CHAPTER

# 13 AUD (Optional)

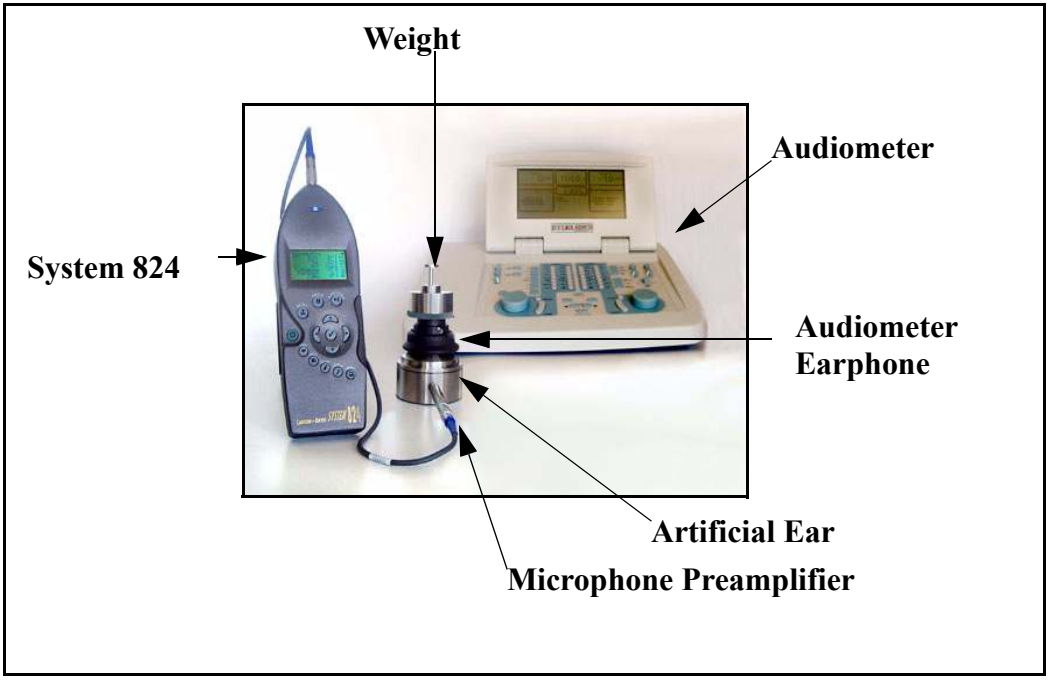
The System 824 precision sound level meter with the 824-AUD firmware option is the heart of the Larson-Davis audiometer calibration system. This instrument and its firmware maintain and exceed the performance of previous Model 800B-based systems when used with the AUDit™ software. However, the System 824 with 824-AUD firmware alone still possesses numerous analysis features useful for audiometer testing tasks such as:

- Level
- Frequency
- Linearity
- Total harmonic distortion
- Pulse measurements
- Crosstalk
- Frequency modulation
- Narrow band, broad band and speech noise

Some of these tests are slightly more tedious when performed manually. The following overview of the 824-AUD instrument should be augmented by familiarizing yourself with the 824 Reference Manual.

# Connecting the Test System

For performing audiometric calibration measurements, connect the components as shown below.

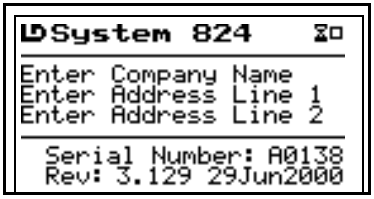



The microphone is threaded into a connection inside the artificial ear and the microphone preamplifier is inserted into the opening on the side of the artificial ear base and threaded into place. A microphone extension cable connects the microphone preamplifier to the input of the System 824.

One of the audiometer earphones, connected to the audiometer via a cable (not visible here), is placed on top of the artificial ear and then the weight is placed on top to hold it firmly in place.

# Selecting the 824-AUD Operation Mode

To enable the 824 audiometer testing firmware option, turn on the 824.



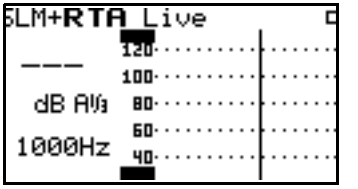

After the start screen is appears, press SETUP and use the arrow keys up/down arrows to highlight the AudTest.AUD setup (or your customized AUD setup).


Press the check key to retrieve the AudTest.AUD setup. The Linearity FFT display will appear.

## Microphone Sensitivity Calibration

Press the VIEW key ⦿ to open the View Menu.


Highlight SLM/RTA and press the check key ✓ to obtain the SLM+RTA Live screen shown below.




*A more detailed description of the calibration procedure can be found in the section "Turning On and Calibrating the System 824" on page 4-1.*

This screen shows the third octave spectrum. In this example, the measurement is reset and the cursor is placed on the 1000 Hz third octave frequency. At this time, the instrument should be calibrated manually.

Press the Tools key ✓, use the down ▼ arrow key to highlight “Calibration”, press the check key ✓ twice, use the down ▼ arrow key to highlight “Change” and press the check key ✓. Follow the prompts to perform the calibration.. Please refer to the 824 Reference Manual for information on calibrating the instrument.

