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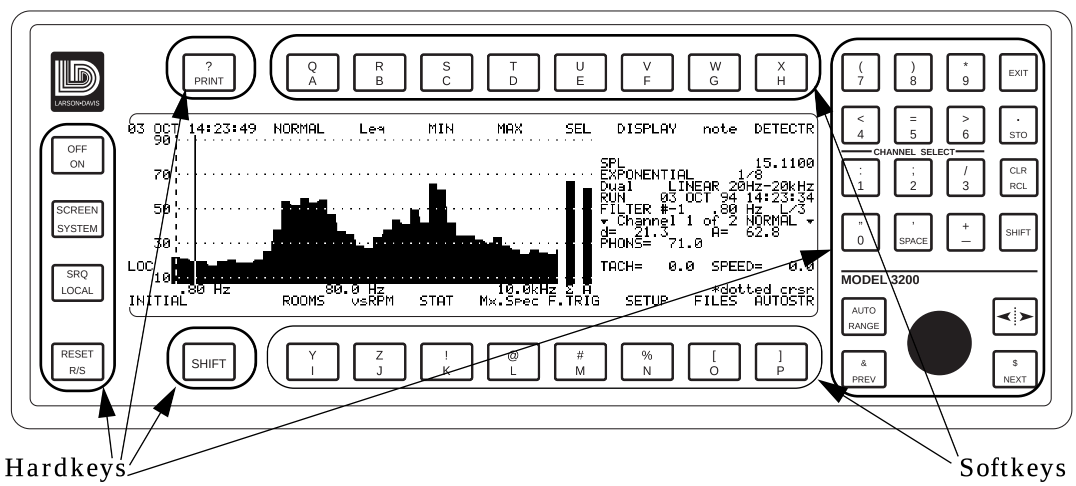
CHAPTER

# 1 Introduction to LD Real Time Analyzers (RTAs)

Welcome to the Larson•Davis Analyzer training manual. This manual is designed to help you become familiar with your analyzer and it's capabilities. Topics that will be covered range from basic operations to advanced system setups for complex measurements. It is not intended to replace, but to use in conjunction with, the operators manual received with the analyzer.The following graphic identifies the softkeys and hardkeys used in the keyboard operation of the LD 3200.



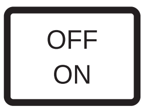

Throughout this manual the following conventions will be used to denote the keyboard operation of the LD 3200.

**BOLD** words — Represent a HARDKEY function. The HARDKEYS are the keys permanently labeled on the analyzer keyboard, (i.e. ON, EXIT, R/S).

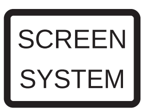
**BOLD [A]** words — Represent a SOFTKEY function, where **Bold** represents the text that appears either on the top or the bottom of the LCD display, and can change depending upon which menu you have selected and **[A]** identifies the key associated with the function.

## Analyzer Setup

1. Attach the microphone / preamp, or whatever transducer you may have, to the analyzer through an input card. If more than one input card is installed, Channel one is the card furthest from the power supply module.

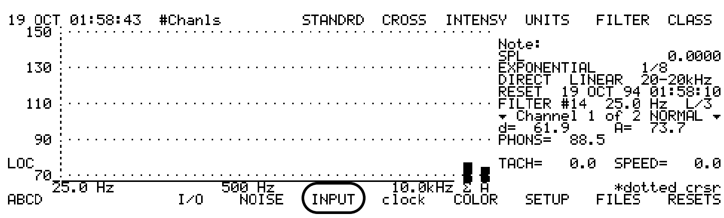



2. Turn the analyzer on by pressing the **ON** key located on the upper left of the keyboard. (Make certain the Main switch is in the ON position in the back of the analyzer.)

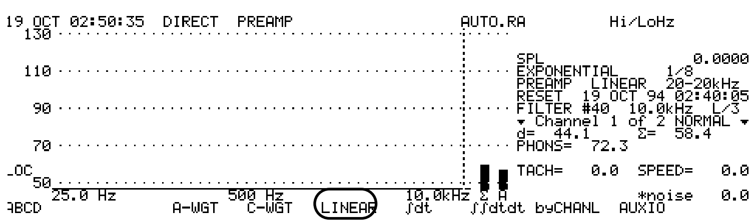



3. Press the **SYSTEM** hardkey.

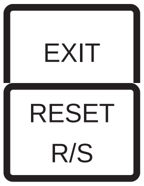
4. Press the **INPUT [K]** key.




5. Press either the **Direct [A]** key, for direct input, or **PREAMP [B]** key, for input from the preamp.

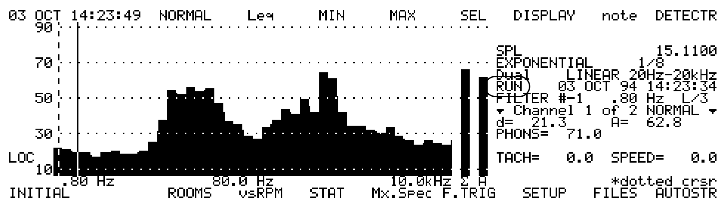



6. Verify that the 200v bias has been turned on. The bias switch is located on the input module in the back side of the analyzer.



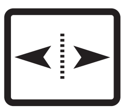

**7.** Press the **EXIT** hardkey twice to return to the Main menu.

**8.** Press the **R/S** key to RUN or STOP the unit. You can verify the status of the unit by looking on the right side of the display.

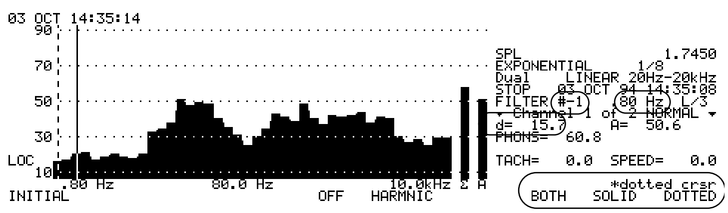




**9.** Select a range to optimize the spectra in the display without overloading the analyzer. To do this, first press the **RANGE** key. Then press the down arrow key until the overload “OVL” is seen on the screen. Next press the up arrow key until the “OVL” disappears.



**10.** Press the double arrow **CURSOR** key to select which cursor options you desire to use. Press one of the following softkeys: the **dotted [P]** will display a d=, the **solid [O]** will display s=, the **both [N]** will display a “Δ=”, which indicates the amplitude difference between the two cursors.



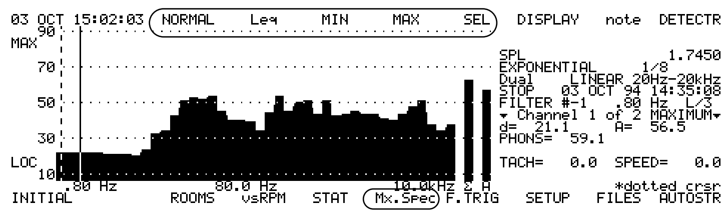

The filter band number and frequency are shown for the current cursor position. Press the left or right arrow keys to move the cursor to the desired frequency.


**11.** Press the **EXIT** hardkey to return to the Main Menu.

# Main Menu

## Selecting a display parameter

**1.** Press one of the following keys to select the desired display parameters:




**Normal [A]** Displays the averaged spectrum according to the parameters selected in the **Detector [H]** menu.

**Leq [B]** Displays a spectrum that represents the steady level which, integrated over a period of time, would produce the same energy as the actual signal. The period of time is the actual run time of the analyzer.

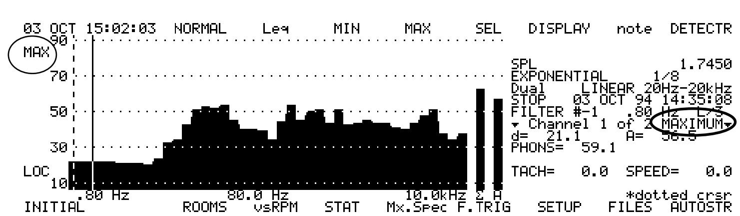
**Min [C]** Displays the minimum level measured for each filter band since the last reset.

**Max [D]** Displays the maximum level measured for each filter band since the last reset.

**SEL [E]** Sound Exposure Level is similar to the Leq except the signal is the equivalent energy if it occurred over a 1 second time period.

**Max.Spec. [L]** This display type should not be confused with **Max [D]** (see above). Max.Spec displays the spectrum corresponding to the highest broadband level that occurred during a measurement.

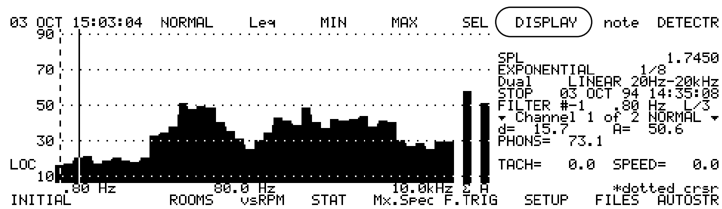
**2.** After selecting the desired display parameter the analyzer will display your selection on the left side of the display, and on the center of the right side. See figure below.



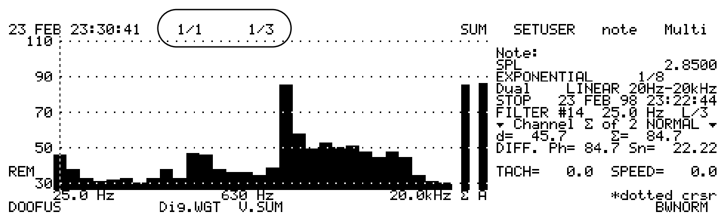
## Display weighting

Your analyzer has the capability of digitally weighting the displayed data. This feature is independent to the input signal analog weighting that is selected from the **Input** menu.


**1.** Press the **Display [F]** key to access the digital display menu.




**2.** Press one of the following keys to select the desired display:

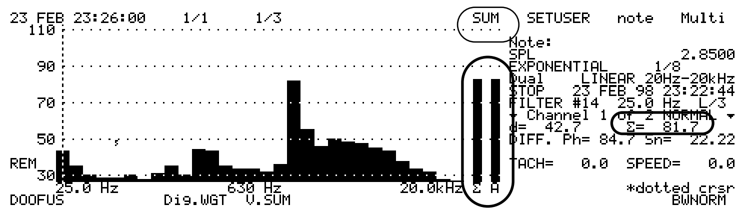



**1/1 [A]** This key permits you to view a displayed spectrum, that was taken in 1/3 octave, in 1⁄1 octave. This will sum the 1⁄3 bands into groups of three to produce the spectrum having 1⁄1 octave bandwidths.

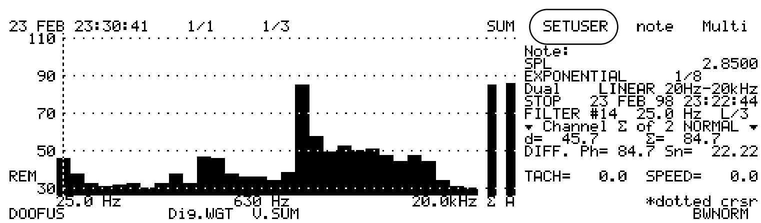
**1/3 [B]** This key will return you to a 1/3 octave bandwidth from a 1/1 octave bandwidth.

**NOTE:** If the measurement was taken in a 1/1 octave bandwidth you may not view it in 1/3 octave bandwidth. The 1/1 [A] or 1/3 [B] will not appear in the menu.

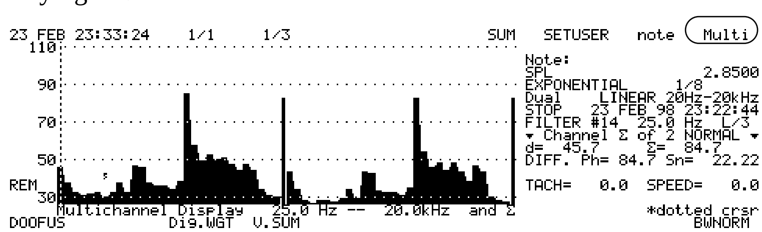
**SUM [E]** This key controls the digital readout of the broadband levels, A-weighting or Linear Summation, shown on the right side of the spectrum by the two vertical bars. The actual numeric readout for these vertical bars is identified by A=; for A-weighting, and Σ=; for linear summation shown below.



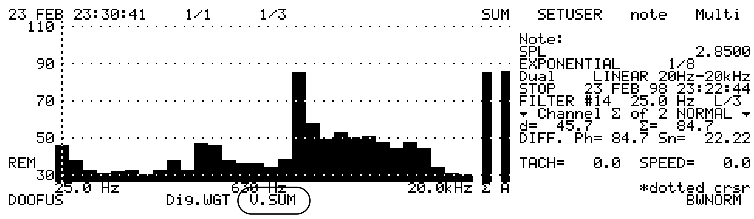

**SETUSER [F]** If you are making a measurement that requires a special weighting curve you may create your own by pressing this key and entering the desired weighting values. For a detailed explanation of User curves, see Chapter 10 of the operations manual.



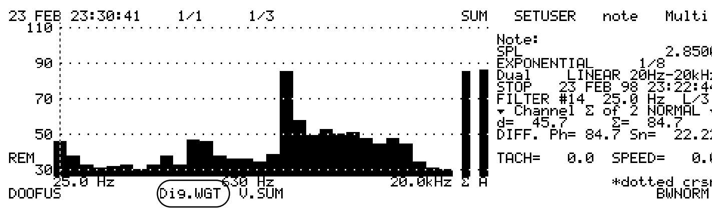

**Multi [H]** This key permits the analyzer to simultaneously display multiple channels. The maximum number of channels displayed will be determined by the number of input channels configured in your analyzer (i.e. if you analyzer is configured with four channels, you may select up to four channels to be displayed simultaneously). To return to single channel display, you press the **Multi [H]** key again.



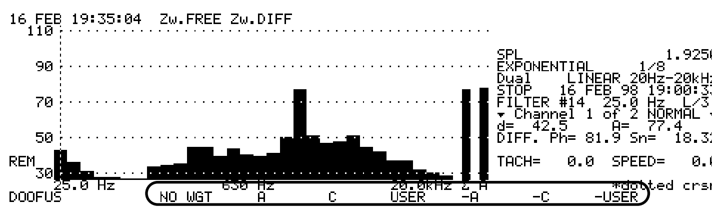
**V.SUM [J]** This key give you the vector sum which displays the square root of the sum of the squares between channel 1 and channel 2 spectrum.




**3.** Press the **Dig.Wgt [I]** key to access the weighting menu:




**4.** Press one of the following keys to select the desired display weighting:




**NOWGT [I]** This key returns the display to a flat response - No Weighting

**A[J]** Adds an A-Weighting curve to the displayed spectrum.

**C [K]** Adds a C-weighting curve to the displayed spectrum.

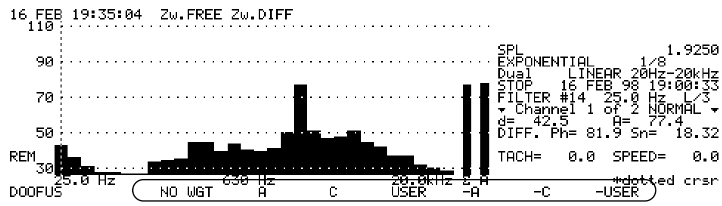
**USER [L]** Adds a User defined weighting curve to the displayed spectrum.

**-A [M]** Adds a weighting curve that is the inverse of the A-weighting curve to the displayed spectrum (negative).

**-C [N]** Adds a weighting curve that is the inverse of the C-weighting curve to the displayed spectrum (negative).

**-USER [O]** Adds a weighting curve that is the inverse of the User defined curve to the displayed spectrum (negative).

5. Select **Zw.Free [A]** or **Zw.Diff [B]** to apply Zwicker loudness function to the displayed spectrum.

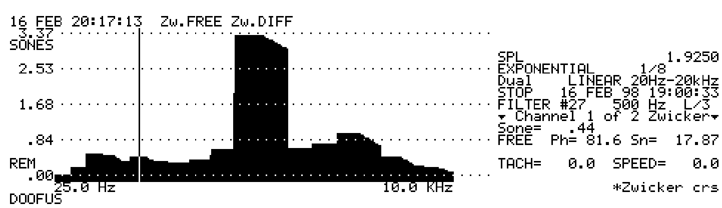



**Zw.Free [A]** Applies Zwicker free field loudness function to the displayed spectrum.

**Zw.Diff [B]** Applies Zwicker Diffuse loudness function to the displayed spectrum.

When in the standard analysis mode with 1/3 octave filtering, the Loudness corresponding to ISO Recommendation R523 Method B (sometimes referred to as Zwicker loudness after the researcher who developed the method) is calculated and displayed on the lower right of the screen. There are two forms of this loudness which correspond to measurements made in diffuse acoustic fields where energy is from all directions such as inside a reflective space, and measurements made in the free-field where the sound is radiated without reflection from a single acoustic source.

6. Select **Zw.FREE [A]** to display Zwicker Free-field loudness function to the spectrum.

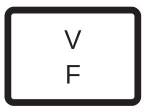




7. Press the **EXIT** hardkey twice to return to the Main Menu.

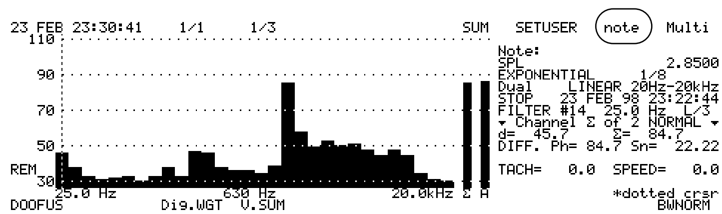
## Annotation of a Measurement

With the LD analyzer you can attach a note to each spectrum stored. This feature can be found in both the RTA mode, and the SLM mode of the analyzer.



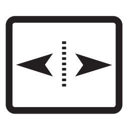

**1.** Press the **DISPLAY [F]** key from the Main menu.


**2.** Press the **note [G]** key.




Alpha characters A through P will appear across the top and bottom of the display. To select the rest of the alpha characters press the **SHIFT** hardkey and Q through Z will appear. A flashing cursor will also appear in the middle of the display, this is where you can enter the desired note.

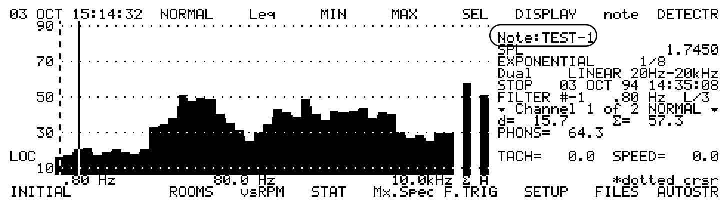

**3.** Begin entering note, TEST-1, in the text field. If you make a mistake entering the text you can highlight the character by moving the cursor with the **PREV** or **NEXT** keys, then press the double arrow **CURSOR** hardkey to delete the wrong character.



If a note has been previously entered and you desire to modify or delete it and start new, press the **SHIFT**, **CLEAR** hardkeys and the entire text field will be erased ready for a new entry.

EXIT

**4.** Press the **EXIT** hardkey once the desired note has been entered into the text field. You will now see the new note on the right side of the display.



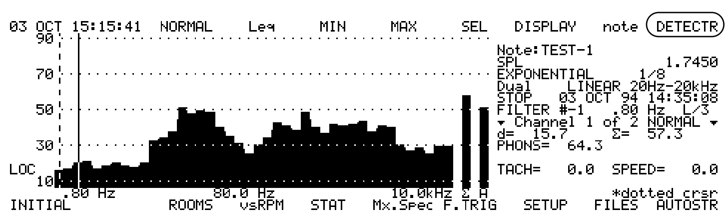

When a spectrum is stored this note will be stored along with the data. It is important to remember to update the note field each time a different measurement is taken. Note that this note will be stored with all future measurements, unless modified for each measurement.

## Selection of Detectors

From the Main Menu locate the **DETECTR [H]** key. The selection of choices of averaging types in this menu will be different depending upon whether Octave filtering or FFT has been selected. (See Chapter 2 for details on filter selection.)

X
H

**1.** Press the **DETECTR [H]** key.




**2.** Select the desired averaging method by pressing one of the following keys:

**Averaging type: Octave Filters**

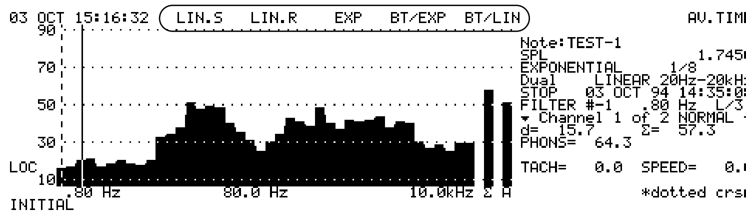
**LIN.S [A]** Linear Single (seconds)

**LIN.R [B]** Linear Repeat (seconds)

**EXP [C}** Exponential (seconds)

**BT/EXP [D]** Constant Confidence with Exponential Averaging

**BT/LIN [E]** Constant Confidence with Linear Averaging




**Averaging type: FFT Filters**

**LIN.S [A]** Linear Single (seconds)

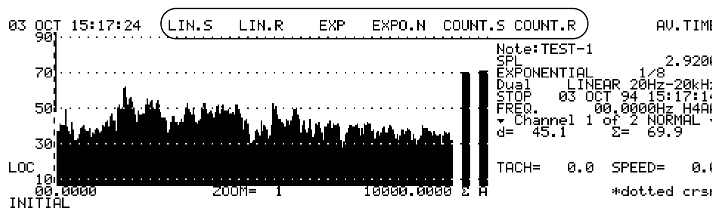
**LIN.R [B]** Linear Repeat (seconds)

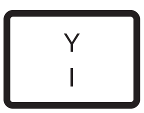
**EXP [C]** Exponential (seconds)

**EXP.N [D]** Exponential averaging based on number of spectra.

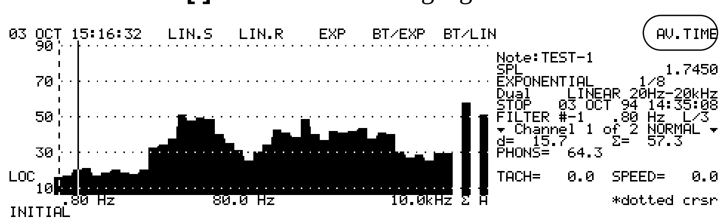
**Count.S [E]** Spectral Single (# spectra)

**Count.R [F]** Spectral Repeat (# spectra)

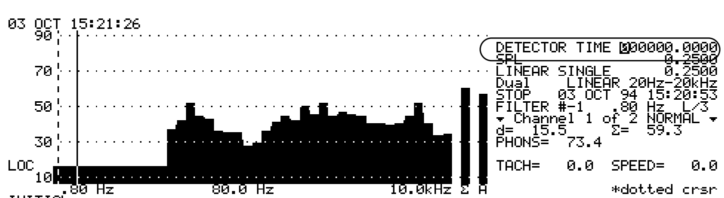


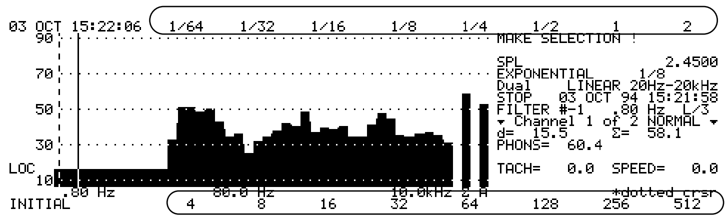

**3.** Press **AV.TIME [I]** to select an averaging time.




If you selected a Linear type of averaging, Lin.S or Lin.R, you will be prompted to enter an averaging time in seconds.



If you selected an Exponential of averaging a display with 16 different values of averaging times will be presented.





**4.** Press the **EXIT** hardkey to return to the Main Menu.

## Special Measurements

**ROOMS [I]** Room Acoustics

**vsRPM [J]** Versus RPM measurements

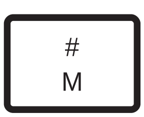
**STAT [K]** Statistics and Ln calculations

Each of these measurements and keys will be discussed in detail later in the manual.

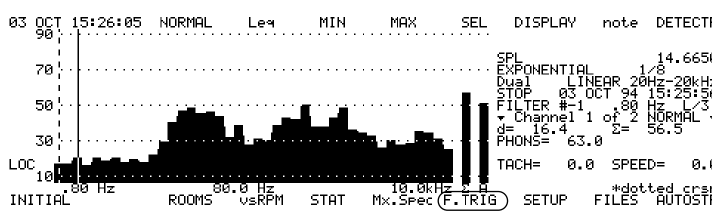
## Triggering

The analyzer has the capability to begin averaging automatically when a specific trigger criteria has been satisfied. The analyzer can trigger in both the Frequency-domain, and the Time-domain (FFT mode only.)

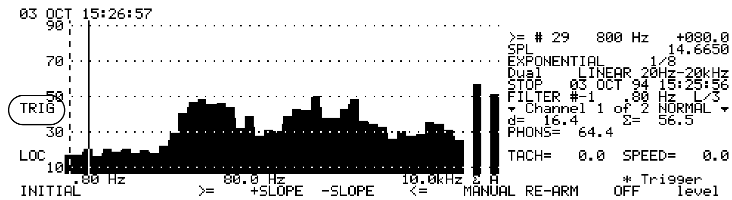
### Frequency-domain triggering




**1.** Press the **F.TRIG [M]** key.



The word “TRIG” will appear on the left side of the display. This indicates that the trigger function is activated. This type of triggering can be used with either Octave filtering or FFT.




**2.** Setup the desired trigger criteria, trigger frequency, and the trigger level.

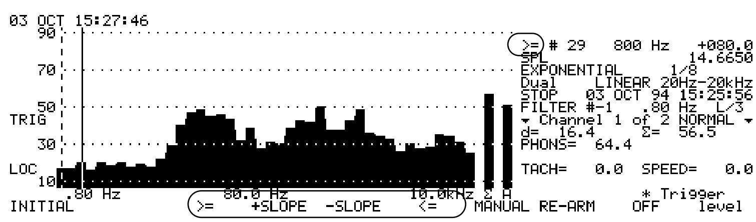
a. Press one of the following keys to setup the trigger criteria.

**>= [I]** Triggering will occur whenever the level in a specified frequency band equals or exceeds the programmed value.

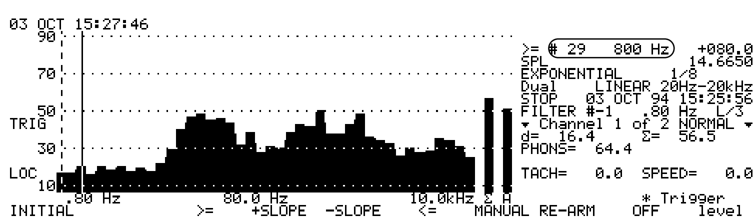
**<= [L]** Triggering will occur whenever the level in a specified band is less than or equal to the programmed value.

**+Slope [J]** Triggering will occur whenever the signal in a specified band has both the appropriate trigger level and has a positive slope.

**-Slope [K]** Triggering will occur whenever the signal in a specified band has both the appropriate trigger level and has a negative slope.

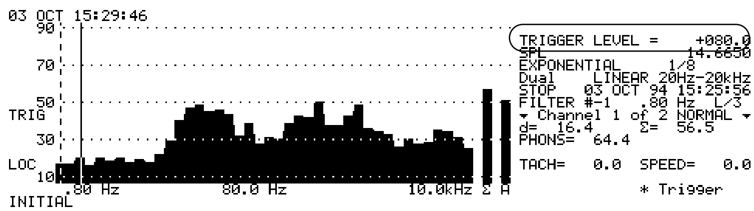



b. Turn the knob to select the desired trigger frequency. By turning the knob you can page forward and backward through the available frequency range as indicated by the changing value on the display. See figure below.



One step beyond the highest available frequency band you will find “Spectrum Σ”, which means that the measurement will trigger based on the level or slope of the overall level.

c. Press the **level [P]** key to input the desired trigger level. Upon pressing this key the following message will appear on the upper right of the display.

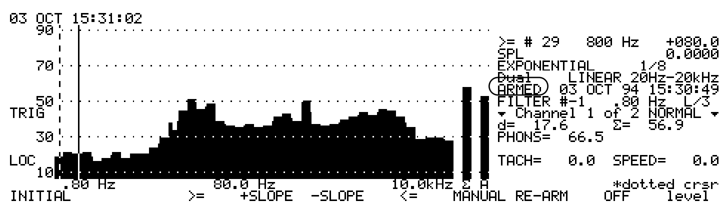



EXIT

Enter the desired level using the numeric keypad and press the **EXIT** hardkey.

RESET
R/S

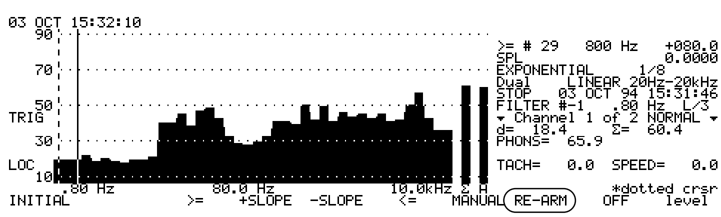
**3.** Press the **R/S** key to ARM the analyzer.

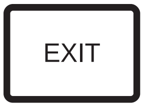



When triggered, the display will change from “armed” to “run” and timer will start running. The measurement will commence once the triggering criteria have been satisfied.

%
N

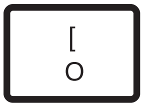
**4.** Press the **RE-ARM [N]** key if you wish to have the analyzer reset itself following a triggered autostored sequence. This will re-arm the trigger ready to autostore following a subsequent event. You can toggle this feature on and off by pressing this key repeatedly.






**5.** Press the **EXIT** key to return to the Main Menu.

Note that pressing **OFF [O]** in the **F.TRIG** menu also exits you to the Main menu.




**6.** To de-activate the trigger function press the **OFF [O]** key located in the F.TRIG menu. The word **TRIG** on the left side of the display will no longer appear.

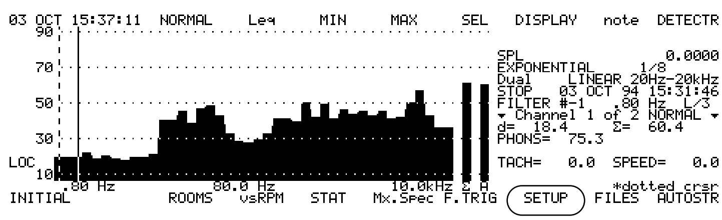
### Time-domain triggering

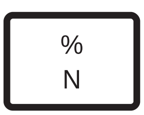
Time-domain triggering is often used for transient capture and structural testing (i.e. Modal analysis). This topic will be covered in the Modal Testing section in Chapter 10.

## Storage and Recall of instrument setups

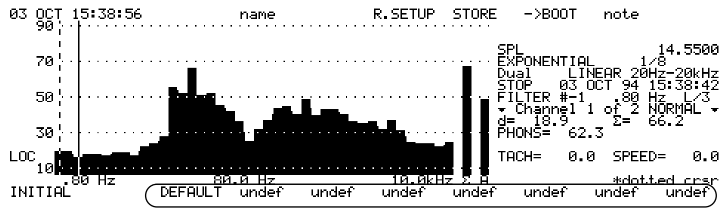
The analyzer has the capability of permitting the user to define a number of setups other than the default setup that was configured at the factory.

**1.** Setup the analyzer as desired. Then from the Main Menu or System Menu locate the **SETUP [N]** key.



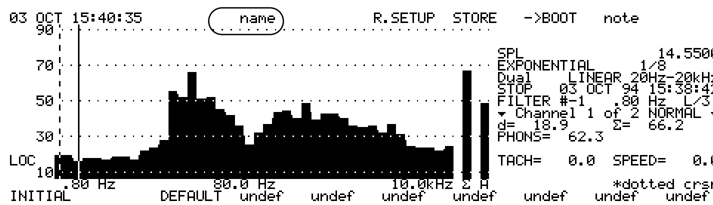




**2.** Press the **SETUP [N]** key. The softkeys [I]-[P] along the bottom of the display are where you may define up to seven different setups. These keys are originally labeled “undef” for “undefined”. You may create a specific instrument setup and store it under one of these keys labeled with an associated name. The **DEFAULT [I]** key is a default setup delivered from the factory and **can not** be modified.

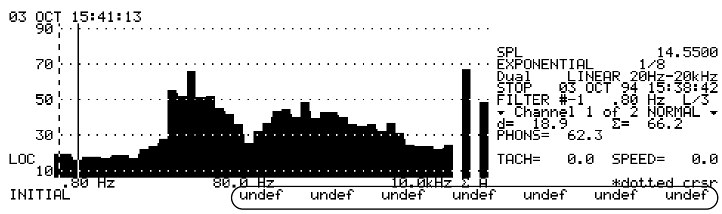



R
B

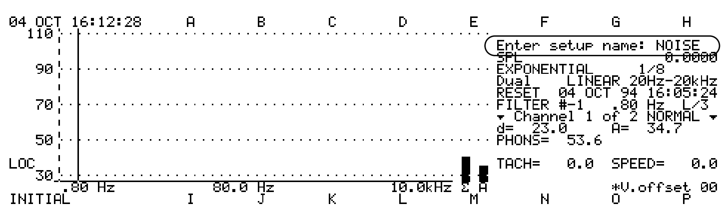
**3.** Press the **name [B]** key to assign a name to one of the "undef" sofkeys that will be used to store the analyzer setup.




You will be prompted on the bottom of the screen to select one of the softkeys [J]-[P].




After pressing one of the softkeys [J]-[P] enter the desired setup name. Press the **Shift**, **CLEAR** hardkeys to delete any entered text. For this example enter the name **NOISE** by pressing the alpha characters appearing on the display.



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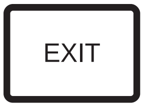
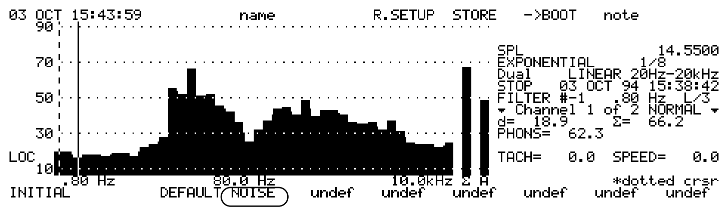
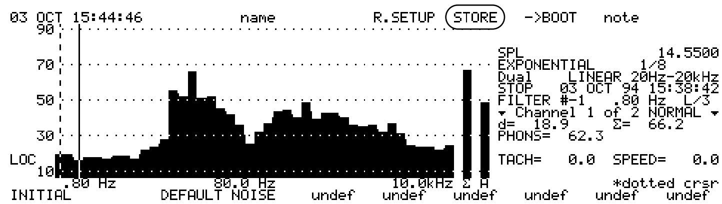



Press the **EXIT** key after entering the new name. The new name you entered will appear on the softkey that you previously selected. See figure below.

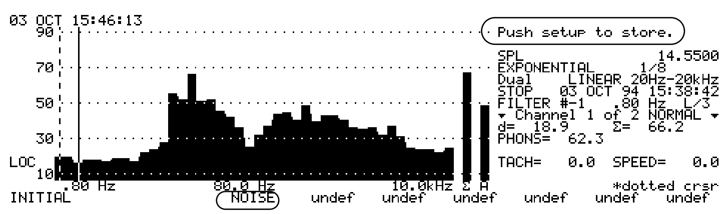




4. Press the **STORE [E]** key to store the present setup to one of the named softkeys.




The message “Push setup to store” will appear on the upper right of the display.

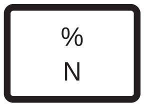



5. Press the labeled softkey **NOISE [J]** to assign the current setup.

The current setup has now been assigned to the softkey and will remain assigned to this key until you modify it, or you perform a “reset setup” (explained later).You may assign up to seven different setups, and may reconfigure the analyzer at anytime to one of these user-defined Setups.

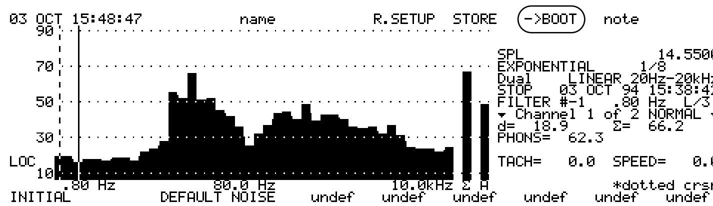
### Booting directly to a user-defined setup

If you desire to boot the analyzer directly to one of the user-defined setups instead of the default setup assigned by the factory perform the following:



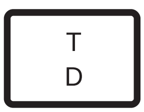

1. Press the **Setup [N]** key.


2. Press the **>BOOT [F]** key.

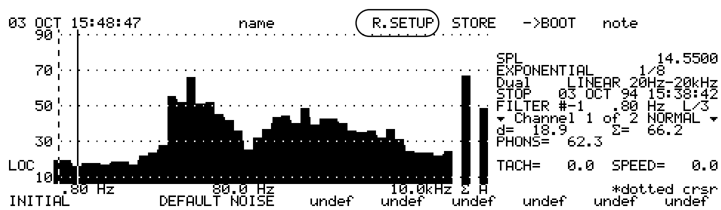



3. Press one of the previously defined softkeys [J]-[P] which represents the setup to be activated upon boot up of the analyzer.

You may reset all of the user-defined setups to assign a new group of setups. To do this perform the following:




1. Press the **R.SETUP [D]** key. This will clear all of the defined softkeys [J]-[P] and bring them back to an undefined state.



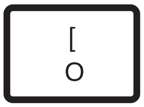

2. Re-assign any desired analyzer setups to the softkeys [J]-[P].

3. Press the **EXIT** key to return from the Setup menu.

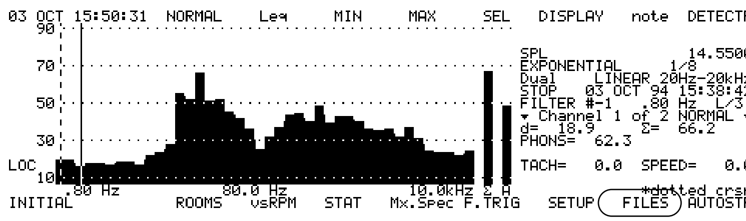
## File Operations

Data measured are stored to non-volatile RAM into files that have been created by the user. With the optional disk drive, DVX003, these files can be subsequently transferred from internal memory to a floppy drive, and also from a floppy disk back into the internal memory.

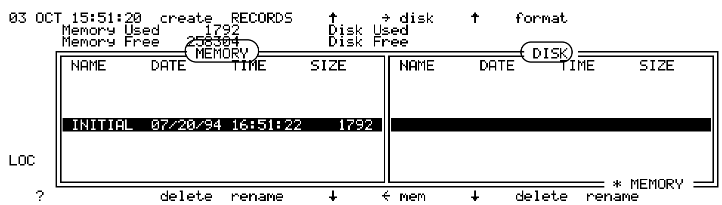
## Creating a new file

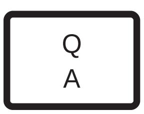



1. Press the **FILES [O]** key to access the Files menu of the analyzer.This key can be found from either the Main Menu or the System Menu.

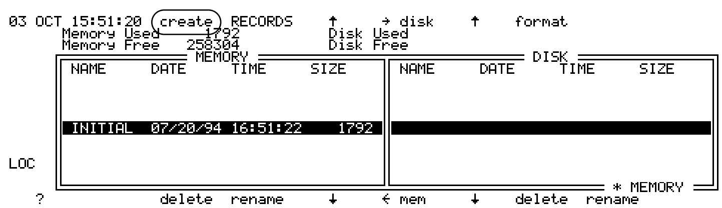



The display will be separated into two sections: the section on the left shows the created memory files, the section on the right displays the files that are stored on a floppy disk if the optional floppy drive is attached. If no floppy is attached, the analyzer will display a message indicating that no floppy drive was found.

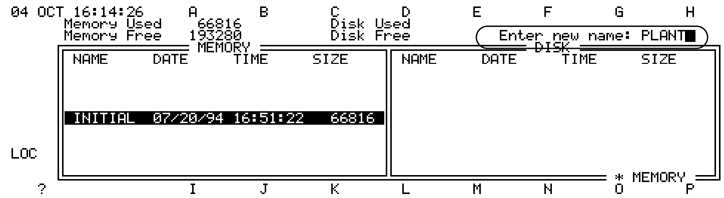



2. Press the **create [A]** key.

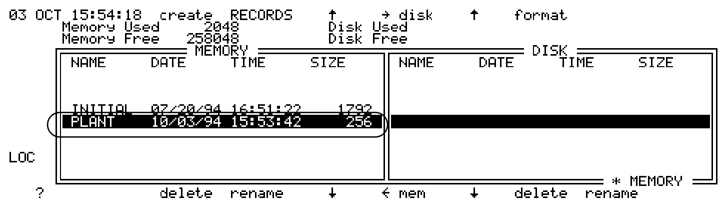


3. Enter the desired new file name (for this example use the name “PLANT”) by pressing the alpha keys appearing on the display.

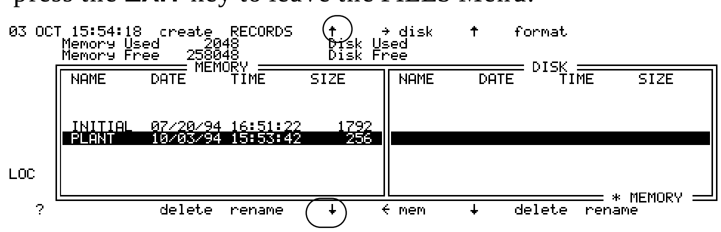




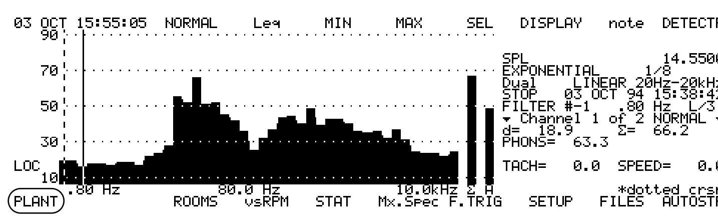
4. Press the **EXIT** key when finished entering file name. The file name “PLANT” will appear on the left side of the display with the associated date, time, and size.



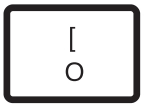

After creating a few files you may select which of these files you wish to use to store your data into. To do this use the ↑ **[C]** or ↓ **[K]** arrow keys to highlight the file “PLANT” and press the **EXIT** key to leave the FILES Menu.




The file name “PLANT” that you selected will appear on the lower left side of the display. This indicates that this is the active file and all subsequent data storage will be placed into this file.

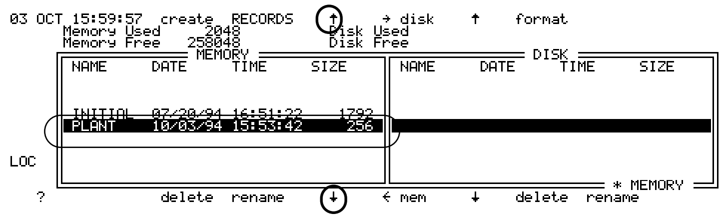


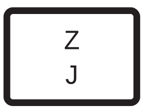
## Renaming a file



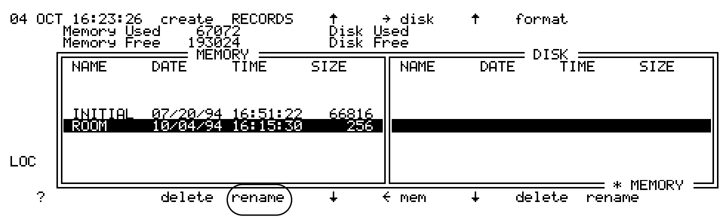

1. Press the **FILES [O]** key found in either the Main Menu or the System Menu.

2. Select the file “PLANT”, or a desired file to be renamed, by using the ↑ **[C]** or ↓ **[K]** key.

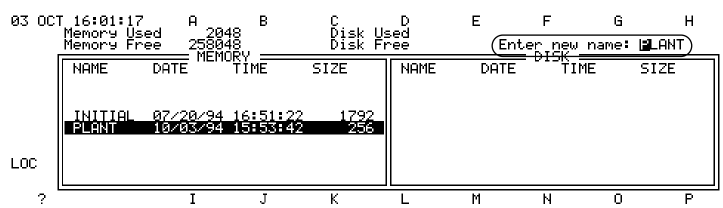


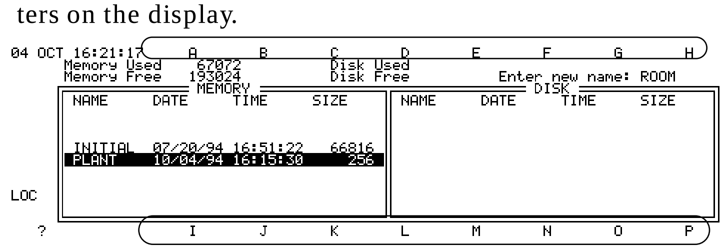

3. Press the **rename [J]** key.

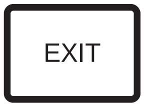



The following message, “Enter new name:”, will appear on the right side of the display.

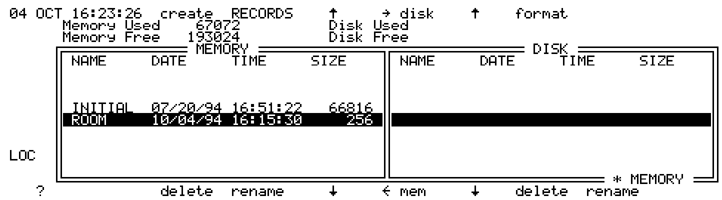



4. Enter the new file name “ROOM” by using the alpha characters on the display.

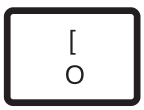





**5.** Press the **EXIT** key. The new file “ROOM” has replaced the old file name “PLANT”.

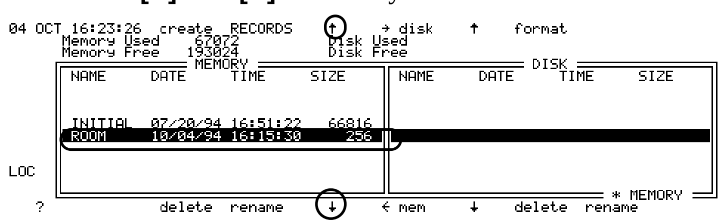


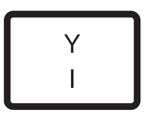

## Deleting a file



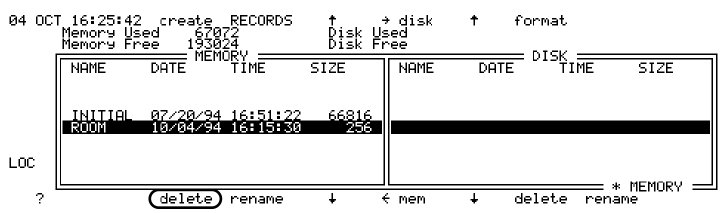

**1.** Press the **FILES [O]** key found in either the Main Menu or the System Menu.

**2.** Select the file name “ROOM”, or a desired file to be deleted, with the ↑ **[C]** or ↓ **[K]** arrow keys.

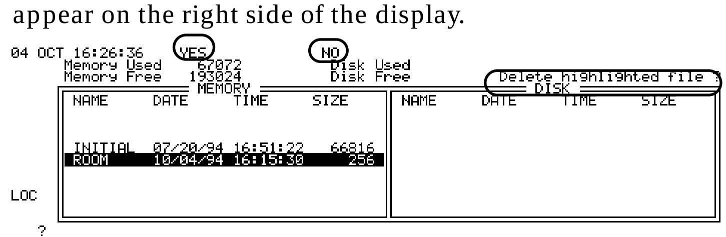


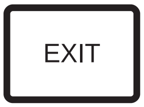

**3.** Press the **delete [I]** key.




The following message, “Delete highlighted file?”, will appear on the right side of the display.

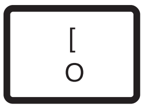


**4.** Press either the **YES [A]** or **NO [C]** to answer the message. Pressing YES will delete the file, pressing NO will return you to the files menu without affecting the file.



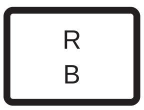

**5.** Press the **EXIT** key to leave the FILES menu

### Recalling a previously stored record:

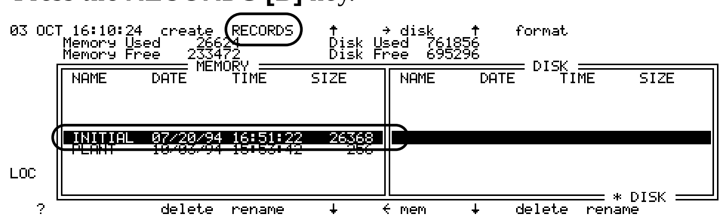



**1.** Press the **FILES [O]** key found in either the Main Menu or the System Menu.

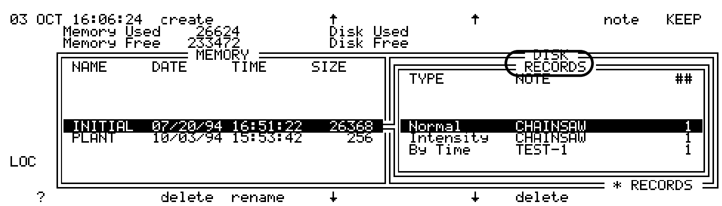
**2.** Select the FILE where the desired stored data record to be recalled can be found by using the ↑ **[C]** or ↓ **[K]** arrow keys.



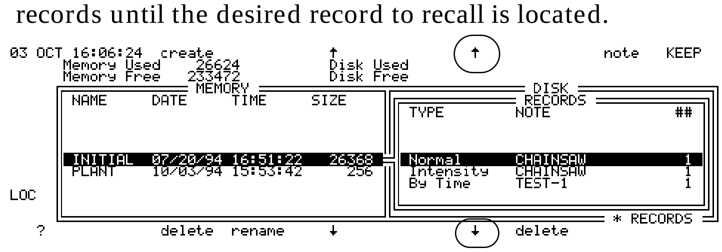

**3.** Press the **RECORDS [B]** key.




A listing of the stored data records will appear on the right side of the display. The record listing will show the TYPE of record stored (i.e. Normal, Intensity, byTime, SLM, etc.), and a note, if any, that was attached when the data was stored.

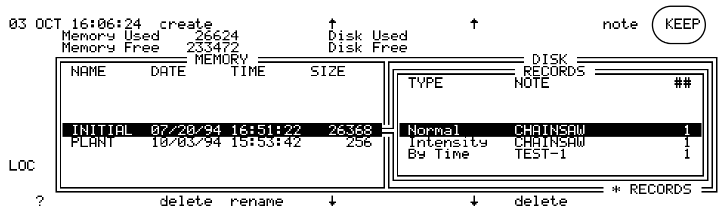



**4.** Press the ↑ **[E]** or ↓ **[M]** key to scroll through the stored records until the desired record to recall is located.

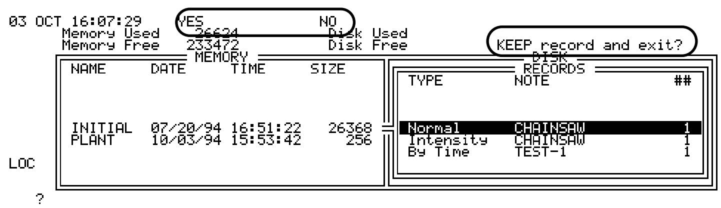


X
H

**5.** Press the **KEEP [H]** key.




The message, “KEEP record and exit?”, will appear on the right side of the display.




**6.** Press either the **YES [A**] or **NO [C]** key to answer the message. Pressing YES will recall the stored data record and analyzer configuration to the display, leaving the FILES menu. Pressing NO will return you to the FILES menu.

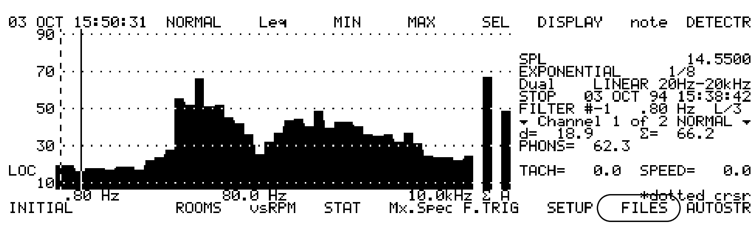
EXIT

**7.** If you answered NO to the above step and no longer desire to manipulate the files, press the **EXIT** key to return from the FILES menu.

### Transferring stored files to a floppy disk

[
O

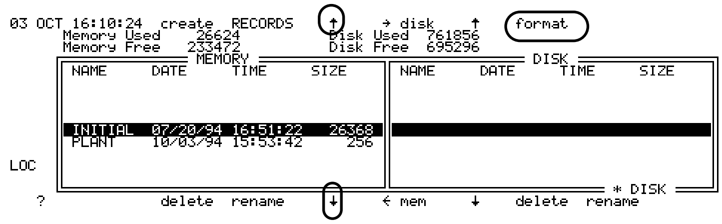
**1.** Press the **Files [O]** key found in either the Main Menu or the System Menu.



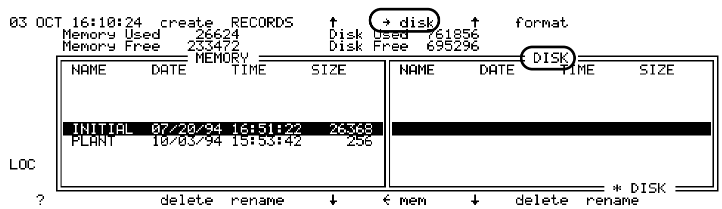

V
F

Place a 3.5 inch floppy disk into the disk drive located in the back of the analyzer.

**2.** Select the desired file to be transferred to the floppy disk by using the ↑ **[C]** or ↓ **[K]** key.




**3.** Press the →**disk [D]** key.




The disk drive will activate, and the following sequence of messages will appear on the upper right side of the display:

**A.** Opening disk file.

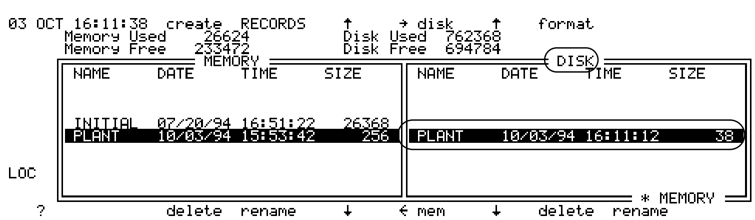
**B.** Copying file to disk.

**C.** Copy done.

**D.** O.K. to remove disk.

**NOTE:** Do not remove the floppy disk from the disk drive until the analyzer tells you that it is okay to remove the disk. The file transfer will not be completed if the disk is removed prematurely.

The file name will now appear in the section of the display labeled “DISK” indicating the file has been transferred to the floppy disk.




**4.** Press the **EXIT** key to leave the FILES menu.

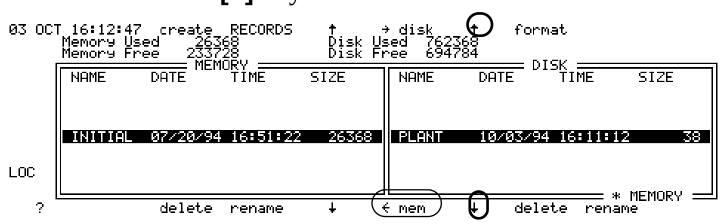
### Transferring disk files to analyzer memory

[
O

**5.** Press the **Files [O]** key found in either the Main Menu or the System Menu.Place a 3.5 inch floppy disk drive located in the back of the analyzer.Select the desired file to be transferred into the analyzer memory by using the ↑ **[E]** or ↓ **[M]** keys.

@
L

**6.** Press the ←**mem [L]** key.

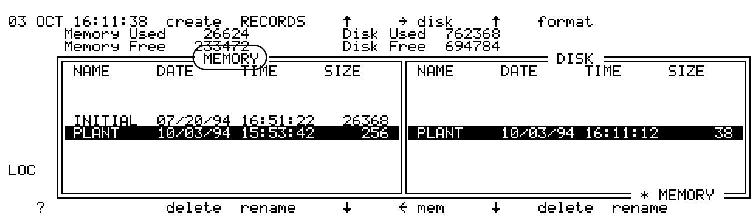



The disk drive will activate and the following sequence of messages will appear on the upper right side of the display:

**A.** Copying file to memory.

**B.** Copy done.

The transferred file name will appear on the section of the display labeled “MEMORY” indicating that the file has been transferred to the internal memory of the analyzer.




EXIT

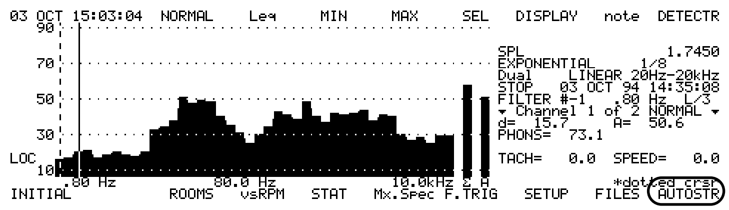
5. Press the **EXIT** key to return from the analyzer menu.

## Autostore by time

Before beginning an autostore operation you should select a data file in which you want the autostore data record to be stored. To select the desired file refer to the previous section titled “FILE operation”.

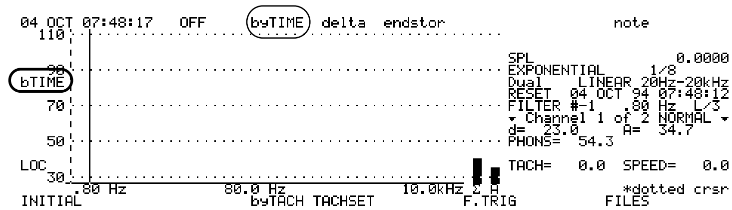
]
P

**1.** Press the **AUTOSTR [P]** key, found in the Main Menu.



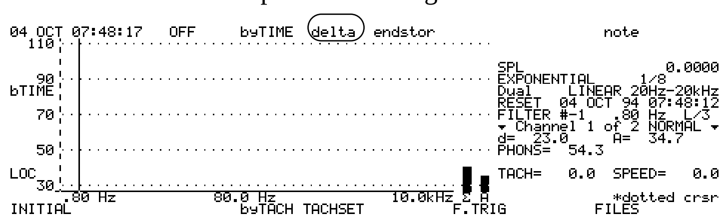

R
B

**2.** Press the **byTIME [B]** key. A “bTIME” indicator will appear on the middle left side of the display. This indicates that the Autostore by time is activated.

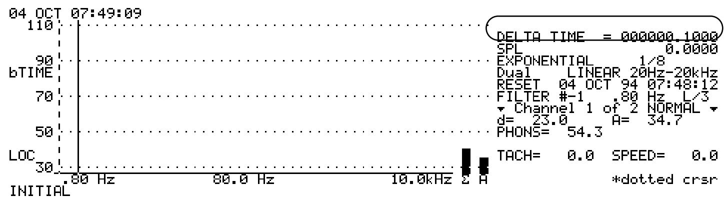



S
C

**3.** Press the **delta [C]** key to set the desired time interval between successive spectrum storages.



The message “DELTA TIME = XXXXXX.XXXX” along with a flashing cursor will appear on the upper right side of the display. The “DELTA TIME” indicates how often a spectra will be stored during a measurement.

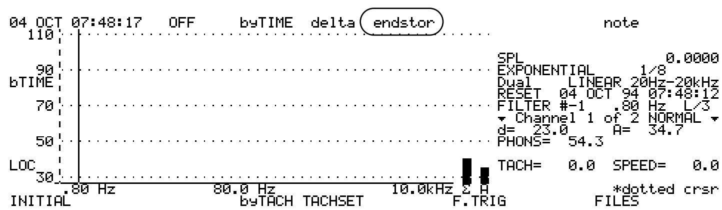



EXIT

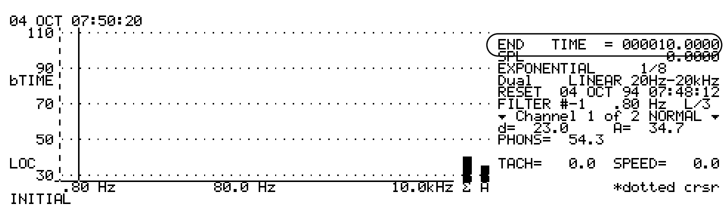
**4.** Use the left and right arrows keys to navigate through the time displayed and enter the desired time interval by using the numeric keys on the analyzer and press the **EXIT** key.

T
D

**5.** Press the **endstor [D]** key to set the desired run time period of the measurement.




The message “END TIME = XXXXXX.XXXX” along with a flashing cursor will appear on the upper right side of the display. The “END TIME” indicates how long the measurement will run. Upon reaching the selected “END TIME” the analyzer will stop the measurement.




EXIT

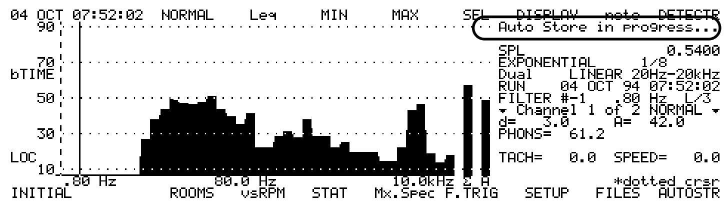
**6.** Using the numeric keys of the analyzer, enter the desired value, in seconds, for how long you want the analyzer to store data. Then press the **EXIT** key.

EXIT

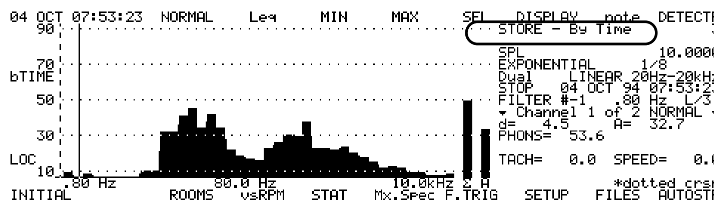
**7.** Press the **EXIT** key to return from the AUTOSTOR menu.

RESET
R/S

**8.** Press the **R/S** key to begin the Autostore. The message, "Autostore in progress....", will appear on the upper right of the display.




When the analyzer has reached the endstore time, that was previously entered, the message "STORE - By Time X" will appear indicating the data has been stored to the memory of the analyzer. The "X" indicates the record number of this type that has been stored in the pre-selected file. Any subsequent presses of the **R/S** key will re-initialize the Autostore function.



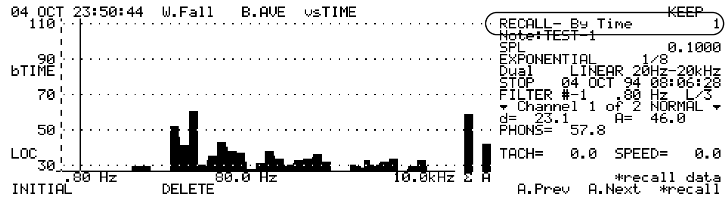

## Recalling an Autostore

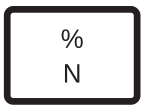
To recall an Autostore measurement you must have the Autostore feature activated on the analyzer. (See the section, "Autostore byTime")

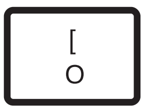
To recall an Autostored file you may either press the **FILES [O]** key or by pressing the **RECALL** hardkey. To recall a file with the **FILES [O]** key, refer to "Recalling a previously stored record" in Chapter 1.

