# RT$_{60}$ Manual

## for the

# IE-35 & IE-45

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# Introduction and Theory of RT60 Measurements

*In theory, reverberation measurements seem easy and straight-forward to make. In actual practice, they are not as easy as they might appear. RT60 is defined as the time, in seconds, it takes sound in a reverberant environment to decay 60dB in level. Measurements are usually made in narrow bands (octave or 1/3 octave), rather than broadband (20Hz to 20kHz). ISO standard, octave bandwidths are the most common basis of measurement, with ISO standard, 1/3 octave bandwidths being often used as well.*

*To make RT60 measurements, the following items are needed: A sound source to excite the environment being measured, a sound level meter to measure the sound decay and a clock to measure the time over which the decay occurs. If our sound source were sufficiently power-ful, and we had good hearing protection, we could excite an environment to a level 65 or 70dB (60dB of decay plus 5 to 10dB of headroom) above the ambient sound level. We could note the overall SPL, then shut off the sound while simultaneously starting a stop watch. We could watch the SPL meter until the sound level decayed 60dB, and then punch our stop watch. The time showing on the stop watch could be defined as RT60.*

*The accuracy of the measurement would, of course, be affected by our ability to punch the stop watch at just the right times, and by our ability to read the SPL meter, determining exactly when the sound had decayed 60dB. In actual practice a number of other factors affect both the accuracy and the interpretation of the data gathered. In the first place, it is usually not possible to generate sound levels which are 65 to 70dB above ambient - in many environments, such a level would approach the threshold of pain. This means that decay has to be measured over smaller windows than 60dB, with extrapolated RT60 then being calculated, rather than actually measured. Also, the rate of decay can vary over the measure-ment window, so, if an average of all rates of decay is desired, more calculations are involved. Additionally, methods of exciting the environment, along with other factors, can cause dramatic differences in the rate of decay for the first 5dB, when compared to the rest of the decay window. Consequently, we may want to be selective as to the section of the decay window we use to calculate decay time.*

*If we create a graphic plot of sound level versus time, we can observe the behavior of the sound as it decays. Of course, the number of amplitude samples we take over our time window will affect the resolution of decay curve we construct. Once we have this decay curve, we can make some decisions about which section of the curve to use to calculate RT60. After a suitable section of curve has been selected, we face the problem of determin-ing what the average rate of decay over that section of curve is. Once we have that, we can finish the RT60 calculation.*

*Perhaps the best way to handle all of these variables and calculations is through the use of a computer. The IE-35 and IE-45 do just that. The diagram across the page helps to explain how they work and what exactly they do.*

