- d: no data was present (error)
- r: not enough range (warning)
- b: bandwidth-time product too low (error)
- n: snr too low (warning)
- s: start time before knee point of the decay curve (warning)
- c: correlation of the decay curve fit is low (warning or acceptable, depending on value)

Multiple letter codes may be stored with a single measurement value.

LAEQ Logging

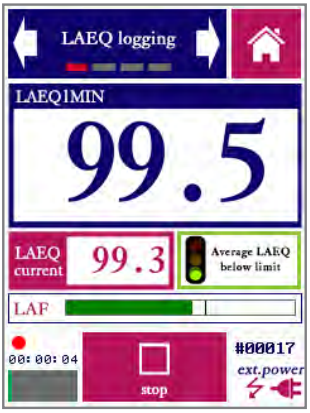
The LAEQ logging module is intended for long-term monitoring and logging applications. When running this module, the VOX-01 keeps track of how the equivalent-continuous A-weighted sound pressure level (LAEQ) develops over time. This is displayed on the device and also logged, for download to a PC later on. This module can be used for several purposes:

- monitoring of environmental noise sources
- monitoring and logging of sound levels at music venues
- measuring sound levels of multiple events across a large time span (e.g. measuring of multiple train passages)

Instantaneous and time-averaged data are shown on the display. If you enter a level limit, a warning ("traffic light") will be displayed to indicate whether the limit is currently being exceeded. The log file is automatically saved, and can be used to demonstrate that (legal) limits were not exceeded.

The LAEQ logging app measures three different metrics:

- The LAEQ during a short time period between 1 and 60s. This is level ("LAEQ current") can be thought of as the current contribution to the overall sound exposure.
- The LAEQ across a longer time span (1-60 minutes), calculated as a movering average of a series over shorter time periods (i.e. a moving average of the series of "LAEQ current" measurements). For example: the average LAEQ across a time span of 15 minutes is indicated as LAEQ15MIN.
- The current instantaneous level with FAST time weighting (LAF). This measure is not logged; it is only displayed as in the form of a bar plot, to obtain a quick impression of how the instantaneous level at any moment is affecting the LAEQ.



The LAEQ module showing the moving average LAEQ across 15 minutes.

The LAEQ logging module has a start/stop button similar to all other modules, but unlike other modules, it has no "save" button. Since this module is specifically intended for logging purposes, all data is always saved to a text file. Whenever a new measurement is started, the measurement number is automatically incremented and a new file is opened. This means that data is never inadvertently discarded (e.g. by forgetting to press save after a lengthy session).

LAEQ logging sessions can run for a long time, up to many hours or even days (when operating on external power. Before starting a long session, always check if there is enough free storage on the device. When recording audio (which is an option available through the settings module), the memory fills up in 3-4 hours. We recommend disabling audio recording on long sessions.

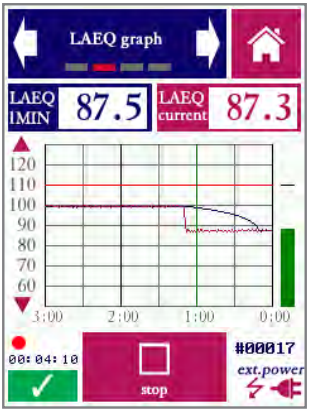
As an example (for the purposes of this manual), we will assume that time averaging takes place over a window of 15 minutes, resulting in LAEQ15MIN (which is a commonly used setting for sound exposure monitoring at music venues). However, note that the averaging time can be adjusted to any period between 1 and 60 minutes.

The LAEQ15MIN as displayed on the screen is the moving average of a series of "LAEQ current" measurements. The shorter the time period used for LAEQ current, the more values are used to compute LAEQ15MIN (and the longer your log file will become, since a line is written for every LAEQ current period). If you choose a short period for LAEQ current then you will be able to determine fluctuations in the measured level more accurately, but you may end up with a lot of data to sort through. There is a trade-off; the optimal choice depends on the application.

"Traffic light" indicating whether the limit is being exceeded.

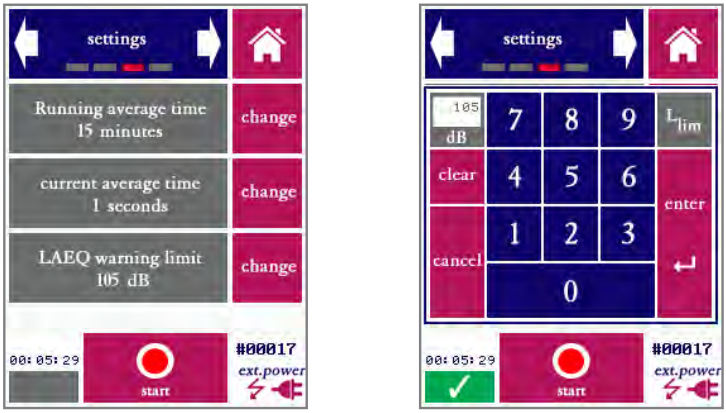
If the LAEQ15MIN exceeds the preset level limit, the traffic light indicator will turn red. If the LAEQ15MIN is still below the limit, but LAEQ current exceeds the limit, this implies that the LAEQ15MIN will eventually reach the limit if the current levels do not go down. In that case, the traffic light will be yellow/orange. If the LAEQ15MIN as well as the current value are below the limit, then the traffic light shows green.

The first screen of the LAEQ monitoring module (see previous page) gives the levels in large digits, and creates a quick overview. The second screen (see next page) shows a graph of the running series of "LAEQ current" measurements, which gives a good feel of how the overall level is developing.



