

RT-60

This chapter describes the measurement features associated with the RT-60 optional firmware 831-RT.

Accessing RT-60 Mode

There are two ways to activate RT-60 measurement mode. One way is to select the RT-60 icon on the Control Panel and the other is to recall an RT-60 setup using Setup Manager.

Using the RT-60 Icon

A shortcut is to press the  (TOOLS) key and then the Up Arrow key twice to highlight the RT-60 icon.

Note: The RT-60 icon is replaced by the Room Acoustics icon if the 831-RA option is installed.

To access the RT-60 mode, press the  (TOOLS) key to open the Control Panel, select the RT-60 icon as shown in FIGURE 13-1.

Changing modes using the icon on the control panel will load the setup that was previously in use for that mode.

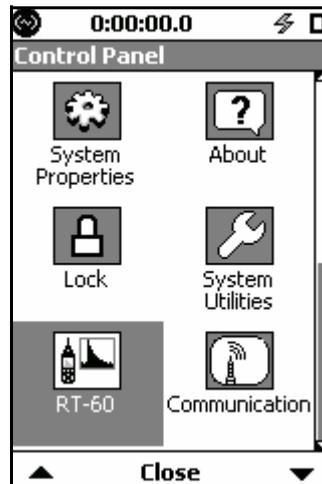


FIGURE 13-1 RT-60 Icon

Press the  (ENTER) key to open the RT-60 mode tabs as shown in FIGURE 13-2.

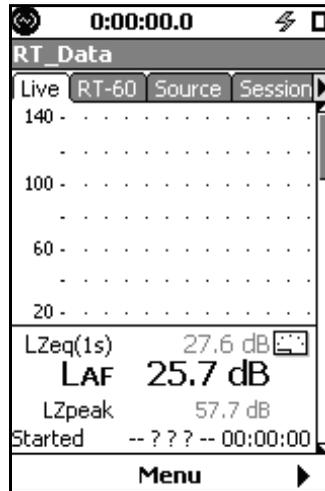


FIGURE 13-2 RT-60 Pages

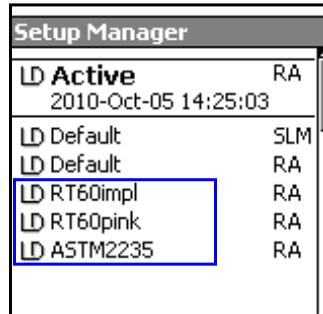
Using the Setup Manager

To load a setup file via the Setup Manager, press the  (TOOLS) key to open the Control Panel. Select the Setup Manager icon as shown in FIGURE 13-3.



FIGURE 13-3 Setup Manager Icon

Open the Setup Manager to display the available setups as shown in FIGURE 13-4. Note that the instrument mode associated with each setup file is indicated in the right-hand column. RA indicates RT-60 (Room Acoustics) mode.



Setup Manager	
ID Active	RA
2010-Oct-05 14:25:03	
ID Default	SLM
ID Default	RA
ID RT60impl	RA
ID RT60pink	RA
ID ASTM2235	RA

FIGURE 13-4 RT60 Setups in Setup Manager

If you have created and saved your own RT-60 setups, these will also appear in the list and can be similarly selected.

As a “quick start”, several predefined RT-60 setups are provided (see the ‘Making a Measurement’ on page 13-4’):

- **RT60impl** - Impulse method
- **RT60pink** - Interrupted Noise method using pink noise via the internal noise source
- **ASTM2235** - Specific to ASTM E2235 using the internal noise source

Any setting changes made while one of these setups is active will become permanent. Refer to the Setup Manager section in Chapter 4 for information on creating custom setup files.

Making a Measurement

Selecting the Method

There are two methods available for measuring reverberation time:

- Impulse Method (using Schroeder reverse integration)
- Interrupted Noise Method

In many instances, RT60 measurements can be made using the predefined setup files provided.

Impulse Method

Step 1 Recall RT60impl from the Setup Manager.

Step 2 Make a measurement using a starter pistol or balloon burst (operator is in room).

Step 3 Move microphone or source position and repeat as desired.

Interrupted Noise Method

Step 1 Recall RT60pink from the Setup Manager.

Step 2 If using the internal noise generator, connect the AC output of the Model 831 to an amplifier/speaker system. If using an external generator, set the RT-60 noise type to "OFF" (see the 'Customizing Measurements' on page 13-22') and generate noise externally.

Step 3 Make a measurement (operator exits room until the desired number of decays is obtained). A trial measurement may be needed to ensure the noise source is sufficiently loud and the trigger level is exceeded.

Step 4 Move microphone or source position and repeat the number of times needed for desired accuracy grade (see 'Accuracy Grade' on page 13-32).

Measurement State Sequence

This section presents the sequence of Model 831 screen displays and actions taking place during a measurement.

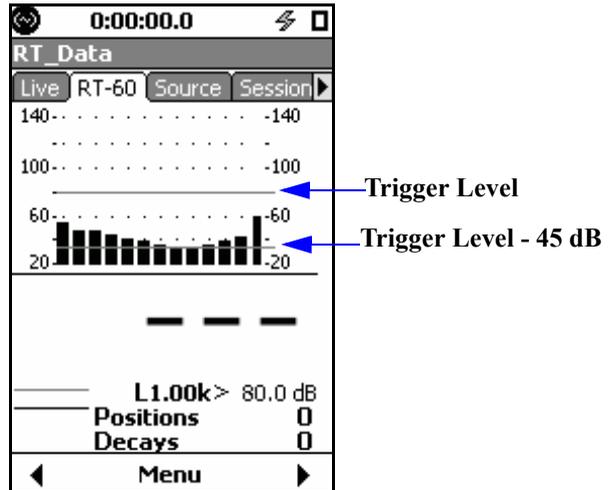


FIGURE 13-5 RT-60 Status Screen

Initiate Measurement

Initiate a measurement by pressing the  (RUN/PAUSE) key, at which time the icon shown in FIGURE 13-6 will appear in the lower left corner of the screen. This lasts as long as the configured Exit Time. No data is taken while this icon is shown.