# RT$_{60}$ Decay Curve
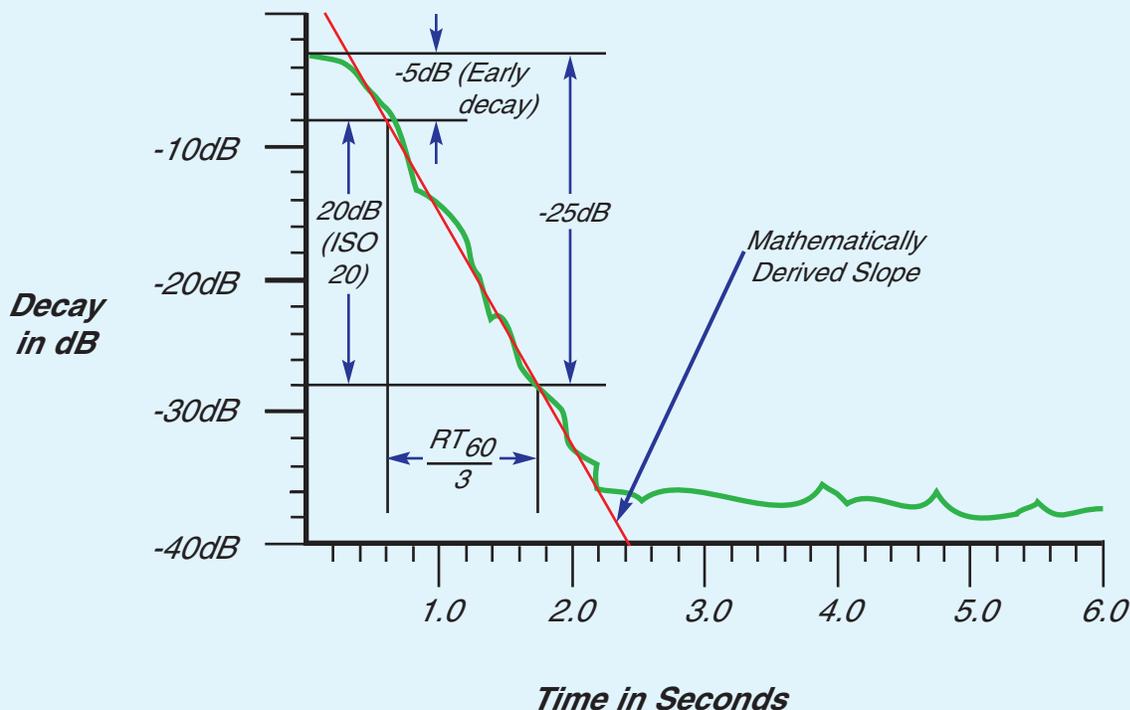


The above plot shows a decay curve and identifies sections of that decay curve. To insure statistical accuracy in measuring and plotting decay, the IE-35 and IE-45 take samples (of amplitude in dB) at the rate of 100 samples per second, regardless of the length of the measurement window selected.

Notice that a 20dB section of decay curve has been identified. It begins at -5dB and ends at -25dB. Since 20dB is one third of 60dB, the decay time over this 20dB window would be 1\3 of the total RT60, as the diagram shows. The international ISO standard requires that RT60 calculations be made based upon this specific section of a decay curve. The IE-35 and IE-45 call RT60 measurements based on this decay curve section "ISO (20)." This standard also specifies a 30dB decay window, from -5dB to -35dB, which can be used for calculations if there is sufficient decay available. The IE-35 and IE-45 designates this measurement as "ISO (30)." Additionally, the first 5dB of decay is often of interest. Calculation of RT60 based on this section of the decay curve is designated by the IE-35 and IE-45 as "Early Decay." Both the IE-35 and IE-45 calculate ISO (20), ISO (30), and Early Decay times for each frequency band. A numeric printout of RT60 would include numbers for each of these. If there were insufficient decay to calculate ISO (30), dashes would be printed to indicate insufficient data.

In our example above, a straight, red line has been mathematically fitted over the green decay

curve which represents the average slope of the decay. It is the slope of this line from which the final RT60 calculation is made.

The last item that needs to be mentioned is the improved statistical accuracy provided when several decay samples are taken and averaged together before RT60 calculations are made. Five or more samples are sufficient to provide excellent statistical accuracy. The IE-35 and IE-45 are capable of averaging far more decay samples than five, even though five is normally sufficient.

## Measuring RT60 Using the Pink Noise Mode

Measuring RT60 with the IE-35, or IE-45 is really very simple and fast. Let's go through the procedure step by step, which is the same for both the IE-35 and IE-45. In an actual RT60 measurement, we would be feeding pink noise into a sound system. The pink noise would be generated by the IE-35, or IE-45, and would be fed to the sound system using a connecting cable between the IE-35, or IE-45 audio output jack and an appropriate sound system input. The setup and measurement procedures are shown below:

**To Make a Pink Noise RT60 Measurement:**

**Step 1:** Select RT60 from the "Functions" Menu.
**Step 2:** Select "Pink Noise Mode" from the "Options" Menu.
**Step 3:** Use the Stylus Buttons to select octave, or 1/3 octave measurement.
**Step 4:** Use the "Options" menu to select the desired measurement time window.
**Step 5:** Use the Stylus Button to turn on pink noise.
**Step 6:** Adust the level well up on the display screen as shown to the right.
**Step 7:** Tap the "Test RT60" stylus button to begin a test.
**Step 8:** Use the "Measure" stylus button to add a second measurement for averaging with the first.
**Step 9:** Repeat step 6 until you are satisfied with the average. (Tapping the "Re setup" stylus button clears the measurement data so a new set of measurements can begin.

*Shielded Audio Cable to Sound System Input.*

*The level of Pink Noise should be well up on the display screen to make an RT-60 measurement. To accomplish this, turn up the Q1 audio output level and/or the sound system amplifier, and adjust the analyzer screen display range.*