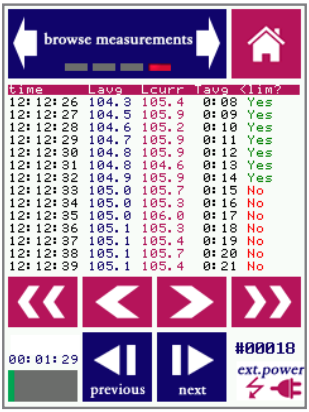
Screen 2 of the LAEQ module, showing a graph of how the average LAEQ is developing.

In cases where the operator has control over the measured sound level (i.e. through control of a PA installation), and is using the VOX-01 to make sure that the level is kept below the limit, the graph gives a useful insight into how much "room" there is below the limit. In cases where noise events (such as train passage) are monitored, the graph shows a recent history of events.



Settings screen; the right picture shows the keyboad that appears when the "change" button is pressed to adjust the warning limit

As with all modules, the LAEQ logging module has a screen which can be used to set all parameters (in this case: LAEQ averaging time (1-60 minutes), current intervals (1-60 seconds) and the level limit. Values are entered through a keyboard that appears upon pressing "Change."



Browsing through measurement data

Browsing through measurement data works a little differently than in other modules, since the amount of data associated with a measurement file can be very large. In many cases, it will not be practical to inspect the data from the device itself, and data will be downloaded to a PC first.

The blue buttons are used to browse through all earlier log files stored on the device. Note that each file may span anywhere between a few seconds and many hours, depending on how much time elapsed until the "stop" button was pressed. Within each file, you can scroll through the data with the red arrow buttons (single arrow to scroll line-by-line, double arrow to quickly scroll page-by-page). Each line shows the time, the current level for the corresponding measurement interval, the average LAEQ and an indication whether or not the limit was exceeded.

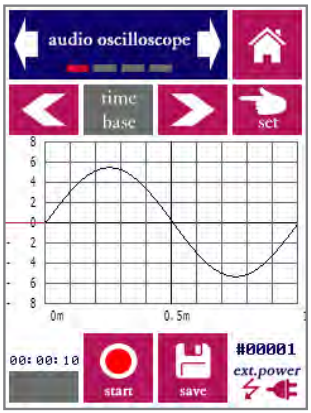
Long sessions may be broken into multiple files by pressing stop and (immediately) again start. If the device crashes unexpectedly (e.g. in case of power failure), there is a chance that (part) of the log file may be lost. By breaking the session up in multiple files, the risk of losing data is reduced.

For long sessions (>3 hours), you will need to power the device from an external power source (such as a PC, power bank or the USB charger).

Note that the log file contains more information than shown on the device. In particular, not just the time but also the date is stored. Make sure that the date and time are set correctly (though the settings module).

Oscilloscope

The oscilloscope module is intended to quickly inspect acoustic signals, in particular periodic signals, in the time domain.



Sine wave with a frequency of 1000Hz as seen through the oscilloscope module

Directly from the first screen of the module (see above), you can control the horizontal scale (time base) and vertical scale of the graph, as well as the trigger mode. Select which setting you want to adjust, and press "set." Then choose the intended setting; by pressing "back" you can go back to reach the other settings again. Under trigger mode, you can set the level and slope (rising/falling). Red lines by the vertical axis indicate the trigger level.

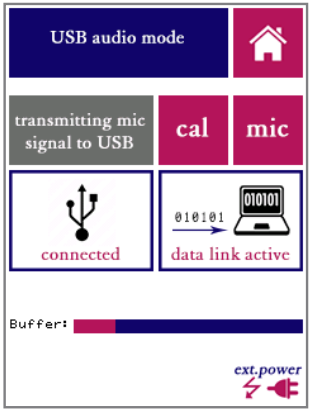
Additional settings can be accessed through separate screens of the oscilloscope module. These include the measuring time, the choice whether or not to apply linear interpolation on the data, enabling or disabling frame averaging, and a choice between acoustic and electric measurements. If you are measuring sounds (with the microphone mounted), choose "acoustic." The amplitude scale will be expressed in the unit Pascal (Pa). If you are measuring without microphone, but directly into the XLR input, select "electric." The vertical scale will be expressed in Volts (V). Similar to any other oscilloscope, the settings for the time based and sensivity are expressed relative to the division lines on the screen (s/div, V/div, Pa/div).

Remember to turn of the 48V phantom power through the settings menu if you intend to do electric measurements. Note that the input impedance of the XLR input is (nominally) 2 kOhms.

The basic operation of the oscilloscope module is similar to the common (hardware) oscilloscopes that many engineers are familiar with. Note that the frequency response of the system is limited to audio frequencies (up to 20 kHz).

USB audio device mode

When starting this module, a special mode of the device is activated, in which it performs no other tasks than simply streaming audio to a PC, applying the VOX-01 level calibration. This is done in the form of a single-channel stream, at a fixed bandwidth of 48 kHz and a bit depth of 32 bits. All current versions of MS Windows should recognize the VOX-01 while operating in this mode as a "USB audio device" and may also indicate that it is an "omnidirectional microphone." Once the device is detected by Windows, make sure that the software that you intend to use is also configured for the device. A small Windows test application is included on the USB flash drive that came bundled with your VOX-01



The VOX-01 display while in USB audio mode

Once the device is connected via USB (and the PC has recognized it as an audio device), an indication showing "USB connected" will appear. Once data starts streaming, an animated picture and the message "data link active" will indicate that data is being transferred. This will happen once an application initiates streaming audio from the VOX-01.

