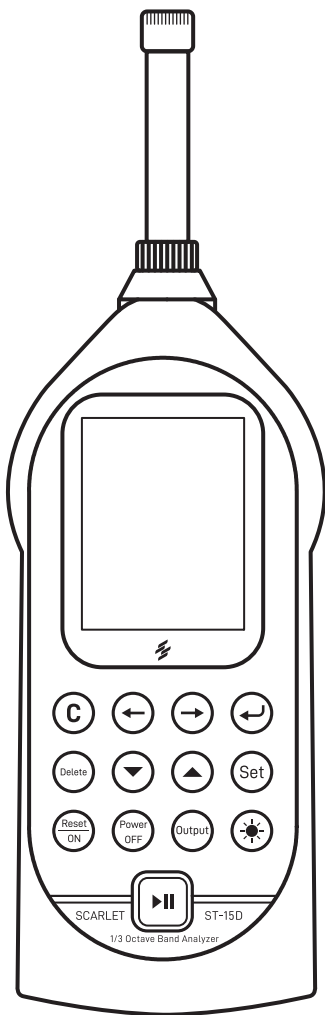SCARLET | TECH

SCARLET ST-15D
1/3 Octave Band Analyzer

ST-15D
Sound Level Meter
User Guide

Precaution

* Use the sound level meter gently, especially for microphone part, microphone is delicate sensor that require careful handling, please avoid any crashing, knocking and hitting, no water or oil entering.

* If choose to use alkaline batteries, please use high capacity of alkaline batteries. And remember to remove the batteries when don't use sound level meter for more than one week.

* Do calibration before and after measurement if needed.

* Keep sound level meter powering on status at least 8 hours every month for charging internal clock battery.

Contents

1. General Introduction

Model ST-15D has advantages of low power dissipation, powerful function, friendly and colorful display screen and abundant content. The instrument can measure A, C, Z frequency weighting and F, S, I time weighting, and it can also measure multiple assessment indexes at the same time. Its dynamic range is higher than 122dB.

The instrument has multiple analysis function: statistics and 1/3 Oct which can be activated synchronously. The design of low power dissipation and the automatic switchover of battery and the external power can support the instrument to work for a long time. 32 Mb FLASH RAM assures reliable data storage.

The instrument can be applied in environment protection, labor health, industrial enterprise and research and teaching etc. It can also achieve measurement of environmental noise, sound power level, machine equipment noise and building acoustics.

2. Specification

Model	ST-15D
Fulfils standard	IEC 61620:2014 Class 1; IEC 61672:2013 Class 1
Normal frequency	10 Hz ~ 20KHz
Measurement range	20 ~142dB; 1/3 OCT: > 90dB
Accuracy	± 0.7dB
Resolution	0.1dB
Frequency Weighting	A, C, Z parallel (synchronous); 1/3 OCT only: B, D, T(User- defined), U(User-defined)
Time Weighting	F, S, I, parallel (synchronous)
Main Parameters of Measurement	[Statistical] $L_{xy}i$, $L_{xy}p$, $L_{x}eq$, $L_{xy}max$, $L_{xy}min$, $L_{x}N$, SD. Note[1]: x is A, C, Z; y is F, S, I; LxN has five parameters, the user can define them and N is chosen from 1 to 99. Note[2]: 24H Measurement indexes：Ld, Ln, Ldn besides the indexes above [1/3 OCT] Lp, Max, Min, Leq,T
Filter Type	Parallel (real-time) third octave band, $G_{10}=10^{3/10}$
Filter Center Frequency	12.5Hz, 16Hz, 20Hz, 25Hz, 31.5Hz, 40Hz, 50Hz, 63Hz, 80Hz, 100Hz, 125Hz, 160Hz, 200Hz, 250Hz, 315Hz, 400Hz, 500Hz, 630Hz, 800Hz, 1kHz, 1.25kHz, 1.6kHz, 2kHz, 2.5kHz, 3.15kHz, 4kHz, 5kHz, 6.3kHz, 8kHz, 10kHz, 12.5kHz, 16kHz, 20kHz.
Datalogging	32MB Flash memory
GPS	Location, Transport speed
Bluetooth	Build-in; Support print measurement data or device controlled by mobile
Power Supply	4 x AA Batteries or USB 5V external power supply
Output Interface	AC*, DC**, RS-232, USB, Bluetooth
Application	Sound Level Meter/ Analyzer
Run Mode	Key, Limit, Clock, Interval
Dimensions	260 x 80 x30 mm
Display	2.6-inch color display with 240*320 resolution
Graphic	Statistic distribution graph, Accumulative distribution graph, 1/3 OCT frequency spectrum distribution graph
Weight	0.35kg
Operation Environment	Air temperature: - 15 ℃ ~ + 55 ℃ Relative humidity: 20% ~ 90%
Package Contents	Sound Level Meter, Calibration Certificate, ½" Prepolarized Condenser Microphone(Pre-installed), Windscreen, RS-232 Cable, Mini USB Cable, 5V Power Adapter, AA batteries, External GPS Antenna, User Manual, Waterproof Carry Case

*AC: Chosen between AC and 1 kHz. Its output can be connected to 8 Ω earphone (output power: 150mW, harmonic distortion: <0.1%).
**DC: Output the instantaneous sound pressure level of three frequency weighting (A, C, Z) and three time weighting (F, S, I), output scale: 15mV/dB. For 100dB, its output voltage is 1.54V (sensitivity level:-28dB)

3. Structure Features and Function

The outline of the Sound Level Meter is shown in Figure 1. It consists of microphone, preamplifier and the main unit. During normal operation, the measuring microphone and the preamplifier are installed on the head of the main unit, connected with the main unit through knurled nut. Extension cable can also be used between the main unit and the preamplifier. The function of the connector's pin between preamplifier and the sound level meter is shown in Figure 2.
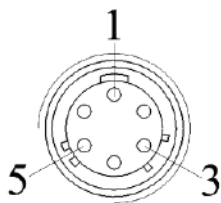
The outline of the sound level meter is sharp to reduce the reflection of the sound wave. The nominal influence caused by the reflection on the shell and the indication features under different incidence direction can be found in annexes. The shell is mold with ABS plastic. The batteries are put in battery box, which is very convenient for users to replace the batteries just by taking off the battery cover plate. All buttons are located at the central of the obverse side. Measuring results are shown on the 240×320 OLED display.

The GPS antenna port is located on the side, AC output (3.5mm phone jack), GPS indicator, Status indicator, RS-232 and mini USB port are on the bottom of the device, the detail definition and function of pins is shown in the following figures.

Fig 1 Main structure

Microphone

Windscreen anti-drop hook

Preamplifier

Knurled nut

Windscreen

Security slot

Display

GPS antenna port

Keypad

AC output

Mini USB port
Battery indicator

GPS indicator

Status indicator

RS 232

Fig 2 Preamplifier-Main device connector (X9 socket)

Pin	Definition
1	Power supply
2	Not connected
3	Signal input
4	Not connected
5	Signal ground
6	Not connected

Fig 3 AC output (3.5mm phone jack/stereo socket)
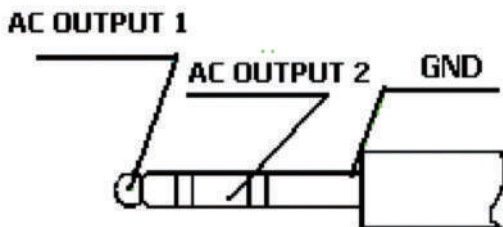
AC output signal's amplitude won't exceed 1V. Its relationship with input signal is shown in the table below:
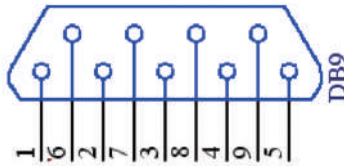
AC output	AC	AC
1	input signal minus 10dB	0.44V, 1kHz sine wave
2	input signal plus 10dB	0.7V, 1kHz sine wave

Fig 4 Mini USB port
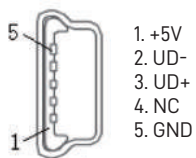
1. +5V
2. UD-
3. UD+
4. NC
5. GND

Fig 5 RS232 port

Pin	Definition
1	Power
2	RXD
3	TXD
4	Online
5	Ground
6	DC Output
7	Not connected
8	Not connected
9	Not connected

Fig 6 LED indicators

GPS status indicator

Working status indicator

Working status indicator	
LED behavior	Status
Flashes	Measurement starts
Static On	Measurement paused
Off	Measurement Stopped

GPS status indicator	
LED behavior	Status
Flashes in every 1 second	Positioning information is available
Off	GPS module is not installed or in sleep mode

Fig 7 Keypad
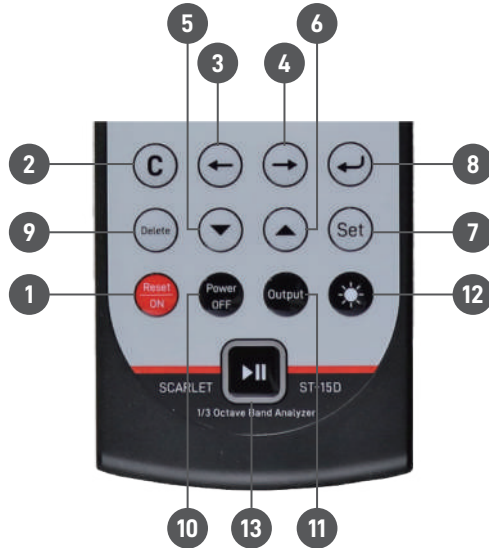
No	Button	Definition
1	(Reset ON) On/Reset	Power on; Restart the instrument
2	(C) Cancel	Return to previous menu from the current menu
3	(←) Left	Move the cursor to left
4	(→) Right	Move the cursor to right
5	(▲) Up	The value is added by 1; Page up; Change option
6	(▼) Down	The value is deceased by 1; Page down; Change option
7	(Set) Set	Enter the settings interface
8	(↵) Enter	Enter the current operation
9	(Delete) Delete	Delete the current data or cancel the current operation; Load the default parameters in the main menu interface
10	(Power OFF) Off	Power off the instrument
11	(Output) Output	Finish the measurement ahead of time and save the measurement data
12	(☀) Backlight	Turn on/off the backlight
13	(▶II) On/pause	Start or pause the measurement

Fig 8 Status bar & icon definition

No	Displayed content	Meaning	Remark
1	**Statistics**	Analysis mode	
	1/3 OCT	Analysis mode	
	GPS	GPS poisoning measurement	
2	icon	The number of working analyzers	Color: white means open, blue (no straight line) means close, red means startup status The bars from the left: statistics, 1/3 Oct
	icon	The 1/3 Oct is measuring. And the Statistics is opened.	
	Overload	Overload	There is overload indicator when exceeds the measurement upper limit.
3	**Calendar Clock**	The upper line are hour, minute and second, the bottom line is year, month and day.	
4	icon	Status of power supply, means the instrument is powered by external power supply.	Power supply switchover: When the battery and external power supply power the instrument meanwhile, battery power is cutoff completely, the analyzer first uses external power source. When external power is low and cutoff, the instrument switches back to battery power and the instrument won't closed down.
	icon	Status of power supply, means the instrument is powered by battery.	
	icon	Status of power supply, means the voltage of external power supply and the battery is low.	
5	**List**	Display interface	Statistics, 1/3 Oct
	All		The measuring interface of 24H in statistics
	Fig.		Statistics, 1/3 Oct
	Big		1/3 Oct
6	**Once**	Measuring mode	Statistics
	24H		
	Wei: A, Wei: C, Wei: Z, one of them	Frequency weighting	1/3 OCT
7	**Ts**	The setting measuring time	Pressing ☺ key in the measuring interface can choose the measuring time by grade
	Tm	The start-up measuring time	
	Tl	The remaining time	
8	**Ready**	The measurement is not started.	
	R: -（number）	The remaining time of voice note	
	W:（number）	The remaining time of run mode of key and delay	
	Run	The measurement is going on.	
	End	The measurement is finished.	
	Pause	The measurement pauses.	
	ATE	Sending data to mini-printer	Mini-printer is optional
	SMS	Sending message to mobile-phone	GSM modular is optional
9	icon	Slave mode of Bluetooth	Bluetooth is optional
	icon	Master mode of Bluetooth	

4. Preparation

4.1 Preparation before using

1. Check whether the microphone has been installed correctly.
2. Check whether battery has been put in.
3. If necessary, calibrate it with a sound calibrator. Regular method is in chapter 5.
4. The meter should be tested by relevant department regularly (such as one year), so as to ensure its accuracy.

4.2 Use of windscreen

If windy, you may use a windscreen to reduce the influence of wind noise. There are different models for you to choose. Windscreen can reduce noise about 10-15 dB · See Appendix D the influence of free-field responses for a meter with a windscreen when there are no wind.