FIGURE 13-6 Exit Prompt

Background Noise Measurement

After the Exit Time has passed, the background noise is measured, as indicated by the icon shown in FIGURE 13-7. The background noise level is measured for 5 seconds and is then used for determining signal-to-noise ratio on successive decays. The background noise level is measured for every position, i.e., every time "Run" is pressed.

T20 uses data from -5 dB to -25 dB and requires a signal to noise ratio of at least 35 dB. T30 uses data from -5 dB to -35 dB and requires a signal to noise ratio of at least 45 dB.



FIGURE 13-7 Background Measurement Display

Filling Pre-trigger Buffer

When the background measurement has completed, the pre-trigger buffer fills as indicated by the icon shown in FIGURE 13-8.

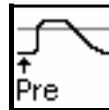


FIGURE 13-8 Pre-Trigger Buffer Display

Ready For Excitation Signal

When the pre-trigger buffer is full, the “Ready” icon shown in FIGURE 13-9 will appear in the lower left corner of the screen, and the  (STOP/STORE) key will flash red to indicate that the source within the room should be activated. If using the internal noise source, it will start automatically.



FIGURE 13-9 Ready Display

Valid (Interrupted Method Only)

The Valid display will not appear when using the Impulse Method.

When using the Interrupted Noise method, the “Valid” icon shown in FIGURE 13-10 indicates that the room has been successfully energized. This occurs when the trigger level is exceeded for at least as long as the configured Build Time. If using an external noise source, do not stop the noise output until this icon is displayed. The  (STOP/STORE) key will stop flashing to indicate that an external noise source should be turned off. If using the internal noise source, it will stop automatically.

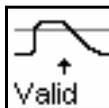


FIGURE 13-10 Valid Display

Triggered

When the measurement has been triggered, the “Triggered” icon shown in FIGURE 13-11 will appear in the lower left corner of the screen.

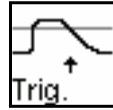


FIGURE 13-11 Triggered Display

Measurement Complete

When the measurement has completed, the display shown in FIGURE 13-12 will appear. The icon in the lower left of the screen indicates a successful measurement, and the position count has been incremented. The spectrum graph displayed is for the last excitation.

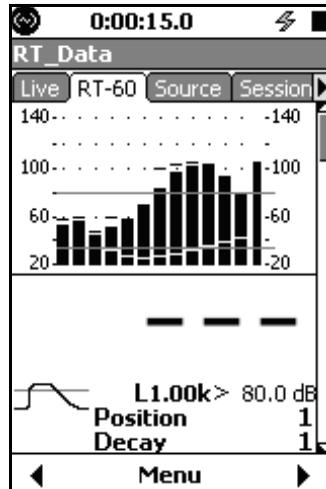


FIGURE 13-12 Measurement Completed

Repeat Measurement

The operator can now move the microphone and/or noise source and press the  (RUN/PAUSE) key to initiate another measurement sequence.

Viewing and Analyzing Results

The data displays are the same regardless of the method used for the measurement.

Following a measurement, the data can be viewed on the RT-60 tab pages as follow:

- RT-60 Status
- RT-60 Spectra
- RT-60 Decay Curve
- Excitation Levels
- Quality Summary (two pages for 1/3 octave data)
- Quality Detail
- Accuracy Grade

RT-60 Status

The RT-60 Status display shows the previously described measurement states. After the measurement is complete, it also shows the Lmax, Leq, and background level for each frequency, as well as the Z-weighted Leq value.

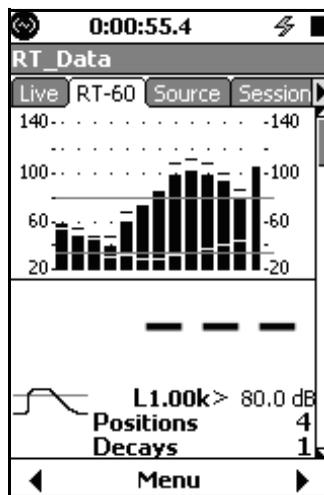


FIGURE 13-13 RT-60 Status

RT-60 Spectra

The RT-60 Spectra display shows a graph of the reverberation times for each frequency of the ensemble average or an individual decay. Both T30 (black line) and T20 (grey line) data are displayed.

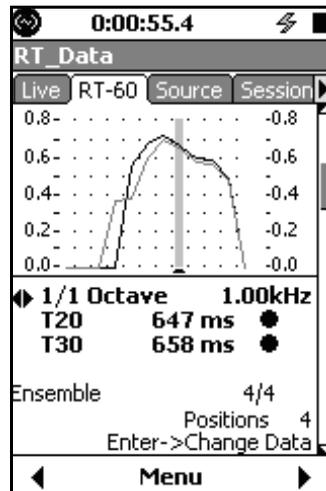


FIGURE 13-14 RT-60 Spectra

Note: The navigation described here applies to most of the pages on the RT-60 tab.

A prompt near the bottom of the display ("Enter-> Change Data" in figure 13-4) indicated where the focus of the left/right arrows will go when the  (ENTER) key is pressed.

When viewing information for the ensemble average, pressing the  (ENTER) key will toggle the role of the left/right arrow keys between changing ensemble/decay and changing frequency.

When viewing information for an individual decay, pressing the  (ENTER) key will toggle the role of the left/right arrow keys between changing ensemble/decay, frequency, and decay number. See FIGURE 13-5.