The audio signal is scaled so that full scale corresponds to 150 dB (e.g, a signal with a level of 94 dB will correspond to a level of -56dB relative to full scale). Windows drivers and applications may digitally adjust the level, by applying software-based volume settings. If left unadjusted, the volume of the signal when directly played back on the PC may be quite low. This is done on purpose, so that high levels of up to 150 dB can be accommodated. Given the fact that 32-bit audio has a dynamic range of 192 dB, this does not affect the integrity of even the lowest-level signals. The entire dynamic range of the VOX-01 is available digitally. If the audio is too soft, simply adjust the volume control on the PC.

If you want to explicitly calibrate your windows software to work with the VOX-01, press the "cal" button to generate a synthetic 1000Hz sine at 94.0 dB. If you calibrate your software to this level, then all audio measured by the VOX-01 will be registered at the correct levels in your software as well. Press "mic" to return to normal operation.

Settings

The settings module will allow you to configure the generic settings of the device, in addition to the module-specific settings found in each module. The following attributes can be set:

- Time and date
- Time interval before the backlight automatically switches off to save power
- Phantom power to the microphone
- Microphone pre-amplifier gain
- Calibration of the touch screen digitizer

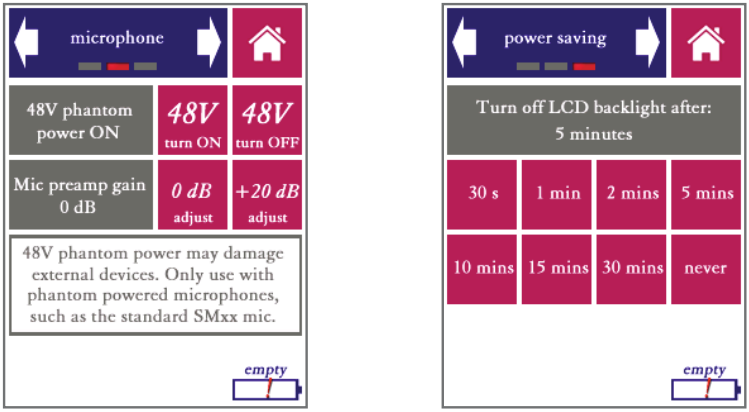
The system date and time are changed by means of the arrows (up/down). Remember that you changes are not applied until you press “set clock.”

Date and time in the settings module

The VOX-01 has an internal real-time clock that keeps running even when the device is powered off. The clock needs to be adjusted if the battery has been depleted completely, for instance when the device has not been used for a very long time. The system date and time are used for time-stamping the saved data. If you download measurement data over USB, the file creation date/time are only accurate if the internal real-time clock of the VOX-01 was updated to the right date and time.

Press the "calibrate touch" button if the response of the touch screen appears to be inaccurate. Calibration takes place by pressing exactly on the indicated marks near the corners of the screen.

We strongly recommend that you use a stylus for calibration, to obtain calibration settings that are as accurate as possible. Not that false responses during the calsibration procedure (tapping completely in the wrong place) may render the touch screen unusable.



Microphone pre-amp settings (left) and power saving settings (right)

The internal microphone amplifier of the VOX-01 features an adjustable gain setting. Adjust Adjustment of the pre-amp gain is hardly ever necessary, since the system has a very wide (linear) dynamic range of 130 dB. However, if you wish to connect an external signal source which operates at lower signal levels than the VOX-01 microphone, you can choose adjust the pre-amp gain by (approximately) +20 dB. Note that this value of +20 dB is not exact; recalibration will be needed. With the standard microphone, this setting should be 0 dB.

You can also set the backlight to automatically switch off if the touch screen has not been touched for a while. This time-out can be set between 30 seconds and 30 minutes, or the backlight can be set to never turn off at all.

The backlight time-out option saves a considerable amount of battery power. But keep in mind that it will cause the screen to black out *without turning the device off*. Don't forget to turn the device off when you finish working with the device; the fact that the screen is dark does not necessarily mean that the device is turned off. If the LED next to the USB port burns, then the device is still turned on. To turn the backlight back on again if a backlight time-out has occurred, press the power button. The touch screen will not respond to presses while the backlight is turned off, but measurements will continue to run whether the backlight is on or off.

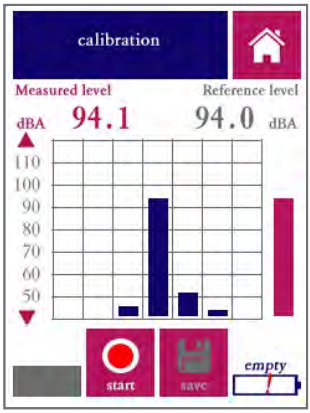
Calibration

The VOX-01, the instrument itself as well as the microphone, is calibrated before leaving the factory. A calibration certificate is included with the device. However, it is recommended that you carry out your own “user calibrations” from time to time, especially under the following conditions:

- You are using the device in temperatures considerably above or below room temperature
- You are planning to use the device again after a prolonged period of storage
- You are planning to do measurements for which a high degree of accuracy is required, e.g. certification measurements

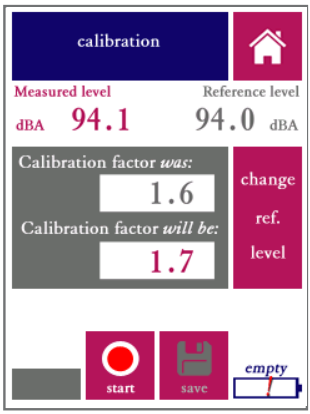
Compact calibrators (with Class 2 / Type 2 compliance) are available from a number of vendors. These calibrators generate a test tone which is adaptively adjusted to a fixed, accurately know signal level (usually 94.0 dB). This makes calibration relatively easy: insert the microphone tip into the port of the calibrator, using an adapter with suitable dimensions for the microphone tip (1/4” / 7mm). The device should now measure the nominal signal level produced by the calibrator.