## AUD Modes

There are three measurement modes for the AUD instrument:

- SLM+RTA — used to measure 1/3 octave spectra and broadband weighted SPL.
- FFT — used to measure constant bandwidth narrow band spectra with special functions to perform attenuator linearity, frequency flatness and harmonic distortion measurements.

- Pulse/FM —— used to measure pulse and frequency modulation functions of the audiometer.

The mode is controlled by the display being shown. The View menu is divided into three sections for the three modes and can be used to select the display needed for a particular measurement. Most of the displays are also grouped together and alternately accessed by pressing the up ⏶ and down ⏷ arrow keys.

## View Menu

The structure of the View menu is described below. Press the VIEW key ⦿ to open the View Menu.


**SLM/RTA Submenu**

Highlighting SLM/RTA and pressing the right arrow key ⏵ will produce the SLM+RTA Submenu.


**FFT Submenu**

Highlighting FFT and pressing the right arrow key ⏵ will produce the FFT Submenu.


**Pulse/FM Submenu**

Pulse/FM has no submenu. Pressing he right arrow key ⏵ will produce the Pulse/FM - a display screen.

The display screens associated with these menus will be described in detail in the following sections.

## Display Sequence

The primary displays are grouped together and will cycle through the following in sequence by pressing the down arrow key ⏷ (the up arrow key ⏶ will sequence these displays in the opposite order):

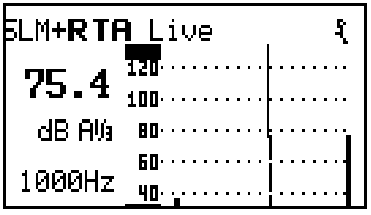
*Note: The FFT Display mode can be accessed from the VIEW menu or from the THD check menu. See "FFT Display" on page 25 for details on this display type.*

- **SLM+RTA Live**
- **Any Level-a, Any Level -b**
- **Linearity RTA**
- **Linearity FFT** (activated by default when AUD is activated)
- **Flatness FFT**
- **THD**
- **Pulse/FM**

## SLM+RTA Live Display

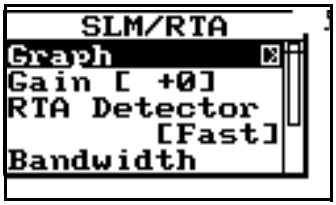
The SLM+RTA Live display provides a display of the real-time fractional octave spectrum. To access this display, press the VIEW key ⦿ to obtain the display shown below.

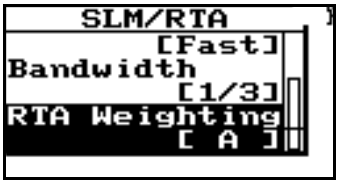

Then select the SLM/RTA with the up/down arrows ⏶ ⏷ and press the check key ✓. This will produce the SLM+RTA Live Display shown below.




The right and left arrow keys control the filter cursor.

The check menu (accessed by pressing the check key ✓ while this display is active) provides the setting choices shown in the next two screen shots.




**SLM+RTA Live Check Menu**

The SLM+RTA Live check menu items are:

- **Graph** -Allows control over the resolution and scaling of the spectrum graph.
- **Gain** -Changes the gain setting of the instrument. Generally use 0dB gain for levels at 70dB SPL and above, and 30dB gain for levels less than 70dB SPL. The Auto Gain Control (AGC) function of the linearity displays step between 0 and 30 dB gain, if the gain setting is something other than 0 or 30 the AGC function is inhibited.
- **RTA Detector** -This setting controls the rate of change of RTA filter output, Slow or Fast, which provides 1 second or 1/8th second exponential time constants, respectively.
- **Bandwidth** -The fractional octave bandwidth of 1/1 or 1/3 are selected with this setting.
- **RTA Weighting** -This setting selects either A, C or Flat frequency weighting as a filter prior to fractional octave filtering.

To measure the level in dB (re. 20 micro Pascals), place the cursor on the frequency of interest and read the frequency and value on the left hand side of the screen. Levels must be

corrected by using coupler/earphone RETSPLs and microphone or other such corrections to arrive at the dB HL value.

*Several different linearity measurements can also be performed as described in "Linearity RTA Display" on page 13-10, "Linearity FFT Display" on page 13-14and "Flatness FFT Display" on page 13-18.*

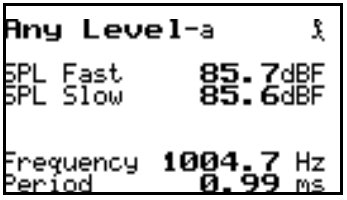
Linearity evaluation can easily be performed by placing the cursor on the audiometric presentation frequency, then varying the hearing level output and monitoring the measured level on the 824.

Similarly, cross talk measurements are performed with the non-test earphone being measured, then comparing the test earphone level to that measurement.