*Adjust level to about here.*
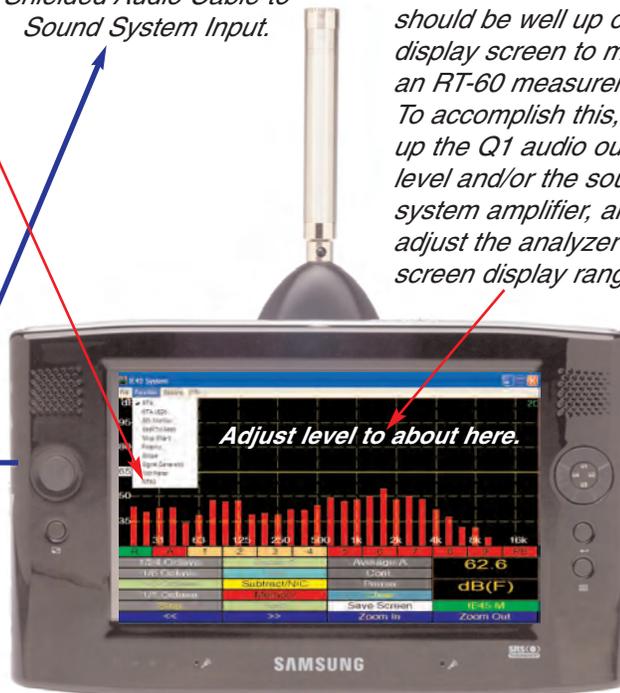
As can be seen, making a Pink Noise Mode RT60 measurement is easy and straight forward. Now, let's look at the steps required to make an Impulse Mode RT60 measurement. Next, we'll examine the results of an RT60 measurement. The measurement data gathering and formatting is the same for either mode of measurement.

## Measuring RT60 Using the Impulse Mode

*When you select "RT60" from the "Functions" menu, the RT60 measurement screen comes up in Impulse Mode, which is the default mode. You will not need to select the Impulse Mode. The setup and measurement procedures are shown below:*

***To Make an Impulse Mode RT60 Measurement:***

***Step 1:*** *Select RT60 from the "Functions" Menu.*
***Step 2:*** *Use the Stylus Buttons to select octave, or 1/3 octave measurement.*
***Step 3:*** *Use the "Options" menu to select the desired measurement time window.*
***Step 4:*** *Adust the display such that the ambient level is well down on the display screen.*
***Step 5:*** *Tap the "Test RT60" stylus button to "arm" the analyzer for response to the impulse noise event that will automatically begin the measurement*
***Step 6:*** *Initiate the external sound (balloon burst, blank pistol, etc.) to begin the measurement.*
***Step 7:*** *Use the "Measure" stylus button and repeat Step 6 to add a second measurement for averaging with the first ("Stop" stylus button changes to "Measure" after data is taken).*
***Step 8:*** *Repeat step 7 until you are satisfied with the average. (**Note:** Tapping the "Re setup" stylus button clears all the measurement data so a new measurement set can begin.)*

*For an "Impulse Mode" RT60 measurement, the ambient noise level should be at the very bottom of the display screen*

*To "trigger" a measurement, the level of the sound impulse must cause the amplitude of the filters to rise to this level, or above. Otherwise, the measurement will fail to initiate.*
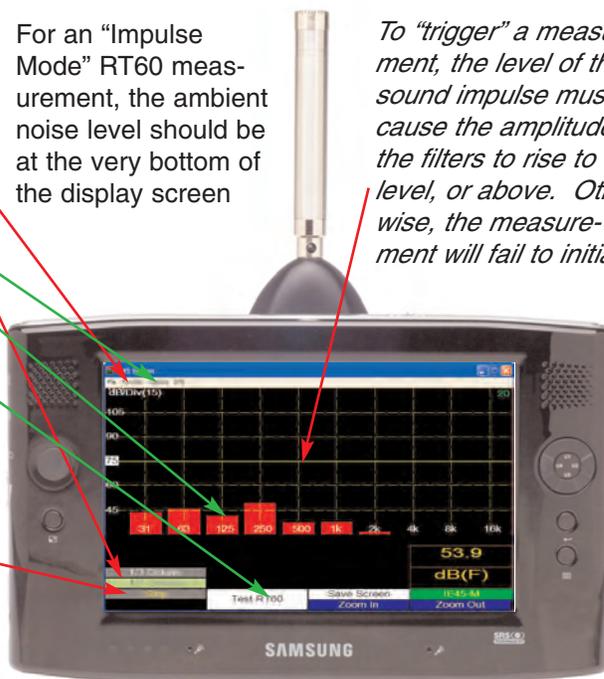
*Proper selection of the measurement time window (Step 3) will assure the optimum view of the decay curve (not too steep \ , or elongated ── on the display screen.*