The VOX-01 is easily calibrated with any stable sound source of a known reference level. This can be a calibrator, but a steady sound field (the level of which is measured by another, calibrated, SPL meter) will also work.



Calibration module while measuring a 1 kHz calibration tone.

To start calibrating, apply the calibrator to the microphone, or place the microphone in a known sound field. Then press “start.” Do not worry if the reference level shown is incorrect; you can change this after the measurement. An octave band spectrum will be shown while the equivalent-continuous A-weighted sound level is measured. Once this measurement is finished, the VOX-01 will show the results.



Calibration module showing calibration results.

The new calibration factor (sensitivity adjust) of the device is shown, as well as the original calibration factor as currently used in the device. The differences between the old and new value are typically small (less than one dB), unless you have connected a different signal source or microphone than the device is currently calibrated for.

The calibration factor is derived from the measured LAeq, as well as the reference level of your calibration signal source. You can now change the reference signal level; press the corresponding button on the right of the screen, and enter the correct value. The calibration factor will be re-calculated.

If you are satisfied that the new calibration factor is correct, press save. Note that the new calibration settings only take effect once you press save.

We recommend that you verify your new calibration in the SPL meter app. Re-apply your calibration signal source, and check that the correct reference level is measured.

Once you press “save”, the measured calibration factor is committed permanently to the device’s non-volatile memory. This overrides earlier calibrations.

Status

System status information can be read using the status module If you contact SDi for technical support, you may be asked to provide some of the information displayed here (such as the firmware version and hardware revision). The status app is not used to make changes to the system.

Accessing saved measurements from a PC

When you connect the VOX-01 to the USB port of a PC or Mac, a dialog window will appear on the VOX-01 asking if you wish to start data transfer. If the VOX-01 is powered off when you connect it through USB, it will power on automatically.

The VOX-01 will present itself to the USB host as a mass storage device. This allows you to access the internal file system of the VOX-01. You will see these directories/folders:

- Battery: battery status information
- Calibr: Calibration data
- SPL: SPL measurement results
- STIPA: STIPA measurement results
- System: system files
- Update: place update packages here to update the firmware upon reboot

IMPORTANT: you can access the VOX-01 system files so that you can easily backup and restore the device. However, keep in mind that some of the internal software of the VOX-01 is run directly from the files displayed here. If you remove or change any of these files, your VOX-01 will not work properly anymore.

Instructions on how to perform firmware updates is given in the section 8 of this manual.

In order to process and analyze the results further, copy all results files from the VOX-01 to a local folder on your PC. If you leave the measurements on the VOX-01, then the VOX-01 will simply continue its measurement numbering series where it left off. If you remove the measurements, the VOX-01 will start over with measurement #1.

The measurement files are saved in .csv format. These files can be imported in almost all worksheet application, such as Microsoft Excel. This will allow you to analyse the data further, and pre-process the data for the purpose of reporting.

Remote control from a PC

In certain situations you may wish to control your VOX-01 remotely from a PC. To achieve this, keep the VOX-01 connected via USB, and run the "Remote Display" application under Windows. This application works on any 64-bit version of Windows. A self-extracting installer of the application is included on the flashdrive bundled with your device, and can also be downloaded from our website.

The remote display application does exactly what the name says: you will get the exact same controls that you have on the VOX-01 device itself, but the entire display is simply moved to a window on your PC.

The Remote Display application needs to have the exact same firmware version that your VOX-01 is running on. Make sure that you use the correct installer package for your model, and follow instructions in the installation process.

When you first run the application, you will have to choose the correct COM port (as assigned by Windows to the VOX-01). If you select the wrong port, or if you want to change the COM port setting later on, press TAB from within the Remote Display application. You can now select any of the available COM ports on your PC.

The resolution of the display is 240x320 pixels. You can stretch the window of the Remote Display application to enlarge it. It may be convenient to use an enlarged version of the display (e.g. in classroom settings), but while increasing the size, the resolution remains 240x320. It is therefore normal for the enlarged display to look somewhat blurry.

All functions on touch screen on the VOX-01 are temporarily disabled as soon as a connection to the Remote Display application is made. Touch the display to return control to the VOX-01

Always make sure that you are using high-quality USB cables, especially when operating with a long cable between the VOX-01 and your PC. Most USB connection issues are traced back to poor quality cables.

5. Power and charging

Charging instructions

We recommend that you charge your VOX-01 only with the USB charger supplied with the instrument. Alternatively, you can charge the device through any external USB wall charger ("wall wart") with a charge current of 1500 mA or higher. Some PCs allow increased charge currents to be drawn from their USB ports (sometimes through special ports marked "Boost" or "Charge"). These can then also be used to charge the instrument.

Note: the instrument will NOT charge from a standard USB port on a PC or Mac. The current supplied through a computer USB port is normally insufficient to charge the device. The fact that the device may be powered from such a USB port does not necessarily imply that there is sufficient current left to also charge the battery.

The VOX-01 has internal charge circuitry that optimizes your charge time while safeguarding the life span of your battery pack. If you are not using the VOX-01 for a prolonged period, you can safely keep the VOX-01 connected to a charger. A small "trickle charge" will be drawn, making sure that your VOX-01 stays at full charge.

A few charging tips:

- When connected to the supplied charger, the battery is usually at 90% charge within 2.5 hours. The last 10% is topped off at a much lower current. When in a hurry, you may choose not to wait for this much slower "top off phase."
- A LED next to the USB shows the charge status. While blinking (alternating between green and orange), the battery is still charging. The LED burns constant green as soon as the battery is full.
- If you find, over time, that the battery capacity is reduced significantly compared to its original capacity, we recommend that you fully discharge the batteries, and then fully recharge them. If necessary, this procedure may be repeated a few times.
- If the battery charge indicator appears to become inaccurate (e.g., the battery is drained quickly from the point that the indicator still shows 50% charge), it also helps to completely discharge and recharge the battery.
- If you start using the VOX-01 after a long period of storage, we recommend that you first top off the charge before using the instrument. You may also want to check if the date and time settings were preserved.