To recall a stored Autostore file with the **RECALL** hardkey:

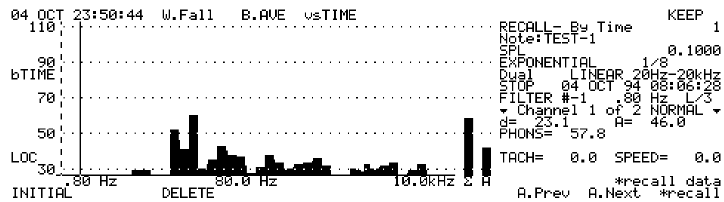

1. Press the **RECALL** hardkey to recall the Autostore measurement. The recalled record number is identified on the upper right side of the display.



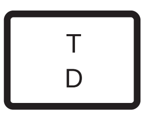



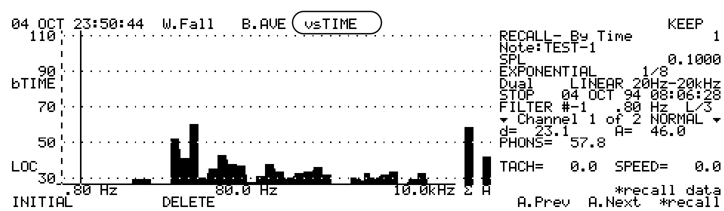

2. Press the **A.Prev [N]** or **A.Next [O]** to scroll through the autostored records until the desired record is displayed.



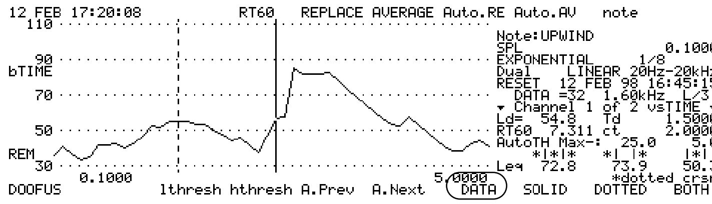

3. Turn the knob to move through the autostored measurement. Each spectrum displayed, by turning the knob, is a time slice that correlates to the autostore delta rate set at the time of the measurement. The last spectrum displayed will be the last autostore performed when the “End Time” was reached.

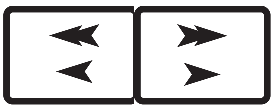



4. Press the **vsTIME [D]** key to view the stored spectrum vs. time.

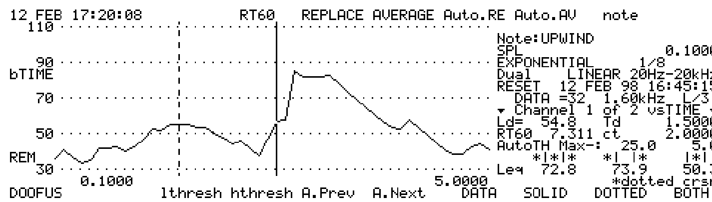



**5.** Press the **DATA [M]** key to assign the **PREV** and **NEXT** keys as frequency selectors, which will permit you to scroll through the frequency bands.



**6.** Press the **PREV** and **NEXT** keys to display the response of each frequency band over time. The run time of the autostore is shown on the x-axis of the display.



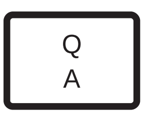


**7.** Press the **EXIT** hardkey to return to the **RECALL** menu.

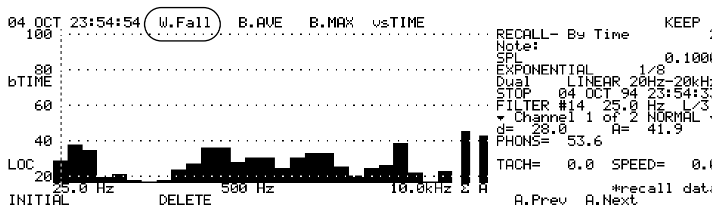
## Waterfall display of Autostored Records

The waterfall display function permits the sequential display of a series of individual spectra within a byTime type autostored record.

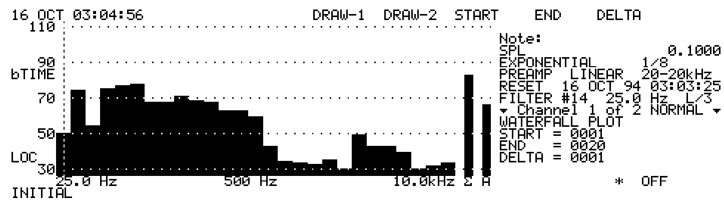

**1.** Press the **RECALL** hardkey and press the **A.Prev [N]** or **A.Next [O]** keys to select the desired autostored record to be displayed as a Waterfall.




**2.** Press the **W.Fall [A]** key to enter the Waterfall display menu.



**3.** Press the following keys, if you desire to indicate the Start and End spectra to be displayed, and the Delta (incremental record number) between displayed spectra.



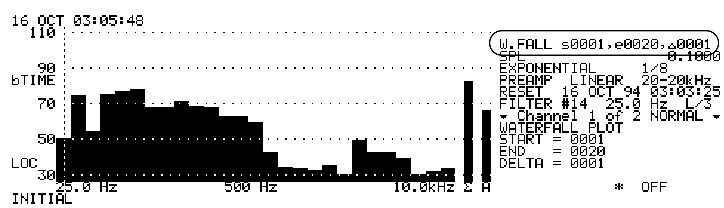

**START [E]** Selects the first spectra in sequence that will be displayed.

**END [F]** Selects the last spectra in sequence that will be displayed.

**DELTA [G]** Selects the incremental record number between displayed spectra.

Upon pressing anyone of these keys the following message will appear:

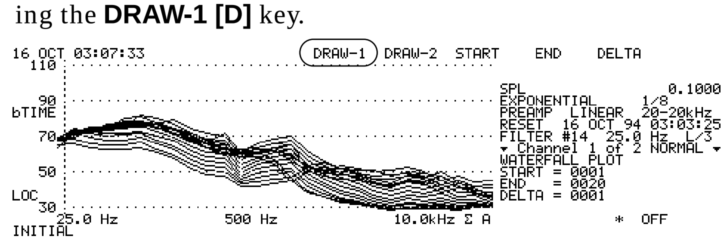
“W.FALL sXXXX,eXXXX,dXXXX”, and instead of pressing each individual key listed above you may edit all the display parameters at the same time by entering the numbers with the numeric keypad and the horizontal arrow keys.




EXIT

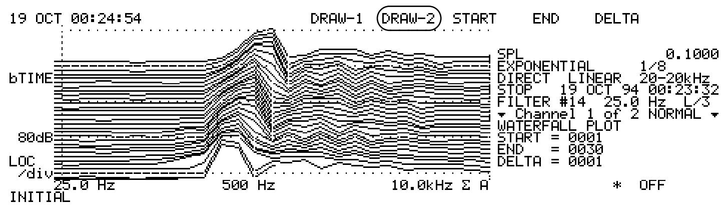
T
D

**4.** Press the EXIT hardkey, the display sequence will begin immediately. You may repeat the display sequence by pressing the **DRAW-1 [D]** key.



There are two formats available for the presentation of the waterfall plots. In the two dimensional format, produced by pressing **DRAW-1 [D]** as described in this step, the spectra are simply overlaid, one at a time without any offsets in the vertical and horizontal directions.

In the three dimensional format, produced by pressing the **DRAW-2 [D]** key, an offset in both the vertical and horizontal directions is added to each successive spectrum curve, providing perspective to the view.




EXIT

**5.** Press the **EXIT** hardkey to return to the RECALL Menu. If you are finished viewing the recalled data press the **EXIT** hardkey again to return from the RECALL Menu.

## Block Averaging of Autostored Spectra

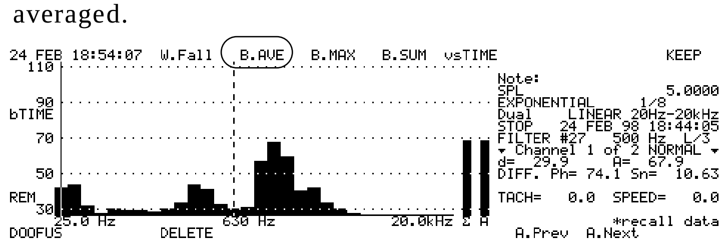
Sequentially stored autostored or non-autostored records can be averaged together using the Block Averaging Function, summed together using the Block Summation function or the Block Maximum function can be applied giving the highest level occurring at the same frequency across all the Nth spectro in the separate autostore records.

CLEAR
RECALL

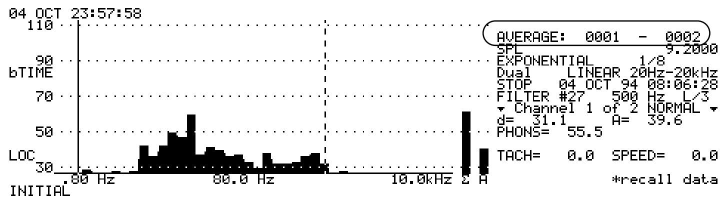
**1.** Press the **RECALL** hardkey to enter the Recall Menu.

R
B

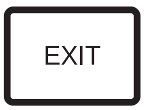
**2.** Press the **B.AVE [B]** key to select the desired records to be averaged.



The message “AVERAGE: 0001 - 0002" will appear on the upper right side of the display.

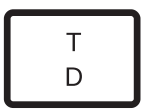



3. Press the numeric keys and horizontal arrow keys to enter the range of record numbers of the autostored records to be averaged together.

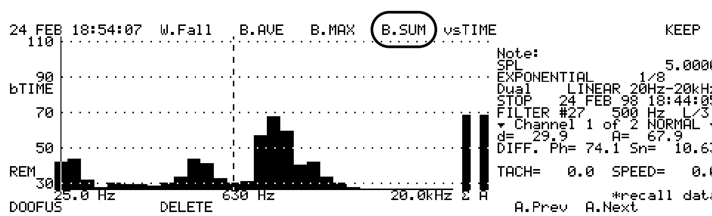



4. Press the **EXIT** hardkey

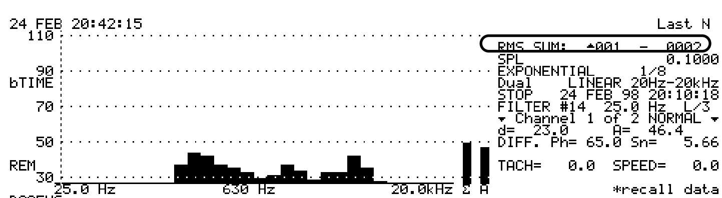
Upon pressing **EXIT** a single averaged autostored record will be created and stored into the next available record number. The word AVERAGED will also appear on the right side of the display indicating that this autostored record is an averaged record.



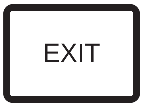

5. Press the **B.SUM [D]** key to select the desired records to be summed together.




The message “RMS SUM: 0001 - 0002” will appear on the upper right side of the display.

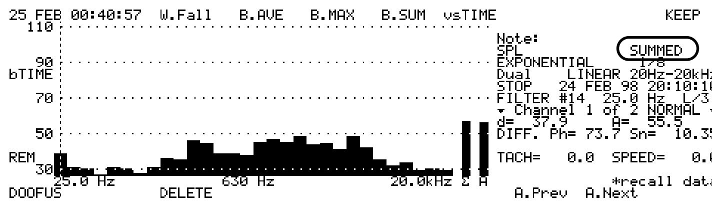


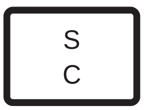
**6.** Press the numeric keys and horizontal arrow keys to enter the range of record numbers of the autostored records to be summed together.



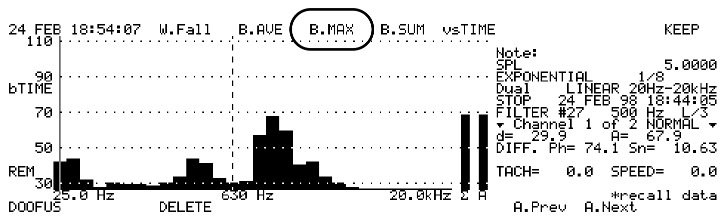

**7.** Press the **EXIT** hard key.

In the third line down on the right hand side of the display the word “SUMMED” will appear indicating that this autostored record is a summed record.

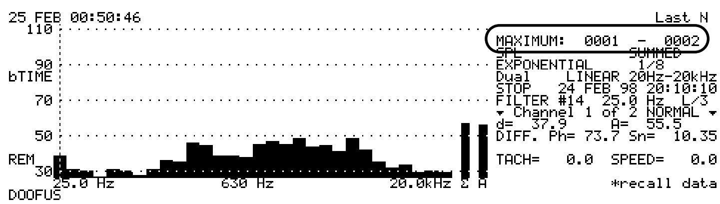



**8.** Press the **B.MAX [C]** key to apply the Block Maximum function.



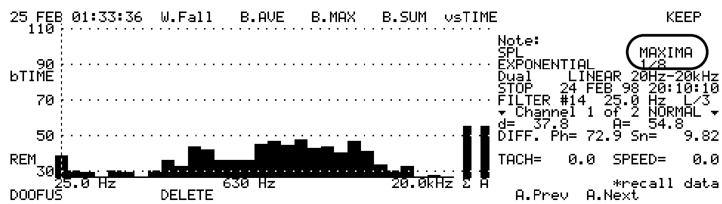

The message “MAXIMUM 0001-0002” will appear on the upper right side of the display.




**9.** Press the numeric keys and horizontal arrow keys to enter the range of record numbers of the autostored records to be applied in the Block Maximum function.

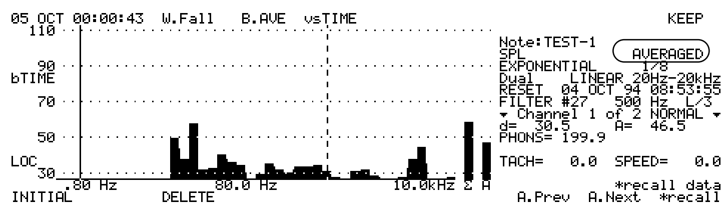

**10.** Press the **EXIT** hardkey.

In the third line down on the right hand side of the display the word “MAXIMA” will appear indicating that this autostored record is a maximum record.

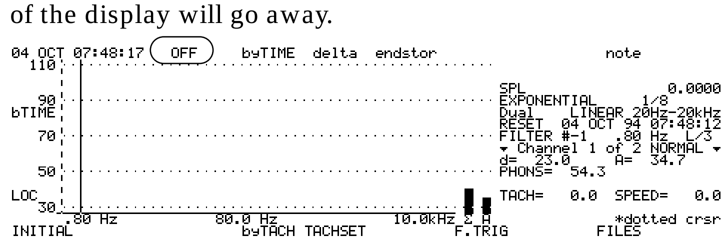




**11.** Press the **EXIT** hardkey, if you are finished viewing the recalled data, to return from the Recall Menu.




To turn off the Autostore function press the **OFF [A]** key in the AUTOSTOR menu. The byTIME message on the left side of the display will go away.




The routine just explained is for a manual start of the Autostore function. The analyzer has the capability to begin the Autostore function automatically by setting a frequency trigger (explained earlier in this manual). After setting the frequency trigger and activating the Autostore feature, press the R/S hardkey to place the analyzer in the ARM mode. Upon satisfaction of the trigger criteria the analyzer will begin the Autostore and stop automatically when the end-store time has been reached.

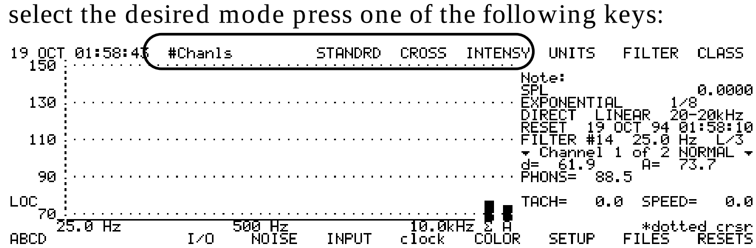
CHAPTER

# 2 System Menu

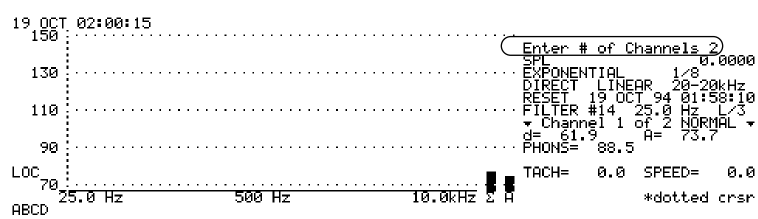
To access the System menu from the Main menu, press the **SYSTEM** hardkey located on the left side of the analyzer. In this menu you can select the desired mode of operation, perform a calibration, select the desired filter band-width, I/O communications, or change the input filters.

## Operation Modes

There are three basic modes of operation of the analyzer. To select the desired mode press one of the following keys:




**#Chanls [A]** This key permits you to select the number of input channels to be used for measurements. You may select up to the number of input channels with which your analyzer is configured with.




**STANDARD [C]** This key places the analyzer in a standard operation mode where spectral data are measured for each of the different input channels, but no cross channel parameters are measured.

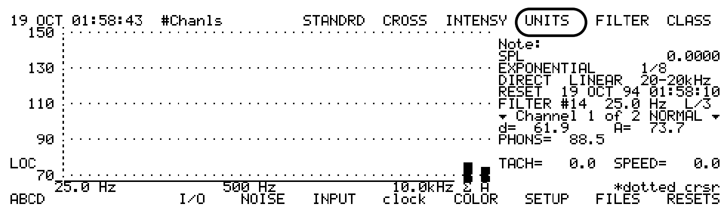
**CROSS [D]** This key places the analyzer in a cross channel mode for performing Autospectrum, Cross spectrum, Transfer functions, and Coherence measurements. This implies a cross channel measurement between channel 1 and channel 2.

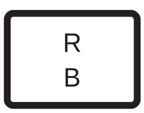
**INTENSITY [E]** (optional) This key places the analyzer in the intensity mode for performing; intensity, sound power, and quality measurements. This mode of operation is discussed in detail later in this manual.

## Selection of Units and Calibration

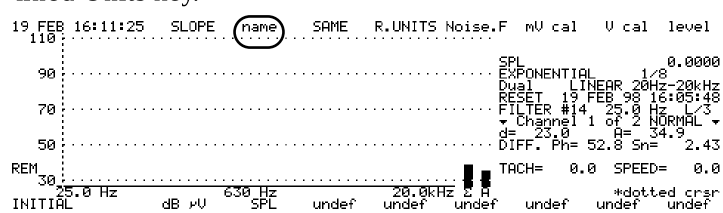
In the Units menu you can select either dBμv, SPL, or define your own units of calibration. To select a units type or define a new unit of calibration:


1. Press the **UNITS [F]** key from the System menu.

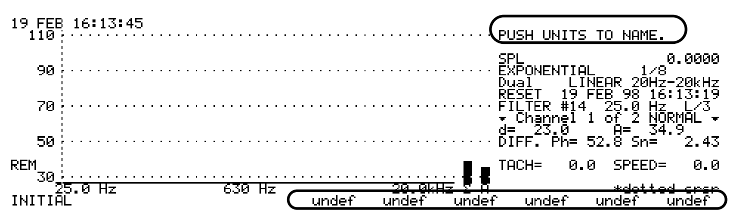


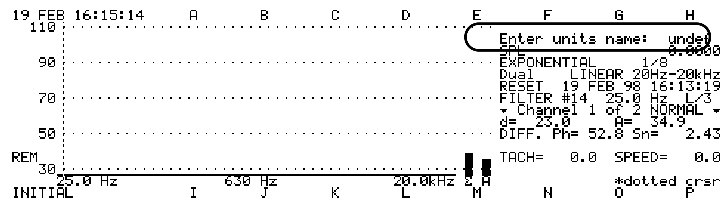

2. Press the **name [B]** key to assign a Units name to an undefined Units key.



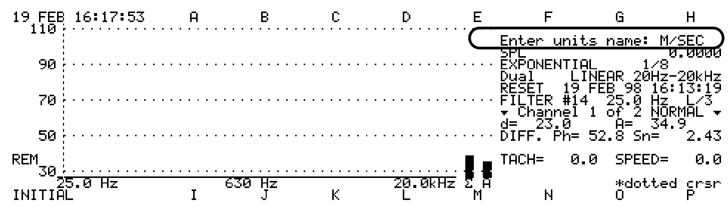

The message “Push setup to name” will appear prompting you to press on the undefined softkeys **[K]-[P]** that are labeled “undef”.



3. Press one of the undefined softkeys to be named. The message “Enter units name” with a flashing cursor will appear on the display. (Push **SHIFT CLEAR** to clear old name.)

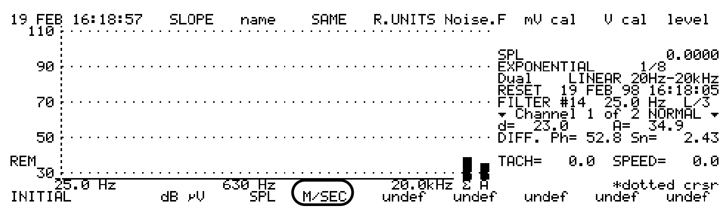



4. Enter the new desired Unit name “M / SEC” by using the alpha characters appearing on the display. Typical names for Units are: g, m / sec, ft. / sec, or psi.

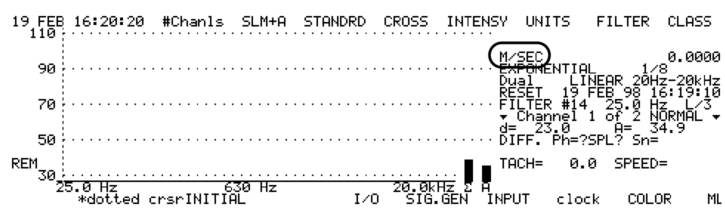




5. Press the **EXIT** hardkey. The new name “M / SEC” will appear on the softkey previously selected.




6. Press the newly named unit key (M / SEC). The new name will appear on the upper right side of the display.





7. Press the **EXIT** hardkey to return to the System Menu.

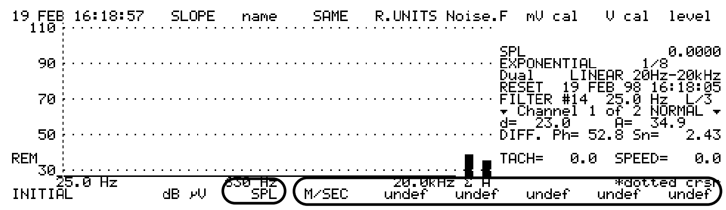
## Calibration based on a Reference Signal

Before calibrating the analyzer, verify that the exponential detector has been selected. To calibrate the system based on a reference signal:

V
F

1. Press the **UNITS [F]** key from the System menu.

2. Select either the **SPL [J]** key or one of the user-defined keys **[K]-[P]** to which the calibration level will be assigned.

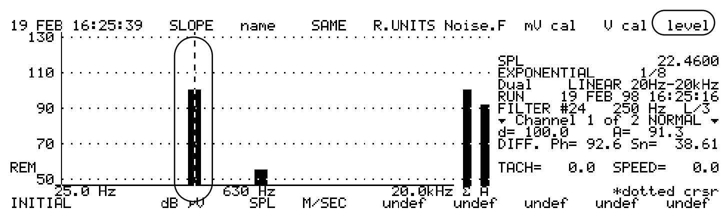



3. Apply a known excitation level, say from a microphone calibrator, to the transducer (in this case a microphone).

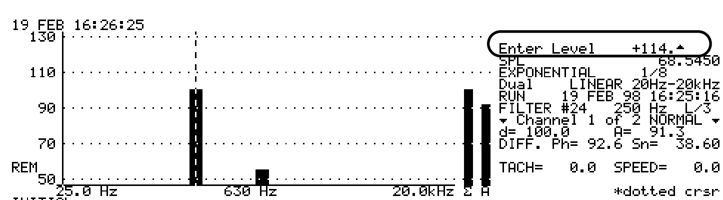
RESET
R/S

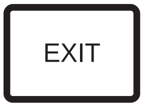
4. Press the **R/S** hardkey to run the analyzer.

5. Move the cursor to the frequency of excitation by using the left or right arrow keys. Press the level [H] key.



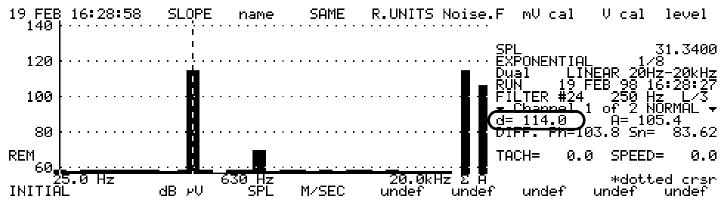

The message 'Enter Level XXX' will appear on the right side of the display prompting you to enter the known excitation level, via the numeric keypad. For a Larson•Davis Model CAL250 calibrator the level will be 114.0dB.






**6.** Press the **EXIT** hardkey to return to the System Menu

Verify the calibration by placing the unit in the RUN mode and turn the calibrator on. The level displayed should agree to the level entered when calibrated.




The analyzer has now been calibrated to a reference level, and the reference level assigned to a Unit name. You may assign up to 6 different Unit names with 6 associated calibration reference levels.

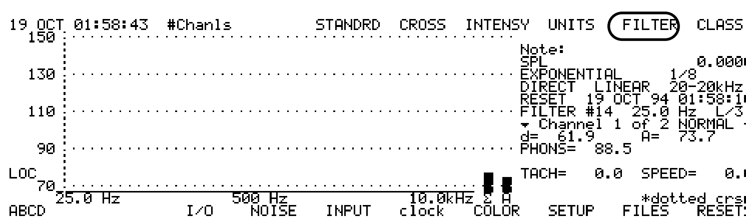

These names and reference levels may be stored as a file to the memory of the analyzer by pressing the **STORE** hardkey for future recall.

## Calibration based on a Transducer Sensitivity Value

This topic will be covered in detail in the Vibration Analysis section of this manual.

## Selection of Filter Type - Octave, Fractional Octave, and FFT

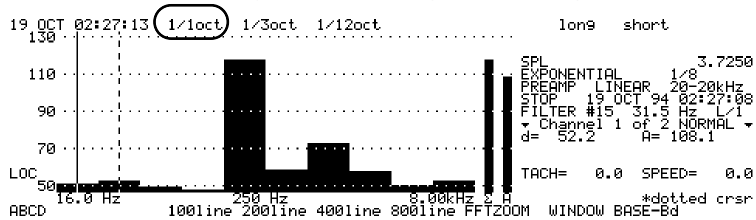
To select a filter type, press the **Filter [G]** key from the System Menu.



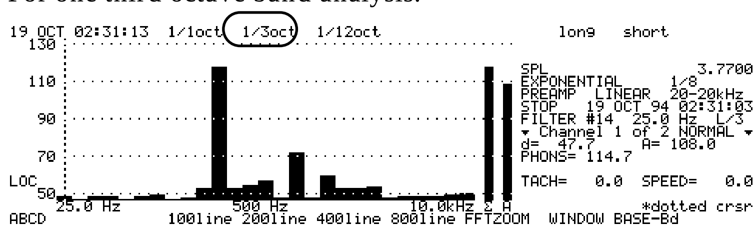

**For Octave and Fractional Octave analysis perform the following:**

**1.** Press one of the following keys:

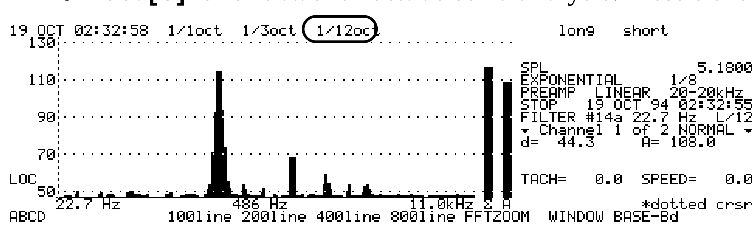
**1/1oct [A]** For octave band analysis. Note designation in right hand corner.




**1/3oct [B]** For one third octave band analysis.

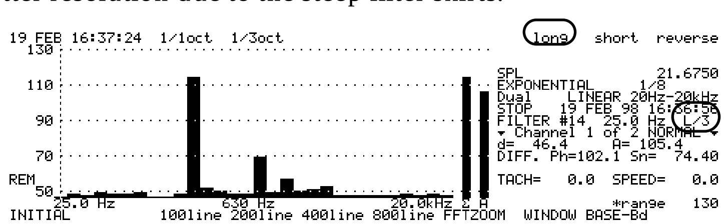



2. **1/12oct [C]**For one twelfth octave band analysis. Press either

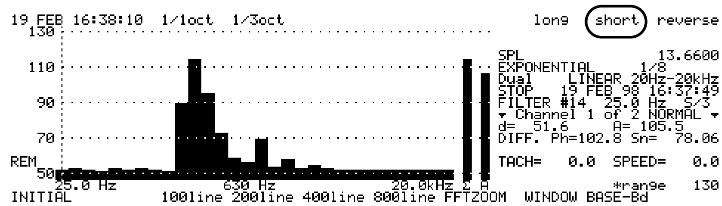



the **long [F]**, **short [G]**, **reverse [H]** key to select the type of digital filter algorithm used.

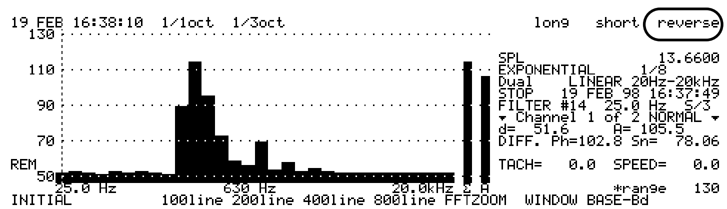
**long [F]** Satisfies the ANSI S1.11-1986 requirements for Type 0-AA classification with optimal passband flatness and stopband rejection. This is used more for measuring steady state noise, because of the better resolution due to the steep filter skirts.




**short [G]** Satisfies the ANSI S1.11 -1986 requirements for Type 1-D classification. This is used for measurements which require a particularly fast filter time response such as gunshots. The slope of the short filter skirts is less than that of the long filter, however, the resolution of the short filter is not as fine as that of the long filter.




**reverse [H]** The reverse time short filter is used for measuring short RT. It reduces residual time of the filter by a factor of 10. It allows measurements of RT at 200 Hz down to about 20 ms.




EXIT

3. Press the **EXIT** hardkey to return to the System Menu.

**For FFT Analysis perform the following:**

There are three parameters which must be defined to perform an FFT analysis; the number of lines, the window type, and the full scale frequency.

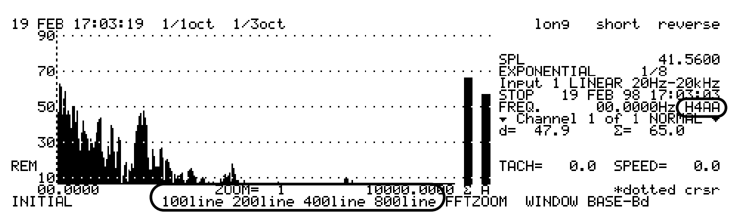
1. Press one of the following keys to select the FFT analysis mode and the number of lines. Note H4AA designation when 400 lines is selected.

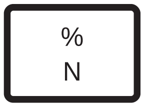
**100line [I]** 100 line FFT

**200line [J]** 200 line FFT

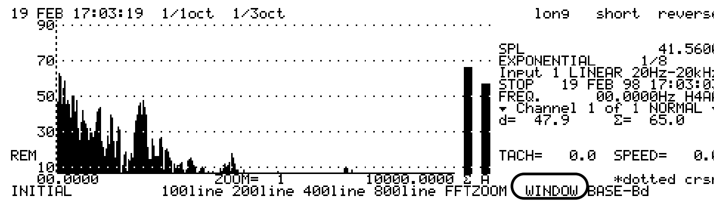
**400line [K]** 400 line FFT

**800line [L]** 800 line FFT

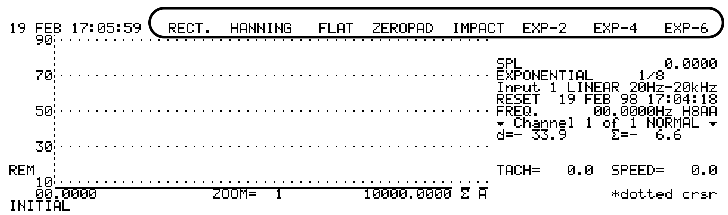





**2.** Press the **Window [N]** key to select the desired time weighting window.




**3.** Press one of the following keys to select the time weighting window.




**RECT. [A]** For Rectangular Weighting on all channels. Provides the finest frequency resolution but is often accompanied by excessive leakage of energy to the neighboring sidebands.

**HANNING [B]** For Hanning Weighting on all channels. Used with steady signals, gives better frequency resolution.

**FLAT [C]** For Flat Top Weighting on all channels. Used with steady signals, gives better amplitude accuracy in the passband.

**ZEROPAD [D]** For Zero Pad with / without Bow Tie Correction on all channels

**IMPACT [E]** For Impact Weighting on channel 1 Rectangular Weighting on Channel 2.

**EXP-2 [F]** Impact Weighting on channel 1 Exp-2 Weighting on channel 2

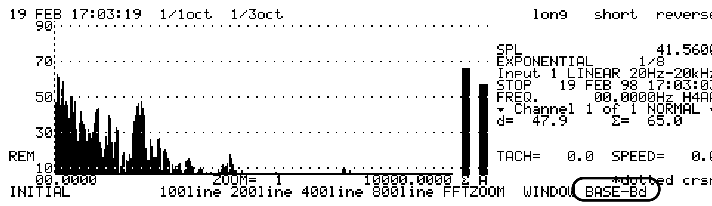
**EXP-4 [G]** Impact Weighting on channel 1 Exp-4 Weighting on channel 2.

**EXP-6 [H]** Impact Weighting on channel 1 Exp-6 Weighting on channel 2.

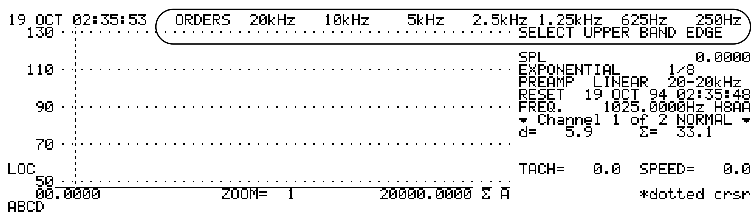
The Impact and Exponential Weighting windows are generally used for modal analysis applications.

[
O

**4.** Press the **BASE-Bd [O]** key to select the Full Scale Frequency Baseband.




**5.** Press one of the following keys to select the upper band edge. Your selection will be identified on the lower right side of the frequency axis.

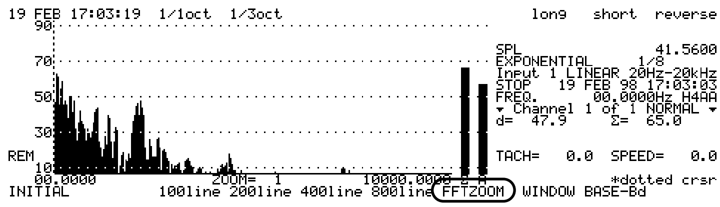



| | |
|---|---|
| **Orders[A]** | Highest order in Hz. |
| **20kHz [B]** | 20kHz upper band edge. |
| **10kHz [C]** | 10kHz upper band edge. |
| **5kHz [D]** | 5kHz upper band edge. |
| **2.5kHz [E]** | 2.5kHz upper band edge. |
| **1.25kHz [F]** | 1.25 kHz upper band edge. |
| **625Hz [G]** | 625 Hz upper band edge. |
| **250Hz [H]** | 250 Hz upper band edge. |

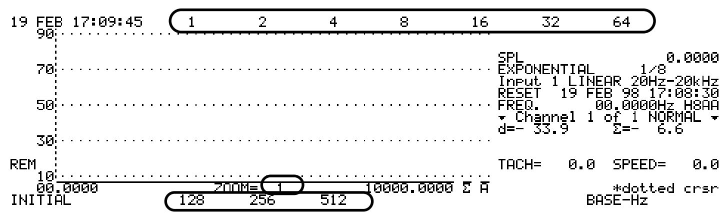
**NOTE:** When performing a baseband analysis, if the selected full-scale frequency is >10kHz using two channels the analysis will not be performed in real-time.

#
M

**6.** Press the **FFTZOOM [M]** key to select the desired Zoom factor.




**7.** Select the desired Zoom Factor, 1 through 512, by pressing a key **[A] - [K]**. Your selection will appear below the frequency axis of the display.




EXIT

**8.** Press the **EXIT** hardkey to return to the FILTER Menu.

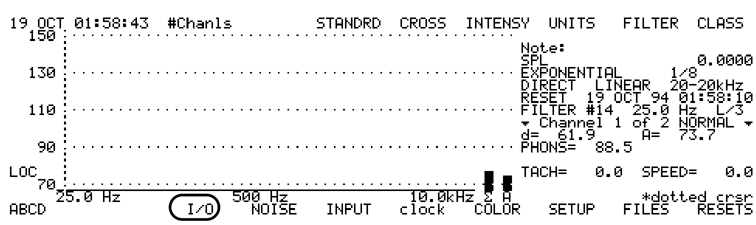
**9.** Press the **EXIT** hardkey to return to the SYSTEM Menu.

## I/O Communications

### Selecting a baud rate

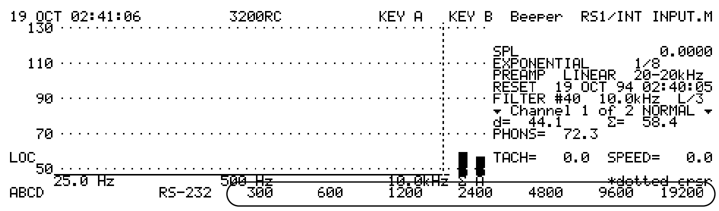
Y
I

**1.** Press the **I/O [I]** key from the System menu.



**2.** Select the desired baud rate by pressing one of the keys **[J]-[P]**.

The message “RS232 XXXX BAUD SELECTED” will appear on the upper right of the display. The XXXX indicates which baud rate you have selected.





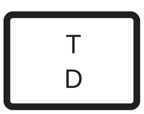
**3.** Press the **EXIT** hardkey to return to the System menu.The analyzer is ready for communication to a peripheral device.

## I/O port control

### Key A and Key B control

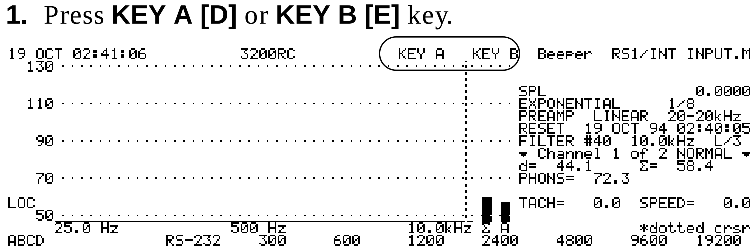
The most common use of these keys is in conjunction with the Larson•Davis Model 2260 Intensity probe, which has two keys (thumb and forefinger) on the handle. These two keys can be programmed such that a press of each of these keys simulates a press of the softkeys or hardkeys on the analyzer.

To program either of these keys perform the following:

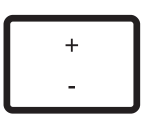




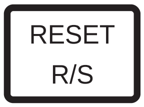
**1.** Press **KEY A [D]** or **KEY B [E]** key.




The message “PRESS [-], THEN THE KEY” will appear on the upper right side of the display.



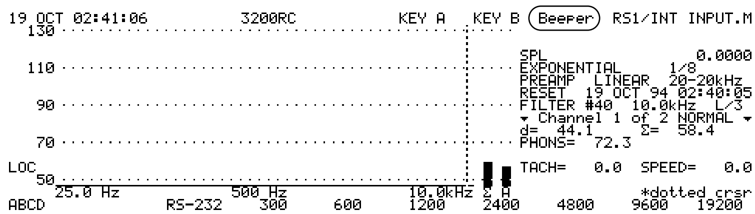

**2.** Press the “**-**” minus hardkey



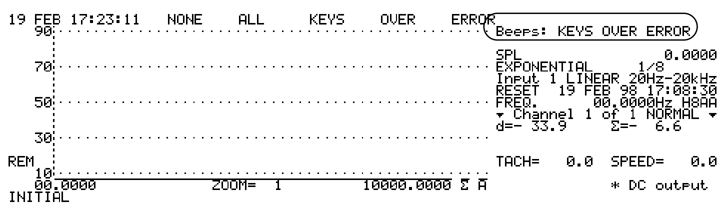

**3.** Press the softkey or hardkey to be assigned to Key A or Key B. Typically the **R/S** hardkey is assigned to Key A, and the **STORE** hardkey is assigned to Key B.

## Beeper Control


**1.** Press the **Beeper [F]** key.




**2.** Press one of the following keys to program the beeper function:




**NONE [A]** No beeper signal at all.

**ALL [B]** Beeper signal for a key press, an overload condition, and an error condition.

**KEYS [C]** Toggles On / Off the beeper signal for a key press.

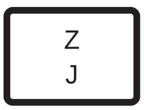
**OVER [D]** Toggles On / Off the beeper signal on an overload condition.

**ERROR [E]** Toggles On / Off the beeper signal on an error condition.

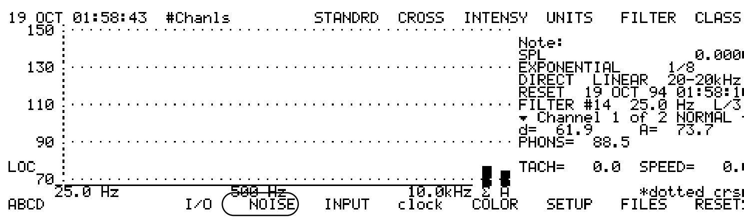
# Operation of the Noise and Signal Generator (Opt 10 & Opt 11)

## Option 10 Noise Generator

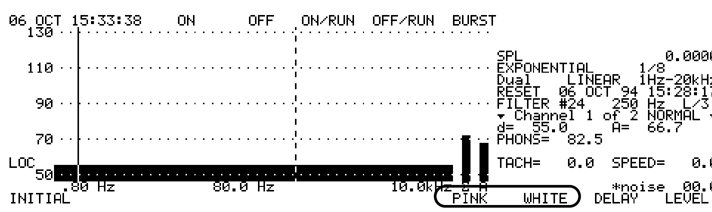
The Option 10 Noise Generator has the capability to produce Pink noise, or White noise, and control the mode of operation of the noise. It is accessed in the System Menu.




**1.** Press the **NOISE [J]** key from the System menu.



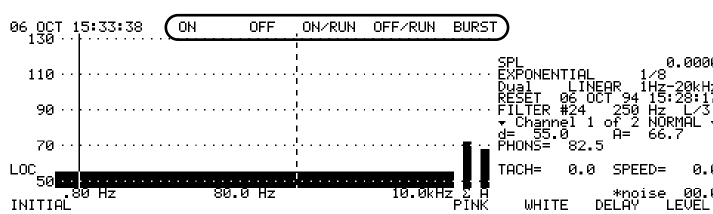

**2.** Select the desired spectral content by pressing the **PINK[M]** or **WHITE [N]** keys:




**PINK [M]** Equal energy content per percentage bandwidth.

**WHITE [N]** Equal energy content per constant bandwidth.

**3.** Press one of the following keys to select the mode of operation:



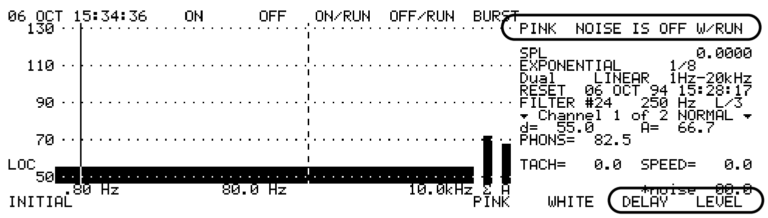

**ON [A]** Turns the noise source on.

**OFF [B]** Turns the noise source off.

**ON/RUN [C]** Will activate the noise generator when the analyzer is in the RUN mode.

**OFF/RUN [D]** Will de-activate the noise generator when the analyzer is in the RUN mode.

**BURST [E]** Selects the burst mode. The repetition of the burst key is set by pressing the Delay [O] key and using the horizontal keys to adjust the rate in seconds.



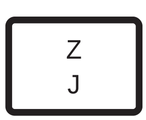

**DELAY [O]** The Delay function permits you to set a delay for when the noise will be turned on. Typically used in conjunction with the ON/RUN [C] function.

**LEVEL[P]** Level is used to set the output level of the noise generator.

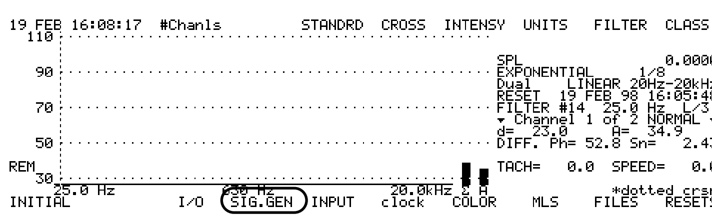
The noise generator output is located on the top of the instrument identified by the label “source output” located on the back of the instrument. This output is typically used to drive a loud speaker for room acoustics.

## Option 11 Signal Generator

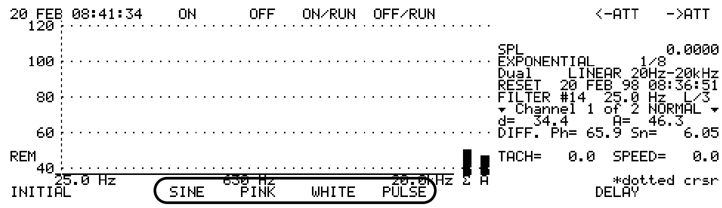
The OPT 11 Signal Generator provides swept sine (with tracking filter and feedback level control), dual frequency swept sine and a pulse generator in addition to the pink and white noise provided by the OPT 10 Noise Generator. Also, there is an autolevel feature for use with the pink noise to assist in equalizing the noise level in a test room.




**1.** Press the **SIG.GEN [J]** key from the System menu.



**2.** Select the desired spectral content by pressing one of the following keys:



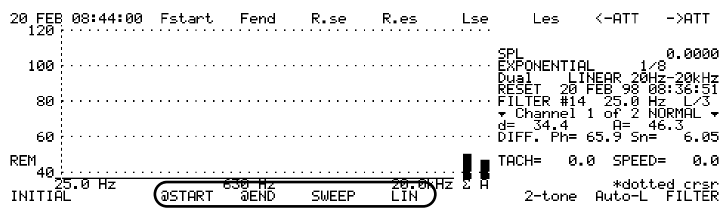

**SINE [I]** Swept sine generator.

**PINK [J]** Equal energy content per percentage bandwidth.

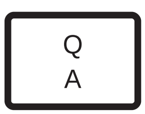
**WHITE [K]** Equal energy content per constant bandwidth.

**PULSE [L]** Pulse noise generator.

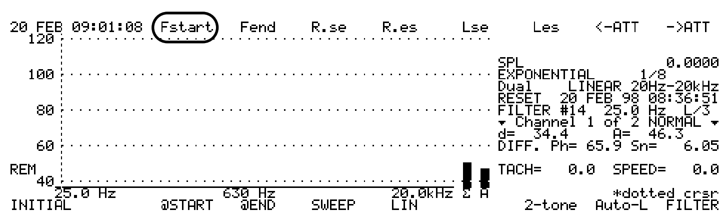
**3.** Select the **SINE [I]** key.




**SINE [I]**




**A.** Press **Fstart [A]**. You will be prompted to set the lower frequency limit via numeric keypad where the sweep will begin.

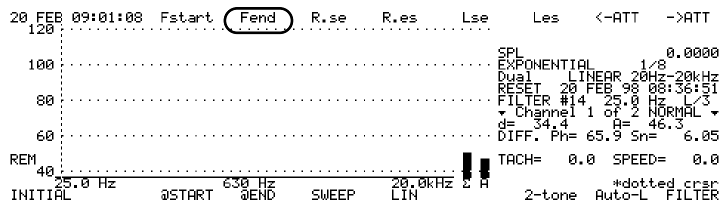




**B.** Press the **EXIT** hardkey.

R
B

**C.** Press **Fend [B]** key. You will be prompted to set the upper (end) frequency limit, via the numeric keypad, where the sweep will end.



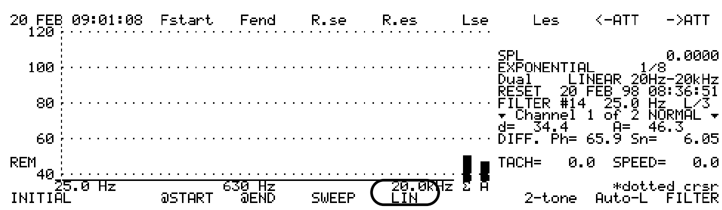

EXIT

**D.** Press the **EXIT** hardkey.

The rate of the sweep can be either logarithmic or linear in the frequency domain. Whenever one of the parameters of the sine generator is changed,

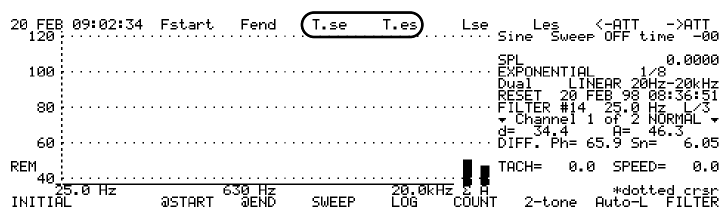
@
L

**E.** Press the softkey **[L]** to select between Log and Lin.



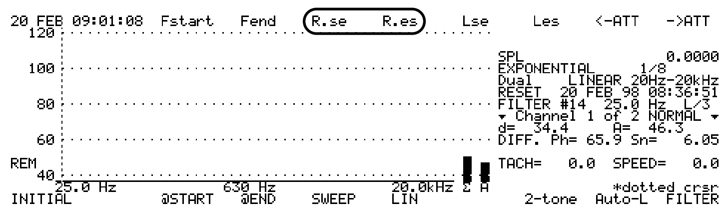

### Log Mode

When the Log mode is selected the sweep rate (decade/second) is controlled by pressing **R.se [C]** and **R.es [D]**.



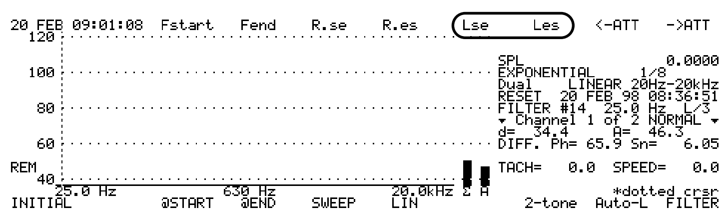
### Lin Mode

When the Lin mode is selected the sweep rate is still controlled by pressing the softkeys **[C]** and **[D]**, but in this mode the sweep rate is in time (seconds) instead of a rate.

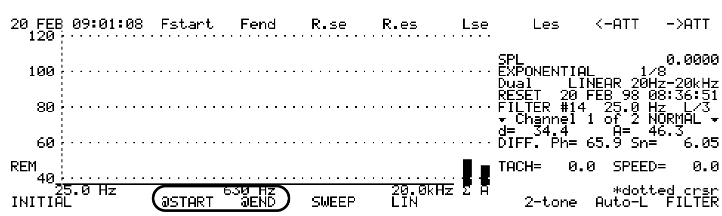



As mentioned above, press **T.se [C]** and **T.es [D]** to enter the desired start to end and end to start sweep times.

**F.** Press **L.se [E]** and **L.es [F]** to adjust the output level, start to end and end to start.

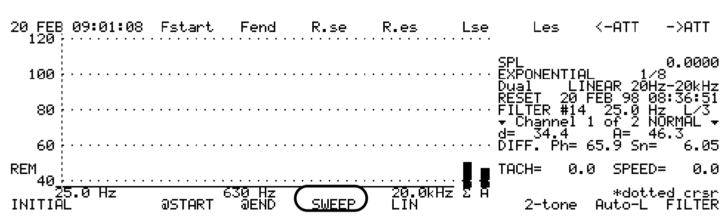



**G.** Press **@START [I]** or **@END[J]** to assign the sweep to begin at the pre-selected start frequency or end frequency.




!
K

**H.** Press **SWEEP [K]** to initialize or pause the sweep.

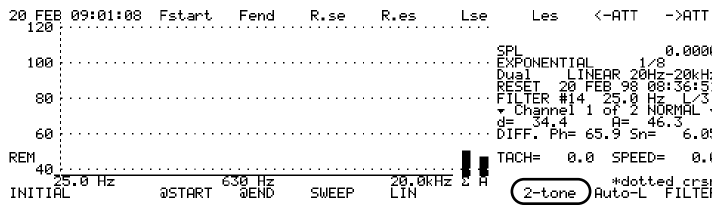


## Dual Tone

The signal generator has the capability to activate a second tone that will sweep simultaneously with the original tone. To look at the signal generator output on the screen, you will have to put a cable between the Sig Out on the back of the 2900B to one of the 2900B inputs.

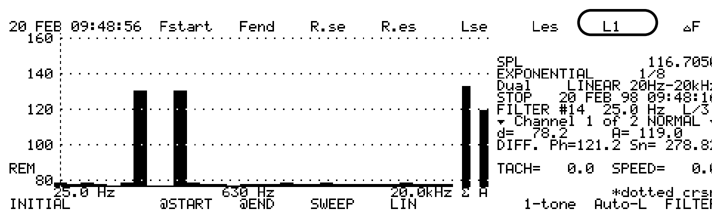
%
N

**I.** Press the **2-tone [N]** key to activate the dual tone.




W
G

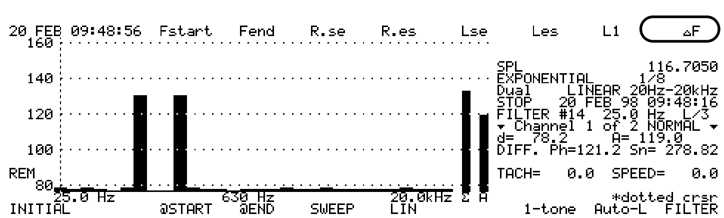
**J.** Press the **L1 [G]** key to adjust the level of the first tone.




The Sum Of The Relative Amplitudes Of The Two Tones Are Set Equal To One, So The Relative Amplitude Of The Second Tone Will Be Given By The Relationship L2 = (1 - L1). Setting L1 To 0.5 Will Result In Both Tones Having Equal Amplitudes. Once Setup, Both Tones Can Be Swept In The Same Manner As A Single Tone.

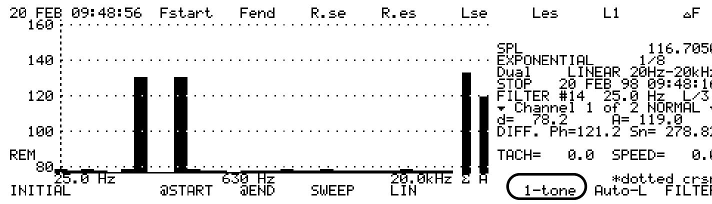
X
H

**K.** Press the **ΔF [H]** to select the separation, in cycles, between the two tone.



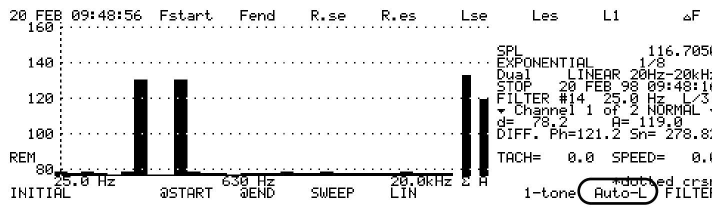
%
N

**L.** Press **1-tone [N]** to return to the single tone mode.




[
O

### Autolevel Control (Auto-L [O])



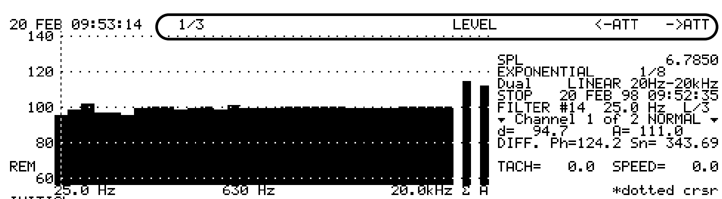

This feature is used with the dual channel Model 2900B to perform calibration of accelerometers and microphones. For accelerometer testing, the output of the sine generator is used to drive a shaker, upon which are mounted both a reference accelerometer and a test accelerometer. The signal from the reference accelerometer is connected to the Channel 1 input and the signal from the accelerometer under test is connected to the Channel 2 input. The instrument is set to the STAND 2 Mode with FFT filtering active and the Max level selected for display.

**M.** Press **Exit** to return to the signal generator screen.

### PINK [J]

Z
J

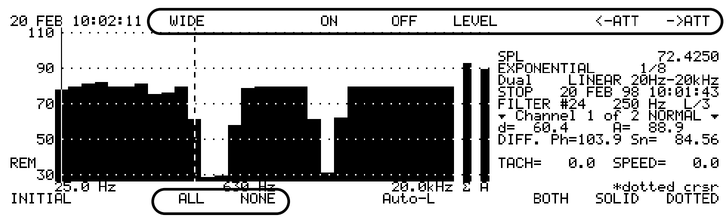
The Wideband Pink Noise Menu, shown below, is accessed from the Signal Generator Menu by pressing PINK [J].




Pink noise has equal energy per percentage bandwidth (e.g., octave or 1/3 octave). As with the sine generator, the level is set using the softkey LEVEL [E] and entering a value between 0 and .9999 using the numeric keypad.

The keys <-ATTEN [G] and ->ATTEN [H] will produce attenuation or reduction in attenuation in 20 dB increments, also as described for the sine generator.

When 1/3 octave digital filters have been selected, the generator can also produce 1/3 octave bandlimited pink noise. From the Broadband Pink Noise Menu, the Bandlimited Pink Noise Menu, shown below, is accessed by pressing 1/3 [A].



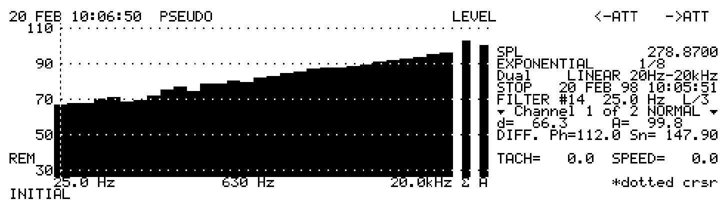

As with the wideband pink noise, the key LEVEL [E] is used to set the relative output level of the signal, and the keys <-ATTEN [G] and ->ATTEN [H] are used to add and remove attenuation at all frequencies in increments of 20 dB. The keys ALL [I] and NONE [J] are used to turn On or Off the noise in all 1/3 octave bands simultaneously. The On/Off status of the noise in individual bands can also be set on a band-by-band basis, using the keys ON [C] and OFF [D] to set the status of the band indicated by the active cursor. In this manner, noise can be generated for any combination of 1/3 octave bands, contiguous or not.

When using the analyzer to measure the spectrum of the noise generated, the user should bear in mind the effect of filter selectivity (due to filter skirts not being perfectly vertical) on the measured spectrum. For example, with noise generated in a single band, the measurement will produce a spectrum indicating noise in the two adjacent sidebands at levels approximately 17 dB lower. This phenomenon is associated with the measurement process only, and does not represent the much more accurate bandlimited noise actually being produced.To return to the Wideband Pink Noise Menu, press WIDE [A], then press **Exit** to signal generator window.

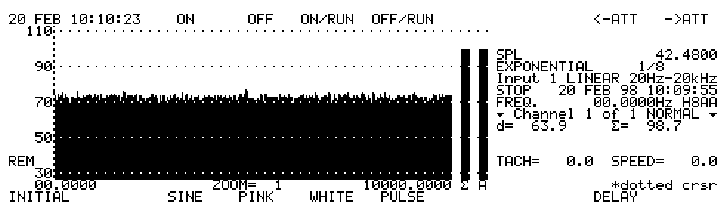
**White [K]**

!
K

The Wideband White Noise Menu, shown below, is accessed from the Signal Generator Menu by pressing WHITE [K] .




White noise has equal energy per constant bandwidth (e.g., narrowband FFT analysis). To view the change, go back to the System menu, press **FILTER**, and choose 800 line FFT, press **EXIT** and go back to Signal Generator. Wideband white noise can be used with either digital filters or FFT analysis. The LEVEL [E], <-ATTEN [G] and ->ATTEN [H] keys are used in the same manner as described above for the pink noise generator.



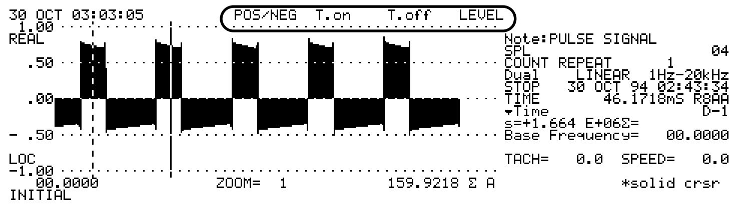

When FFT analysis has been selected, a pseudo-white noise output is possible. The Pseudo-White Noise Menu, shown below, is accessed from the White Noise Menu by pressing the key PSEUDO [A].

When FFT analysis is taking place, the analysis represents a finite number of frequency bands based on the number of lines selected for the measurement (100, 200, 400 or 800). It is not really necessary, therefore, for the generator to produce a truly wideband signal. In the pseudo-white noise mode, the signals are generated at the center frequency of each of the bands represented by the lines of the frequency analysis. This permits the generator output power to be concentrated on the same frequencies which are being measured by the FFT analysis, even when zoom analysis is being performed.

**PULSE [L]**

@
L

The Pulse Generator Menu, shown below, is accessed from the Signal Generator by pressing PULSE [L].



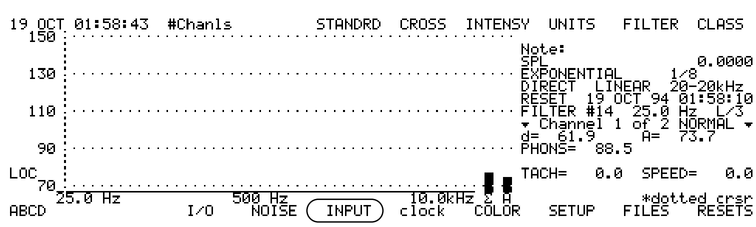

A series of either positive or negative pulses can be generated from this menu. The status of the generator is indicated briefly by a message on the upper right of the screen whenever one of the keys is pressed. The key POS/NEG [B] will toggle the polarity between positive and negative going pulses, as indicated on the upper right of the screen. The time increment for which the pulse is Positive or Negative, in milliseconds, is set by pressing T.on [C], entering a value using the numeric keypad and pressing ENTER. The time increment for which the pulse is to have a zero value, in milliseconds, is set by pressing T.off [C], entering a value using the numeric keypad and pressing ENTER. The LEVEL [E] key is used to set the output in the same manner as explained in the preceding sections.

## Selecting Analog Input Filters

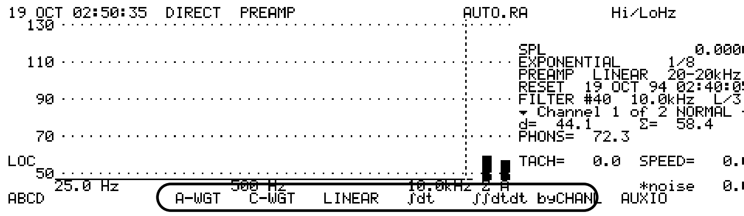
The analyzer has the capability of adding High Pass and Low Pass analog filters to the Spectrum to cutoff any unwanted frequencies without limiting the bandwidth of the instrument.