4.3 External power supply

The Sound Level Meter can be connected with external power through the USB socket at the lower right of the instrument. At this time, the inner battery will be cut-off automatically. The voltage range of the external power supply is 4.3 V~6.5 V. The shell of plug is the cathode and the core of plug is the anode. When the Sound Level Meter is used for long time continuously, it is recommended to use external power supply.

4.4 Check and change battery

While operating, the meter will check battery power automatically, if it is low, the under-voltage indicator on will be lighted, which reminds to change battery. After you change the battery, the meter will operate normal again.

5. Calibration

There are two interfaces: calibrate and record. The instrument can save sound calibration record of 256 groups.

5.1 Sound calibration Interface

When the user enters the "Calibrate" submenu from main menu, shown below:
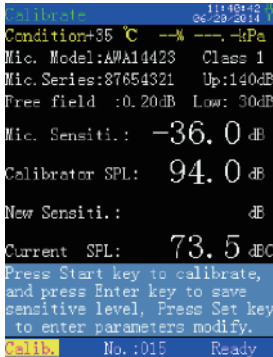
"Condition": the temperature of the environment.

"Mic. Model", "Mic. Series" and "Class 1" are preset when the meter leaves the factory, which can't be changed by the user.

"Up" is the upper limit of measurement when the instrument is equipped with the current sensitivity of microphone. The upper limit is defined according to the maximum RMS value of 1kHz sine wave.

"Low" is the lower limit of the instrument under the current sensitivity of microphone which is 7dB more than self-generated noise.

"Free field" is set according to the microphone that the instrument is equipped. The amendment value of free field is 0.2dB which also can be changed by the user.

"Mic. Sensiti." is the sensitivity level of the microphone after last calibration. This sensitivity level includes the preamplifier's attenuation.

"Calibrator SPL" is the actual level after calibration by the sound level calibrator.
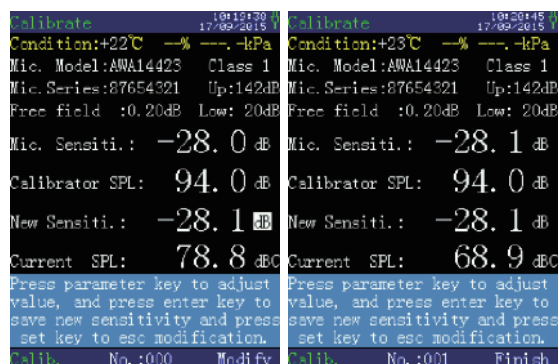
"New Sensiti" is the sensitivity level of the microphone after new calibration or the modification by hand.

"Current SPL": is changing with the environment which is shown as dBA or dBC. When the instrument is calibrated by 1kHz calibrator, the unit of Current SPL is recommended to use dBA. And when calibrated by 250Hz pistonphone, the unit is recommended to use dBC.

Function of main keys is shown below:

⏯ : Press ⏯ key to calibrate.
↵ : Press ↵ key to save the new sensitivity level.
Set : Press Set key to enter the modified parameters.

In the current mode, the cursor can only be moved on "dBA" at the right side of "Current SPL" and "Calib.". If the user wants to modify the parameters, they should press ⓢₑₜ Key, shown below:

The status changing from "Ready" to "Modify" allows the user to modify "Free field", "Calibrator SPL", and "New Sensiti." by pressing ⏶ or ⏷ key. When ↵ key is pressed, the modified content will be saved.

When the new sensitivity level that is calibrated differs from the last one by more than 4dB, then the new sensitivity level can't be saved. And the instrument should be recalibrated according to the prompt, if the microphone is verified with no problem (such as change the microphone), the user can set the new sensitivity level manually and calibrate it again.

5.2 Use ST-120 to calibrate

At the first time of sound calibration, set the "calibrator's sound pressure level" according to the certificate of inspection of the corresponding sound level calibrator. Generally, the sound level calibrator's sound pressure level is 94.0dB. If the sound pressure level is not 94.0dB, set it according to the actually inspected result.

Take 94.2dB for example, press ⓢₑₜ key, and press ← or → key to move the cursor to "Calibrator", and then adjust the value to 94.2 by ⏶ or ⏷ key. At last, press ↵ to save the Calibrator SPL.

Every time the user presses ⏶ or ⏷ key, the value increases or decreases by 0.1dB. When the user presses and holds ⏶ or ⏷ key, the value increase or decreases by 1dB. The adjustment continues till the key is released. The above steps can be performed only when the displayed sound pressure level differs from the used sound pressure level.
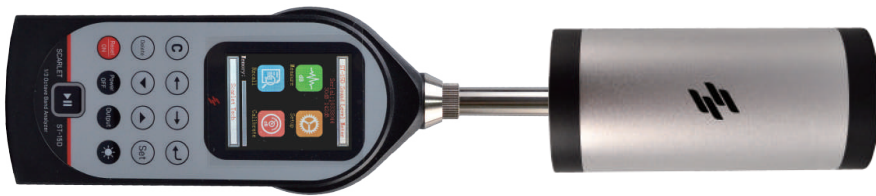
Insert the ½ inch microphone to the hole of ST-120 sound calibrator, turn on the power supply. Press [▶‖] key. The meter automatically starts calibration. The sound pressure level is displayed after "Current SPL". This sound pressure level is approximately equal to the calibrator's sound pressure level minus free field correction. The sensitivity level is displayed after "New Sensiti.".

During calibration, a number is displayed on the bottom right corner of the screen, which changes from 0 to 21 and then stops. Then the user presses ↵ key, the new microphone sensitivity level will be saved.

If the newly calibrated sensitivity level differs from the last saved sensitivity level by over 4dB, the meter will prompt "As the sensitivity level difference exceeds 4dB, it can't be saved. Please check whether the calibration is correct.". The user should check whether the microphone is damaged. If the user doesn't press ↵ key, the meter will still use the original microphone sensitivity level.

5.3 Directly input sensitivity level

If no calibrator is available, the user can also directly input the microphone's sensitivity level. Press ⑤ key, and press ← or → key to move the cursor to "New Sensiti.", and then adjust the value by ⊙ or ⊙ key until it arrives the expected value. At last, press↵ to save the Calibrator SPL.

5.4 Calibration record

When the cursor is moved to the "Calibrate" and press the ⊙ or ⊙ key to enter the Calibration record interface, shown below:

The interface displays the calibration message of current serial number, move the cursor to the "No", and press ⊙ or ⊙ key to view the calibration message of the other serial number. The message includes: calibration date, environment condition, type and serial number of microphone, correction value in free field, sensitivity level of microphone, measurement range and so on.

6. Operation

There are four display interfaces in the main menu interface: measurement interface, setup interface, recall interface and calibration interface.

6.1 Main menu

When the user presses ⊙ key for above 2s and then releases it, the meter goes to the main menu:

In the main menu, there are four submenus: Measurement, Setup, Recall, and Calibrate. The bottom shows status bar of storage space, the blue indicates the used space. When the user presses ⊙ key, the system parameters are restored to the default values. The ⊙ and ⊙ keys allow the user to move the cursor leftwards/rightwards. When pressing ⊙ key, the user can go to the corresponding submenu. There are two submenus in setup interface: analyzer setup and basic setup.

6.2 Measurement interface

When the cursor is on the "Measure", if the user presses ⊙ key, the meter goes to the measurement interface which consists of statistical analysis interface, 1/3 Oct analysis interface and GPS positioning interface.
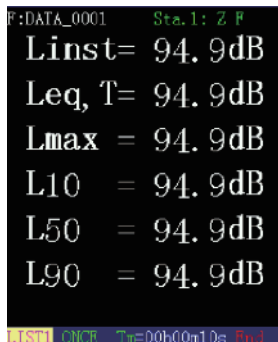
Note: The green options mean the menu status can be changed by ⊕, ⊕ and ⊙, ⊙ keys.

The blue background frame at the first line respectively displays from left to right: current analyzer mode, work status, calendar clock and power indication. When the cursor is moved to the option of "Statistics", the user can use ⊙ or ⊙ key to change the menu options. Power indication displays socket icon which means the instrument is powered by external power supply, and battery icon means the instrument is powered by batteries. The power voltage symbol can accommodate up to 16 lines. When these 16 lines are filled, the power voltage is about 5.6V. When the power voltage is lower than 3.6V, the indication is changed to " 🔋 ", which means the meter is in under-voltage status.

The black background frame in the middle shows measurement content. The blue background frame at the bottom line respectively displays from left to right: display mode, measurement mode, measurement time and measurement status. The measurement status includes: Ready, Start, Pause, Wait, Print and Over. The cursor can stay on "LIST1", "ONCE" and "Ts", the user can use ⊙ or ⊙ key to change the menu options.

▰▰ 6.2.1 Statistic Analyzer

At Main menu, pressing the ⏎ key when the cursor is at "Measure" will enter the measuring interface. In the Statistic analyzer, there are two mode: Once and 24H.

The setup parameters can't be changed in measurement interface but they can be displayed by turn. The parameters of "Sta.1" and "Sta.2" only can be changed in "Setup" ->"Analyzer" -> "Statistic".

6.2.1.1 Once measurement interface

In the noise measurement interface, when the menu in the measurement mode displays "Once", the meter goes to "Once" measurement mode. In the "Once" measurement interface, there are two display modes: List and Fig. interface.

6.2.1.1.1 List measurement interface

The list interface has two pages: List1 and List2. In this interface, the meter synchronously displays six measurement indexes on one screen. The display content includes Instantaneous value and Statistic value, shown below:
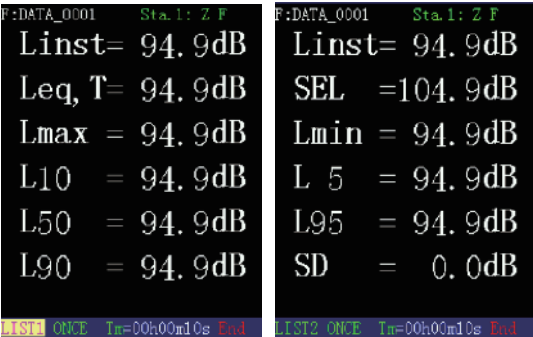

"Sta.1: A F:" means the current weighting is A frequency weighting and F time weighting. When the cursor is on "Sta.1: A F", the user can press ⊙ or ⊙ keys to enter "Sta.2: Z F" measurement interface which means the current weighting is Z frequency weighting and F time weighting. "Sta.1" and "Sta.2" open at the same time in the measurement interface which can be displayed switchover, and the operation won't affect the measurement result.

The black background frame in the middle shows six measurement indexes of the current frequency weighting and time weighting in the "List1": Linst, Leq,T, Lmax, Lmin, L10, L50 and L90. The indexes shown in "List2" include: Linst, Lmin, L5, L95, SEL and SD.

6.2.1.1.2 Fig. measurement interface

When the cursor is on "List2", the user can enter Fig. display interface by pressing ⊙ or ⊙ keys. The statistic distribution graph and accumulative distribution graph is displayed in the interface. When the measurement is started, the statistic distribution graph and accumulative distribution graph are calculated at the same time and refreshed every 0.5 second.

1) Statistic distribution graph
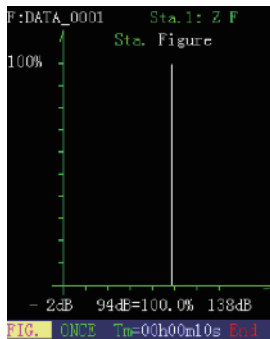
Note: The green options mean the menu status can be changed through cursor and parameters key.

In the middle is "Sta. Figure", the y-ordinate is percentage, and the x-ordinate has 140 points, every point represents 1dB. When the cursor is moved to "94dB", the user can view the percentage that every sound pressure level takes up by pressing the ⊙ or ⊙ key.

2) Accumulative distribution graph
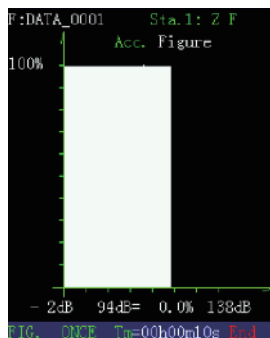
In the middle is "Acc. Figure". The y-ordinate of the graph is percentage, and the x-ordinate is the sound pressure level which has 140 points, every point represents 1dB. When the cursor is moved to "94dB", the user can view the accumulative percentage that every sound pressure level takes up by pressing the ⊙ or ⊙ key. We can figure out any statistical sound pressure level with this method.