## Reading, Viewing, Manipulating and Storing RT60 Measurement Data

*Once you have successfully taken RT60 measurement data, you can view it graphically, or numerically. From the "Options" menu, you can display the Schroeder curve (it displays just above the decay curve) for comparative purposes. If, for some reason, you are not satisfied with the ISO 20 or ISO 30 measurement data, you can manually select a portion of the decay curve of any octave or 1/3 octave channel you have measured. This calculation is labeled as "User Defined" ("User"), by the software. This is done by manually placing the left cursor and the right cursor on the decay curve at the positions you prefer. The calculation or RT60, based on the cursor positions, is automatic.*

*The steps to make a "User Defined" calculation of RT60 are outlined in the illustration on the following page:*

**Note:** In the example RT60 curve display below, the frequency is 1000 Hz (1kHz). This is the default frequency display channel, whether octave or 1/3 octave measurements have been made. To view, or manipulate a different channel, use the stylus arrow next to the frequency readout window to select the channel desired.
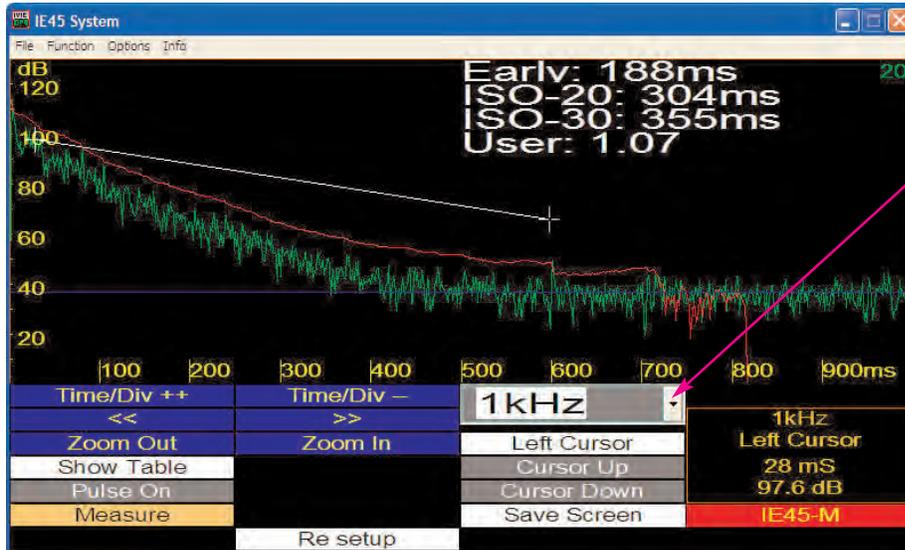


**Note:** Tapping here pops up a window which allows you to select for viewing the decay curve for any octave, or 1/3 octave channel. The default display channel is 1 kHz.

To select a portion of the decay curve for a "User Defined" RT60 calculation, tap the decay curve at the upper section (or, if you prefer, you can instead use the Schroeder curve, which is the decay curve with a smoothing algorithm applied) with the stylus to place the left cursor. If your stylus misses the curve a little, use the "Cursor Up," or "Cursor Down" stylus buttons to place the left cursor exactly on the decay curve.

Next, tap the cursor button labeled "Left Cursor." It will change colors and be relabeled "Right Cursor." Tap the lower section of the decay curve with your stylus to position the right cursor on the decay curve. Again, if you "miss" a bit, you can use the "Cursor Up," or "Cursor Down" stylus buttons to fine tune the right cursor so it is exactly on the decay curve.
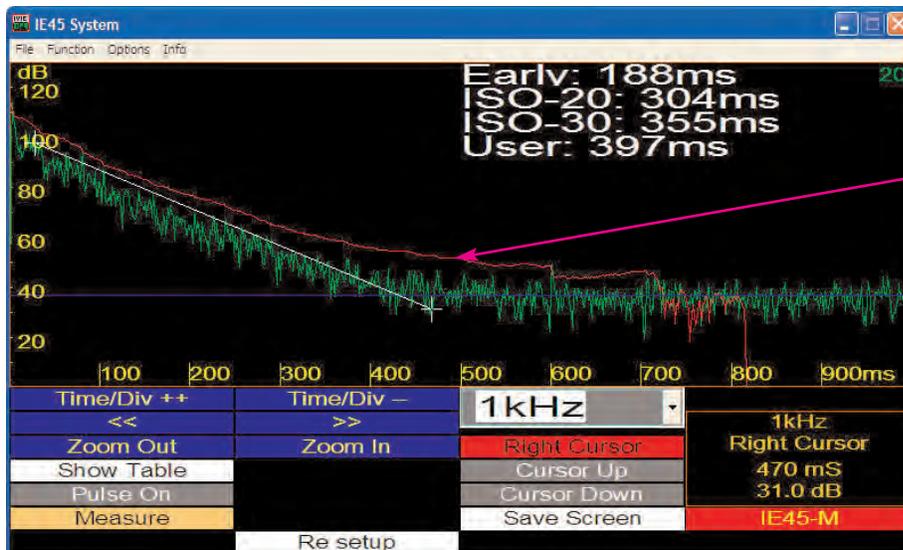


**Note:** The Schroeder curve is the decay curve with a smoothing algorithm applied. The left and right cursors can be placed on it, instead of the decay curve, to calculate RT60, if desired.