!
K

**1.** Press the **INPUT [K]** key from the System menu.



**2.** Select one of the following analog filters:




**A-WGT [I]** A-Weighting.

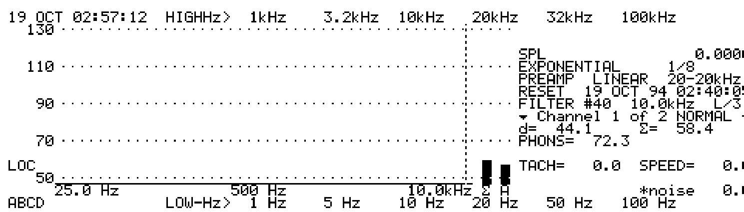
**C-WGT [J]** C-weighting.

**Linear [K]** Linear with selectble highpass and lowpass filters.

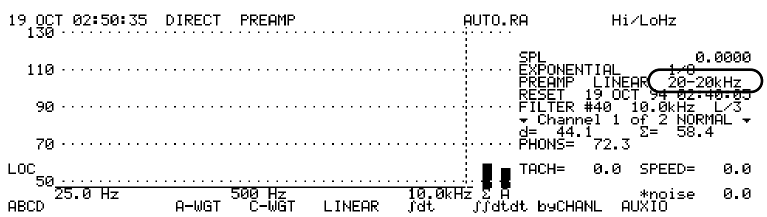
**∫dt [L]** Single time integration.

**∫∫dtdt [M]** Double time integration.

**3.** To select the high pass and low pass filters press the **Hi/Lo Hz [G]** key.




The analog filters selected are identified on the right side of the display.

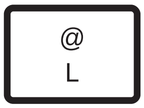




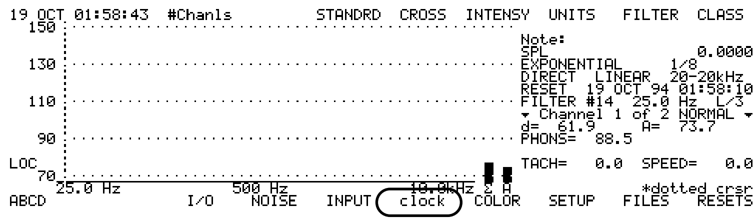
**4.** Press the **EXIT** hardkey to return to the SYSTEM menu.

## Setting the Clock

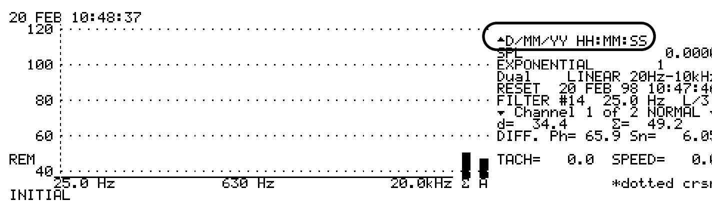
The analyzer has a built in internal real time clock for time stamping measurements.




**1.** Press the **clock [L]** key.



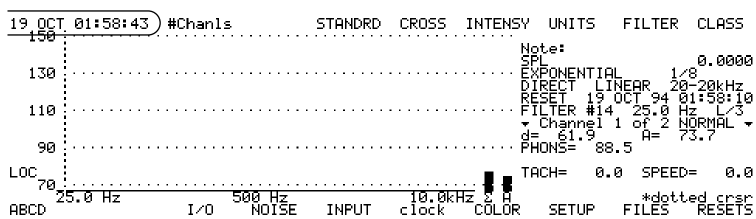

The following prompt will appear on the upper right of the display "DD/MM/YY HH:MM:SS" prompting you to enter the current time and date via the numeric keypad.





**2.** Press the **EXIT** hardkey after entering the time and date to return to the SYSTEM Menu.

The new time and date will appear on the upper left side of the display.

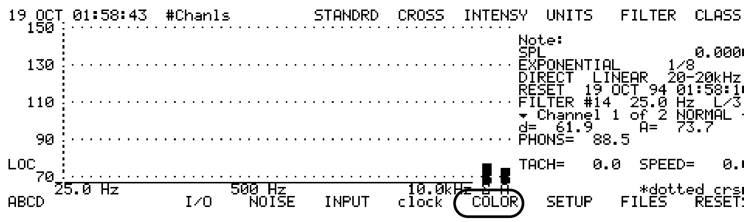



## Activating the External Color Monitor: (LD Model 2500 Color Video

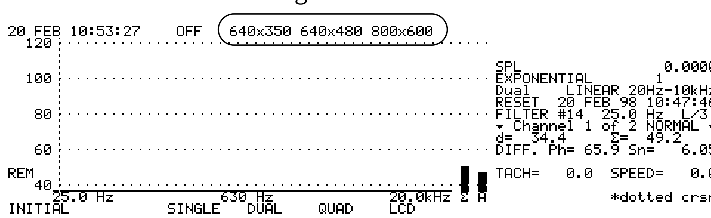
## Adaptor required)

The Model 2500 Color Video Adaptor permits the analyzer to communicate with an external color monitor (EGA, VGA, or Super VGA) via the printer port of the analyzer.


**1.** Press the **COLOR [M]** key.




**2.** Press one of the following keys to select the proper resolution of the monitor being used.

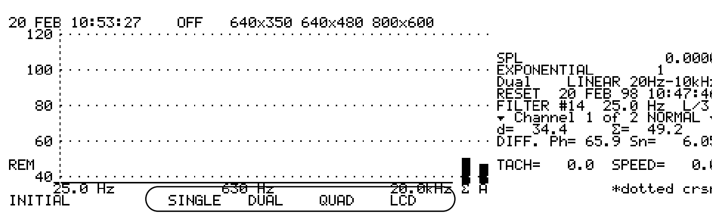



**640X350 [B]** For EGA Monitors

**640X480 [C]** For VGA Monitors

**800X600 [D]** For Super VGA Monitors

**3.** Press one of the following keys to select the number of data display windows to appear on the monitor.

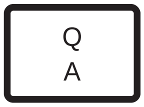



**SINGLE [I]** Single data display window

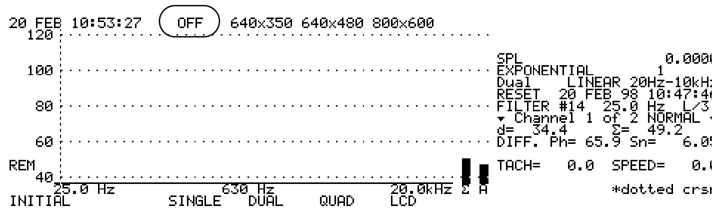
**DUAL [J]** Two data display windows

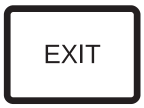
**QUAD [K]** Four data display windows

**LCD [L]** This will display a reproduction of the display on the analyzer.




**4.** Press the **OFF [A]** key when finished using the external monitor.



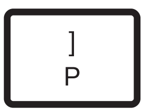




**5.** Press the **EXIT** hardkey to return to the SYSTEM Menu.

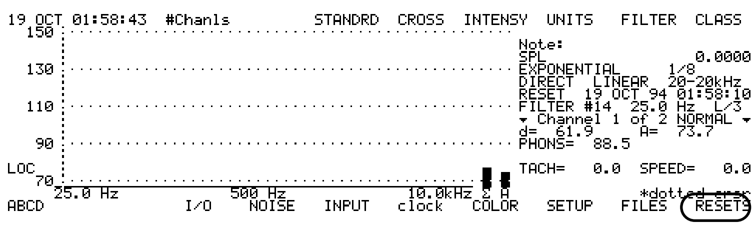
## Resets

You can reset data and setups stored in the internal memory of the analyzer.

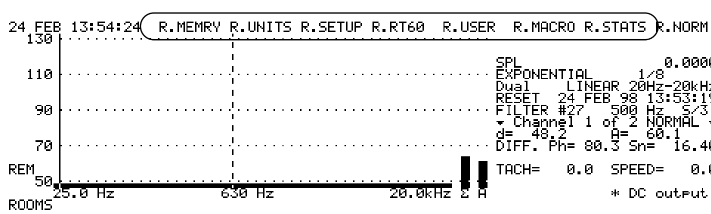
To reset data or setups:




**1.** Press the **RESETS [P]** key.




**2.** Press one of the following keys to perform the desired reset:




**R.MEMRY [A]** This will perform a reset of the internal RAM of the instrument and clear out all stored data and all user-defined setups bringing the unit to a default state.

**R.UNITS [B]** This will perform a reset of the user-defined Units only.

**R.SETUP [C]** This will perform a reset of the user-defined Setups only.

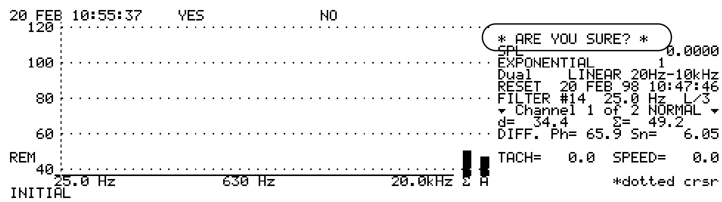
**R.RT60 [D]** This will perform a reset of the RT60 data only.

**R.USER [E]** This will perform a reset of the user-defined Weighting curves only.

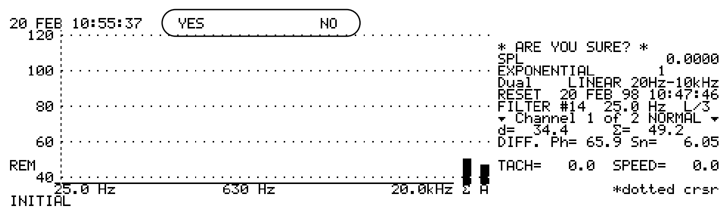
**R.MACRO [F]** This will perform a reset of the user-defined Macros only.

**R.STATS [G]** This will perform a reset of the Statistics tables only.

After pressing one of the above mentioned keys, a message will appear on the upper right side of the display “*ARE YOU SURE?*” to make sure that you really want to perform the RESET.




3. Press either the **YES[A]** key or the **NO[C]** key.




The RESET will be performed if you press the YES key. If you press the NO key, the RESET will not be performed and you will be returned to the Reset menu.


4. Press the **EXIT** hardkey to return to the System Menu.

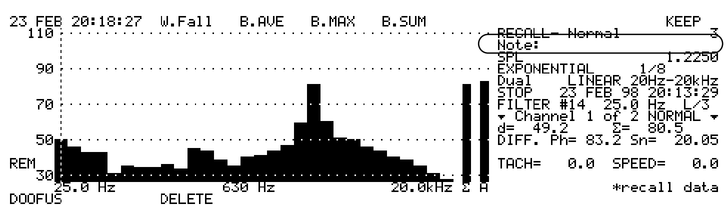
CHAPTER

# 3 Shift Menu

## Defining a reference spectrum

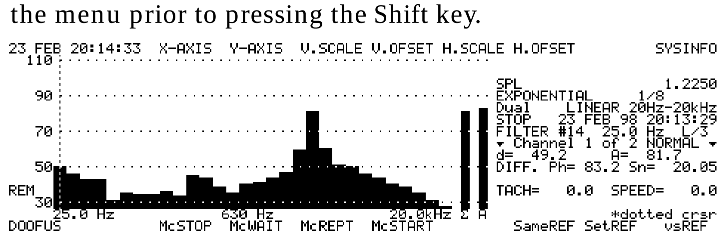
In some applications it is desirable to compare two spectra, or to display spectra relative to some user-defined spectrum.

The spectrum which is to be defined as the reference spectrum must first be displayed on the analyzer. In most cases this would be a spectrum that has been stored to the memory of the analyzer. If the desired reference spectrum has not been stored to the memory do so now by pressing the **STORE** hardkey, then press the **RECALL** hardkey to bring the spectrum to the display.



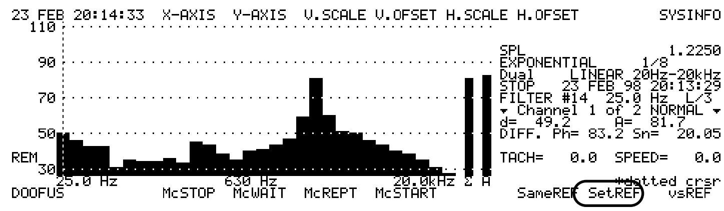


**1.** Press the **SHIFT** hardkey to activate the Shift Menu (This menu will only be active for 6 seconds, it will then return to the menu prior to pressing the Shift key.

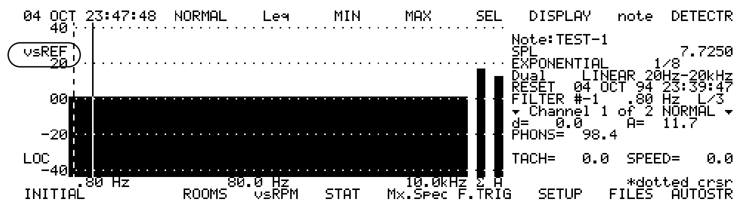


[
O

**2.** Press the **SetREF [O]** key to assign the displayed spectrum as the reference.

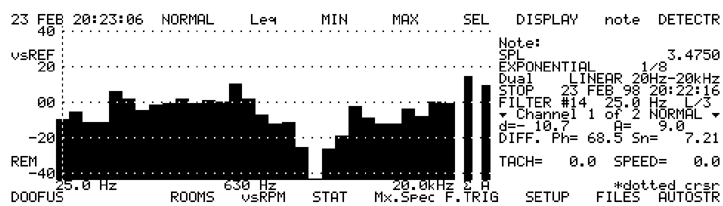



The spectrum will be placed to zero across all frequency bands, and the vsRef indicator will appear on the upper left side of the display.



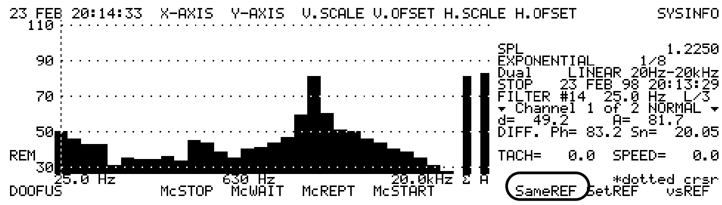

RESET
R/S

**3.** Press the **R/S** key. Note that how the current data are being compared to the reference spectrum. If the data in any of the frequency bands are greater than that of the reference spectrum, the level will be above the “00” db line. If the data in any of the frequency bands is less than the reference spectrum, the level will be below the “00” reference line.

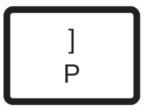



%
N

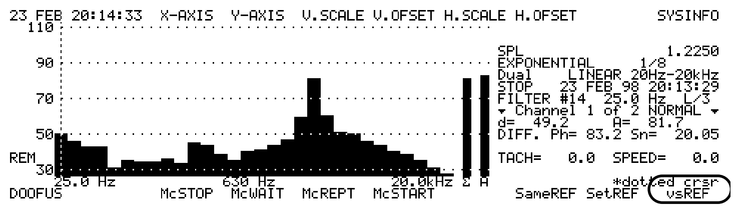
If you desire that both Channel 1 and Channel 2 have a reference spectrum assigned at the same time press the **SameREF [N]** key. This will assign a spectrum as a reference to ch. 1 and ch.2. As new data is analyzed you may switch between ch.1 and ch.2 and view the comparison of the new spectrum to the respective reference spectrum.







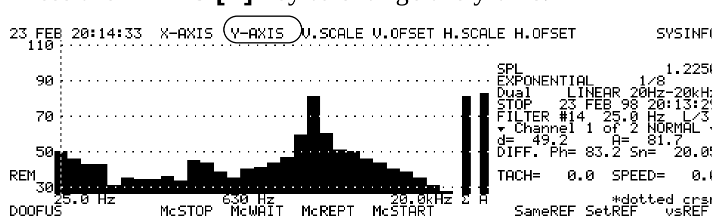

4. Press the **SHIFT** hardkey, then the **vsREF [P]** key to return to a normal display format.



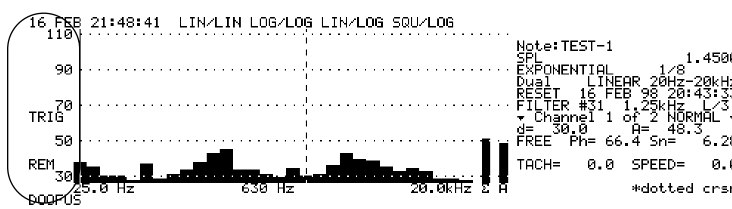

## Changing from a logarithmic scale to a linear scale


1. Press the **SHIFT** hardkey to enter the shift menu.

2. Press the **Y-AXIS [B]** key to change the y-axis.




The following menu appears:




**LIN/LIN [A]** Changes Y-axis to a linear scale and cursor reads out linear.

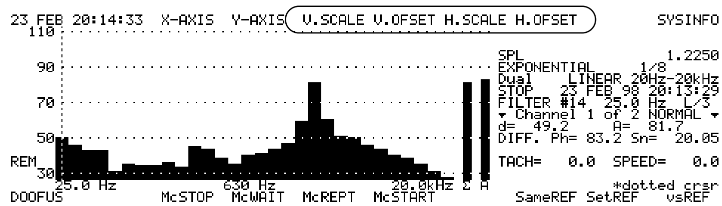
**LOG/LOG [B]** Changes Y-axis to a log gradations and cursor reads out log.

**LIN/LOG [C]** Changes Y-axis to a linear scale and cursor reads out log.

**SQU/LOG [D]** Changes Y-axis to squared linear gradations and cursor reads out log; useful for display of power spectral density.

## Changing the Vertical and Horizontal Zoom

To change the scaling and offset of the display select one of the following keys:




**V.SCALE [C]** User selectable zoom factor from 1 to 8.

**V.OFSET [D]** User selectable offset. Use the horizontal arrow keys to shift the window in multiples of 10 dB.

**H.SCALE [E]** User selectable zoom factor from 1 to 8.

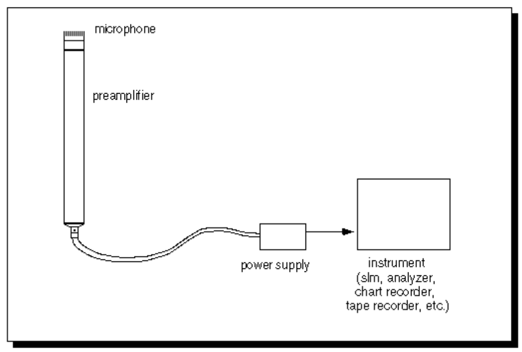
**H.OFSET [F]** User selectable offset. Use the horizontal arrow keys to shift the window.

To check the analyzer battery:

CHAPTER

# 4 Basic Acoustics

## MEASURING SOUND




Basic Acoustics

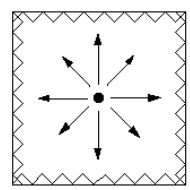
## BASIC ACOUSTICS MEASUREMENTS

- **Determine what type of measurements is to be made.**
  - **- free field**
  - **- diffuse field**
- **Choose the correct microphone for the measurement.**
  - **- free field**
  - **- random incidence**
- **Position operator correctly**

Basic Acoustics

## MEASUREMENT TYPE

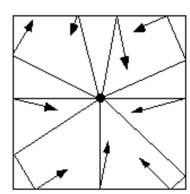
- **Free field measurement**
  - **- outdoor**
  - **- anechoic chamber**
  - **- no reflective objects in field**
  - **- sound is absorbed by the environment**



**Basic Acoustics**

## MEASUREMENT TYPE (CONT)

- **Diffuse field**
  - **- Gymnasium**
  - **- Warehouse**
  - **- Shower**
  - **- contains hard or reflective surfaces**



**Basic Acoustics**

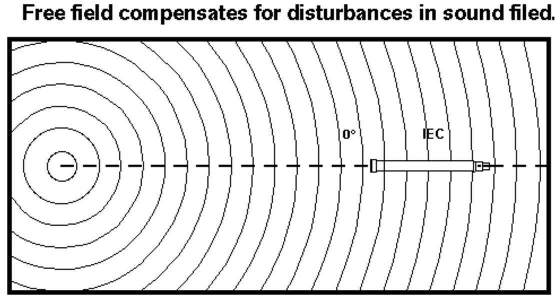
## MICROPHONE SENSITIVITY

- The quieter the sound level, the more sensitive the microphone must be.
- Conversely, the louder the sound level, the less sensitive the microphone need be.
- Applications requiring measurements of very small sound levels such as: outdoor night measurements, quiet products, or quiet rooms demand the use of a sensitive microphone.
- Higher sensitivity on a microphone is acheived by using a looser diaphragm.
- In general, larger diameter microphones are more sensitive than smaller microphones.

Basic Acoustics

## FREE FIELD MICROPHONE

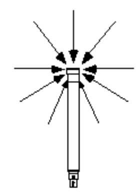
- Measuring in a free field
- Testing to IEC 651 standards (Europe & Japan)
- Noise source is clearly identifiable. Microphone pointed at the noise source
- Free field compensates for disturbances in sound filed.




Basic Acoustics

## RANDOM INCIDENCE

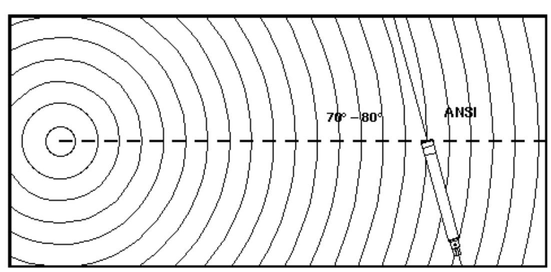
- Used when measuring in a diffuse field.
- Use when testing to ANSI S1.4 standards.
- Used when location of noise source is unknown.
- Responds uniformly to sounds arriving from all angles at the same time.
- Characteristics very similar to a pressure microphone.



Basic Acoustics

## RANDOM INCIDENCE MICROPHONE

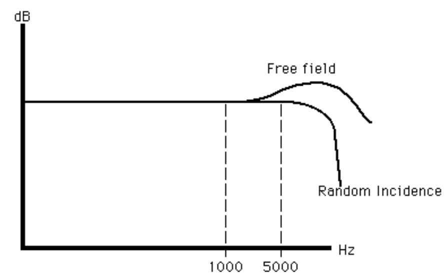
- If random incidence microphone is used in a free field, microphone should be angled approximately 85 degrees to the sound source. Otherwise the resultant measurement will be overestimated.




Basic Acoustics

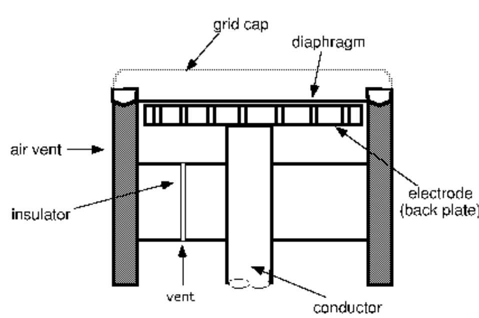
## MICROPHONE RESPONSE

- **Free field microphones compensate for self created disturbances in the sound field.**
- **Random incidence microphones respond uniformly to sound, regardless of the location of the sound source(s).**




**Basic Acoustics**

## CONDENSER MICROPHONE




**Basic Acoustics**

## MICROPHONE TYPES

- **Condenser microphones**
  - requires a polarization voltage. Change in capacitance between diaphragm and "charged" backplate is proportional to change in sound pressure.
- **Prepolarized (electret) microphones**
  - requires no polarization voltage. Uses a pre-charged "foil" to detect change in capacitance which is proportional to a change in sound pressure.
- **Piezoelectric microphones**
  - sound pressure causes a deflection in piezoelectric crystal. This generates a charge proportional to sound pressure.
- **Dynamic microphones**
  - uses velocity imparted to diaphragm by sound pressure to move a coil through a magnetic field. This induces a current proportional to sound pressure.

Basic Acoustics

## HOW A CONDENSER MICROPHONE WORKS

- Sound pressure deflects the diaphragm which causes a change in capacitance between the diaphragm and electrode (backplate).
- Change in capacitance is converted into an electrical signal by maintaining a constant charge on the electrode (via a polarization voltage).
- Advantages
  - good acoustic sensitivity
  - good frequency response
  - low self generated noise
  - low sensitivity to mechanical vibration
- Disadvantages
  - fragile diaphragm (easy to damage)
  - susceptible to humidity

Basic Acoustics

## NEAR FIELD AND FAR FIELD

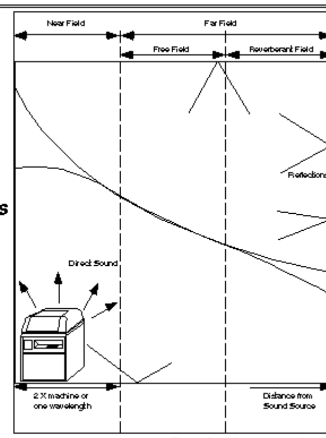
- **Near field**

  **- the distance from a noise source less than 1 wavelength (of the lowest frequency of interest) away from the noise source... or 2 times the dimension of the test item.**

  **- Difficult to make measurements in the near field.**

- **Far field**

  **- the area beyond the near field composed of the free field and reverberant field.**




**Basic Acoustics**

## FAR FIELD

- **Free field**

  **- the area between the near and reverberant field.**

  **- this is the area where measurements should be made.**

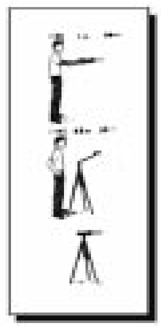
  **- this area is characterized by a 6 dB drop in sound pressure per doubling of distance.**

- **Reverberant field**

  **- the area away from the sound source where reflections from walls and other objects can be just as strong as the sound you are trying to characterize.**

**Basic Acoustics**

## OPERATOR POSITION



- The operator should be positioned at least 1 meter behind the microphone.
- The operators body should be to the side of the microphone.
- Body reflection causes low frequency errors. These errors occur below 500 Hz and can be as large as 6 dB.
- Use a tripod if possible

Basic Acoustics

## SOUND LEVEL METER

- **Features**
  - measures sound pressure level (SPL)
  - weighted and unweighted SPL (rms)
  - weighted and unweighted peak
  - fast, slow, impulse response
  - typically overall SPL
  - some provide octave (1/1, 1/3) SPL's
- **Limitations**
  - SPL is a scalar quantity; provides no information on direction of sound
  - SPL dependent on measurement environment

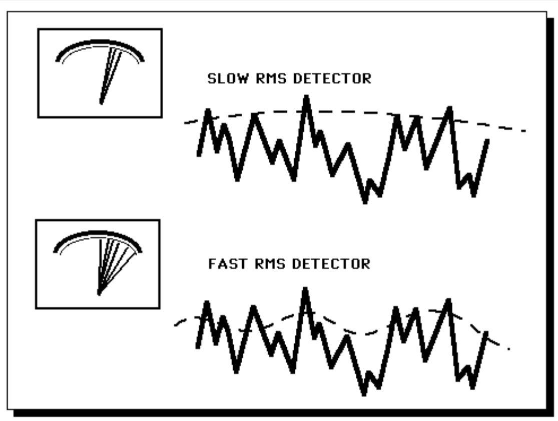
Basic Acoustics

## WEIGHTING NETWORKS

| FREQUENCY (Hz) | A-WEIGHTING RELATIVE RESPONSE | B-WEIGHTING RELATIVE RESPONSE | C-WEIGHTING RELATIVE RESPONSE |
|---|---|---|---|
| 10 | -70.4 | -38.2 | -14.3 |
| 12.5 | -63.4 | -33.2 | -11.2 |
| 16 | -56.7 | -28.5 | -8.5 |
| 20 | -50.5 | -24.2 | -6.2 |
| 25 | -44.7 | -20.4 | -4.4 |
| 31.5 | -39.4 | -17.1 | -3 |
| 40 | -34.6 | -14.2 | -2 |
| 50 | -30.2 | -11.6 | -1.3 |
| 63 | -26.2 | -9.3 | -0.8 |
| 80 | -22.5 | -7.4 | -0.5 |
| 100 | -19.1 | -5.6 | -0.3 |
| 125 | -16.1 | -4.2 | -0.2 |
| 160 | -13.4 | -3 | -0.1 |
| 200 | -10.4 | -2 | 0 |
| 250 | -8.6 | -1.3 | 0 |
| 315 | -6.6 | -0.8 | 0 |
| 400 | -4.8 | -0.5 | 0 |
| 500 | -3.2 | -0.3 | 0 |
| 630 | -1.9 | -0.1 | 0 |
| 800 | -0.8 | 0 | 0 |
| 1000 | 0 | 0 | 0 |
| 1250 | 0.6 | 0 | 0 |
| 1600 | 1 | 0 | -0.1 |
| 2000 | 1.2 | -0.1 | -0.2 |
| 2500 | 1.3 | -0.2 | -0.3 |
| 3150 | 1.2 | -0.4 | -0.5 |
| 4000 | 1 | -0.7 | -0.8 |
| 5000 | 0.5 | -1.2 | -1.3 |
| 6300 | -0.1 | -1.9 | -2 |
| 8000 | -1.1 | -2.9 | -3 |
| 10000 | -2.5 | -4.3 | -4.4 |
| 12500 | -4.3 | -6.1 | -6.2 |
| 16000 | -6.6 | -8.4 | -8.5 |
| 20000 | -9.3 | -11.1 | -11.2 |

Basic Acoustics

## DETECTOR RESPONSE




Basic Acoustics

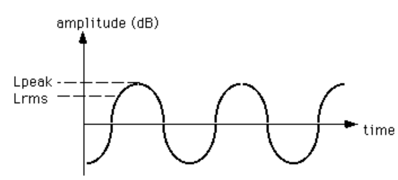
## DETECTOR RESPONSE (CONT)

- **Fast detector**
  - used when measuring noise/sound that is fluctuating rapidly
  - has a time constant of 125 ms; display updates quickly
- **Slow detector**
  - used when measuring "steady state" sound or when one wishes to average out fluctuations
  - has a time constant of 1 second
- **Impulse detector**
  - used when measuring impulsive phenomena such as gun fire
- - rise time can vary (typically < 1ms); decay time 2.9 dB per second

Basic Acoustics

## BASIC SLM MEASUREMENTS
## RMS & PEAK LEVELS

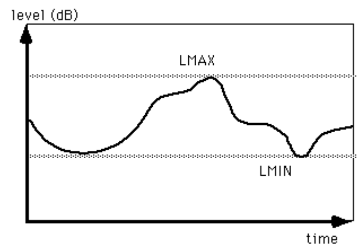
- The peak detector shows the highest "peak" value for the measurement.
- The rms (root mean square) amplitude of a wave is the square root of the mean squared displacementsduring the measurement.
- For a sine wave the rms amplitude is .707 times the peak




Basic Acoustics

## BASIC SLM MEASUREMENTS
## LMIN & LMAX

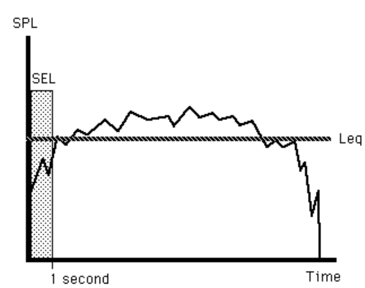
- LMIN is the minimum rms level that occured during the measurement period.
- LMAX is the maximum rms level that occured during the measurement period.




Basic Acoustics

## BASIC SLM MEASUREMENTS
## LEQ & SEL

- Leq is the equivalent continuous sound pressure level; the average SPL.
- SEL is the sound exposure level. It is the acoustic energy of the entire sound event compressed into 1 second.




Basic Acoustics

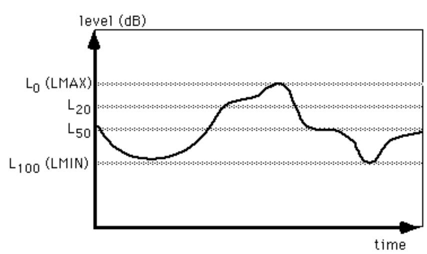
## SPL AND LEQ MEASUREMENTS

- **Sound Pressure measurements**
  - **done with a sound level meter**
  - **set detector rate to fast**
  - **max hold feature is handy for capturing "events"**
- **Leq**
  - **requires an integrating sound level meter**
  - **Leq is a single continuous dBA level that would produce the same acoustic energy as the actual noise history**
  - **often measured in interval (hourly)**

**Basic Acoustics**

## STATISTICAL DESCRIPTORS

- **Ln is the sound level (in dBA) that was exceeded n% of the measurement duration**
- **done with an environmental noise analyzer**
- **used to characterize "non ambient" events**



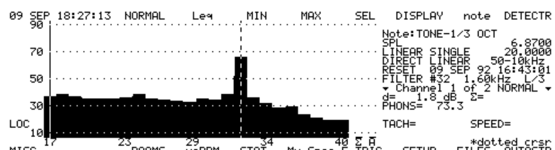

**Basic Acoustics**

## FULL OCTAVE AND ONE THIRD OCTAVE BANDS

| Band | OCTAVE Lower band limit (Hz) | OCTAVE Center (Hz) | OCTAVE Upper band limit (Hz) | ONE-THIRD OCTAVE Lower band limit (Hz) | ONE-THIRD OCTAVE Center (Hz) | ONE-THIRD OCTAVE Upper band limit (Hz) |
|---|---|---|---|---|---|---|
| 12 | 11 | 16 | 22 | 14.1 | 16 | 17.8 |
| 13 | | | | 17.8 | 20 | 22.4 |
| 14 | | | | 22.4 | 25 | 28.2 |
| 15 | 22 | 31.5 | 44 | 28.2 | 31.5 | 35.5 |
| 16 | | | | 35.5 | 40 | 44.7 |
| 17 | | | | 44.7 | 50 | 56.2 |
| 18 | 44 | 63 | 88 | 56.2 | 63 | 70.8 |
| 19 | | | | 70.8 | 80 | 89.1 |
| 20 | | | | 89.1 | 100 | 112 |
| 21 | 88 | 125 | 177 | 112 | 125 | 141 |
| 22 | | | | 141 | 160 | 178 |
| 23 | | | | 178 | 200 | 224 |
| 24 | 177 | 250 | 355 | 224 | 250 | 282 |
| 25 | | | | 282 | 315 | 355 |
| 26 | | | | 355 | 400 | 447 |
| 27 | 355 | 500 | 710 | 447 | 500 | 562 |
| 28 | | | | 562 | 630 | 708 |
| 29 | | | | 708 | 800 | 891 |
| 30 | 710 | 1000 | 1420 | 891 | 1000 | 1122 |
| 31 | | | | 1122 | 1250 | 1413 |
| 32 | | | | 1413 | 1600 | 1778 |
| 33 | 1420 | 2000 | 2840 | 1778 | 2000 | 2239 |
| 34 | | | | 2239 | 2500 | 2818 |
| 35 | | | | 2818 | 3150 | 3548 |
| 36 | 2840 | 4000 | 5680 | 3548 | 4000 | 4467 |
| 37 | | | | 4467 | 5000 | 5623 |
| 38 | | | | 5623 | 6300 | 7079 |
| 39 | 5680 | 8000 | 11360 | 7079 | 8000 | 8913 |
| 40 | | | | 8913 | 10000 | 11220 |
| 41 | | | | 11220 | 12500 | 14130 |
| 42 | 11360 | 16000 | 22720 | 14130 | 16000 | 17780 |
| 43 | | | | 17780 | 20000 | 22390 |

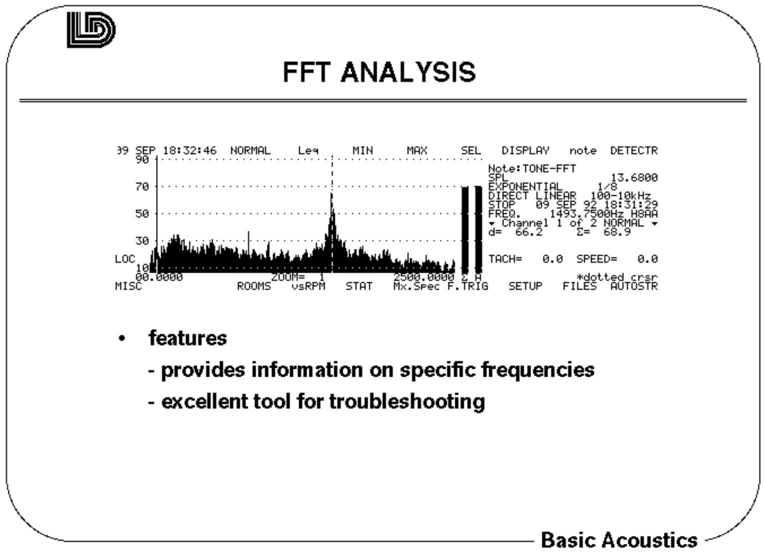
Basic Acoustics

## OCTAVE BAND ANALYSIS




- **features**
  - **- provides information on frequency content of sound**
  - **- many standards based on 1/3 (and 1/1) octave bands**
  - **- easy to see trends or patterns**
- **limitations**
  - **- cannot isolate specific frequencies ( pure tone)**

Basic Acoustics




## Using the Model 3200 as a Sound Level Meter in Standard Analysis Mode

One may wish to use the 3200 RTA to measure Sound Pressure Levels in the analysis mode. Although this method does not meet ANSI S1.4-1983 or IEC 651 or IEC 804 standards for Sound Level Meter instrumentation, the results will be sufficiently accurate.

### Setting up the 3200

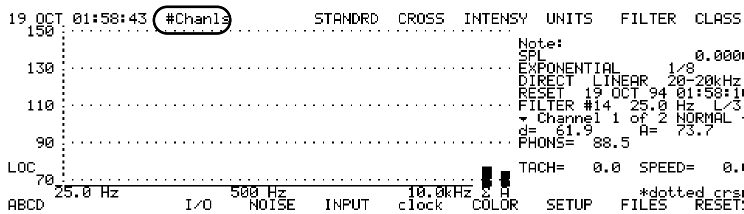
For this example, we will use the1Channelanalysis mode of the Model 3200. It should be understood that using the 2Channelanalysis mode of the 3200 will provide two channel measurements of Sound Pressure Levels. Before we begin setting the parameters in the RTA, connect the microphone preamplifier / microphone to channel one of your 3200.

SCREEN
SYSTEM

S
C

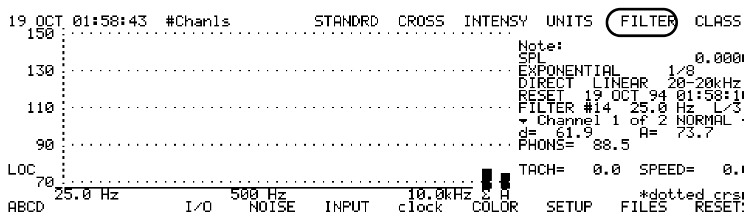
Q
A

**1.** From the **SYSTEM** menu, press **#Chanls [A]** and then **#Chanls** to select single channel analysis.



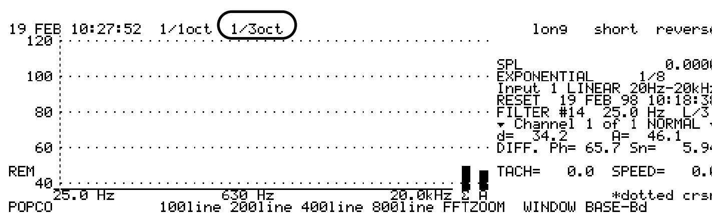

W
G

**2.** If the filters in your analyzer are not set for 1/3 octave band analysis, press **FILTER[G]** to enter the filter menu area.




R
B

**3.** Press **1/3oct[B]** to enable to 1/3 octave band digital filters.

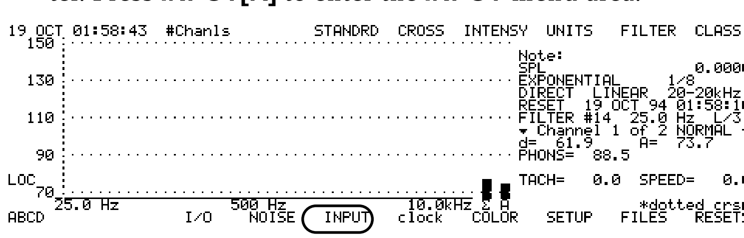



EXIT

**4.** Press **EXIT** to return to the **SYSTEM** menu.

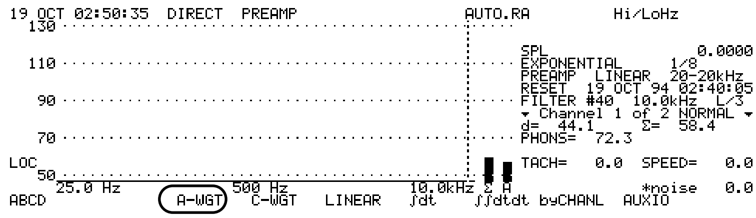
!
K

**5.** Typically, for Sound Pressure Level measurements, one would use either A or C analog weighting filters when gathering data. For this example, let's enable the A-weighting filter. Press **INPUT[K]** to enter the **INPUT** menu area.



Y
I

**6.** Within the **INPUT** menu, press **A-WGT[I]** to activate the A-Weighting filter.




EXIT

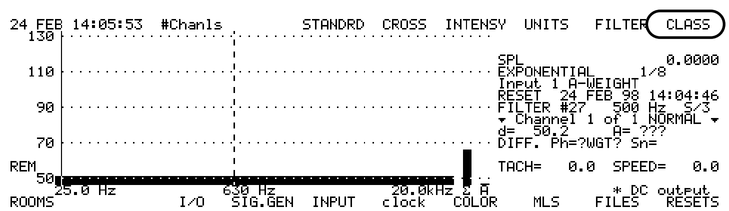
**7.** Press **EXIT** to return to the **SYSTEM** menu.

EXIT

**8.** Next, we need to establish a detector type and averaging time to simulate the slow or fast detector response time of a sound level meter. Press **EXIT** again to enter the **STANDARD** feature menu.

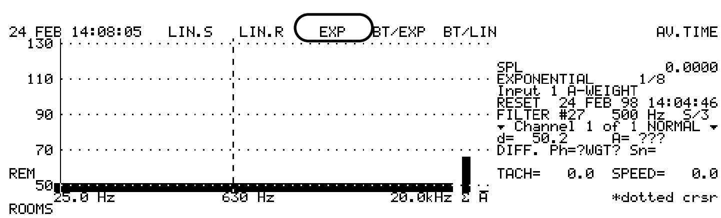
X
H

**9.** Within this menu, Press **DETECTR[H]** to enter the detector setup menu.



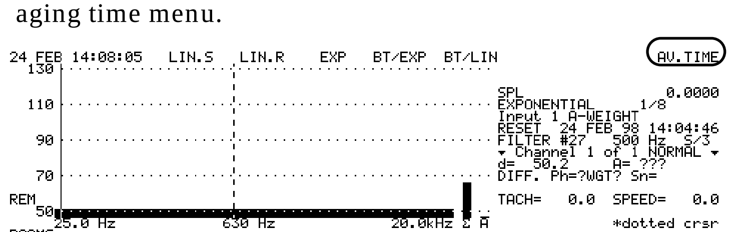

S
C

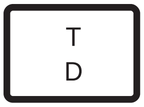
**10.** Press **EXP[C]** to enable the exponential detector.

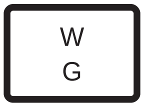



X
H

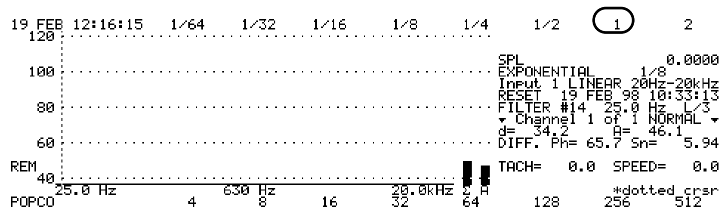
**11.** Next, we need to establish the exponential detector averaging time or rate. Press **AV.TIME[H]** to enter the detector averaging time menu.

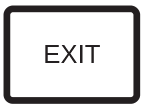






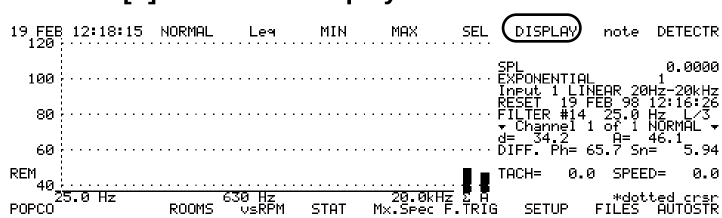

**12.** Within this menu, you need to choose a detector time (integrating time) that would either simulate a slow or fast detector rate. If one wishes to simulate a fast detector rate, then **1⁄8[D]** seconds should be selected. For a slow detector rate, **1[G]** second is the choice. For this example, we will use a slow detector rate. Press **1[G]**.



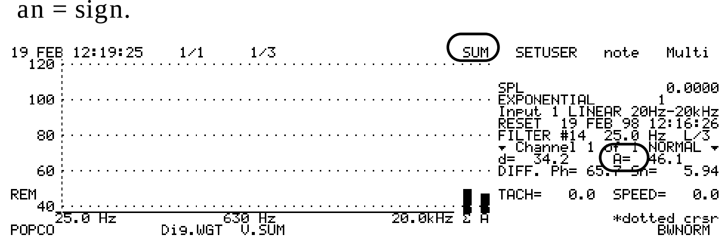

**13.** Press **EXIT** to return to the **MAIN** menu.


**14.** During the measurement, we will want to view the overall summation band for the Sound Pressure Measurement. Press **DISPLAY[F]** to enter the **Display** menu.





**15.** Press **SUM[E]** to enable the linear summation feature. At the right of the display you will see a sigma symbol followed by an = sign.





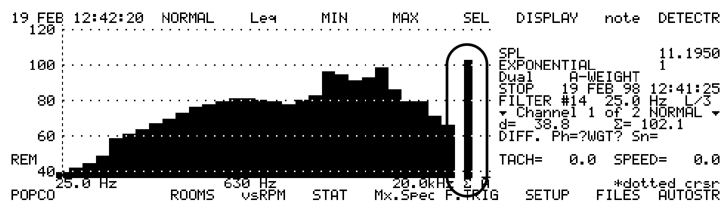
**16.** Press **EXIT** to return to the Main menu.

## Sound Pressure Level measurement

To make a Sound Pressure Level Measurement:

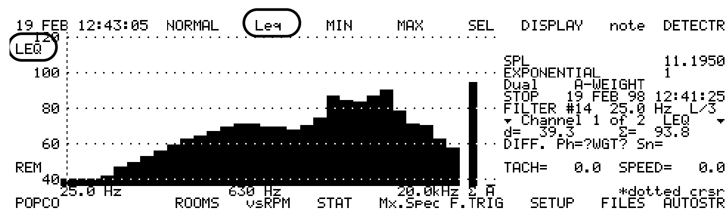
RESET
R/S

1. Press the **R/S** to initiate a measurement. Notice on the display you will see an A-Weighted 1/3 octave band spectrum that is being integrated over a one second duration. Notice also that the summation value at the right is showing numerically the overall Sound Pressure Level (summation of all of the 1/3 octave bands).



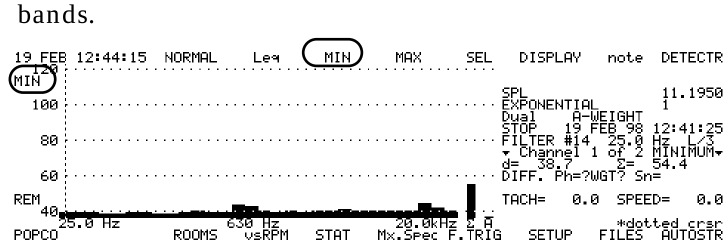

R
B

2. To view the Leq during the runtime, press **Leq[B]**. You will notice the Leq spectrum on the left and the overall (summed) Leq value on the right of the display.



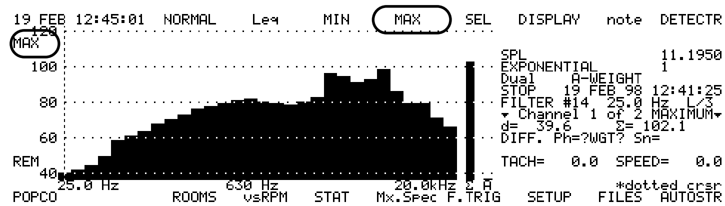

S
C

3. To view the MIN during the runtime, press **MIN[C]**. You will notice the MIN spectrum on the left. This is a spectrum showing the minimum value that occurred in each 1/3 octave bin during the time of the test. The overall MIN value on the right of the display is the summation of these MIN bands.



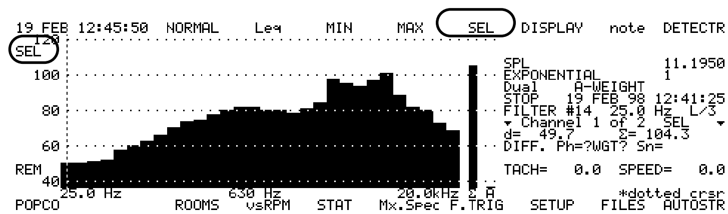
T
D

**4.** To view the MAX during the runtime, press **MAX[D]**. You will notice the MAX spectrum on the left. This is a spectrum showing the maximum value that occurred in each 1/3 octave bin during the time of the test. The overall MAX value on the right of the display is the summation of all of the MAX bands.




U
E

**5.** Last, to view the SEL during the runtime, press **SEL[E]**. You will notice the SEL spectrum (normalized to 1 second) on the left and the overall (summed) SEL value on the right of the display.



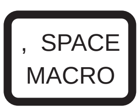
CHAPTER

# 5 Macros

The operation of the analyzer can be simplified by the use of the user-defined key macros. Each macro permits the user to define up to fifty sequential key presses, and when executed will simulate the manual key press operation of the analyzer.

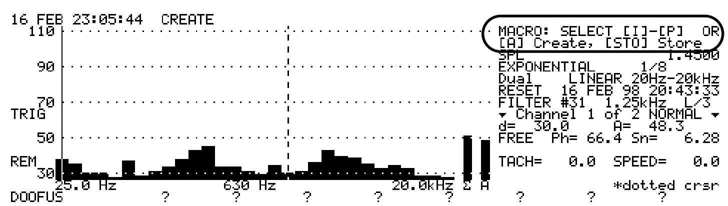
## Defining macros

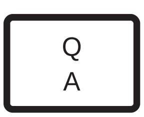
It is recommended to begin from the Main Menu of the analyzer. Press the **EXIT** hardkey until you have returned to the Main Menu.




**1.** Press the **MACRO** hardkey to enter the Macro Define mode.

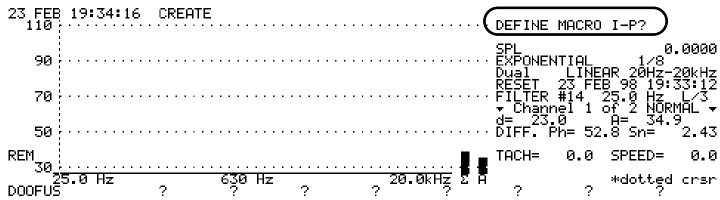
The message “MACRO: Select [0]-[9] or [-] Create, [STO] Store” will appear on the upper right side of the display.




**2.** Press the “A” minus key to create the macro.

The message “Define MACRO I-P?” will appear on the upper right side of the Display.




**3.** Press a letter “**I-P**” to assign where the macro will be stored. For this example press the letter “**K**”.

Alpha characters A-P will appear across the top and bottom of the display. To select the rest of the alpha characters, press the **Shift** hardkey and Q-Z will appear. A flashing cursor will also appear in the upper right hand corner of the display after the message “Enter macro name:”.

**4.** Begin entering the name of the macro. If you make a mistake entering the text you can move the cursor with the left and right arrow keys, then press the **SPACE** hardkey to erase the last character.

**5.** Begin defining the macro, by pressing the following keys:

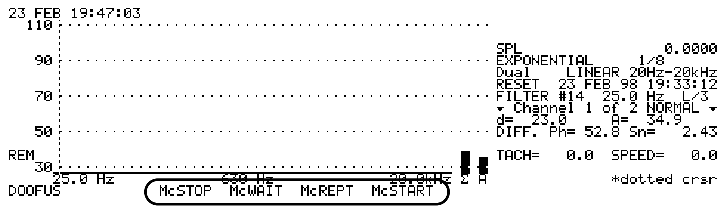
- **DETECTR [H]**
- **LIN.S [A]**
- **AV.TIME[H]**
- Enter “5 seconds” for the detector time.
- **EXIT** hardkey (twice)
- **System** hardkey
- **Filter [G]**
- **400line [K]**
- **EXIT** hardkey
- **SPACE** hardkey
- **R/S** hardkey

+
-

**6.** Press the"**-**" minus key. This will terminate the definition of the macro.

SHIFT

There are four special Macro keys that can be found by pressing the **SHIFT** hardkey. They are labeled **McStop [I]**, **McWait [J]**, **McRept [K]**, **McStart [L]**. These special Macro keys are typically used for special applications.




**McStop [I]** Will cause the macro processor to pause during its execution until the analyzer is in the STOP state, at which time the execution will continue.

**McWait [J]** Used to provide a wait state during the execution of a macro.

**McRept [K]** Used to generate a repeat of the macro. When this is used, the macro will continue to be repeated until the analyzer is stopped manually by pressing the **SPACE** hardkey.

**McStart [L]** Sets the analyzer up with a time and date for the macro to start.

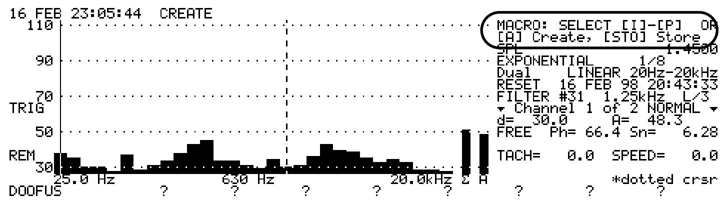
## Executing Macros

To execute a defined Macro the analyzer must be in the menu where the Macro was initially defined, (i.e. Main Menu, System Menu). The error message "Macro Menu Mismatch" will appear if the analyzer is not in the menu where the menu was initially defined.

, SPACE
MACRO

**1.** Press the **MACRO** hardkey to enter the Macro field.

The message “MACRO: Select [0]-[9] or [-] Create, [STO] Store” will appear on the upper right side of the display.




!
K

**2.** Press a letter (I-P) where the Macro was stored. For this example press the letter “**K**” key.

The Macro that was assigned to key **1** in the previous step, (Defining Macros), will immediately be executed upon pressing the numeric key.

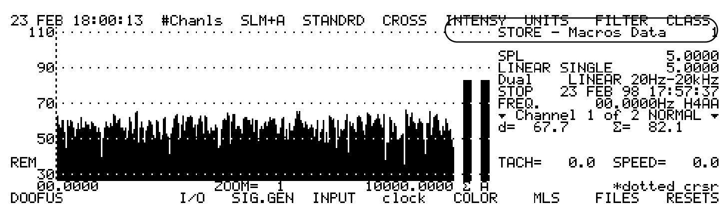
## Storing Macros

After defining a marco to one or all of the ten registers **0-9,** you may store them as a set of Macros as a file to the memory of the analyzer.

&
STORE

**1.** To do this press the **STORE** hardkey.

The message “Store-Macros Data XX” will appear on the upper right side of the display. This indicates that the Macros have been stored as a file to the memory of the analyzer and have been assigned a record number xx.



CHAPTER

# 6 Printing

The analyzer can print any displayed data directly to an Epson compatible, Canon BubbleJet, or Hewlett-Packard LaserJet printer equipped with graphics capability and a Centronics parallel interface.

Before printing you will want to make certain that the desired spectrum has been recalled from memory, or is currently displayed on the analyzer.

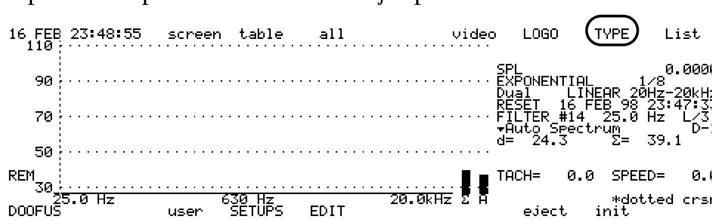
1. Connect the printer to the printer port on the right side of the analyzer.

? PRINT

2. Press the **PRINT** hardkey.

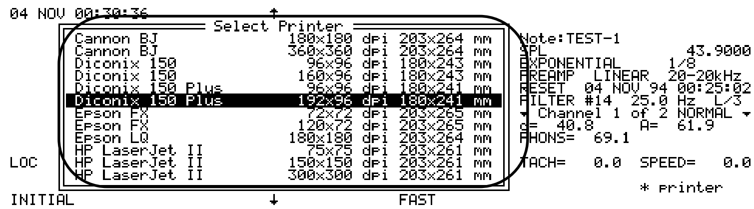
W G

3. Press the **TYPE [G]** key to select the type of printer being used. The analyzer has a list of printer drivers ranging from Epson compatibles to HP Laserjet printers.



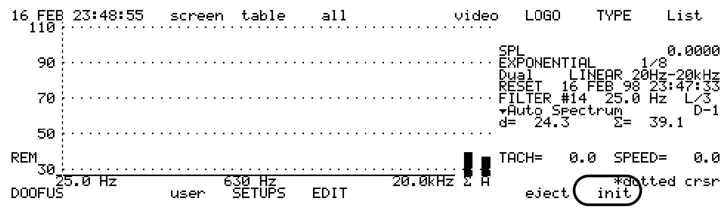
EXIT

**4.** Highlight the desired printer driver and press the **EXIT** hard-key.



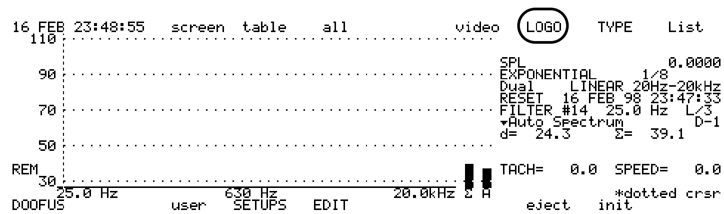

[
O

**5.** Press the **init [O]** to initialize the printer. If the printer was hooked up to the analyzer when it booted up the initialization is performed as part of the boot up procedure.




V
F

**6.** (optional) Press the **LOGO [B]** key to create a user-defined logo that will be printed as a heading on top of each printout from the analyzer. The default logo is Larson • Davis.




**7.** Press one of the following keys to print a desired data record:

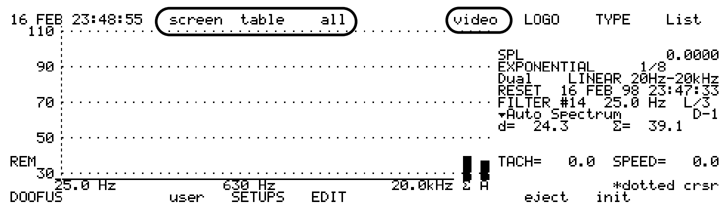
**screen [A]** Prints the display presently on the LCD screen of the analyzer.

**table [B]** Prints the data presently on the display in a tabular form.

**all [C]** Prints both the data presently on the LCD screen and a data table representing the data being displayed.

**List [H]** Prints the data table to the screen instead of a printer.

**video [E]** Prints a black and white printout of the display shown on the optional Model DVX001 Color Video Adaptor.





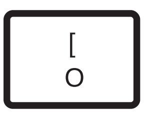
**8.** Press the **EXIT** hardkey to return from the Print Menu.

CHAPTER

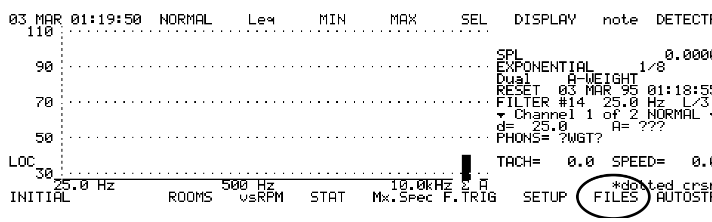
# 7 *Vibration Measurements*

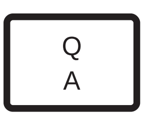
The following is a procedure for setting up the Model 3200 Real Time Analyzer's (RTA's) for basic vibration measurements. In this exercise, we will use the FFT (narrowband) analysis feature of the analyzer. We will setup the RTA for a single channel measurement with the understanding that dual channel vibration measurement is a simple extension. Cross channel measurements, such as cross spectra, transfer functions, coherence functions, etc. will not be addressed in this section.

## Creating a Measurement File

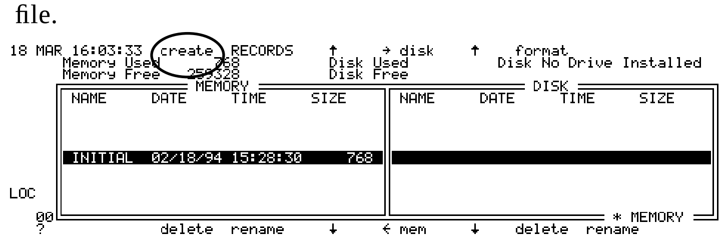



**1.** Before starting any test, it is always a good idea to establish a new measurement file. Data records that are measured will be stored in this measurement file. After turning on the power to your RTA, press **FILES [O]**.



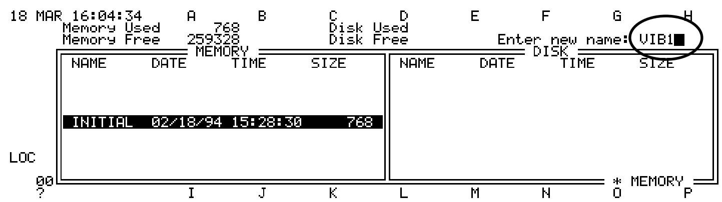

**2.** Within the files menu, press **create [A]** to make a new data file.



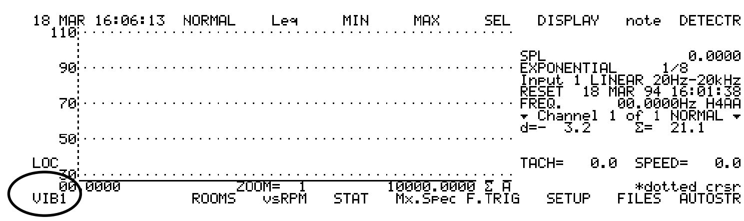
3. You are now being prompted to define a name (8 characters or less) for the data file. For this example, type in **VIB1**. To do this, press the softkey above or below the display. To access alpha keys beyond P, press the **SHIFT** hardkey once, then the desired letter.

EXIT

4. Numeric entries are entered using the numeric hardkeys on the keyboard. After you have typed in VIB1, press **EXIT**.



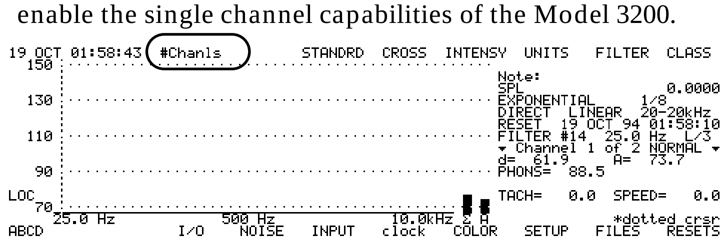

Notice at the lower left corner of the display, the VIB1 filename appears. This indicates that measurement records stored in the future will be placed in the VIB1 measurement file.

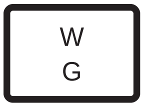



## Setting up the FFT

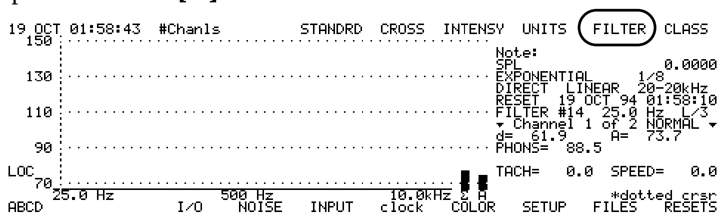
R
B

1. The next step is to configure the RTA to acquire single channel, FFT data. First, press **SYSTEM**. Select **#Chanls [A]** to enable the single channel capabilities of the Model 3200.