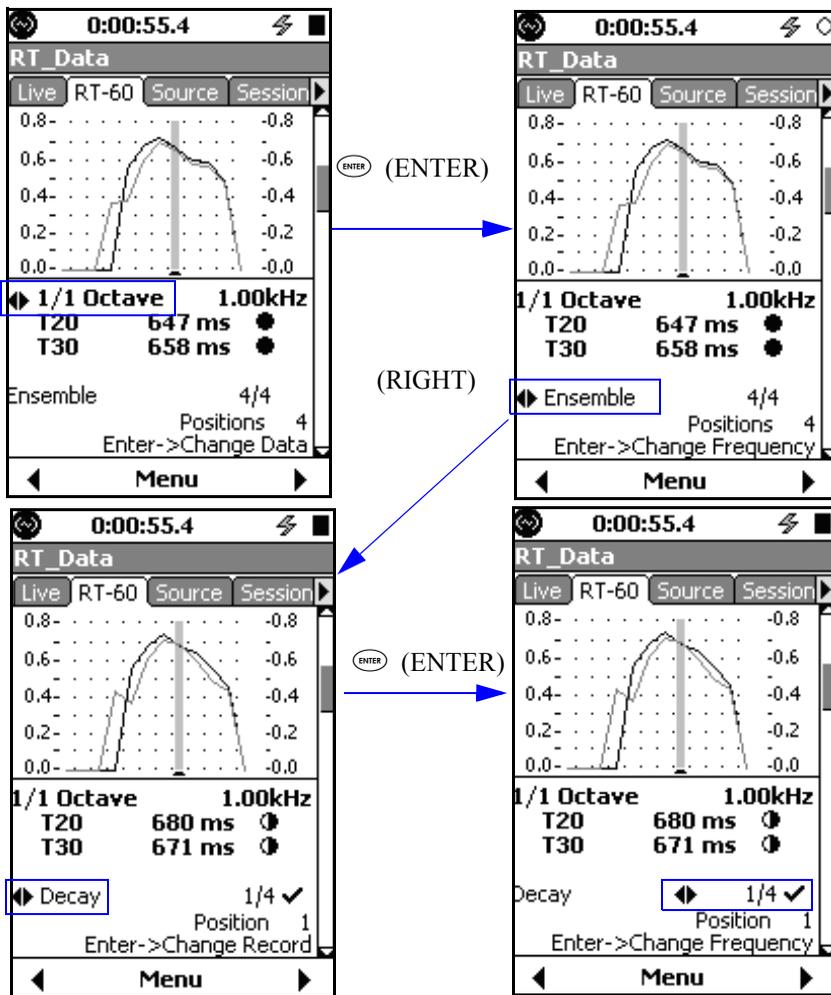


FIGURE 13-15 Navigation

RT-60 Decay Curve

Note: In the upper right corner of the display is a $t=1.98s$. This value represents the time duration of the data being displayed

The RT-60 Decay Curve display shows the time domain ensemble or individual decay curve.

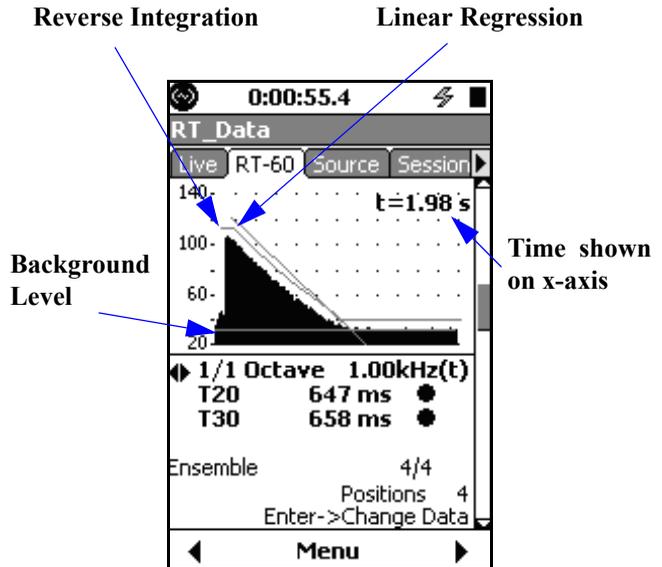


FIGURE 13-16 RT-60 Decay Curve

The linear regression line on the graph is usually associated with the T30. However, if the T30 decay time was undetermined, the T20 data is used. When the Impulse method is used, the reverse integration curve is also shown on the graph.

Excitation Levels

The Excitation Levels display shows the equivalent, maximum, and background levels for all frequency bands of the ensemble average or for an individual decay. From this it can be determined which frequencies were sufficiently energized for a desired decay range.

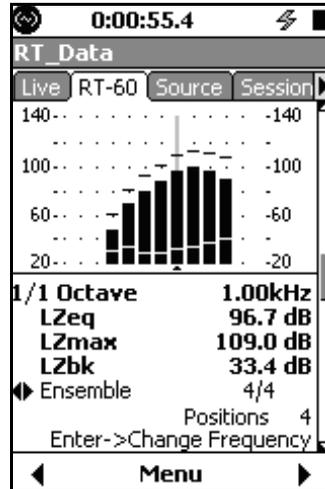


FIGURE 13-17 Excitation Levels

LZeq is computed as the Leq between the initial exceedance of the trigger level to when the signal falls below the trigger level minus 5 dB.

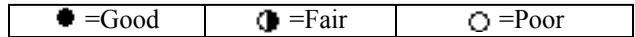
LZmax is the maximum value of the time history.

LZbk is the background level measured for this frequency at this position.

Quality Summary

The left/right arrows keys will toggle between T20 and T30.

This display provides a summary of the quality indicators for all frequencies between the configured highest and lowest filters. For 1/3 octave measurements, this display may span two pages. For more information about the quality indicators, see the 'Quality Indicators' on page 13-30.



Note: If a decay time could not be determined, the quality indicator icon will not be present.