## Any Level -a, -b and -c Displays

The Any Level Displays -a, -b and -c are accessed from the SLM+RTA Live display by pressing the down arrow key ⊛

The Any Level -a display, shown below, displays Flat weighted broadband SPL values for Fast and Slow simultaneously.

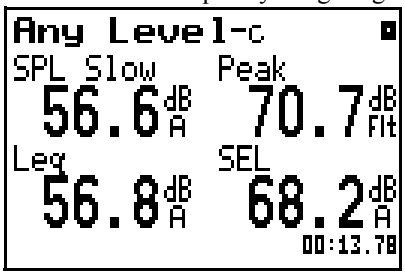



The Any Level -b display, shown below, displays the Fast SPL for A, C and Flat frequency weightings simultaneously.


*Frequency is also available on the FFT mode displays using a more stable FFT frequency calculator.*

Both the -a and -b displays show the output of the frequency counter, showing Frequency and Period. The frequency counter is a hardware count based on zero crossing; significant amplitude is needed to ensure an accurate reading.

The Any Level -c display, shown below, displays the Slow SPL, Leq and SEL for the selected frequency weightings and the peak level with its frequency weighting.




Use the right and left arrow keys to step between the -a, -b and -c displays.

Press the check key ✓ to access the check menu, shown below.


## Any Level Check Menu

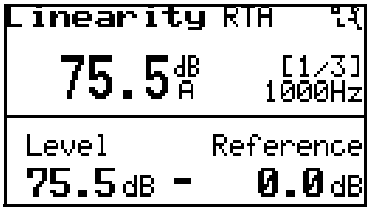
The Any Level check menu items are:

- **Gain** -Changes the gain setting of the instrument.
- **Weighting** -This setting selects either A, C or Flat frequency weighting for the sound level meter and FFT (not used by the Any Level displays).

## Linearity RTA Display

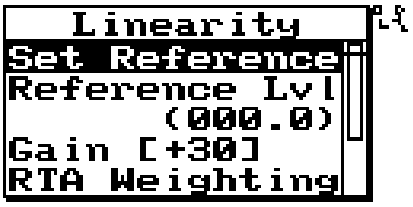
*The Linearity RTA display can also be accessed from the View Menu as shown in "View Menu" on page 13-5.*

The Linearity RTA display, shown below, is accessed from the Any Level a and b Displays by pressing the down arrow key ⏷ .




The Linearity RTA display shows the level of the highest fractional octave RTA data relative to a set reference level. Also shown are the filter frequency of the selected level and the RTA Bandwidth setting. The frequency weighting set by the RTA Weighting setting is used; Flat by default. For testing attenuator linearity at 1 kHz, it is recommended to use A weighting to reduce low frequency ambient noise that my be coupled into the microphone.

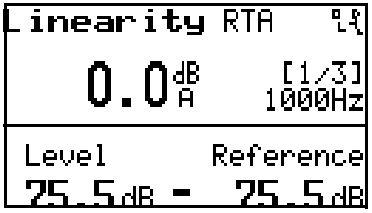
Set the reference level to the current level by pressing the check key ✓. This will open the Linearity RTA check menu, shown below.




Highlight “Set Reference” and press the check key ✓ again.

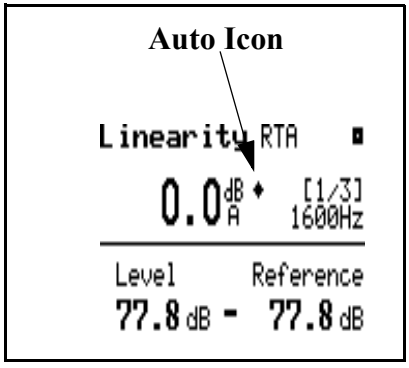
The reference can also be set to an absolute level using the "Reference Lvl" setting on the check menu.

Once the reference has been set the level is shown relative to the reference level as shown below.




This display is used to measure the attenuator linearity of an audiometer. The highest amplitude fractional octave RTA bin is found and displayed in the lower left corner of the display. The chosen reference level is displayed in the lower right corner.

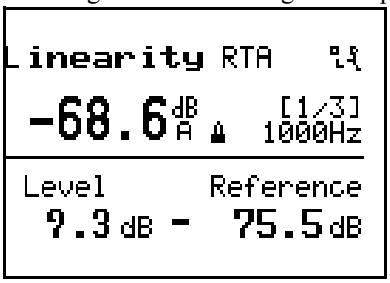
This display has a manual and an automatic filter lock feature to lock to the desired filter frequency when going to low amplitudes when other noise signals—ambient noises or vibrations present in the environment—may be higher than the signal being output by the audiometer. The right and left arrow keys control the lock mode. Press right once to manually lock to the current frequency; a lock icon will appear. Press the left arrow key once to activate the automatic lock mode, a diamond shaped icon will appear.




The lock mode will step in sequence from unlocked to manual locked to automatic and back to unlocked with the right arrow. The left arrow will sequence through the modes in the reverse order.