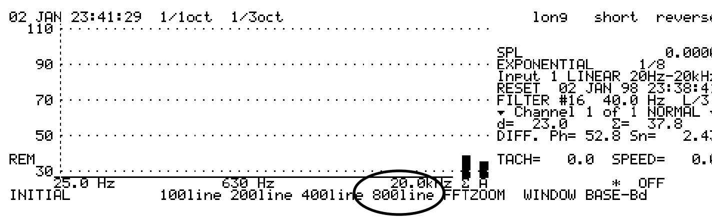


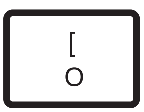



**2.** To configure the RTA for FFT (narrowband) analysis, first press **FILTER [G]**.

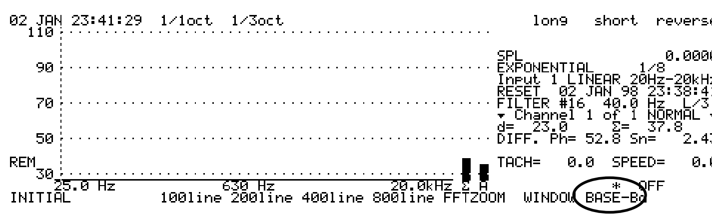



**3.** Within the filter menu, notice that the keys on the top of the measurement display correspond to the full octave and 1/3 octave analysis features. The keys on the bottom of the display relate to the FFT capabilities of the RTA. Keys **100line [I]** thru **800line [L]** are used to select the resolution of the FFT (100 line, 200 line, 400 line, or 800 line). Select **800line [L]** to choose 800 line resolution.



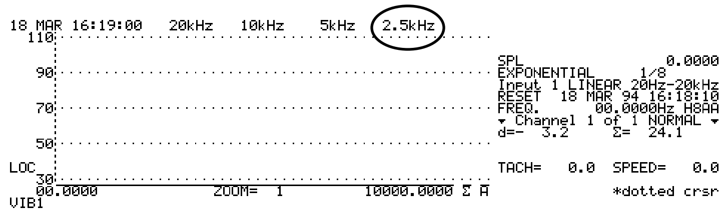




**4.** The next item to establish is the frequency range or analysis baseband. This is the maximum frequency of interest for the test item. Press **BASE-Bd [O]** to access the baseband options.

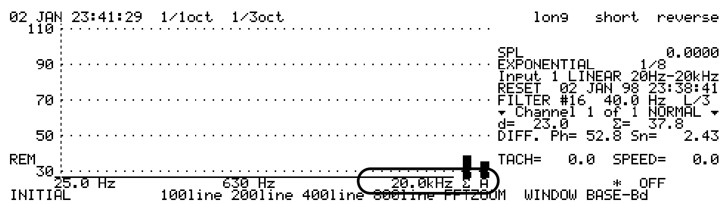


T
D

**5.** Within the baseband menu, you will be prompted in the upper right hand corner of the screen to “select UPPER BAND EDGE” frequency. Press **2.5kHz [D]**.




The frequency scale on the horizontal axis will immediately change to reflect this selection.




## Background on FFT Windows

Windows are used to prevent spectral leakage. Without getting into a long discussion about FFT theory, leakage is a phenomena that can occur as a result of the certain assumptions of the Fast Fourier Transform algorithm. As you may or may not know, FFT analyzers capture time blocks of data, assumes they are periodic, and then applies the FFT algorithm to transform the data blocks into the frequency domain.

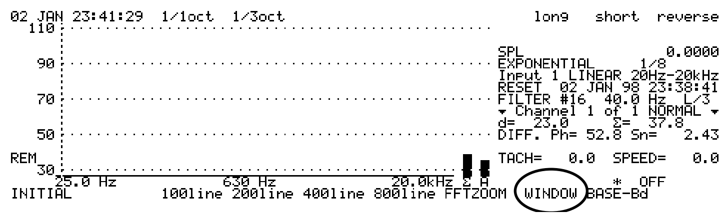
If the time signals that are processed are not periodic, as in the case of a sine wave that has not completed an integral number of cycles, the energy from the “non-captured” portion of the signal leaks into adjacent spectral line in the frequency domain. The result is a distorted frequency spectrum. Leakage also occurs when measuring transients that are not entirely captured in the time block, and when characterizing random signals.

The Larson•Davis Model 2900B offers a variety of window choices. Each has its relative strengths and weaknesses. In general, the Hanning window is preferred when one is measuring periodic (cyclical) signals, or random signals. The drawback to the Hanning window is that it can attenuate the signal amplitude. If amplitude accuracy is critical, a flat top window can be used. The drawback with the flattop window is that you may lose the ability to resolve small signals that are in the presence of larger signals. The rectangular window is the preferred choice when measuring transients. The zeropad window should be used when doing autcorrelation and crosscorrelation measurements. The Impact and Exponential windows in the 3200 are used only when one is performing impact (hammer) measurements as in the case when one is measuring transfer functions (frequency response functions) for a modal test.

## Selecting an FFT Window

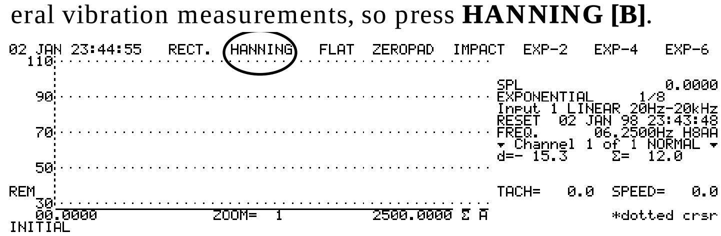
%
N

1. Press **WINDOW [N]** to enter the window selection menu.




R
B

2. The Hanning window is the most common choice for general vibration measurements, so press **HANNING [B]**.

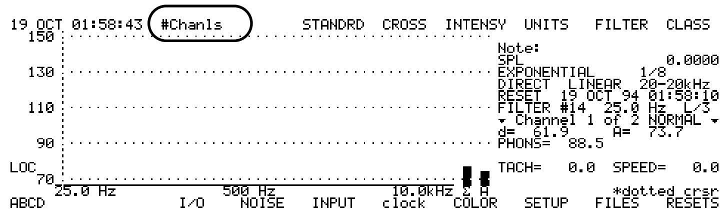



EXIT

3. The last item of interest in the filter menu is FFTZOOM. We will delve into this powerful function later. Press **EXIT** to leave the filter menu.

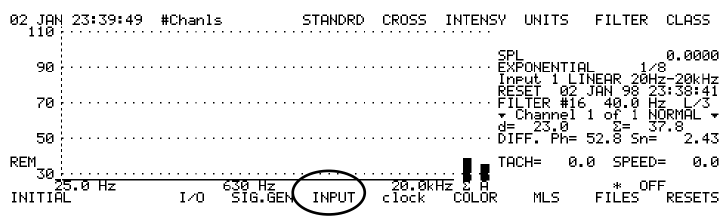
## Selecting the High and Low Pass Filters

The default high and low pass filter setting for the RTA are typically 20Hz and 20kHz as can be verified by looking in the appropriate field on the right of the display.



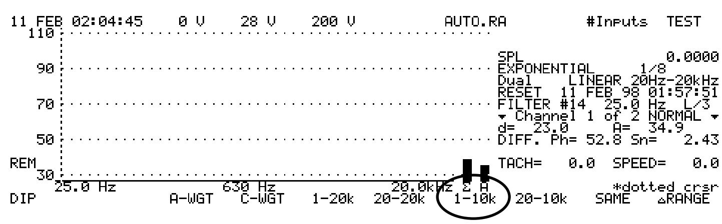

! K

1. In general, vibration data of interest tends to be in the lower frequencies. Let's modify the high and low pass filters to reflect this desire by pressing **INPUT [K]**.



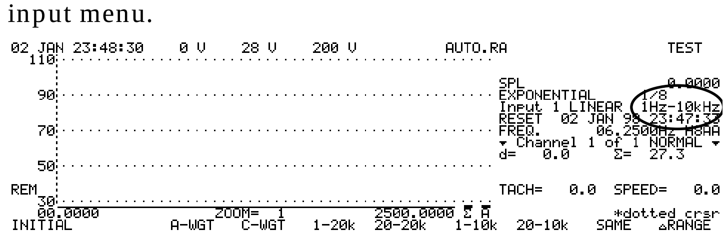

# M

2. Press the **1-10k [M]** high / low pass filter option. This establishes the high pass filter at 1Hz (actual roll off starts at about 0.8 Hz) and the low pass filter at 10 kHz.




EXIT

3. Notice that this selection is now reflected on the right portion of the measurement display. Press **EXIT** to leave the input menu.

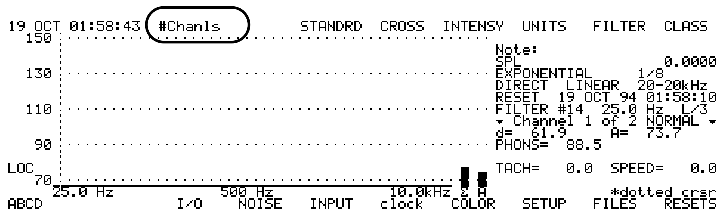


## Selecting Units

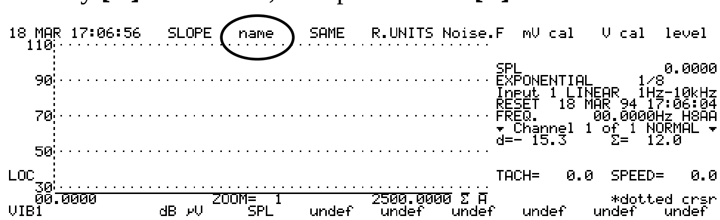
Now let's establish the measurement units and calibration for the transducer that will be used to measure the vibration. The most common transducer used for measuring vibration is an accelerometer. For this example, we will set our acceleration units to be in g's understanding that we could easily make it meters per second squared, feet per second squared, etc.

V
F

1. Press **UNITS [F]** to enter the units field.

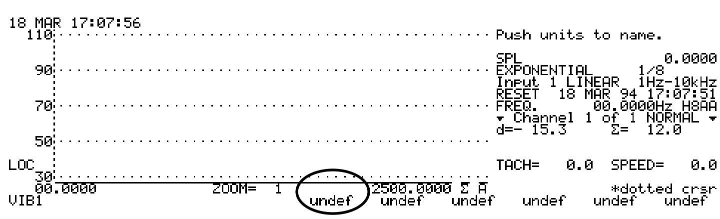



2. The softkey selections at the bottom of the measurement display relate to the unit name that we would like the measurement amplitudes to be displayed. The softkeys **[K]** thru **[P]** are undefined fields. You can assign any unit label that you like to each of the six keys. Let's assign the unit label G to softkey **[K]**. To do this, first push **name [B]**.




!
K

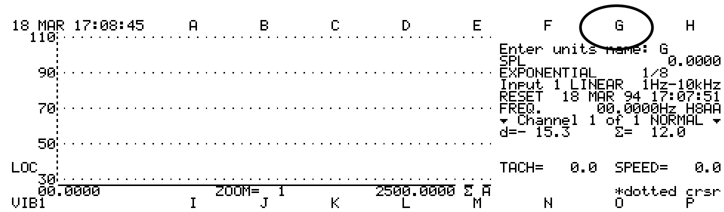
3. You are then prompted to select one of the six undef name keys. Press **undef [K]**.




V
F

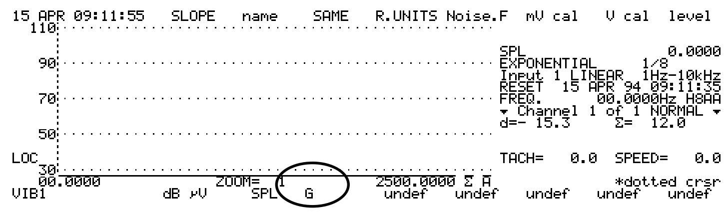
4. You will now see a number of alpha character choices above and below the display. Since we will be measuring vibration in G's, type in the letter **G [G]** followed by 5 presses of the

**SPACE** key to clear the remaining characters. You can also press **SHIFT** and then **CLEAR** to clear the unit entry field, then press the letter **G [G]**.

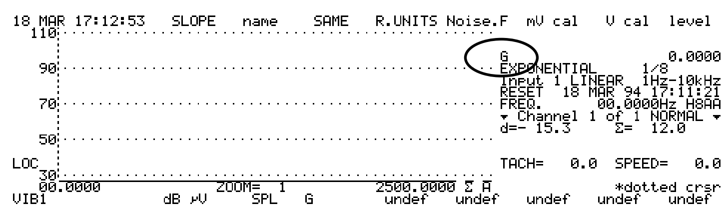



!
K

**5.** Press **EXIT** to enter this unit name. Select **G [K]** to enable the unit label G.




Notice that the unit label, G, appears in the right portion of the display. Note that the unit label, G, has been assigned to the [K] key.

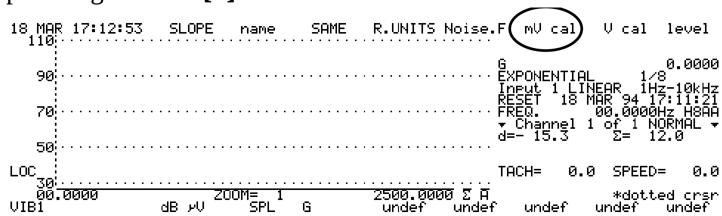



## Calibration

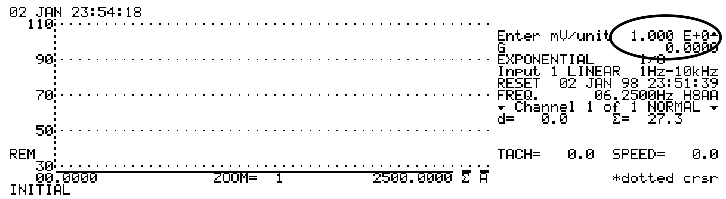
Calibration values of the accelerometer (or any other transducer) can be entered in several ways in the RTA. The easiest way is to enter the sensitivity or calibration value directly from the calibration paperwork that came with the transducer. In the case of an accelerometer, this may be a certain number of millivolts per g (mV/g).

V
F

1. If the number was 10 mV / g, you would enter this by first pressing **mV cal [F]**.




2. At the “Enter mV / unit” prompt, type in **1.000 E+01** using the numeric keys on the RTA keypad (use the Shift key then “+” key to enter a +).




EXIT

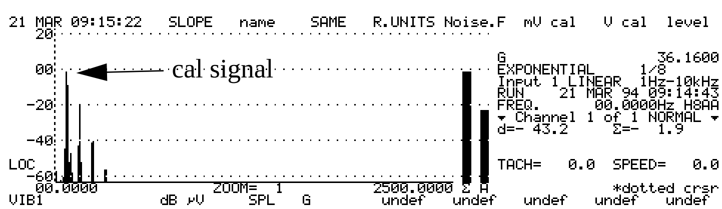
3. Then press **EXIT** to enter the value. Assuming that the sensitivity value from the transducer paperwork was still valid, we would now be calibrated and ready to make vibration measurements.

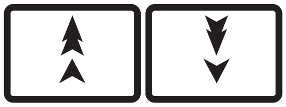
Another way to calibrate the RTA is to utilize a shaker calibrating device that puts out a known vibration level at a specific frequency. These are manufactured by a number of transducer manufacturers.

To calibrate the 2900B2800B with an exciter, attach the transducer firmly to the exciter head. The transducer output will go directly into the analyzer or via a power supply (depending on the type of transducer and connectors available).

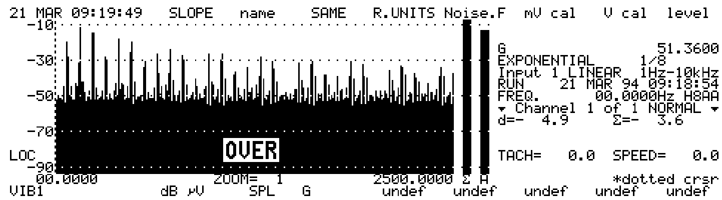
RESET
R/S

4. The calibrator that is being used for this example outputs a signal of 1.0 $g_{rms}$ at 81.25 Hz. Turn on the calibrator. Press **R/S** to run the RTA. The 81.25 Hz calibration signal will appear in the measurement display.



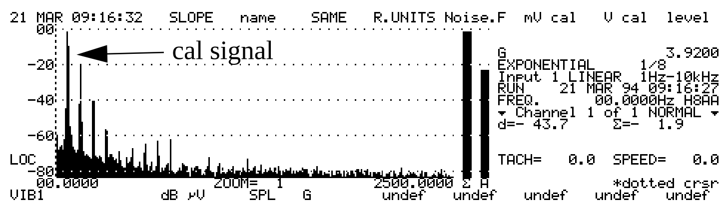


**5.** Press the up or down arrow on the keypad to optimize the range. One way to do this is to range down one increment at a time until an overload is reached. Then range up one or two increments.

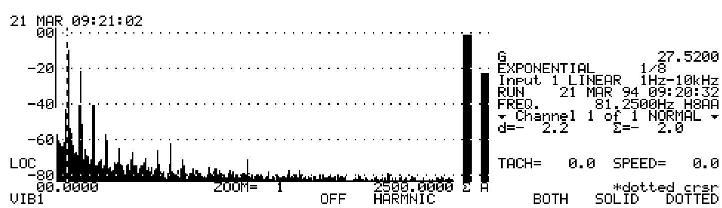


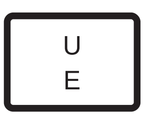


**6.** Notice the prominent signal at the calibration frequency (81.25 Hz). After the signal has stabilized, press **R/S** to stop the measurement.

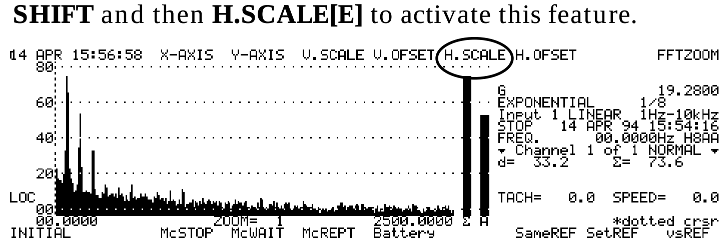



**7.** Move the active cursor to the calibrator frequency (81.25 Hz) by pressing the horizontal arrow keys. You can accelerate the movement of the cursor by holding **SHIFT** and pressing the desired arrow key at the same time.



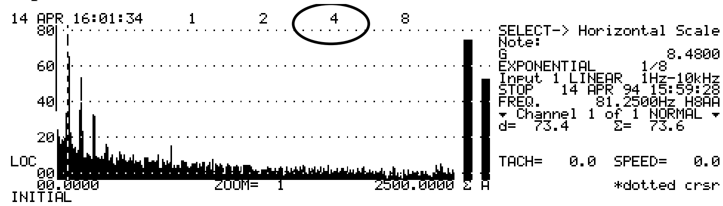




**8.** At this point, we should take advantage of the RTA's horizontal expansion feature. This will expand the display so that the calibration signal can be viewed in more detail. Press **SHIFT** and then **H.SCALE[E]** to activate this feature.



S
C

**9.** Within the H.SCALE menu, you have a number of choices for the scale multiplier. Choose **4[C]** to select the 4 times multiplier.

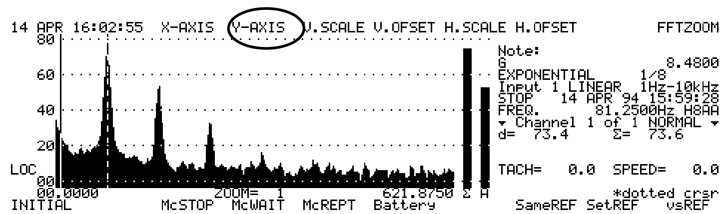



The display is now expanded by a factor of 4. Since we plan to enter the calibrator level (1.0 $g_{rms}$) in linear units, we need to change the vertical scale to linear (from the default logarithmic scale).

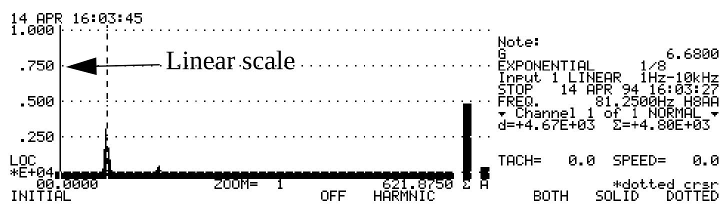
SHIFT

R
B

**10.** Press **SHIFT** and immediately select **Y-AXIS [B]**.

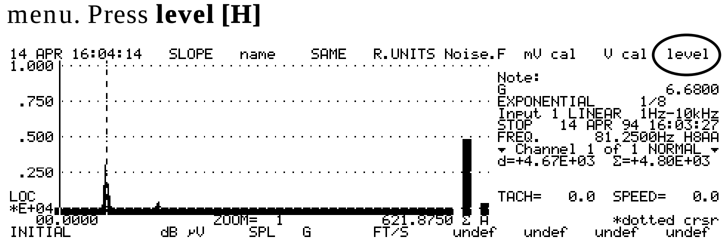



This feature toggles between linear and log vertical scaling. Notice that the vertical scale is now in linear units.



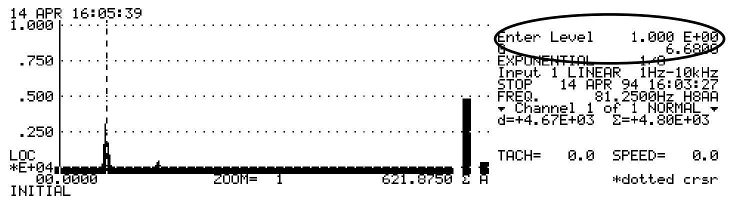

V
F

**11.** Press **SYSTEM** and then **UNITS [F]** to return to the units menu. Press **level [H]**



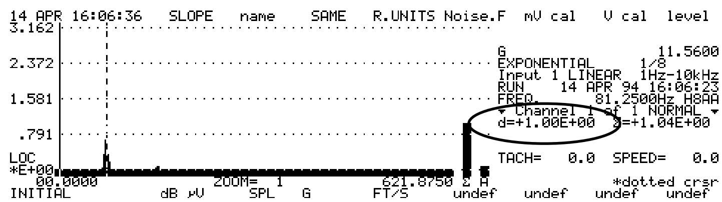
EXIT

**12.** Enter the output level (in linear units) of your calibrator. The level is entered in engineering notation. For this example, enter 1.0 $g_{rms}$ as 1.000 E00. This will actually be entered as **100000**. Then press **EXIT**.



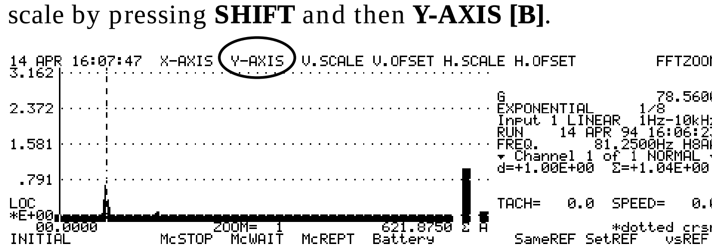

RESET
R/S

**13.** To check the calibration, make sure the calibrator is still on, then press **R/S** to run the RTA.

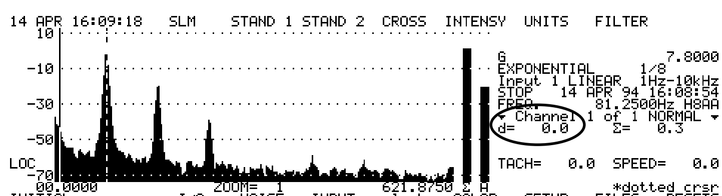



SHIFT R B

**14.** The level at the cursor position should read about 1.0 $g_{rms}$. This represents the reference level. In other words, on a logarithmic scale, this would be 0 dB. Return to logarithmic (dB) scale by pressing **SHIFT** and then **Y-AXIS [B]**.

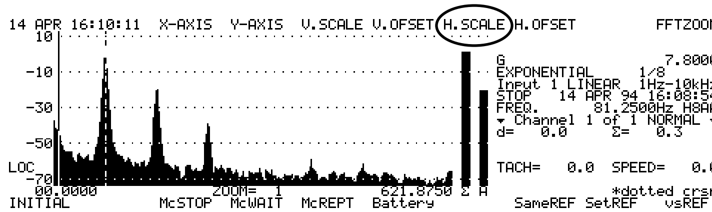



Once you have returned the display to a logarithmic vertical scale, notice that the calibration level is indeed 0 dB.

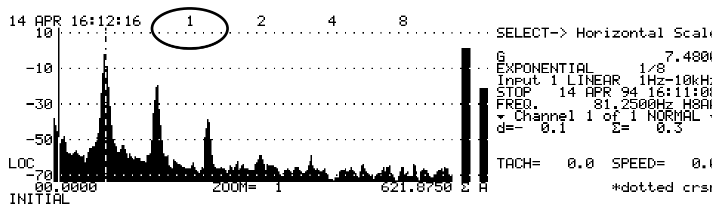



RESET
R/S

**15.** Press **R/S** to stop the measurement. Now disconnect the transducer from the calibrator, and then attach it to the test structure from which you wish to acquire vibration measurements. Next, let’s change the horizontal scaling back to full scale. Press **SHIFT** and **H.SCALE [E]** to enter the horizontal scale menu.



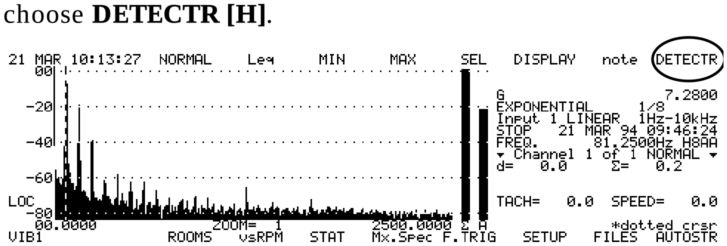

**16.** Change the scale multiplier to 1 by pressing **1[A]**.




## Averaging

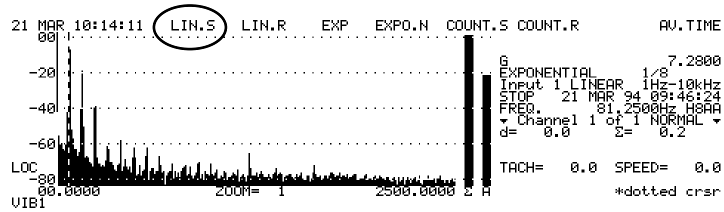
When possible, vibration measurements should be acquired using a linear average over a finite amount of time. Averaging will improve the quality of the measurement by negating the contribution of nonlinearities, and external random noise. Normally, the longer that you average, the better the measurement quality.


**1.** To establish linear averaging, press **EXIT** twice, and then choose **DETECTR [H]**.



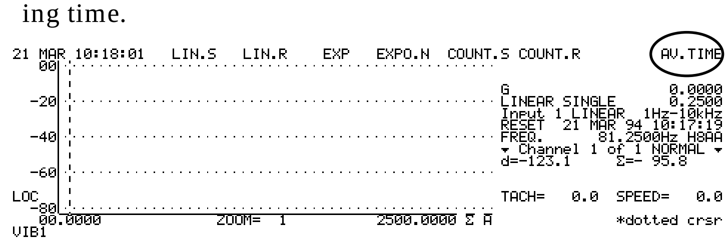
Q
A

**2.** Press **LIN.S [A]** to enable linear single averaging.



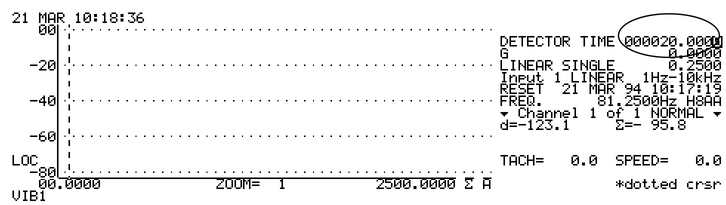

X
H

**3.** Next choose **AV.TIME [H]** to select the measurement averaging time.

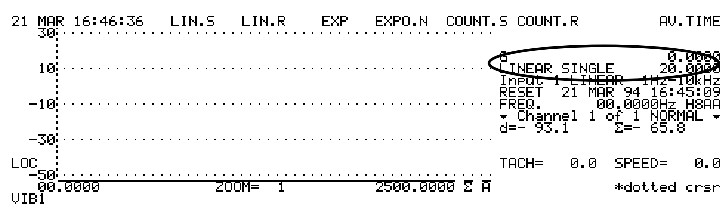



EXIT

**4.** For this example, select a 20 second averaging time (detector time) by typing **000020.0000** using the alpha keys on the RTA keyboard. Then press **EXIT** to enter the number.

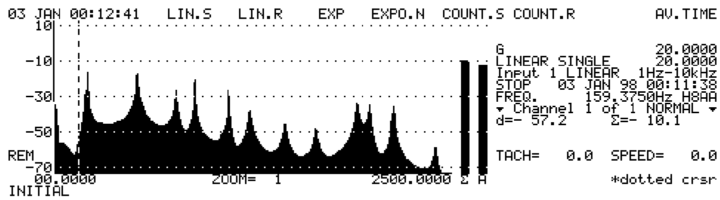



Notice that the right side of the display reflects the averaging options that we've selected. Now we're ready to take “real” vibration measurements.



RESET
R/S

5. Press **R/S** to begin the measurement process. Use the up and down arrows to optimize the range setting as we did during calibration.




After 20 seconds, the measurement is complete. At this point, you could choose to save the data, print it, clear it, or take it over again.

## Zoom Processing

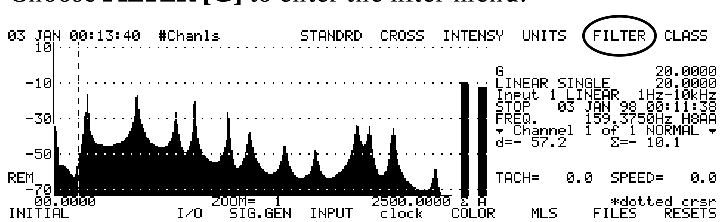
A very powerful feature of the RTA is the FFTZOOM feature. FFTZOOM allows one to apply the full FFT resolution (in the current case: 800 lines) to a small frequency range. This is particularly useful if one is interested in acquiring detailed frequency information within a relatively small band (say 1200 Hz to 1800 Hz). With FFTZOOM, you can apply all 800 lines of resolution to this section.

SCREEN
SYSTEM

1. Press **SYSTEM** to return to the main System menu.

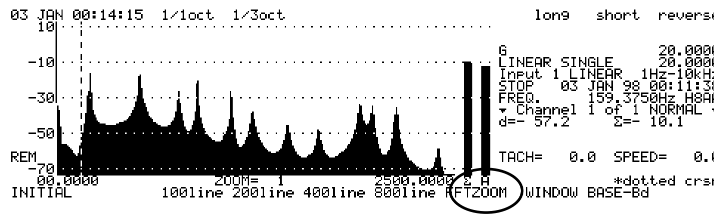
W
G

2. Choose **FILTER [G]** to enter the filter menu.



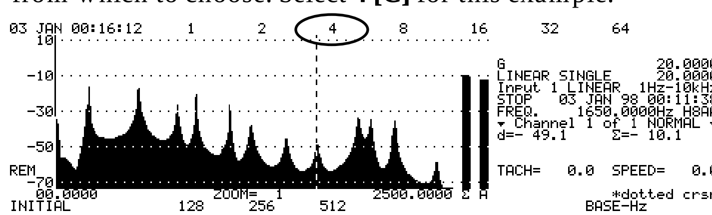
# 
M

3. Before selecting the zoom multiplier, first move the cursor to a center frequency about which you would like to apply the zoom. For the example, move the cursor to 1650 Hz. Then press **FFTZOOM [M]**.



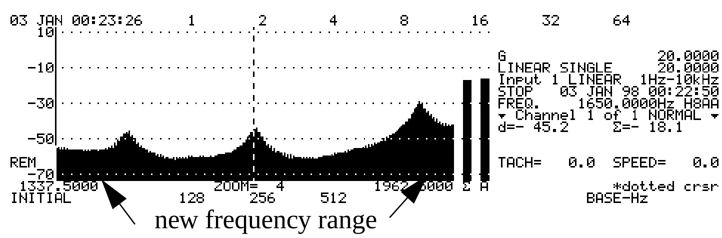

S
C

4. Notice that you have a number of zoom multiplier options from which to choose. Select **4 [C]** for this example.




RESET
R/S

5. Note that the frequency span has changed. It is now 1337.5 Hz to 1962.5 Hz. All of our 800 lines of frequency resolution will be applied to this 625 Hz span. Press **R/S** to begin another measurement. After 20 seconds, the measurement will be complete.




In this measurement, it should be clear that we have achieved much greater detail of the of the data within this reduced frequency range.

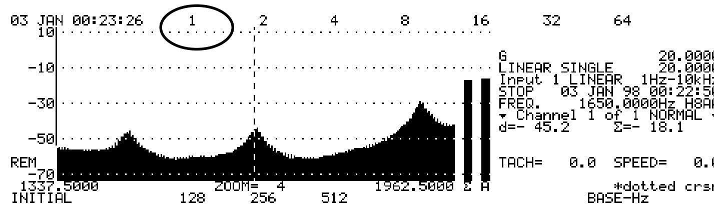
## Integration and Double Integration

A common goal in the measurement of vibration is to extrapolate velocity or displacement values from accelerometer data.

This can be done in the RTA by using the integration and double integration functions. Let's first change our zoom factor back to 1 so that we can view the entire 0 Hz to 2.5 kHz baseband.

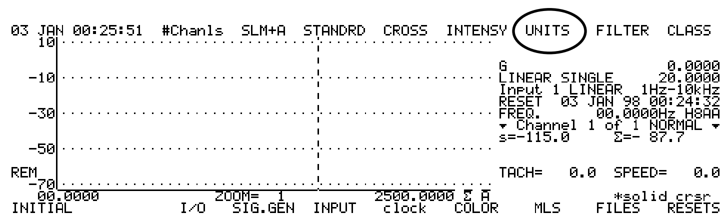
Q
A

**1.** Press **1 [A]** from within the FFTZOOM window.



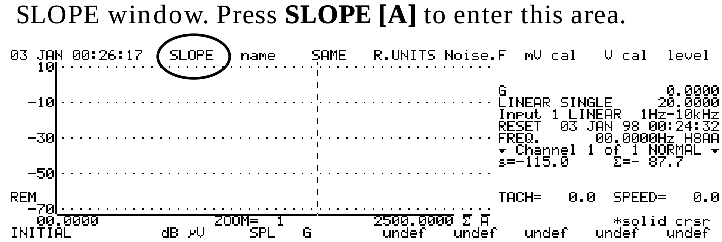

SCREEN
SYSTEM

**2.** Press **SYSTEM** to exit back to the main system menu. Choose **UNITS[F]** to enter into the units menu.




Q
A

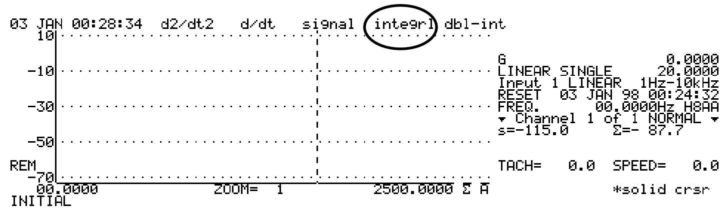
**3.** The integration and differentiation functions are in the SLOPE window. Press **SLOPE [A]** to enter this area.



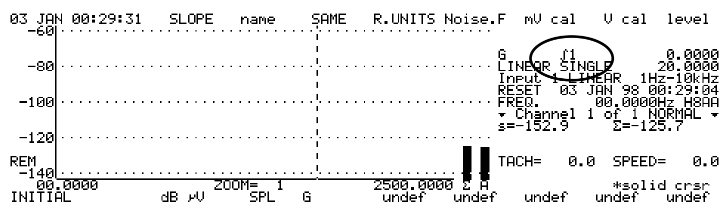

Within this menu, you have four choices: differentiation, double differentiation, integration, and double integration. The differentiation functions: d2/dt2 and d/dt are used in the instance where one uses a displacement or velocity transducer, and they wish to display acceleration. In this case, the user should be cautious to analyze data only within the frequency response constraints of the transducer. Velocity and displacement transducers typically have limited frequency response characteristics.

T
D

**4.** For this experiment, let's perform a single integration on our accelerometer. The result will be a velocity spectrum. Press **integrl [D]**. to activate the single integration feature.

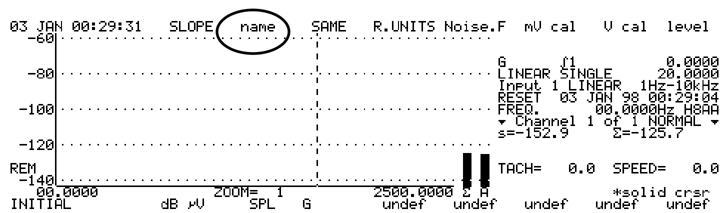


**NOTE:** This selection will be reflected in the upper right side of the LCD.



R
B

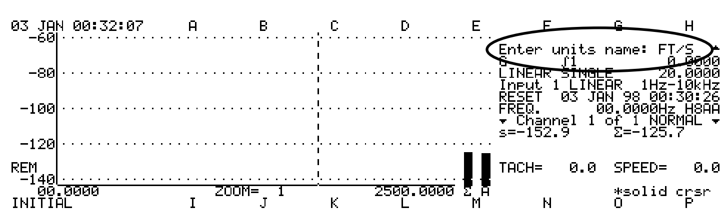
**5.** We now need to modify the calibration value and label to read in velocity units. We are currently calibrated to display the data in g's. Since the integral of a g is meaningless, let's create a velocity unit labeled ft/s. Press **name [B]** to enable the label unit feature.



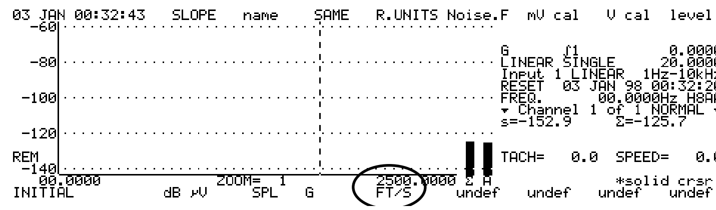
@
L

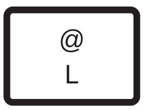
**6.** Press the **undef [L]** to edit the label.

**7.** Press **SHIFT** then **CLEAR** to clear the label. Type **FT/S**. Then press **EXIT** to enter the new label.

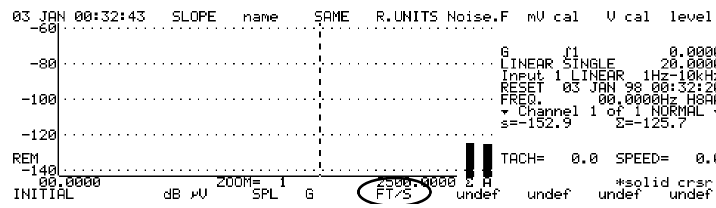


**8.** Notice the newly created label FT / S at the bottom of the display.

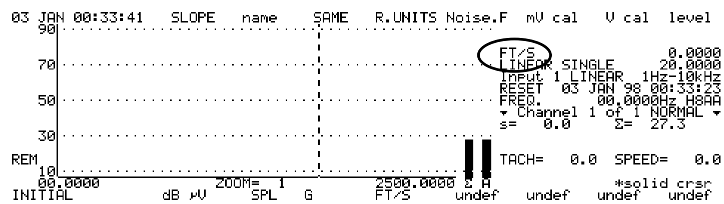



**9.** Press **FT/S [L]**to activate the label.

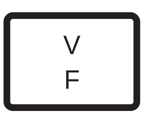



**10.** FT / S has now replaced “G” in the unit field of the display.

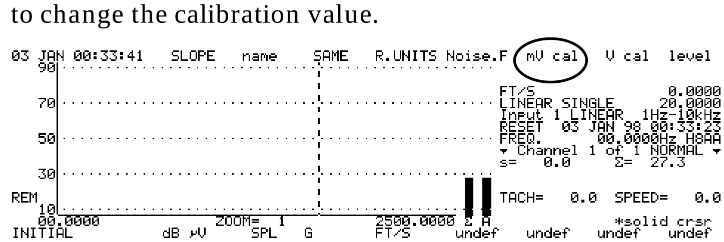


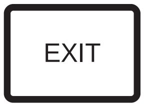

Next, the calibration value (sensitivity) needs to be changed. When we calibrated originally, we did so in g’s. Recall that we first calibrated the RTA by typing in the calibration value from the accelerometer calibration paperwork directly into the “mv cal” field. In the example we discussed, 10 mv / g was the value entered. In this case, we need to convert this sensitivity value to mv per ft / sec$^2$:

(10 mv / g) x (1g / 32.2 ft / s$^2$) = 0.31 mv / ft / s$^2$.

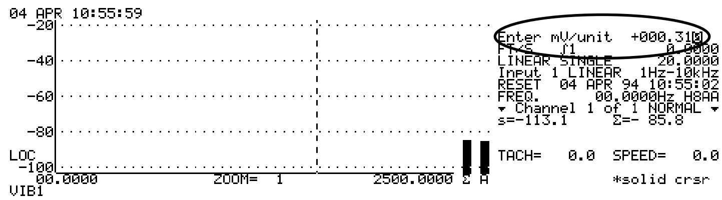



**11.** Note that the integral of ft / sec$^2$ will be ft / s. Press **mv cal [F]** to change the calibration value.





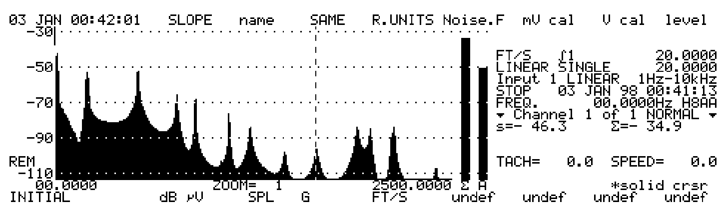

**12.** Next, type **000310** using the alpha keys on the keypad to enter the new sensitivity number. Then press **EXIT** to enter the value. Press **EXIT** 2 more times to return to the main menu.

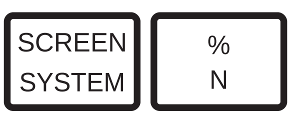



If a shaker calibrator was used to calibrate the RTA, the same method as was outlined earlier in this note would be used. In this case, when the "level" of the shaker signal is entered, it must be in ft/s$^2$. For our example, a 1.0 $g_{rms}$ shaker was used. Since 1.0 g equals 32.2 ft/s$^2$, this would be the calibrator reference level. Follow the procedure that was previously outlined to calibrate using the shaker calibrator, entering 32.2 ft/s$^2$ in the level field.

Now, the RTA is ready to analyze vibration signals and display the data in calibrated velocity units.


**13.** Press **R/S** to gather velocity data from your vibrating structure.

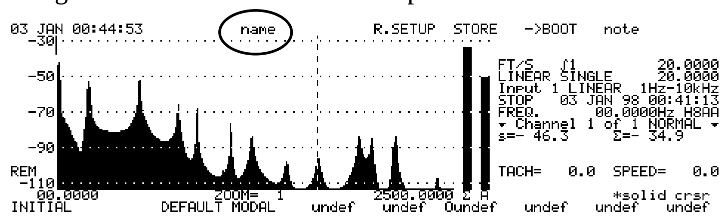



**14.** The last task that we need to accomplish is to save the vibration measurement setup so that we can avoid having to reconfigure the analyzer should we wish to make additional vibration measurements in the future. Press **SYSTEM** and then **SETUP [N]** to enter the SETUP menu.

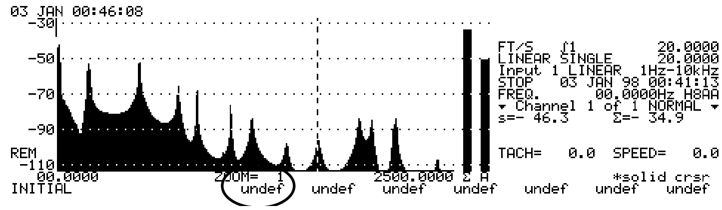
R
B

**15.** From within the SETUP menu, press **name [B]** so that we can assign a name or label to this setup.



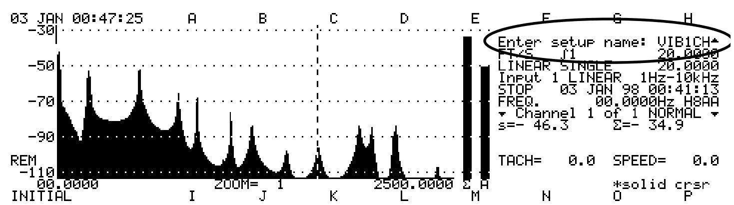

!
K

**16.** Next, press **undef [J]**. This will select the [K] softkey (within the SETUP menu) as the key to which our vibration setup is stored.



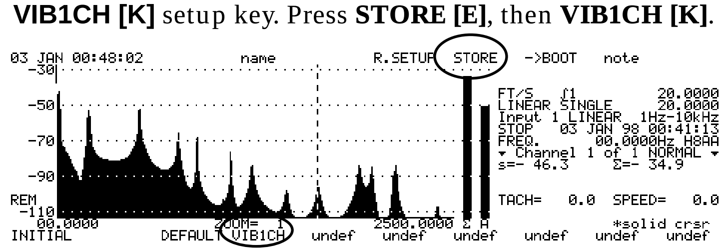

EXIT

**17.** At the “Enter setup name:” prompt, type in **VIB1CH** (or whatever label you like). Then press **EXIT**.




!
K

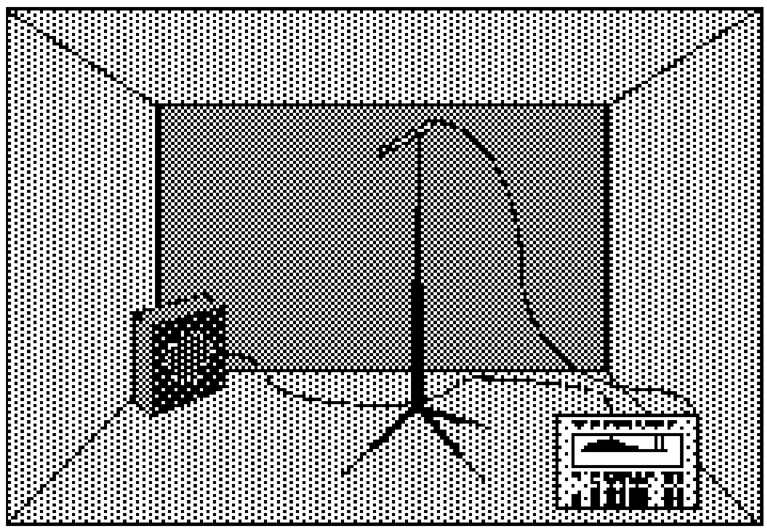
**18.** Next, we need to store the current (active) setup to the **VIB1CH [K]** setup key. Press **STORE [E]**, then **VIB1CH [K]**.




The vibration setup is now stored to the **VIB1CH [K]** key. This setup can be activated at any time by pressing this soft-key from within the SETUP menu.

CHAPTER

# 8 *Room Acoustics*



Among the many built-in capabilities of the Larson•Davis Real Time Analyzers, a very important and useful tool is the Room Acoustics feature. Acousticians that are involved in determining decay times of rooms, theatres, etc., or in analyzing the absorptive qualities of walls, doors, barriers or partitions will find the Room Acoustics capabilities of the RTA's to be very complete.

These types of measurements require only a single channel analyzer such as the Model 2800B. Using a dual channel analyzer like the 2900B or 3200 can save time but is not necessary.

# Sound Decay Measurements (RT60's)

Sound decay measurements are used to determine the sound absorbtion characteristics of a room. This is also known as the reverberation time or the decay time.

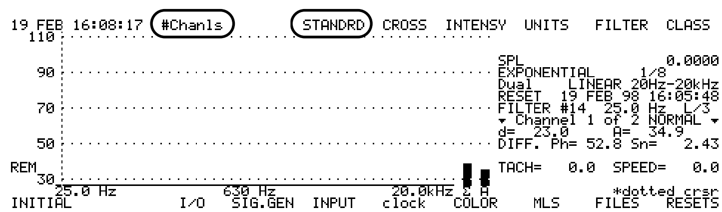
**RT60 defined -** an RT60 is the amount of time required for a room to absorb 60 decibels of sound pressure. Example: Someone excites a room with a gun blast or a balloon pop and the maximum sound pressure level reached is 115 dB. RT60 is the amount of time it would take for the room to absorb the noise such that the sound pressure level reaches 55 dB (115-60). Typical values of reverberation times are 0.1 to 3.5 seconds.

Highly reverberant or reflective rooms, such as a gymnasium or a tiled bathroom have longer sound decay times.

## Setting up the RTA for RT60 measurements

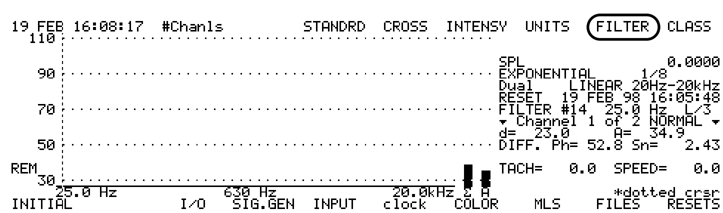
R
B

1. From the System menu, press **STANDARD[C]** and **#Chanls [A]** in order to activate a single channel measurement.



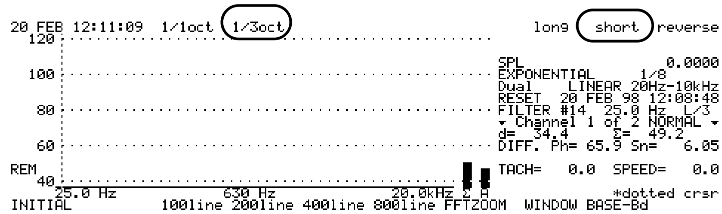

W
G

2. Since RT60 measurements are typically done in 1/3 octave bands, press **FILTER [G]** to enter the filter menu.



R
B

3. Choose **1/3oct [B]** to activate the 1/3 octave band digital filters of the RTA. Choose **short [g]** or for the short response time choose **reverse [H]**.




EXIT

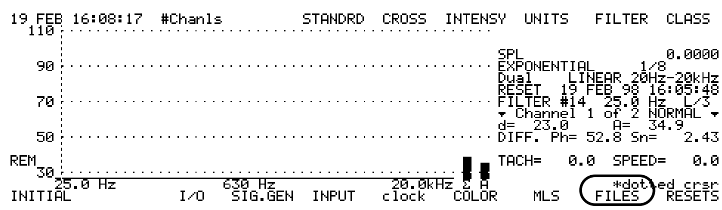
4. Press **EXIT** to return to the System menu.

## Creating a Measurement File

Now, create a measurement file for the measurement records that will soon be acquired.

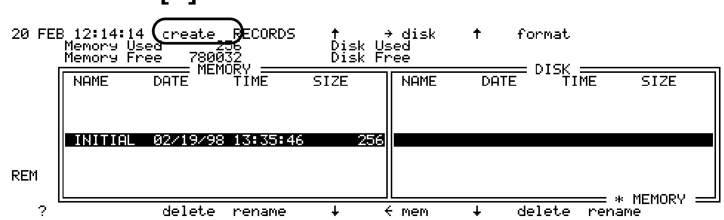
[
O

1. Press **FILES[O]** to enter the files menu.

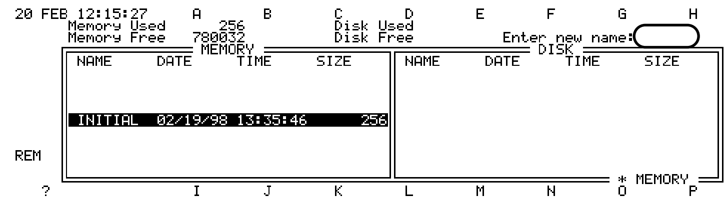


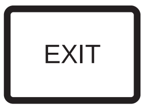

Q
A

2. Press **create[A]** to create and name a measurement file.



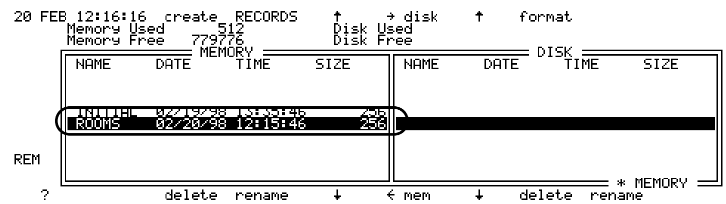
**3.** Using the alpha keys, type in a filename such as ROOMS.




**4.** Press **EXIT** to enter this name.

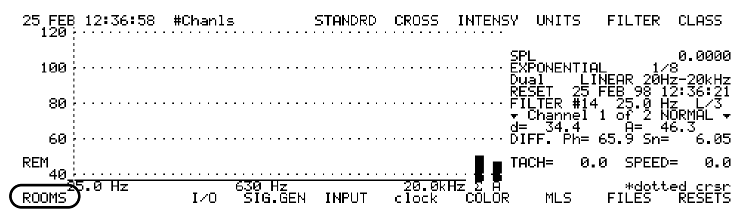
Notice that the filename ROOMS is shown in the file display along with the date and time of the file creation.





**5.** Press **EXIT** again to get back to the System menu.

The filename ROOMS now appears in the lower left corner of the display indicating that it is the active measurement file. From this point on, all measurement records that are stored will reside in the ROOMS file.



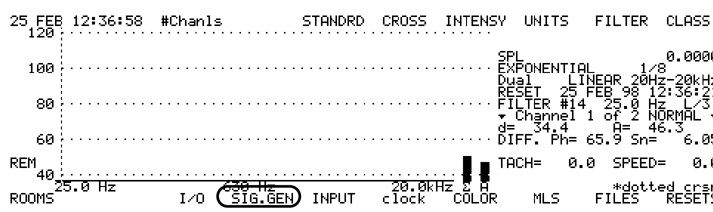
## Setting up the Microphones and Noise Source

Connect a microphone, microphone preamplifier, and appropriate length of microphone cable to the channel one input of the RTA. Place the microphone (using a tripod) at the desired location for your first measurement.

There are many techniques that can be used to “excite” a room. The more common methods include popping a balloon, firing a starting pistol, or driving an amplifier / speaker with broadband random noise. Balloons and starting pistols are inexpensive and portable, but lack low frequency components (also not very repeatable). The best method is to use a random noise generator and an amplifier / speaker system. An excellent device to drive the speaker / amplifier is the LD SRC20 portable pink and white random noise generator or the generator in the RTA. If the RTA has the Noise Generator or Signal Generator option, connect your speaker / amplifier to the Source Output jack. Place the speaker in a corner of the room, facing the center of the room.

Z
J

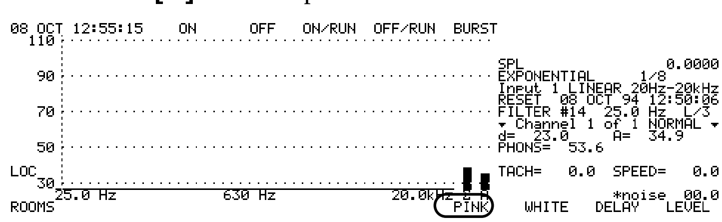
1. To enable the signal generator, press **SIG.GEN [J]**, from the System menu.




Pink noise is better to use for this type of testing since it provides constant energy for all of the 1/3 octave frequency bands.

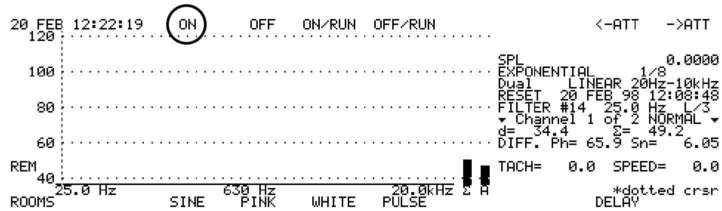
#
M

2. Press **PINK [M]** to select pink noise.



Q
A

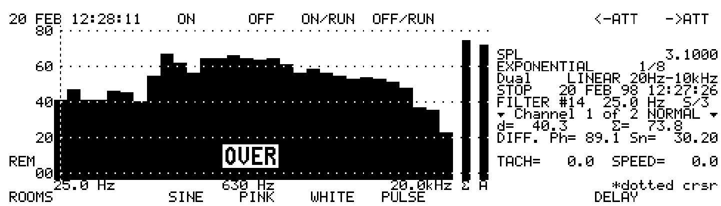
**3.** Turn the noise generator on by pressing **ON[A]**.



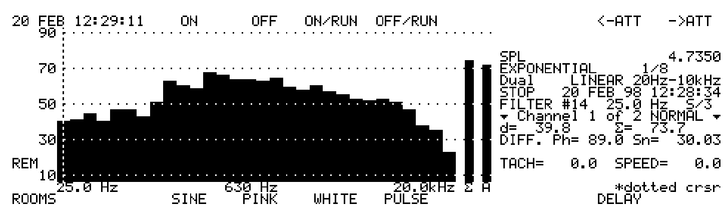

The noise generator will deliver a pink noise signal to the speaker / amplifier system.

RESET
R/S

**4.** Press **R/S**. Adjust the channel one input gain of the RTA, such that the signal is optimized without creating an overload condition. The best way to do this is to press the down arrow hard key until and overload occurs.



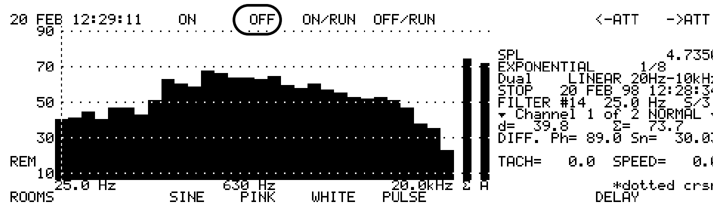

**5.** Range up (by pressing the up arrow hard key) until the overload indicator disappears.




You may also need to adjust the output level of the amplifier / speaker in order to insure that all of the frequencies of interest are being excited equally. The spectrum displayed on the RTA should be fairly flat within this frequency range. The output level of the speaker / amplifier should also be loud enough such that there is a significant difference between the background (ambient) level and the excited level (for each frequency of interest).

R
B

**6.** Once the desired output level and input gain have been achieved, press **OFF [B]** to turn off the noise generator.




EXIT

**7.** Press **EXIT** to return to the System menu.

RESET
R/S

**8.** Press **R/S** to stop the measurement.

## Establishing the Averaging Parameters for the RT60 Measurement

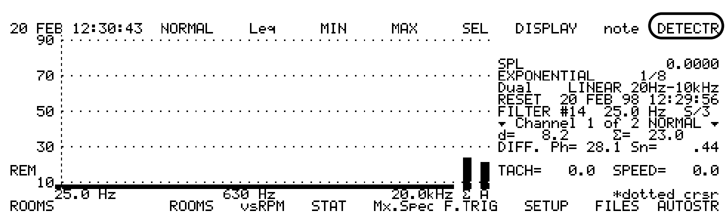
The RTA utilizes the built-in Autostore capability when making RT60 measurements. Before enabling the autostore feature, the desired detector needs to be established. Typically one would use either exponential or linear repeat averaging for this type of test. For this example, you will use the linear repeat detector.

EXIT

**1.** Press **EXIT** once to enter the Main menu.

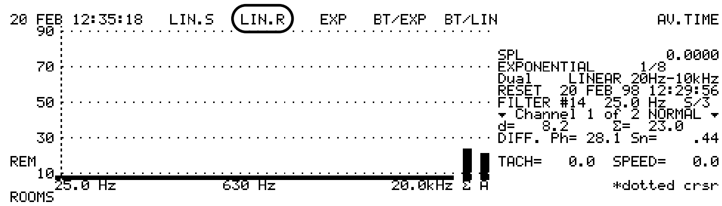
X
H

**2.** Select **DETECTR [H]** to enter the detector (averaging) selection menu.



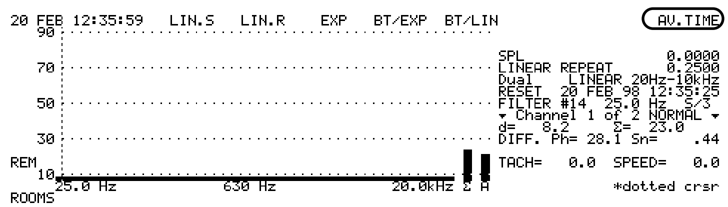
R
B

**3.** Choose **LIN.R [B]** to select linear repeat averaging.

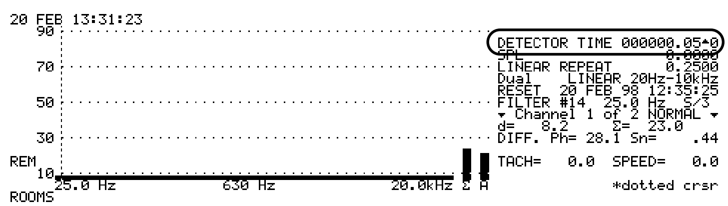



X
H

**4.** Press **AV.TIME[H]** to establish a linear repeat averaging time.

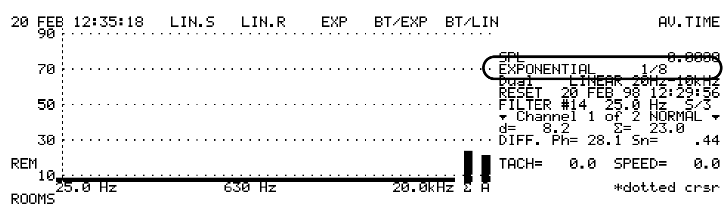



**5.** For the RT60 autostore measurement, you should select a very short averaging time. Type in 0.05 seconds as shown.




EXIT

**6.** Press **EXIT** to enter this value. Notice that the established detector parameters appear on the right of the display.

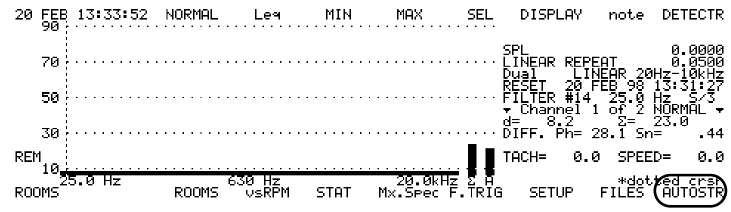



EXIT

**7.** Press **EXIT** to return to the STANDRD analysis menu.

]
P

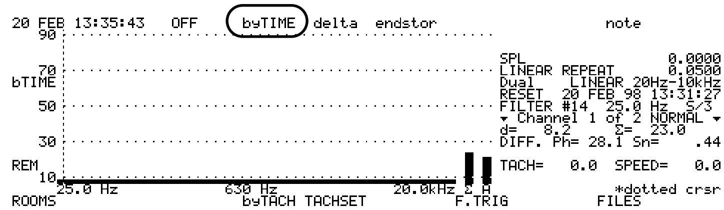
**8.** To enter the Autostore menu, choose **AUTOSTR [P]**.



