

FONIX[®] 8000

Hearing Aid Test System

Operator's Manual

v.2.81, v2.91, v3.00



FRYE ELECTRONICS, INC.

P.O. Box 23391 • Tigard, OR 97281-3391 • USA

(503) 620-2722

Fax: (503) 639-0128

www.frye.com • e-mail: sales@frye.com

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Introduction & Setup

Welcome to the 8000 Hearing Aid Test System, the newest innovation in hearing aid testing technology! The 8000 Hearing Aid Test System performs a broad range of hearing aid measurements from basic, everyday tests of distortion, battery current drain, and frequency response to advanced tests of digital processing delay and phase.

The 8000 Hearing Aid Test System was designed to be a workhorse, capable of performing test after test, day after day, week after week and month after month for years with little to no component failure (although microphones are inherently fragile and must always be handled with care). Whenever possible, we used sturdy components designed to withstand the test of time.

The 8000 Hearing Aid Test System was also designed for accuracy in every respect, from the generation of its test signals to the sensitivity of its microphones and the design of its test chamber. Hearing health professionals from all over the world rely on the accuracy of our measurements, and we do our best to meet (and even exceed) their expectations. This durability and accuracy is combined with an easy-to-use interface, a high-resolution color display, and a flexible architecture that ensures new tests can easily be added as hearing aid technology (and its testing techniques) evolve.

The FONIX 8000 is composed of a main electronics module with a front panel for controlling the operation of the analyzer and a wide-format thermal printer. An external video monitor is used to view test results. You can connect either the optional 8120 Polar Plot sound chamber, or the smaller 8050 sound chamber (with no polar plot capability) for performing coupler measurements. If the Real-ear Option is ordered, a probe remote module is connected to the main electronics module, and dual probe microphones, a sound field speaker, a monitor headset, and an insert earphone can be connected to the probe remote module. Finally, the FONIX 8000 can also be connected to a personal computer, if desired, which allows the user to collect test results electronically and even control the analyzer remotely.

Indications for use

This device performs electro-acoustical real-ear and coupler measurements of hearing aids. Telecoil and battery current measurements of the hearing aid can also be performed. It is meant to be used by hearing health professionals with some knowledge of testing hearing aids. In particular, real-ear measurements should be performed by professionals experienced in hearing aid fitting. Users performing real-ear measurements should be professionals with experience in fitting hearing aids.

1.1 History

The following is a brief history of the major changes and updates in the 8000 Hearing Aid Test System.

- December 2009: Initial release (v2.00).
- December 2010: Added Real-ear measurements (v2.10)
- January 2012: Added ISTS screen (v2.20).
- September 2012: Added pre-recorded signals in visible speech screen (v2.30)
- August 2013: Added ANSI 09 and Profiler automated test sequences (v2.41)
- April 2015: Added Frequency Shift signal type and calibrated telecoil (v2.50)
- August 2015: Added random noise to source type in coupler screen (v2.60)
- June 2016: Additional features available through computer interface (v2.70)

1.2 Basic Test Functions

The basic 8000 can perform the following coupler tests:

- Pure-tone signal measurements
- Composite and Digital Speech signal measurements
- ISTS: International Speech Test Signal according to IEC 60118-15
- Phase measures for binaural hearing aid pairs
- Group delay (processing delay) measurement of digital hearing aids
- Battery Current as a function of amplitude and frequency
- I/O Curves
- Attack and Release
- Choice of IEC 60118-7:1994/2005, ANSI S3.22-2009/03/96/87/92, JIS, or Profiler automated test sequences

An additional function that comes standard with the 8000 is RS232 communication with an external personal computer. This allows remote operation of the analyzer from the computer, and lets you save test results onto your computer's hard drive. Firmware upgrades to the 8000 Test System can also be performed through the computer.

1.3 Options

The 8000 test system has the following software (and hardware) options available:

ANSI Option

The ANSI Option gives the user access to the ANSI 03, ANSI 96, ANSI 87, and ANSI 92 test sequences. These perform measurements according to the ANSI S3.22 2009, ANSI S3.22 2003, ANSI S3.22 1996, ANSI S3.22-1987, and ANSI S3.42-1992 standards, respectively.

This option also includes the Telewand, which is used for performing ANSI 96/03 telecoil measurements.

IEC Option

The IEC Option gives the user access to the IEC 94 and IEC 05 automated test sequences. These sequences are performed in accordance with the IEC 60118-7: 1994 and 2005 standards, respectively.

VA CORFIG

The VA-CORFIG Option supplies a frequency response in the ANSI test sequence that includes correction factors that make the measurement closer to a real-ear response. These correction factors were developed by the United States Veterans Administration.

Polar Plot

This option includes both the 8120 Polar Plot Chamber and the Coupler Directional measurement screen.

Real-ear

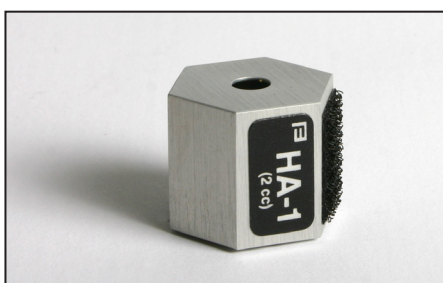
Add the real-ear option with single or dual probe microphones to perform insertion gain, Real-ear SPL, and Visible speech measurements

1.4 Accessories

The following are accessories that are standard and optional on your FONIX 8000 hearing aid analyzer.

1.4.1 Standard Accessories

The following accessories come standard with each 8000 test system.



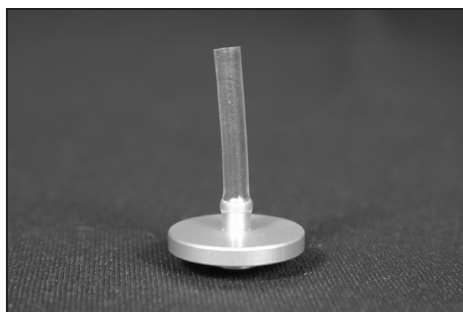
HA-1 2-cc Coupler

Dimensions per ANSI S3.7 for testing in-the-ear aids, canal aids, and aids fitted with earmolds. When the FONIX 8000 is ordered with the 8120 Polar Plot Sound Chamber, this coupler has a magnetic strip. (p/n 044-1031-xx)

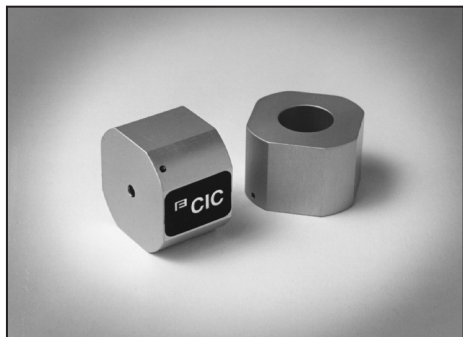


HA-2, 2-cc Coupler

Dimensions per ANSI S3.7 for testing behind-the-ear aids, eyeglass aids, and body aids. When the FONIX 8000 is ordered with the 8120 Polar Plot Sound Chamber, this coupler has a magnetic strip. (p/n 044-1029-xx)

**Ear-Level Adapter (BTE)**

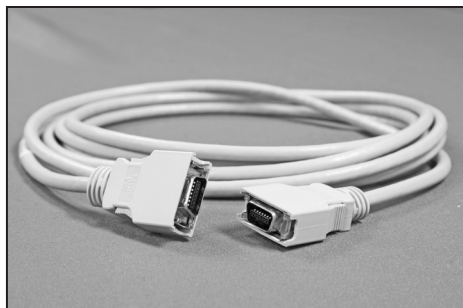
Snaps into the 1/4" (6.35 mm) diameter cavity of the HA-2 and MZ-2 couplers for testing BTE hearing aids. (p/n 044-1003-00)

**CIC Coupler**

Non-standard (0.4 cc) coupler used for realistic testing of CIC hearing aids. This coupler is always used in conjunction with the CIC software correction factors. (p/n 044-1027-xx)

**Microphone Adapter**

14 mm to 1" (25.4) mm adapter for coupling the M1950E microphone and reference microphone to a 1-inch device such as a sound level calibrator. (p/n 044-1006-01)

**Test Chamber Cable**

Connects the main module to the test chamber. (p/n 119-0282-00)

**Auto-Detect Battery Substitution Pills**

Used to power hearing aids, measure battery drain, and estimate battery life. Standard sizes:

675/76

13

312

10A/230

Other Standard Accessories:

Thermal Paper

Adhesive Putty

USB Cable

Dummy Microphone (for testing to ANSI specifications)

Operator's Manual

Maintenance Manual (upon request at time of purchase)

1.4.2 Optional Accessories**Coupler Microphone—M1958E**
(discontinued)

14 mm pressure-type electric instrumentation microphone. (This Mic can be selected to use with 8050 and 8120 sound chamber with no additional cost.)