**Manual Lock**

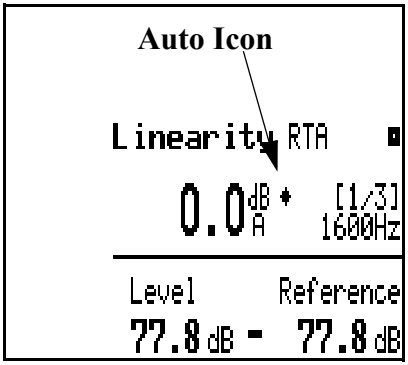
For manual operation select unlock while at a high amplitude (70dB HL or above) where the highest amplitude filter can be detected easily. When the correct frequency is displayed press the right arrow to manually lock the filter so that it does not change when measuring low amplitudes.




AGC is not active in the manual unlock or lock modes.

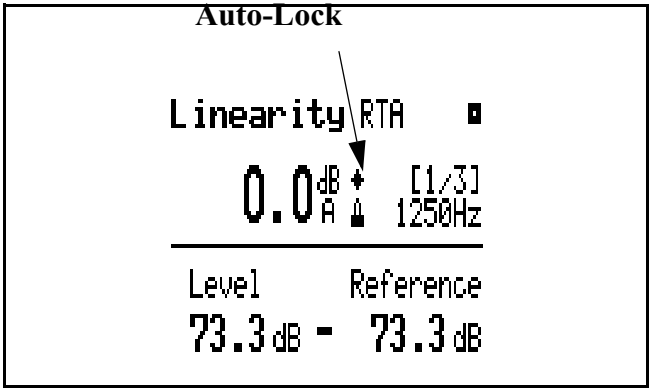
**Automatic Lock**

For automatic operations select the auto mode by pressing the left (or right) arrow key until the diamond icon appears as shown below.




A trigger level setting is found on the check menu that defines the amplitude below which the lock is set. When above the trigger level the filter frequency will track the highest amplitude signal. When the level of that filter drops below the trigger level the lock is activated and the filter

frequency is unchanged. The icons will show this condition with the lock and diamond icons as shown below.

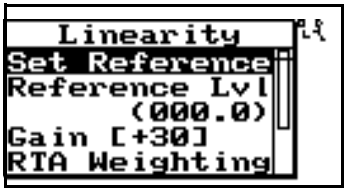



Note: To change to another filter in auto mode, just increase the amplitude until the level is above the trigger level.

When in automatic mode the Automatic Gain Control will be activated. When the gain is set to 0dB, it will be changed to +30dB when the signal is more than 45dB below the overload level for 1.5 seconds. When the gain is set to +30dB, the gain will be changed to 0dB whenever the instrument becomes overloaded or the level is within 8dB of the overload level for 1.5 seconds. The instrument will beep once when the gain is changed automatically to 0dB and twice when it is automatically changed to +30dB.

**Linearity RTA Check Menu**

Press the check key ✓ to open the Linearity RTA check menu, shown below.




The Linearity RTA check menu contains the following items:

- **Set Reference** -Set the reference level to the current level, i.e. zero the display.
- **Reference Lvl** -Reference level setting that may be entered manually.

- **Gain** -Changes the gain setting of the instrument. Generally use 0dB gain for levels at 70dB SPL and above, and 30dB gain for levels less than 70dB SPL. The Auto Gain Control (AGC) function of the linearity displays step between 0 and 30 dB gain, if the gain setting is something other than 0 or 30 the AGC function is inhibited.

- **RTA Weighting** -This setting selects either A, C or Flat frequency weighting as a filter prior to fractional octave filtering.

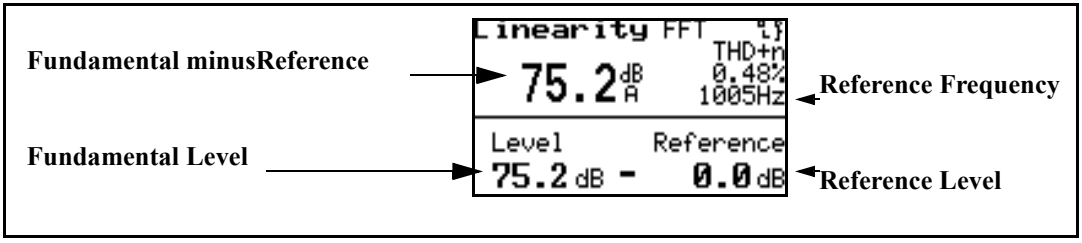
- **Trigger Level** -The Trigger Level setting defines the level below which the automatic frequency lock becomes active.

## Linearity FFT Display

*The Linearity FFT display can also be accessed from the View Menu as shown in "View Menu" on page 13-5.*

The Linearity FFT display, shown below, is accessed from the Linearity RTA display by pressing the down arrow key ⊙ to produce the display shown below.

.

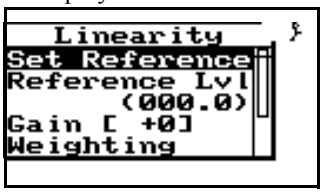



The Linearity FFT display shows the relative level of the highest FFT bin and the true frequency of the input signal derived from FFT data. The frequency weighting selected by the Weighting setting is used, A by default, to offer reduced out of band noise influence.