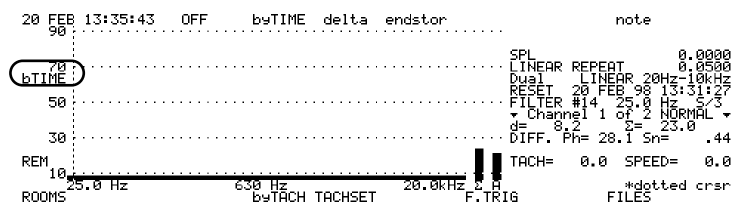

As mentioned earlier, reverberation time measurements are acquired with the RTA using the Autostore feature.

R
B

**9.** To enable Autostore, press **byTIME[B]**.



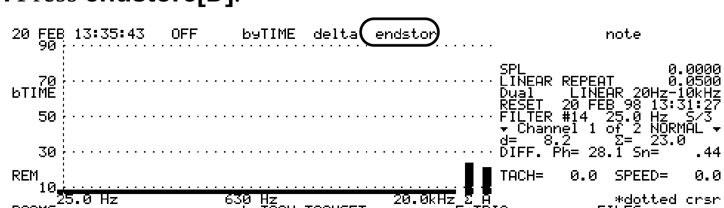

Notice that the label “bTIME” appears on the left side of the display.



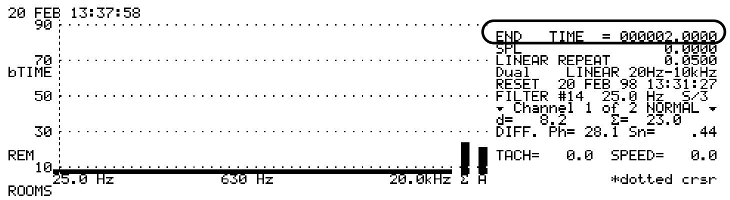

You now need to establish the Autostore endstore (duration) and the Autostore delta. The endstore is the amount of time that is allocated for the total reverberation time measurement. 3 to 4 seconds is usually more than sufficient for most rooms.

T
D

**10.** Press **endstore[D]**.



**11.** Type in 2.0 seconds as shown below.



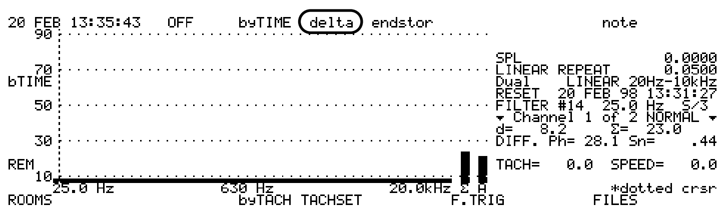

EXIT

**12.** Press **EXIT** to enter this endstore time.

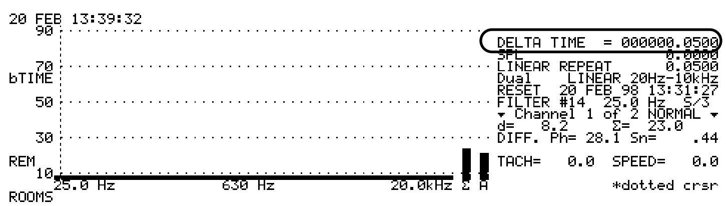
The delta is the parameter that establishes how often a spectrum is to be captured. you will choose a delta that matches the averaging time that you previously established when you selected the linear repeat detector. Thus, you will use .05 seconds.

S
C

**13.** Press **delta [C]**.




**14.** Type in a delta value of.05 seconds as shown below




EXIT

**15.** Press **EXIT** to enter this Autostore delta time.

Now that the Autostore measurement parameters are established, let’s review what will happen during the measurement. You will drive the room with pink noise until it is excited at all of the frequencies of interest. You will then begin the Autostore measurement by pressing R/S on the RTA.

At this point the RTA will start capturing spectra at a rate of 20 per second (every .05 seconds). After 1 second the noise generator will be shut off (due to the way the noise generator is configured), but the RTA will continue to capture spectra as the room "absorbs" the reflecting sound that remains from the now inactive speaker / amplifier. This will continue for 1 second until the 2 second Autostore endstore is reached. At that point, the RTA will cease capturing spectra.

The end result is that you will have 40 spectra (20 per second for the 2 second measurement) that will characterize the reverberation time of the room.

SCREEN
SYSTEM

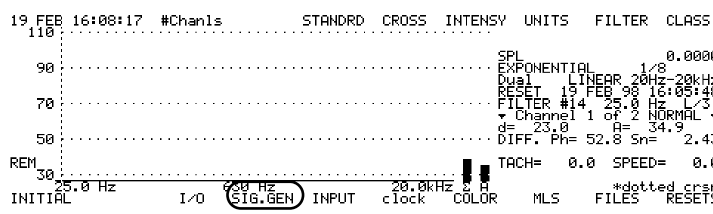
**16.** Press **SYSTEM** to go to the System menu.

## Setting the Signal Generator Delay

The next thing that you need to establish is the noise generator duration. As mentioned, for this test you would like the pink signal generator to automatically shut off 1 second after the Autostore measurement has begun.

Z
J

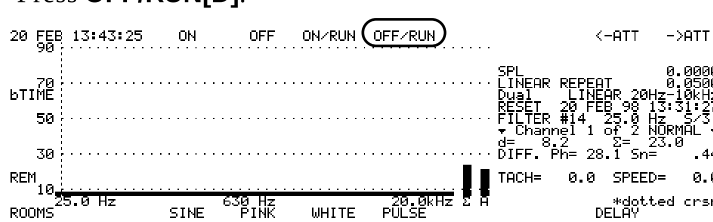
**1.** Press **SIG.GEN[J]** to enter the Signal Generator menu.




Since you want the noise generator to turn off after the measurement has begun, you will use the Off with Run feature.

T
D

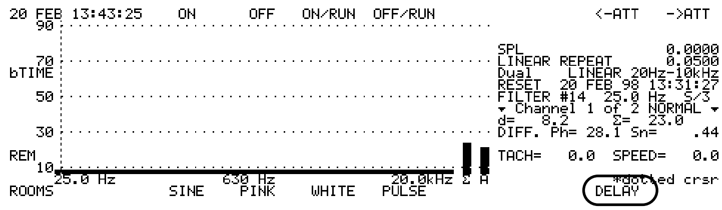
**2.** Press **OFF/RUN[D]**.



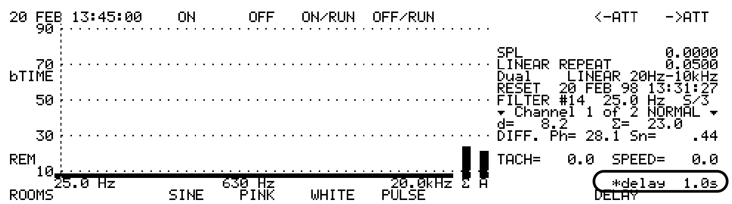

Since you want the pink noise generator to automatically shut off after 1 second into the Autostore, you will use the delay feature of the noise generator.

[
O

**3.** Press **DELAY [O]**.




**4.** Use the left and right arrow hard keys to establish the 1.0 second delay.




EXIT

**5.** Press **EXIT** to return to the SYSTEM menu.

## Making the RT60 Measurement

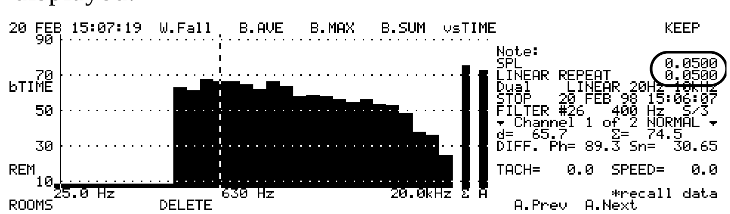
You are now ready to make the RT60 measurement. Verify that the speaker and microphone are placed in the desired positions.

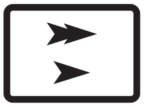
RESET
R/S

**1.** Then press **R/S** to begin the RT60 measurement.

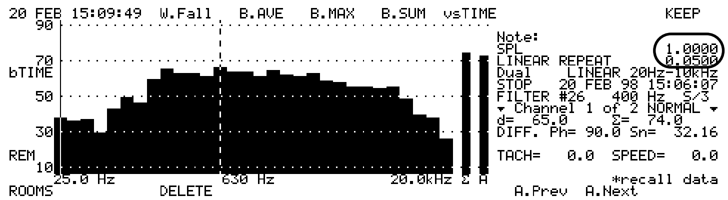
CLEAR
RECALL

**2.** After the measurement is complete, press the **RECALL** hard-key. The first spectrum (at 0.05 seconds into the measurement) that was captured during the autostore process will be displayed.





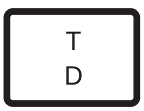
**3.** Press the right arrow hard key until you get to 1 sec. Beyond this point you will see the spectrum start to attenuate.



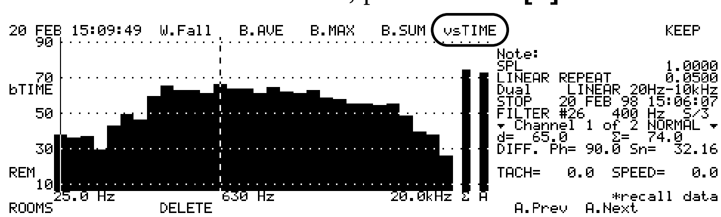

**4.** Continue pressing the right (or left) arrow hard key to page back and forth through the individual spectra.

You will now use the vsTIME feature of the RTA to see how specific frequencies changed in amplitude during the 2 second Autostore measurement.

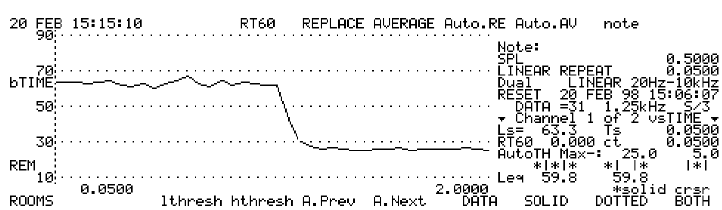

**5.** Press **CURSOR** to activate the dotted cursor. Then use the right (or left) arrow hard key to a desired frequency value such as 1.25 kHz.




**6.** To view how the 1.25 kHz band changed during the 2.0 second Autostore measurement, press **vsTIME[E]**.

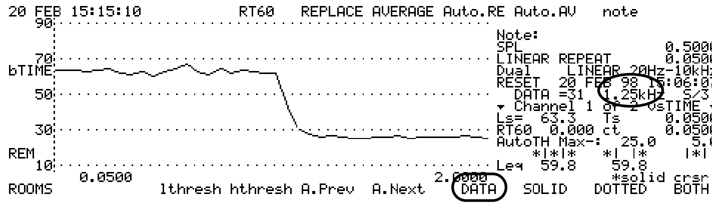



Notice that the horizontal scale of the measurement display has changed to time with values of 0.5 to 2.0 seconds on either end. You can see how much acoustic energy the room experienced when the pink noise generator was on, and how the reflective sound was absorbed after it was shut off. The time between when the noise generator was on to the ambient noise level of the room (no pink noise) is a measure of the reverberation time.

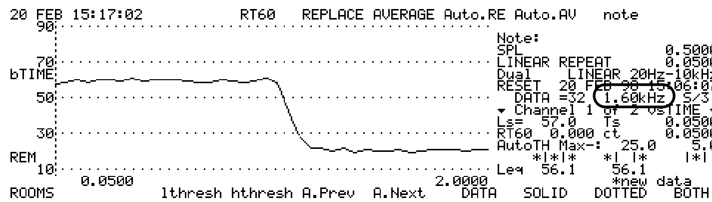


# M

**7.** To see the sound decays of the other frequency bands, press **DATA [M]**.




**8.** Then press the right or left arrow hardkeys to step through the different frequency bands.




EXIT

**9.** Press **EXIT** to return to the amplitude vs. frequency. Press **EXIT** again to return to the SYSTEM menu. Note that the measurement display is cleared.

It is almost always desirable to make a number of Autostore RT60 measurements within a room and average them together to come up with a single “averaged” measurement. This helps reduce errors caused by background noise, room modes (dead spots), etc. Move the microphone to a different positions and repeat the measurement.

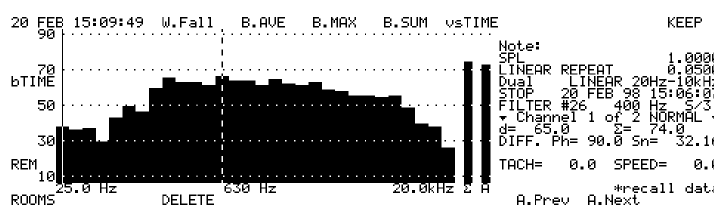
RESET
R/S

**10.** Press **R/S** to acquire the second Autostore measurement.

For this exercise, take 5 additional Autostore records at different microphone positions.

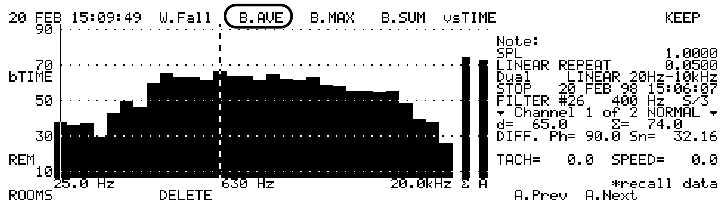
CLEAR
RECALL

**11.** After the 6th measurement is done, press **RECALL**.

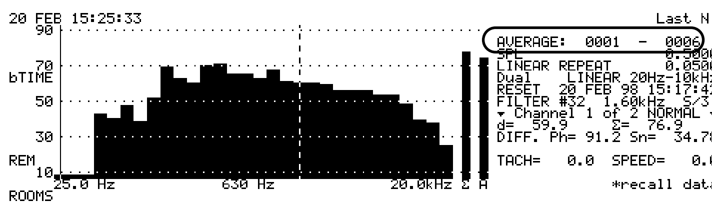


R
B

**12.** To average the 6 Autostored measurements together, press **B.AVG[B]** (Block Average).



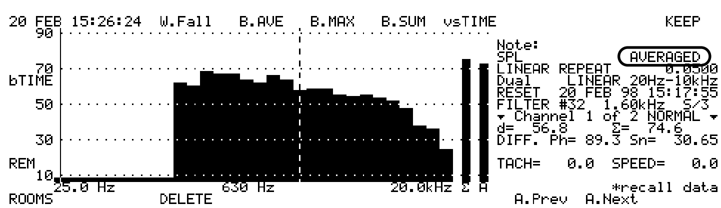

**13.** At the top right side of the display, answer the prompt for the Autostore records that you wish to have averaged together. Since you want to average all 6 records, type in 001-006.




EXIT

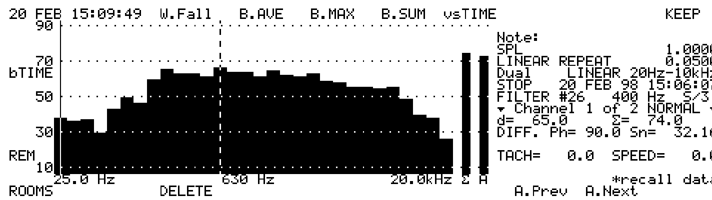
**14.** Then press **EXIT** to enter the selection.

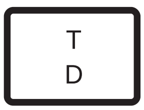
Notice that the new “averaged” Autostore record is displayed and is stored as By Time record number 7. Note also that the word “AVERAGED” appears on the right of the display.



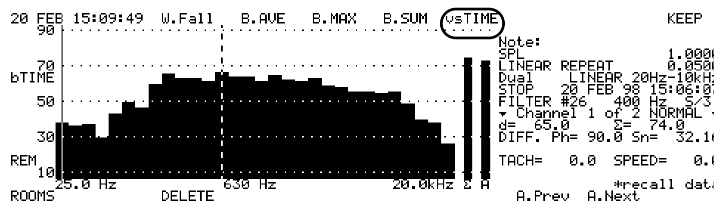
## Viewing the RT60 (Reverberation Time) Values.


1. Press **CURSOR** to activate the horizontal cursor. Then move the left or right arrow hard key to the 1.6 kHz frequency band.

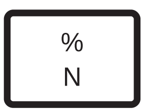


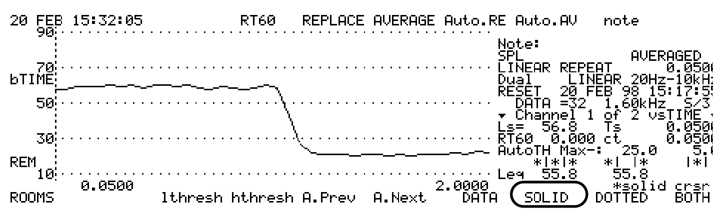

2. To display the 1.6 kHz band decay curve, press **vsTIME[E]**.



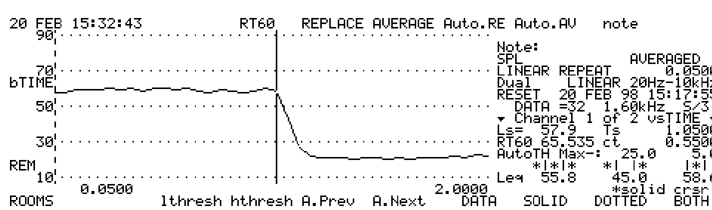

In order to view the actual values of the RT60 for the decay curve, both the solid and dotted cursors are used.




3. First, press **SOLID[N]** to activate the solid line cursor.

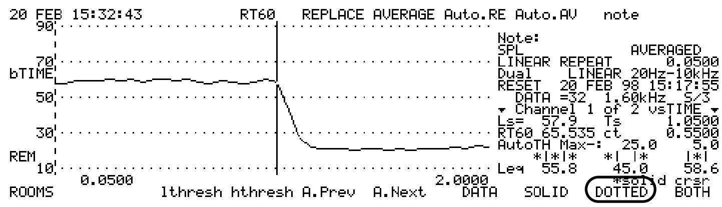



4. Next, press the right (or left) arrow hardkey until the solid cursor is somewhere along the leading edge of the linear portion of the decay curve.

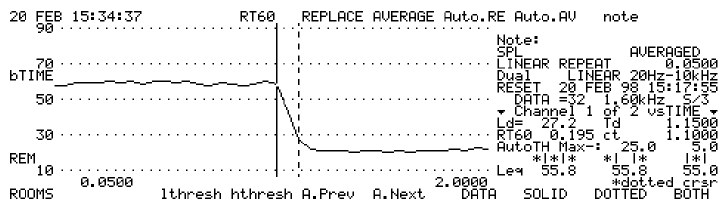


[
O

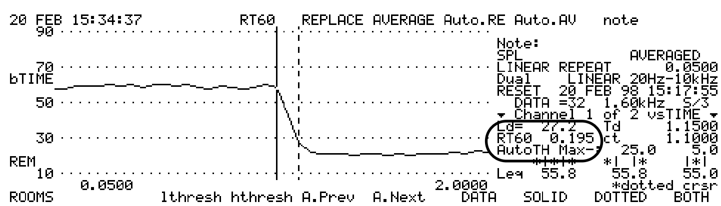
**5.** Then, press **DOTTED[O]** to activate the dotted line cursor.




**6.** Press the right (or left) arrow hardkey until the dotted cursor is somewhere along the trailing edge of the linear portion of the decay curve.



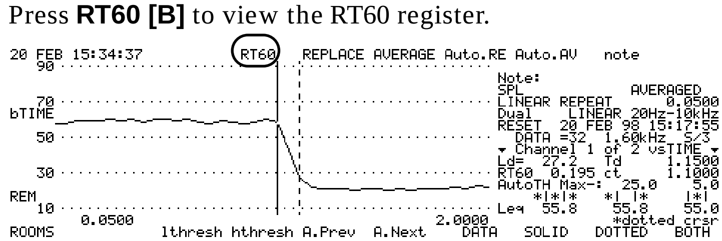

The RTA automatically computes the RT60 for values between the two cursors performing a linear regression curve fit. The RT60 value for the 1.6 Hz 1/3 octave band. is 0.195 seconds. This is the time that it would take the room to absorb 60 dB of noise at the 1.6 kHz band.




There is a storage area in the RTA for archiving RT60 data. It is called the RT60 register. The RT60 table is a convenient place to store RT60 values for each of the frequencies.

R
B

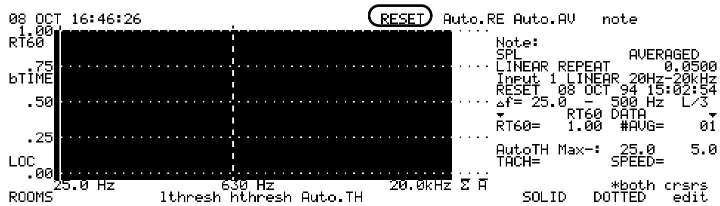
**7.** Press **RT60 [B]** to view the RT60 register.



In order to store data in the RT60 register, you must first clear out any old RT60 data that may already reside there.

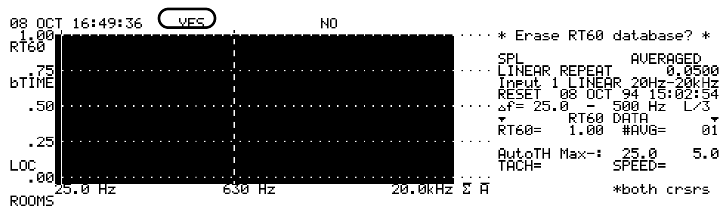
T
D

**8.** Press **RESET[D]** to clear the RT60 register.

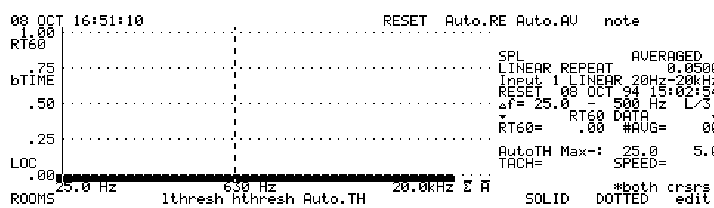



Q
A

**9.** Press **YES[A]** to verify that you wish to erase the RT60 database.




Notice that the RT60 registered is cleared and all RT60 values (for all of the frequencies) are set to zero. You are now ready to curve fit the data and fill the RT60 register.

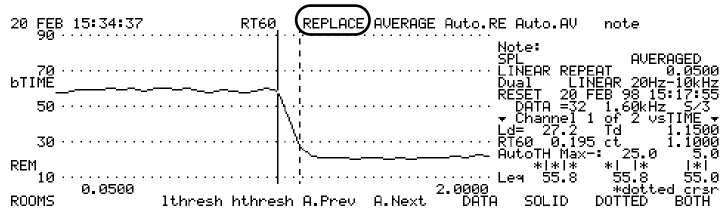



EXIT

**10.** Press **EXIT** to get back to the decay curve of the 500 Hz band frequency.

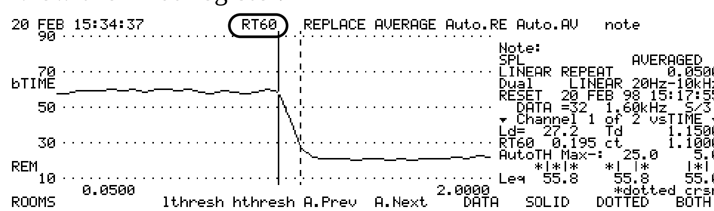
S
C

**11.** Since the solid and dotted cursors have already been placed on the beginning and end of the linear part of the decay curve, you are ready to fill the 1.6 kHz. band of the RT60 register. Press **REPLACE[C]**.

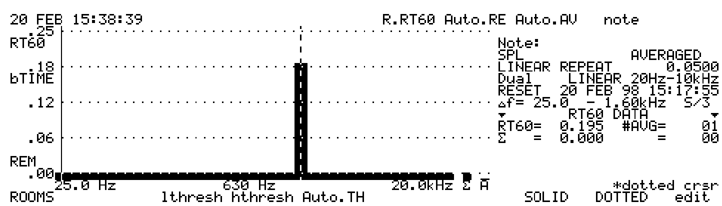



R
B

**12.** To verify that the register has been filled, press **RT60[B]** to view the RT60 register.



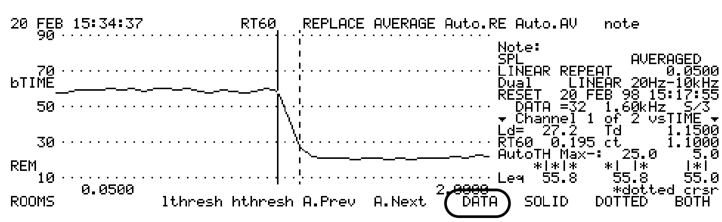

Notice the RT60 value of 0.195 seconds at the 1.6 kHz. band. All of the other frequency's RT60's are still set to 0.

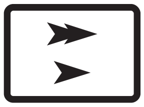



EXIT

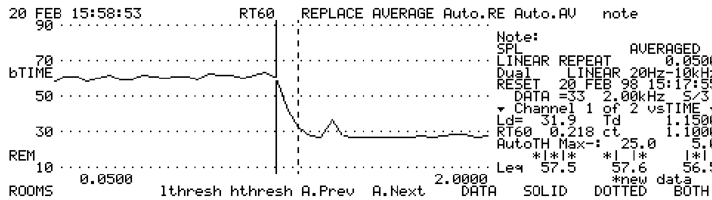
#
M

**13.** Let's continue the manual process of completing the RT60 register. Press **EXIT** to return to the decay curve display. Then, press **DATA [M]**.

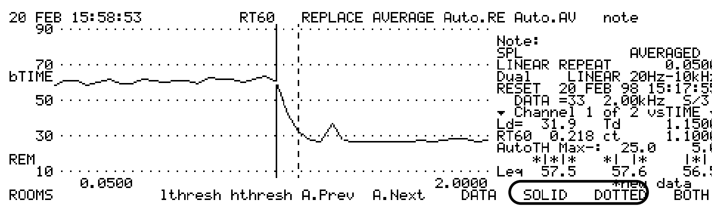


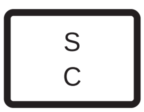


**14.** Press the right arrow hardkey or increment to the next 1/3 octave band (2 kHz.)

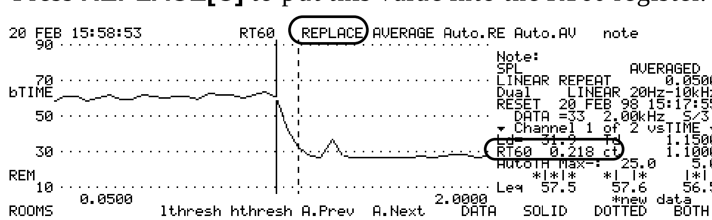


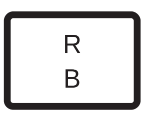

**15.** If necessary move the solid and dotted cursors such that they are both on the linear part of the decay curve. Remember to activate the cursor first by pressing either **SOLID[N]** or **DOTTED[O]**.



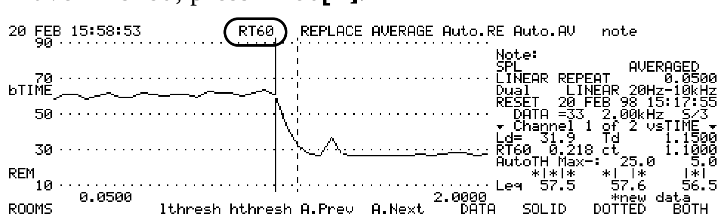




**16.** Notice that the RT60 for the 2.0 kHz. band is 0.218 seconds. Press **REPLACE[C]** to put this value into the RT60 register.

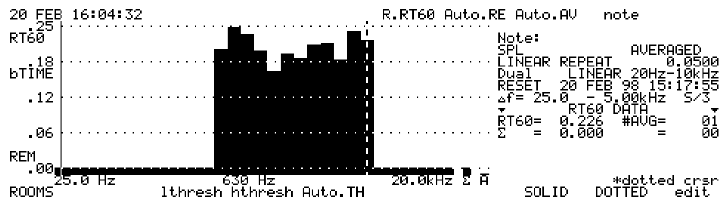



**17.** Continue this process moving the cursors to the linear areas of the decay curves and pressing REPLACE[C] for each of the frequencies until you get to the 5 kHz band. Once you have finished, press **RT60[B]**.

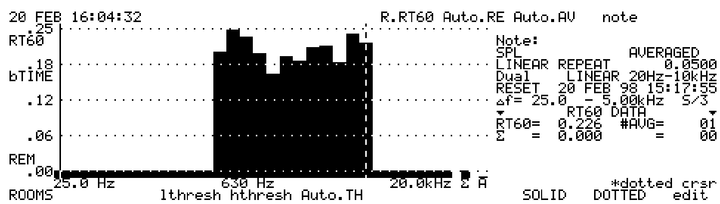


**18.** Below is the completed RT60 register. For this example you are only concerned with the frequencies from 400 Hz. to 5 kHz.




You have finished the RT60 portion of this exercise. At this point, the data could be sent to a printer which would yield a graph like that on the display. The printout would also include a table that lists the RT60 values for all of the 1/3 octave band frequencies between 400 Hz and 5 kHz.


**19.** Press **STORE** to archive the RT60 register.




## Sound Transmission Loss Measurements

Sound Transmission Loss measurements (and Sound Transmission Class or STC measurements) are commonly used to evaluate the acoustical effectiveness of walls, partitions, doors, etc. for isolating noise between adjoining rooms. This is typically accomplished by placing a speaker in one of the rooms, producing noise in that room, and making the measurement in the adjoining room. Three measurements need to be made to accomplish this type of measurement: A 1/3 octave band sound pressure measurement in the source room; a 1/3 octave band measurement in the receiving room, and an RT60 data measured in the receiving room.

Following is a procedure to determine the Transmission Loss and STC of a partition/wall between two adjoining rooms. You will use the RT60 data that was just acquired as the receiving room RT60. All that needs to be done at this point is a SPL measurement in a source room and one in a receiving room.

## Setting Up the RTA for Sound Transmission Loss Measurements

SCREEN SYSTEM | R B

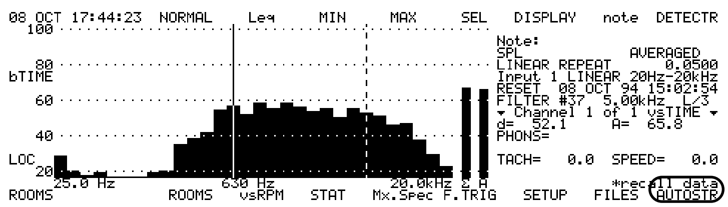
1. Press **SYSTEM**, **STANDRD [C]** to get back to the SYSTEM menu.

EXIT

2. Then **EXIT** to the Main menu.

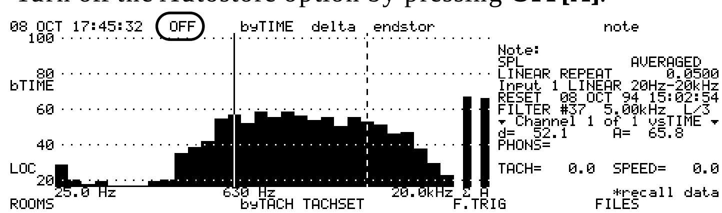
] P

3. Press **AUTOSTR[P]** to get back to the Autostore menu.

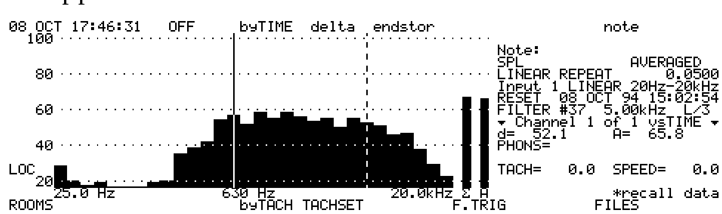



Q A

4. Turn off the Autostore option by pressing **OFF[A]**.




Notice that the bTIME label on the left side of the screen has disappeared. Autostore is now disabled.



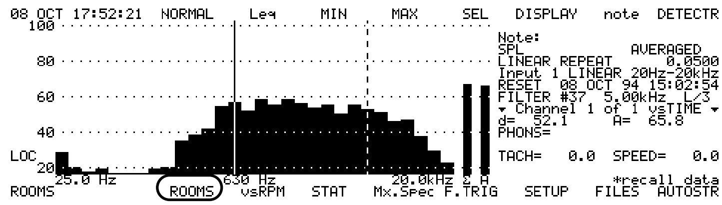

EXIT

5. Press **EXIT**

The RT60 register that was completed earlier will be used for the receiving room reverberation time and thus will be included in the Sound Transmission Loss calculation. Let's verify that it is the current or active RT60.

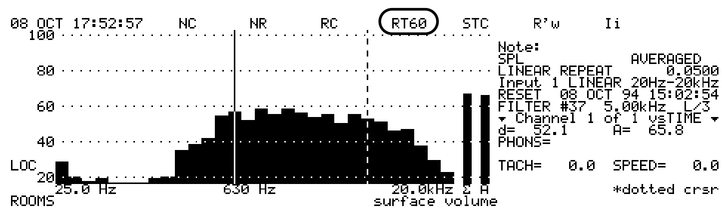
Y
I

**6.** To check this, press **ROOMS[I]**.

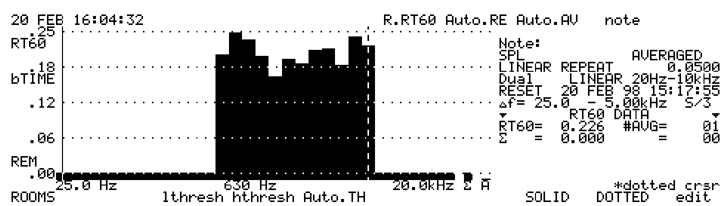



T
D

**7.** Next, press **RT60[D]**.




You should be viewing the RT60 register that you previously filled.



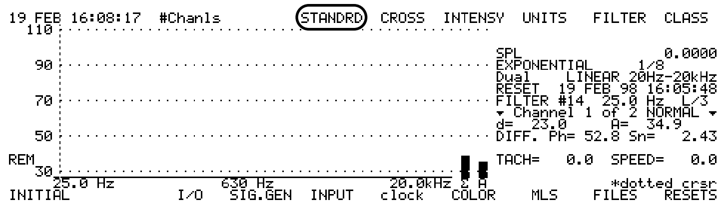

SCREEN
SYSTEM

**8.** Press the **SYSTEM** hardkey to get back to the system menu.

Next, measure the sound pressure levels (in 1/3 octave bands) of the source and receiving rooms. You can do this one of 2 ways. You can measure them one at a time (using the analyzer in the STANDRD single channel mode) or measure them simultaneously (using STANDRD dual channel mode of the 3200). For simplicity, lets measure one channel at a time.

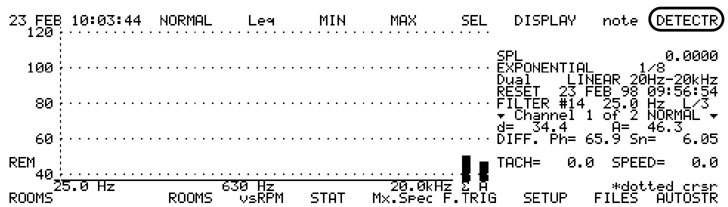
S C | Q A

**9.** Put the analyzer in single channel mode by using the **STANDRD [C]** key and #**Chanls [A]** key.



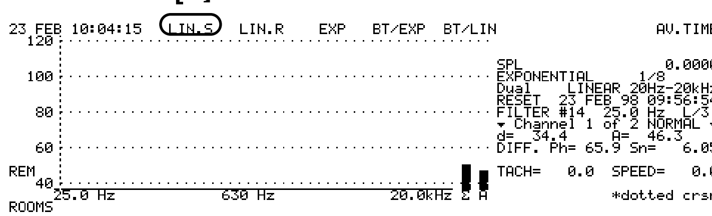

X H

**10.** Set the averaging type and time by first pressing the **EXIT** hardkey, and then select **DETECTR[H]**.



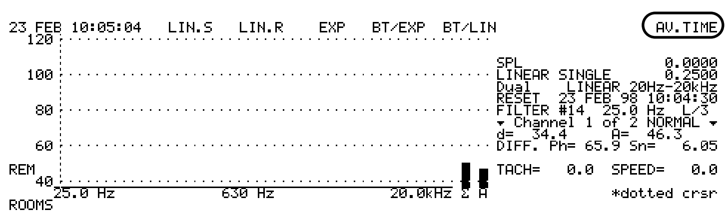

Q A

**11.** For this part of the test, you will use linear single averaging. Choose **LIN.S[A]**.




X H

**12.** Choose an averaging time (20 seconds for example), by first pressing **AV.TIME[H]**.



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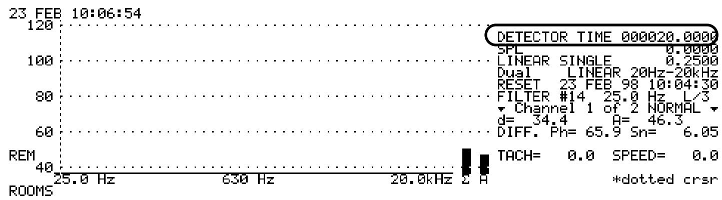
**13.** Enter 20 seconds by typing in the value shown in the following graph.




EXIT

SCREEN
SYSTEM

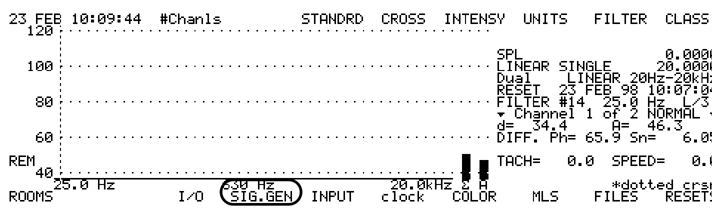
**14.** Press the **EXIT** to enter the 20 second averaging time and then press **SYSTEM** to return to the System Menu.

You are now ready to make a measurement. you'll start with the source room sound pressure measurement. Again, using the pink noise generator of the 3200 with a speaker/amplifier is the ideal way to make this measurement.

Place the speaker in a corner of the source room (facing into the room). Next, put the microphone on a tripod in the room. Turn on the pink noise generator of the RTA.

Z
J

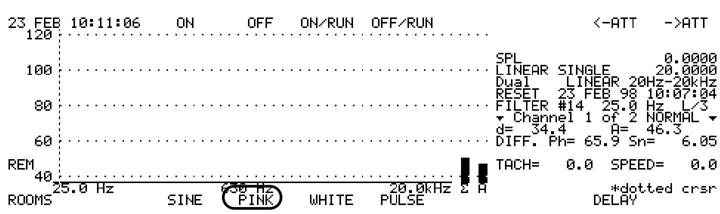
**15.** To enable the noise generator, first press **SIG.GEN [J]** or **NOISE [J]**, from the System menu.




Pink noise is better to use for this type of testing since it provides constant energy for all of the 1/3 octave frequency bands.

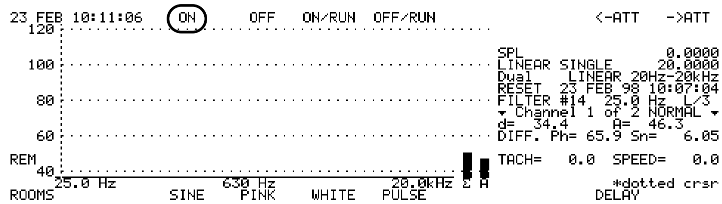
#
M

**16.** Press **PINK [J]** to select pink noise.



Q
A

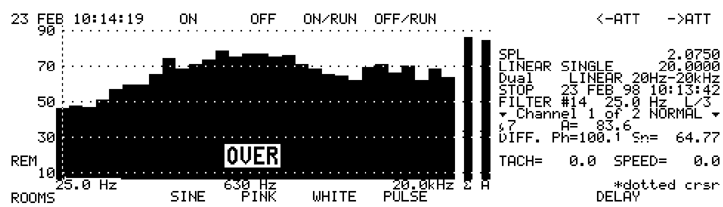
**17.** Turn the noise generator on by pressing **ON[A]**.



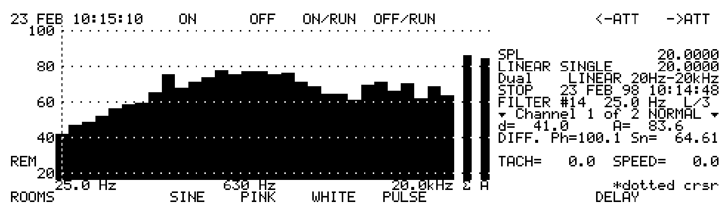

The noise generator will deliver a pink noise signal to the speaker / amplifier system.

RESET
R/S

**18.** Press **R/S**. Adjust the channel one input gain of the RTA, such that the signal is optimized without creating an overload condition. The best way to do this is to press the down arrow hard key until an overload occurs.




**19.** Then range up (by pressing the up arrow hard key) until the overload indicator disappears.




You may also need to adjust the output level of the amplifier / speaker in order to insure that all of the frequencies of interest are being excited equally. The spectrum displayed on the RTA should be fairly flat within this frequency range.

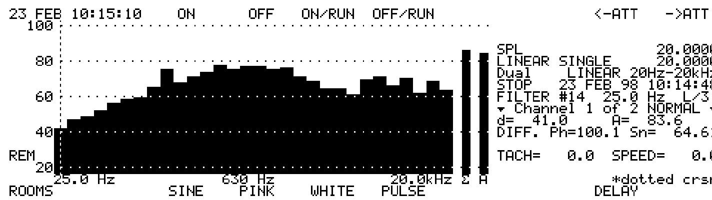
The output level of the speaker / amplifier should also be loud enough such that there is a significant difference between the background (ambient) level and the excited level (for each frequency of interest) in both rooms. Leave the noise generator on.

## Making Airborne Sound Transmission Loss Measurements

You are now ready to make a measurement in the source room. Verify that your speaker and microphone are both located in appropriate locations within the source room.

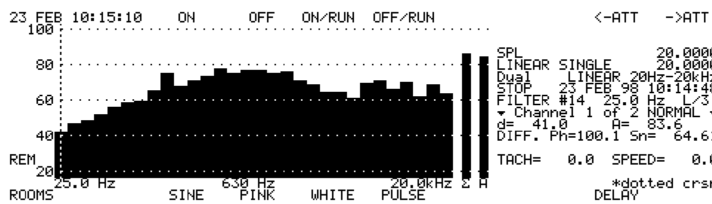
RESET
R/S

**1.** Once the desired output level and input gain have been achieved, press **R/S** to begin the 20 second measurement.




&
STORE

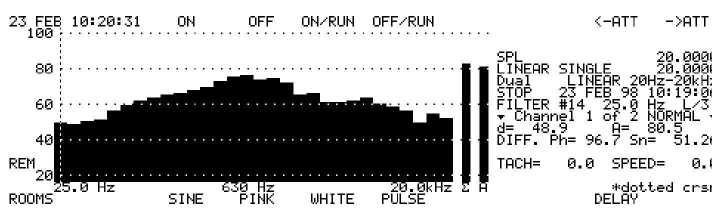
**2.** Upon completion of the measurement, press the **STORE** hardkey to save the record into the ROOMS file.




Once again, it is common practice to make a number of measurements at various locations in the source room, and then average them together. This yields a better statistical result by averaging out background noise, etc.

RESET
R/S

**3.** Move the microphone to another location. Press **R/S** to begin the second measurement.

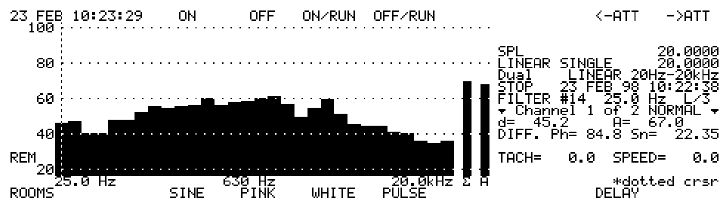



**4.** Once the measurement is complete, press **STORE** again to save the data to memory.

For this exercise, make one more measurement in the source room at a different microphone location, then store it. you now have a total of 3 measurements in the source room. Before you average them together, let’s perform the measurements in the receiving room.

RESET
R/S

5. Leave the speaker in the source room, and move the microphone to a desired location in the receiving room. Assuming the pink noise generator is still turned on, press **R/S** to begin a 1/3 band octave sound pressure measurement in the receiving room.

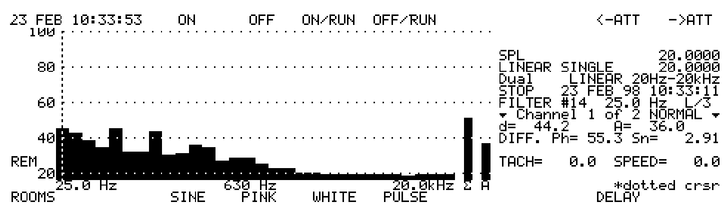



&
STORE

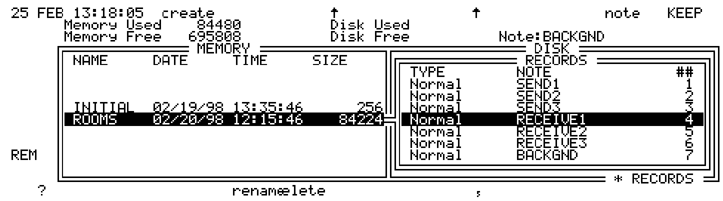
6. Press **STORE** to save this first receiving room measurement.

Perform two additional measurements (at different microphone locations) and store them to the memory of the RTA.

7. Turn the Pink Noise Generator off by pressing OFF [B]. Now it is time measure the background noise of the receive room. Press R/S to begin the background noise measurement. Store the measurement when complete (memory 7).



**8.** If you wanted to keep the memory records straight, you could go to the FILES menu in the SYSTEM menu and attach notes to the records. The first three could be labeled “sendx.” The next three could be labeled “receivedx.” Record number 7 could be labeled “backgnd.”




You should now have 3 source room measurements., 3 receiving room measurements with noise, and one background noise measurement in the receiving room. Now use the block averaging capabilities of the RTA to compute an averaged source room measurement, and an averaged receiving room measurement.

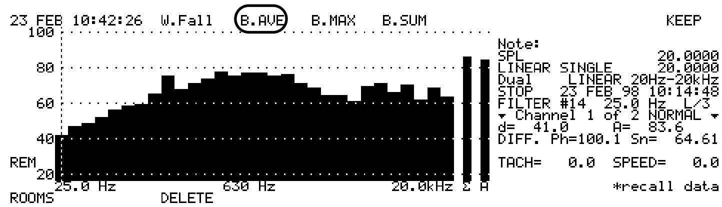
CLEAR
RECALL

**9.** To average them together, first press the **RECALL** hardkey.

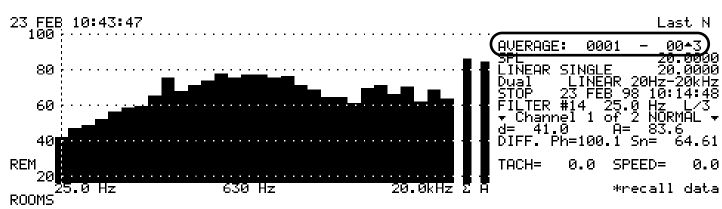
The last receiving room measurement that you acquired will be on the display. You can display the 5 other measurements by pressing the left arrow key hardkey.

R
B

**10.** Now, let’s average the source room measurements together (Normal 1 thorough 3). Press **B.AVG [B]**.

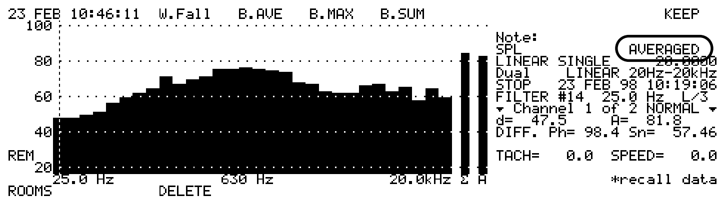



**11.** In the field on the top right side of the display, type in 0001 - 0003. This tells the 3200 that you want to average the 3 source room spectra.



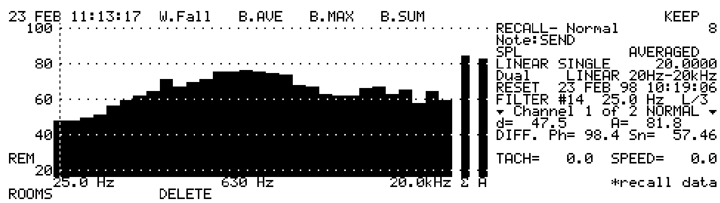
EXIT

**12.** Then press the **EXIT** hardkey to initiate the calculation. The new spectrum that appears in the display is the average of the 3 source room spectra. Notice that the word AVERAGED appears on the right side of the display next to SPL.



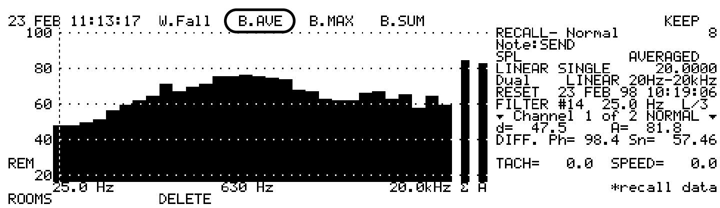

&
STORE

**13.** Press the **STORE** hardkey to save the data to memory. Note that this new averaged spectrum is stored in the ROOMS file as Normal record 8.

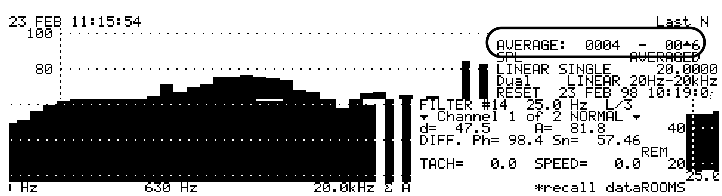



R
B

**14.** Now, let's average the 3 receiving room spectra together. Press **B.AVG[B]**.

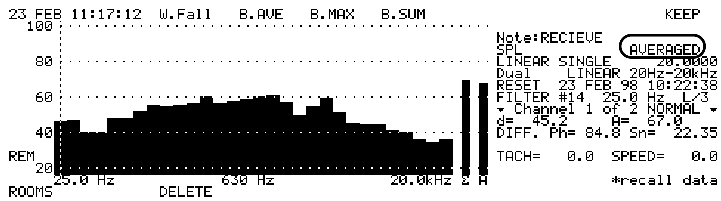



In the field on the top right side of the display, type in 0004 - 0006. This tells the 3200 that you want to average the 3 receiving room spectra.



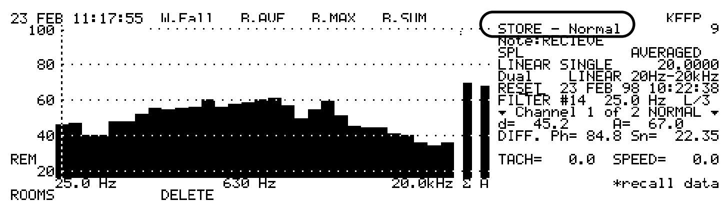
EXIT

**15.** Press **EXIT** to initiate the averaging calculation. The new spectrum that appears in the display is the average of the 3 receiving room spectra.




&
STORE

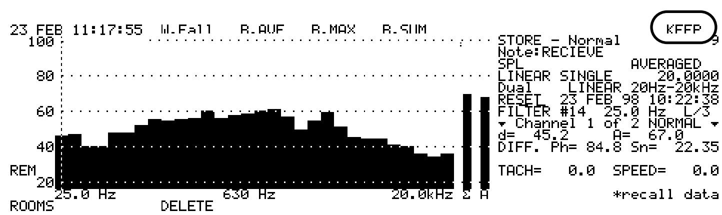
**16.** Press **STORE** to save the averaged receiving room spectra into the ROOMS file. Notice that it is stored as Normal 8.




X
H

EXIT

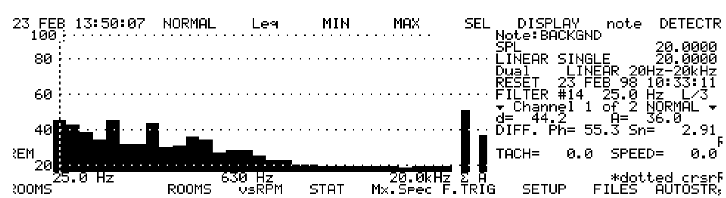
**17.** Press **KEEP[H]** to get back to the Noise menu and then press **EXIT**.

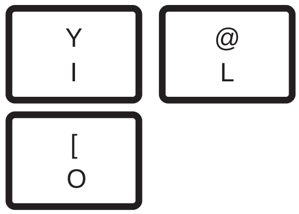



CLEAR
RECALL

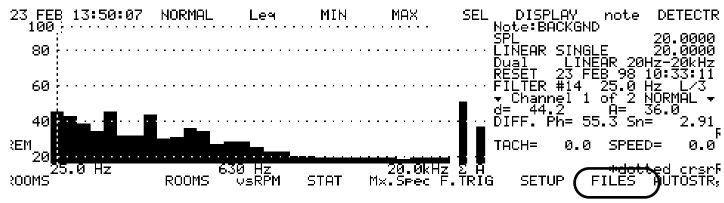
X
H

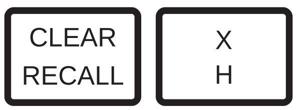
**18.** Recall the background spectrum by pushing the **RECALL** hard key and locating memory 7. Now push the **KEEP [H]** key to “keep” the spectra and return to the main menu.



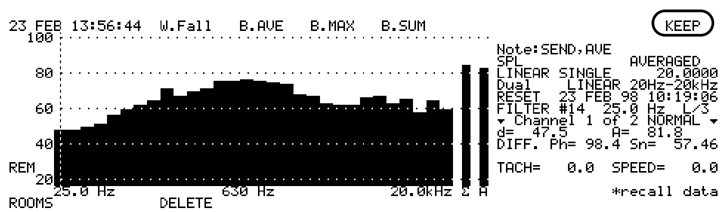


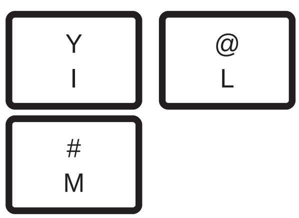

**19.** Return to the Rooms menu by pressing **ROOMS [Y]**. Enter this background spectrum by pushing the **SET-> [L]** and **BACK.GD [O]** keys. Exit to the Main menu by pressing the **EXIT** key.



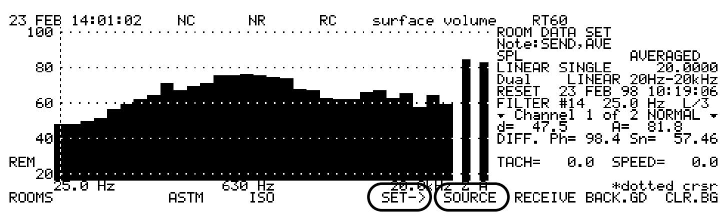



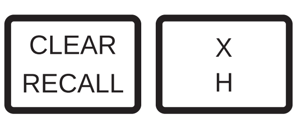

**20.** Recall the send or source room spectrum by pushing the **RECALL** hard key and locating memory 8. Now push the **KEEP [H]** key to "keep" the spectra and return to the Main menu.



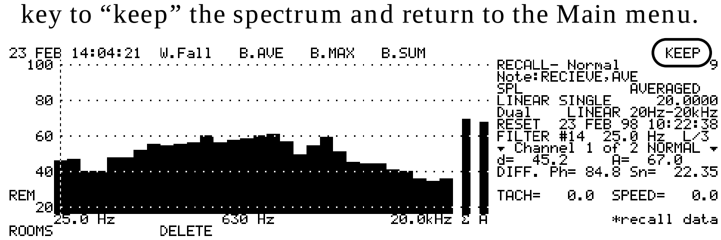



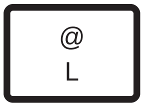

**21.** Return to the Rooms menu by pressing **ROOMS [Y]** and enter this source room spectrum by pushing **SET-> [L]** and **SOURCE [M]**. Exit back to the Main menu.

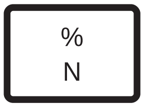


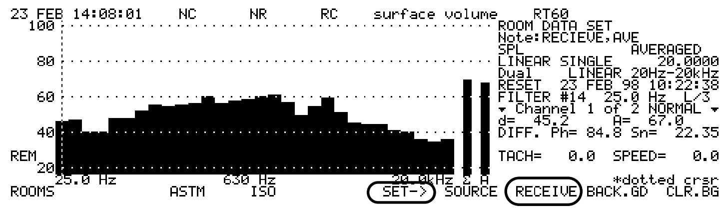

**22.** Recall the receive room spectrum by pressing the **RECALL** hard key and locating memory 9. Now push the **KEEP [H]** key to "keep" the spectrum and return to the Main menu.

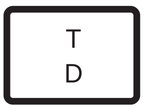




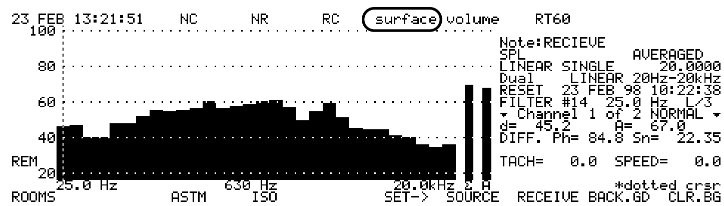



**23.** Return to the Rooms menu by pressing ROOMS [Y] and enter this receive room spectrum by pressing SET-> [L] and RECEIVE [N].



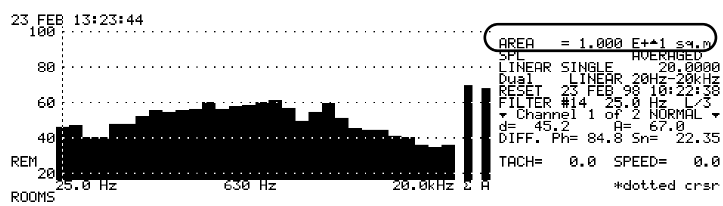




**24.** As part of the Transmission Loss (and STC) calculation, the surface area of the partition in square meters and volume of the receiving room in cubic meters need to be factored in as part of the calculation. Press **surface[D]** to access the surface area entry field.



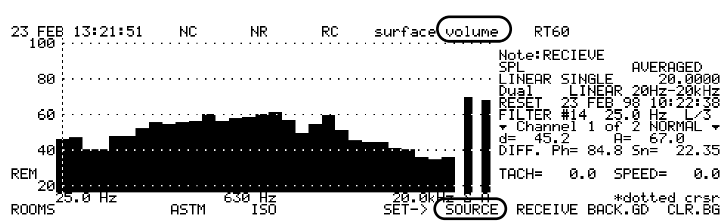


**25.** Enter the surface area of the partition room (10 square meters). Then press the **EXIT** to enter this value.



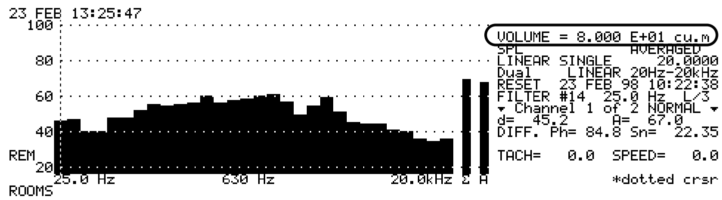


**26.** Next, press **volume [E]** to access the room volume entry field.



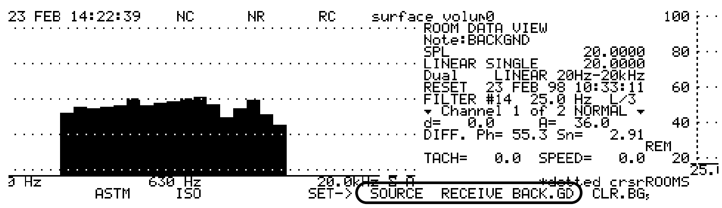
EXIT

**27.** Type in the volume of the receiving room (in cubic meters). Press **EXIT** to enter the volume.




\#
M

**28.** Now that they are defined, the data blocks can be displayed by pressing **SOURCE [M]**, **RECEIVE [N]**, or **BACK.GD [O]**. Only the data in the frequency range 100 Hz-4 kHz are saved in these files since the analysis is limited to that frequency range.




Y
I

**29.** Select the standards organization whose standards you wish to follow for the determination of the airborne sound transmission parameters by pressing either **ASTM [I]** or **ISO [J]**. For this exercise use the American Standard **ASTM [I]**.

Q
A

**30.** Now you have a choice of looking at Noise Reduction **NR [A]**, Normalized Noise Reduction **NNR [B]**, Transmission Loss **TL [C]**, and Field Transmission Loss **FTL [D]**.

Now, assuming the RT60 table is full of RT60 values taken in the receiving room, all the pieces are in place.

## Impact Sound Isolation

Impact sound isolation is a measure of sound generated in a room resulting from repeated impacts (is. Footsteps) on the floor of the room above. In practice, a standardized tapping machine is utilized as a source of impacts on the floor above and the resulting sound pressure level produced in the room below is measured in 1/3 octave frequency bands.

Resultant measurement choices are found at the bottom of the screen in either the ASTM or ISO menus. These include Ln (ASTM) and L'n and L'nT (ISO).

# Noise Ratings

## Noise Criterion (NC [A])

A single number technique for representing the character of steady indoor background noise is based on the 1957 Noise Criteria Curves. These are a set of similar octave band reference curves which are overlaid graphically upon an octave frequency spectrum measured in the room to represent the background noise. Each of the curves is designated by a number, called the Noise Criterion, which represents the value of sound pressure level corresponding to the 1 kHz band. Since the curves are stored in the 2900B, this function can be performed automatically using a displayed 1/1 octave spectrum which has either just been measured, or has been recalled from memory.

SCREEN SYSTEM | W G | Q A

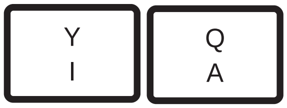
1. To enter the 1 octave mode, press **SYSTEM**, press **FILTER [G]** and then press **1⁄1 OCT [A]**.

EXIT

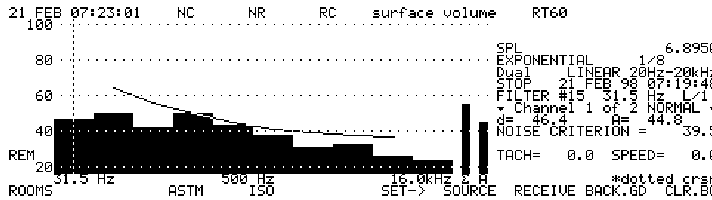
2. Press **Exit** twice to get back to the main menu.

RESET R/S

3. Press **R/S** to begin the measurement. To stop the measurement press **R⁄S** again.



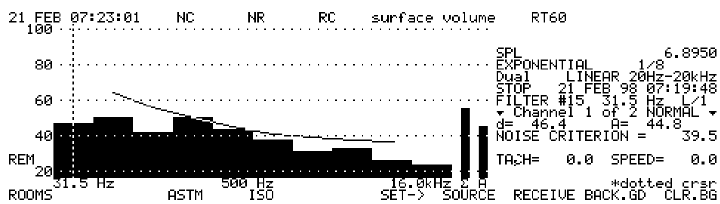

**4.** While in the Main menu, press **ROOMS [I]** and then **NC [A]** to look at the NC curve.




**5.** Press **EXIT** to return to the Main menu.

## Noise Rating Curves (NR [B])

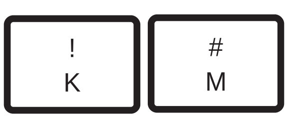
The Noise Rating (NR) curves are used in the same manner as the Noise Criteria curves, but are used to measure noise in conformance with international standards. NR is obtained the same way as Noise Criterion and is found in the Rooms menu.