6.2.1.1.3 Extra interface

The option of extra Ln is open in the analyzer setup, the measurement interface of STA will add an interface named EXTRA, shown below
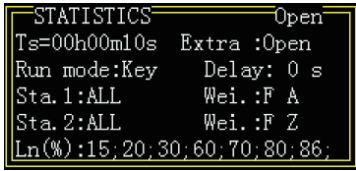
6.2.1.2 24H automatic measurement interface

24H measurement means that the measurement automatically starts every one hour at integral o'clock, totally 24 times. The measurement duration of every one hour can be set by the user. It must be bigger than 1min and less than 59min. If it is not within this range, the meter will automatically adjust it to 1min-1h. During 24H measurement, Ld, Ln and Ldn are calculated synchronously. 24H measurement mode consists of List, All and Fig. display interface.

6.2.1.2.1 List measurement interface
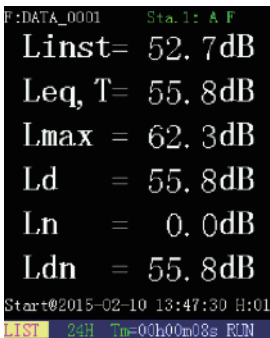
There are six measurement indexes: Linst, Leq,T, Lmax, Ld, Ln, Ldn in the current frequency weighting and time weighting. The bottom line "Start@2015-02-10 13:47:30" in the black background is the first time of starting the measurement. "H01" is the first time section.

Note: Don't start the 24H measurement by hand, it will start the measurement automatically at the hour.

6.2.1.2.2 ALL measurement interface
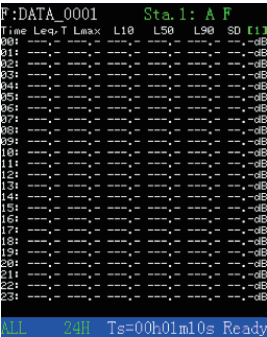
"Time Leq,T Lmax L10 L50   L90 SD" at the second line in the black background is the current measurement indexes, the corresponding 24 lines below are the measurement data.

"[1]" is the first page of measurement indexes, when the cursor is moved there, this can be changed to "[2]" by pressing ⌃ or ⌄ keys and the measurement indexes are changed to "Time Leq,T Lmin L5 L50 L95 SD". The part of "---.-" in the middle means the measurement has not reached the period.

6.2.1.2.3 Fig. display interface

The Fig. display interface can display 24h sound pressure level chart. The y-coordinate is sound pressure level and the x-coordinate is hour, totally 24 columns. "Leq,T" means that the currently displayed index is Leq,T. When the cursor is moved to this place, press the ⊙ or ⊙ keys to change it to Lmax, Lmin, L5, L10, L50, L90, and L95 etc.

"Time Leq,T Lmax Lmin L5 [1]" under the graph are measurement indexes at the current page. When the cursor is on "[1]", press Up and Down keys to display "Time L10 L50 L90 L95 [2]". The line below is the measurement data at specified period. When the cursor on period "08", by pressing the ⊙ or ⊙ keys, the user can view the measurement results of other periods.

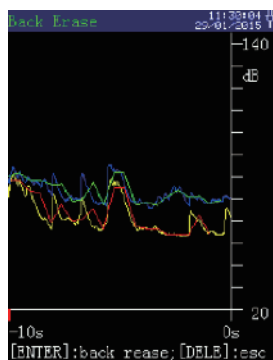■■ **6.2.2 Statistics Measurement**

6.2.2.1 Once measurement
According to the specific requirement, after checking and adjusting the clock, set the time and run mode (See details in Settings), frequency weighting and time weighting used in statistics and group name etc. In the measurement menu, when the cursor is moved to the bottom line in blue background, change the second menu option to "Once" to go to one measurement interface.

Press the ⊡ key to start measurement. In this case, the meter's status display line prompts "Start". And the color of Status bar in the first line will turn white to red. ■■

After starting the measurement, the meter synchronously calculates all measurement indexes. The user can switch among different display contents and display modes, which will not affect the measurement. In the measurement process, if the user wants to pause the measurement, the user can press the ⊡ key again. The meter's status display line prompts "Pause". And the meter pauses the statistic analysis and integral measurement; the statistic sound level and equivalent sound level stop refreshing; but the instantaneous value still changes with the measured noise. To stop measurement and save the current measurement result, the user can press the ⊙ key. To stop measurement and delete the current measurement result, the user can press the ⊙ key. To continue the measurement, the user can press the ⊡ key again.

If there is unexpected noise during the once measurement, press the ⊙ key, and press the ⊙ key according to the prompt given by the instrument, the noise changing curve of the last 10s will be displayed. Pressing the cursor key and ⊙ key can choose to delete the data in the last 5s or 10s, and then press the ⊡ key the measurement will go on.

6.2.2.2 24H automatic monitoring

According to the specific requirements, after checking and adjusting the clock, set the time and run mode, frequency weighting and time weighting used in statistics and group name etc. In the measurement menu, when the cursor is moved to the bottom line in blue background, change the second menu option to "24H" to go to the 24H automatic measurement interface. In this case, the meter's status display line displays "Ready". When the calendar clock reaches the integral o'clock, the meter automatically starts the measurement. When its duration reaches the measurement time, the measurement stops and the measurement in one period ends. The meter's status display line displays "Wait" till the next integral o'clock. It stops automatically till the measurements in 24 time periods are completed. In the 24h automatic monitoring process, the user can't pause the operation. For the first period, the user can start the measurement with the   key. However, for the other periods, the meter automatically starts the measurement when it reaches the same integral time point. If the user hopes the instrument will continue the next 24H measurement automatically after a "24H" measurement, the run mode of should be set as "Continuous". Doing so, the instrument will proceed the 24H measurement constantly until the data storage is fulfilled.
Note1: The other analyzers can't go started when the 24H mode is going on.
Note2: If there is a overload in the measurement, the "overload" indication will be displayed for a while.

■ 6.2.3 1/3 OCT Analyzer

At main menu, pressing the ⏎ key when the cursor is at "Measure" will enter the measuring interface. Move the cursor the STATISTICS, press ⌃ or ⌄ to switch analyzer. In the 1/3 Oct analyzer, there are three modes: List (List1, List2 and List3), Big, Fig..

6.2.3.1 List interface

There are three pages in List interface: List1, List2 and List3. It's able to switch by pressing ⌃ or ⌄ key.

In the middle black background are sound pressure leve1s at 11 center frequencies between 2kHz and 20kHz and A, C, Z frequency weighting, and the right side corresponding values are the values of Lp, Max, Min and Leq,T in current frequency and time weighting. The bottom line is menu options and measurement status indication. The measurement re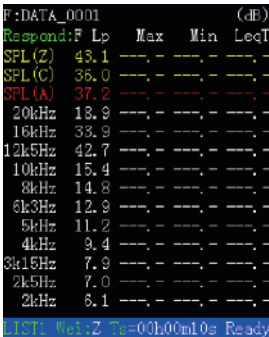sult is refreshed every 0.5 second and changing with the environmental noise. When the integral measurement isn't started, the values of "Max", "Min", "Leq,T" are shown as "---.-". Max is the maximum of exponential mean values during the measurement time, Min the minimum of exponential mean values during the measurement time, and Leq,T is the integral mean value during one time period.

When the cursor is on "Respond:", the time weighting can be changed from F to S by pressing ⌃ or ⌄ keys. When the cursor is moved to "Wei:", the time weighting can be switched among A, C and Z by pressing ⌃ or ⌄ keys.

When the cursor is on "List1", the user can enter "List2" display interface by pressing ⌃ or ⌄ keys, shown below:
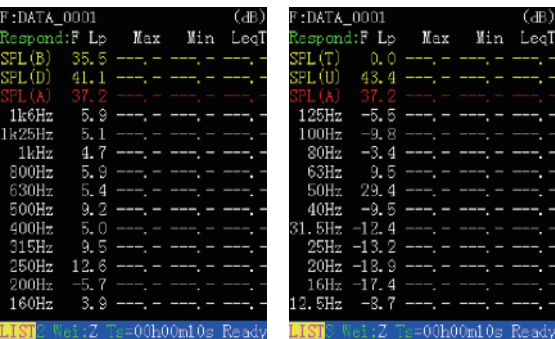
List 2 interface has 11 center frequencies between 160Hz and 1.6kHz and B, D, A frequency weighting, and the right side corresponding values are the values of Lp, Max, Min and Leq,T in current frequency and time weighting. The other operation is the same with that of the "List1" display interface. When the cursor is on "List2", the user can enter "List3" display interface by pressing ⌃ or ⌄ keys.

List 3 interface has 11 center frequencies between 12.5Hz and 125Hz and T, U, A frequency weighting, and the right side corresponding values are the values of Lp, Max, Min and Leq,T in current frequency and time weighting.

SPL (T) and SPL (U) are the results of frequency weighting that the user defines. The frequency weighting that the user defines can be modified in "Basic"-> "Basic Setup2"-> "Other Setup".

$$W\_U=10\log[\sum 10^{(Lfm+Wfm)/10}] \ (dB)$$

The formula above is also suitable for W_T, Lfm is the sound pressure level at each center frequency, and Wfm is the weighting value at each center frequency.

User-defined frequency weighting U can be adjusted among the weighting values of 33 center frequencies between 12.5Hz and 20kHz. User-defined frequency weighting T can be modified at the center frequencies between 20Hz and 200Hz. When the instrument leaves factory, the attenuation of the two weightings is setting as the following table.

Default value of User-defined weighting

Center frequency (Hz)	U weighting (dB)	T weighting (dB)	Center frequency (Hz)	U weighting (dB)	T weighting (dB)
20k	0	-∞	400	0	-∞
16k	0	-∞	315	0	-∞
12.5k	0	-∞	250	0	-∞
10k	0	-∞	200	0	-10.8
8k	0	-∞	160	0	-13.2
6.3k	0	-∞	125	0	-16.2
5k	0	-∞	100	0	-19.1
4k	0	-∞	80	0	-22.4
3.15k	0	-∞	63	0	-26.2
2.5k	0	-∞	50	0	-30.3
2k	0	-∞	40	0	-34.5
1.6k	0	-∞	31.5	0	-39.5
1.25k	0	-∞	25	0	-44.8
1.0k	0	-∞	20	0	-50.4
800	0	-∞	16	0	-∞
630	0	-∞	12.5	0	-∞
500	0	-∞			

6.2.3.2 Fig. interface

When the cursor is on "List3", the user can enter "Fig." display interface by pressing ⌃ or ⌄ keys, shown below:
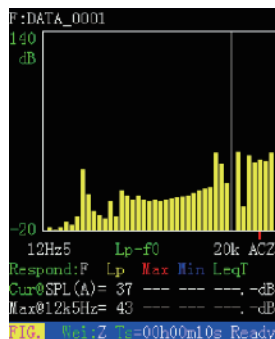
The middle part in the black background displays the spectrum chart of sound pressure levels at 33 center frequencies and A, C, Z, B, D, U, T frequency weighting. "140" at the left upper side of the graph means upper limit of the displayed graph is 140dB, when the cursor is moved to "140", the upper limit can be adjusted 10dB up and down every time by pressing the ⌃ or ⌄ keys. "-20" at the left lower side of the graph means lower limit of the displayed graph is -20dB, when the cursor is moved to "-20", the lower limit can be adjusted 10dB up and down every time, and the lower limit should be at least 10dB less than the displayed upper limit.

"Lp-f0" in the middle part under the graph means the current graph is displaying the values of Lp, When the cursor is moved to "Lp-f0", the displayed content can be switched among LMax, LMin, LeqT and ALL by pressing ⊙ or ⊙ keys. ALL means four indexes are displayed at the same time, the color of the graph can be adjusted which stays the same with "Lp Max Min LeqT" in black background. The cursor can be moved at "Lp Max Min LeqT" and click one of them, then the color of the chosen one can be changed by pressing the ⊙ or ⊙ keys. When the cursor is on "Respond:", the time weighting can be changed from F to S by pressing ⊙ or ⊙ keys.

The "Cur@" line under the graph displays the measurement content of "Lp Max Min LeqT" where the cursor is located in the current graph. When the cursor is moved to "Cur@", the location of the cursor can be changed (the red part under the bar graph) by pressing ⊙ or ⊙ keys. "Max@12k5Hz" at the bottom line in the black background means the frequency of the maximum noise is 12.5kHz, behind which is the measure-ment content of "Lp Max Min LeqT" at the specified frequency. When the cursor is moved to "Wei:", the time weighting can be switched among A, C and Z by pressing or ⊙ keys. When the cursor is moved to "Ts", the time weighting can be changed to ⊙ "Tm" and "T1".