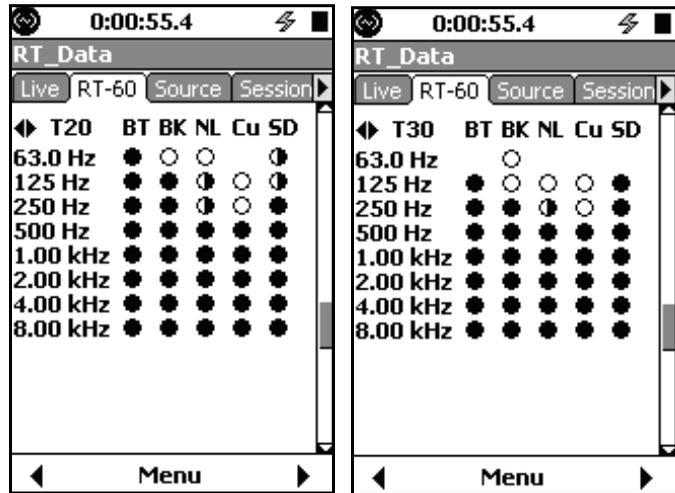


FIGURE 13-18 Quality Summary

Quality Detail

The left/right arrow keys will scroll through the frequencies.

This display provides details about the quality indicators for the selected frequency. If a metric is determined to be "Fair" or "Poor", the criteria that failed is shown in the right-hand column as shown in FIGURE 13-19.

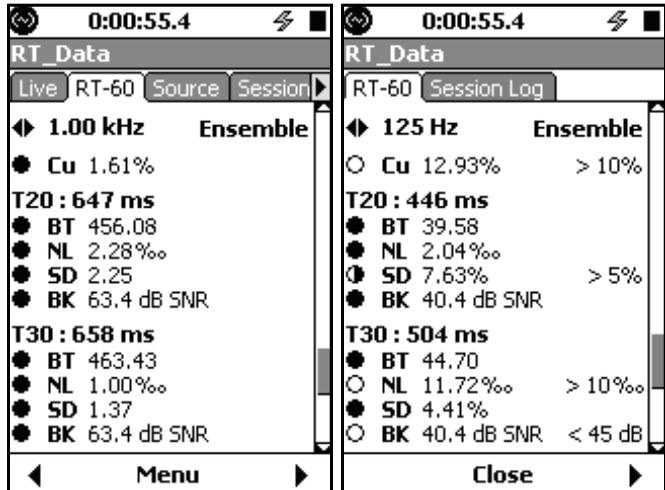


FIGURE 13-19 Quality Detail

Accuracy Grade

See definitions on page 13-29

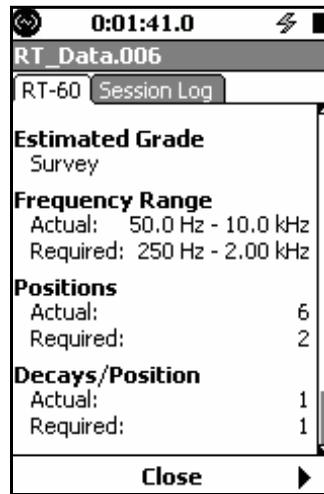


FIGURE 13-20 Accuracy Grade

Excluding Samples from the Ensemble

Excluding a decay will exclude all frequencies for the selected decay.

Note: Once the data has been stored, it cannot be edited in the Model 831; therefore individual decays cannot be included or excluded from the ensemble.

When the display is showing data for an individual decay, the operator has the option of excluding the current decay from the ensemble average. Excluding decays from the ensemble is useful when one or more are corrupt, as is evident in FIGURE 13-21. In this case, the operator coughed during a measurement.

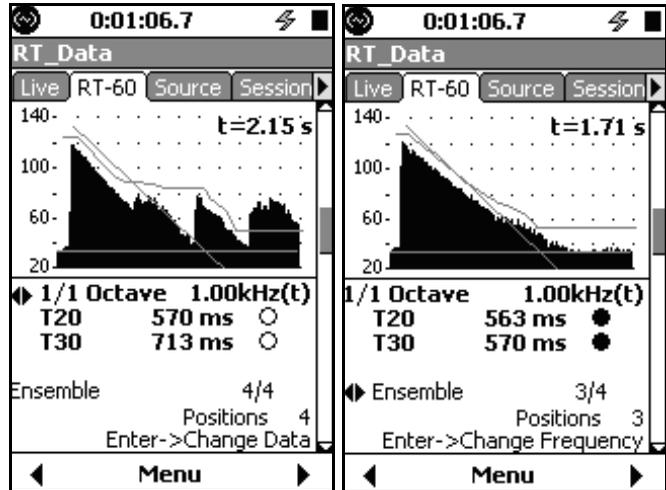


FIGURE 13-21 Ensemble Before and After Excluding a Corrupt Decay

To exclude a decay, press the Center Softkey labeled **Menu**, highlight **Exclude**, press the **ENTER** key. An "X" will appear next to the sample number to indicate it is excluded..