- It is normal for the total battery capacity to slowly decrease over time. After 500 charge/recharge cycles, the battery capacity is normally at 80% to 90% of its original capacity, depending on the way the device is used and recharged.

- We recommend that you do not charge while measuring. The instruments' measuring electronics are highly sensitive; the digital charging circuitry may have an impact on the noise floor of the pre-amplifier and microphone, while noise and hum from the AC charger may also be inserted. Although the electronics have been protected against such sources of interference, we still recommend against recharging while doing actual measurements.

Power saving recommendations

How long the device can be used on a single charge depends on the mode and intensity of use. Power conservation settings can be controlled from the device's "hardware settings" menu. With its default settings, approximately 350 STIPA measurements can be carried out over the course of an 8 hour day without recharging.

Some ways to extend the battery life:

- Switch off the device when you do not plan to use it for a while.
- Choose conservative power settings in the hardware menu. The LCD backlight is a considerable factor in the overall drain on the battery.
- Disable "pre-amp phantom power" if you use a microphone that does not need it.

Use of power banks and external battery packs

For very long measurement sessions, the battery capacity of the internal battery may be insufficient. If you cannot spare a few hours of recharge time in the middle of your session, we recommend that you use an external USB battery pack (aka power bank). You can also power the VOX-01 from an AC power source through its own charger (or any USB power source), but it is not recommended to power the device this way while measuring. The device will be more susceptible to electronic noise and ground loop effects. Even though the device has been certified to comply with the applicable EMC standards, also when connected to an AC source, the signal quality is always slightly better when powered from batteries.

When you connect the VOX-01 to an external battery pack, a dialog will appear asking you whether you want to charge the device. We recommend that you do not recharge the internal battery from the power bank, so choose "no." This way, all power will be supplied by the external power bank. The internal battery will not be charged, nor discharged, while measuring. Note that the battery pack should have an output current rating of at least 1500 mA.

6. Cleaning, maintenance and calibration

With normal use, no further maintenance is needed beyond normal cleaning periodic re-calibration of the device. We recommend that you have the device checked and calibrated at our factory or at an external calibration specialist at least once every 2 years.

We recommend having the battery pack replaced after approx. 500 charge/recharge cycles.

We recommend that you clean the instrument with a soft cloth. LCD display cleaner can be used to clean the touch screen, provided that the following precautions are taken:

- Do not spray cleaner directly onto the display
- Only use cleaning liquids specifically intended for LCD screens

Battery disposal

The device contains an 4.8v rechargeable NiMH battery pack. At the end of the life cycle of this product, care should be taken to dispose of this battery pack responsibly, in compliance with rules and regulations for recycling of batteries that apply in your region. MAKE SURE THAT THIS BATTERY PACK IS REMOVED BEFORE DISPOSING OF THE DEVICE. If you are unable to remove the battery pack youself (by unscrewing the back lid of the device), make sure that you mention the presence of an NiMH battery pack when hand in the entire device for recycling.

7. Product warranty

The device is covered by a full-service, worldwide pick-up & return warranty until 24 months after the date of purchase. Please direct all warranty claims to:

SDi,
1345 Campus Parkway, Suite A18
Wall Township,
NJ 08736
Tel: 732-751-9266
Fax: 732-751-9241
Email: sales@sdifire.com
Web: www.sdifire.com

Please email us and wait for our response (typically within a business day) before shipping your hardware back. We may ask you to fill out an RMA form, and we will supply you with a reference number for your warranty claim. If you can provide a complete statement of the problems you are experiencing, this will help us solve your hardware issues as soon as possible. Always provide the ID number of your device (found on the bar code label on the back of the device), your name and address, and your date of purchase. If you did not purchase directly from SDi, also include dated proof of your purchase.

In general, our warranty programme covers all defects except for those resulting from accidents, misuse (including improper electrical connections) and improper maintenance. The following is explicitly excluded from product warranty:

- Any damage resulting from dropping, falling or excess vibration
- Any damage done by liquids, including damage resulting from excessive use of screen cleaning liquids
- Any damage resulting from incorrect electric connections to the device through the USB and/or audio connectors
- Any damage done by power surges or overvoltage on the USB power supply and/or audio connector
- Any mechanical damages to the display caused by mechanical forces applied to the screen surface, such as scratches.
- Normal wear and tear

The following voids warranty:

- Repair attempts by an unauthorized party
- Replacement of battery packs by an unauthorized party
- Removal of product stickers, tamper proof seals, bar codes or serial numbers

Malfunctions that are found to result from any of the above conditions are not covered by warranty. Repairs will take place only at the expense of the owner. If claimed under warranty, an examination fee may be charged and transportation costs will be charged to the owner.

Please do not attempt to open your VOX-01 yourself, as there are no user-serviceable parts inside. If you do see a legitimate need to open the device yourself, please contact SDi first, so we can discuss preserving your warranty rights. Please be aware that the product is protected by tamper-proof seals.

A worldwide pick-up and return service is included in the warranty. This means that we will have the defective unit picked up at your location at no charge, provided that it is presented in its original equipment case, packed in a cardboard box with suitable cushioning material.

Service/maintenance contracts are available from SDi. For further information, please contact SDi at: service@sdifire.com.