This display is used to measure the attenuator linearity of an audiometer. The highest amplitude FFT bin is found and its level is displayed in the lower left corner of the display. The chosen reference level is displayed in the lower right corner. A precise measurement of the frequency is displayed to the center right of the display. If the level is greater than the

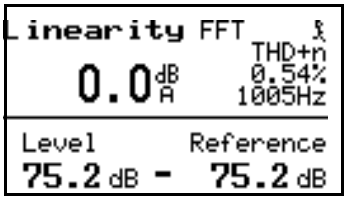
trigger level setting the THD plus noise value will be displayed in the upper right corner.

To set the reference level to the current level first press the check key ✓ to display the check menu shown below.



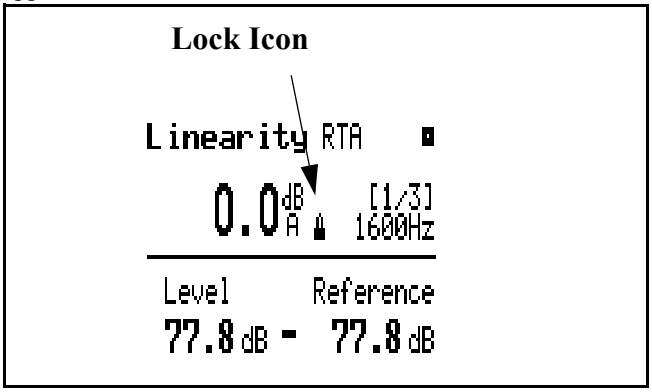

Then highlight "Set Reference" and press the check key ✓ once more. The reference can also be set to an absolute level using the "Reference Lvl" setting on the check menu. This zero level may be set at the 70dB HL point as a reference.

Once the reference has been set the level is shown relative to the reference level as shown below.




This display has a manual and an automatic filter lock feature to lock to the desired filter frequency when going to low amplitudes where other noise signals—ambient noises or vibrations present in the environment—may be higher than the signal being output by the audiometer. The right and left arrow keys control the lock mode. Press right once to

manually lock to the current frequency; a lock icon will appear as shown below.




Press the left arrow key once to activate the automatic lock mode, a diamond shaped icon will appear. The lock mode will step in sequence from unlocked to manual locked to automatic and back to unlock with the right arrow. The left arrow will sequence through the modes in the reverse order.

**Manual Lock**

For manual operation select unlock while at a high amplitude (70dB HL or above) where the highest amplitude filter can be detected easily. When the correct frequency is displayed press the right arrow to manually lock the filter so that it does not change when measuring low amplitudes. AGC is not active in the manual unlock or lock modes.

**Automatic Lock**

For automatic operations select the auto mode by pressing the left (or right) arrow key until the diamond icon appears. A trigger level setting is found on the check menu that defines the amplitude below which the lock is set. When above the trigger level the filter frequency will track the highest amplitude signal. When the level of that filter drops below the trigger level the lock is activated and the filter frequency is unchanged. The icons will show this condition with the lock and diamond icons.

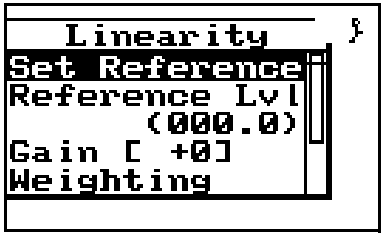
Note: To change to another filter in auto mode, just increase the amplitude until the level is above the trigger level.

When in automatic mode the Automatic Gain Control will be activated. When the gain is set to 0dB, it will be changed to +30dB when the signal is more than 45dB below the overload level for 1.5 seconds. When the gain is set to

+30dB, the gain will be changed to 0dB whenever the instrument becomes overloaded or the level is within 8dB of the overload level for 1.5 seconds. The instrument will beep once when the gain is changed automatically to 0dB and twice when it is automatically changed to +30dB.

### Linearity FFT Check Menu

Press the check key ✓ to open the Linearity FFT check menu, shown below.




The Linearity FFT check menu contains the following items:

- **Set Reference** -Set the reference level to the current level, i.e. zero the display.
- **Reference Lvl** -Reference level setting that may be entered manually.
- **Gain** -Changes the gain setting of the instrument. Generally use 0dB gain for levels at 70dB SPL and above, and 30dB gain for levels less than 70dB SPL. The Auto Gain Control (AGC) function of the linearity displays step between 0 and 30 dB gain, if the gain setting is something other than 0 or 30 the AGC function is inhibited.
- **Weighting** -This setting selects either A, C or Flat frequency weighting as a filter prior to FFT filtering.
- **Trigger Level** -The Trigger Level setting defines the level below which the automatic frequency lock becomes active.

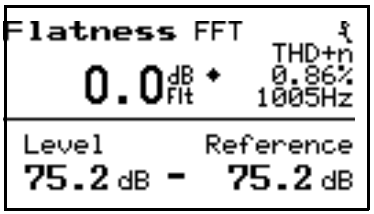
Note: The Linearity FFT display when using A or C weighting should not be used to measure frequency response and is not good to use for absolute amplitude measurement. Always zero the display at your reference point and use the relative level to see changes in amplitude relative to that reference. Note also that the FFT's A and C weighting filters

may have up to ±0.2dB variation compared to the FFT Flat weighting (due to component variations and tolerance).