**Coupler Microphone—M3058E**

18 in. cable. (This Mic can be selected to use with the 8050 and the 8120 sound chamber for additional cost.)

**Coupler Microphone—M3000E**

6 ft. cable. (This Mic can be used with the 8060, the 8070 and the TBS25 sound chamber)

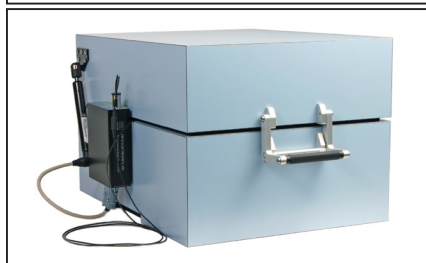
**8050 Sound Chamber***

This sound chamber can be used with the M1958E and the M2058E microphones. (p/n FC8050-1)

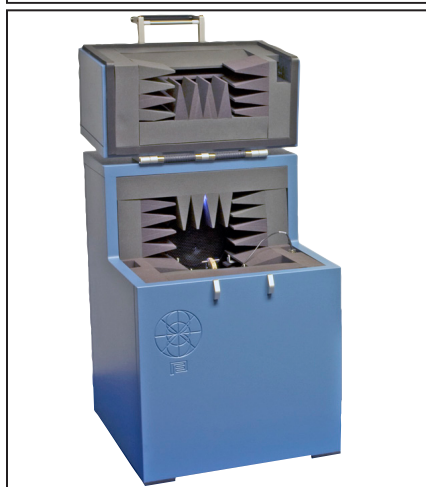
*When ordering the 8000 system, it requires to purchase one sound chamber. There are four models to choose from.

**8060 Sound Chamber***

This sound chamber can be used with the M1950E and the M2050E microphones.
(p/n FC8060)

**8070 Sound Chamber***

This sound chamber can be used with the M1950E and the M2050E microphones.
(p/n FC8070)

**8120 Polar Plot Sound Chamber***

This sound chamber can be used with the M1958E and the M2058E microphones.
(p/n FC8120)

**Chamber Remote Module**

It is used with either the 8060, 8070, or TBS25 chambers. (p/n REMOTE)

**6-cc Coupler**

Enables checking the response of standard audiometer headphones. It is designed around the NBS 9A coupler specifications.
(p/n 044-1004-03)

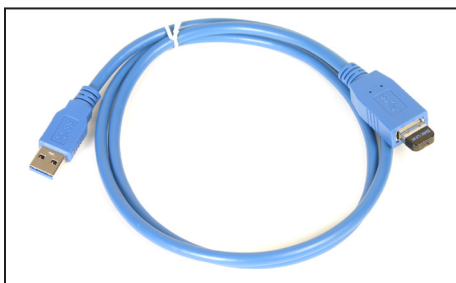
*When ordering the 8000 system, it requires to purchase one sound chamber. There are four models to choose from.

**Sound Level Calibrator**

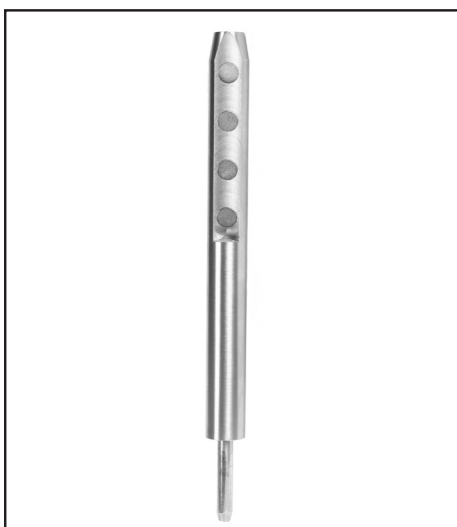
A portable, self-contained, field-type calibrator for calibrating the microphone amplifier. It operates on one nine-volt transistor battery. Use with 14 mm-to-1" adapter. Calibration is traceable to the U.S. National Institute of Standards and Technology. Conforms to ANSI @1.40-2006 and IEC 942: 2003. (p/n 030-0004-01)

**Android Tablet Package**

The FONIX 8000 Hearing Aid Test System can be controlled remotely through Bluetooth® technology with an Android Tablet running the FONIX keyboard app. This package includes an Android tablet with the installed FONIX keyboard app and a wireless dongle for the analyzer. (p/n TABLET)

**Bluetooth Dongle Cable Set**

(p/n BLUETOOTH ADAPTER)

1.4.3 8120 Accessories**BTE Rotator Post**

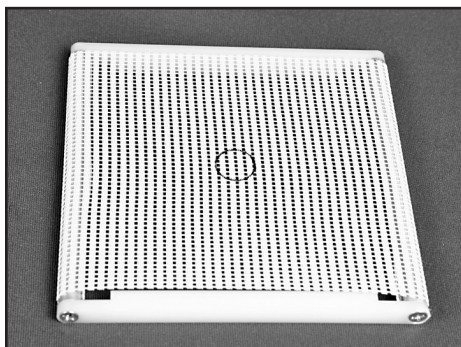
Used for mounting BTE hearing aids in the 8120 Polar Plot sound chamber (p/n 053-1013-00)

**Clamp Assembly BTE**

Attached to the BTE Rotator post and used to position the BTE hearing aid for Polar Plot testing. (p/n 034-1974-00)

**ITE Rotator Post**

Used for mounting canal hearing aids to the 8120 Polar Plot sound chamber for directional testing. (p/n 053-1012-00)

**8120 Removable Test Surface**

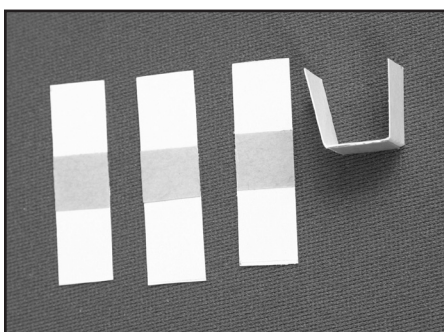
Placed over the 8120 cavity for non-directional hearing aid testing (p/n 053-1014-00)

**Magnetic HA-1 Coupler**

This coupler is included with the 8000 in place of the standard HA-1 coupler when the 8120 Polar Plot sound chamber is ordered. It has a square magnetic surface attached to the coupler for easy positioning on the ITE Rotator Post for directional testing. (p/n 044-5031-01)

**Magnetic HA-2 Coupler**

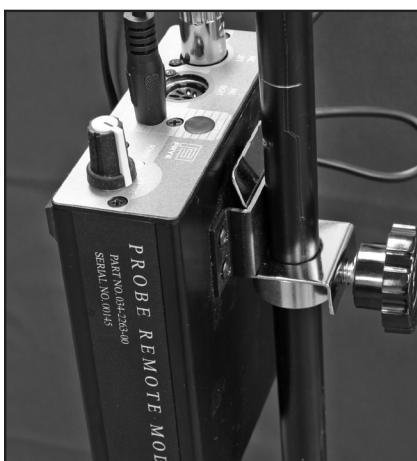
This coupler is included with the 8000 in place of the standard HA-2 coupler when the 8120 Polar Plot sound chamber is ordered. It has a magnetic surface attached to the coupler for easy positioning on the BTE Rotator Post for directional testing. (p/n 044-5029-01)

**Paper shims**

Paper shims (or "gaskets") are provided for use inside the BTE Clamp Assembly to prevent scratches to the hearing aid. (p/n 011-0001-00).

1.4.4 Real-ear Accessories

When the Real-ear Option is ordered, the following accessories are included.