8. Firmware updates

Firmware updates are released through the website www.sdifire.com. Before updating your firmware, always check: www.sdifire.com/support/#productsoftwareupdates

- If the update you downloaded is intended for your device type (the VOX-01)
- If you have sufficient battery charge to complete the update cycle without interruption

Interrupting the power supply during the update process may render your device unusable. If this happens, try to repeat the update procedure. If this does not work, please contact support@sdifire.com.

Executing a firmware update is easy:

- Choose and download the correct firmware update package from www.sdifire.com
- Connect the VOX-01 to any PC or Mac through USB
- When prompted on the LCD screen, choose “connect through USB”
- The VOX-01’s internal file system can now be accessed from your computer in the same way as any mass storage device
- Copy the firmware updated package to the folder named “updates”
- Now restart the VOX-01 using its power button

The firmware update procedure will automatically start. You will be able to see the progress of the update procedure (which may take between 3 and 30 minutes, depending on the size of the update package) on the LCD display.

Never interrupt the firmwate update procedure. Make sure that the VOX-01 is fully charged or connected to a stable power source before starting the update procedure.

Please be aware that the update procedure may take a significant amount of time, depending on the update package that you are installing.

9. Technical specifications

Functionality	Speech Transmission Index (STIPA) Octave band Real-Time Analyzer (in STIPA pro mode) Sound Pressure Level meter (A, C, Z, slow, fast, Leq) *Anounced for 2014 firmware updates*: 1/3 and 1/1 RTA, FFT analyzer
Standards compliance	IEC 60268-16 rev. 4, IEC 61672 (class 2), ANSI S1.4 (type 2)
Acoustic	Effective noise floor: < 26 dB(A) Linear range: 30 -124 dB (with supplied microphone) Linear range, electric input: 22 - 125 dB
Microphone	Omnidirectional free-field microphone Flat frequency transfer (conforms with class 2 / type 2 requirements) 48V phantom powered 30 mV/Pa sensitivity
Display	Resistive LCD touch screen 320x240 pixels, 65k colors Luminance typ. 250 Cd/m2 Durability: 100k finger slides, 1M taps
Data storage	4 GB internal storage for data and program code Accessible from PC through USB (mass storage mode)
Environmental	Temperature: 5 -35C (41-95F) Relative humidity: 5% - 90% (non-condensing)
Power	NiMH battery pack 4.8V nominal, typ. 2200 mAh Typical battery lifetime >4h Max. charge current 1.8A
Electromagnetic compatibility	Complies with EN 61326-1:2006 FCC part 15 compliant (class A device)
Mechanical specs	Size approx. 210 x 85 x 55 mm (excl. microphone) Weight 530 g (including microphone) Rear-mounted tripod adapter Hook for carrying cord
Bundled items	Carrying case, measuring instrument, class 2 microphone, USB charger, int. charger adapters (US, EU, UK,AU), USB charging/data cable, manual, carrying cord, USB flash drive with test signals

10. Troubleshooting

Problem	Possible cause	Solution
System does not power on after pressing power button	Battery empty	Connect wall charger for at least 30 minutes
System does not recharge after connecting through USB	Charge current too low	Use bundled wall charger; standard PC USB ports do not supply enough current to charge
Display shows error messages (green text).	Error on display processor or in communication between DSP and display processor	If the problem persists, contact support.
Battery lifetime is too short	Battery not fully charged Battery is worn	Keep device on charger for at least 4 hours Have battery replaced after approx. 400 charge cycles
Battery indicator is inaccurate	Battery charge measurement system poorly calibrated (e.g. due to self-discharge after prolonged shelving)	Completely drain the battery, and then fully recharge. Repeat if necessary.
Device warms up during use	Lack of ventilation	Warming up of the device to temperatures of approx. 35°C/95°F is normal. If the device runs considerably hotter than that, check ventilation and contact support if the problem persists
Device not recognized by PC when connected through USB	Driver problem Device in measurement mode	Update PC drivers (VOX-01 is approached as a mass storage device) Select USB data transfer mode when dialog window appears on the VOX-01 screen
Display backlight turns off, no response to touch screen	Backlight time-out event	Adjust backlight time-out in power saving settings. Pressing power button turns the display back on
Device “hangs,” becomes unresponsive, or will not power up after resetting, and/or LED next to USB port burns red.	Internal software problem	Keep the power button pressed for 10s. This forces the device to shut down. Then press the power button again to restart. If the problem persists, contact support

6.3 Full STI

New in v2.0

The Speech Transmission Index (STI) can be measured by means of various test methods. The STIPA method, as implemented by the Quick STIPA and STIPA pro modules, is a fast and efficient version of the STI originally developed for public address systems. Although fast and robust, STIPA has its limitations: only 2 modulation frequencies are measured per octave band, whereas the complete Speech Transmission Index measurement scheme calls for 14 modulations per octave band. This means that STIPA is undersampled in the modulation domain. For many systems, the measured STI is not (or hardly) affected. However, some cases call for "Full STI" measurements:

- Whenever echoes are present (delayed loudspeakers, large halls and cathedrals)
- When tested systems or channels feature complex combinations of distortion factors.

Full STI measurements were available in commercial measuring tools up to the late 1990s, but have subsequently been absent from the market for two decades. The fact that a full STI measurement used to take around 15 minutes made Full STI measurements entirely impractical. Also, the introduction of STIPA around 2002 made a reasonable alternative available.