## Room Criterion (RC [C])

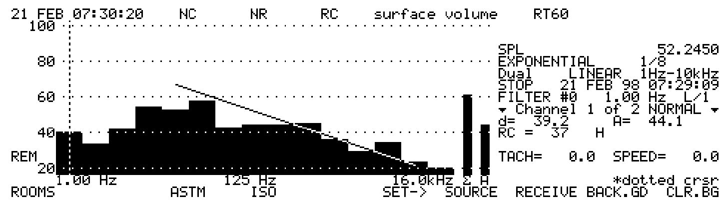
The Room Criterion procedure is can be found in ANSI S12.2-1995. In addition to producing a single number rating of the steady background noise, the quality of the spectra is described in terms of one or more of the following: Neutral Spectrum (N), Rumbly spectrum (R), Hissy Spectrum (H), tonal Spectrum (T), and Acoustically Induced perceptible vibration (Va and / or Vb).

As with the NC and NR rating procedures, the steady background noise spectrum is displayed in the 1/1 octave bandwidths format. The main difference is the low frequency needs to be set with a low limit frequency of 1 Hz. This is done by pressing **INPUT [K]** in the System menu and setting the frequency limits to **1-10K [M]**. If this low limit isn't set, the instrument will give you an error message.



S
C

To access RC, simply press **RC [C]** in the Rooms menu.



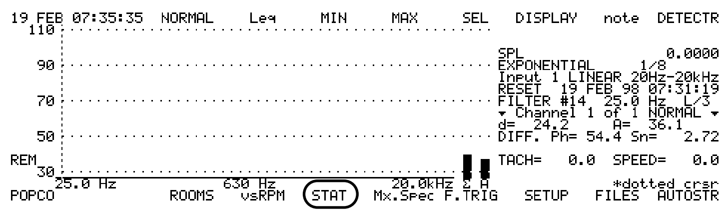
CHAPTER

# 9 Statistics and Ln Calculations

Statistical analysis can be performed with the analyzer in either the 1/1 or 1/3 octave frequency bandwidths.

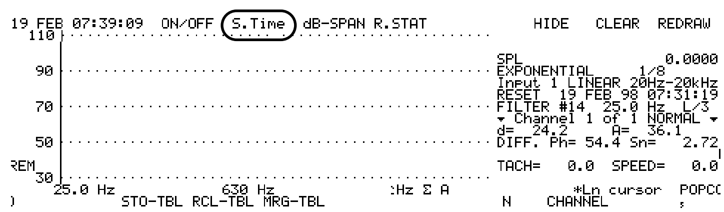
! K

1. Press the **STAT [K]** key from the Main menu to access the statistics menu.



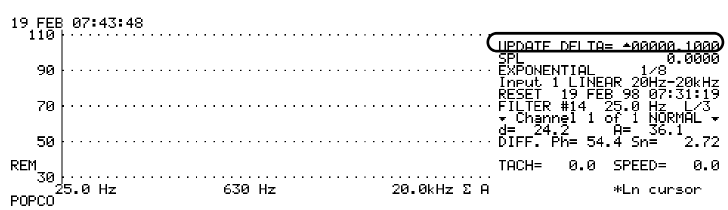

R B

2. Press the **S.Time [B]** key to enter the desired time interval that the data will be taken from the measurement buffer to the Statistics Table.



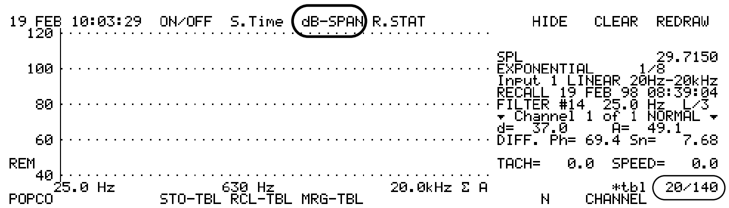

EXIT

3. Enter the desired interval time in seconds via the numeric keypad. Press the **EXIT** hardkey.



S
C

**4.** Press the **dB-SPAN [C]** key to set the measurement range. The present range is indicated on the lower right side of the display. (Note that statistics must be off.)

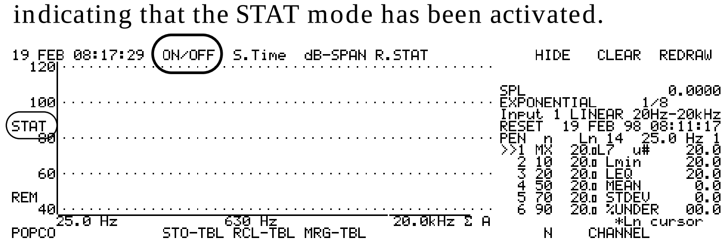



CURSOR

**5.** Press the horizontal keys to move the 120dB range to encompass the desired range of input values for the measurement to be made. After you have made the range selection press the **CURSOR** hardkey to re-assign the control of the cursor to the horizontal keys.

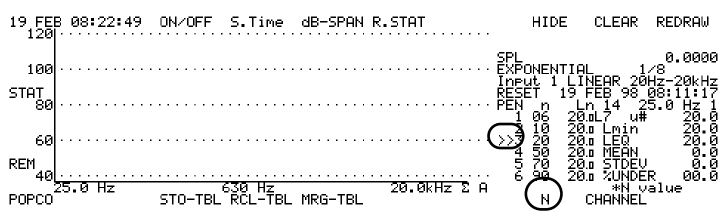
Q
A

**6.** Press the **ON/OFF [A]** key to turn on the Statistics mode. (Repeated presses will toggle between on and off.). The "STAT" indicator will appear on the left side of the display indicating that the STAT mode has been activated.




%
N

**7.** Press the **N [N]** key to select the desired Ln to be calculated.




**A.** Select the trace number (1-6), via the numeric keypad, whose parameter value is to be changed. a ">>" will appear next to the selected trace number.

**B.** Press the horizontal keys until the desired Ln value appears. The analyzer is capable of calculating Ln values between 1 and 99.

CURSOR

**C.** Press the **Cursor** hardkey to re-assign Ln control of the cursor to the right and left arrow keys.

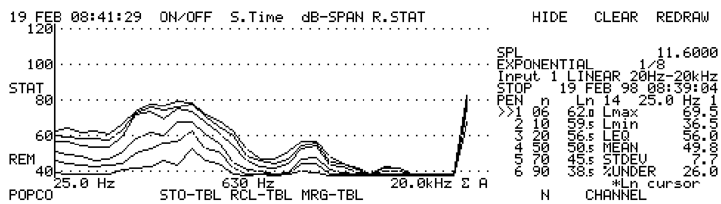
RESET
R/S

**8.** Press the **R/S** hardkey to begin the analysis. The state of the analyzer will change to RUN, which is indicated just above "PEN" on the right side of the screen.

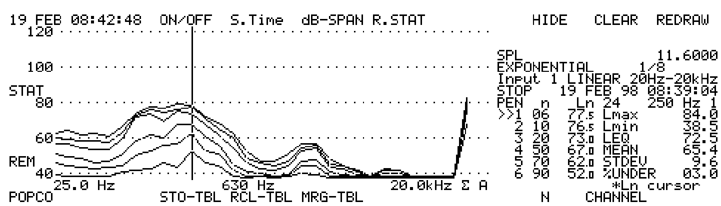
You will not see any update of the display until either the analysis is stopped by pressing the **R/S** hardkey or by pressing the **REDRAW [H]** key.

RESET
R/S

**9.** Press the **R/S** hardkey to stop the analysis. The display will update with the Ln values and curves.




**10.** Press the horizontal keys to move the cursor to the desired frequency of interest. Note that as you move the cursor through the different frequencies the Ln values change.



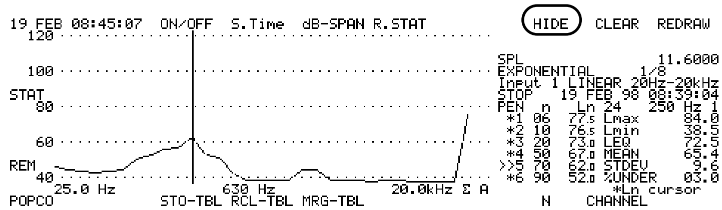

These values are correlated to the amplitude of the trace drawn on the display.

## Hiding a trace

1. Select the desired trace to hide by pressing the trace number via the numeric keypad.

V
F

2. Press the **HIDE [F]** key. An “*” asterisk will appear next to the trace number indicating that the trace has been hidden.



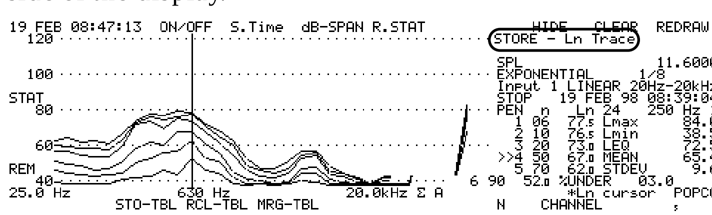

To un-hide a trace, select the trace with the “*” asterisk next to it and press the **HIDE [F]** key. The “*” will disappear and the hidden trace will re-appear.

## Storing the Ln Trace

Prior to storing an Ln trace it is recommended that a descriptive note be attached to the trace for future reference. (See “Annotation of a Measurement” in Chapter 1.

&
STORE

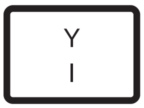
1. Press the **STORE** hardkey to store the data associated with the statistics parameter table presently displayed. The message “STORE - Ln Trace N” will appear on the upper right side of the display.



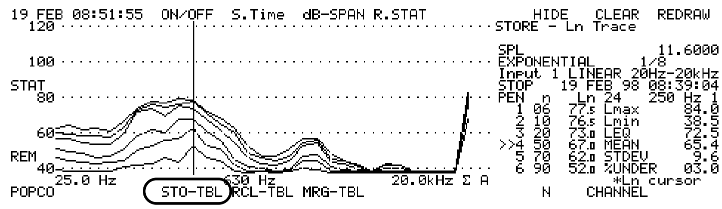

This step will only store enough information to recreate the Ln traces and the Ln values that were active upon storing the information.

## Storing the Statistics Table

Prior to storing the Statistics table it is recommended that a descriptive note be attached to the table for future reference. (See "Annotation of a Measurement" in Chapter 1.




1. Press the **STO-TBL [I]** key to store the complete Statistics Table to memory. Note that the storage of the Stats table requires a large amount of memory, in excess of 22k bytes.

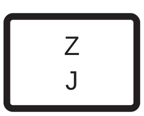



This step will store the entire Ln Table which will re-create the traces and the Ln table to enable you to select different Ln values (1-99) and view the associated dB values.

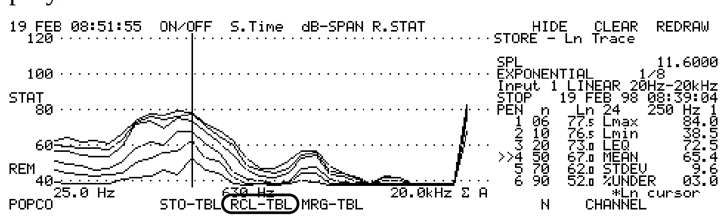
## Recalling Ln traces

While in the STATS mode press the **RECALL** hardkey. The message "RECALL - Ln Trace N" will appear. If there is more than one record you may use the horizontal keys to scroll through the stored Ln trace records. The stored traces will appear on the display.

## Recalling a Statistics Table

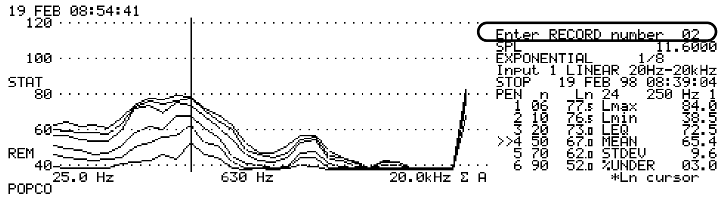



1. Press the **RCL-TBL [J]** to recall a statistics table to the display.

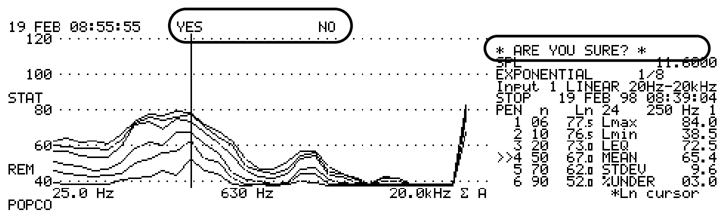


EXIT

**2.** Enter the record number, via key numeric keypad, to be recalled. Press the **EXIT** hardkey.



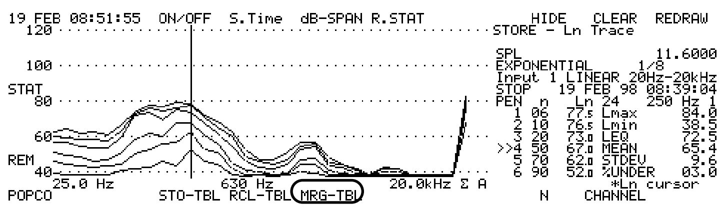

**3.** Press the **Yes [A]** to recall the table, or **No [C]** to return to the Statistics menu.



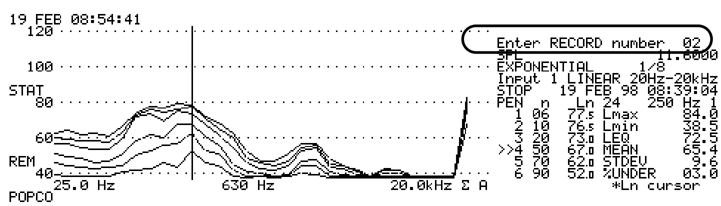

## Merging Statistics Tables

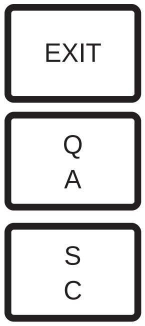
! K

**1.** Press the **MRG-TBL [K]** to merge a stored Stats table into with the active stats table.

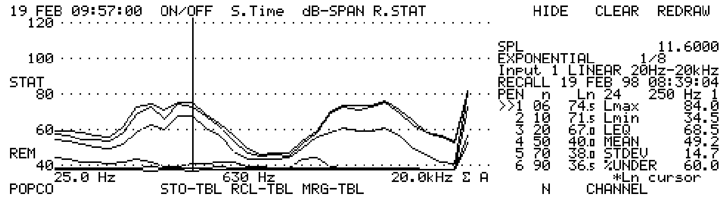



**2.** Enter the record number, via the numeric keypad, to be merged.



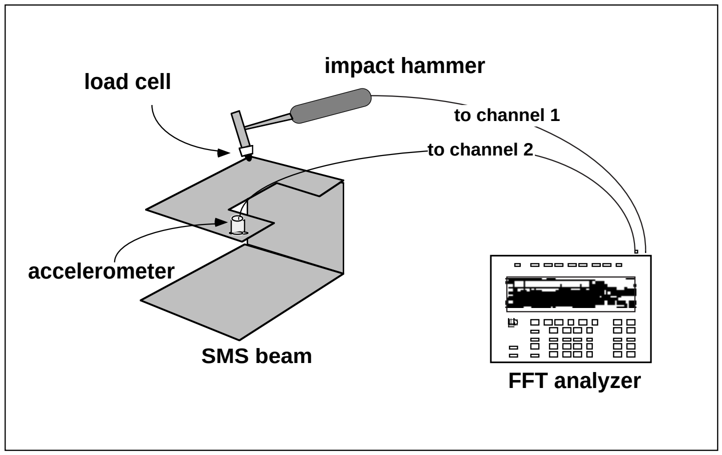



**3.** Press the **EXIT** hardkey. The message “*ARE YOU SURE*” will appear on the display. To proceed press **YES [A]**. To abort the recall and maintain the present Stats table intact, press **NO[C]**. Upon pressing “Yes” the new “merged” traces and statistic table appear on the display.



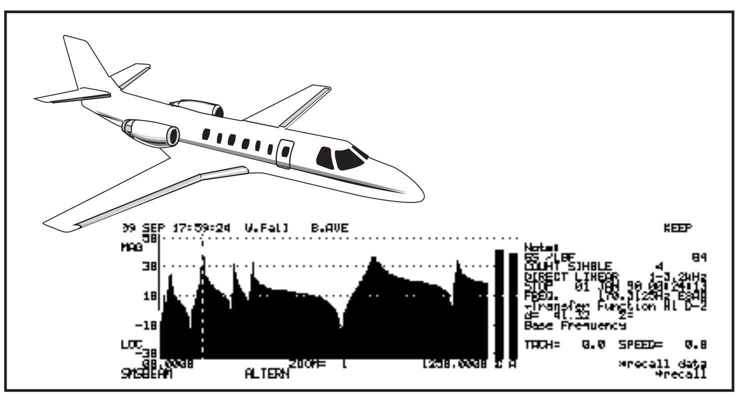
CHAPTER

# 10 Modal Analysis




## What is Modal Analysis?

The process of characterizing the dynamic properties of an elastic structure in terms of its modes of vibration (frequency, damping, & mode shapes).

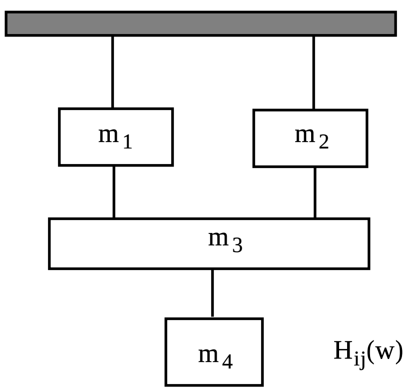


## Dynamic Analysis

- Analytical Modal Analysis
  - Mathematical determination of dynamic properties of a structure using the Finite Element method.
- Experimental Modal Analysis
  - Experimental determination of the dynamic properties.

## Modal Models

The frequency, damping, and mode shape are the properties of a mode of vibration and the basis of the “modal model”.




$$[m]\{\ddot{x}\} + [c]\{\dot{x}\} + [k]\{x\} = \{f(t)\}$$

$$\downarrow$$

$$[Ms^2 + Cs + K]\{X\} = \{F\}$$

$$\downarrow$$

$$\{X\} = [Ms^2 + Cs + K]^{-1}\{F\} \text{ or } \{X\} = [H]\{F\}$$

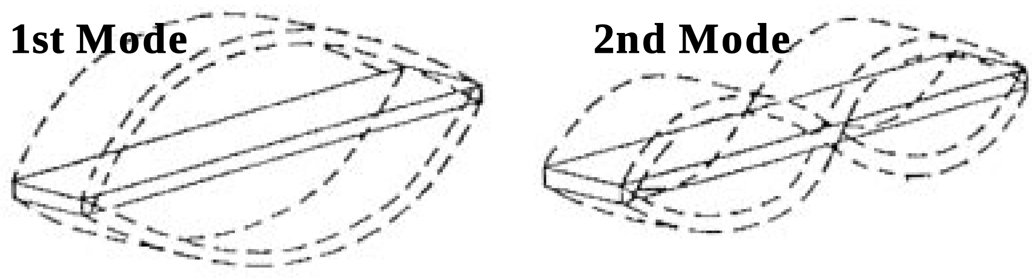
$$\downarrow$$

$$H_{ij}(w) = \sum_{k=1}^{\text{Modes}} ((r_{ij},k / 2j(jw-p_k) - (r^*_{ij},k / 2j(jw-p^*_k))$$

## What is a mode?

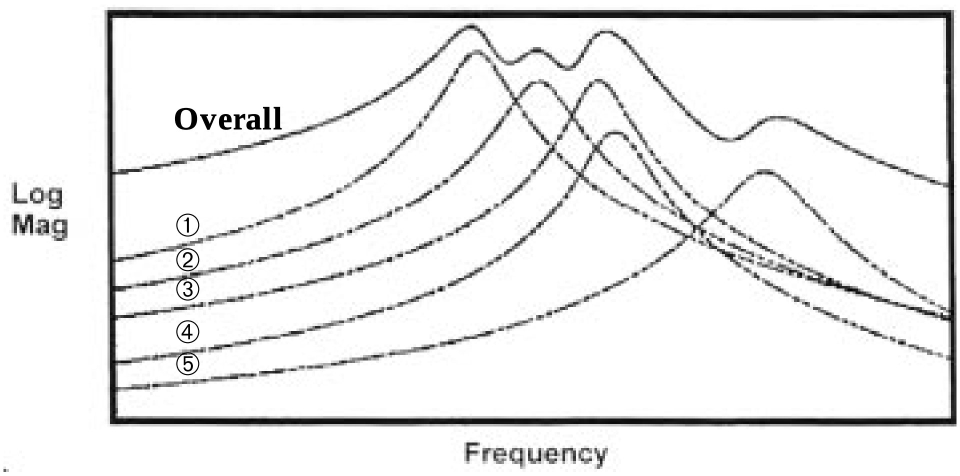
Vibration is caused when energy becomes trapped within the boundaries of the structure, moves freely within the boundaries, and cannot readily escape.

- The mode shapes are standing wave deformations of the structure at certain natural frequencies, caused by trapped energy.



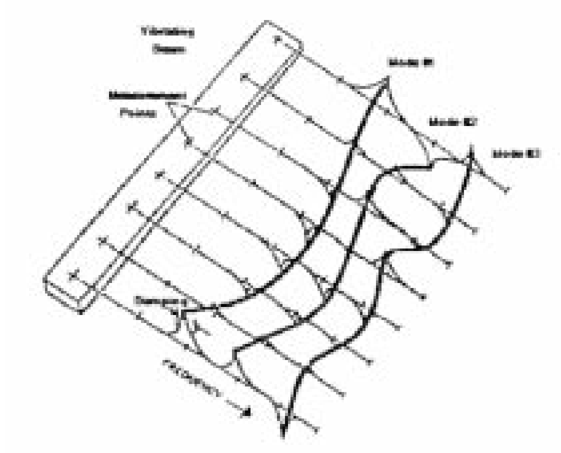

## The Frequency Response Function (FRF)

A structure's overall vibration can be described as a summation of the vibration at each of its modes.




### Modal Parameters from FRF's

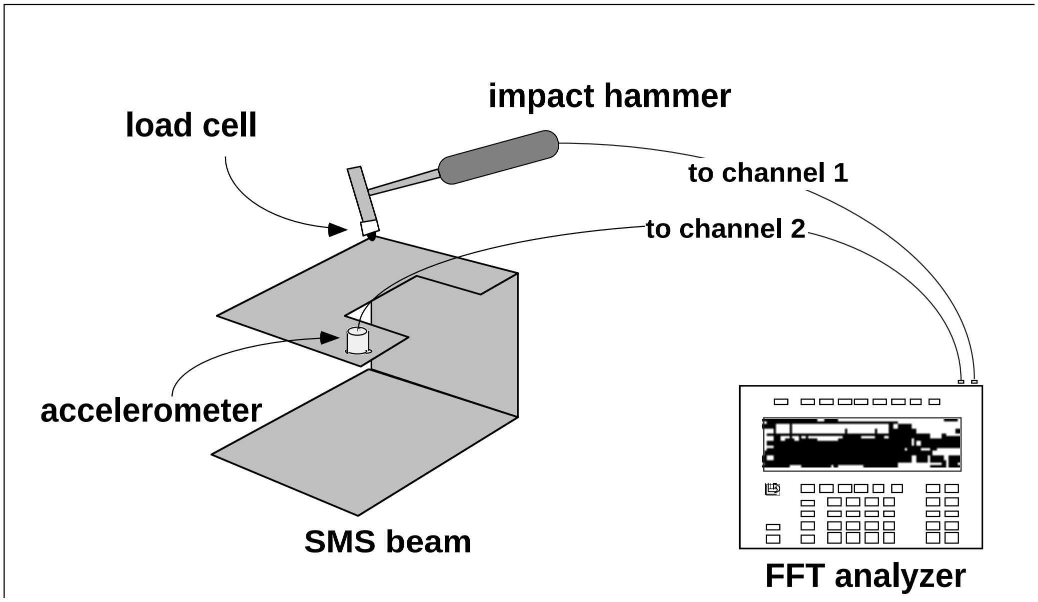
- Damping and frequency are the same at each measurement point.
- The mode shape is obtained at a single frequency from all of the measurement points.



## Why Use Modal Analysis?

- Verify analytical models
  - Verify the accuracy of FEA models by providing an independent check of the modeling accuracy.
  - Experimental modal analysis can be used to provide damping values for the FEA model.
  - If experimental model and mathematical models are closely matched, the FEA model can be used for further analysis and simulation.
- Troubleshoot noise and vibration problems.
- To evaluate fixes.

# Making Modal Measurements




## Excitation Techniques

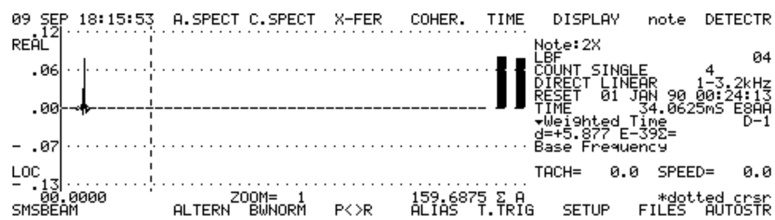
- Impact Hammer
- Shaker
- Servo
- Self Induced Vibration

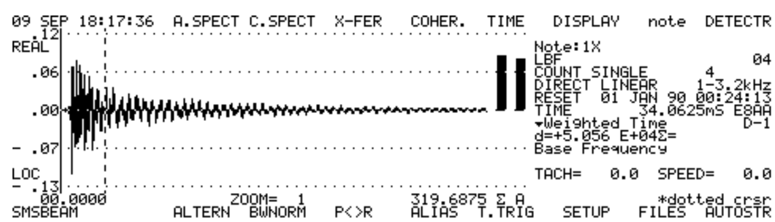
## Impact Hammer

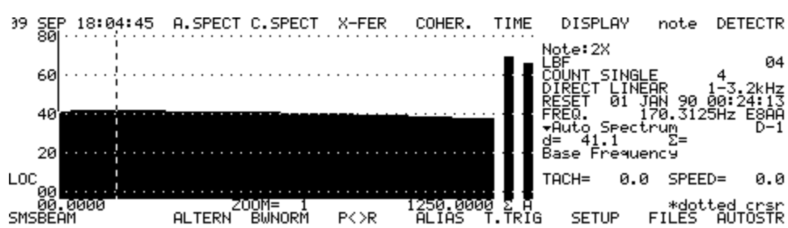
- Advantages
  - Easy set up
  - Easy to make measurements
  - Inexpensive
  - “Field portable”

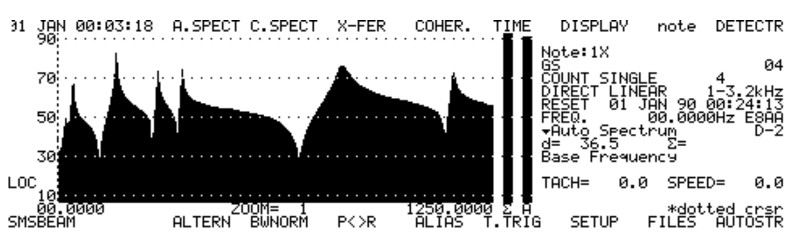
- Disadvantages
  - Large amplitude on the impulse can cause non-linear behavior.
  - Difficult to excite large structures (especially at distances far from the impact point).

## Time Domain and Frequency Domain Signals



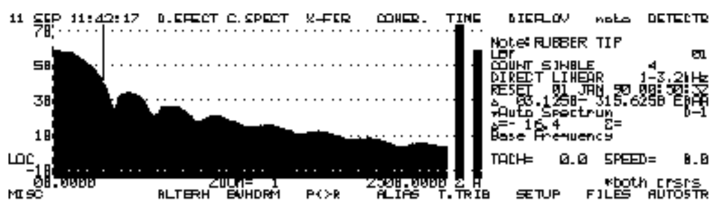



## Impact Hammers - Frequency Range

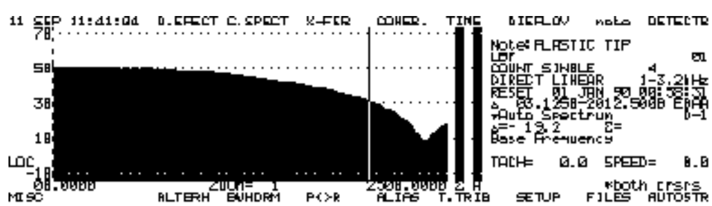
- The usable frequency range is determined by the tip and the mass of the hammer.
- Soft tips (such as rubber) provide a long impulse and yields a lower frequency range, centered at low frequencies.
- Hard tips (such as steel or hard plastic) provide a short impulse and a short frequency range, at higher frequencies.
- Heavier hammers will lower the frequency but increases the amplitude of the force spectrum.
- The useful frequencyrange of an impact hammer is from DC to where the spectrum rolls off (10 to 20 dB).

## Impact Hammer Tips

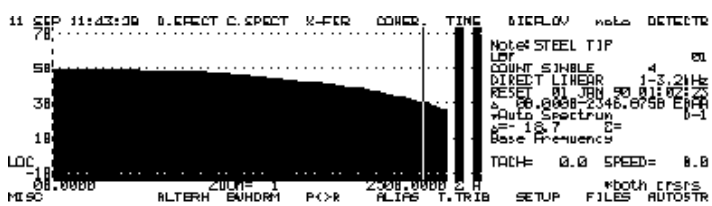
**Soft rubber tip**



**Plastic tip**

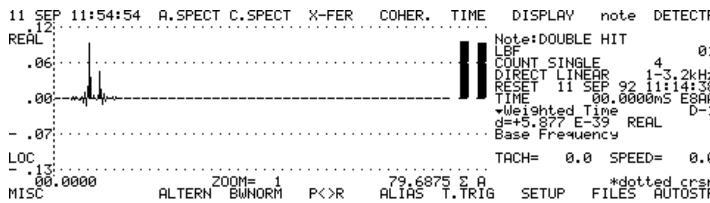


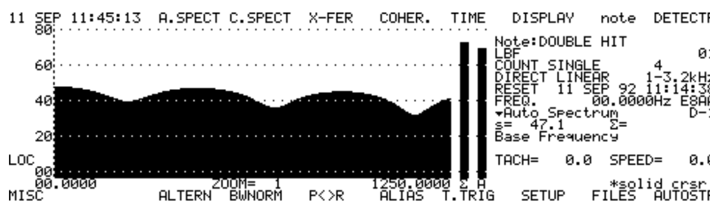
**Steel tip**



## Impact Hammers-Double Hits

- Double hits occur when the hammer strikes the test item twice.
- Double hits render the measurement useless.
- Double hits are difficult to avoid at measurement points on the test item that exhibit a lot of motion at resonance.
- Impact testing is easy but does require practice and technique. Pulling the hammer back, or letting it recoil naturally after impact helps.




## Impact Hammers - Off Axis Hits

- Off axis his will result in reduced energy in the intended direction. This causes errors in the measurement.
- This may excite modes (resonances) that would not normally be excited.
- The actual force that the test item experiences is less than the measured force that the load cell see. The amplitude of the frequency response function will be too high.

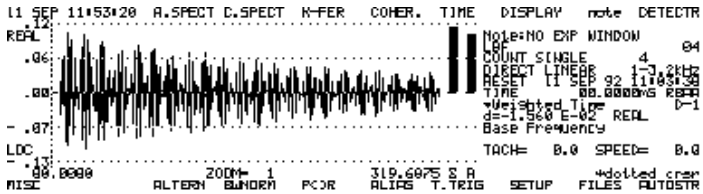
## Impact Hammers - Averaging

- Averaging a number of measurements together will improve the quality of the measurement.
- 4 to 20 averages should be sufficient.
- If the measurement does not improve by increasing the number of averages, something is wrong.

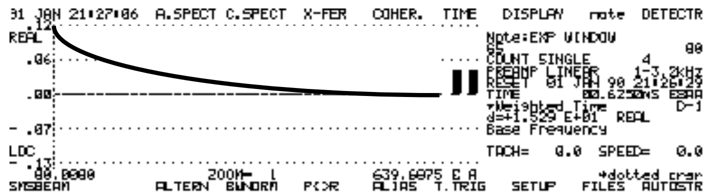
## Exponential Windowing

- Exponential windowing prevents spectral leakage.
- Leakage causes measurement errors, particularly in lightly damped structures.
- The response signal is multiplied times the decaying exponential curve (window) to insure that there is no amplitude at the end of the measurement.
- The exponential window is a time domain window.
- You do not always need to use an exponential window.
- Exponential windows introduce artificial damping to the FRF's. If you are concerned with damping values, you'll need to correct for this.

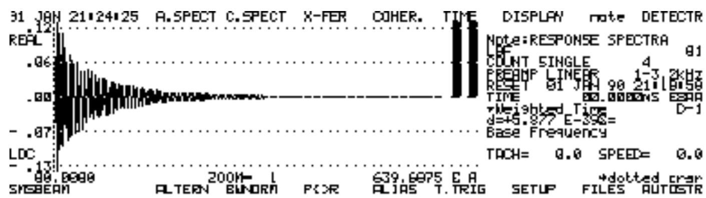
**No Exponential Window**



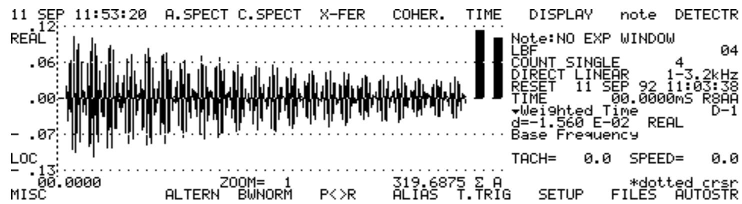

**Exponential Window**

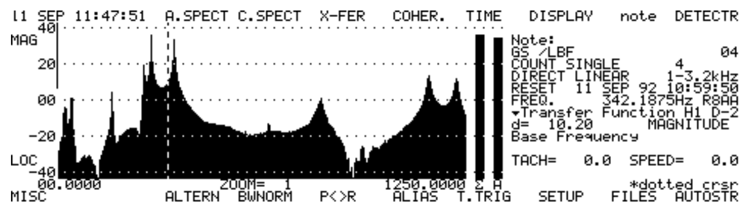



**Exponential Window applied**



## Leakage (Why We Use Windows)

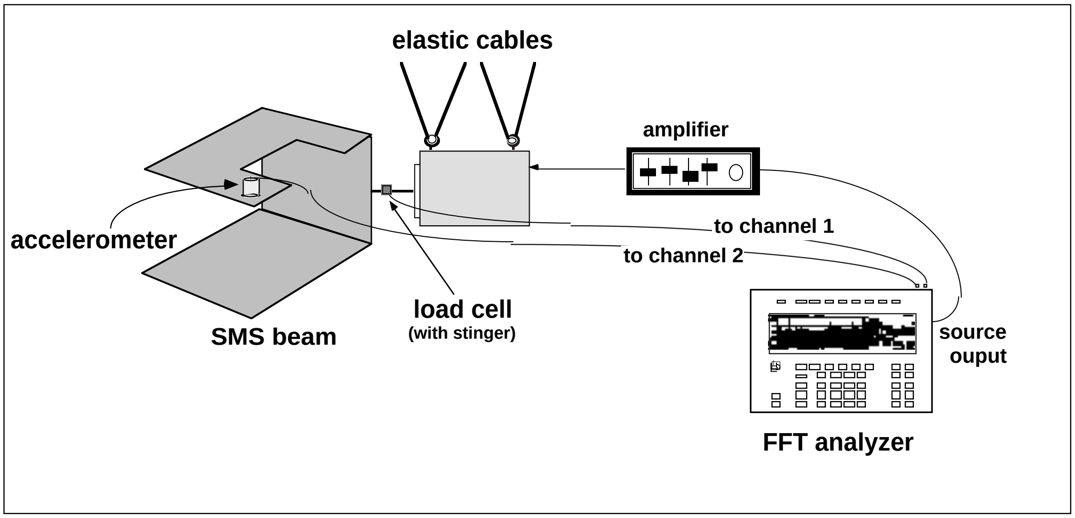



## Shaker Excitation

- Advantages
  - Shakers normally provide more accurate results.
  - Actual test time is significantly reduced.
  - Shakers provide more energy to larger structures.
  - Shakers can be driven by a variety of signals (sine, swept sine, random, etc.), which provides flexibility.
- Disadvantages
  - Requires more equipment and setup time.
  - Shakers not generally transportable; not convenient for field measurements.
  - Shaker systems tend to be expensive.

## Shaker Test Schematic




## Shaker Excitation Functions

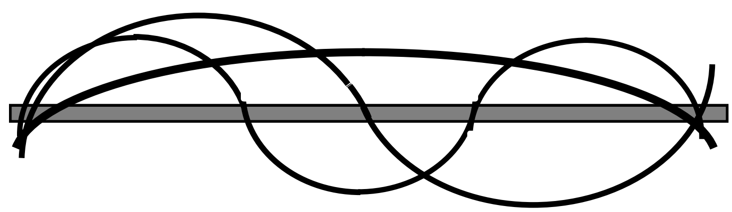
- Swept sine
  - Highest accuracy; excellent signal to noise ratio; often used when testing very non-linear structures; test times are very long.
- Random Noise
  - Good general purpose excitation; best linearized approximation for non-linear system; test times are very short; not good for testing systems with backlash (such as a gear drive).
- Chirp
  - Similar to swept sine but faster; good signal to noise ratio; good for testing “noisy” systems.

## Attaching Accelerometers

- Metal Stud
  - Very secure; usable frequency range: DC to 20 KHz.
- Cement / Wax
  - Easy to attach & remove. Usable frequency range: DC to 15–20 KHz.
- Magnet
  - Easiest to attach & remove; usable frequency range: D.C. to 5 Khz.

## Test Setup - Establishing a Measurement Grid

- How many measurements?



- Need to take enough measurements to be able to resolve the highest order mode of interest.
- Too many measurements is a waste of time; too few measurements yields little information about the dynamics of the structure.

# Test Setup - Determining the Reference Point

- When using a shaker, the location of the load cell is the “reference point” (fixed excitation).
- When using an impact hammer, you can do one of two things:

- impact at a single point and move the accelerometer (fixed excitation).
- fix the accelerometer at one point and move the hammer (fixed response).

• Fixed response is preferred.

• Once you select a method (fixed response or fixed excitation), you must adhere to it.

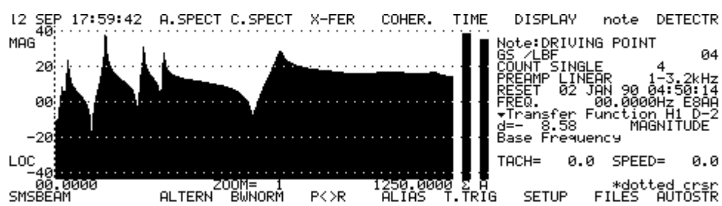
• The reference point is determined by performing a “driving point” survey.

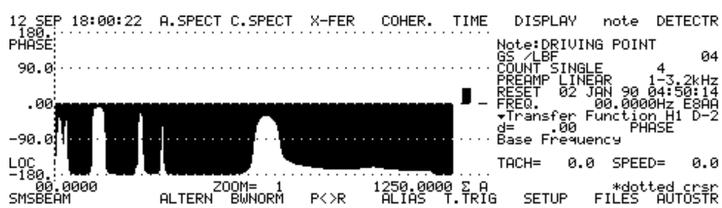
## Test Setup - The Driving Point Survey

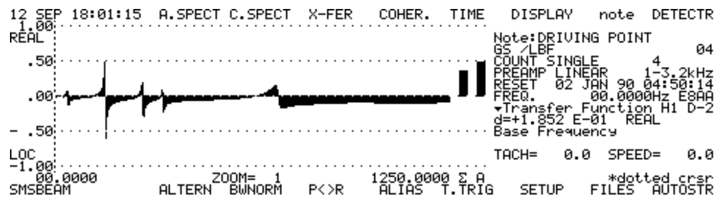
• Driving point measurements are Frequency Response Functions in which the force impulse (hammer) and the resulting response (accelerometer) have been measured at the same location and axis.

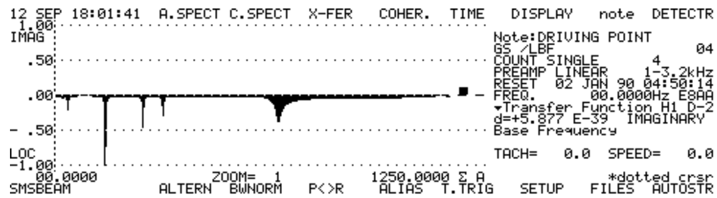
• The driving point survey is used to find the “reference point” that excites all of the modes of interest.

• Used to avoid the mistake of performing an entire modal test with the “reference point” on a nodal line.






## Fixturing (Boundary Conditions)

- Structures can be tested in free or constrained boundary conditions.
- If you are testing the structure in a free-free boundary condition, the structure can be suspended from soft elastic cords, or rested on soft foam.
- The highest rigid body mode frequency should be less than one tenth the frequency of the first structural mode.
- If you are using constrained boundary conditions, you must make sure that the constraining system's dynamic properties do not affect the dynamics of the test item.

## Setting Up the Analyzer

- Set the number of FFT lines to established frequency resolution of your measurements.
- Establish the frequency baseband.
- Select the windowing method.
  - Impact test: force window on channel one, exponential window on channel two.

- Shaker test with a continuous signal (random noise) use a hanning window.

- Choose averaging method or detector.
  - Impact test: select count averaging and the number of averages desired.
  - Shaker test: select the averaging algorithm (linear average) and averaging time.
- Choose measurement units.
- Setup triggering if using the impact method.
- Set the input range (gain) for the A / D.
- Attach the transducers to test item.

## Setting up the Model 3200 for Modal Testing

Modal Analysis measurements can be made using a variety of techniques. The most common utilizes a two channel analyzer (capable of making cross channel measurements), a calibrated impact hammer, and an accelerometer. Integral to the impact hammer is a load cell.

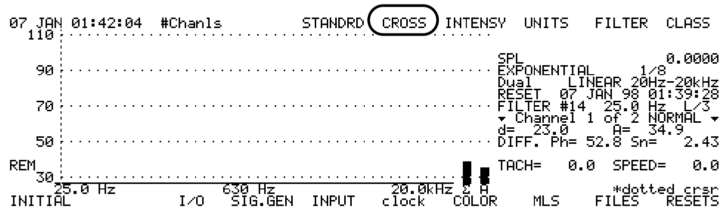
The load cell measures the force of the hammer blow used to excite the test structure. The accelerometer is used to measure the resulting response (acceleration) of the structure. These two signals are measured simultaneously, and a transfer function is calculated between channel one and channel two. Following are the steps used to configure the Model 3200 for measuring transfer functions.

### Setting up the Model 3200

First, verify that the impact hammer signal is connected to channel one of your Larson • Davis Model 3200, and that the accelerometer signal is connected to channel two.

T
D

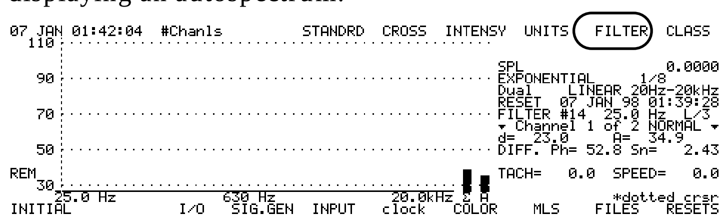
**1.** Turn on the Model 3200 analyzer. After the analyzer has completed its bootup procedure, enter the System Menu by pressing SYSTEM. Next, press **CROSS [D**].




CROSS enables the Model 3200 to measure cross channel properties. The transfer function is a cross channel measurement between channel one and channel two.

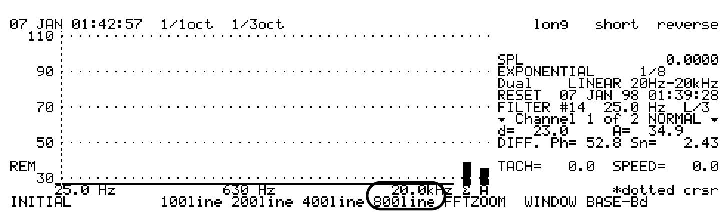
W
G

**2.** Next, the analyzer needs to be set up to measure in narrowband, or FFT mode. Press **FILTER [G]**. The analyzer is now displaying an autospectrum.



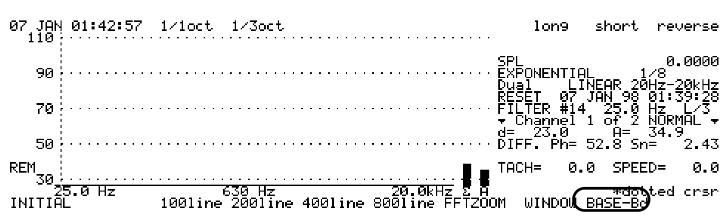

@
L

**3.** Then select the desired resolution of the narrowband measurement (100 line [I], 200 line [J], 400 line [K], or 800 line [L]) by pressing one of these soft key options. For this exercise, choose **800 line[L]**.



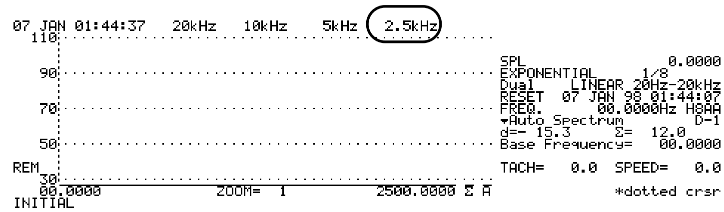

[
O

**4.** After selecting the resolution, select the measurement baseband frequency by pressing **BASE-Bd [O]**.



T
D

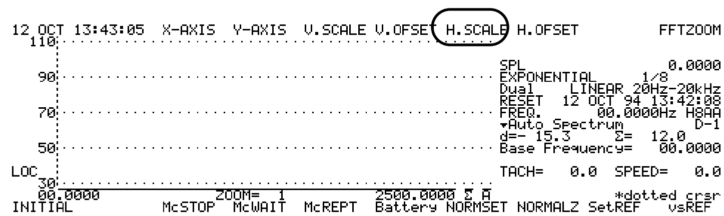
**5.** Your choices for baseband or upper frequency limit are 20 kHz [A], 10 kHz [B], 5 kHz [C], and 2.5 kHz [D]. Since most of the interesting structural resonances occur at the lower frequencies, and the impact technique is limited to lower frequency excitation, choose **2.5kHz [D]**.




If you wish to expand the frequency scale further, first move the dotted cursor to the extreme left side of the display. To do this, press **CURSOR**, then press the left arrow key until the dotted cursor is at the left side of the display as far as it can move.

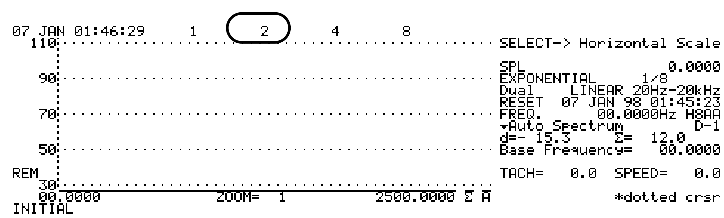
U
E

**6.** Next, press **SHIFT** and the **H.SCALE[E]**.




R
B

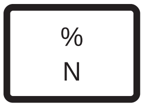
**7.** The **1 [A], 2 [B], 4[C]**. and **8[D]** keys will expand the display by the associated numerical multiplier. Press **2[B]** to expand the display by a factor of 2.



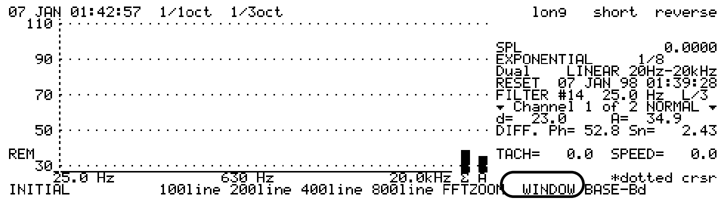

EXIT

**8.** Press **EXIT** to return to the filter menu.

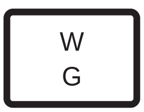
When making FFT measurements, windows often need to be applied to the data to prevent a phenomena called spectral leakage. In the case of an impact modal test, an impact window should be applied to channel one and an exponential window to channel two.



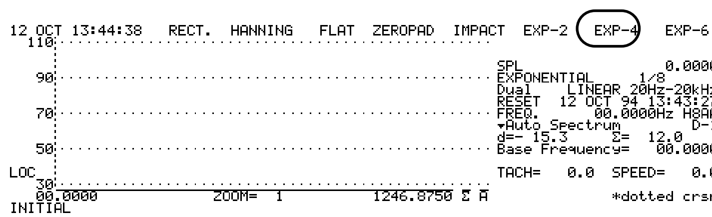

**9.** Select **WINDOW [N]**.



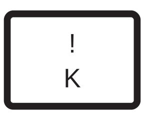

Selecting an exponential window (EXP-2 [F], EXP-4 [G], EXP-6 [H]) automatically assigns an exponential window to channel two and an impact window to channel one. EXP-2 [F] applies an exponentially decaying curve to the time domain response (acceleration) so that the response decays to zero at approximately 50% of the measurement duration. EXP-4 [G] insures that the measurement decays to zero at about 25% of the measurement duration. EXP-6 [H] insures that the measurement decays to zero at about 16.7% of the measurement duration.



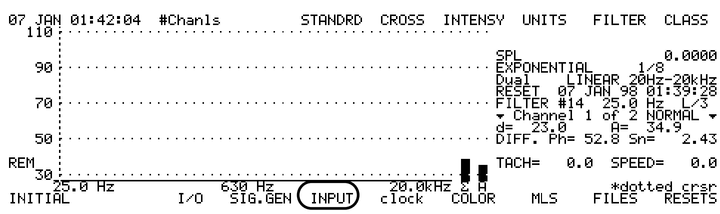

**10.** Press **EXP-4 [G]**





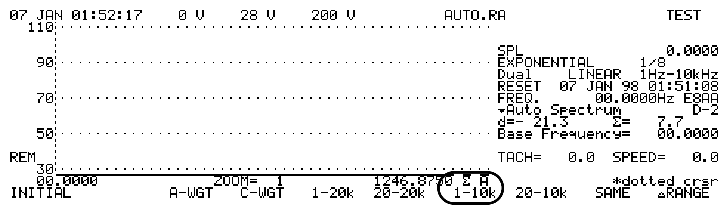



**11.** After selecting the desired exponential window, leave the FILTER menu by choosing **EXIT**. Then, press **INPUT [K]** within the SYSTEM menu.



#
M

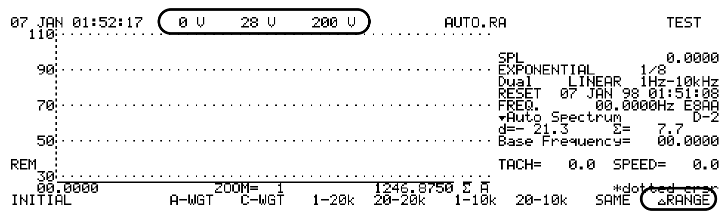
**12.** Next, select a high and low pass filter (typically in a modal test, one would choose 1-10K [M]). Choose **1-10K [M]** (press CH2 hardkey and repeat step 12).




$
CH2

]
P

In the process of making impact measurements, it is often necessary to establish an offset between the channel one input range and the channel two input range. This is done because the channel two response signal is normally greater than the channel 1 force signal (due to structural resonances). Select **CH2** to activate channel two of the analyzer. Next, press Δ**RANGE [P]** to activate the range offset.




**13.** Then press the right arrow key once to establish a 10 dB offset between channel two and channel one.

EXIT

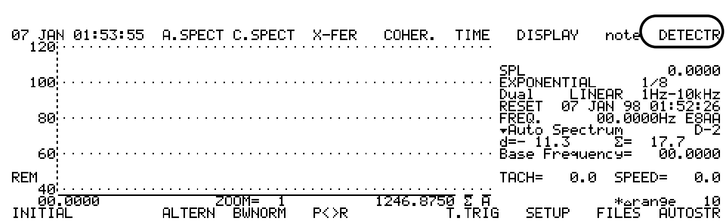
**14.** Toggle CH1 and CH2 to verify (on the measurement display) the 10 dB range difference. Press **EXIT** to leave the INPUT menu.

EXIT

**15.** Press **EXIT** again to enter the MAIN menu.

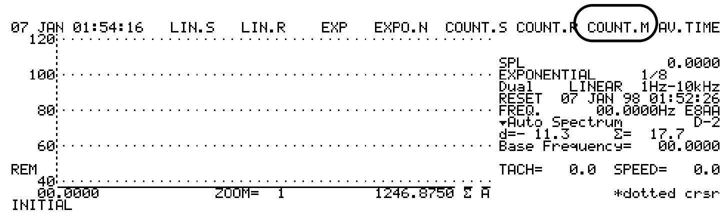
X
H

**16.** Next, press **DETECTOR [H]** to set up the measurement averaging method.



W
G

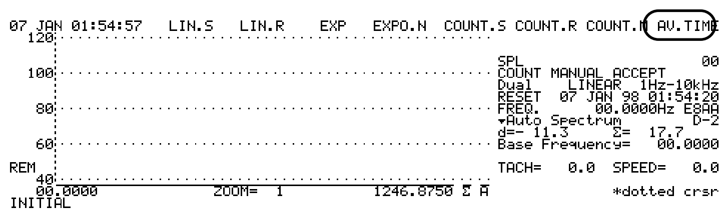
**17.** Select **COUNT.M [G]** averaging.




COUNT.M (count manual accept averaging) is the averaging method that should be used when one is measuring transfer functions using an impact hammer. The COUNT.M method permits the user to examine the data before the spectrum is accepted and averaged in with other spectra.

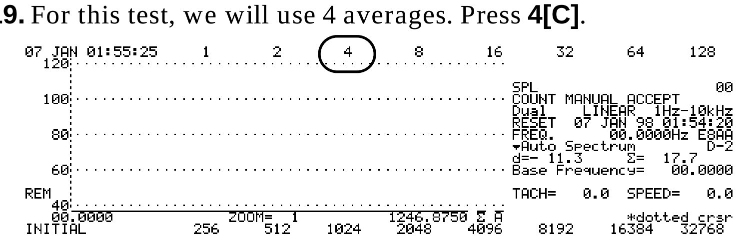
X
H

**18.** Next, choose **AV.TIME [H]** to establish the number of spectral averages for the FRF measurement.




S
C

**19.** For this test, we will use 4 averages. Press **4[C]**.

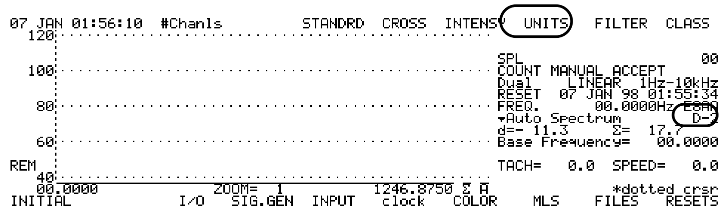



SCREEN
SYSTEM

**20.** Press **SYSTEM** to get back into the SYSTEM menu.

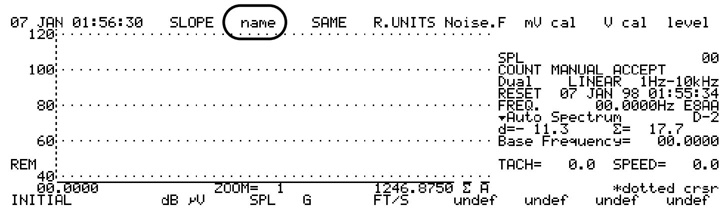
V
F

**21.** You now need to define the measurement units that we wish to work with. Press **UNITS[F]** to enter the UNITS menu. Note that Channel 2 is selected.



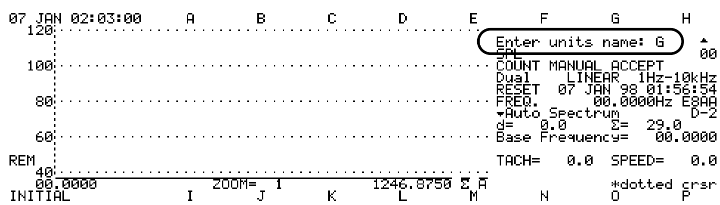

R
B

**22.** From within the UNITS menu, press **name[B]** so that you can create the label for the response channel (accelerometer). We will use g's.




W
G

**23.** Press one of the undef (undefined) UNITS keys, such as **undef[K]** and type in **G**.

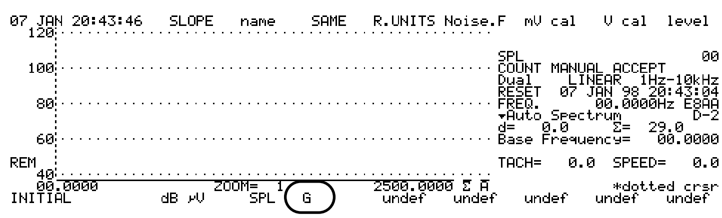


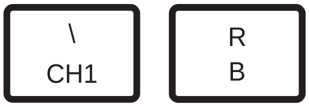

EXIT

!
K

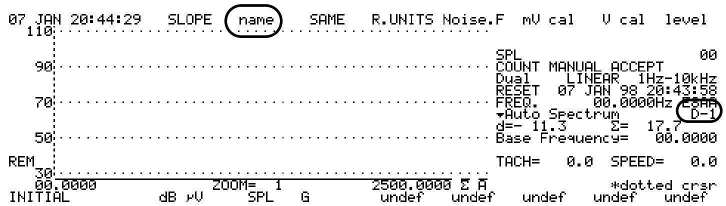
**24.** Type **EXIT** to enter this label.

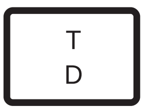
**25.** Press **G [K]** to activate the label.



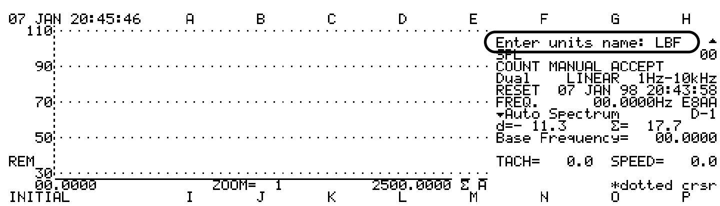


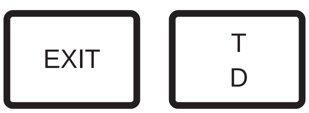

**26.** Press **CH1** to activate channel one. Press **name[B]** so that we can create the label for the input channel (load cell). Note that Channel 1 is selected.




**27.** Press one of the undef (undefined) UNITS keys, such as **undef[L]** and type in **LBF** (pounds force).

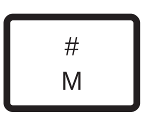


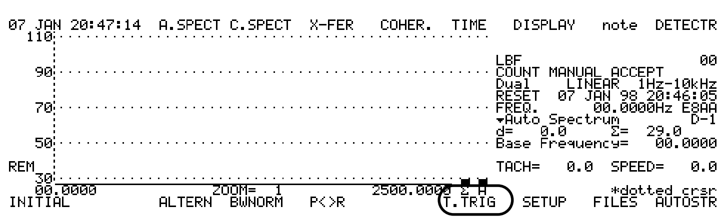

**28.** Press **EXIT** to enter this value. Then press **LBF[D]** to activate the label.

The last parameter that needs to be configured is triggering. When using the impact hammer technique, the measurement needs to begin at or before the exact moment of the hammer blow. Consequently, the analyzer needs to be set up to trigger from channel one on the positive slope of the time domain impulse. You also need to establish a delay (or pre-trigger on channel one) so that the entire impulse is captured.


**29.** Press **EXIT** twice to return to the MAIN menu.

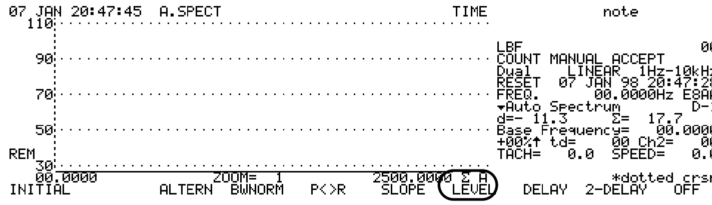



**30.** Press **T.TRIG [M]** from the DISPLAY menu.



#
M

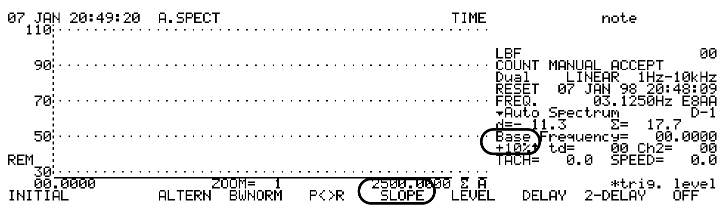
**31.** Next, select a trigger level as a percentage of full range by pressing **LEVEL [M]**.




**32.** Use the right arrow hard key to increment the trigger level (+10% for example). The trigger level can be viewed on the lower left portion of the 3200 set up summary on the right hand side of the display screen. Note, positive % indicates a positive trigger level; negative % indicates a negative trigger level.

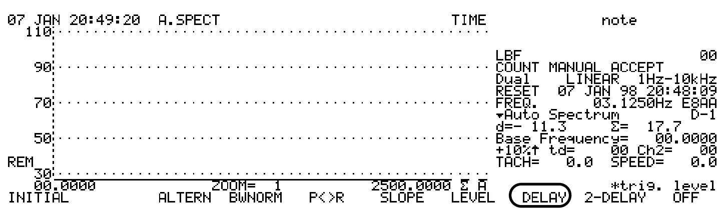
@
L

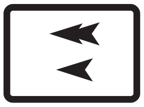
**33.** Next, check that the analyzer is set up to trigger on a positive slope. This can be verified by the arrow next to the trigger level. An arrow pointing upward indicates positive slope while an arrow pointing downward indicates a negative slope. The slope can be changed from negative to positive by pressing **SLOPE [L]**.



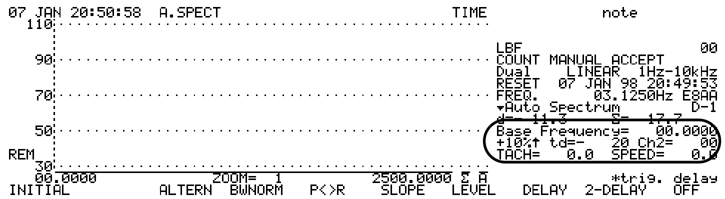

%
N

**34.** Press **DELAY [N]** to establish a pretrigger on channel one.



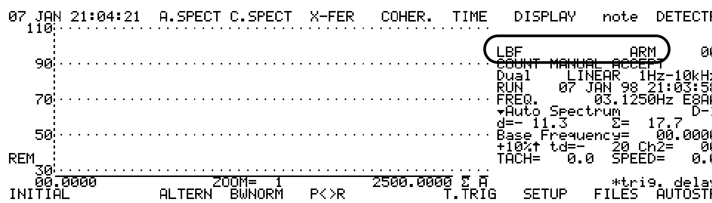


**35.** Press the left arrow hard key to increment the desired negative delay (-20 samples for instance). This value may need to be experimented with to make sure that the time domain impulse has been fully captured. If this signal is not fully captured (unclipped), measurement errors will result.