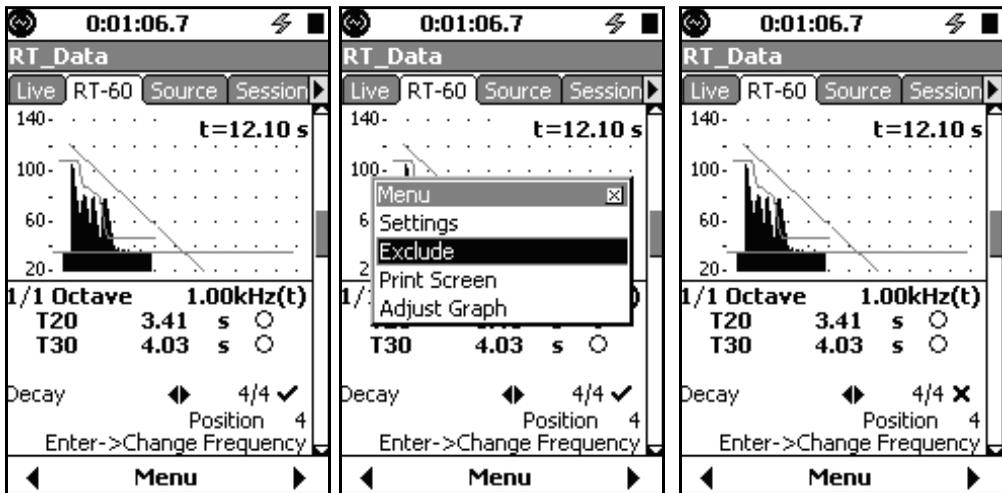


FIGURE 13-22 Steps to Exclude a Measurement

To re-include a decay that has been excluded, follow the same steps except highlight **Include** on the menu.

Manually Controlling the Internal Noise Source

When operating in the Room Acoustics instrument mode, the Model 831 provides an internal noise generator capable of outputting white or pink noise via the AC output jack.

The noise source is controllable from the Source display as follows:

- The  and  keys control the noise type.
- The  and  keys control the attenuation, which adjusts in 3dB steps.
- The  key toggles the mute on and off.

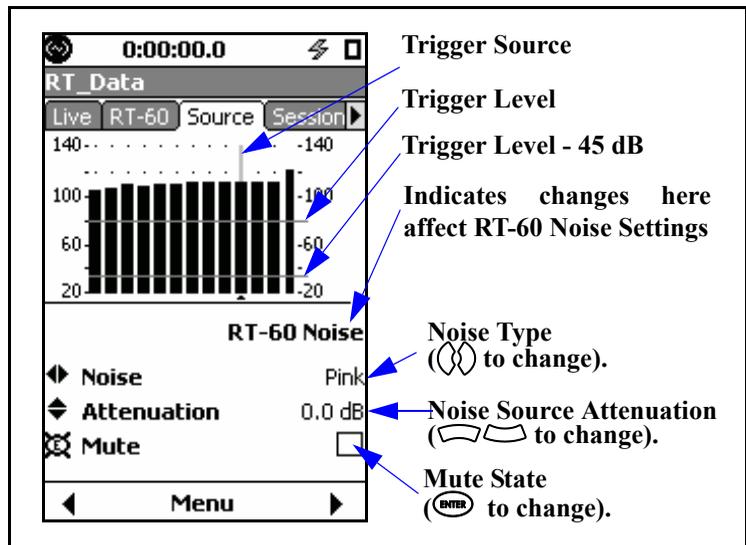


FIGURE 13-23 Source Display Summary

When the measurement method is set to Impulse or the Link to Source Display control is unchecked, the source is controllable independent of the RT-60 measurement.

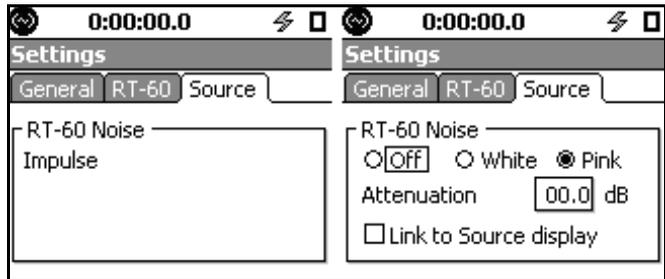


FIGURE 13-24 No Link to Source Display

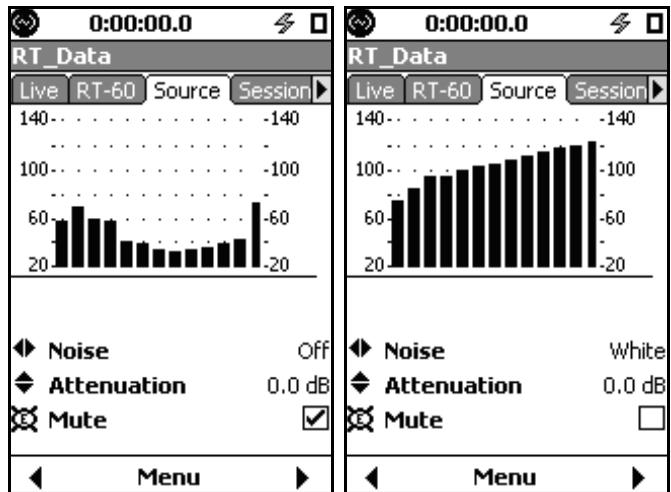


FIGURE 13-25 Independant Controls

When the measurement method is set to Interrupted Noise and the Link to Source Display control is checked, adjustments made on the display are reflected in the RT-60 Noise controls. In this case there is a notification under the graph and the trigger level and trigger source are shown.

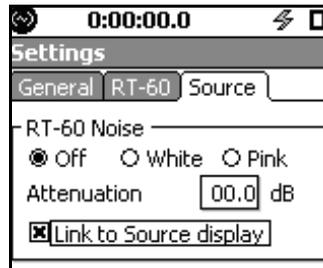


FIGURE 13-26 Link to Source Display

Note: If the trigger source is set to Z or Mid Band, a cursor will not be shown.