The Full STI module now available on the VOX-01 fully implements every aspect of the Speech Transmission Index model, making it the most universally applicable speech intel-ligibility metric to date:

- Fully compliant with the Full STI definition according to IEC-60268-16
- Computes the complete 14x7 Modulation Transfer Function matrix
- Uses an efficient algorithm that completes the measurement in approx. 1 minute
- Implements the *direct measurement method* as defined in IEC-60268-16

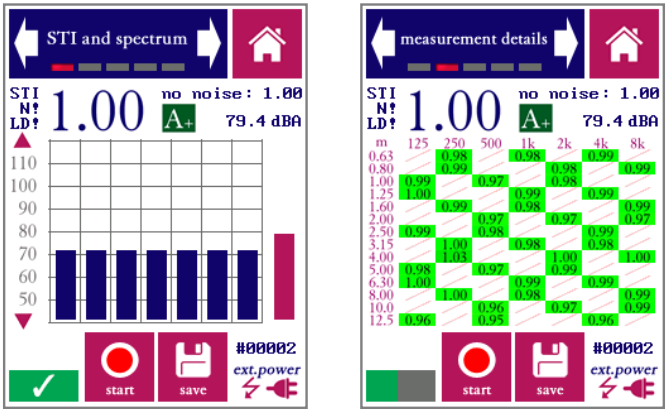
The "direct method" (in which a modulated test signal is presented to the channel under test), as implemented here, has crucial advantages over the "indirect method" (where the STI is estimated based on a measured impulse response). The indirect method implicitly assumes that the channel under test is a linear time-invariant system. Whenever electro-acoustic components are involved, the tested channel never fully satisfies the linearity re-quirement. Indirect estimates are notoriously inaccurate in many real-life scenarios, but have nonetheless been used extensively, for lack of alternatives based on the direct method (such as this module).

The Full STI module implements a novel measurement algorithm, that leverages the ad-vanced signal processing capabilities of the VOX-01. This algorithm, which is documented separately in an Embedded Acoustics white paper, has: he following characteristics:

- A novel test signal is used, which repeats 7 different patterns (segments) in a circular fashion.
- Each pattern roughly follows the approach of STIPA: each octave band is simultaneously modulated with 2 modulation frequencies.
- Each pattern takes approx. 9 seconds to complete. The whole measurement is completed in 65 seconds.
- The patterns are set up in such a way that all modulation frequencies (out of the set of 14) have been used in each octave band once the full 65 second cycle is completed. Hence, all 14 modulation frequencies are tested in all 7 octave bands.
- The first phase of a new measurement is a synchronization phase, during which the analysis algorithm determines when to expect transitions between patterns.

The Full STI test signal is included on the flashdrive bundled with the VOX-01, and will be available on the VOXBOX starting May 2017. Note that the Full STI signal is copyrighted material; all audio files of the signal released by Embedded Acoustics are watermarked. Use of the signal other than directly with the VOX-01 requires a license from Embedded Acoustics.

The measurements themselves are no more difficult or complex to carry out than STIPA measurements. The procedure is largely the same; only the duration is longer and the results are more universally representative of true speech intelligibility.



Full STI measurement result (left) and MTF details (right)

The Full STI module has the same overall design as the STIPA pro module, including the option to computationally add noise. The main difference is the second screen, which visually represents the Modulation Frequency Transfer (MTF) matrix as it gradually fills up during the measurement. The user has the option to stop the measurement before the full cycle has completed, shortening the duration of the measurement. This makes sense if the STI remains stable across multiple phases of the signal. The result of a prematurely

ended Full STI measurement can be thought of as a compromise in between STIPA and Full STI.

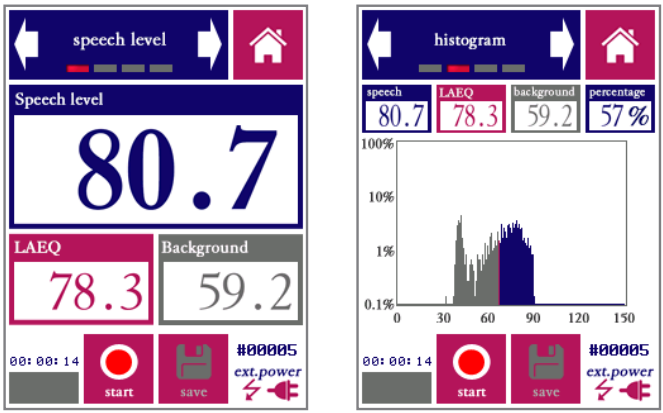
Please refer to the section on the STIPA pro module (page 11) for a description of the various features and controls of the module (additive noise, qualifications bands, disabling level-dependent masking, etc).

6.4 Speech Level Meter

In the context of speech intelligibility measurements, special care is needed when determining the sound pressure level of running speech. As human talkers use their articulators to form speech utterances, they alternately produce high-intensity bursts of acoustic energy and naturally occurring pauses. Across the length of a spoken sentence, periods of silence roughly account for half of the total time (length) of the sentence. Those pauses do not necessarily contribute to the intelligibility of the sentence, but they do have an influence on the overall (equivalent continuous) sound pressure level of the sentence. There is a firmly established relation between speech-to-noise ratio (SNR) and speech intelligibility - but how do we determine the speech level to calculate (SNR)?

It has been shown that removing the pauses from speech increases the correlation between SNR and subjective speech intelligibility. In the 1990s, a method was developed within European ESPRIT project 2589 (SAM) to assess speech levels while removing the influence of natural pauses. This method is known as Speech Level Meter (SLM) and is included in IEC-60268-16 as part of a normative annex (Annex J). This Speech Level Meter module is a direct implementation of this method.

The procedure consists of the compilation of a level histogram, which normally reveals a bimodal distribution: a low-level mode which represents the background noise, and a higher-level mode which represents speech. The RMS of speech and background noise can be calculated separately by summing the two modes in the histogram separately. The criterion for separating the two modes is a threshold that is set 14 dB below the SPL presumed to correspond to speech.



Estimated speech level (left) and histogram on which the estimate is based (right)

To use the Speech Level Meter, simply carry out a measurement while sampling running speech. The SPL of speech and background noise are calculated, as well as the total LAeq.