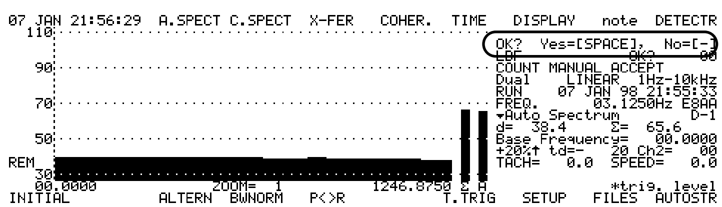

**36.** Press EXIT to return to the MAIN menu.

**37.** The 3200 is now set up to make transfer function measurements. Press **R/S** to arm the trigger.




The 3200 is now waiting for the first average. If you impact the structure and do not have a resulting measurement, the input ranges may need to be adjusted. Also, the trigger level and delay may need to be fine tuned.

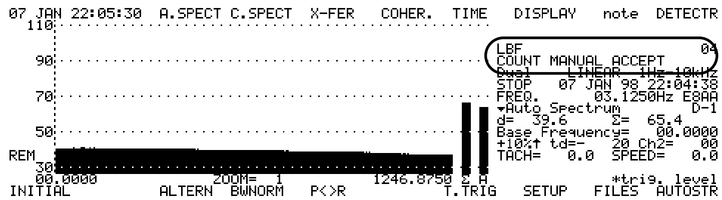
Providing that you are successful and have a good measurement on the screen, press **SPACE** to save the spectra, and impact the structure again.




Continue taking averages until you feel you have a successful transfer function (typically 4 to 10 averages should suffice).

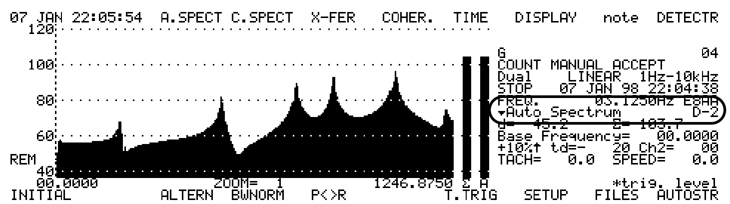
RESET
R/S

**38.** Then, press **R/S** to halt the measurement.



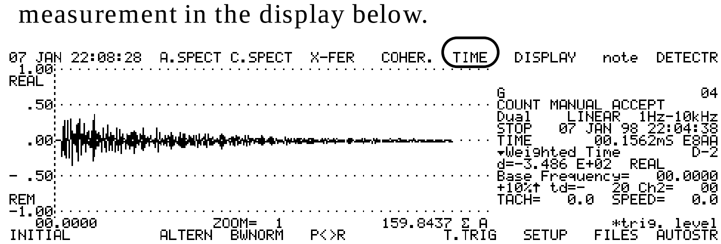

$
CH2

**39.** You are now viewing the input autospectra for channel one. It should look similar to the display above. Notice that the spectra is somewhat flat across the frequency band, rolling off at the higher frequencies. Press **CH2** to view the channel 2 autospectra.



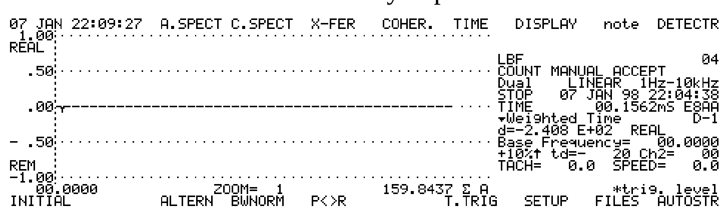

U
E

**40.** Now press **TIME [E]** to view the response time history for channel two. The signal should decay to zero as does the measurement in the display below.




\
CH1

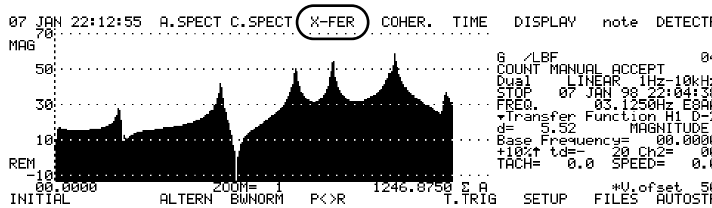
**41.** Press **CH1** to view the input time history for channel one. It should also look similar to the display below. The impulse from the hammer should be fully captured



S
C

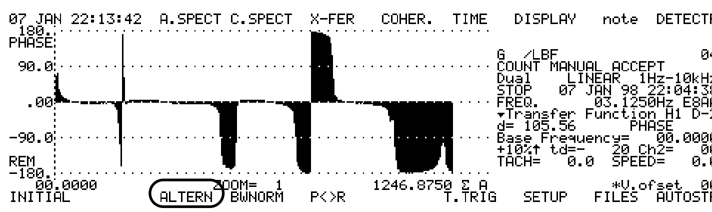
**42.** Press **X-FER [C]** to display the transfer function. This is the averaged transfer function (sometimes called a frequency response function) from the test item. Notice the peaks (resonances of the structure).

**NOTE:** A vertical offset may need to be used to view the transfer function. To do this press **SHIFT**, then the **V-OFFSET[D]** key. Press the right arrow key to bring the spectrum into view.



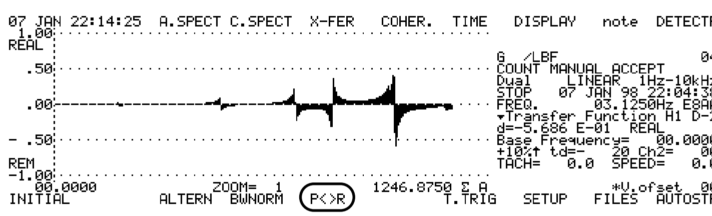

Y
I

**43.** Press **ALTERN[I]** to view the phase of the transfer function.



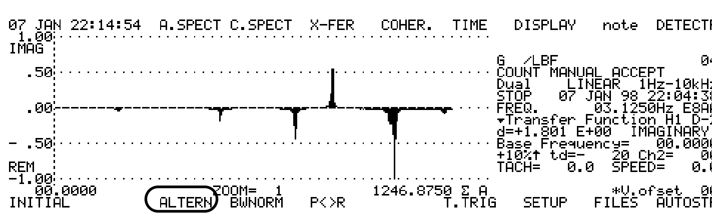

!
K

**44.** Press **P<>R[K]** to switch from rectangular coordinates to polar coordinates of the transfer function.



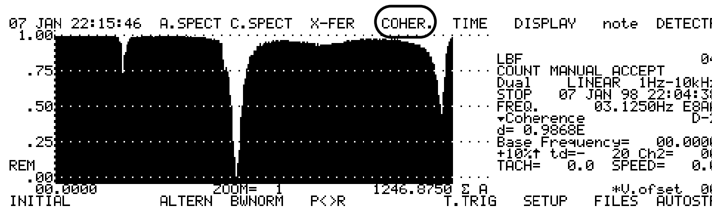

Y
I

**45.** You are viewing the real portion of the transfer function.To view the imaginary part, press **ALTERN[I]**



T
D

**46.** Press **COHER. [D]** to display the coherence function. The coherence function is a measure of signal to noise ratio and is an indicator of the quality of the measurement. A good "coherent" measurement has a value at or near one all the way across the frequencies of interest (except at anti-resonances).

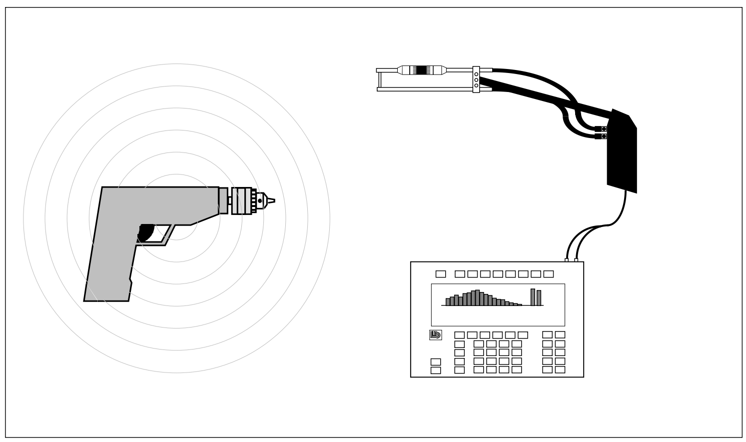


CHAPTER

11

# Acoustic Intensity

## Why use Acoustic Intensity?



- Determine the Sound Power of a noise source
- Locate and rank sources of the sound

### Sound Pressure versus Sound Power

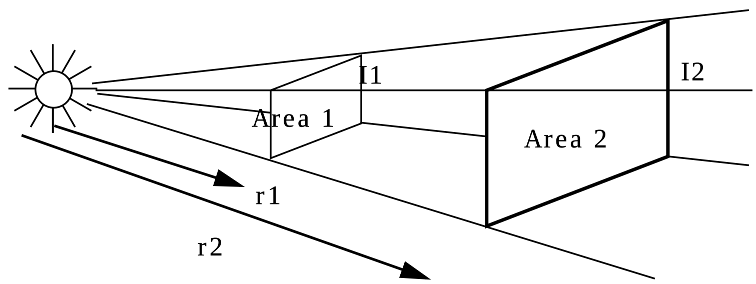
- A sound source radiates Sound Power. The result is sound pressure.
- The perceived Sound Pressure is dependent on the distance from the sound source plus the measurement environment.

## Sound Power Analogy

- A heat source (heater) emits power in watts. The result is a temperature.
- A sound source emits sound in watts. The result is sound pressure.

## Acoustic Intensity? What is it?

- Sound Intensity is a vector quantity. It describes the net amount and direction of flow of acoustic power at a point in space.
- Sound Intensity multiplied times the area over a measured surface yields sound power.

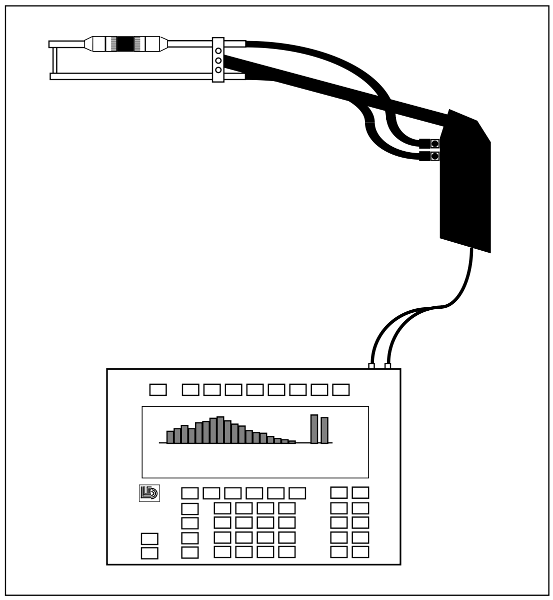



## Advantages of Acoustic Intensity

- Does not require a special test space (can be done in-situ).
- Measurements not affected by steady ambient noise.
- Easy conversion to Sound Power.
- Can be used to locate sound sources.
- Provides a means to rank sound sources.

# Acoustic Intensity measurement hardware

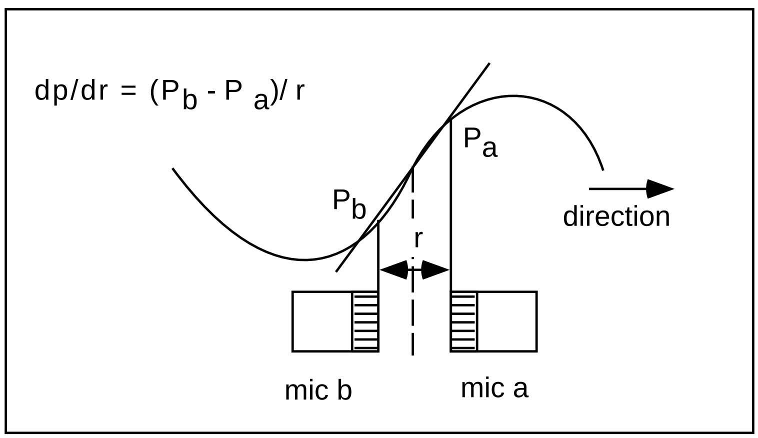
- Microphone probe and a spectrum analyzer.
- Spectrum analyzer should make measurements in octave bands and / or FFT.
- Spectrum Analyzer should make measurements in real time.



# Acoustic Intensity - nuts & bolts

- Acoustic Intensity measurements require simultaneous measurement of sound pressure and particle velocity.
  - $i = p \cdot v$
- The velocity is estimated by measuring a pressure gradient (sound pressure difference between the two microphones).
  - $v_r = -1/\rho \int (dp/dr)\, dt$
  - $v_r = -1/\rho \int ((p_a - p_b)/dr)\, dt$

$\rho$ = fluid density




## Time Domain

- Pressure estimated by averaging the two microphone pressure.
  - $p = (pa + pb)/2$
- Intensity = $(Pa + Pb)/2f\Delta r \int (pa - pb)\, dt$
- This yields the intensity at a given location and direction for all frequencies

## Frequency Domain

- The Acoustic Intensity in the frequency domain is computed using the cross spectra between the two microphone channels.
  - $I = (-1/\rho w \Delta r) \mathrm{Im}(G_{ab})$

    $\rho$ = fluid density

    w = angular frequency

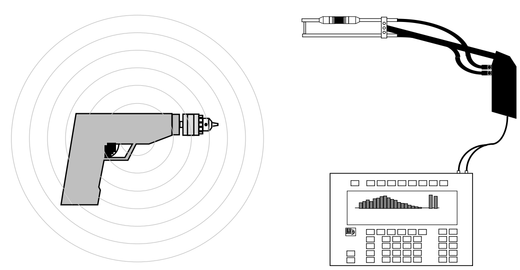
    $\Delta r$ = microphone spacing

    Im ($G_{ab}$) = Imaginary part of the cross spectra
- This computation is the acoustic intensity at a given location in a given direction for a single frequency

# Measuring Sound Power

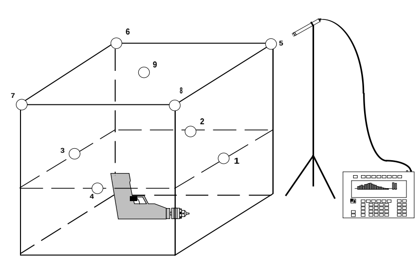
Method 1

Acoustic Intensity



Method 2

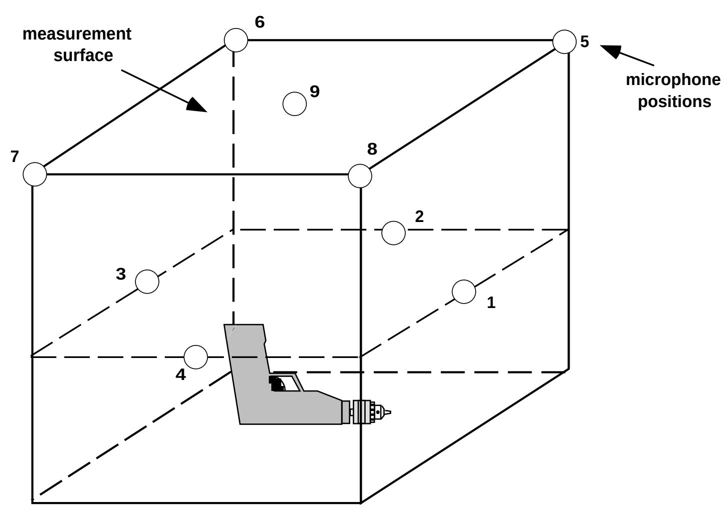
Sound Pressure



## Sound Pressure Method

- Performed typically in an hemi -anechoic or reverberation room.
- Background sound pressure level should be at least 10 dB lower than the noise generated by the test article.
- Test procedures are outlined in ANSI S1.34, ISO 7779, ECMA 74, etc.
- Measurements in free-field are taken in a parallel piped rectangle, or a hemispherical dome around the test item.
- Sound pressure is measured in 1/3 octave bands at each of the microphones
- Sound pressure level is averaged for 8 - 32 seconds.

## Sound Power Setup using the Sound Pressure Method



## Sound Power Calculation for Hemi-Anechoic

- Step 1: Calculate the total averaged sound pressure level
  - $L_p = 10 \log (1/n \sum 10^{0.1 L_{pi}})$

  n = the number of microphone locations

  $L_p$ = the total averaged sound pressure level

  $L_{pi}$ = the sound pressure at each microphone
- Step 2: Calculate the total sound power level
  - $L_w = L_p + 10 \log (S/S_o)$

  $L_w$ = the total sound power level

  S = the total area of the measurement surface

  $S_o$ = the reference area (= 1 square meter)

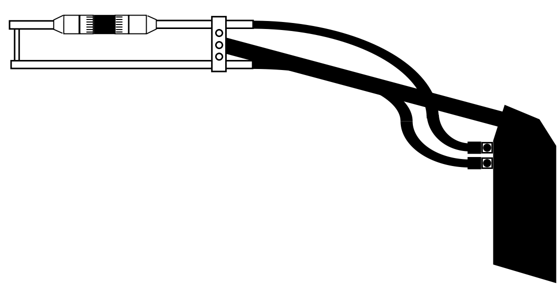
## Sound Pressure Method (pros and cons)

- Advantages
  - good repeatability
  - standards are well documented
  - instrumentation is relatively inexpensive and easy to use
- Disadvantages
  - anechoic and hemi-anechoic chambers are very expensive
  - field measurements are difficult or impossible
  - test is very time consuming
  - setup is very time consuming
  - background noise (air conditioning, voices, etc.) may invalidate the test

# Why Use Acoustic Intensity?

- Does not require a special test space
- Measurements not typically affected by steady and stationary sources
- Easy conversion to sound power
- Yields location of sound sources
- Provides a means to rank sound sources

## The Acoustic Intensity Probe



The Acoustic Intensity probe consists of two phase matched microphones, hardware to fix the microphones in the proper orientation, signal conditioning, and microphone polarization voltage.

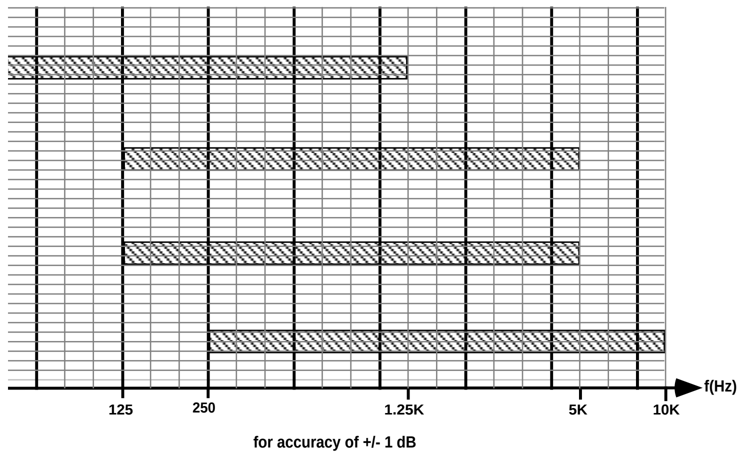
The microphones are kept at a fix distance apart by means of a spacer.

Typical microphone orientation is face to face.

The probe is directional. A signal in the front of the probe will register as positive intensity, while a signal at the back of the probe yields negative intensity. A signal at 90 degrees will result in zero intensity.

## Intensity Probe Spacer Selection

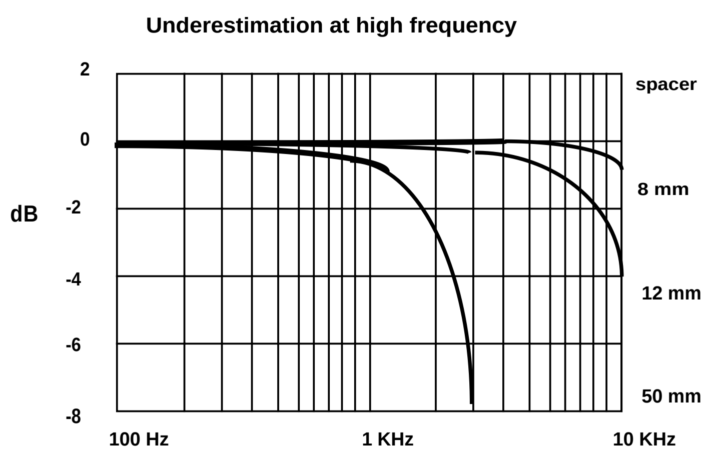
The probe spacer and the microphone diameter will determine the frequency range for the intensity measurement.



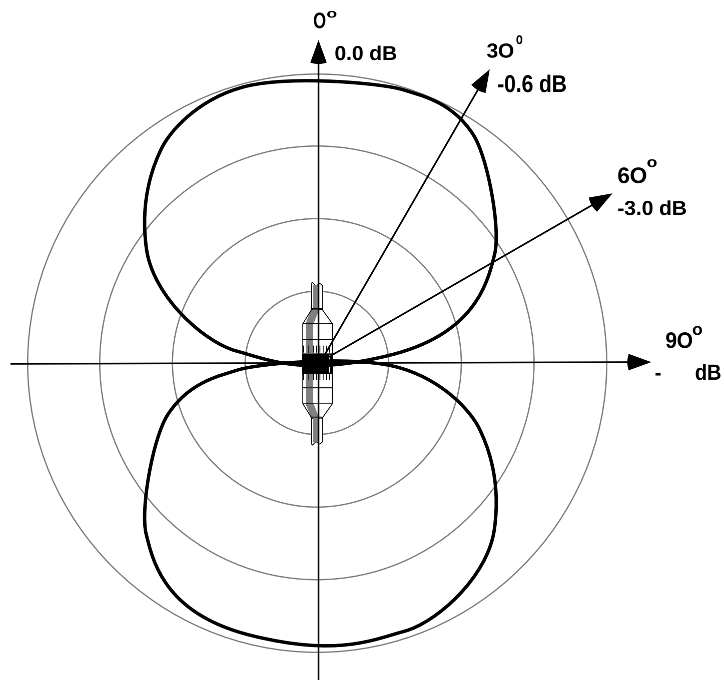

Large spacer / large microphone diameter for large wavelengths.

Small spacer / small microphone diameter for short wavelengths.

## Spacer Errors (High Frequency)



## Intensity Probe Directivity Pattern




- Off axis measurements will result in measurement errors.

## Measurement Considerations

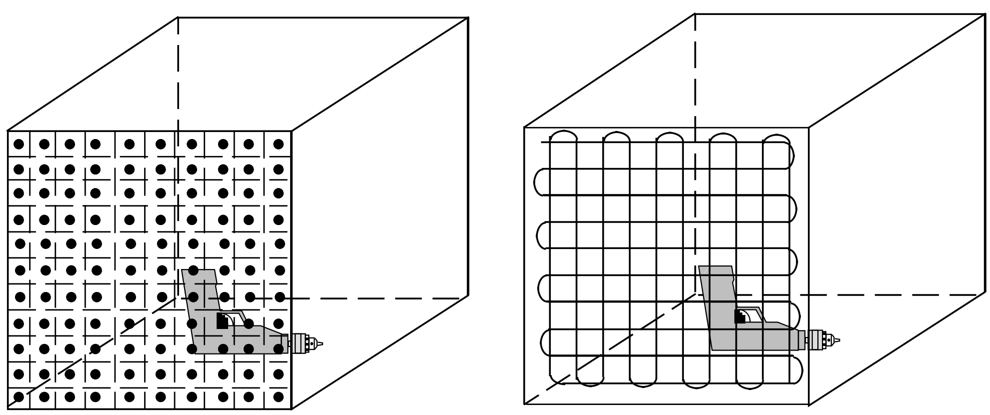
- Acoustic Intensity measurements can be performed using FFT (narrowband) or octave bands. Measurement should be made in real time.
- Acoustic Intensity is measured by spatial averaging. Spatial averaging is achieved by either taking measurements at a number of fixed points, or by scanning the probe about a surface. The Acoustic Intensity for the area tested is the average of the fixed point measurements, or the value determined during the scan.
- The Acoustic Intensity measurements are done across a measurement surface. The standard measurement surfaces are:
  - Parallel piped or box

- Hemispherical
- Conformal

## Measurement Techniques

1. Select the spatial averaging technique (fixed point or scan).
2. Establish a measurement grid.
3. Measure the surface area (in square meters).
4. Divide the measurement surface (rectangle or sphere) into components and subcomponents.
5. Measure the ambient pressure and temperature.
6. Select the proper spacer and microphones. This is determined by the frequency range of interest.

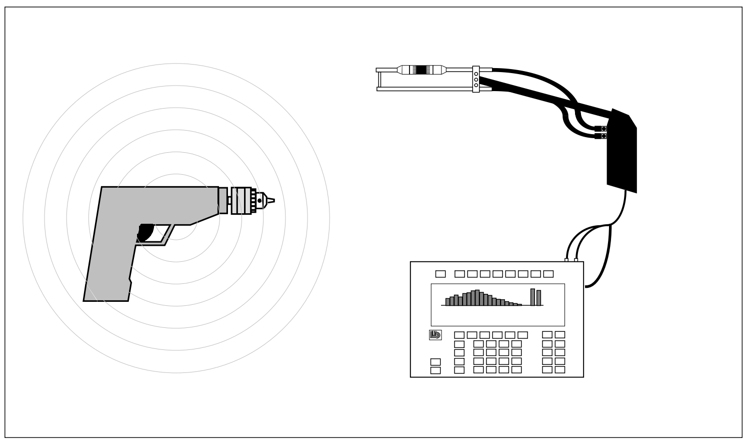
### Fixed Point or Scanning



- The fixed point method is preferred if you wish to generate detailed graphics such as contour maps. (Although you could scan within a small grid.)

- The fixed point method is more repeatable.
- The fixed point method requires a longer setup time.
- The scanning method is quicker.
- The scanning method is more accurate.

## Setting up the Model 3200 for Acoustic Intensity Measurements



Connect the Larson•Davis Model 2250 (or 2260) Acoustic Intensity probe to channel one and channel two of the 3200 RTA. Probe cable one (near) should be plugged in the channel one microphone input. Probe cable two (far) should be plugged in the channel two microphone input. Connect the remote control cable (15 pin connector) to the I/O port on the right side of the 3200.

Next, insert the appropriate spacer between the phase matched microphones (13 mm or 50 mm). In general, the 13 mm spacer is the appropriate choice for most measurement applications. In the case where one is interested in low frequency data, the 50 mm spacer should be used.

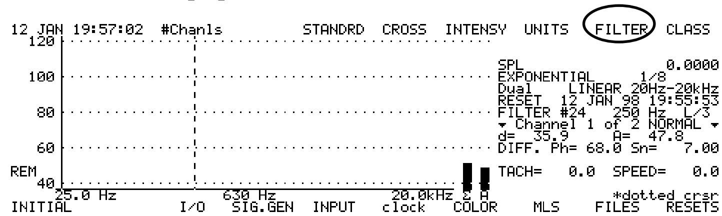
Acoustic Intensity measurements can be done in full octave bands, 1/3 octave bands or narrowband (FFT). Since most intensity surveys are performed in 1/3rd octave bands, we will setup the 3200 RTA accordingly.

SCREEN
SYSTEM

**1.** Press **SYSTEM** to enter the main menu of the 3200.

W
G

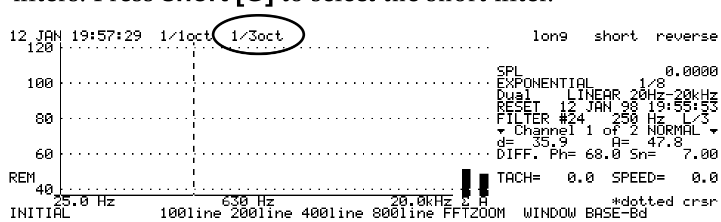
**2.** Select **FILTER [G]** to enter the filter menu.




R
B

Y
I

**3.** Then choose **1/3oct [B]** to activate the 1/3 octave band digital filters. Press **short [G]** to select the short filter.

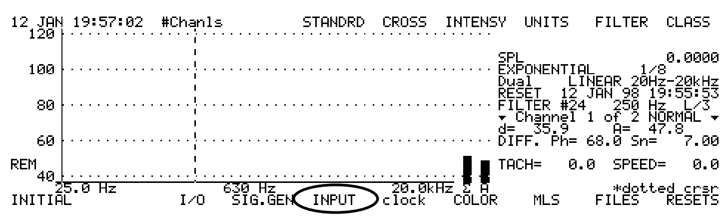



EXIT

**4.** Press **EXIT** to get back to the System menu.

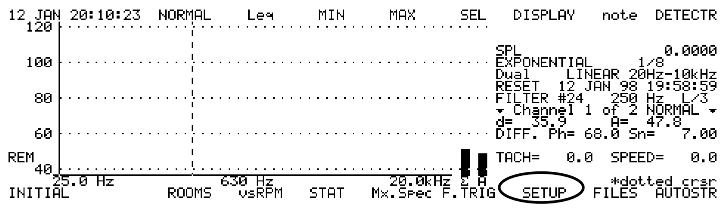
!
K

**5.** Next, we need to select the high and low pass analog filters. For this example, we will set the high pass filter at 20 Hz. and the low pass filter at 10 KHz. To do this, press **INPUT [K]**.



% N

**6.** Then select **20-10k [N]** to activate the 20 Hz and 10KHz filters.




**7.** Press the **SAME[O]** key to assign the 20-10 kHz to channel 2.

EXIT

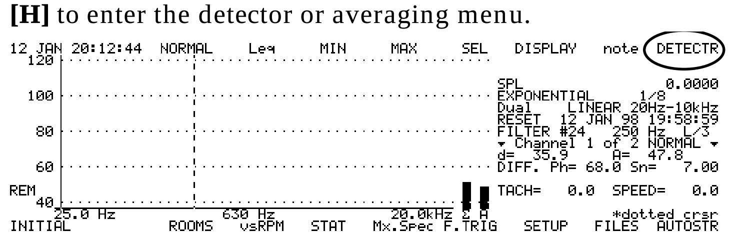
**8.** Press **EXIT** twice to return to the MAIN menu.

## Selecting an Exponential detector

For now, keep the detector type set for exponential averaging and the integrating time at 1/8 sec. If the 3200 is not already set up for this averaging option (see right side of display), do so at this time.

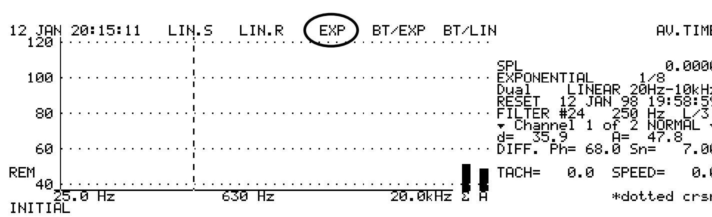
EXIT X H

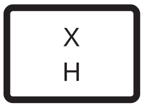
**1.** To set these values, first press **EXIT**. Then choose **DETECTR [H]** to enter the detector or averaging menu.



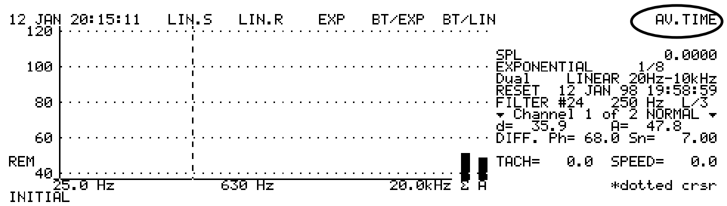

S C

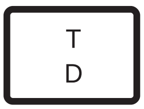
**2.** Select **EXP [C]** to activate the exponential detector.



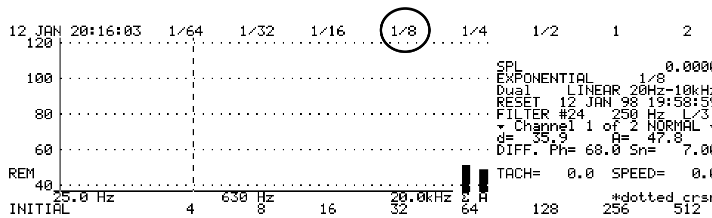



**3.** Then press **AV.TIME [H]** (averaging time).




**4.** Next, select **1/8 [D]** sec.

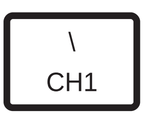





**5.** Press **EXIT** to return to the MAIN menu, then press the **SYSTEM** hardkey.

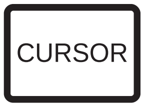
## Microphone calibration

Next, perform an amplitude calibration for the two probe microphones. To do this, first loosen the microphone fixture on the probe so that the microphones can be separated. Remove the spacer. Next, insert the channel one microphone into the opening of your Larson Davis CAL200 or CAL250 calibrator (or any other SPL calibrator you have).



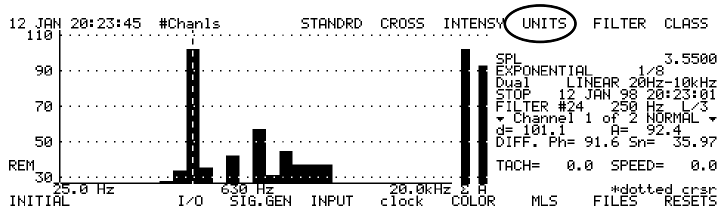


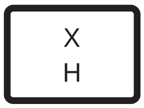
**1.** Press the **CH1** hard key to display channel one. Turn the calibrator on, then press **R/S** to begin a measurement. Adjust the input range up or down (using the up or down arrow hard keys) until the gain level is optimized. One way to do this is to press the down arrow until an overload occurs. Then press the up arrow one or two steps.



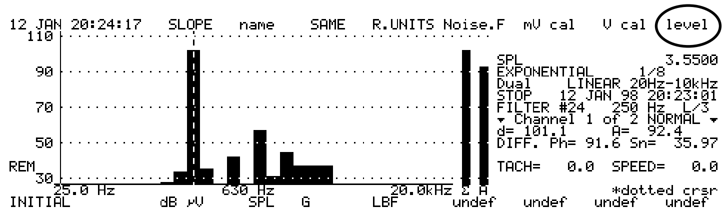



2. Press **CURSOR** and then move the dotted cursor to the cursor band within which the calibration tone resides (250 Hz for the CA250 calibrator). Press **R/S** to stop the measurement. Press **UNITS [F]**,

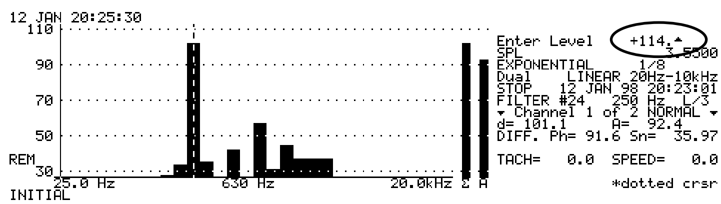



3. Press **level [H]**.




4. Type in the output level of your calibrator (114.0 dB for the CA250).

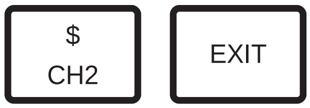




5. Press **EXIT**. Channel one is now calibrated.


6. To verify calibration, make sure that your calibrator is still on and press **R/S** to begin another measurement. The level that you read at the cursor location should be the output level that you defined (114.0 dB for the CA250). If not, repeat the calibration.

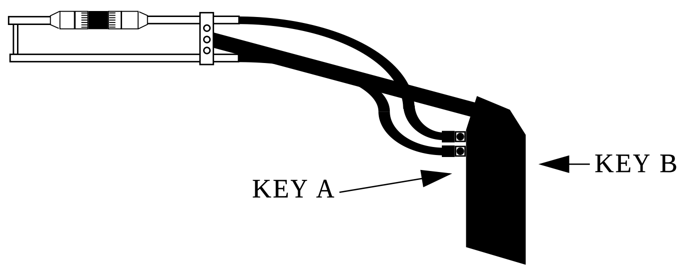

7. Press **R/S** to stop the measurement.

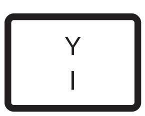



**8.** Now calibrate the Channel two microphone. First, remove the channel one microphone from the calibrator, and insert the channel 2 microphone. Press **CH2** to activate the channel two display. Repeat the above calibration procedure for channel two. Press **EXIT**.

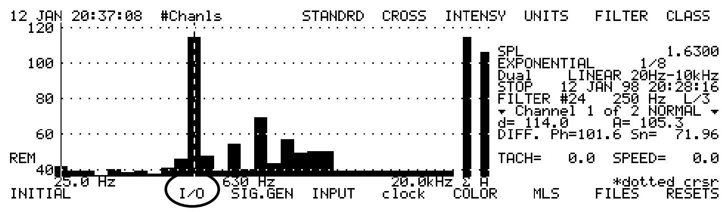
## Programming remote control keys

The next step is to program the remote control keys on the 2260 (or 2250) acoustic intensity probe. Notice on the probe handle that there are two keys or buttons: one on the front of the handle and one on the back of the handle. The key on the front is KEY A; the one on the back is KEY B. KEY A and KEY B can be assigned any function or keystroke of the 3200 RTA. Typically, one assigns KEY A the task of initiating and terminating a measurement, and KEY B the task of storing a measurement. Let's go with this convention.

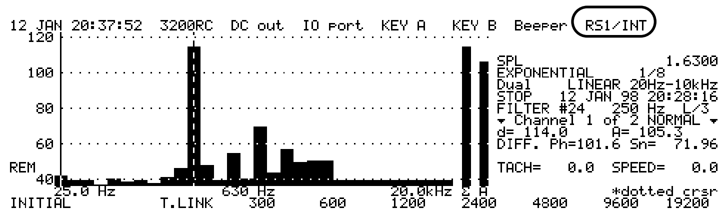


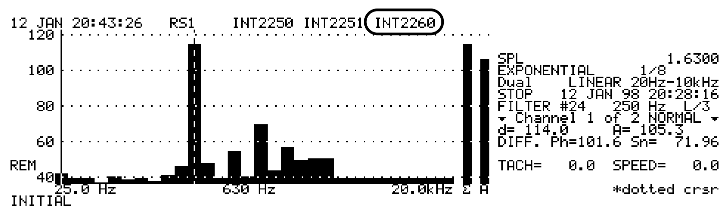

**1.** Press **I/O [I]** to enter the communications menu.



**2.** Next, press the **RS1/INT[G]** key.



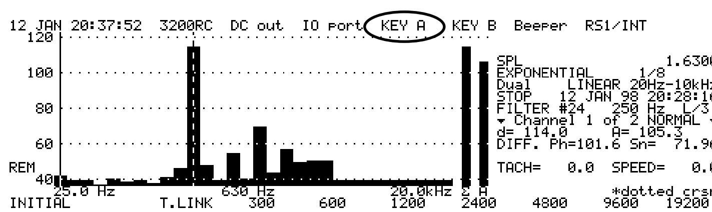

**3.** Press **INT2260[D]** (or **INT2250[B]**) to initialize the probe.




**4.** Press **EXIT** key.

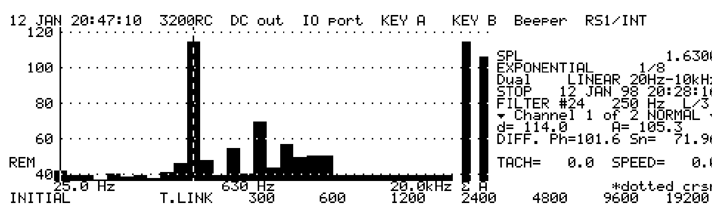
T
D

**5.** Now, to program the KEY A to activate the **R/S** hard key, pressthe **KEY A [D]** first.



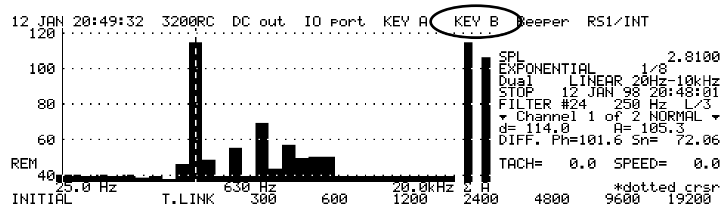

RESET
R/S

**6.** Then press the "**-**" hard key followed by the **R/S** hard key. Pressing KEY A on the probe will now remotely activate the measurement process in the 3200.



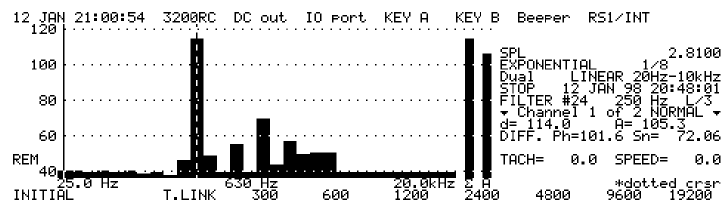

U
E

**7.** Press **KEY B [E]** to program KEY B on the probe to remotely store data.




& STORE

**8.** Then press “**-**” followed by the **STORE** hard key. Pressing KEY B on the probe will now store the current (displayed) measurement to the active data file in the 3200 memory.




EXIT

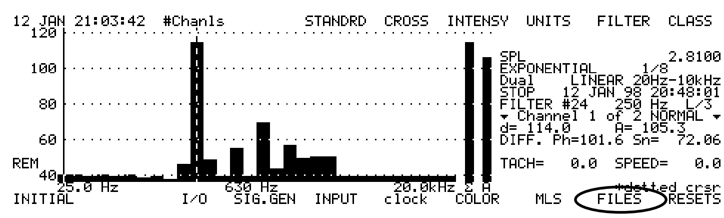
**9.** Press **EXIT** twice to return to the SYSTEM menu.

## Creating a measurement data file

Next, we need to create a measurement data file. This is the file where our Acoustic Intensity measurements will be stored.

[ O

**1.** Press **FILES [O]** to enter the file menu.



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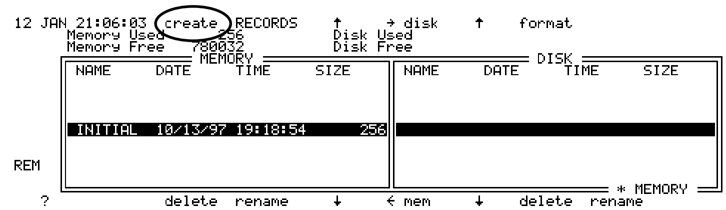
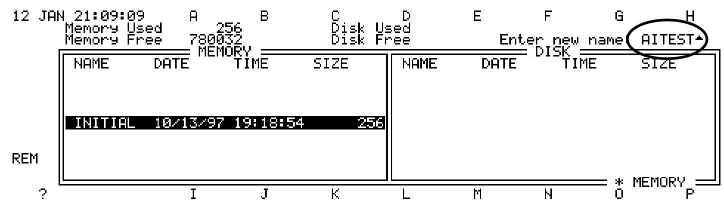
Q
A

**2.** Next, press **create [A]**.




**3.** Using the alpha keys above and below the display, create a file name (such as AITEST).



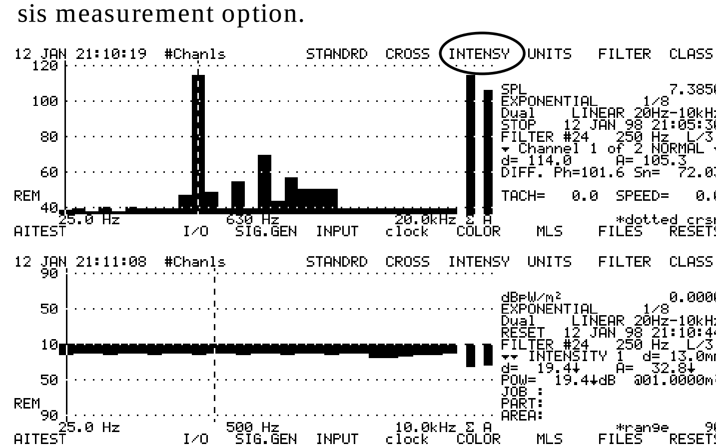

EXIT EXIT

**4.** Then press **EXIT** to enter the file name. Press **EXIT** again.

Notice the file name appears at the lower left corner of the display. This indicates that this is the active measurement file. All of our acoustic intensity data records will be stored in this file.

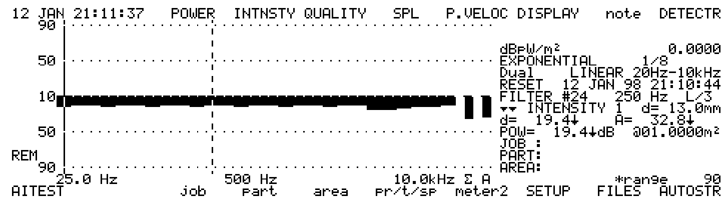
U
E

**5.** Select **INTENSY [E]** to activate the Acoustic Intensity analysis measurement option.




EXIT

**6.** Press **EXIT** to leave the SYSTEM menu and enter the Acoustic Intensity display menu.



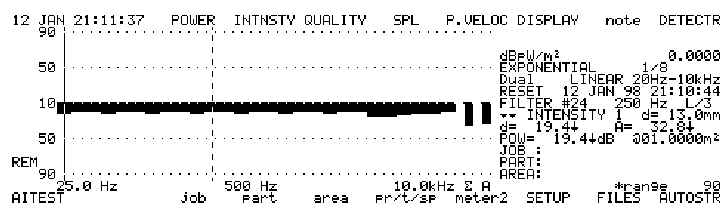

## Normalization of input channels

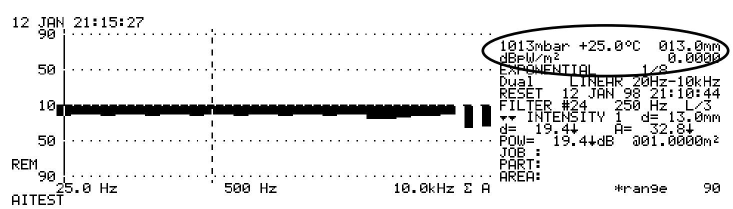
At this point, it is recommended that you phase and amplitude match the input channels (1 and 2) by performing a channel normalization. You can use the optional built in noise generator of your Model 3200 or an external noise generator to do this. Please refer to your user manual to perform a channel normalization. This is recommended but not required.

Within the Intensity display screen, one can establish the various acoustic intensity measurement correction parameters. These include the ambient barometric pressure, temperature and spacer length.

@
L

1. Press **pr/t/sp [L]** to edit and enter the values for static pressure (in millibars), temperature (degrees Celsius), and the spacer length (in millimeters).




EXIT

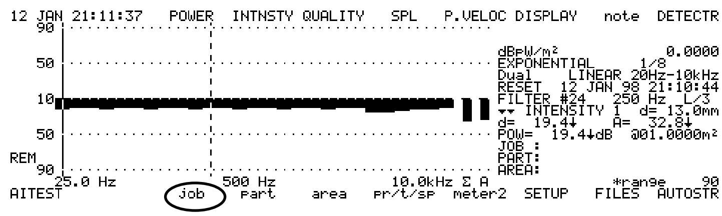
2. After you have established the values of these parameters, press **EXIT** to enter the changes.

## Naming a job, part, and area

For a sound power determination, we need to give the test a job name, and create names for the components (part), and subcomponents (area).

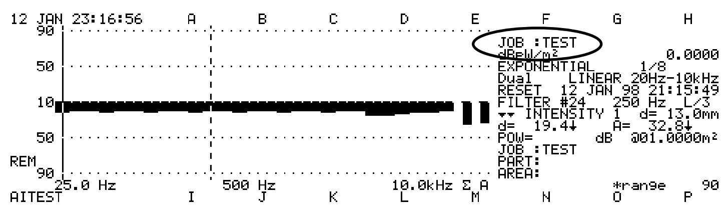
Y
I

1. Press **job [I]** to enter the name creation field for the job name.



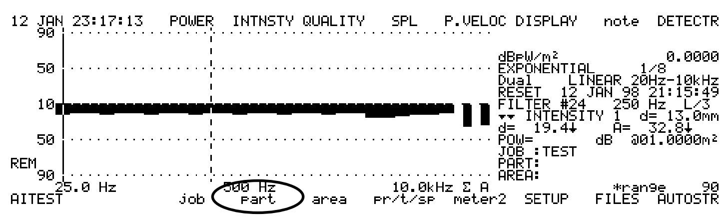

EXIT

2. Press the various alpha soft keys to build the job name that you desire. Then choose **EXIT** to enter the job name.



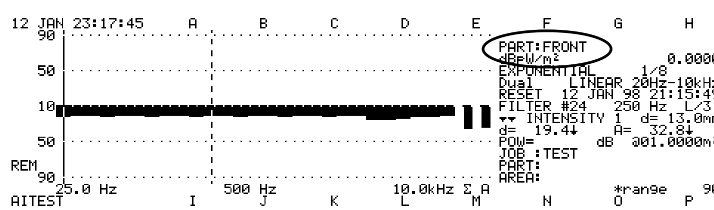

Z
J

3. Press **part [J]** to enter the name creation field for the part name.



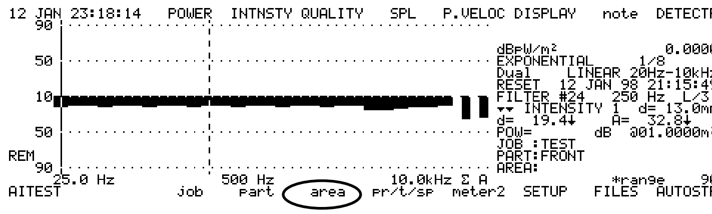

EXIT

4. The part would be a subcomponent of the job. Again, press the various alpha soft keys to create the part name that you wish. Then choose **EXIT** to enter the part name.



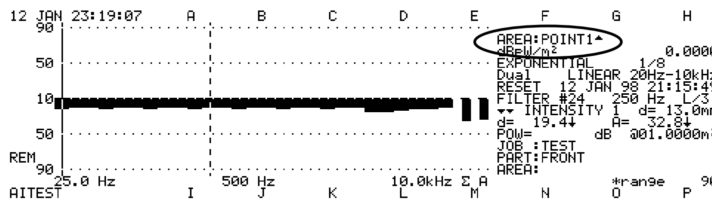
! K

5. Press **area [K]** to enter the name creation field for the area name.



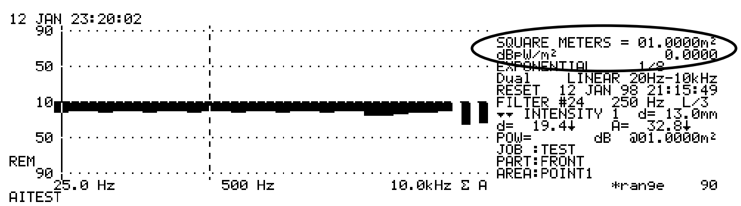

EXIT

6. The area would be a subcomponent of the part. Once again, press the various alpha soft keys to create the area name. Then choose **EXIT** to enter the area name.




EXIT

7. After you enter the area name, you will be prompted to enter the "area" (in square meters) of the test area. Type in this value, and then press **EXIT** to enter this value.



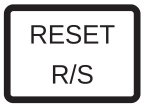

## Selecting a Linear Detector

Prior to performing a measurement, adjust the input range of the 3200 so that it is optimized for the test that you are performing. To do this, first make sure that your test item is on and is generating noise.

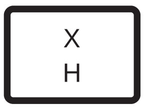
RESET R/S

1. Then, press **R/S** to begin a measurement. Adjust the input range of the 3200 using the up and down arrow hard keys.

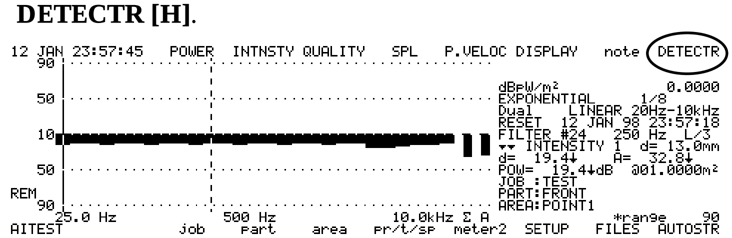
2. The proper input range would be at the range setting one or two steps above the setting where the 3200 overloads. Starting from a high range, step down (using the down arrow key), the range one 10 dB increment at a time until OVER appears on the screen. Then arrow up one or two 10 dB steps. You are now range optimized.

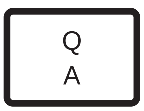



3. Press **R/S** to stop the measurement. The autorange feature of the 3200 can also be used but usually more time consuming than the manual method.

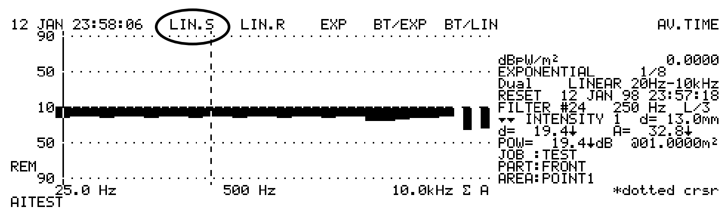


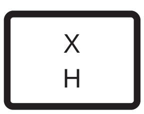

4. Set the detector for linear single averaging by first pressing **DETECTR [H]**.



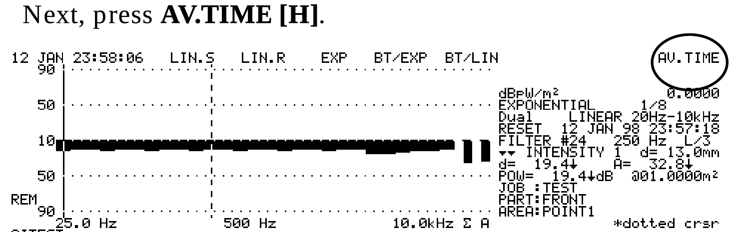




5. Then choose **LIN.S[A]**.



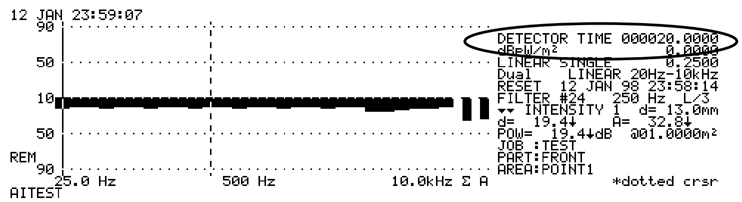




6. Next, press **AV.TIME [H]**.



EXIT

**7.** Enter a DETECTOR TIME of some value between 20 and 60 seconds. In general, you will get a more accurate measurement with a longer averaging time. Press **EXIT** to enter this value.



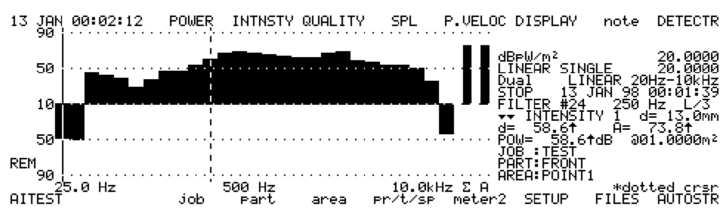

**8.** Press **EXIT** to return to the MAIN menu.

## Performing a measurement

Now to make a measurement, point the front of the intensity probe towards the noise source.

RESET
R/S

**1.** Press KEY A on the probe (or the **R/S** hard key) to initiate the measurement. Either “scan” the probe about the measurement surface (in an orthogonal fashion) or fix the probe at a single point (orthogonal to the surface) until the end of the averaging time is reached. The first measurement is now complete.




The 1/3 octave bands above the center line of the display denote positive acoustic intensity. Bands below the center line indicate negative intensity.

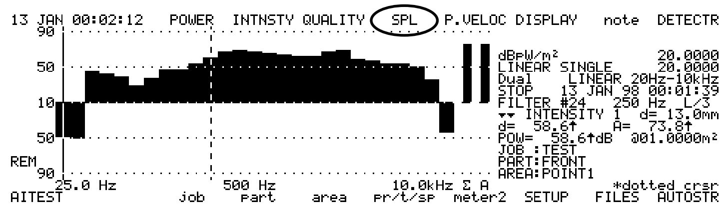
On the right hand side of the screen, the values for intensity and sound power are listed for each of the 1/3 octave bands for this particular spectra and for the overall summations. If you would like to look at the power and intensity values at other specific frequencies.

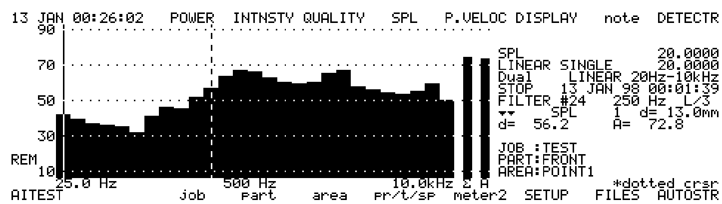
CURSOR

2. Press the **CURSOR** hard key, then press the left or right arrow key to move the cursor to the various 1/3 octave bands.

T
D

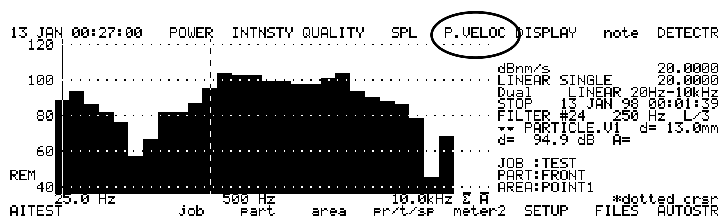
3. Press **SPL [D]** to view the averaged sound pressure level that was measured.



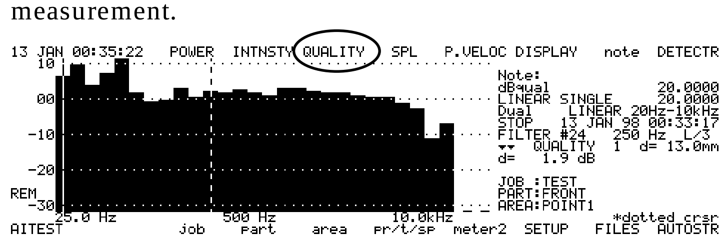

U
E

4. Press **P.VELOC [E]** to view the Particle Velocity that was measured.

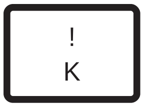



S
C

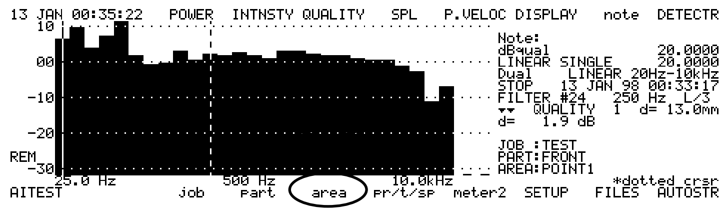
5. Press **QUALITY [C]** to view the Quality Indicator Function measurement.



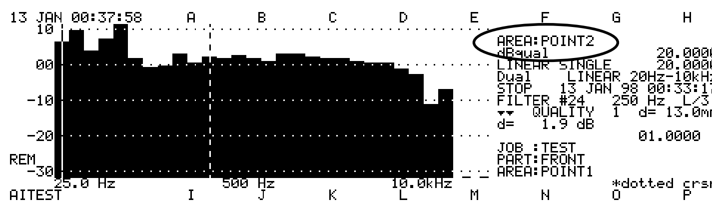

In general, the Quality should be between 0 and -10 dB (no greater than -15 dB) for the measurement to be deemed “acceptable”.

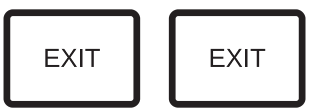



**6.** If you wish to continue the sound power survey, first store this initial measurement (to RAM) by pressing KEY B on the probe (or the **STORE** hard key). Before beginning the next measurement, change the name of the area by pressing **area [K]**.

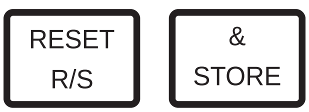



**7.** As you did earlier, type in the new area name using the alpha soft keys.



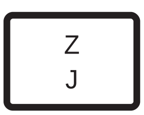




**8.** Then press **EXIT** to enter this area name. If the surface area of the measurement is different, change the value (in square meters). Then press **EXIT** to enter the new value.

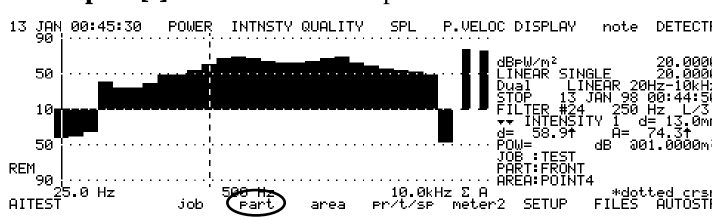



**9.** You are now ready to take the next measurement. Press **R/S** to begin the measurement. When the measurement is complete and you are satisfied with the Quality, press **STORE** to store the data to memory.

Continue the sound power survey until you have acquired all of the area measurements for the current part and have stored them away. You are now ready to go to the next “part” in the acoustic intensity “job”.

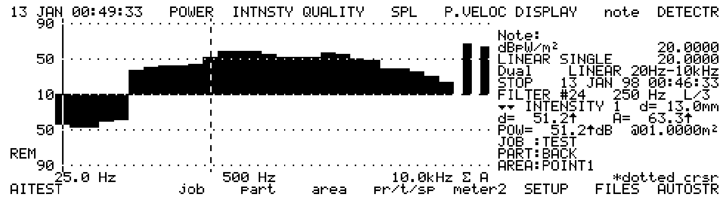



**10.** Press **part [J]** to create the next part name.



EXIT

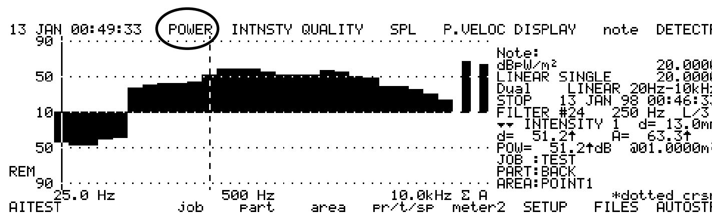
**11.** After you have created the new part name, press **EXIT**. Continue the test, modifying the area names (and sizes) as you go along.




**12.** When you have completed the acoustic intensity test of the "job", you can use the summing capabilities of the 3200 to generate sound power totals for the entire job, or for individual parts.

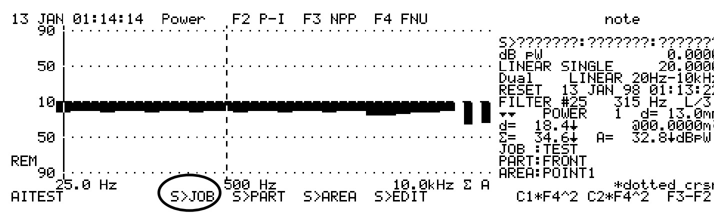
Q
A

**13.** To do this, first press **POWER [A]** to bring up the sound power summation menu.

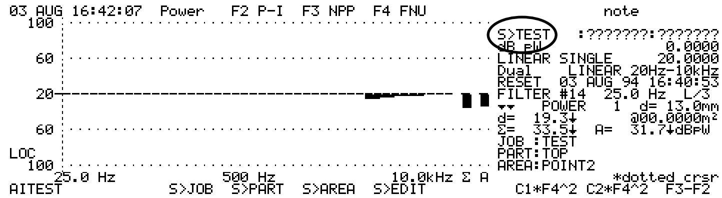



Y
I

**14.** If you are interested in determining the total sound power emanating from your test item, press **S>JOB [I]**.

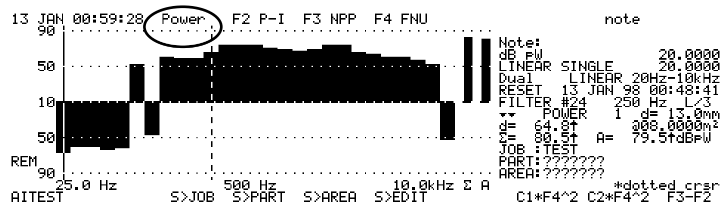



Notice that the job name appears at the top right corner of the display. This field tells you which data will be used for the sound power summation calculation.