## Flatness FFT Display

*The Flatness FFT display can also be accessed from the View Menu as described in "View Menu" on page 13-5.*

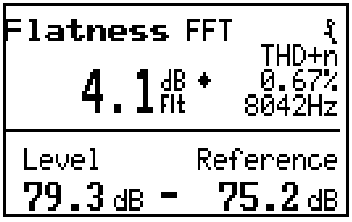
The Flatness FFT display, shown below, is can be accessed from the Linearity FFT display by pressing the down arrow key ⏷ .

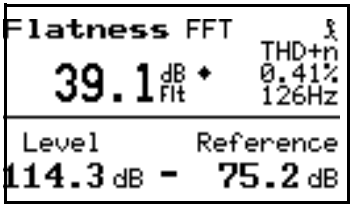



The Flatness FFT display shows the relative level of the highest FFT bin, the true frequency of the input signal derived from the FFT data and the THD plus noise metric. The frequency weighting for this display is forced to Flat regardless of the Weighting setting.

This display is used to measure the frequency response of an audiometer. The highest amplitude FFT bin is found and its level is displayed in the lower left corner of the display. The chosen reference level is displayed in the lower right corner. A precise measurement of the frequency is displayed to the center right of the display. If the level is greater than the trigger level setting the THD plus noise value will be displayed in the upper right corner.

The example display shown above is for a measurement at 1kHz. Measurements at 8kHz and 125Hz would appear as shown below.



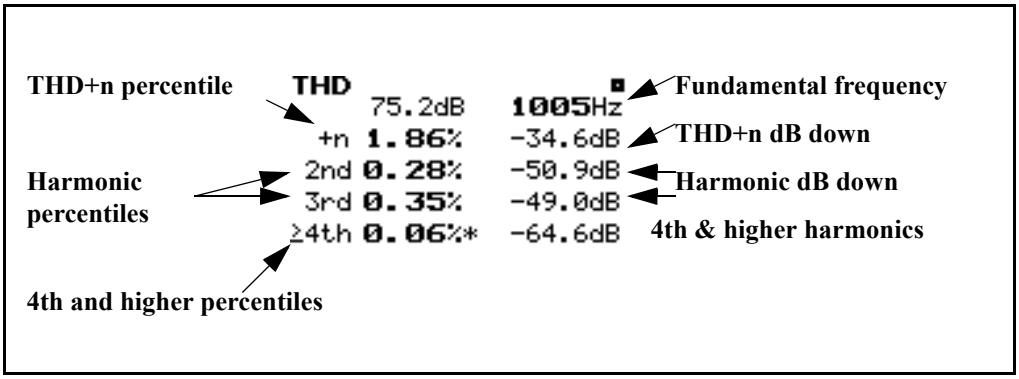



The operation and menus for this display are the same as Linearity FFT; please refer above for operation instructions.

## THD Display

The THD display, shown below, is accessed from the Flatness FFT display by pressing the down arrow key ⏷

.




The THD display provides harmonic distortion measurements of an audiometer and its phones. The FFT capabilities of the 824 are used to measure the fundamental level, fundamental frequency and harmonics. THD data is output in dB down from the fundamental level and in percent. The display also shows the level and frequency of the fundamental. An asterisk following a THD percentage indicates that influences of system noise floor are present.

Results are reported in dB down difference and units of percentile. The dB down difference is calculated by subtracting the harmonic level from the fundamental level. The percentage is equal to one hundred times ten raised to

the power of the result of the dB down difference divided by twenty.

*Entering the THD display will auto-position the cursor to the fundamental frequency on the FFT screen.*

THD is calculated by scanning the full spectrum to find the fundamental frequency and selecting the highest peak. The actual frequency is extrapolated from the fundamental bin frequency and the highest sideband bin frequency. The second harmonic is found by doubling the fundamental frequency, then finding the nearest bin frequency and summing its level with its side-band levels. The third harmonic is found by tripling the fundamental frequency, then finding the nearest bin frequency and summing its level with its side-band levels. The fourth and higher harmonics are found by the process described above by summing the energy of these harmonics.

THD+n is calculated by summing the energy of the fundamental bin with the five bins on each side, then subtracting the energy sum of all the other levels.

*The THD as calculated in the 824 satisfies all of the requirements for ANSI S3.6.*

For THD to be calculated, the following criteria must be met:

- The window must be in Hanning mode after an overall reset. If not, "Available only in Hanning Window" is shown.
- The fundamental must be above the 4$^{th}$ bin or 10 Hz, whichever is higher. In the case where the fundamental frequency is near the 5$^{th}$ bin and it's skirt extends into some or all of the first four bins, the fundamental energy sum calculation will include only the 3$^{rd}$ and/or 4$^{th}$ bins but not the 1$^{st}$ or 2$^{nd}$ bin. In any case the noise energy sum calculation will never include the first four bins.
- The fundamental must be higher than any of the first four bins. There must not be excessive DC or near DC levels.
- THD+n must be at least 10 dB below the fundamental level. There must be an identifiable tone.
- The fundamental frequency will be displayed whether there is an identifiable tone or not.