*Once the right cursor has been placed, RT60 is automatically calculated for the section of decay curve selected, and that calculated number (labeled "User") appears with the Early Decay, ISO 20 and ISO 30, RT60 calculations displayed.  In this manner, "User Defined" RT60 calculations can be made for any octave or 1/3 octave channel.*

**Numeric Data Display**

*While graphic information can be displayed for only one channel at a time, numeric RT60 data can be displayed for all channels simultaneously.  To display the measurement data numerically, tap the stylus button labeled "Show Table."  A window will pop-up, displaying  the measurement data for all channels (octave, or 1/3 octave, depending on what was selected before making the measurement).  The data is first calculated (this may take a moment or two, so be patient), then displayed in a spread sheet format, as shown below:*
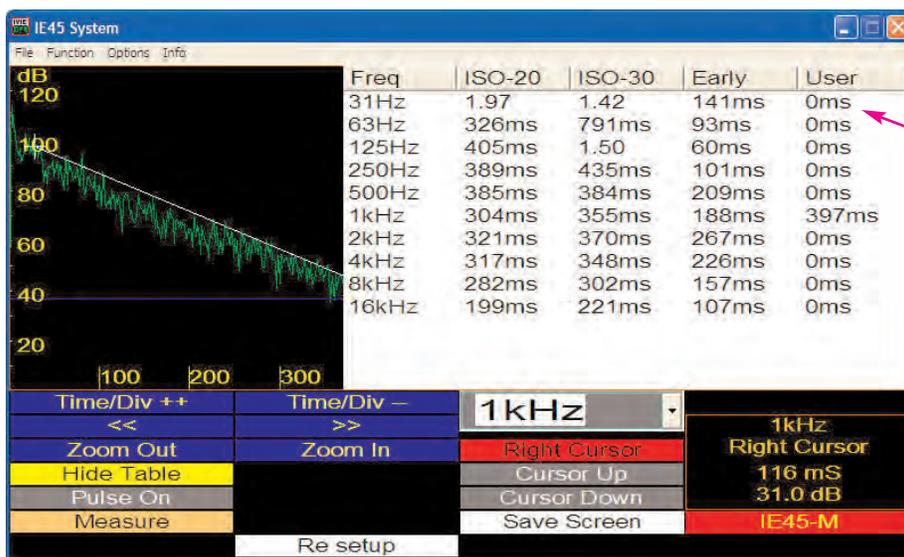


**Note:** *Numeric measurement data is displayed for octave channels, or 1/3 octave channels, depending on whether you selected octave, or 1/3 octave RT60 measurements.*

**Note:**  *In our example above, notice that the 1 kHz octave band shows a"User" RT60 number and the other channels do not.  The channel with "User" numbers attached to it is the one where the cursors have actually been physically employed to define a "User" calculation.  If you don't make a "User" calculation in a channel, one will not print out in the numeric data.*

*To hide the numeric table, tap the stylus button labeled "Hide Table."*

**Storing and Saving RT60 Measurement Data**

*There are some options when it comes to saving your RT60 measurement data.  If you simply want to print out what you see on the IE-35 or IE-45 display screen (whether decay curve graphics or the numeric table of measurement data) simply tap the white stylus button labeled*

*"Save Screen." This will automatically save the screen to your "My Documents" folder.*

***Important Note:*** *When you tap, "Save Screen," storage is automatic, but no feedback that storage has been accomplished is given, visual or otherwise. Tapping the "Save Screen" stylus button again will save the screen a second, and third and fourth time, and so on, depending on how many times you tap.*

*If saving a "screen snapshot" is not sufficient for your documentation requirements, you can save the raw RT60 measurement data by using the "Options" menu to select "Save RT60 Data." Selecting this option will guide you through saving the RT60 data, and giving it a file name. The saved file can be imported to a PC using Ivie's RT60 XLS software. Once imported, the Ivie RT60 XLS software facilitates printouts and reports, thus enabling you to provide complete documentation when required.*

*An example of a printout employing Ivie RT60 XLS software is show below:*