6.2.3.3 Big interface
When the cursor is on "Fig.", the user can enter "Big" display interface by pressing ⊙ or ⊙ keys.
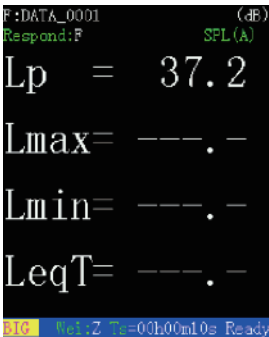
The big characters displayed in the middle are the measurement content of "Lp, LMax, LMin and Leq,T" and sound pressure leve1s at 33 center frequencies and A, C, Z, B, D, U, T frequency weighting, the user can choose anyone of them.

When the cursor is on "SPL (A)", the displayed pressure leve1s can be chosen among 33 center frequencies and A, C, Z, B, D, U, T frequency weighting by pressing ⊘ or ⊘ keys.

When the cursor is on "Respond:", the time weighting can be chosen among A, C and Z by pressing ⊘ or ⊘ keys.

When the displayed content is sound pressure leve1 of A, C, Z, B, D, U, T frequency weighting, changing the frequency weighting won't affect the result of weighting sound pressure level.

When the cursor is moved to "Ts", the time weighting can be changed to "Tm" and "Tl".

6.2.3.4 1/3 Oct measurement

According to the requirements, set the time, run mode and group name etc (See details in Basic information). In the measurement interface, press ⊘ or ⊘ keys on the Analyzer mode to enter the 1/3 Oct measurement interface, shown below:
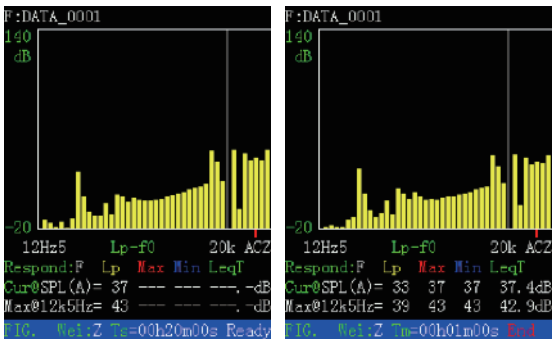
The frequency weighting and time weighting in the interface are adjustable by ⊙ , ⊙ , ⊘ and ⊘ key (See details in Basic information) the meter's status display line displays "Ready". Pressing the ⏸ key, the meter automatically starts the measurement, and the status bar displays "Start".

After starting the measurement, the meter synchronously calculates all measurement indexes. The user can switch among different display contents and display modes, which will not affect the measurement. In the measurement process, if the user wants to pause the measurement, the user can press the ⏸ key again. The meter's status display line prompts "Pause". And the meter pauses the statistic analysis and integral measurement; the statistic sound level and equivalent sound level stop refreshing; but the instantaneous value still changes with the measured noise.

7. Setup
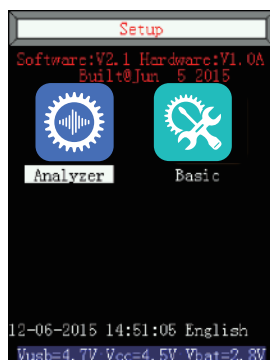
The second line is the version of software and hardware; the middle is the two setup options with icon. The user moves the cursor to any option and press ⏎ key, then will go into the setup interface of the option.

Below the icon options are the options of time and language, the cursor can stay at the year, month, day, hour, minute and second option, the user can setup the calendar clock by pressing ⏶ or ⏷ key.

The bottom line is the message of power supply, "Vusb" is the voltage of external power supply, "Vcc" is the voltage of battery (the instrument will be powered by external power supply when the battery is not connected.), "Vbat" is the voltage of backup battery (the instrument will be powered by external power supply when the backup clock battery is not connected.).

7.1 RTC

RTC option: the cursor can be moved among year, month, day, hour, minute and second. Press ⌃ or ⌄ key to set the RTC.

The bottom line shows the message of battery voltage. "Vusb" is the voltage of USB socket, "Vcc" is the voltage of battery, "Vbat" is the voltage of backup battery socket. When GPS is authorized, it's recommended to use the GPS to calibrate the RTC, and it's with higher precision. RTC of GPS is the UTC time which is earlier than UTC+8 time. When the instrument is connected to the satellite, press the ⏎ key to finish the calibration.

When the instrument is turned off, the RTC is relied on the backup clock battery. The backup battery can support the RTC for 1 month continuously, and the backup battery is rechargeable when the instrument is turned on. When the voltage of backup battery is less than 2V, the RTC will be disabled and needs setup again. 8 hours of continuous working every month is recommended.

7.2 Analyzer setup interface

In the analyzer setup interface, user can setup for statistics, 1/3 Oct.
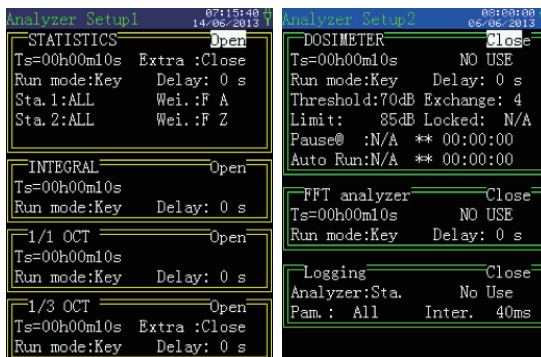
At the left upper side of double line frame is analysis mode. "Open" at the right upper side is the switch of the corresponding analysis module, when the cursor is moved there, the user can choose open or close by pressing ⌃ or ⌄ key. When the Open status is chosen, the color of the frame is yellow, and close status is green. Only supported analyzer can be setup in the analysis module.

▮▮ 7.2.1 Setup of measurement time

"Ts=00h00m10s" is the pre-setting measurement time, Ts=00h00m00s means the measurement time doesn't have limit (Hand) until the integral result exceeds the measurement range. When the cursor is on "Ts", the user can choose the time among 00h00m00s, 00h00m10s, 00h01m00s, 00h05m00s, 00h10m00s, 00h20m00s, 00h30m00s, 01h00m00s, 02h00m00s, 04h00m00s, 08h00m00s, 16h00m00s and 24h00m00s by pressing ⌃ or ⌄ key. When the cursor is moved to h, m and s, the time can be set from 1s to 99h59m59s arbitrarily.

When the measurement is started, once getting the time, the instrument will finish the measurement and save the measurement result.

In the analyzer setup interface, "Ts" in every module can be set independently.

▄▄ 7.2.2 Run mode setup

"Run mode": the trigger source to startup, there are four modes that can be chosen: Key, Time, Limit and Interval. The use of the startup trigger source is shown below:

Run mode

No	Source	Remark
1	Key + Delay	Press the key and startup is delayed for a while
2	Clock	Startup at a certain time
3	Interval	Startup after the same interval time
4	Limit	Startup when exceeding the setting limit

a) Key
When the mode of "Key" is chosen, shown below:

```
Run mode:Key    Delay: 0 s
```

"Delay": press ⏎ key and the startup is delayed for a while. When the delay time is 0s, the measurement will be started right now. When the cursor is moved to "Delay", the parameter can be chosen from 0 to 99.
Note: When the user chooses the other startup trigger modes, the measurement can be started by pressing ⏎ key in the measurement interface.

When the cursor is moved to "Run mode", the user can enter setup interface of time run mode by pressing ⏶ or ⏷ key.

b) Clock
When the mode of "Clock" is chosen, shown below:

```
Run mode:Clock 00-00-00 00:00:00
```

At the left is calendar, and the right is clock, the user can set a time here. When the calendar clock arrives the time, the instrument will be started. The cursor can moved to year, month, day, hour, minute and second which are adjustable by pressing ⏶ or ⏷ key. When one of the options is adjusted to end, there will display "**", which means this option won't take part in the compare. Doing so, the instrument will be started every hour, every day, every month......

When the cursor is moved to "Run mode", the user can enter setup interface of Limit run mode by pressing ⏶ or ⏷ key.

c) Limit
When the mode of "Limit" is chosen, shown below:

`Run mode:Limit   Sta.1 > 70dB`

"Limit": When the value exceeds the setting limit, the instrument will be started. The value can be chosen from 0 to 180.

When the cursor is moved to "Run mode", the user can enter setup interface of Interval run mode by pressing ⊙ or ⊙ key.

d) Interval
When the mode of "Interval" is chosen, shown below:

`Run mode:Inter.  △T =  1min`

 "Inter. $\triangle$T=1 min": the time between startup of two measurements, the user can choose among 10s, 30s, 1min, 2min, 5min, 10min, 20min, 30min and 1hour. 1min means the instrument will be started at the exact minute, 5min means the instrument will be started at the exact 5 minute

Note1: The instrument will save the measurement data automatically after the measurement is finished, during this period, the instrument won't response to the order of measurement startup, so the Ts should better shorter than $\triangle$ T.
Note2: When the setting measurement time Ts is longer than interval, the measurement time will be Ts, and the interval will be prolonged.

▦ 7.2.3 Analyzer setup
Analyzer setup includes: Statistics, 1/3 Oct. Other options are valid only with authorization.
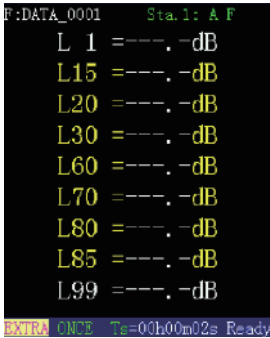
a) Statistics
The setup of Ts and Run mode is seen in previous section.

"Extra": close, the basic percentile levels are L5, L10, L50, L90 and L95. If the "Extra" is open, besides the 5 basic ones, there are 7 percentile level including L1, L99 and five user defined levels. And the measurement interface of Statistics will have one more interface: EXTRA.

```
┌STATISTICS─────────Open┐
│Ts=00h00m10s  Extra :Close│
│Run mode:Key    Delay: 0 s│
│Sta.1:ALL       Wei.:F A │
│Sta.2:ALL       Wei.:F Z │
└──────────────────────────┘
```
```
┌STATISTICS─────────Open┐
│Ts=00h00m10s  Extra :Open │
│Run mode:Key    Delay: 0 s│
│Sta.1:ALL       Wei.:F A │
│Sta.2:ALL       Wei.:F Z │
│Ln(%):15;20;30;60;70;80;86;│
└──────────────────────────┘
```

User defined percentile level in STA


```
F:DATA_0001      Sta.1: A F
     L 1 =---.-dB
     L15 =---.-dB
     L20 =---.-dB
     L30 =---.-dB
     L60 =---.-dB
     L70 =---.-dB
     L80 =---.-dB
     L85 =---.-dB
     L99 =---.-dB
EXTRA ONCE  Ts=00h00m02s Ready
```

Time weighting: F, S and I can be chosen.
Frequency weighting: A, C and Z can be chosen.

1/3 Oct: sound pressure level at 33 center frequencies and A, C, Z frequency weighting can be chosen.

The parameters setup of "Sta.1" and "Sta.2" are shown below:

	Analysis mode	Frequency weighting	Time weighting	Center frequency and total value
Sta.1	Total value	A, C, Z	F, S, I	
Sta.2	1/3 OCT (optional)	A, C, Z	F, S	Center frequency and total value of A, C, Z, B, D, T and U weighting sound pressure level

b) 1/3 OCT

```
┌─1/3 OCT ════════════Open─┐
│Ts=00h00m10s  Extra :Close│
│Run mode:Key    Delay: 0 s│
└──────────────────────────┘
```

When "Extra" status is Close, the analyzed center frequencies are from 12.5Hz to 20kHz. And the "Extra" is open, there are three more frequencies: 10Hz, 8Hz and 6.3Hz. But the data is not shown in measurement interface only in data recall interface, shown below:

Note: Ts, Run mode settings (See 7.2.1 & 7.2.2)

There are three pages in the basic setup interface: "Basic Setup1", "Basic Setup2" and "Basic Setup3".

```
┌Multi-analyzer      sync ┐    ┌Auto Power        N/A ┐
Ts=00h00m10s  √ key:N/A        Auto Power On :00 00:00:00
Run mode:Key    Delay: 0 s     Auto Power Off:00 00:00:00

┌Name Setup┐                   ┌Other Setup┐
Name@01:DATA_0001        √     1.24H Measuring:Once
Name Choice: Manual      √     2.Auto enter:  Main menu
                               3.Inside Frequency:   0.00Hz
┌Hardware Setup┐               4.Weight--U: 20kHz;    0.0dB
1.Backlit: 900s     Bright:26  5.Weight--T: 20kHz;-Inf. dB
2.MIC. Type: Free field        6.Write protect:Open
3.GPS:    Save  Zone:+08       7.Voice note:N/A
4.Output:  N/A   DC  :LAFp
5.Print:Hand  Mode:Simple
6.SMS OUT:OFF            √
7.Range:     20dB~132dB        1.Authorize:
```

In the Setup interface, move the cursor to "Basic" and enter the "Basic Setup1" interface, and press (Set) key to switch.