- If a harmonic is less than 10 dB above the noise floor, the level of the harmonic is marked with an asterisk. The noise floor is calculated as the maximum of the minimum in the two adjacent valleys.
- If one of the harmonic's side-bands is higher than the harmonic then the harmonic is marked with an asterisk.

### THD Check Menu

Press the check key ✓ to open the THD check menu. This menu contains the following items.

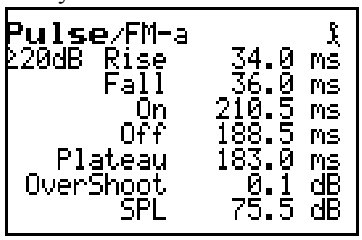
- **View FFT** -View the current FFT spectrum.
- **Gain** -Changes the gain setting of the instrument. Generally use 0dB gain for levels at 70dB SPL and above, and 30dB gain for levels less than 70dB SPL. The Auto Gain Control (AGC) function of the linearity displays step between 0 and 30 dB gain, if the gain setting is something other than 0 or 30 the AGC function is inhibited.
- **Bandwidth** -Setting to select the FFT bandwidth, choices are include 200, 500, 1k, 2k, 5k, 10k and 20k Hertz. The default is 10kHz. If the THD of signals with fundamental frequencies above 2500Hz is to be measure, choose a Bandwidth of 20kHz so that the 2nd through 4th harmonics are captured.

## Pulse/FM Display

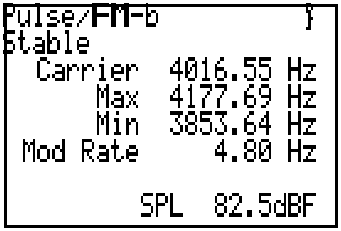
The Pulse/FM displays provide measurements to qualify the pulsed amplitude and frequency modulation (FM) response of an audiometer.

There are two Pulse/FM displays. The Pulse/FM-a display, shown below, is accessed from the THD display by pressing the down arrow key ⊛

" ≥220dB indicates that the On/Off level ratio is greater than 20 dB.




The Pulse/FM-b display is obtained by pressing the right arrow key.




The left and right arrow keys left or right arrow ⊛ ⊛ can be used to toggle between the Pulse/FM-a and the Pulse/FM-b displays.

## Pulse/FM-a Display

The Pulse/FM-a display shows all the required values for the calibration of the pulsed tone capabilities of an audiometer. Present the pulsed tone at a proper level and press the RUN/STOP key ⊛. The stability of the measurement can be evaluated visually. To retrieve data, press RUN/STOP again ⊛ and read the values from the screen.

The following values are displayed: rise time, fall time, on time, off time, plateau duration, in milliseconds, as well as overshoot in dB.

*See Figure 13-1 on page 13-23 for greater clarification of the values displayed.*

- **Rise Time** (B-C) - time in milliseconds between the -20 dB point (referred to the maximum level) and -1 dB point on the rising edge of the pulsed signal envelope, nominally between 20 and 50 ms

- **Fall Time** (E-G) - time in milliseconds between the -1 dB point and -20 dB point on the falling edge of the pulsed signal envelope, nominally between 20 and 50 ms

- **On Time** (J-K) - time in milliseconds between successive -5 dB points of the envelope of the pulsed signal during which the signal is present, nominally between 190 and 260 ms

- **Off Time** (F-J)) - time in milliseconds between successive -5 dB points of the envelope of the pulsed signal during which the signal is absent, nominally between 190 and 260 ms

- **Plateau or Pulse Width** (C-E) - duration in milliseconds of the plateau during which the signal is within -1 dB of its nominal value

- **Overshoot ($L_{ov}$)** - the level in dB that the signal rises above the normal "ON" level (SPL on).