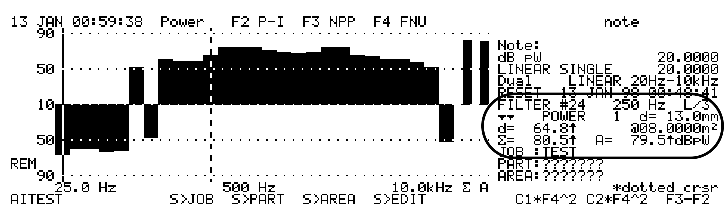


Q
A

**15.** In this case, all of the sound intensity measurements for the job are used. Press **Power[A]** to initiate the sound power summation.




**16.** On the display you will see the total sound power spectra of the job. At the right of the display you can read the values of the total overall sound power (Linear & A-Weighted) of the job, plus the sound power at each 1/3 octave band.



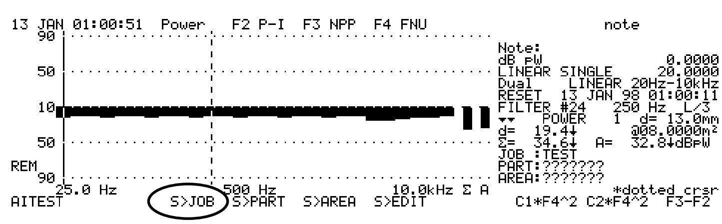

CURSOR

EXIT

**17.** Press **CURSOR** and then the left or right arrow keys to move the cursor to view the sound power levels at the other 1/3 octave bands. Press **EXIT**

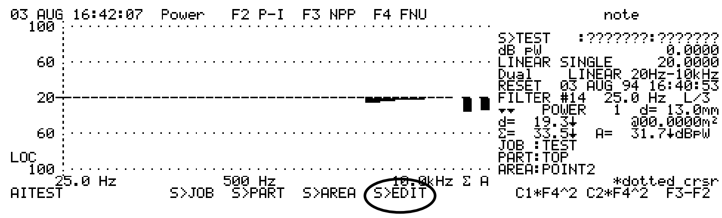
Q
A

**18.** To generate sound power totals for an individual "part" of the "job", press **S>JOB [I]** .

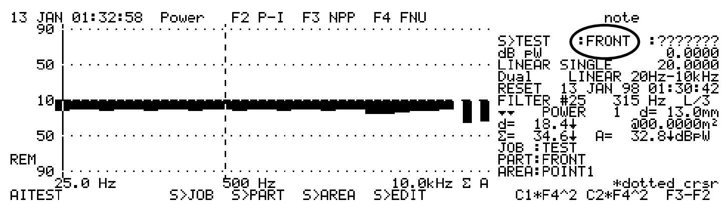


Z
J

**19.** Next, press **S>EDIT [L]**. Use the arrow keys to move to the desired “Part” field. Enter the name of the part for the sound power calculation.

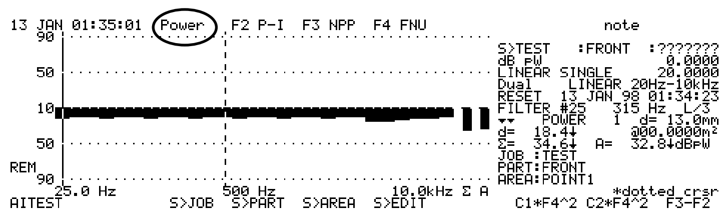



Now the name of the last part that you created / measured will appear at the top corner of the display (next to the job name).

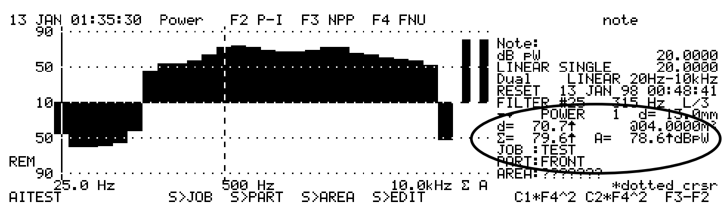



Q
A

**20.** Press **Power[A]** to perform the sound power summation.

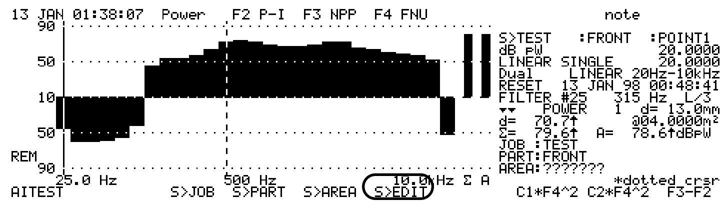



On the display you will see the total sound power spectra of the specified part.

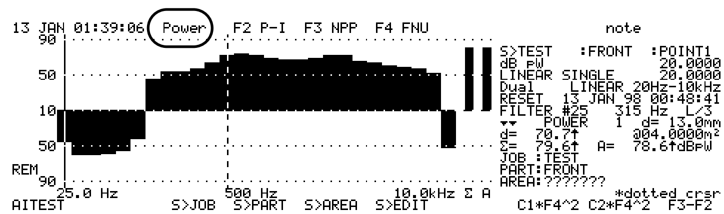



At the right of the display you can read the values of the total overall sound power (Linear & A-Weighted) of the part, plus the sound power at each 1 / 3 octave band.

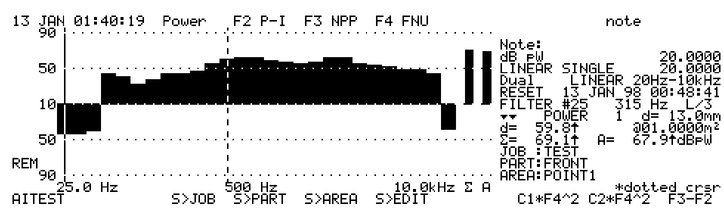
**21.** To view the sound power of a specific area of a part, press **S>EDIT [L]**. Enter the desired area and press **EXIT**.




**22.** Press **Power [A]** to perform the sound power summation.




On the display you will see the total sound power spectra of the specified job, part, and area.



CHAPTER

# 12 Autostore byTACH, vsRPM Display and Order Tracking

The Model 3200 has the capability to acquire data as a function of RPM (speed) utilizing the built in tachometer input feature. This is very useful when measuring vibration or noise from a device that has a variable operating speed such as a turbine, transmission, etc.

For this exercise, you will explore the vsRPM features of the 3200 by making vibration measurements on plate that is attached to a dc motor. As the motor “runs up” or increases in RPM, the vibration frequencies of the plate will also shift upward as a function of speed. You will measure the vibration using an accelerometer although other transducers could be used for this test as well.

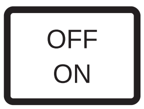
The TACH INPUT of the 3200 is designed to be used with a tachometer that outputs an analog pulse (TTL) train that is proportional to the rate of rotation of the test device. For this test you will use an optical pickup in conjunction with the Larson Davis Model T100 tachometer to detect one pulse per revolution of the dc motor.

## byTACH Autostore Measurements

The first method that you will use to acquire variable RPM data is the Autostore byTach feature. This method is very similar to the Autostore byTime function. The key difference that instead of gathering spectra over a time duration at a specified time interval, you will capture spectra over a range of RPM values at a predetermined RPM delta.

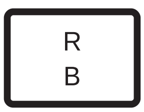
For this test, you will capture spectra from the dc motor plate (as it "runs up" in speed) between 500 RPM and 3000 RPM at 20 RPM increments using autostore. The end result will be a set of frequency spectra starting at 500 RPM with roughly 20 RPM increments between them (500, 520, 540...). The last spectrum acquired will be at 3000 RPM.

## Setting up the 3200 Measurement Parameters

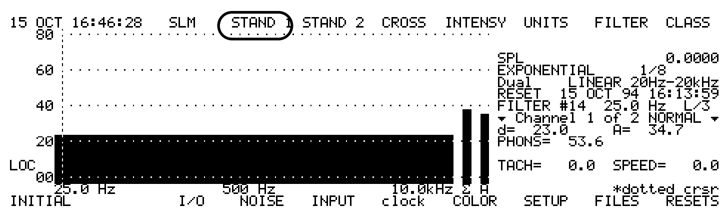


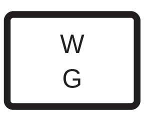

**1.** Connect the output of the tachometer to the TACH INPUT of the Model 3200. Attach the accelerometer (either via a 950B or AD012 adaptor) to the Channel 1 input. Press **ON** to boot up the 3200.


**2.** Press **SYSTEM** to get to the main System menu.

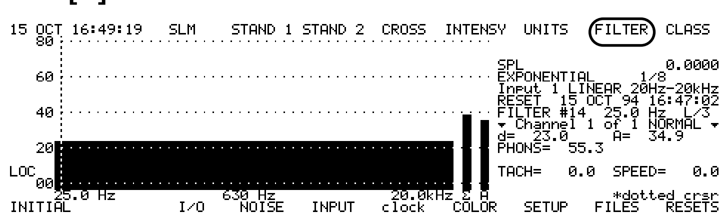



**3.** Press **STAND1[B]** to enable a single channel measurement.



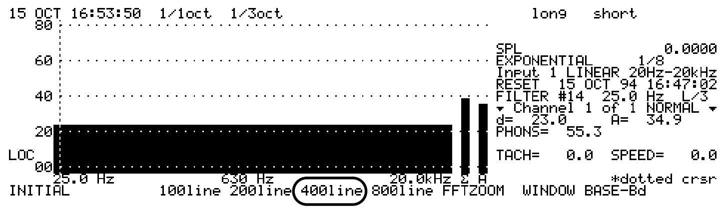




**4.** For this exercise, you will use FFT filters and analyze the data in a range of 0 to 5 kHz. frequency baseband. Press **FIL-TER[G]** to enter the filter menu.



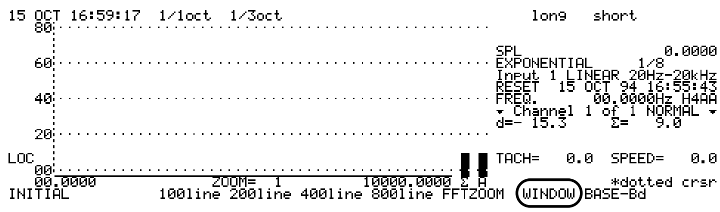
! K

**5.** You will use a 400 line FFT for this test. Press **400line[K]** to establish this frequency resolution choice.



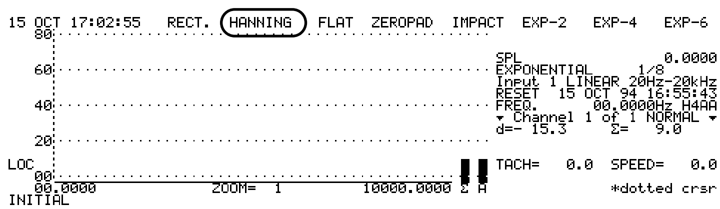

% N

**6.** Choose an FFT window. You will use a Hanning window for this measurement. If Hanning is not already enabled, press **WINDOW[N]** to enter the Window selection menu.



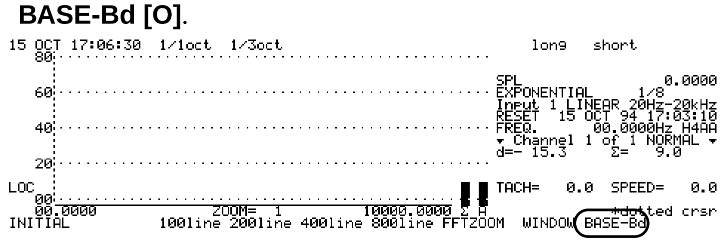

R B

**7.** Press **HANNING[B]** to activate the Hanning window.



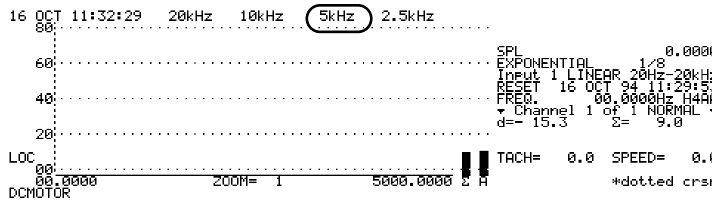

[ O

**8.** As mentioned, you will measure our FFT spectra out to 5 kHz frequency. Let's establish this baseband by pressing **BASE-Bd [O]**.



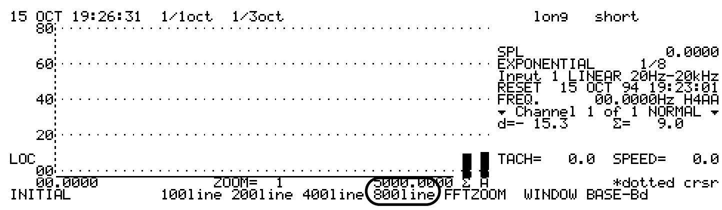
S
C

**9.** Select **5kHz[C]** as the upper band edge frequency.



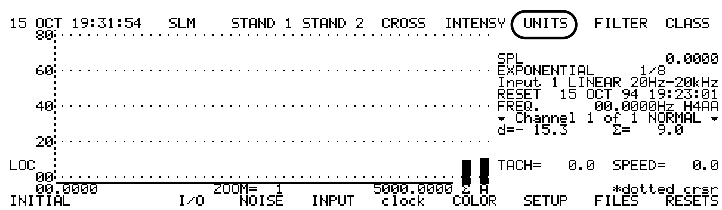

EXIT

**10.** Notice that the frequency scale has changed to reflect this baseband selection. Press **EXIT** to get back to the System menu.



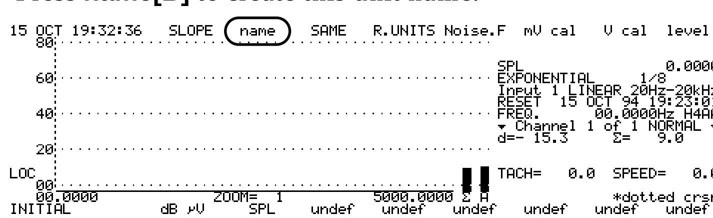

V
F

**11.** Next, let's establish a units label and calibration value for our accelerometer (or whatever transducer you are using). Press **UNITS[F]** to enter the Units selection menu.



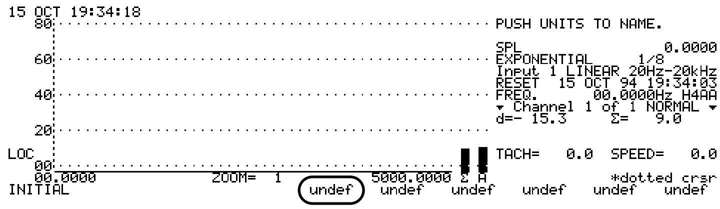

R
B

**12.** For this exercise you will use the acceleration label “G's”. Press **name[B]** to create this unit name.



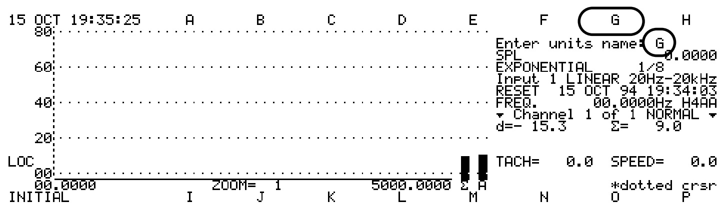
! K

**13.** You will assign this label to one of the undef keys. Press **undef [K]** or another undef key if [K] is already assigned to another label.




W G

**14.** Type in **G[G]** as the units name.

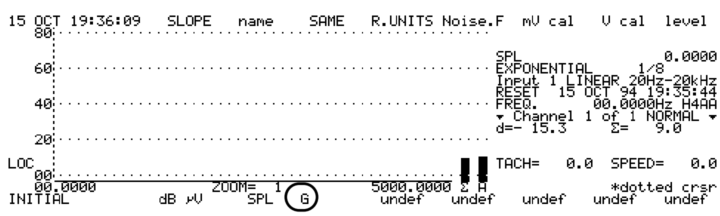



EXIT

**15.** Press **EXIT** to enter this new label.

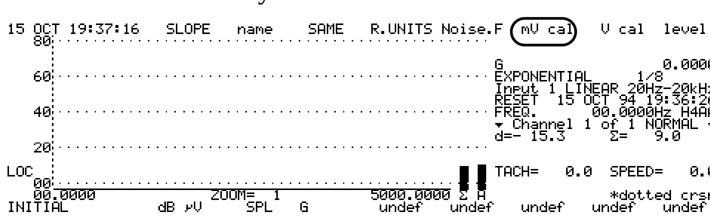
! K

**16.** Now select this new unit key to activate it. Press **G [K]**.

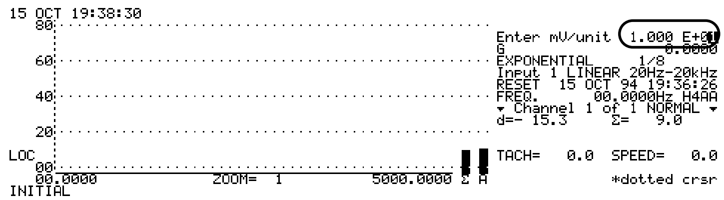



V F

**17.** Next, let's enter a calibration value for the accelerometer. For this test you will use the manufacturers specification of the accelerometer sensitivity of 10 mv / G. Press **mV cal [F]** to enter the mV cal entry field.



**18.** Type in the accelerometer sensitivity value. For this exercise, type in 10 mV/G as 1.00 E+01.




EXIT

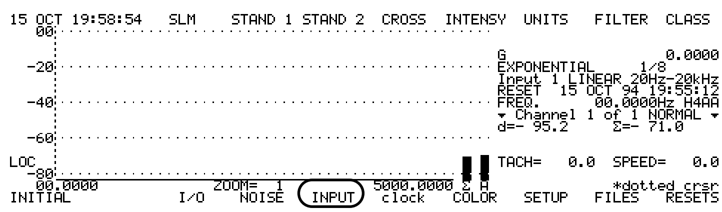
**19.** Press **EXIT** to enter this scale factor.

EXIT

**20.** Press **EXIT** again to return to the System menu.

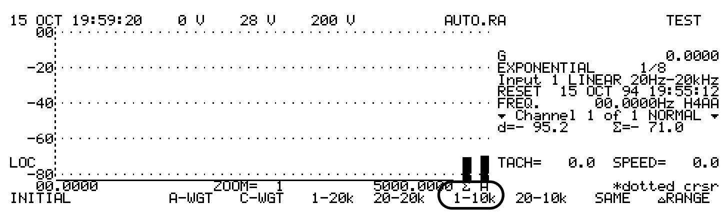
!
K

**21.** Typically with vibration measurements, one is interested in low frequency information. Let's modify our high and low pass filters from the current 20Hz. to 20 kHz. selection. Press **INPUT [K]** to enter the Input menu.




#
M

**22.** Choose **1-10k [M]** to activate a high pass filter at 1 Hz. and a low pass filter at 10 kHz.




EXIT

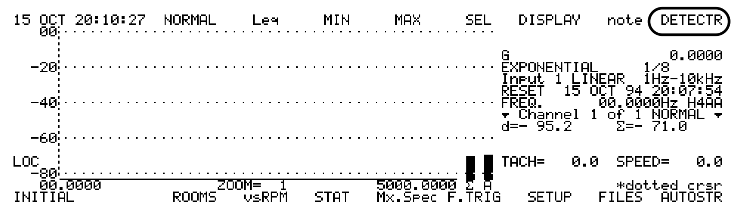
**23.** Press **EXIT** to return to the System menu.

EXIT

**24.** Next, you need to modify the exponential detector integration time to a faster rate than the 1/8 seconds that it is currently set at. Press **EXIT** to enter the STAND1 analysis menu.

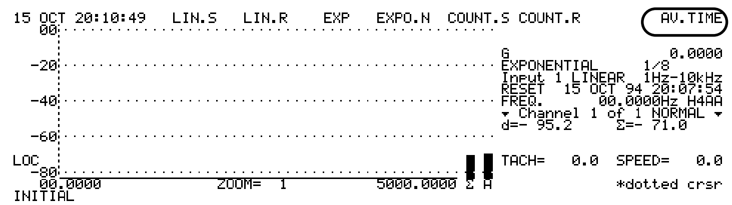
X
H

**25.** Press **DETECTR [H]** to enter the Detector (averaging) menu.



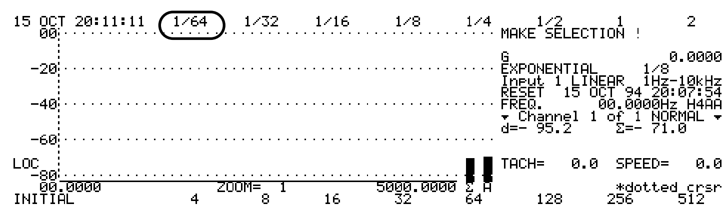

X
H

**26.** Within the Detector menu, choose **AV.TIME [H]** to modify the integration time.




Q
A

**27.** Press **1/64 [A]** to select the fastest exponential detector integration time.



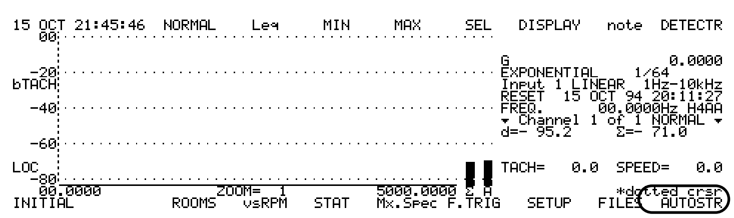

EXIT

**28.** Press **EXIT** to return to the STAND1 analysis menu.

## Setting the byTACH Autostore parameters

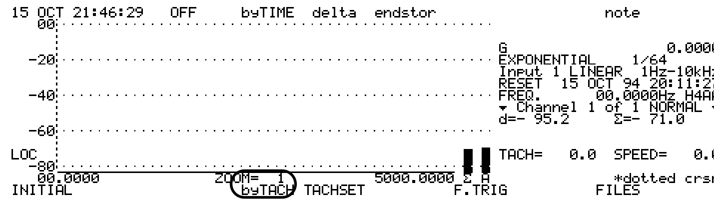
]
P

**1.** As mentioned earlier, you will be utilizing the Autostore byTach feature for this test. Press **AUTOSTR [P]** to enter the autostore menu



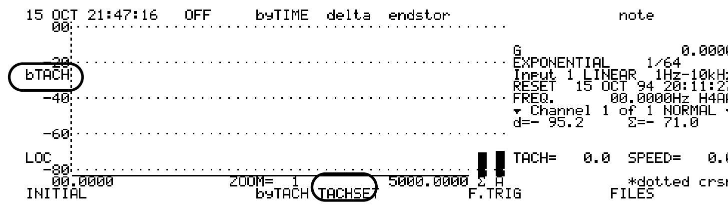
Z
J

**2.** To activate byTACH autostore, press **byTACH [J]**.



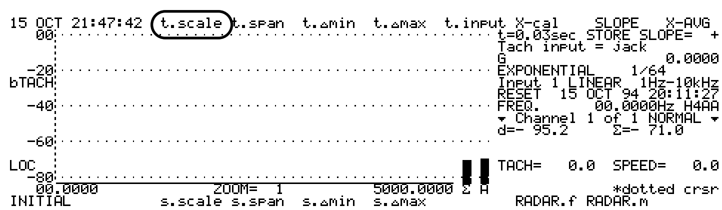

!
K

**3.** Notice that the label bTACH appear on the left side of the display. You next need to configure the tachometer parameters for the autostore acquisition. Press **TACHSET K]** to enter the Tach parameter setup menu.

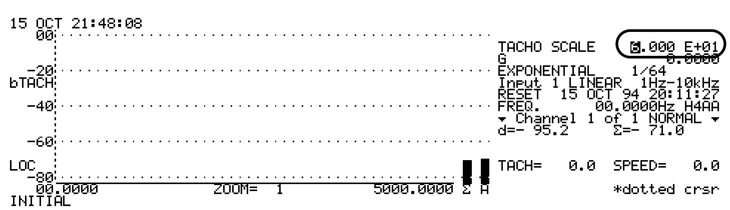



Q
A

**4.** The first item that you need to concern yourself with is the scaling of the tachometer signal as it enters the TACH INPUT of the 3200. The tach signal enters the 3200 with units of frequency (cycles or pulses per second). Since you would prefer to view the tach signal in units of RPM (cycles per minute) you need to apply a scale factor (multiplier) of 60 to the signal (60 x (cycles / sec)= cycles / min). Press **t.scale [A]** to enter the tachometer scaling entry field.

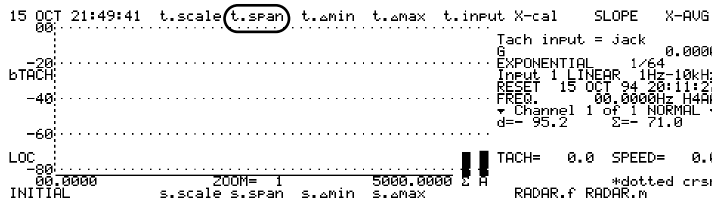



**5.** Type in the scale factor of 60 as 6.000 E+01.

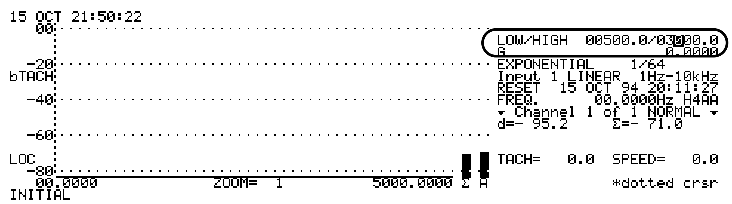


R
B

6. As mentioned at the beginning of this chapter, you will be acquiring spectra from an accelerometer attached to a plate on a dc motor at 20 RPM increments as it sweeps up in speed from 500 RPM to 3000 RPM. The range of 500 to 3000 RPM is our measurement span for the autostore. This range is entered in the t.span field. Press **t.span [B]** to get into the tachometer span entry field.




7. Type in the desired RPM range as LOW / HIGH 00500.0 / 03000.0




EXIT

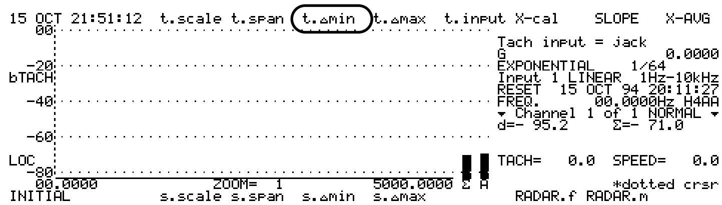
8. Press **EXIT** to enter this span.

As discussed, for this exercise you would like to capture spectra during the autostore at 20 RPM increments. Unfortunately, it is nearly impossible to capture data at exactly 20 RPM steps because of the difficulty to precisely control variable speed machinery. Because of this, you need to establish a range for the autostore “delta” that you would accept a spectrum using the t.Δmin and t.Δmax parameters. For t.Δmin you will use 20 RPM. What you are telling the 3200 here is that the minimum increase in speed of the dc motor is 20 RPM before you will capture a spectrum. t.Δmax establishes a maximum change in RPM that you would accept. Normally, one would choose a large number such as 1000 RPM to insure that something is captured.

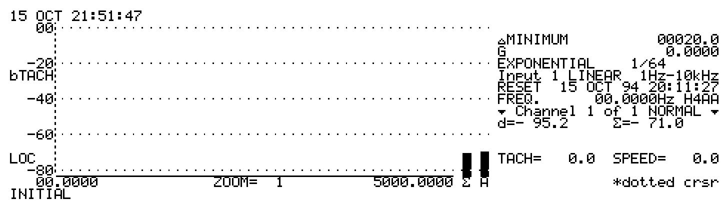
Setting these delta values is particularly important when testing things like chain saws whereby it is extremely difficult for the operator to control the running speed.

S
C

1. Press **t.∆min [C]** to enter the minimum tach delta entry field.

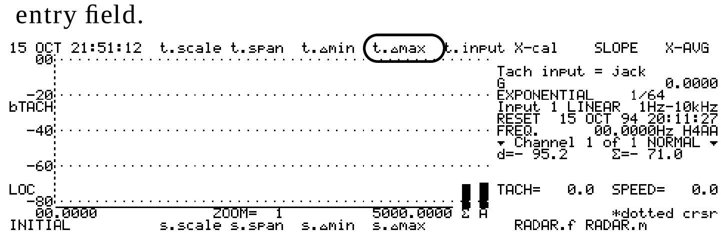



2. Type in 20 RPM as 00020.0 to establish this minimum delta value.

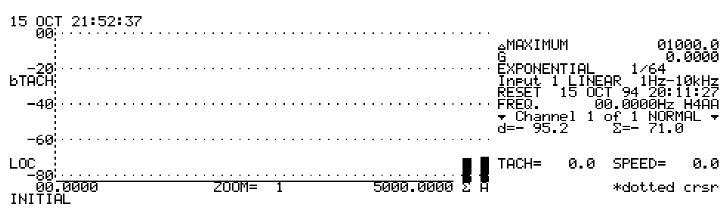



T
D

3. Next, press **t.∆max [D]** to enter the maximum tach delta entry field.

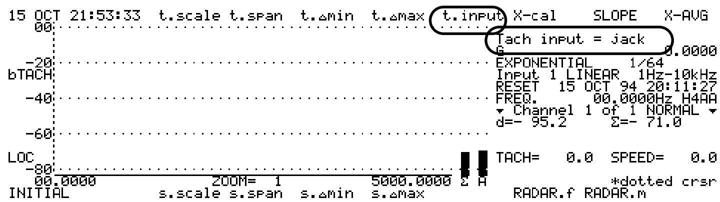



4. Type in 1000 RPM as 01000.0 to establish this maximum delta value.



U
E

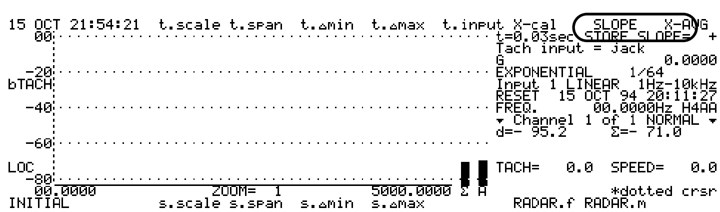
**5.** t.input toggles between the various options for the TACH INPUT. The choices are CH1, CH2, and jack. Press **t.input [E]** to toggle through the choices until jack is selected.




x-cal is a feature that allows you to calibrate a tachometer from a known reference. You feed a known tachometer signal into the TACH INPUT of the 3200. For example, a signal at 1000 RPM exactly is fed into the 3200. Within the x-cal field, the 1000 RPM factor is entered as a reference signal. The 3200 would then be calibrated for this tachometer. You will not use this feature for this exercise. Please refer to the 3200 User Manual for more details on this feature.

W
G

**6.** As established earlier, you will acquire data from the dc motor plate as it sweeps up (runs up) in RPM. You first need to let the 3200 know that you want to trigger the autostore when the speed (RPM) reaches 500 RPM as it sweeps up. In other words, you want the autostore to trigger on the positive slope. If you were doing a rundown measurement you would establish a trigger on the negative slope. Press **SLOPE [G]** and toggle through the choices until “STORE SLOPE = +” is chosen.




X-AVG is used to average out the errors in the tachometer signal that might be caused by DC “jittering”. DC “jitter” is caused by vibrations on the surface of the device that the tach signal is coming. For example, someone is using an optical pickup to capture a tach signal on a rotating shaft, which is vibrating due to looseness, imbalance, etc. You will not use the X-AVG feature for this exercise. Please refer to the 3200 User Manual for more details on this feature.

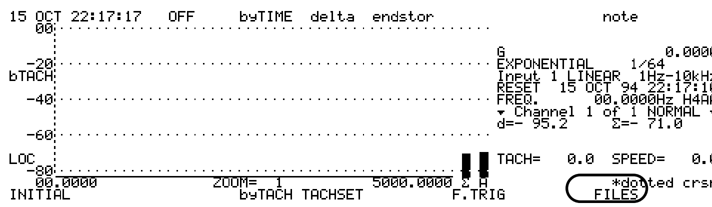
EXIT

You have now established all of the parameters necessary to perform the byTACH Autostore measurement. Before you begin the test, let's create a measurement file where the data records will be stored. Press **EXIT** to return to Autostore menu.

## Creating a Measurement File

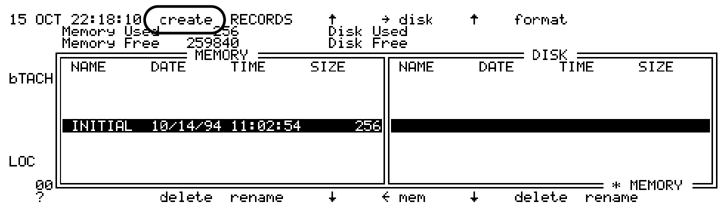
[
O

1. Press **FILES [O]** to enter the Files menu.

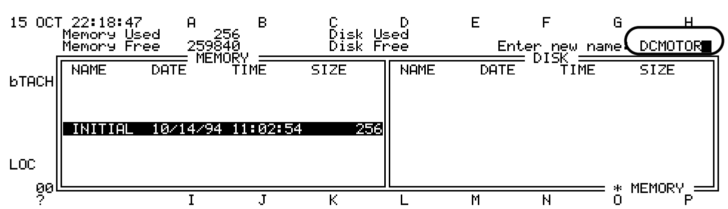


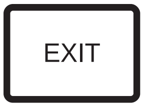

Q
A

2. Next press **create [A]**.

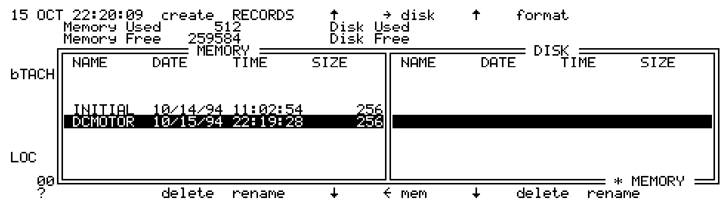



3. Type in a name for the measurement file such as DCMOTOR.



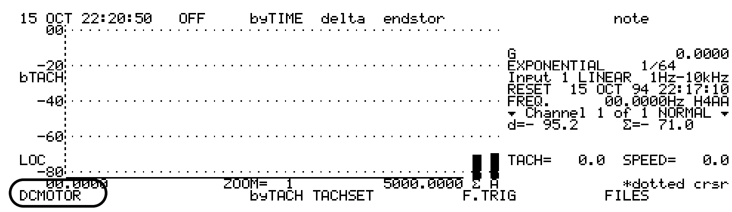



**4.** Press **EXIT** to enter this filename. Notice that the filename and creation date and time appear in the MEMORY file window.





**5.** Press **EXIT** to return to the Autostore menu.Notice that the filename appears at the lower left corner of the display. This indicates that it is the active file where measurement records will be stored.



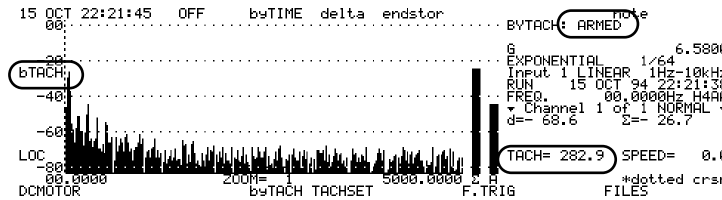

You are now ready to make byTACH autostore measurements.

## Performing the byTACH Autostore Measurement

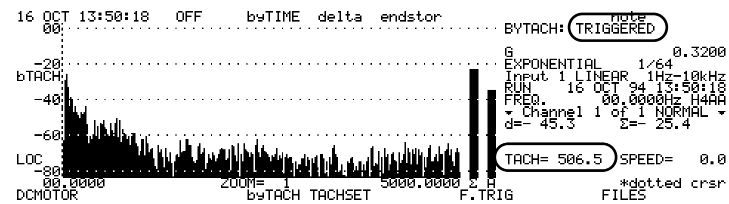
Verify that the output of the tachometer is connected to the TACH INPUT jack of the Model 3200. Also check that the accelerometer is connected (either via a 950B or AD045 adaptor) to the Channel 1 input. Make sure that your tachometer is turned on and is reading an accurate tach signal from the rotating test article that is below the trigger speed (500 RPM).

RESET
R/S

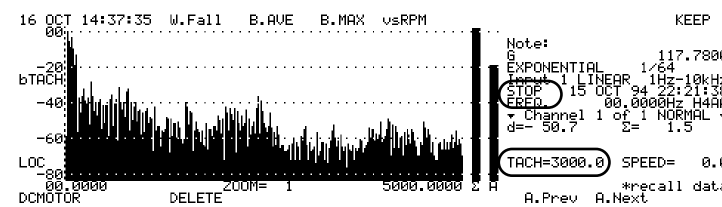
1. Press **R/S** to initiate the measurement. Notice that the FFT from the accelerometer is being displayed on the 3200 screen. Also notice that the trigger is ARMED and waiting. Note the current RPM reading from the tachometer is displayed on the lower right side of the display.




2. Next, you will increase the speed of the DCmotor until the autostored is triggered at 500 RPM. Notice that TRIGGERED appears at the top corner of the display indicated that the byTACH autostore has begun.



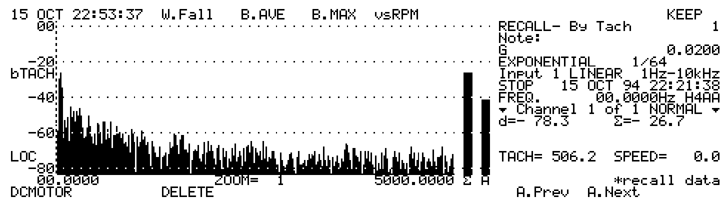

3. As you continue to increase the speed of the DC motor, spectra will be stored in approximate 20 RPM increments until the speed reaches 3000 RPM. At that point the autostore is complete and the data will be automatically stored. Below is the final spectra acquired at 3000 RPM.



## Viewing the byTACH Autostored Data

CLEAR
RECALL

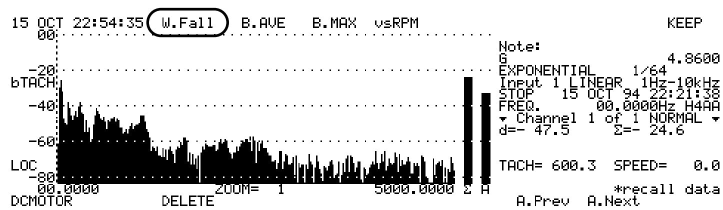
**1.** To view the individual spectra that were autostored during the “run up”, press **RECALL**.




Press the right arrow hardkey to increment through each of the captured spectra.

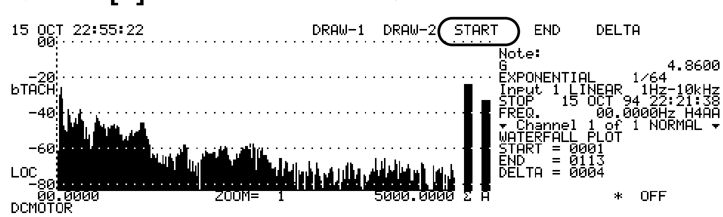
Q
A

**1.** Another interesting way to view the autostored data is to utilize the waterfall display capability of the 3200. Press **W.FALL [A]** to enter the Waterfall display window.

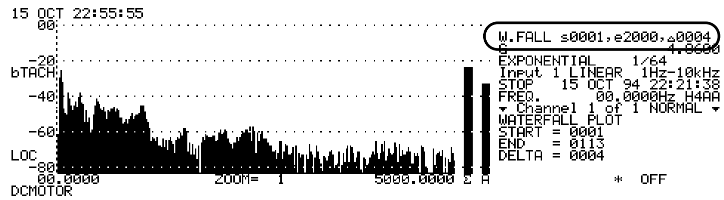



U
E

**2.** First, you need to establish which spectra to show in the display. You do this by establishing a start spectra (typically the first or 1), an end spectra (typically the last or in this case number 113), and a delta. You'll set a delta of 3. This means that it will plot every 3rd spectra in the waterfall map. Press **START [E]** to enter these values.



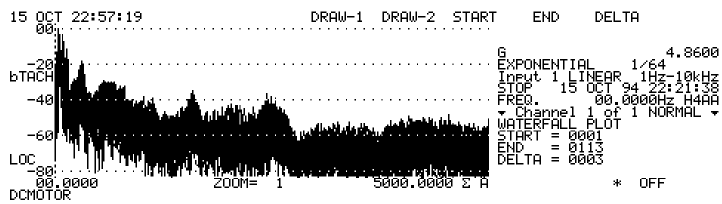
3. These number should be entered as W.FALL s0001, e0113, d0003.

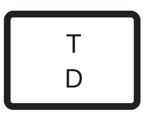




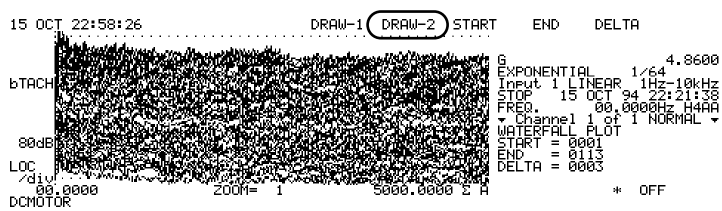
4. Press **EXIT** to enter the waterfall display values and initiate the plot.

Below is the DRAW-1 waterfall display. Notice that it plots the individual spectra on top of one another. Notice how the frequencies have shifted as the speed increased.




5. To view the waterfall map in a skewed, quasi-3D format, choose **DRAW-2 [D]**.





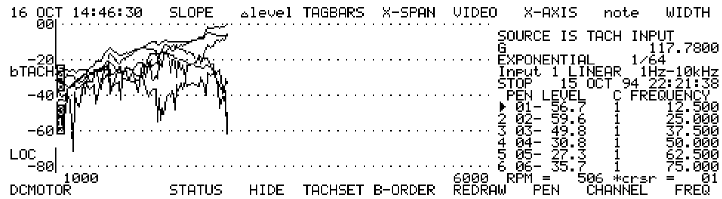
6. Press **EXIT**.

## vsRPM Graphics

Another useful way to view byTACH autostored data is by using the vsRPM graphics display feature of the Model 3200.This feature allows one to view either frequencies or orders in an amplitude vs. RPM format.

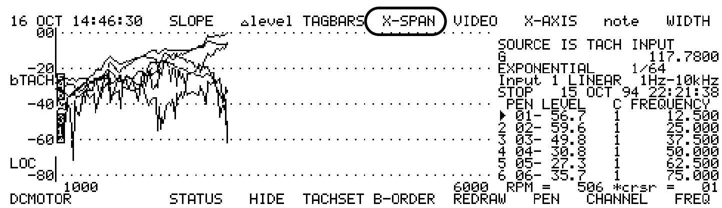
T
D

**1.** Press **vsRPM [D]** to enter the vsRPM Graphics menu.

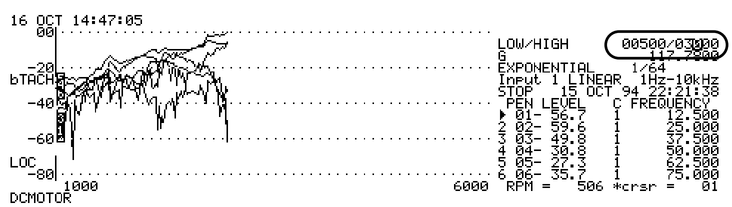



T
D

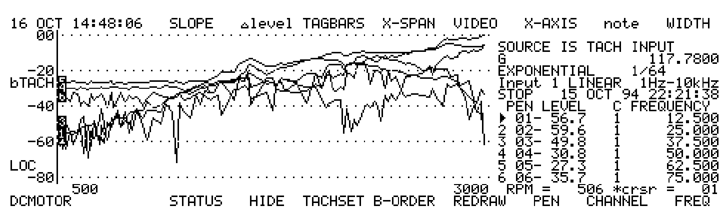
**2.** The data that is displayed in the vsRPM graphics displayed is the data that you just acquired during the vsRPM autostore measurement of the dc motor run up.If the horizontal scaling is different that the 500 to 3000 RPM t.span that you used to acquire the vsTACH data, you'll need to modify the X-SPAN. To do this, press **X-SPAN [D]** to enter the x-axis scaling entry field.

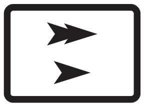



**3.** Type in 00500 / 03000 into the LOW / HIGH entry field.

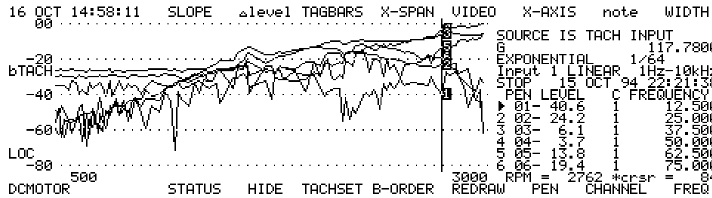



The vsRPM graphics display has some interesting features. First, notice that the display is currently viewing 6 different frequencies (from the accelerometer) as they changed in amplitude during theDC motor run up. The frequencies that are currently displayed are shown on the right of the display. Notice also that each of the 6 traces are labeled accordingly on the left side of the display.

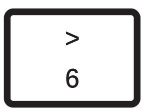




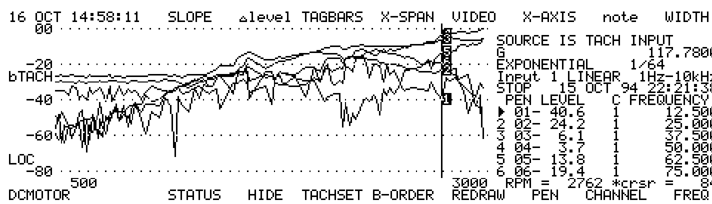
**4.** Push the right arrow hardkey to move the cursor along the RPM axis.The amplitudes of the frequencies at a particular RPM are shown at the right.

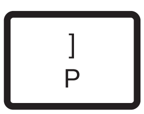



You are currently viewing the following frequency bands in the vsRPM mode: 12.5 Hz., 25.0 Hz., 37.5 Hz., 50.0 Hz., 62.5 Hz., and 75.0 Hz. To change these values so that you can view other frequencies, first select a frequency that you wish to modify. For example, if you would prefer to view the 200 Hz. frequency band instead of the 75 Hz. band, you can make this change by first pressing the numerical PEN key associated with the 75 Hz frequency. In this case it would be PEN 06.

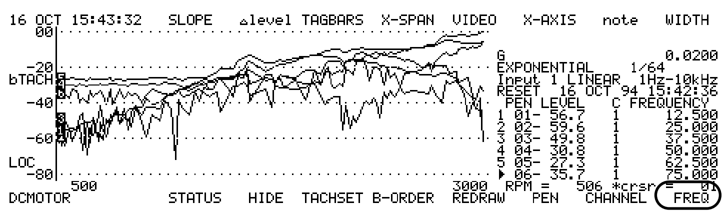



**5.** Press the numerical hardkey **6** to activate PEN 06.

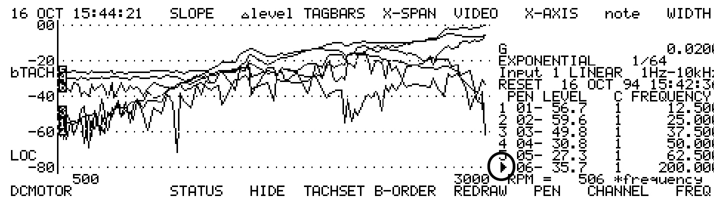


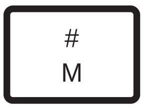




**6.** Then, press **FREQ [P]** to enable the frequency modification mode.

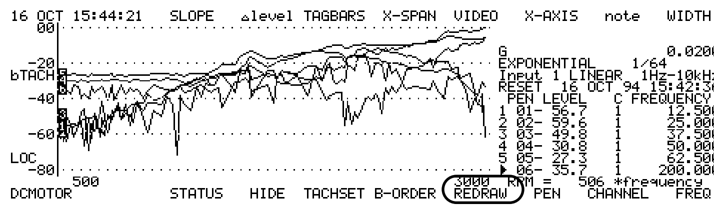


**7.** Next, press the right arrow key until the PEN 06 frequency has changed to 200 Hz.

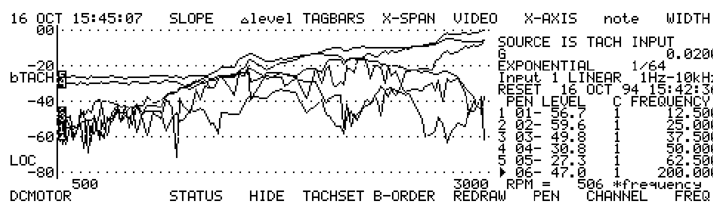



**8.** Press **REDRAW [M]**.




The 6 frequency traces will be redrawn on the display. PEN 06 now contains the 200 Hz frequency band. PENS 01 through 06 can be modified in this fashion to display any frequencies that you wish.

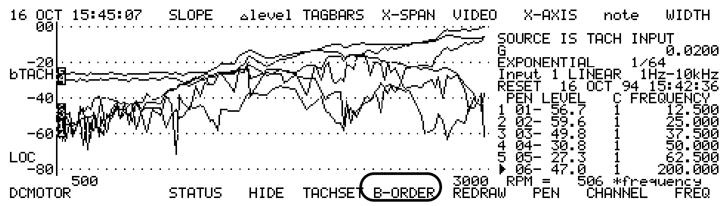



## Post Process Order Tracking

The vsRPM graphics display also allows us to view orders rather than frequencies in the amplitude vs. RPM format. The orders for the byTACH autostored data are calculated using the tachometer information that is appended with each of the frequency spectra that were acquired during the autostore.

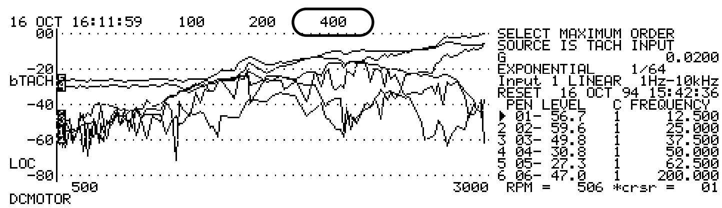
@
L

**1.** To change the display to orders, Press **B-ORDER [L]**.

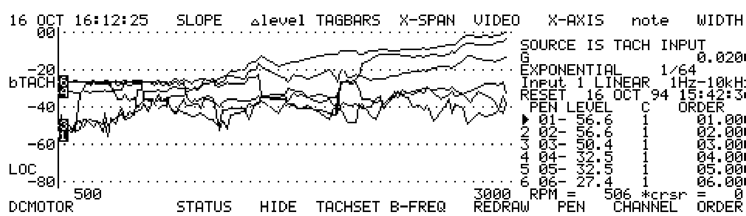



S
C

**2.** The next screen will ask you to SELECT THE MAXIMUM ORDER. Press **400 [C]**.




The vsRPM graphics display is now viewing the first 6 orders (harmonics) as they changed in amplitude during the dc motor run up. The orders that are currently displayed are shown on the right of the display. Notice also that each of the 6 traces are labeled accordingly on the left side of the display.




➤➤
➤

Push the right arrow hardkey to move the cursor along the RPM axis.The amplitudes of the orders at a particular RPM are shown at the right. As you did with the frequency display, you can easily modify the order number that you wish to display in the same way.

## Real-time vsRPM Graphics

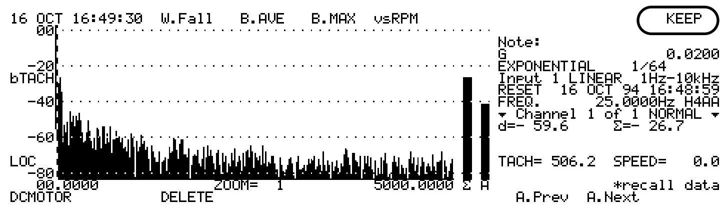
There is a method of acquiring vsRPM data without using the Autostore feature. This technique allows you to view frequency and order curves live as the data is being acquired. You will repeat the dc motor run up test using the Real-time graphics capability of the 3200.

EXIT

1. Press **EXIT** to return to the Autostore display menu.

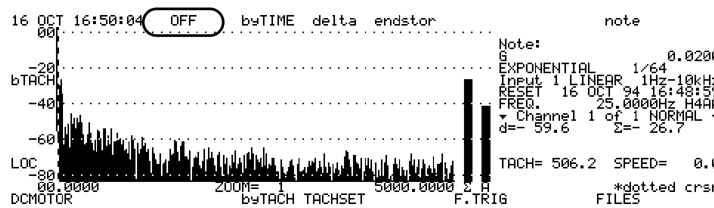
X
H

2. Press **KEEP [H]** to get back to the Autostore enable menu.




Q
A

3. Turn autostore off by pressing **OFF [A]**.



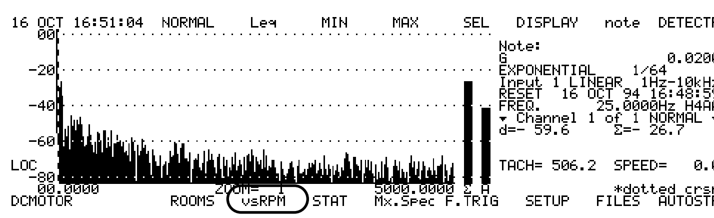

Notice that the bTACH label is removed from the left side of the display.

EXIT

4. Press **EXIT** to return to the STAND1 display menu.

Z
J

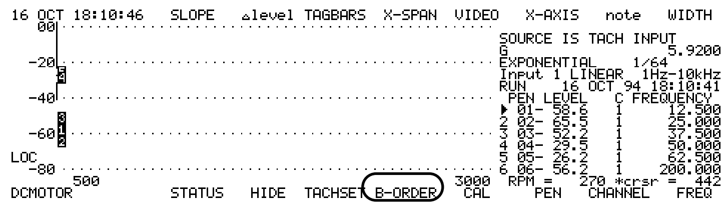
1. Press **vsRPM [J]** to enter the Real-time vsRPM graphics display.




The measurement parameters from the byTACH autostore are still active and will be used for the Real-time vsRPM measurement. Thus, there is no need to modify the parameters. Let's do a live frequency vs. RPM measurement first.

@
L

1. Press **B-ORDER [L]** to change the trace display to frequency.




You will use the current PEN frequencies. If you wish to change them, refer to the previous section (vsRPM Graphics). Note that the frequencies (or orders) need to be established before the test. You cannot change PEN frequencies (or orders) after the measurement is complete and redraw the display as you did with the byTACH autostore data.

Verify that the output of the tachometer is connected to the TACH INPUT jack of the Model 3200. Also check that the accelerometer is connected (either via a 950B or AD045 adaptor) to the Channel 1 input. Make sure that your tachometer is turned on and is reading an accurate tach signal from the rotating test item that is below the beginning of our X-SPAN (500 RPM).

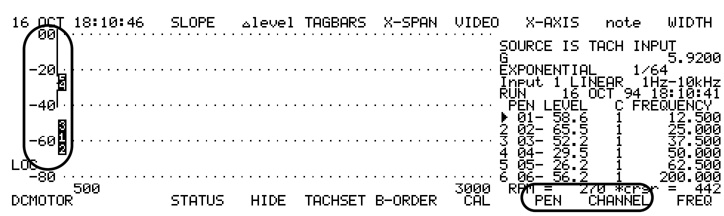
SHIFT

RESET
R/S

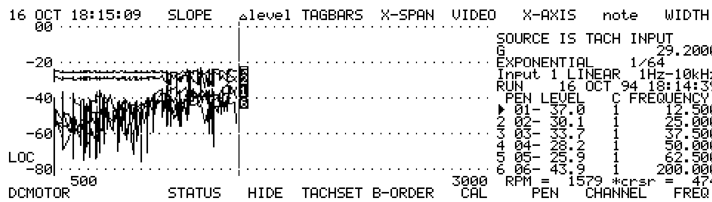
RESET
R/S

2. Press **SHIFT** then **R/S** to reset the measurement.you are now ready to begin the live vsRPM measurement.

3. Press **R/S** to initiate the measurement. Notice that since the RPM of the tachometer signal is below 500 nothing appears on the display although you can see the trace labels on the left side. Note the current RPM reading from the tachometer is displayed on the lower right side of the display.

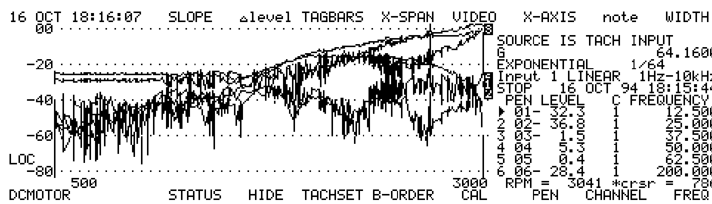


Now as you sweep up the running speed of the dc motor, you can watch as the selected frequencies change in amplitude as you run up from 500 RPM to 3000 RPM.




RESET
R/S

**4.** When the speed of the motor reaches 3000 RPM, press **R/S** to halt the measurement.The completed measurement appears below.




As with the vsRPM autostore test, notice that the display is currently viewing 6 different frequencies (from the accelerometer) as they changed in amplitude during the dc motor run up. The frequencies that are currently displayed are shown on the right of the display. Notice also that each of the 6 traces are labeled on the display

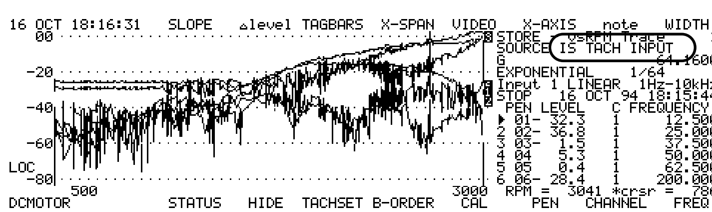
CURSOR

**5.** Press **CURSOR** to activate the dotted cursor. Push the right arrow hardkey to move the cursor along the RPM axis.The amplitudes of the frequencies at each RPM are shown at the right.

&
STORE

**6.** When you are finished viewing the data, press **STORE** to store the measurement record into the DCMOTOR file.

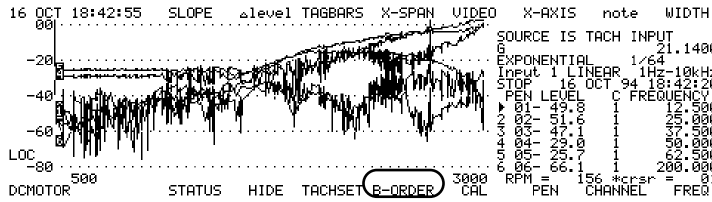
Notice the message “STORE vsRPM Trace 1" appears at the top right corner of the display indicating that the data have been archived.



## Real-time vsRPM Order Tracking

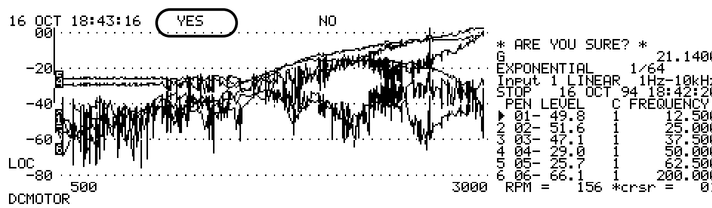
@
L

1. Now, let's do a Real-time vsRPM order analysis. Change from frequency display to order display by pressing **B-ORDER [L]**.



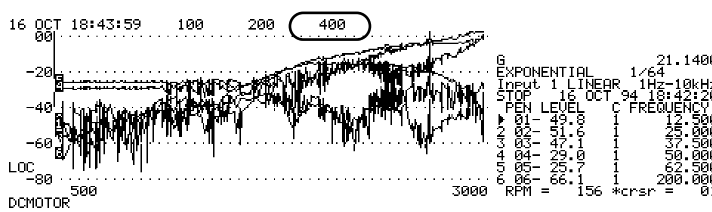

Q
A

2. Press **YES [A]** to answer the question: “ARE YOU SURE?”. You are being scrutinized because answering yes will clear the display. You will lose the data unless you have already saved it to the 3200 memory.




S
C

3. The next screen will ask you to SELECT THE MAXIMUM ORDER. Press **400 [C]**.

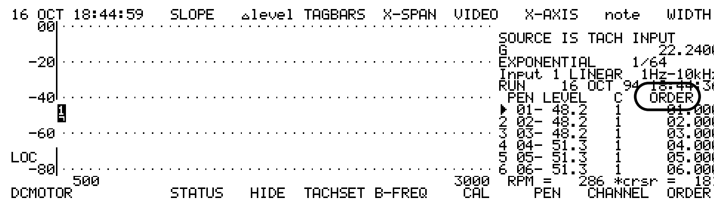



You are now ready to make the measurement. Notice that the FREQUENCY column on the right side of the display has changed to ORDER. The measurement is currently set up to do a live display of orders 1 through 6. If you would prefer to look at different orders, you can change the order number as shown in the earlier section, “vsRPM Graphics”.

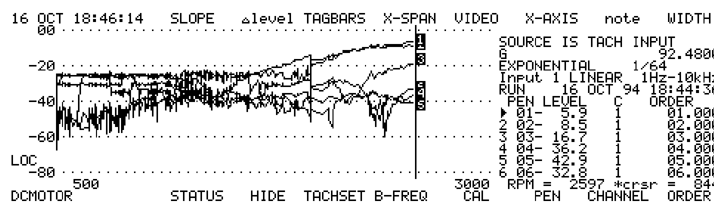
Once again, check that the output of the tachometer is connected to the TACH INPUT jack of the Model 3200. Also check that the accelerometer is connected to the Channel 1 input. Make sure that your tachometer is turned on and is reading an accurate tach signal from the rotating test item that is below the beginning of our X-SPAN (500 RPM).

RESET
R/S

4. Press **R/S** to initiae the measurement. Notice that since the RPM of the tachometer signal is below 500 nothing appears on the display although you can see the trace labels on the left side. Note the current RPM reading from the tachometer is displayed on the lower right side of the display.

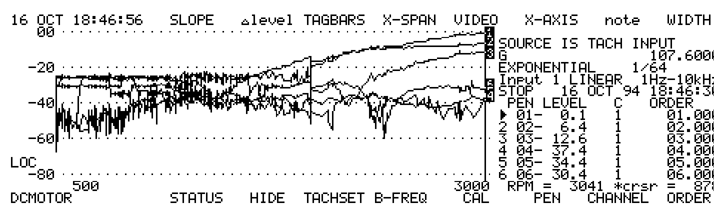



Now as you sweep up the running speed of the dc motor, you can watch as the selected orders change in amplitude as you run up from 500 RPM to 3000 RPM.



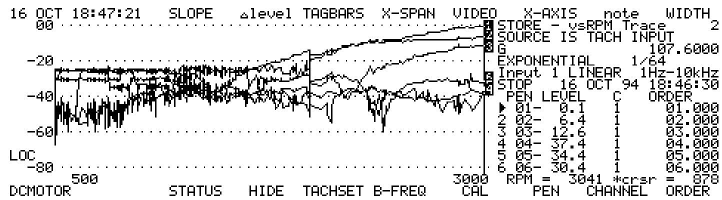

RESET
R/S

5. When the speed of the motor reaches 3000 RPM, press **R/S** to halt the measurement.The completed measurement appears below.




The display is currently viewing 6 different orders as they changed in amplitude during the dc motor run up. The orders that are currently displayed are shown on the right of the display (orders 1 through 6). Notice also that each of the 6 traces are labeled on the display.


**6.** Press **STORE** to archive the measurement to the DCMOTOR file.




Notice the message “STORE vsRPM Trace 2” appears at the top right corner of the display indicating that the data has been saved.

# Index

PostScript error (--nostringval--, --nostringval--)