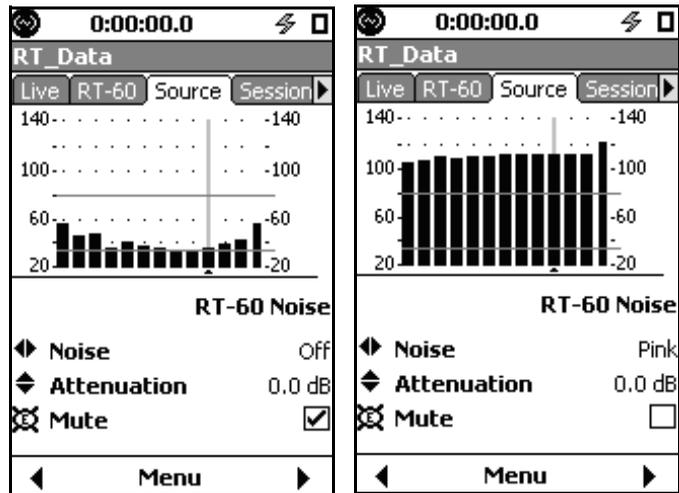


FIGURE 13-27 Linked Controls

Hints on Making a Good RT-60 Measurement

- Make sure the exit time is long enough to allow egress and any residual noise to die down
- Turn off your cell phone and remove other possible sources of sound contamination.
- Be quiet during the background level measurement (between the exit period and filling the pre-trigger buffer. See the 'Measurement State Sequence' on page 13-5'.
- Minimize the ambient noise in the room by turning off the mechanical equipment (i.e., HVAC units).
- Close doors, windows, and partitions to reduce reverberant energy from adjoining areas.
- Use a sound source with repeatable amplitude and spectral content.
- Use the exclude feature when something goes wrong. It is a good idea to configure the instrument to take a few more decays than what is required just in case.
- Trigger near the maximum level. For interrupted noise method measurements, a few trial runs may be required to determine a good trigger point due to the requirement that the noise source level be above the trigger level for a specific duration (Build Time).
- Energize the room sufficiently. It may take multiple sound sources and measurements to characterize the decay times over the full desired spectrum.
- Make measurements at many different source-microphone combinations to improve the ensemble uncertainty. See the "Accuracy Grade section on page 13-28 for more information.
- Minimize what is in the room (see ISO 3382-2:2008(E) Section 4.1).

- ASTM E2235 requires working with a diffuse field (random incidence) microphone. You can select the correction FF->RI to adapt your microphone characteristics if needed.

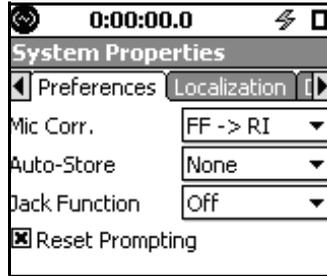


FIGURE 13-28 Microphone Correction

Customizing Measurements

From any of the pages on the RT-60 tab, press the Center Softkey labeled **Menu**, highlight **Settings**, press the **ENTER** key to display the settings tabs shown below. These pages are used to modify the measurement parameters. The active parameter values shown represent the default values.

General Settings

Impulse and Interrupted Methods

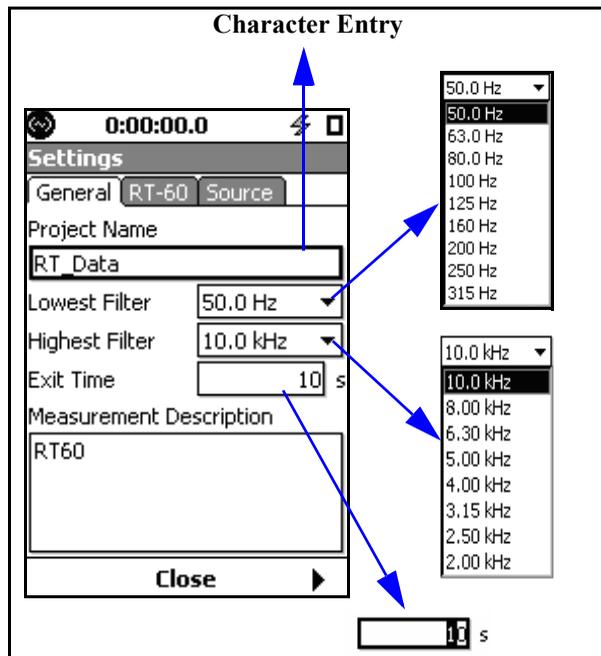


FIGURE 13-29 General Settings

Lowest and Highest Filters define the frequency range over which the measurement will be made.

The Exit Time is set to give the operator enough time to exit the room and to allow any residual noise to decay before starting a measurement and can range from 0 to 99 seconds.

RT-60 Settings

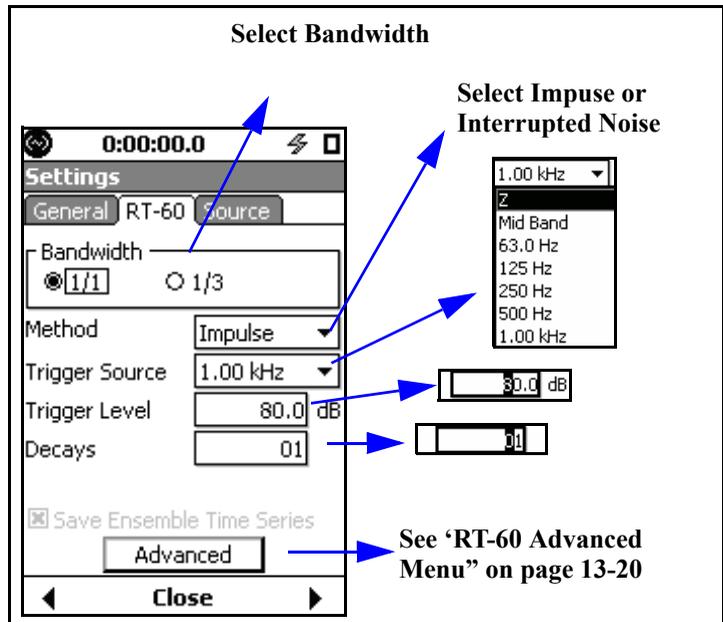


FIGURE 13-30 RT-60 Settings: Impulse Method

Method can be either Impulse or Interrupted Noise.