8.2. Noise curves noise curves

The “noise curves” module implements a series of measurement methods to evaluate noise levels, based on sets of standardized spectral curves. The objective of these methods is to set criteria in terms of a single-number rating, while taking the spectral characteristics of noise into account.

The following methods are implement

Noise Rating (NR). This is an ISO-standardized (ISO-1996) method. Although the method is being pushed into the background by successive updates to the relevant standards, it is still seeing a fair amount of use, in particular in Europe.

Noise Criteria (NC). This method is frequently used in the United States, mostly for evaluating background sound in buildings and for specification of desired levels in advance of construction. Different versions of the NC have been in circulation since the 1950s; the VOX-01 implements the version standardized through ANSI S12.2:2008.

Preferred Noise Criterion (PNC). This is a variant of NC, not included in ANSI S12.2, but proposed originally by Beranek et al (1973) to yield a better correspondence with perceived annoyance by putting more emphasis on the lowest frequency bands and highest frequency bands.

Balanced Noise Criterion (NCB). Standardized through ANSI S12.2:1995, similar in purpose and application to NC; apparently intended upon its introduction to replace NC.

Room Criteria (RC). This method is primarily used to quantify noise from HVAC systems in buildings. In addition to the single number rating (e.g. RC-35) a spectral classification of the signal is also given: Neutral (N), Hiss (H), Rumble (R) and Rattle and Vibration (RV).

Room Criteria mark II (RCII). Updated version apparently intended to eventually replace RC curves.

The Room Noise Criterion (RNC) method is currently not implemented on the VOX-01.

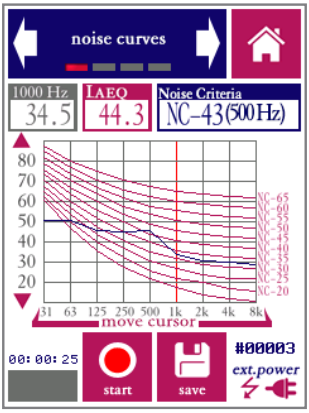
Each method has its own series of preferred limits, depending on the purpose of the room in which it is measured. ANSI S12.2 contains table of recommend maximum NC and RC values, and additional information is available through an abundance of online resources. A full list of these recommend limits is beyond the scope of this manual.

As part of the calculations, various intermediate metrics are calculated including the Speech Interference Level (SIL).

Each method uses its own procedure for rating noise spectra based on the series of curves associated with the method. The so-called "tangency method" plays a central role for NC and related measures; the rating is effectively determined by the highest NC curve "touched" by the spectrum. The frequency band that touches the highest curve (the most dominant noise band) is indicated as part of the rating, e.g: NC-53(125Hz).

A full description of the rating procedures is beyond the purpose of this manual. Please consult the corresponding standards for this information.

Carrying out a Noise Curves measurement is similar to an SPL or RTA measurement: set the duration of the measurement and other parameters, and start the measurement.



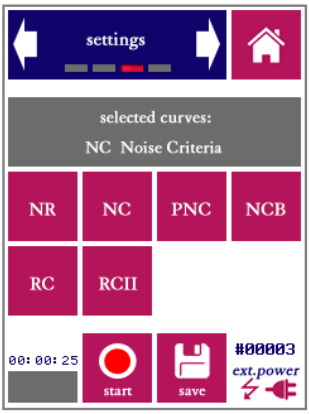
Noise curves. In this example, the curves and rating for NC are displayed

During a measurement, the reference noise curves are shown as red lines. The actual measured spectrum is shown as a blue line. The cursor can be moved around to read the SPL at any of the frequencies. The rating is shown, as well as the LAeq level.

Only one Noise Curves metric can be displayed at a time, but all metrics are calculated for every measurement. If a measurement is saved, the saved file contains data for all noise curve metrics. If you wish to evaluated more than one noise curve metric without measuring more than once, this can be done as follows:

- Select the first type of curves you wish to evaluate (e.g. NC)
- Carry out the measurement.
- Save the results
- Now change to another type of curves (e.g. NCB)
- Go to the measurement browser screen. NCB data will now be displayed
- Repeat this procedure to inspect results for further metrics (RC, RCII, etc).

The second screen of the module is used to set the duration of the measument. Selecting curves (and the associated rating method) is done in the third screen of the module.

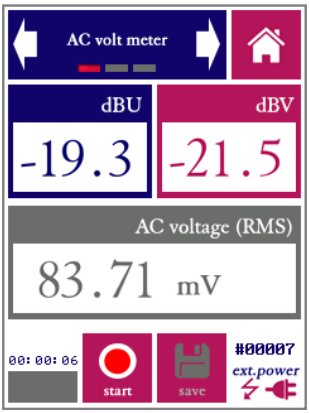


Choose from the available noise curve metrics

9.2. AC Volt meter

The AC Volt meter module is a simple tool to quickly assess the output level of line-level audio equipment. The line output of a device is connected directly to the XLR input of the VOX-01 (after removing the microphone). The VOX-01 then measures the signal level and expresses it in the following three units:

- V rms
- dBU
- dBV



AC Volt meter

The XLR connector supplies 48V phantom power to the microphone. This phantom voltage can be switched on and off through the hardware settings menu. IMPORTANT: connecting equipment not designed for 48V phan-tom power to the XLR connector (with phantom power switched on) may permanently damage the connected device and/or the VOX-01. Disable phan-tom power before connecting to external equipment.

The "AC Volt meter" function of the device is intended for measuring audio output levels of amplifiers and other audio equipment. NEVER connect the XLR input pins to AC voltages over 40V; do NOT try to measure the AC mains with your VOX-01.

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