There are five analyzer setup options from up to down respectively: "Multi-analyzer", "Name Setup", "Hardware Setup", "Auto power" and "Other Setup". The boundary between each other is yellow double lines.

"Basic Setup2" interface has four options: Auto Power, Other setup and Authorize.

"Basic Setup3" interface has three options: Bluetooth, RS232 setup and Default.

```
Basic Setup2    00:53:49     Basic Setup3     15:19:10
                26/01/2015                    12/06/2015
┌Auto Power        N/A ┐     ┌Blue tooth┐
Auto Power On :** **:25:00   1.Power     :       OFF
Auto Power Off:** **:00:00   2.Baud Rate:       9600
                             3.PIN CODE:        0000
┌Other Setup┐                4.New baud:        9600
1.24H Measuring:Only Once
2.Auto enter:  Main menu     ┌RS232 setup┐
3.Inside Frequency:  0.00Hz  1.Baud Rate:      115200
4.Weight--U: 20kHz;   0.0dB  2.FlowCont.:         N/A
5.Weight--T: 20kHz;-Inf. dB
6.Write protect:Open         ┌Default┐
7.Voice note:N/A 8.Save:new   1.Save user parameters    √
                              2.Save user freq. weight  √
┌Record Setup┐                3.Factory default         √
Format  :48kHz,32bit   Close
Trigger :logging;=Ts

1.Authorize:
```

7.3.1 Multi-analyzer Setup

"sync": Press 🔁 key, each analyzer will start measurement at the same time. Press ⌃ or ⌄ key to change "sync" to "async", and press 🔁 key, the instrument will only start the analyzer at the current measurement interface.

"Ts": Ts is the measurement time, the setup method is seen in Chapter 7.2.1.

"Run mode": the trigger source to startup, see details in Chapter 7.2.2.

"Key:N/A" or "Key:Modify": "Key:Modify" means in the measuring interface, we can press the ⏎ key to change the measurement time before and after measurement. And

"Key:N/A" means we can't change the measurement time by pressing the ⏎ key.

7.3.2 Name Setup

"Name @01: DATA_0001" is the name used for saving the current measurement result. 01 means the first group, and the name doesn't affect the measurement result. When the cursor is moved to Group name, the user can choose the other names between 01 and 64 by pressing ⌃ or ⌄ key.

"Name choice" has two options: Manual and Auto. If Manual is chosen, the group name is the current saved name at every turn of measurement. If Auto is chosen, every turn of statistic integral measurement, the group name changes automatically. The meter can save up to 64 group names.
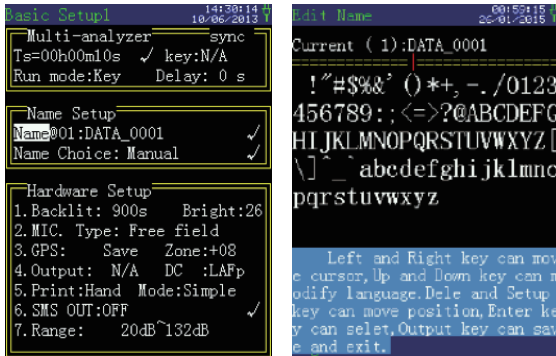
7.3.3 Hardware setup

"Backlit" can be set as "Open" constantly or selected within 10s-900s with 10s intervals. When the user doesn't press any keys in the specified time, the Backlight is automatically turned off.

"Bright": default value is 25 which can be chosen between 4 and 49. When the value is greater, the backlight is brighter.

"Mic. Type": free field (0°), pressure field (90°) and random can be chosen. The microphone used in sound level meter is the type of free field, and it should point to sound source when we take measurement which is incidence of 0°, and the microphone mode should be set as free field (0°). But under some circumstances, the sound source only can income at 90°, and the directivity of the microphone at high frequency will affect the accuracy, the microphone mode should be set as pressure field (90°). The user can use the function to change the free field microphone to pressure field microphone. The influence that the three options of response frequency is seen in Annex.

"GPS": GPS power has three options: Open, Save, Close. If "Open", GPS module's power supply keeps running all the time, the power consumption is high, but the positioning is fast. If "Save", GPS module's power supply is turned on when necessary. Every time that GPS module's power supply is turned on, it needs several seconds to make repositioning. When the GPS positioning signal is poor, it needs long time to make repositioning. It is suggested that the user set it to "Open". When the user doesn't needs the GPS positioning information, "Close" may be set to save energy.

"Zone+8": the time zone where is the instrument is the difference between the local time and the GMT or UTC. GMT+8 means the local time is 8h earlier than then GMT, the instrument will automatically add 8h to the UTC of GPS as the local time when is doing the GPS calibration.

"Output": the type of output signal on AC output interface which can be chosen among N/A, AC and 1 kHz. If 1 kHz is chosen, the meter's self-noise is increased by 3-5 dB. The 1 kHz Output signal will be closed when the measurement is in Oct analysis mode. And the "N/A" means no output.

"DC": can be chosen among LAFp, LASp, LAlp, LAeq,t, LCFp, LCSp, LCIp, LCeq,t, LZFp, LZSp, LZlp, LZeq,t and 33 center frequencies of 1/3 OCT.

 "Print": "Hand" and "Auto" can be chosen. If "Hand" is chosen, it doesn't print out the measurement result after the measurement. If "Auto" is chosen, the analyzer will print out the measurement result automatically after the end of the measurement. In this case, the printer shall be connected and its power supply shall be turned on.

"Mode": "Simple", "No Pic.", "Picture" and "Screen" can be chosen. If "No Pic." is chosen, the measurement result is printed only with text. If "Picture" is chosen, the measure-ment result is printed with statistic chart, accumulative chart, spectrogram etc. If "Screen" is chosen, the printed content is the same with the display screen. If "Sim." Is chosen, the printed content will not include the picture, the serial number, mode number and the message of calibration.

"SMS OUT": "On" and "Off" can be chosen. If "On" is chosen, the meter will try to send the measurement result to the specified mobile phone via SMS after the measurement. Move the cursor to the "6. SMS OUT" and press ⏎ key to go into the interface of entering phone number. In this interface, the user can enter the phone number received measurement result, shown below:

"Range": the instrument has two measurement range, L and H. The L range is from 20dB to 132dB. And when the cursor is here, press the ⊙or ⊙ key to change L to the H range: 30dB～142dB.

According to the notice, press ⏎ key after entering phone number to save it.

■ 7.3.4 Auto Power Setup

"Auto Power": "Yes" and "N/A" can be chosen. When "Yes" is chosen, the instrument can open and off at the specified time shown below.
"Auto Power On": the form is "day, hour, minute and second".
"Auto Power Off": the form is "day, hour, minute and second".

When one of the options is adjusted to end, there will display "**", which means this option won't take part in the compare. The cursor can moved to year, month, day, hour, minute and second which are adjustable by pressing ⊖ or ⊕ key.

```
┌Auto Power─────────N/A─┐
│Auto Power On :** **:25:00│
│Auto Power Off:** **:00:00│
└──────────────────────┘
```

■ 7.3.5 Other Setup

"24H measuring": "only once", "Inaccessible" and "Continuous" can be chosen.
"Auto enter": the instrument will enter the interface when it opens, which includes Main menu and measuring.
"Inside frequency": 0.00Hz and 11 center frequencies of 1/1 OCT can be chosen. When "0.00Hz" is chosen, this means the "Inner calibration" hasn't open.
"Weighting--U": the frequency weighting that defined by the user. When the cursor is on "4." at the left side, the cursor can choose within 33 center frequencies between 12.5Hz and 20 kHz. "dB" at the right side is the weighting value which means the D-value of weighting and non-weighting at the frequency. The negative value of weighting means attenuation, and the positive means amplification, the attenuation at every frequency can be setup by pressing ⊙ or ⊙ key.
"Weighting--T": the frequency weighting that defined by the user. When the cursor is on "5." at the left side, the cursor can choose within 33 center frequencies between 12.5Hz and 20 kHz. But the attenuation at the frequency between 20Hz and 200Hz can be setup whose default value is the same with that of A weighting. The attenuation can be setup by pressing the ⊙ or ⊙ key, the attenuation at other frequencies is infinite great.

Note: The user-defined is only for 1/3 OCT.

"Write protect": when the user write the icon image with the transmission software, the option will be changed to close. The default setting is open.
"Run[off]/Protect": "Run[off]" means the instrument can be turned off by pressing the ⊙ key when the measurement is going. And "Protect" means the instrument can't be turned off when measurement is going.
"Voice note": N/A, 10s, 20s. When 10s is selected, there will be 10 s left for user to say something to express the measurement before the measurement is started.

```
┌Other Setup┐
1. 24H Measuring:Only Once
2. Auto enter:  Main menu
3. Inside Frequency:   0.00Hz
4. Weight--U: 20kHz;   0.0dB
5. Weight--T: 20kHz;-Inf. dB
6. Pic prot.:Yes  7.Run[Off]
8. Voice note:N/A 9.New file
```

▇▇ 7.3.8 Bluetooth

"Power": Master, Slave and off. Press ⌃ key to open the slave mode and press ⌄ key to open the master mode. The master mode can also be connected to the Bluetooth printer to print the measurement result. When the mode is set successfully, the left corner will prompt the master or slave mode is setting.

When the Bluetooth is set successfully, there will be corresponding icon displayed in the measuring interface. The icon ⚡ means slave mode and ▯ means master mode. The color of icon presents different status, such as green color mans the communication status and the white color means wait status.

"Baud rata": 9600, 115200 and 1.382M.
"PIN Code": the code when communicate to other device with default value of 0000.
"New baud": 9600, 115200 and 1.382M.

Note: 115200 is recommended.

▬ 7.3.9 RS232 setup

"Baud rate": 4800, 9600 and 115200.
"FlowCont.": When the control flow is yes, then the instrument will check the voltage of pin DB9-7 before transmitting data to RS232. And low voltage means the outer device is busy and the instrument won't send data to RS232.

▬ 7.3.10 Default

"1. Save user parameter": the setting the user prefers can be saved as default user settings. Move the cursor to the option and press ⏎ key to save the settings. Then the instrument will show "OK" which means the setting is successful.

"2. Save user freq. weight": the user-defined frequency weight.

"3. Factory default": Move the cursor to "Factory default", and press ⏎ key, the settings will recover to the default value when it left the factory.

When the cursor is at "3." and press the ⊙ or ⊙ key to switch to "Load user default".
"3. Load user default" : And press ⏎ key to load the parameters saved in the "1. Save user parameter" and "Save user freq. weighting".

8. Data Recall

ST-15D Sound level meter has 32MB flash memory which assures reliable data storage, and the data stored in the instrument can be transferred to the computer by RS-232, USB, or printed out by mini-printer.

When user enter the "Recall" submenu from main menu, each page displays 15 groups of data, press ⊙ or ⊙ button to move the cursor and press ⊙ or ⊙ button to view the measuring name, data, time and analyzer, then press ⊙ to view the detail of measuring result.

The definition of measuring method:
Stat.-One: Once mode of Statistics
Stat.-24H01: the first time section of 24H measuring mode of Statistics
1/3 OCT-INT: 1/3OCT measurement data

8.1 Once measurement result recall

When the recalled data is the result measured in the one measurement method, the method displays "STA.-One". Press ⊙ key to go into the list interface, and press ⊙ key again to enter the Fig. interface, shown below:
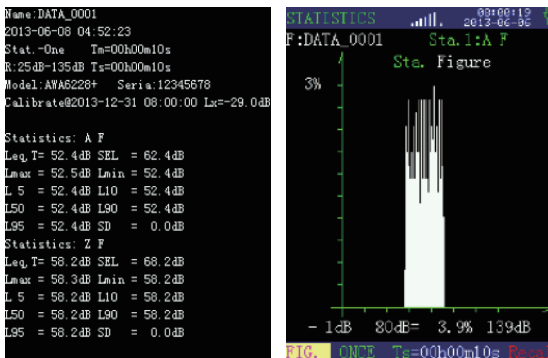
The list interface shows the information of measurement name, date, start time, measurement method, analyzer mode, instrument model, series, calibration date and sensitivity level etc.