**8000 Probe Remote Module**

This module is used for all of the connections necessary for real-ear measurements. When ordered with the speaker floor standard package, a clip is included for attaching this module to the stand. Module part number: 034-2263-00. Clip part number: 034-1331-00

**Integrated Probe Microphone**

This lightweight, adjustable probe microphone is used to perform real-ear measurements. One or two microphones can be purchased with the Real-ear Option. Part number: M767

**Probe Swing Arm**

Speaker, cable, and swing arm that can be mounted to a table or wall. Alternately, the Real-ear Option can be ordered with a floor stand. Swing arm part number (including cable): 034-5456-00. Speaker part number: 034-2261-00

**Probe Microphone Adapter**

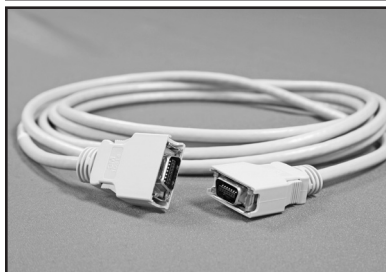
This adapter is used to calibrate the probe microphone and for performing the RECD measurement. Part number 044-0025-01

**Probe Floor Stand**

Speaker, cable, and floor stand. Alternately, the Real-ear Option can be ordered with a swing arm. Stand part number: 030-0020-02. Speaker part number: 034-2261-00. Cable part number: 072-0316-00. Dual Banana Plug to RCA Phono Adapter part number: 044-0047-00

**Reference Microphone Calibrator**

This adapter is used to calibrate the reference microphone. Part number: 044-0208-00

**FPI Cable**

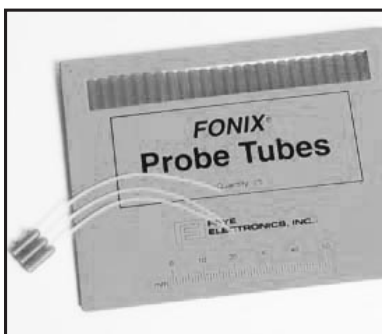
Used to connect the Probe Module to the 8000 Main Module. Part number: 119-0282-00

**Monitor Headset**

For listening to the probe tube during real-ear measurements. Includes adapter. Part number: 015-1214-00

**Dry Erase Marker**

For marking the probe tubes. Part number: 006-0065-00

**Probe tubes**

Package of 25 for performing real-ear measurements. Part number: 074-0020-00

1.5 Layout, Controls, and Safety

This section describes the basic layout of the front and rear panel of the 8000 test system, and special information pertaining to safety regulations.

1.5.1 Front Panel Layout

The front panel of the 8000 test system consists of 8 function keys, 4 arrow keys, and 9 other keys with varying operations. See Figure 1.5.1. Together, all of these keys are used to control all the operations of the 8000 test system. A wide internal thermal printer is located to the right of the front panel. The FONIX 8000 keyboard can also be controlled remotely from an Android tablet running the FONIX keyboard app. See Appendix H for details.

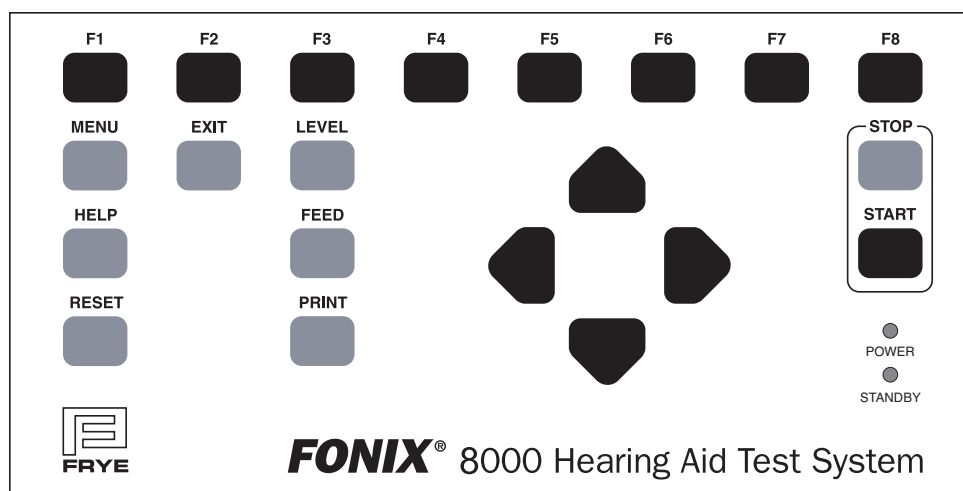


Figure 1.5.1—Front panel

FUNCTION KEYS:

The top row of buttons on the 8000 front panel consists of “function keys” labeled [F1] through [F8]. The function of these keys change from screen to screen, according to the operation displayed on the screen. There are three basic uses of the function keys:

- To navigate from screen to screen
- To toggle a selection
- To pop-up up a selection menu

For a more complete description of the operation of the function keys, see Section 2.1.1.

[RESET]:	Resets the analyzer and returns you to the opening screen. Many settings, measurements, and test conditions are erased or returned to their default conditions with the push of this button. Use [EXIT] instead of [RESET] to avoid the loss of data.
[HELP]:	Displays a pop-up help window, which tells you what functions can be performed in the current screen.
[MENU]:	Opens a local menu, or the Default Settings menu.
[EXIT]:	Exits from the current screen, leaving all settings, measurements, and test conditions as is.
[LEVEL]:	Levels the sound chamber or sound field speaker.
[FEED]:	Advances the internal thermal paper feed.
[PRINT]:	Prints current screen.

[STOP]: Stops testing.

[START]: Starts testing.

ARROW KEYS: The arrow keys perform different functions depending upon the screen and previous buttons pushed. In a test situation, they adjust the source amplitude and frequency. If you press one of the function buttons to bring up a pop-up menu, they are used to scroll through the available options and make selections.

LEDs: Power: When green, this LED indicates that the 8000 Test System is powered on.

Standby: When green, this LED indicates that the screensaver mode is engaged (screensaver not available at this time)

1.5.2 Rear Panel Layout

The rear panel of the 8000 test system contains the external connections for the analyzer. See Figure 1.5.2 for a diagram of the back panel.

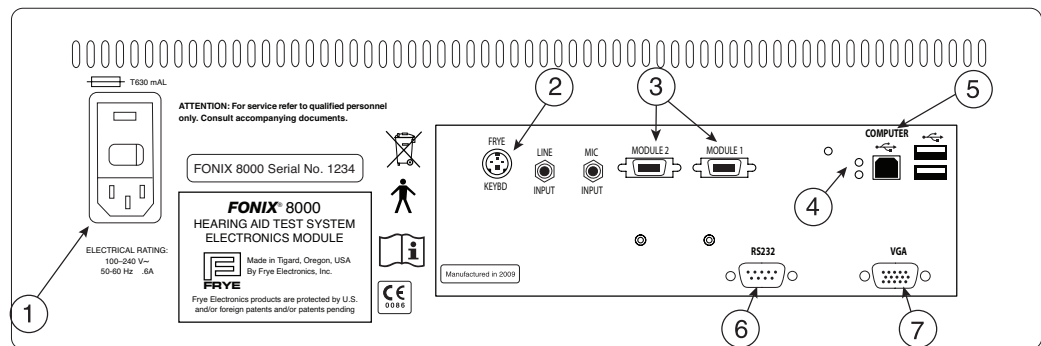


Figure 1.5.2—Back panel

1. **POWER:** Connects to the power cord and houses fuses.
2. **KEYBOARD:** Connects to Frye external keyboard.
3. **MODULE 1&2** Connects to Frye peripheral devices — 8050, 8060 & 8120 Sound Chambers, Chamber Remote Module and/or Probe Remote Module. Only one sound chamber can be connected at a time.
4. **RS232 LEDs:** The red LED indicates the analyzer is sending a poll. This will flash whether or not a computer is connected. The green LED indicates the analyzer is receiving a command from a connected computer.

5. **USB (Type B):** Connects to an external computer. You may need to make a BIOS setting to use this connector. This is the default computer communication connection. This connection is used for software upgrades, FONIX software programs like WinCHAP, FONIX NOAH Module or your own custom programs. Connect only to a standard USB port, 5 Volts maximum.
6. **RS232:** Connects to an external computer. You may need to make a BIOS setting to use this connector. This connector is disabled when shipped from the factory. The USB connection on No.5 above is the preferred method of communication. See the maintenance manual if you must use this legacy 9 pin connector. Connect only to a standard RS232 port, 15 Volts Maximum.
7. **VGA:** Connects to a video monitor.

The coupler microphone is plugged into the inside of the sound chamber. The connectors not labeled in Figure 1.5.2 are not currently active but will have functions in future software versions.

The following safety symbols can be found on the back of the 8000 hearing aid analyzer:



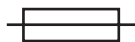
Type B Equipment. The probe microphone and insert earphone are type B applied parts, according to IEC 60601-1.



Read the accompanying documents. Please read this manual before operating the 8000 test system. A separate maintenance manual exists for the 8000 test system. If you wish to obtain a maintenance manual, please contact Frye Electronics, Inc. or your Frye representative.



This symbol indicates that Frye Electronics, Inc. conforms to the Medical Device Directive 93/42/EEC. Any attached video monitor, external printer, or external computer should also have a CE mark in order for the 8000 test system to remain compliant.



Replace fuses only with the same type and rating.



The 8000 and some of its accessories contain lead. At the end of its useful life, please recycle or dispose of the 8000 according to local regulations.