Trigger Source allows the user to select which filter output to use as the trigger source to when making a measurement and can be:

- Z-weighted
- Mid-Band: using the energy from the filters between 500 Hz and 2 kHz
- 1/1 or 1/3 octave filters, based on the bandwidth selected

Trigger Level is the signal level at which a reverberation time measurement is triggered. When using the Impulse method, data acquisition is triggered when the rising sound level exceeds the configured Trigger Level. When using the Interrupted Noise method, data acquisition is triggered when the decaying sound level drops to 5 dB below the configured Trigger Level.

Decays indicates the number of successive reverberation time measurements to take at a location. Once the measurement is started by pressing  (RUN/PAUSE), the

Note: Trigger Source will also be limited to be between the Lowest and Highest filters (inclusive) as set in the General Tab page shown in FIGURE 13-29.

Model 831 will begin making the measurement and automatically stop when the configured decay count has been reached.

RT-60 Advanced Menu

The advanced menu provides additional options that can be used to fine tune a measurement.

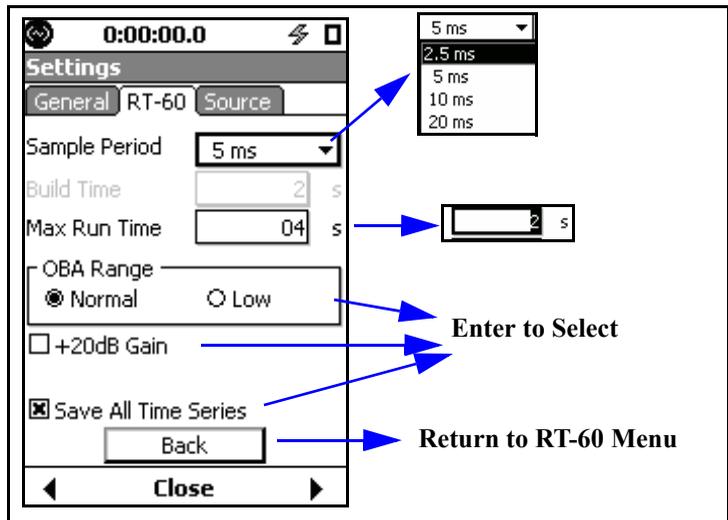


FIGURE 13-31 RT-60 Advanced Settings: Impulse Method

Sample Period sets the time interval between samples of the sound decay curves.

Max Run Time is used to set the post trigger run time. The maximum value is dependant upon the Sample Period as indicated by ‘Max Run Time vs Sample Period’ on page 13-25.

Sample Period (ms)	Max Run Time (s)
20	19
10	18
5	9
2.5	4

Table 13 - 1 Max Run Time vs Sample Period

Care must be taken to ensure the decays are sampled adequately and this can be evaluated using some simple math. Consider that we have a reverberation time of 420 ms for a 60 dB decay. 20 dB is 1/3 of 60 dB, so for T20, we have $420 / 3 = 140$ ms. Sampling at 5 ms gives us $140 / 5 = 28$ data points. For T30 we have 210 ms or 42 data points.

Build Time is available when the method is set to Interrupted Noise. The Build Time is the time the noise level must be above the configured Trigger Level to sufficiently energize the room. For example, if the Build Time is set to five seconds, the sound source will be on for five seconds plus the time it takes for the sound level to reach the trigger level.

Use +20 dB gain only for Interrupted Noise since impulses quickly exceed 120 dBZ.

Source Menu

Impulse Method

The RT-60 noise controls are unavailable when using the Impulse method.

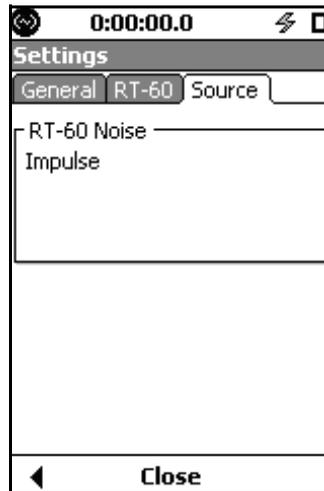


FIGURE 13-32 Source Setting: Impulse Method

The impulse signal is generated externally, i.e., with a starter pistol, a balloon, etc.; there is nothing to configure on this page.

Interrupted Noise Method

Whether using an external source or the internal source, the Model 831 is designed to automate and simplify the process by making measurements based upon triggers.

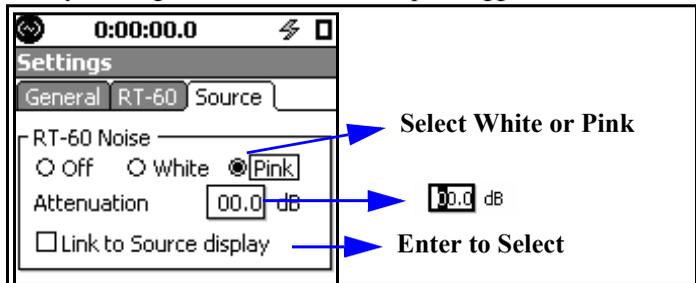


FIGURE 13-33 Source Settings: Interrupted Noise Method

The signal used to energize the room can be generated by an external sound source or using the internal noise source of the Model 831. If using an external source, select "Off". If using the internal noise source, select "White" or "Pink" noise.

The Model 831 outputs the noise signal via the AC output connector. An external amplifier and speaker system are needed to sufficiently energize a room.

Attenuation is used to reduce the output signal from the Model 831 in instances where the level might overload the amplifier input.

The Link to Source Display check box, when checked, will allow the user to control these settings in real-time from the source display.

Storing Data

Press the  (STOP/STORE) key to store data.