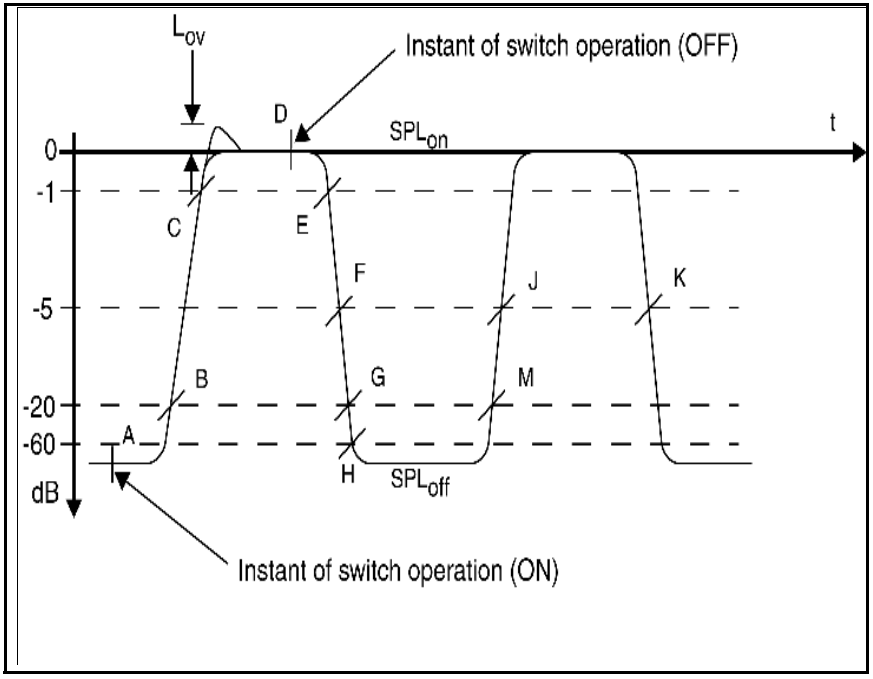
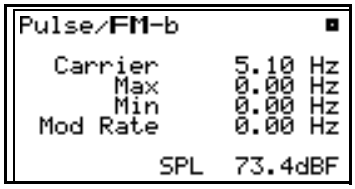


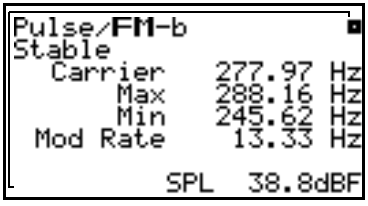

Figure 13-1 Pulse Parameters

### Pulse/FM-b Display




This screen displays required values for the calibration of the frequency modulated tone capabilities of an audiometer. Present the frequency modulated tone at an appropriate level and press the RUN/STOP key ⏯.

When the "stable" message is displayed, as shown below, press RUN/STOP ⏯ again and read the values from the screen.

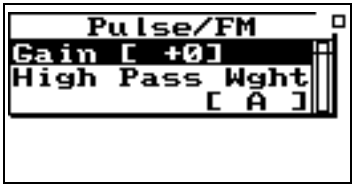



The following values are displayed, all in units of Hz:

- **Carrier frequency**
- Maximum frequency
- Minimum frequency
- Modulation rate

### Pulse/FM Check Menu

While in either the Pulse/FM-a screen or Pulse/FM-b screen the check menu can be accessed by pressing the check key ✓.



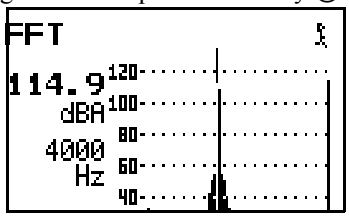

This menu contains the following items.

- **Gain** -Changes the gain setting of the instrument. Generally use 0dB gain for levels at 70dB SPL and above, and 30dB gain for levels less than 70dB SPL.

- **High Pass Wght** -This setting enables the high pass filter section of the A or C weight filters which provide low frequency noise reduction while measuring pulses or FM signals; can be set to Flat weighting also. The default is A weighting high pass.

# FFT Display

The FFT display will show the FFT spectrum. This display, shown below, is activated via the VIEW menu, Press VIEW key ⦿, highlight FFT and press check key ⓥ.




It can also be activated from the THD check menu. The right and left arrow keys control the frequency cursor and the up and down arrow keys control the display horizontal zoom feature.

### FFT Check Menu

Press the check key ⓥ to open the FFT check menu. This menu contains the following items.

- **View THD** -View the THD of the current FFT spectrum.

- **Gain** -Changes the gain setting of the instrument. Generally use 0dB gain for levels at 70dB SPL and above, and 30dB gain for levels less than 70dB SPL. The Auto Gain Control (AGC) function of the linearity displays step between 0 and 30 dB gain, if the gain setting is something other than 0 or 30 the AGC function is inhibited.

- **Bandwidth** -Setting to select the FFT bandwidth, choices are include 200, 500, 1k, 2k, 5k, 10k and 20k Hertz. The default is 10kHz. If the THD of signals with

fundamental frequencies above 2500Hz is to be measure, choose a Bandwidth of 20kHz so that the 2nd through 4th harmonics are captured.

- **Window** -Setting for the FFT window type. Choices are Rectangular, Hanning and Flat-top. Hanning is required for THD and frequency calculations.

- **Weighting** -Frequency weighting setting for the FFT. This setting controls an analog filter prior to analog to digital conversions whereas the RTA/SLM and Pulse/FM mode use Flat analog weighed electronics and digital filtering. The default value is A weighting so that the Linearity FFT display has the greatest noise rejection. The Flatness FFT display overrides this setting and forces the electronics to be Flat weighted.

Note: The Linearity FFT display when using A or C weighting should not be used to measure frequency response and is not good to use for absolute amplitude measurement. Always zero the display at your reference point and use the relative level to see changes in amplitude relative to that reference. Note also that the FFT's A and C weighting filters may have up to ±0.2dB variation compared to the FFT Flat weighting (due to component variations and tolerance).

To make absolute or flat weighted measurements, ensure that the Weighting setting is set to Flat.