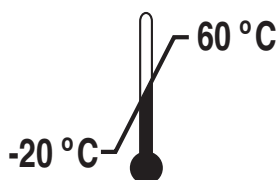
1.5.3 Safety

Shipping

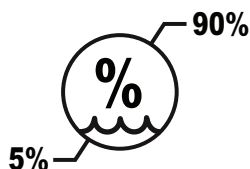
The following symbols are included on the electronic module shipping box:



Keep dry. The 8000 Hearing Aid Test System should not be exposed to water or other fluids. Failure to comply could lead to damage to the equipment or even electric shock in some cases.



The shipping/storage temperature of the 8000 is -20 to 60 degrees Celsius (-4 to 140 degrees Fahrenheit)



The shipping/storage Humidity of the 8000 is 5 to 90 percent relative humidity (non-condensing)

Probe Tubes



This symbol, included on the probe tube packaging, indicates that probe tubes should be discarded after use in order to prevent the possible spread of infection. They cannot be cleaned, sterilized, or reused.

Safety Classification for IEC 60601-1

Type of protection against electric shock: Class I

Degree of protection against electric shock: Type B

Protection against harmful ingress of water: Ordinary

Mode of operation: Continuous

The 8000 does not require sterilization or disinfection.

Warning: This equipment is not suitable for use in the presence of flammable anaesthetic mixture with air or with oxygen or nitrous oxide.

Warning: To avoid the risk of electric shock, this equipment must only be connected to a supply mains with protective earth.

Warning: Do not touch the contacts of connectors and the patient simultaneously.

Connection of peripheral equipment to the 8000

Compliance with IEC 60601-1: 2005 Safety requirements for medical electrical systems must be determined on a case-by-case basis.

All electrical equipment attached to the 8000, such as video monitors, computer equipment, etc. must, at a minimum, meet one of the following conditions:

- a. The equipment complies with IEC 60601-1
- b. The equipment complies with relevant IEC and ISO safety standards and is supplied from a medical grade isolation transformer.
- c. The equipment complies with relevant IEC and ISO safety standards and is kept at least 1.5 meters from the patient.

The allowable leakage currents of IEC 60601-1: 2005 must not be exceeded. IEC 60601-1: 2005 should be consulted when assembling such a system. Failure to comply with these instructions could lead to interference with nearby medical equipment.

Electromagnetic compatibility

The 8000 complies with IEC 60601-1-2.

The 8000 generates and uses radio frequency energy. In some cases the 8000 could cause interference to radio or television reception. You can determine if the 8000 is the source of such interference by turning the unit off and on.

If you are experiencing interference caused by the 8000, you may be able to correct it by one or more of the following measures:

1. Relocate or reorient the receiving antenna.
2. Increase the distance between the 8000 and the receiver.
3. Connect the 8000 to a different outlet than the receiver.

In some cases radio transmitting devices, such as cellular telephones, may cause interference to the 8000. In this case try increasing the distance between the transmitter and the 8000.

Disposal of the 8000 and accessories

The 8000 and some of its accessories contain lead. At the end of its useful life, please recycle or dispose of the 8000 according to local regulations.

If you are located in the European Union, please report all safety-related concerns to our authorized representative:



Sivantos Ltd.
Platinum House
Sussex Manor Business Park
Gatwick Road
Crawley RH10 9NH
ENGLAND

Otherwise, please report all safety related concerns to the Frye factory:



Frye Electronics, Inc.
9826 SW Tigard St.
Tigard, OR 97223
Ph: (503) 620-2722
Fax: (503) 639-0128
email: support@frye.com
sales@frye.com



Frye Electronics, Inc. is a Registered Firm of British Standards Institution, and we conform to the ISO 13485 standard.

1.6 Setup

This section describes the unpacking and setup of the 8000 test system. A description of the front and back panels is also included.

1.6.1 Unpacking the FONIX 8000

Remove the FONIX 8000 test system from the shipping cartons. Store the shipping cartons in a dry place so that they can be used again in the event that the unit must be returned to the factory for repair or upgrade.

See Figure 1.6.1 for a picture of the 8000 test system and a labeling of its basic components. The 8050 & 8060 sound chambers can be substituted for the 8120 Polar Plot sound chamber.

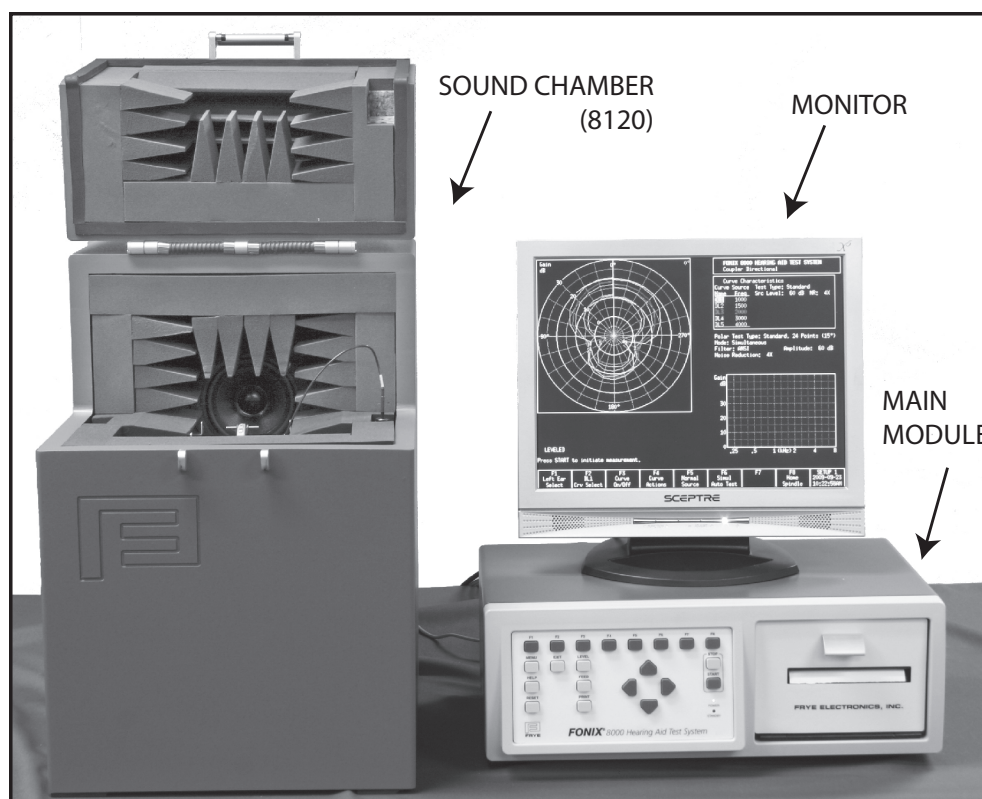


Figure 1.6.1.—The 8000 Test system.

1.6.2 Locating and arranging the 8000 test system

Locate the 8000 test system in a moderately quiet area, such as a private office or laboratory. In order for test results to reliably conform to specifications, the ambient noise, mechanical vibrations, electrical or magnetic fields must not affect test results by more than 0.5 dB (ANSI S3.22). Low-noise acoustic conditions, as found in sound treated rooms and booths, are recommended but not necessary.

Locate the main module near the sound chamber. The video monitor may be placed on top of the main module.

1.6.3 Connecting the Main Module & Components

Connect the main module to the system components as follows (see Figure 1.6.3):

1. Connect the video monitor to the jack marked “VGA” on the back of the main module. Tighten the screws on the connector to secure the connection.
2. Plug the M1958E microphone into the connector marked “MIC” located inside the sound chamber.