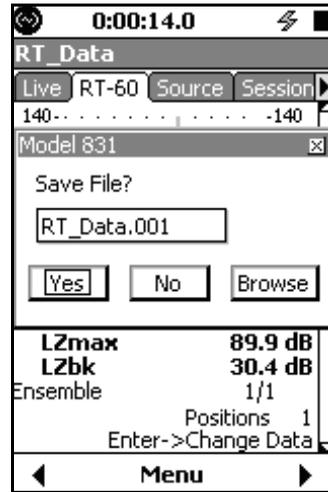


FIGURE 13-34 File Save Dialog

Viewing Stored Data

The stored data displays are the same regardless of the method used for the measurement.

Note: The Data Explorer only shows files from the current instrument mode.

Following a measurement, the stored data can be viewed on the RT-60 tab pages as follow:

- RT-60 Spectra
- RT-60 Decay Curve
- Excitation Levels
- Quality Summary (two pages for 1/3 octave data)
- Quality Detail
- Accuracy Grade

Use the Data Explorer utility to view stored measurements on the 831. Data Explorer is opened by pressing the  (TOOLS) key and then selecting the icon labeled "Data Explorer". When this utility opens, it will display the saved files. To open one of the files, highlight the file and press the  (ENTER) key. The data can now be viewed just as was outlined in the "Viewing and Analyzing Results" section. One exception is that the data cannot be edited, therefore individual decays cannot be included or excluded from the ensemble.

Quality Indicators

The Model 831 provides a variety of measurement “quality indicators” using criteria described in ISO 3382-2:2008(E). For more information, including the equations used to calculate each metric, please refer to ISO 3382-2:2008(E). Each quality indicator is described below, and Table 3-2 shows the criteria for being considered “Good”, “Fair”, or “Poor”.

	● = Good	◐ = Fair	○ = Poor
BT	>16	NA	≤ 16
BK	≥ 35 dB (T20) ≥ 45 dB (T30)	NA	< 35 dB (T20) < 45 dB (T30)
NL	≤ 5‰	5‰ < NL ≤ 10‰	> 10‰
Cu	0% ≤ Cu ≤ 5%	5% < Cu ≤ 10% -5% < Cu < 0%	> 10% ≤ -5%
SD	≤ 5%	5% < SD ≤ 10%	> 10%
NA = Not Applicable			

Table 13 - 2 Quality Indicator Criteria

BT – BT is the product of the filter bandwidth and the T20 or T30 decay time for that frequency. BT is used to determine if the measured reverberation time may have been influenced by the filter response time. See ISO 3382-2:2008(E) Section 7.3 equation 4.

BK – BK is a measure of the dynamic range between the excitation signal and the background noise level. BK is calculated from LZmax when using the Impulse method, and from LZeq when using the Interrupted Noise method. See ISO 3382-2:2008(E), Sections 5.2.1 and 5.3.2.

NL – NL is the degree of non-linearity of the T20 or T30 portion of the decay curve, and is reported as permillage (parts per thousand) deviation from perfect linearity. See ISO 3382-2:2008(E), Annex B.2.

Cu – Cu is the degree of curvature, and is a comparison of the T20 and T30. Cu is expressed as the percentage deviation from being perfectly in-line. See ISO 3382-2:2008(E), Annex B.3.

SD – SD is the standard deviation of the measurement results for the T30 or the T20 decay times. See equations 2 and 3 in ISO 3382-2:2008(E), Sections 7.1. For impulsive excitation, n = 10 is used as defined in section 7.2

Accuracy Grade

ISO 3382-2:2008(E) describes three methods of differing measurement uncertainty as follows:

Survey Method

The survey method is appropriate for the assessment of the amount of sound absorption for noise control purposes, and survey measurements of the airborne and impact sound insulation. It should be used for measurements in ISO 10052. Survey measurements are made in octave bands only. The nominal accuracy is assumed to be better than 10% for octave bands.

Make measurements of the reverberation time for at least one source position. Find the average of results from at least two source-microphone combinations, see Table 13 - 3.

Engineering Method

The engineering method is appropriate for verification of building performance for comparison with specification of reverberation time or room absorption. It should be used for measurements in ISO 140 (all parts) with remarks to reverberation time measurements. The nominal accuracy is assumed to be better than 5% in octave bands and better than 10% in one-third octave bands. See Table 13 - 3.

Measure reverberation time two or more times for each source-microphone combination. At least six independent source-microphone combinations are required, see Table 13 - 3 'Minimum Number of Positions and Measurements'.

Precision Method

The precision method is appropriate where high measurement accuracy is required. The nominal accuracy is assumed to be better than 2.5% in octave bands and better than 5% in one-third-octave bands.

Measure reverberation time three or more times for each source-microphone combination. At least twelve independent source-microphone combinations are required, see Table 13 - 3 'Minimum Number of Positions and Measurements'.

	Survey	Engineering	Precision
Source-microphone combinations	2	6	12
Source-positions	≥ 1	≥ 2	≥ 2
Microphone-positions	≥ 2	≥ 2	≥ 3
No. decays in each position (interrupted noise method)	1	2	3
Method	Impulse or Interrupted	Interrupted	Interrupted
Filter bandwidth	1/1	1/1 or 1/3	1/1 or 1/3
Frequency Range (minimum)	250 Hz to 2 kHz	125 Hz to 4 kHz (1/1) 100 Hz to 5 kHz (1/3)	
Standards	ISO 10052	ISO 140	

Table 13 - 3 Minimum Number of Positions and Measurements

Return to Sound Level Meter Mode

A shortcut is to press the  (TOOLS) key and then the  key to select the SLM icon.

Changing modes using the icon on the control panel will load the setup that was previously in use for that mode.

When the RT-60 mode is active, the SLM icon is available in the Control Panel as shown in FIGURE 13-35 SLM Icon.

To return to the Sound Level Meter mode, press the  (TOOLS) key to open the Control Panel, select the SLM icon and press the  (ENTER) key.



FIGURE 13-35 SLM Icon