In the Fig. interface, move the cursor to weighting selection "Sta.1"at the second line, and press ⊙ or ⊙ key to enter the Fig. interface of "Sta.2", shown below (Left). Move the cursor to "Statistics" distribution graph at the third line, and press ⊙ or ⊙ key to enter the accumulative distribution graph, shown below (Right):
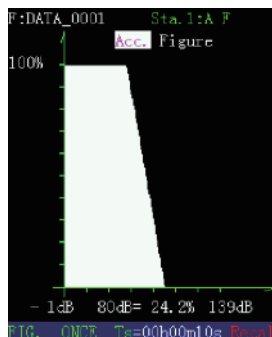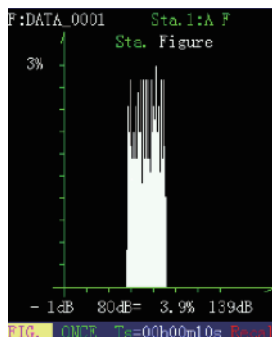
In the sta. Figure and Acc. Figure display interface, the user can move the cursor to the middle "dB" under the graph, press ⊙ or ⊙ key to view the statistic percentage and accumulative percentage of different sound pressure level.

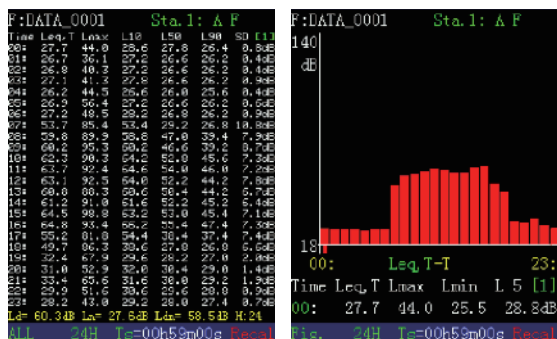If the extra Ln is open in the analyzer setup interface of STA, the measurement data will add L1, L99 and 5 user-defined Ln, shown below:

8.2 24H automatic monitoring result recall

When the measurement result is monitored automatically in 24 hours, the method displays "24H". Press ⊙ key to display the following screen:

Press ⤶ key in the interface to display the graph of Leq-T, shown below:

In this interface, when the cursor is moved to "Leq_T", by pressing ⊙ or ⊙ key, the user can view Lmax, L5, L10, L50, L90, L95-T chart. ⊙ or ⊙ key can move the cursor. When the cursor is on "21:", the user can view the data of each period via ⊙ or ⊙ key. When the cursor is on "Ld", the user can press ⊙ or ⊙ key to view Ln and Ldn, and press ⤶ key to return to the List display location. In the List display interface, press (Set) key to go to the statistic graph and accumulative graph display interface. For the operation, see the graphic view part in "8.1 Once measurement result recall".

If the extra Ln is open in the analyzer setup interface of STA, the measurement data will add L1, L99 and 5 user-defined Ln, shown below:

```
Name:DATA_0001                    Lmax = 68.4dB Lmin = 60.1dB
2015-06-15 09:19:16               L 5  = 66.0dB L10 = 65.0dB
Stat.-One    Tm=00h00m10s         L50  = 63.0dB L90 = 61.6dB
R:23dB-135dB Ts=00h00m10s         L95  = 61.4dB SD  =  1.4dB
Model:AWA6228+ Serial:12345678    L 1  = 68.0dB L99 = 60.6dB
Calibrate@2015-04-20 14:40:20 Lx=-31.1dB  L15 = 64.6dB L20 = 64.2dB
                                  L30  = 63.8dB L60 = 62.6dB
Statistics: A F                   L70  = 62.4dB L80 = 62.0dB
Leq,T= 55.6dB SEL  = 65.4dB       L85  = 61.8dB
Lmax = 64.7dB Lmin = 49.3dB
L 5  = 61.6dB L10  = 59.6dB
L50  = 52.2dB L90  = 50.0dB
L95  = 49.6dB SD   =  3.7dB
L 1  = 64.2dB L99  = 49.4dB
L15  = 58.2dB L20  = 57.0dB
L30  = 54.8dB L60  = 51.6dB
L70  = 51.2dB L80  = 50.6dB
L85  = 50.4dB
Statistics: Z F
Leq,T= 63.4dB SEL  = 73.2dB
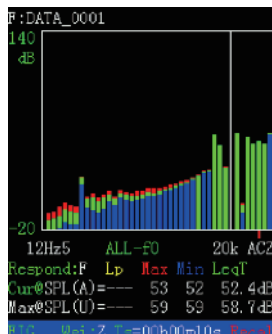```

## 8.3 1/3OCT measurement result recall

When the measurement result is measured by 1/3 Oct, the method displays "1/3 OCT-INT". When the cursor points to the measurement result of this method, press ⏎ key to go into the list interface, and then press ⏶ or ⏷ key to enter the next page, there are three pages. In the list interface, press ⏎ key to go into the Fig. interface, shown below:

```
Name:DATA_0001                           6k3Hz  35.2  11.8  31.1  14.7  24.6dB
2013-12-22 14:23:36                       5kHz  35.8  12.2  31.8  15.5  26.3dB
1/3 OCT-INT  Tm=00h00m18s                 4kHz  37.4  14.0  34.2  17.8  28.4dB
R:25dB-135dB Ts=00h00m18s Wei:Z          3k15Hz 38.3  16.4  35.3  21.2  29.8dB
Model:AWA6228+   Serial:12345678          2k5Hz 44.4  18.0  39.4  21.0  31.8dB
Calibrate@2013-12-31 08:00:00 Lx=-32.0dB   2kHz 46.7  23.1  41.2  25.8  33.8dB
                                          1k6Hz 48.3  25.5  44.0  27.4  35.4dB
        LFmax LFmin LSmax LSmin Leq,T    1k25Hz 53.0  26.6  47.9  28.6  38.2dB
SPL(Z)  77.3  51.2  71.8  55.0  63.1dB     1kHz 58.1  28.7  52.3  30.4  41.9dB
SPL(C)  77.0  48.5  71.5  50.6  61.5dB    800Hz 57.7  26.9  52.0  29.5  41.8dB
SPL(A)  67.7  39.3  62.4  40.8  52.3dB    630Hz 61.9  30.4  55.4  31.9  45.0dB
SPL(B)  45.2  45.2  49.0  49.0  58.5dB    500Hz 61.1  34.1  56.2  36.1  46.0dB
SPL(D)  45.5  45.5  50.6  50.6  58.3dB    400Hz 62.0  32.3  58.0  34.6  47.3dB
SPL(T)  62.7  27.0  57.0  30.0  46.0dB    315Hz 62.9  33.4  58.3  35.6  47.8dB
SPL(U)  78.4  46.1  72.7  51.9  62.6dB    250Hz 67.8  33.0  61.3  35.0  50.7dB
 20kHz  24.1  12.9  19.4  13.2  14.8dB    200Hz 71.8  35.8  66.3  38.2  55.1dB
 16kHz  30.7  12.8  24.4  13.2  17.6dB    160Hz 67.6  31.4  60.8  34.2  50.5dB
12k5Hz  29.1  13.1  27.2  13.6  20.2dB    125Hz 69.2  34.7  64.3  39.0  53.8dB
 10kHz  31.5  12.4  26.6  14.1  21.0dB    100Hz 67.5  33.9  61.1  38.2  50.8dB
  8kHz  32.8  12.0  28.6  14.1  22.7dB     80Hz 68.5  33.8  62.5  37.1  51.7dB
```

```
 63Hz   86.3  85.7  86.1  85.7  86.0dB
 50Hz  105.3 104.6 105.1 104.7 105.0dB
 40Hz   68.9  65.7  67.9  67.1  67.4dB
31.5Hz  36.7  27.6  49.7  41.2  31.9dB
 25Hz   36.0  28.2  47.5  39.4  32.3dB
 20Hz   37.7  24.3  47.6  39.2  34.8dB
 16Hz   38.6  24.8  48.0  39.8  35.3dB
12.5Hz  40.1  24.8  48.4  40.4  34.7dB
```



```
F:DATA_0001
140
 dB




-20
  12Hz5     ALL-f0      20k AC2
Respond:F   Lp   Max  Min  LeqT
Cur@SPL(A)=---   53   52   52.4dB
Max@SPL(U)=---   59   59   58.7dB
FIG.   Wei:Z Ts=00h00m10s Recal
```

The list interface displays the equivalent sound pressure level of each center frequency. In the Fig. interface, press the cursor and ⊙ or ⊙ key to adjust the location of the cursor and the display effect.

If the option of Extra F0 is open in the analyzer setup, the measurement data of 1/3OCT will add the data of 10Hz, 8Hz and 6.3Hz, shown below:

8.4 Delete data

In the data recall interface, the user can choose to delete several groups of data or delete all data.

8.4.1 Delete all data

In the data recall interface, whatever the number is the cursor at, as long as you press ⊙ key, there will a notice on the screen: "Clear all data?", shown below:

Press ⊙ key to delete all data, and press the other keys to return the recall interface.

▅▅ 8.4.2 Delete single group of data

In the data recall interface, whatever number is the cursor at, as long as you press the ⊙ₑₗₑₜₑ key, there will a notice on the screen: "delete this file?" shown below:

```
Name:DATA_0001                        Delete this file?
2013-06-08 04:52:23
Stat.-One   Tm=00h00m10s
R:25dB-135dB Ts=00h00m10s
Model:AWA6228+   Seria:12345678
Calibrate@2013-12-31 08:00:00 Lx=-29.0dB

Statistics: A F
Leq,T= 52.4dB SEL = 62.4dB
Lmax = 52.5dB Lmin = 52.4dB
L 5  = 52.4dB L10  = 52.4dB
L50  = 52.4dB L90  = 52.4dB
L95  = 52.4dB SD   = 0.0dB
Statistics: Z F
Leq,T= 58.2dB SEL = 68.2dB
Lmax = 58.3dB Lmin = 58.2dB
L 5  = 58.2dB L10  = 58.2dB
L50  = 58.2dB L90  = 58.2dB
L95  = 58.2dB SD   = 0.0dB
```

Press ⏎ key to delete this file, and press the other keys to return the recall interface.

▅▅ 8.4.3 Delete multi-group of data

In the data recall interface, press ⊙ₛₑₜ key to choose the number, then the background color of this number will be blue. If the user presses ⊙ₛₑₜ key again, the number won't be chosen. The user can choose more than one group once, and press ⊙ₑₗₑₜₑ key, then there is a notice: "Do you sure to delete the chosen data?" shown below:

```
No.    Name        Date       Delete the selected data?
0001 DATA_0001   2014-11-12
0002 DATA_0001   2014-12-12
0003 DATA_0001   2014-12-12
0004 DATA_0001   2014-12-15
0005 DATA_0001   2014-11-12
0006 DATA_0001   2014-11-12
0007 DATA_0001   2014-12-12
0008 DATA_0001   2014-12-12
0009 DATA_0001   2014-12-12
0010 DATA_0001   2014-12-12
0011 DATA_0001   2014-12-12
0012 DATA_0001   2014-11-12
0013 DATA_0001   2014-11-12
0014 DATA_0001   2014-11-12
0015 DATA_0001   2014-11-12
```

Press ⊙ₑₗₑₜₑ key to delete them and press other keys to go back to the main menu of recall.

9. GPS positioning measurement

When the instrument has GPS module, it can be used for positioning measurement and calibrating the RTC which is with higher precision.

Firstly, connect to the external antenna, and put the antenna outside the room where the antenna can directly receive the satellite signal. The time of searching the GPS signal for the first time will cost 1 minute.

Open the instrument, and enter the basic setup interface, set the GPS option as "Save" or "Open" mode. In the noise measuring interface, move the cursor to the "Statistics" and press ⏶ or ⏷ key to enter the GPS interface. The interface is shown as below when the antenna is not connected to the satellite.

"Zone:+08" in the second line is the Greenwich time, which is same with UTC，+8 means GMT means local time is 8 hours earlier than GMT. "GPS RTC" at the third line is the current time of GPS. Below the table are the latitude, longitude and altitude of the measurement starting point and finishing point. The unit of latitude and longitude is degree (°), and the unit of altitude is meter (m). The last English character of latitude and longitude means: "N" is North altitude, "S" is South altitude, "E" is East longitude, and "W" is West longitude.

"Star Num" below the table is the number of satellite which is connected successfully. "Distance" is the distance between starting point and finishing point. "Dir.:" is the angle calculated clockwise with the north direction as 0 degree. "Vel.:" is the moving speed from starting point to finishing point. "Cal.@" is the time of last calibration.

In this interface, and press the ⓢₑₜ key to calibrate the time of instrument by GPS time. Press the ⏎ key to change the site and measure the distance between the two points.

9.1 Distance measurement

When the antenna is connected to the satellite, the message of GPS time, the current position (starting point) and the working satellites. In this interface, press ↵ key to show the position message of finishing point and the displacement and velocity of the starting point. Press ↵ key again, the position of this moment of pressing the ↵ key will be taken as the start point, and the finishing point shows the message of current position.

9.2 Calibrate the RTC

In the interface of GPS, the GPS RTC shows the RTC, and press (Set) key to finish the calibration.

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9.3 GPS positioning measurement

In the noise measuring interface, move the cursor to the "Statistics" and press ⊙ or ⊙ key to enter the GPS interface. Open the GPS module and startup it, the position message of the starting point will be shown in the interface. The message of GPS refreshes every second. In the process of measuring noise, the measurement interface can switch to GPS interface, and it won't affect the result of statistics and integral measurement. The positioning message of last second will be saved along with the measurement result of statistics and integral, the last four line shows the message of position and velocity.