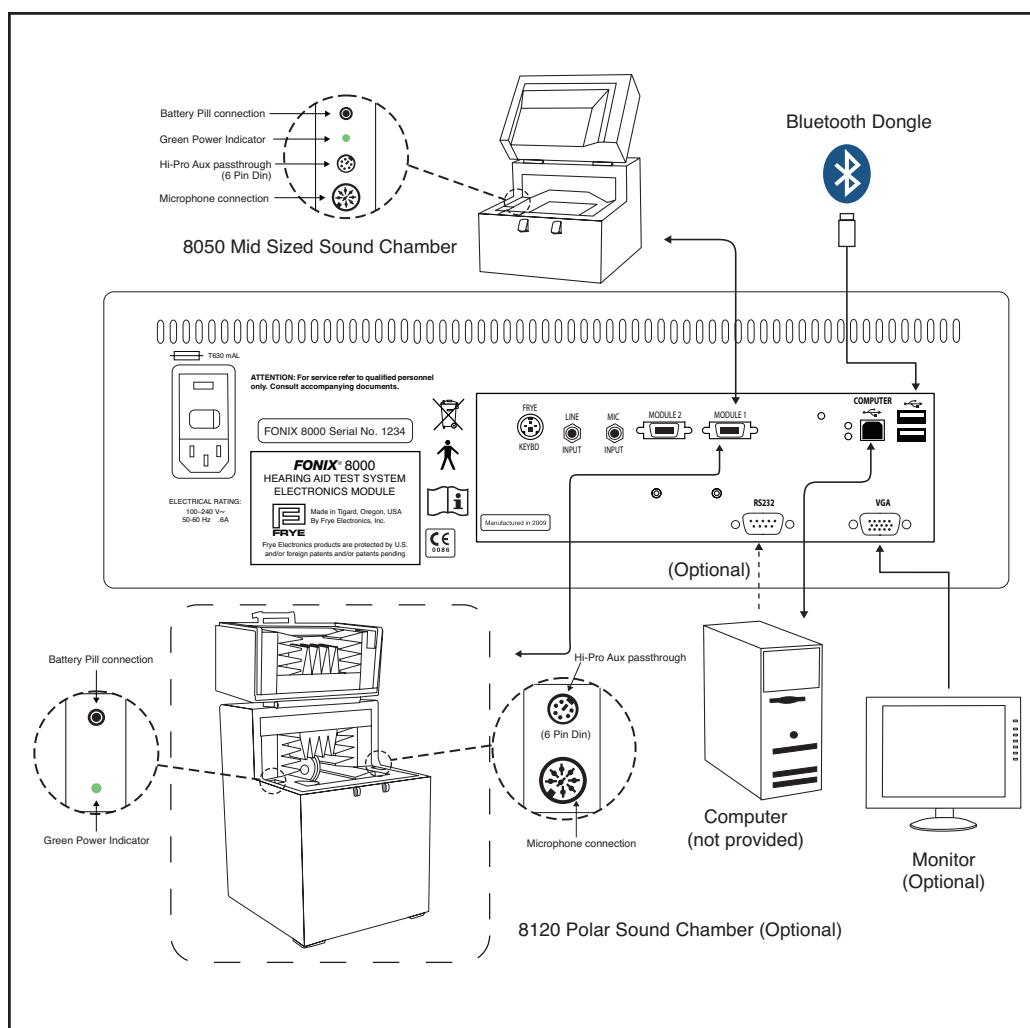


Figure 1.6.3 —8000 test system setup

3. Plug the sound chamber cable into the connector marked "Module 1" on the back of the 8000 unit. Plug the other end of the cable into the back of the sound chamber. This cable provides all the connections necessary for operating the microphone, internal loudspeaker, telecoil, and battery voltage supply of the sound chamber.
4. Plug the power cord into the three-pronged jack on the rear panel of the 8000. Plug the power cords of both the 8000 and the video monitor into an AC outlet. We recommend using a switchable multiple outlet power strip with surge protection. Any voltage between 100 and 240 VAC is acceptable, 50 or 60 Hz line frequency.

1.6.4 Connecting Real-ear Equipment

If you have ordered the real-ear option, your analyzer will have the components pictured in Figure 1.6.4. To connect these components:

1. Connect the Frye peripheral cable to the back of the main module using either the Module 1 or Module 2 connectors (the sound chamber will be connected to the other one. The order doesn't matter.)
2. Connect the other end of the Frye peripheral cable to the Real-ear Connector box (Probe Remote Module) using the connector on the side of the box labeled "TO MAIN MODULE."
3. Connect the probe microphone to the connector labeled "MIC LEFT". If you have a second probe microphone, connect it to the connector labeled "MIC RIGHT." If you are only using one probe microphone, it doesn't matter which probe connector you use. The analyzer will automatically use it for both left and right ear measurements.
4. Connect the sound field speaker to the connector labeled "SPKR A."
5. Connect the monitor headset to the connector labeled "MONITOR."

Warning: Do not connect the monitor headset to either "SPKR A" or "SPKR B." This could result in very loud sounds being delivered to the monitor headset, which could in turn damage your hearing if you are using them. **Plug the monitor headset into the "MONITOR" connector ONLY.**

6. Connect your insert earphone to the connector labeled "EARPHONE" for RECD measurements (optional).

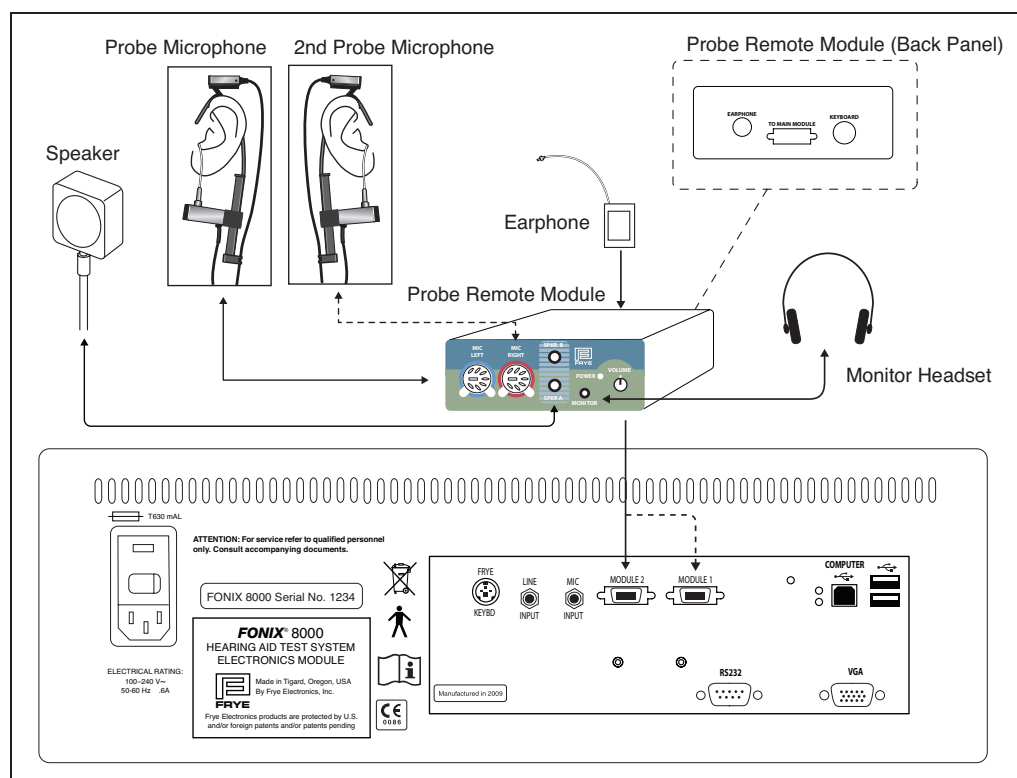


Figure 1.6.4 —8000 Real-ear setup

1.6.5 Powering up the 8000 test system

1. Turn on the 8000 system by reaching back on the right side of the main module (while you are facing the front of the unit), and pressing the POWER switch. The green LED on the front panel, above the words “POWER”, will turn on after a couple seconds.
2. Turn on the video monitor. (Refer to the monitor’s manual for instructions, if necessary.)

The Opening screen of the 8000 test system will be displayed. It contains the FONIX logo, along with the software version, the serial number, and the available options. This information is important in identifying your equipment when you communicate with the company about your FONIX 8000 test system.

Note: Do not disconnect or connect the sound chamber or probe module when the analyzer is turned on. This will not damage the analyzer but it may have trouble detecting the chamber without a power cycle.

1.7 Maintenance

In order to ensure accurate testing, we recommend yearly calibrations of your coupler microphone. These calibrations can be performed by any Frye distributor or by yourself with the aid of a sound level calibrator, such as a Quest QC-10. Please see Appendix B for calibration instructions.

1.7.1 Cleaning

For your safety, disconnect the 8000 from electrical power while cleaning. Wipe the 8000 with a moist cloth. Use plain water or water with mild dish washing detergent. Wipe away any detergent residue with a clear moist cloth. Finally, use a soft dry cloth to eliminate any lingering moisture.

Never allow fluid to enter the 8000:

- enclosure
- power switch
- power connector
- electrical connectors
- front panel buttons

The 8000 microphones should be wiped with a dry cloth. Excess moisture may damage the microphones.

Solvents and abrasives will cause permanent damage to the 8000.

1.7.2 Care & Maintenance of your M1958E Coupler Microphone

Microphones are perhaps the most delicate of FONIX products. They require care and caution when handled. At the risk of sounding negative, the following is a list of the five microphone DON'Ts.

1. **Don't bend the microphone cord at the connection of the cord and the body!**

This is perhaps the most common cause of microphone damage. The place where the cord and the body of the microphone meet is the most fragile part of their connection. The less strain you put on this area, the longer your microphone will last.

2. **Don't hit the microphone against the sound chamber or any other object!**

The microphone head is delicate and easily damaged. Hitting the microphone against anything will do it no good and potentially much harm. Similarly, be careful not to drop the microphone on the floor.

3. **Don't pull the microphone from the coupler by the cord!**

When removing the microphone from the coupler, grip the microphone body, not the cord. Pulling on the cord damages the connection.

4. **Don't get adhesive putty on the grill of the microphone!**

Adhesive putty that accumulates on the grill will fall into the microphone body and onto the diaphragm which will damage the microphone.

5. **Don't touch the diaphragm of the microphone!**

The diaphragm is located inside the grill of the microphone and is extremely sensitive. If you need to take the grill off the microphone, please do so with extreme care, and be especially careful not to touch the diaphragm, as this can cause permanent damage!

Overall, just be aware that your coupler microphone is a delicate device that needs to be treated with care and respect. If you do so, you will find it can provide years of reliable and accurate results.

1.7.3 Locating the serial number and software version

When contacting the factory, it is very useful to have your serial number and software version handy. This information will help us assist you regarding repair, upgrade, and technical questions.

The serial number of your 8000 test system can be found on the back of the main module, just to the right of the power switch. See Figure 1.7.3A. It can also be found on the Opening screen of the 8000 test system.

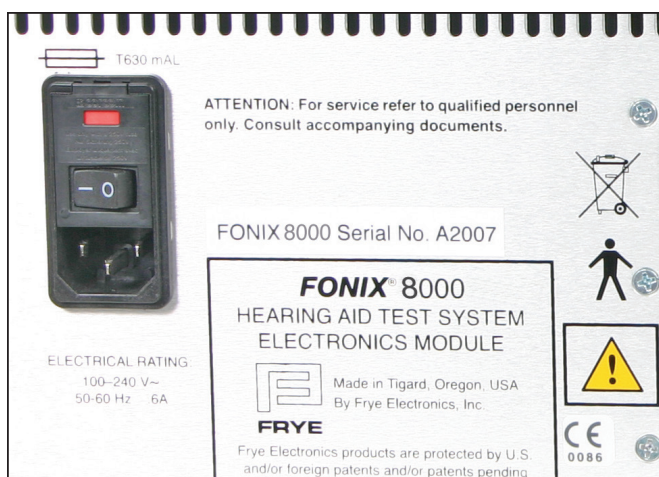


Figure 1.7.3A—Serial number location

The software version of your 8000 test system can be found on the Opening screen. See Figure 1.7.3B.

Press [HELP] to open a help window with more detailed service information. This data may be requested if you call in with a repair-related question. Press [HELP] again to close the help window.

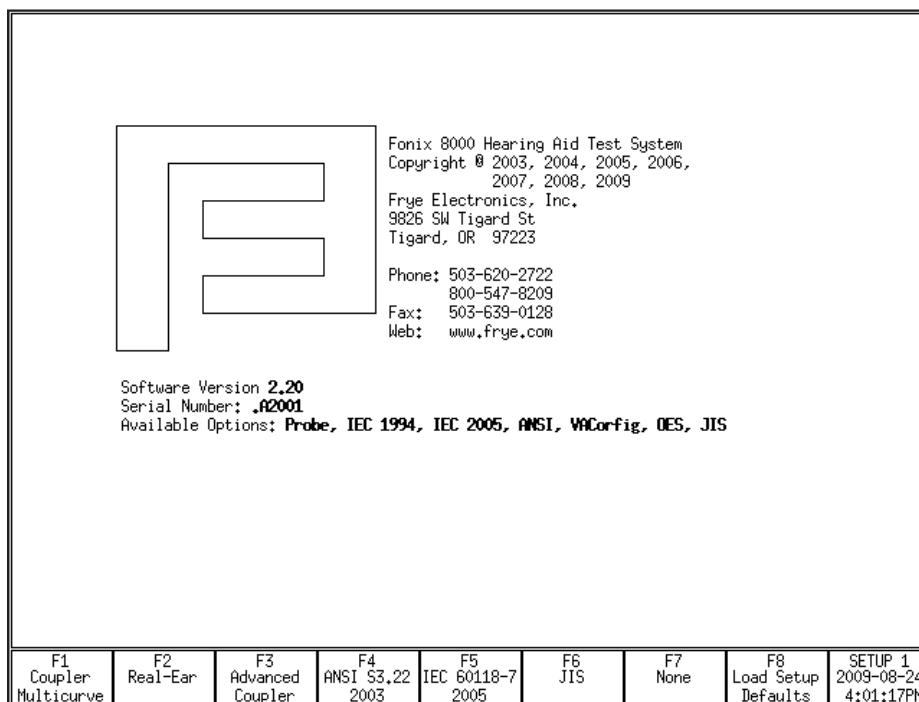


Figure 1.7.3B—Software version location

1.7.4 Contacting the Factory

If you have any questions regarding your instrument, have your serial number and software version ready (see Section 1.7.3), and contact us at:

Mailing address:

Frye Electronics, Inc.
PO Box 23391
Tigard OR 97281-3391
USA

Phone: (503) 620-2722

Fax: (503) 639-0128

Email: sales@frye.com (sales questions)

Support@frye.com (technical questions)

Service@frye.com (repair questions)

Shipping address:

Frye Electronics
9826 SW Tigard St.
Tigard, OR 97223
USA

1.7.5 Warranty

The 8000 test system and its accessories are guaranteed to be free of manufacturing defects that would prevent the product from meeting its specifications (given in Appendix A of this manual) for a period of one year from the date of purchase.

General Operation

This chapter describes the general operation of the FONIX 8000 Test System, including basic operation of the buttons, screen navigation, default settings, source types, printing and other information.

2.1 Operation of buttons

The general operation of the various buttons on the FONIX 8000 Test System are described in this section. This includes a description of the function buttons, the arrow buttons, and the Menu, Help, Reset, Exit, Level, Feed, Print, Stop and Start buttons.

2.1.1 Using the function keys

The top row of buttons on the FONIX 8000 Test System front panel consists of “function keys” labeled [F1] through [F8]. The function of these keys changes from screen to screen, according to the need of the screen. The screen itself always shows the function of each of these buttons in a row of boxes along the bottom of the display. This row is meant to represent the physical buttons on the front panel. See Figure 2.1.

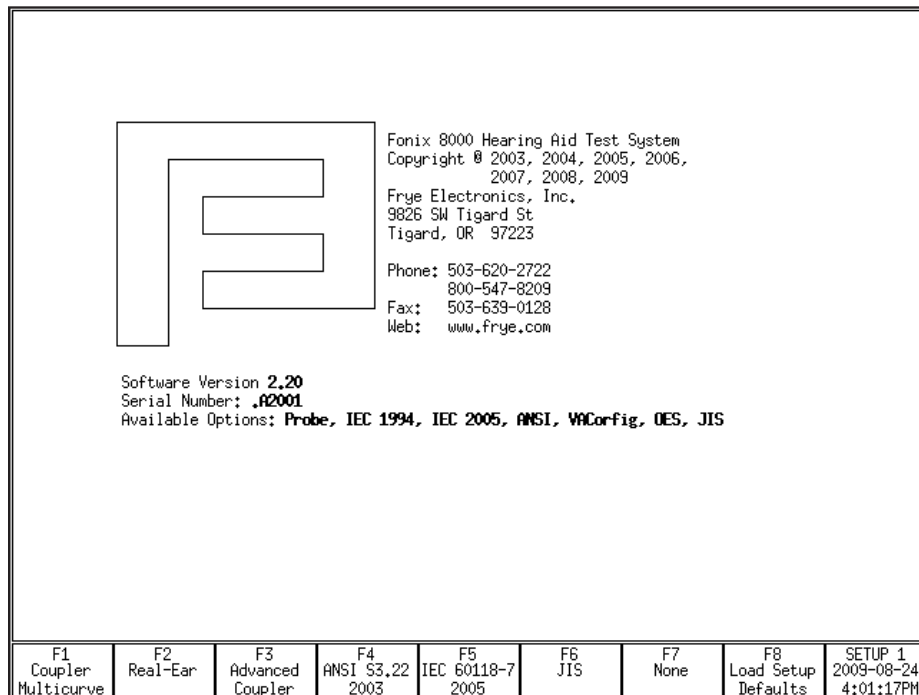


Figure 2.1—Function key display

There are three basic uses of the function keys:

- To navigate from screen to screen
- To toggle a selection
- To pop-up a selection menu

Navigation

In the Opening screen, the function keys are used to navigate between the various measurement screens. For example, pushing [F1] in the Opening screen will take you to the Coupler Multicurve screen.