```
Name:DATA_0001
2014-12-23 09:39:13
OVERALL-INT  Tm=00h01m00s
R:22dB-132dB Ts=00h01m00s Unit:dB
Model:AWA6228+  Serial:00106693
Calibrate@2013-12-31 08:00:00 Lx=-29.0dB

LAFmax= 71.8 LCFmax= 73.4 LZFmax= 92.0
LASmax= 64.0 LCSmax= 68.3 LZSmax= 86.1
LAImax= 75.4 LCImax= 75.9 LZImax= 93.5
LAFmin= 48.7 LCFmin= 56.2 LZFmin= 58.6
LASmin= 50.4 LCSmin= 58.2 LZSmin= 60.3
LAImin= 53.5 LCImin= 59.8 LZImin= 61.9
LAeq,T= 56.8 LCeq,T= 62.0 LZeq,T= 73.3
LApeak= 87.3 LCpeak= 86.2 LZpeak= 94.7
LAE   = 74.5 LC-A  =  5.2 SEL   = 91.0
Latitude:3013.02653N
Longitude:11957.49602E
Altitude:87.3m
Velocity:0.160km/h
```

10. Data Export

ScarletSound for Scarlet Tech Sound Level Meter delivers easy-to-use, intuitive data monitoring and management with Windows based PC.

10.1 Software download and installation

1. Connect the USB drive comes with the package to your PC to find ScarletSound installer.
Alternatively, go to Scarlet Download Center on the official website or go to the following url to download the latest version of ScarletSound.
https://scarlet-tech.com/wp-content/uploads/ScarletSound/ScarletSound.zip

2. Extract and run the program, ScarletSound.exe. If running Windows Vista (or later), you will need to Right-Click on the ScarletSoundSetup.exe file and choose to Run As Administrator.

3. Select destination folder to install ScarletSound application and install.
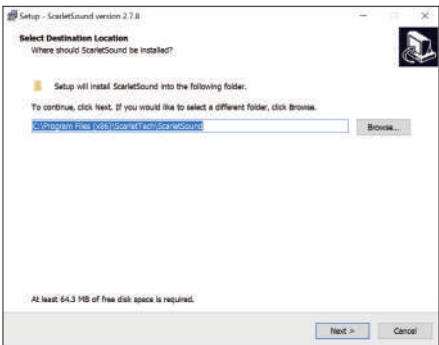
4. After installation finishes, double click to run ScarletSound application.
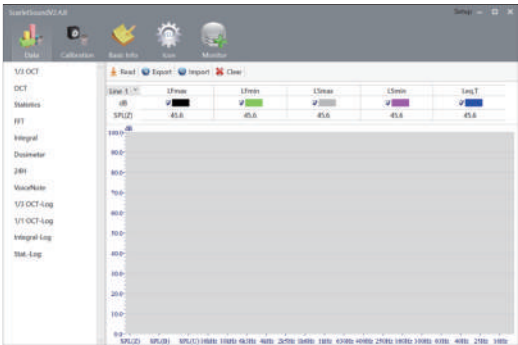
10.2 Settings

The data stored in the sound level meter of ST-15D can be transmitted to the computer by RS232 and USB. Connect the device to the PC by RS-232 or USB cable, and then run the ScarletSound Application. Click Setup to go to Setup menu.
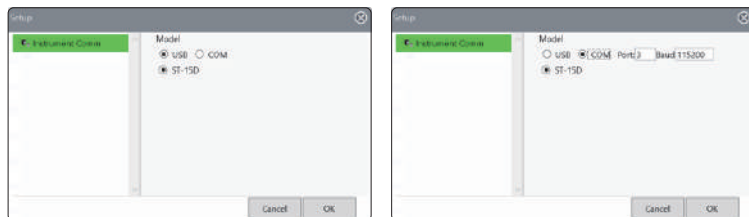
Select the transmission method and click the OK to save the settings. When the COM is selected, the default baud rate is 115200. The working modes of RS-232 are listed below.
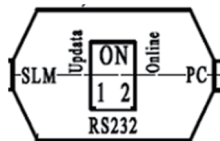
Switch		Working mode	Note
1	2		
OFF	OFF	RS232	Data transmission
ON	OFF	Firmware update	The Dfuse software should be installed and updating needs USB cable.
ON	ON		
OFF	ON	Online monitoring	The instrument will boot automatically when powered on and can also used for data transmission.

Note: The SLM side is connected to the sound level meter and the PC side is connected to the computer.

10.3 Download Data

Download data from the instrument
Click the option of "Read" to download the data from the instrument, and the data will be shown in the interface of the software.

10.4 Recall the data

Select desired file named "dd-mm-yyyy hh:mm:ss", the distribution graph and the data will be displayed in the right side.
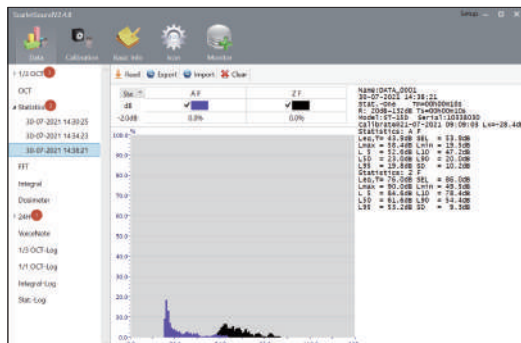
10.5 Save the data to PC

Save the data as the format of .xls by ScarletSound by clicking "Export".
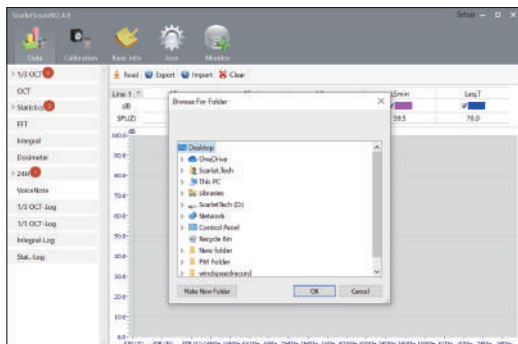
Read data from files
Click "Import" to restore data files previously stored in the installation directory "DataRecord".

10.6 Clear data displayed at the software

When the data in the instrument is deleted, the displayed data in the software won't disappear, by clicking "Clear" or restart the software to clear the displayed data.

10.7 Calibration record

Read the calibration record
Go to Calibration page, click the option of "Read" to download the calibration record from the instrument, and the data will be shown in the interface of the software.
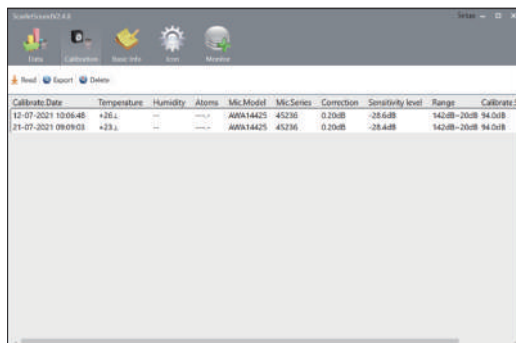
Save the calibration record to PC
Click "Export" to save the calibration record to PC by text filetype.
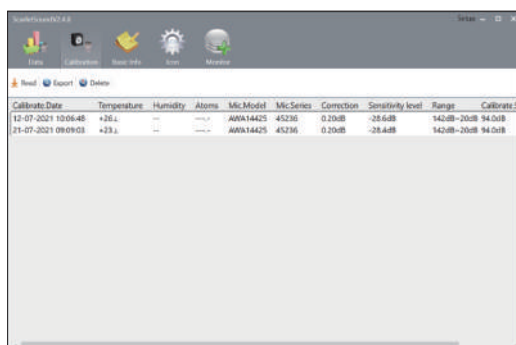
10.8 Basic Information

When the device is connected to PC by RS-232 cable, click "Basic Info" to go to Information page. Serial number of the instrument and microphone will show up.
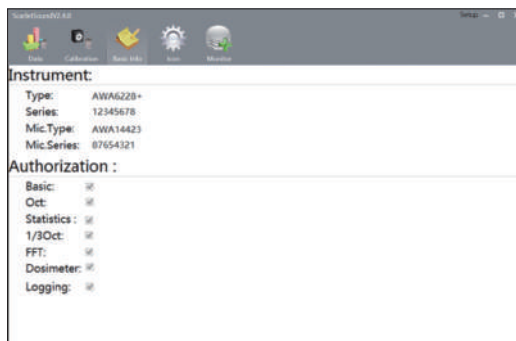
Note: The USB port communication method don't support for reading the basic information

10.9 Online Monitoring

The instantaneous SPL and 0.5s displayed SPL can be monitored. Firstly, set the interval of logging in analyzer setup 2 to at least 100ms. And enter the measurement interface, make sure the corresponding analyzer is open.
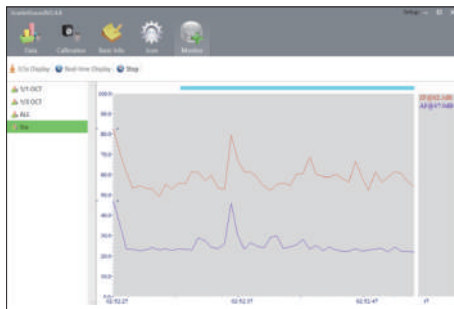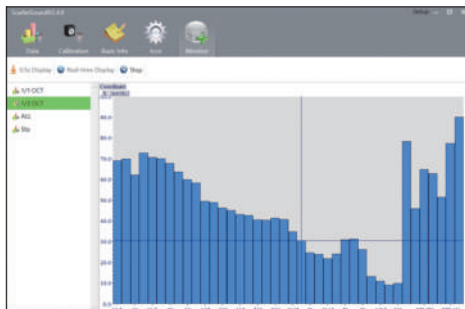
1/3 OCT: 12.5Hz, 16Hz, 20Hz, 25Hz, 31.5Hz, 40Hz, 50Hz, 63Hz, 80Hz, 100Hz, 125Hz, 160Hz,200Hz, 250Hz, 315Hz, 400Hz, 500Hz, 630Hz, 800Hz, 1kHz, 1.25kHz, 1.6kHz, 2kHz, 2.5kHz, 3.15kHz, 4kHz,5kHz, 6.3kHz, 8kHz, 10kHz, 12.5kHz, 16kHz, 20kHz, SPL(D), SPL(B), SPL(A), SPL(C), SPL(Z)
ALL: LApeak, LCpeak, LZpeak, LA0.5, LAIp, LASp, LAFp, LC0.5, LCIp, LCSp, LCFp, LZ0.5

Note:
1. *when the upper limit of y-axis is less than the max of the displayed parameters, click the Y-axis to adjust the range of the Y-axis.*
2. *Don't swith the 0.5s and real-time directly, click the "Stop" firstly.*
3. *Double-click the center frequency in the graph, then the value of the SPL will be displayed on the right side.*
4. *When download the data from the instrument, please don't operate the instrument before finishing reading.*
5. *If you want to change the transmission method, like from RS232 to USB, please reopen the software and reopen the instrument.*

11. Overload indication

When the noise to be measured exceeds for sound level above the upper limit of meter's measurement range, the meter may display "Overload" on the top. The overload indication is presented as long as the overload condition exists or 1s. In the statistical analysis process, if overload appears, the overload indication will latch until the measurement results are reset or next time measurement are started. The overload indication judges the peak value of signal. When the signal's peak value factor is high, the sound pressure level displayed on the meter is lower than measurement upper limit, but overload occurs possibly.

12. Annex

12.1 Annex 1 Response characteristics

Annex 1-1 Directional response

Frequency (Hz)	(dB)											
	15°	30°	45°	60°	75°	90°	105°	120°	135°	150°	165°	180°
500	0.3	0.1	0.2	0.2	0.1	0.3	0.7	0.7	0.5	0.5	0.4	0.5