Toggle

In a measurement screen, when a selection for a function key has only two possible options, pressing the function key will toggle between those options. For example, a function key setting the ear being tested will toggle between “left” and “right.” A red box will appear briefly around the function key box on the display. This red highlight means that the selection is in the process of being toggled.

Pop-up Menu

In a measurement screen, when there are several possible selections to be made with a function key, pressing the function key will display a pop-up menu. When this happens, use the [▼, ▲] keys to select the desired setting, and then use [►] to perform the actual selection.

For example, in the Coupler screen, pressing [F5] will display a selection of source types. To select the desired source, you would use [▼, ▲]. To complete the selection, you would press [►].

2.1.2 Navigating through the screens

The function keys are used to move from screen to screen. Here is a flow chart of all the available screens and the buttons used to open each screen. Some of the screens will only be available to you if you’ve ordered a certain option.

The F4-F7 keys are user configurable and may vary according to the analyzer’s default setup.

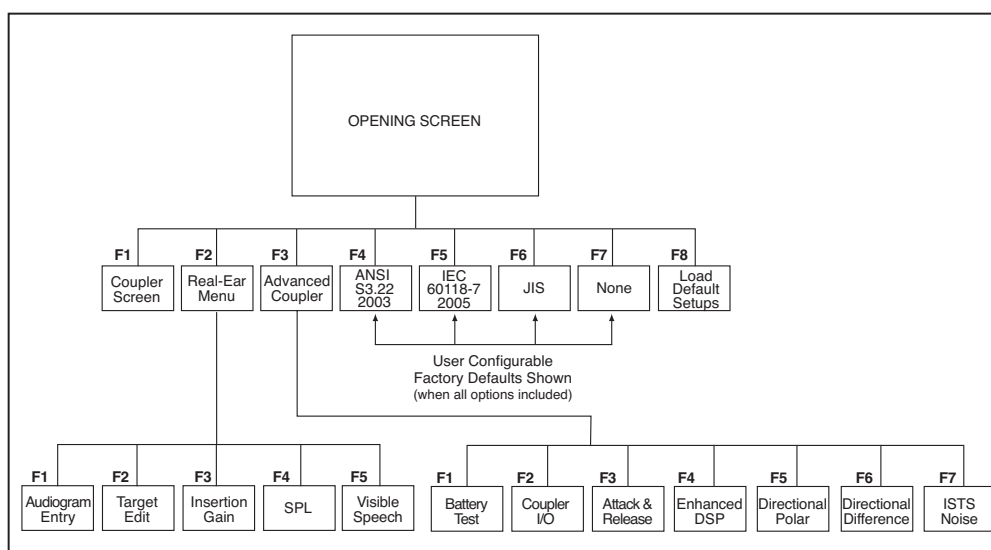


Figure 2.1.2—Navigation Flow Chart

2.1.3 Using the pop-up help windows

Each operational screen on the FONIX 8000 Test System has a local help window designed to give you a basic operational overview of the current screen. In general, these help windows tell you what each button does in the current screen. See Figure 2.1.3 for an example.

In some help windows, you will be able to use the [▼, ▲] keys to display additional help text. This will be noted in the help window.

To close the help window, press [HELP] again or the [EXIT] button.

Help Window

Standard Usage in manual mode:
 Select ear with F1.
 Select curve with F2.
 Change source type with F5.
 Change source level with Up/Down buttons.
 Press Start to measure the curve.
 Press Stop to end the test.

Source Type Abbreviations:
 First characters are: P-Puretone, C-Composite, or D-Digital Speech.
 If the first character is P:
 Second characters are: N-Normal, F-Fast, S-Short, or L-Long sweep.
 If the first character is C or D:
 Second characters are: F-Flat weighted, W-Speech weighted,
 or S-Spectrum.
 Third characters are: P-Power or SPL, and G-Gain.

FONIX 8000 TEST SYSTEM
Coupler Left Ear

Curve Characteristics					
Curv	←Source→	RMS	Cor	NR	
Name	Type	Trans	App	Out	
CL1	DWG	Chamb	60		4X
CL2	DWG	Chamb	60		4X
CL3	DWG	Chamb	60		4X
CL4	DWG	Chamb	60		4X
CL5	DWG	Chamb	60		4X
CL6	DWG	Chamb	60		4X
CL7	DWG	Chamb	60		4X
CL8	DWG	Chamb	60		4X
CL9	DWG	Chamb	60		4X
CLX	DWG	Chamb	60		4X

Source: DigSpeech, ANSI Weighted
 Chamber, Levelled
 Bias Tone: OFF
 Projected Noise Reduction: 4X
 Smoothing: Off
 Battery Current: mA
 Size: Zn-Air Custom

60
50

.25 .5 1 (kHz) 2 4 8

Source 60 dB SPL

Press HELP to close the HELP window.

F1 Left Ear Select	F2 1 Crv Select	F3	F4	F5 DigSpeech Src Select	F6 Off Auto Test	F7 Display Gain	F8 Off/Prev Source	SETUP 1 2012-01-04 2:59:48PM
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Figure 2.1.3—Pop-up help window

2.1.4 Using the local menus

Pressing the [MENU] button will pop up a local menu that, like the help window, will be overlaid on your current screen. Each local menu contains selections specific to your current screen. For instance, when you are in the Coupler screen, the local menu will contain only selections specific to coupler measurements. See Figure 2.1.4 for an example of a local menu.

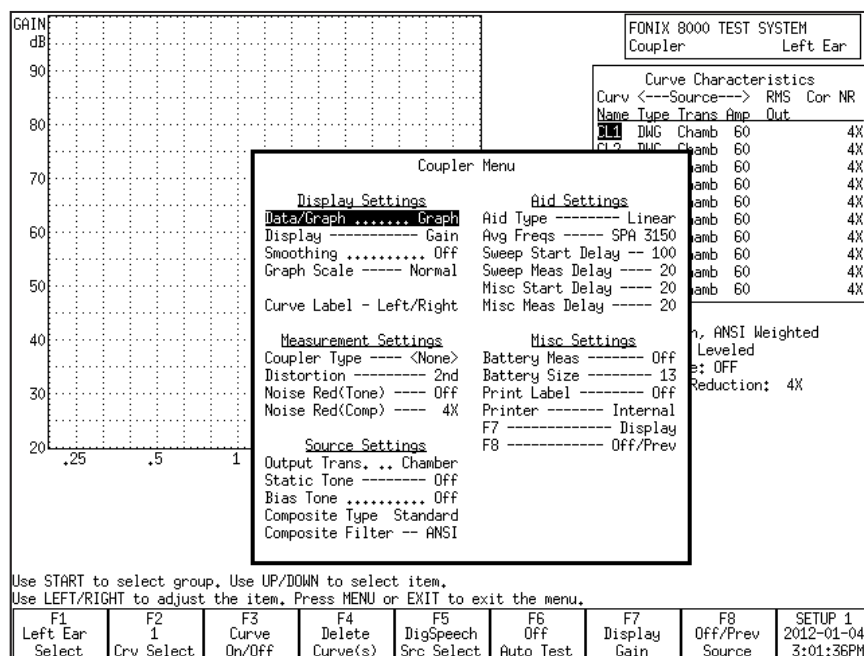


Figure 2.1.4—Local menu

Some local menu selections are common across screens. When this is the case, selections made in one local menu will usually carry across to any other local menu containing that selection. For instance, AID TYPE is a common selection in the local menus of the Coupler and Insertion Gain screens. If you were to set the AID TYPE to AGC in the local menu of the Coupler screen, it will automatically be set in local menu of the Insertion Gain screen.

HINT: Located between each option and its selection in the local menu is a series of dots or dashes. For instance, there are a series of dashes between AID TYPE and AGC in the local menu of the Coupler screen. Dashes indicate the selection can be saved as a default setting in the Default Settings screen. Dots indicate that the selection cannot be saved as a default selection. See Section 2.2 for details.

2.1.5 Using the EXIT and RESET buttons

The [EXIT] and [RESET] buttons can be used to exit from any screen, menu or window.

The [RESET] button resets the analyzer, returns all settings to their default conditions, erases all measurements, and returns it to the start screen. By default, this start screen is the Opening screen with the Frye logo. However, the user can change the start screen to a variety of choices: Opening, Coupler Multicurve, ANSI S3.22-1987, ANSI S3.22-1996, ANSI S3.22-2003, ANSI 3.22-2009, ANSI S3.42, IEC 60118-7 1994, IEC 60118-7 2005, JIS, Profiler, and Coupler Directional (these selections will vary depending upon the options ordered with your analyzer). See Section 2.2.1 for more details.

It is recommended to use [EXIT] instead of [RESET] when moving between screens to avoid the loss of data.