630	0.1	0.1	0.1	0.2	0.2	0.1	0.6	0.9	0.8	0.6	0.6	0.2
800	0.1	0.1	0.1	0.3	0.2	0.1	0.1	0.4	0.4	0.7	0.6	0.3
1000	0.1	0.1	0.0	0.2	0.2	0.3	0.0	0.4	0.8	1.3	1.1	0.5
1250	0.3	0.4	0.2	0.1	0.2	0.1	0.2	0.1	0.2	1.3	1.8	1.0
1600	0.4	0.7	0.8	0.8	0.4	0.5	0.2	0.1	0.2	1.0	1.0	2.0
2000	0.7	0.7	0.8	0.8	0.9	1.2	1.1	1.0	0.6	0.9	2.8	2.7
2500	0.4	0.6	0.7	1.7	1.8	2.1	1.9	2.2	2.0	1.5	3.2	3.6
3150	0.4	0.3	0.9	0.6	0.5	1.1	1.2	1.1	1.7	1.2	2.7	4.2
4000	1.0	0.7	1.3	1.6	0.9	2.4	1.9	1.6	0.8	1.6	1.9	2.5
5000	1.8	1.9	2.7	3.1	4.1	2.8	5.0	4.2	2.8	3.7	3.1	4.6
6300	1.7	2.3	2.3	2.9	3.0	4.8	4.0	5.4	3.0	5.0	3.2	5.3
8000	1.1	1.0	2.0	2.7	4.0	3.7	4.0	5.3	6.2	4.4	4.8	6.2
10000	1.2	1.6	2.0	3.6	3.6	4.9	7.2	5.2	7.3	6.0	7.0	8.0
12500	0.1	0.5	1.3	3.1	3.4	4.3	7.2	8.9	7.4	8.4	9.0	8.5
16000	0.1	0.0	0.8	2.3	3.3	5.1	8.8	10.0	7.0	10.0	8.7	14.3
20000	0.4	0.2	1.1	3.2	5.1	8.4	9.6	11.1	13.4	12.8	13.0	17.3

1-2 Free field response
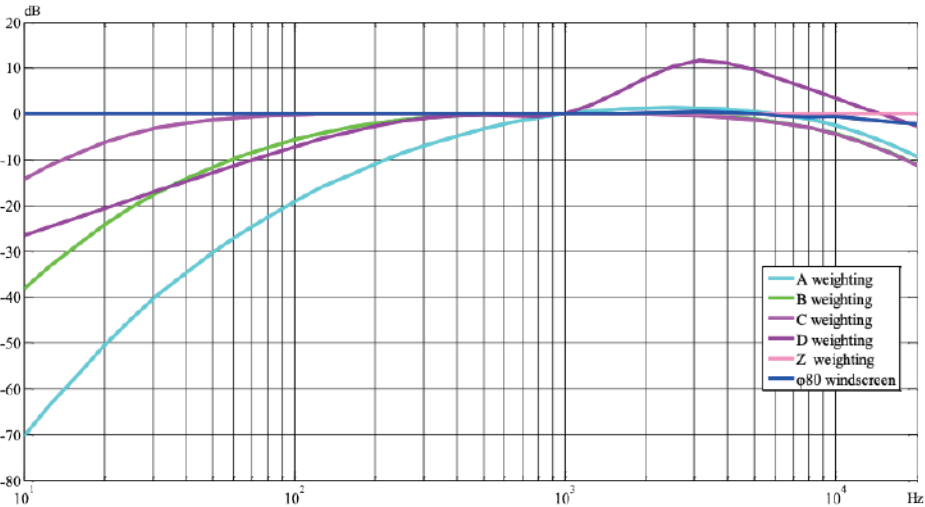
Z weighting response when directivity is 90 degree.

Hz	500	630	800	1000	1250	1600	2000	2500	3150	4k	5k	6k3	8k	10k	12k5	16k	20k
dB	0. 0	0. 0	0. 1	0. 1	0. 1	0. 2	0. 3	0. 4	0. 6	1. 0	1. 5	2. 1	3. 1	4. 3	5. 7	7. 6	9. 0

Z weighting response when microphone type is random.

Hz	250	315	400	500	630	800	1k	1.25k	1.6k	2.0k	2.5k	3.15k	4k	5k	6.3k	8k	10k	12.5k	16k	20k
Series1	0	0	0	0	0	0	0	0.1	0.1	0.1	0.2	0.3	0.5	0.7	1.1	1.7	2.6	3.9	5.9	7.9
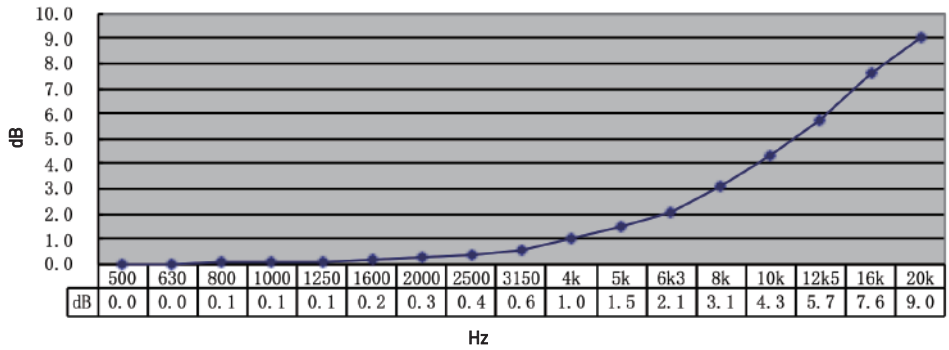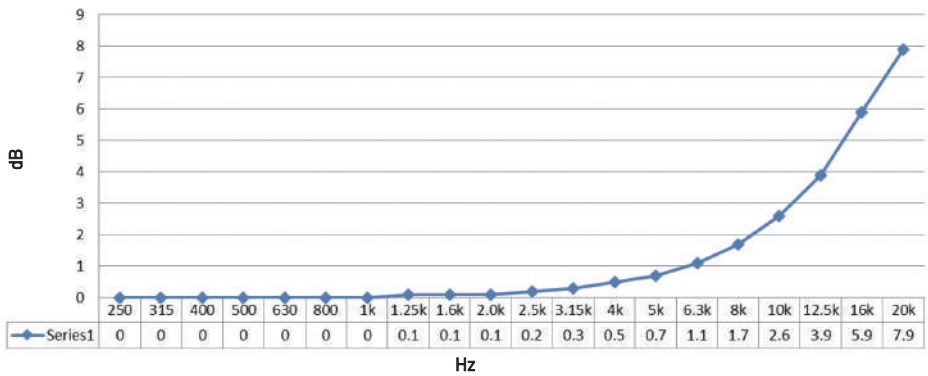
12.2 Annex 2 GPS overview

GPS is short for Global Positioning System. It utilizes 28 satellites flying around the earth to measure the precise position and time of random point on earth. Generally, its position precision is in 20m-1m and its time precision is in 60ns-5ns. It is developed by U.S. Department of Defense for military and civil. The civil signal can be used without charge. 28 satellites are running along six different tracks at a height of 20180km far from the earth. They can make sure any location on the earth is monitored by at least four satellites.

GPS' positioning precision is related to the quality of the received signal. The positioning precision means the result measured by satellite analog signal generator in the lab. The satellites' transmission power is not high and the signal is easy to be blocked or reflected, which affect positioning precision. Therefore, the receiving sensitivity of the receiver shall be high. The meter's embedded GPS module has high receiving sensitivity, so it can receive weak signal for positioning in city center or indoor. As the receiver's catching sensitivity is lower than the tracking sensitivity, so the user can firstly move the receiving antenna to signal-stronger place (such as outside the window) when using it indoor or in the weak-signal environment. After the receiver catches 4 satellites' signal and positioning can be made correctly, move the antenna to the place to be positioned.

GPS positioning measurement of ST-15D mainly measures longitude, latitude, altitude, movement speed, movement direction and straight-line distance between two points. The unit of longitude and latitude is degree. The user can find the satellite pictures of relevant longitude and latitude through inputting the following content on the internet. http://maps.google.com/maps?t=k&hl=en&ie=UTF8&z=18&ll= 25.0309073, 121.5431877& In the "&ll= 25.0309073, 121.5431877&", the 25.0309073 is latitude and 121.5431877 is longitude. It is required to change by users themselves.

The altitude error is larger, and the movement speed and movement direction are calculated by the distance between two points within fixed interval. When the movement speed is lower or in static state, the two data errors are much larger. The movement speed error is about ±3.6km/h. To reduce the error caused by satellite movement, it is suggested for the user to measure the distance within shortest time as can as possible.

12.3 Annex 3 Filter attenuation characteristics

Relative attenuation of 1/3 octave band pass filter at 12.5kHz center frequency.
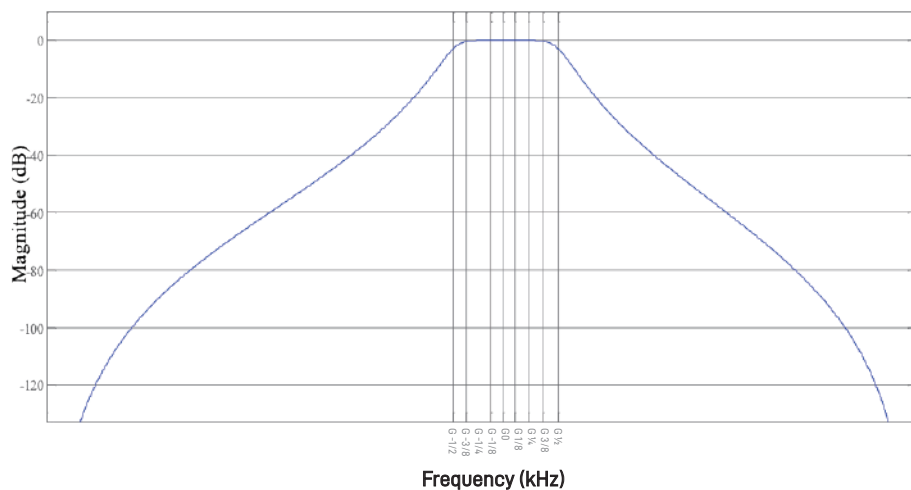
Z weighting response when microphone type is random.
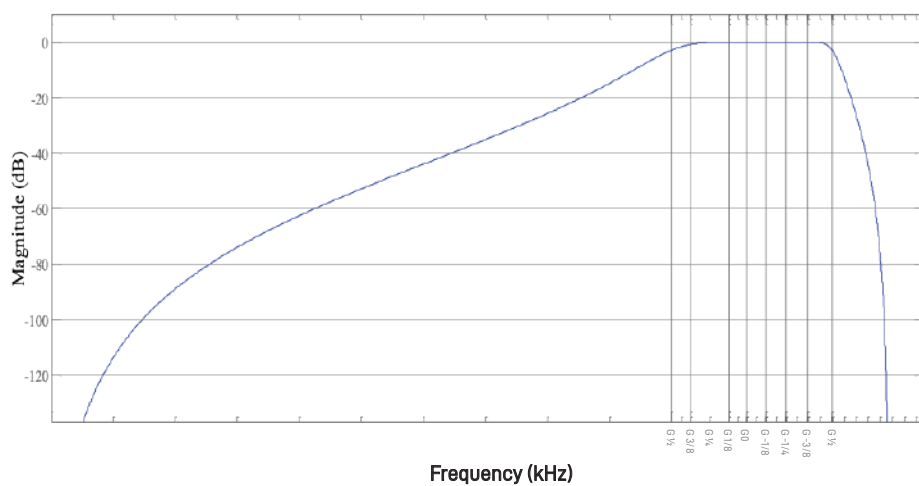
13. Safety, Handling, & Maintenance

Important safety information

> *WARNING:* *Failure to follow these safety instructions could result in fire, electric shock, or other injuries, or damage to sound level meter or other property. Read all the safety information below before using sound level meter.*

Operate Avoid using instrument in humid or wet places. Make sure that humidity is within the limits indicated in the next section. Avoid using meter in presence of explosive gas, combustible gas, steam or excessive dust.. Be sure to turn it off after use. If you expect not to use the instrument for a long period remove batteries to avoid leakages of battery liquid which could damage the its inner components.

Handling Handle the meter with care. It is made of sensitive electronic components. The meter can be damaged if dropped, burned, punctured, or crushed, or if it comes in contact with liquid. Don't use a damaged meter, such as one with a cracked screen, as it may cause injury.

Important handling information

Cleaning Clean instrument immediately if it comes in contact with anything that may cause stains — such as dirt, ink, makeup, or lotions. To clean:
• Disconnect all cables and turn instrument off.
• Use a soft, lint-free cloth.
• Avoid getting moisture in openings.
• Don't use cleaning products or compressed air.

Operating temperature The instrument is designed to work in ambient temperatures between 5° and 40° C (41° and 104° F) and stored in temperatures between -10° and 60° C (14° and 140° F). The instrument can be damaged and battery life shortened if stored or operated outside of these temperature ranges. Avoid exposing the instrument to direct sunlight even the the air temperature is within the limits.

Operating humidity The instrument is designed to work in humidity < 80%rh and stored in dry place where humidity is less than 70%rh.

Store microphone carefully Microphone is the key component of the instrument and keep it dry and avoid severe shake or vibration.