The [EXIT] button closes a popup or local menu. When all such menus are closed, the [EXIT] button exits the current screen without altering the settings, measurements, and test conditions of the analyzer.

2.1.6 Using the remaining buttons

Here is a description of the remaining buttons on the front panel of the analyzer and their use.

[LEVEL]: Levels the sound chamber or sound field speaker. See Sections 3.2 and 6.2.4 for details.

[FEED]: Advances the internal thermal printer paper.

[PRINT]: Prints the current screen. See Section 2.4 for details.

[STOP]: Stops a currently running test.

[START]: Starts a test.

ARROW KEYS: The arrow keys perform different functions depending upon the screen and previous buttons pushed. In a test situation, they adjust the source amplitude and frequency. If you press one of the function buttons to bring up a pop-up menu, they are used to scroll through the available options and make selections.

2.2 Setup Menu

The Setup menu contains a number of different functions that set up your analyzer for testing. These functions include saving and loading default settings, setting the date and time, setting the user mode and performing calibration functions. This section contains instructions for several of these functions. For calibration instructions, see Appendix B. For instructions on leveling and saving leveling, see Section 3.2.

To open the Setup menu, press [MENU] from the Opening screen.

2.2.1 Saving and loading default settings

All of the settings in the General and Coupler, Default Settings windows (described in Section 2.2.4) can be saved as default settings. There are five possible setups, so you can have five different configurations saved into the analyzer's permanent memory. You can also load (but not alter) the factory default configuration.

To save a user configuration:

1. Open the Setup menu by pressing [MENU] from the Opening screen.
2. Set up the General Default Settings as desired. See Section 2.2.4 for an explanation of all the default settings.
3. Use F1 to select the Coupler Default Settings Menu and change the settings as desired.
4. Press [F8] to open the Save Setup Defaults pop-up menu.
5. Use [▼, ▲] to select the desired setup number. If you are only going to use one saved configuration, use Setup 1.
6. Use [►] to complete the selection and close the pop-up menu. This will save all settings in the General and Coupler Default Settings windows. It will take a few seconds for the FONIX 8000 Test System to save the configuration. The saved setup number will automatically be selected as the current user.

To load a setup configuration:

1. Press [F8] in the Opening screen to open the Load Setup Defaults pop-up menu.
2. Use [▼, ▲] to select the desired setup number.
3. Use [►] to complete the selection and close the pop-up menu. This will load the selected setup. Whenever a user configuration is saved or loaded, that user will also be automatically saved as the new default user.

This function can also be performed in the Setup menu.

2.2.2 Setting the date and time

The date and time displayed on every measurement screen can be changed in the Setup menu.

1. Open the Setup menu by pressing [MENU] from the Opening screen.
2. Press [F3] to open the Set Time/Date window.
3. Use the arrow keys to change the Year, Month, Day, Hour, and Minute. The [▼, ▲] keys choose the category and the [◀, ▶] keys make the selection.
4. Use the arrow keys to decide if you want to use AM/PM time or a 24-hour style clock. This is changed in the AmPm setting.
5. Press [EXIT] twice to return to the Opening screen when done. The new time and date settings will automatically be saved.

2.2.3 Setting the user mode

There are two different user modes available on the FONIX 8000 Test System: Beginner and Advanced. In the Beginner mode:

- Extra help windows pop up automatically when function keys are pressed in order to give the user more direction in using the instrument.
- Some local menu settings will not be displayed. These settings will not affect most users.

In Expert mode, the help windows are eliminated and all local menu settings are displayed.

To change the user mode:

1. Press [MENU] in the Opening screen to open the Setup menu.
2. Use [▼, ▲] to select User under Other.
3. Use [◀, ▶] to choose ADVANCED or BEGINNER.
4. Press [EXIT] to return to the Opening screen. The new user mode will be in effect.

2.2.4 Explaining the settings

There are three categories of default settings available: General, Coupler and Real-ear. The third category, Real-ear Default Settings, is only available when the Real-ear Option is included on the analyzer. The following is an explanation of the various settings currently available.

General Default Settings

PRINT LABEL: Status of the label printing option. Choose ON or OFF.

PRINTER: Printer used for printouts. Only INTERNAL is available at this time.

EXT PRINT COLOR: This setting is currently only used for use with the fcapture screen capture program. **B&W captures** black and white pictures of the current screen. **Color captures** color pictures.

EXT PRINT LANGUAGE: External printing is not supported at this time.

EXT PRINT #SCRNS/PAGE: External printing is not supported at this time.

RS232 BAUDRATE: Baud rate of the RS232 connection. This is the speed of the connection between the analyzer and a personal computer. The Windows-based program used on the computer end will need to have the same baud rate selected.

AID TYPE: Type of hearing aid being measured. Choose between Linear, AGC and ADAPTIVE AGC. This will affect the delays of pure-tone sweeps as well as some other measurements. See Section 2.3.1.2 for details.

USER: The selected user mode. See Section 2.2.3 for details.

START SCREEN: The screen shown when the analyzer is powered on or the [RESET] button is pressed. The following screens are available for this purpose: Opening, Coupler Multicurve, ANSI S3.22-1987, ANSI S3.22-1996, ANSI S3.22-2003, ANSI S3.22-2009, ANSI S3.42, IEC 60118-7 1994, IEC 60118-7 2005, JIS, Profiler, and Coupler Directional (these selections will vary depending upon the options ordered with your analyzer).

F4-F7: Function of the F4, F5, F6 and F7 navigation keys in the Opening screen. These keys can be used to create a shortcut to the selected screen. The following screens are available for this purpose: ANSI S3.22-1987, ANSI S3.22-1996, ANSI S3.22-2003, ANSI S3.22-2009, ANSI S3.42, IEC 60118-7 1994, IEC 60118-7 2005, JIS, Profiler, Coupler Directional, Battery, Coupler I/O, Attack & Release, Enhanced DSP, and None (these selections will vary depending upon the options ordered with your analyzer).

SWEEP START DELAY: The amount of time the FONIX 8000 Test System presents the first tone in a pure-tone sweep. See Section 2.3.1.2.

SWEEP MEAS DELAY: The amount of time each subsequent tone is presented before the measurement is made in a pure-tone sweep. See Section 2.3.1.2.

MISC START DELAY: The amount of time the FONIX 8000 Test System presents the first tone in one of the following measurements: reference test gain measurements (in automated test sequences), averaging, harmonic distortion measurements, equivalent input noise, and single-frequency telecoil measurements. See Section 2.3.1.2.

MISC MEAS DELAY: The amount of time each subsequent tone is presented before the measurements is made in one of the measurements listed above. See Section 2.3.1.2.

I/O START DELAY: The amount of time the first tone in an I/O sweep is presented before the measurement is made. See Section 2.3.1.2.

I/O MEAS DELAY: The amount of time each subsequent tone in an I/O sweep is presented before the measurement is made. See Section 2.3.1.2.

RESET FREQ: The frequency the analyzer returns to when RESET is pressed.

AVG FREQS: The frequencies used for averaging in pure-tone measurements. Each frequency set is represented on the screen by the highest frequency in the set. The sets are:

HFA (High Frequency Average)	1000, 1600, 2500
SPA (Special Purpose Average)	800, 1250, 2000
SPA	1250, 2000, 3150
SPA	1600, 2500, 4000
SPA	2000, 3150, 5000
IEC-(HAIC)	500, 1000, 2000

Coupler Default Settings

BATTERY MEAS: Status of the battery current measurement. Choose ON or OFF.

BATTERY SIZE: Size of battery used with the hearing aid being tested. Used in battery current measurements.

BATTERY CHEMISTRY: Type of chemistry of the hearing aid battery. Choices are ZN-AIR(ZincAir), SILVER, and type 2.0V. This choice will almost always be ZN-AIR. *Note:* the 2.0V chemistry type is optional and only available when in advanced mode.

NOISE RED (TONE): Amount of pure-tone noise reduction used in coupler measurements. See Section 2.3.1.1.

NOISE RED (COMP): Amount of composite noise reduction used in coupler measurements. See Section 2.3.2.1.

TONE ANALYSIS: This is the narrowband filter that is used to reduce noise in puretone measurements. Choose Auto or Off.” “Off” means that no narrowband filter will be used when analysing a puretone signal.

RESET SOURCE: The signal type selected in the Coupler screen when the [RESET] button is pushed.

DISPLAY: Display of the Coupler Multicurve screen. Choose between Gain and SPL.

CURVE LABEL: Label used for the two available “ears.” Choose between LEFT/RIGHT and A/B.

GRAPH SCALING: Scaling used when making measurements. NORMAL scales to the upper-most curve displayed. AUTO scales to the current selected curve.

COUPLER TYPE: The type of coupler being used in making sound chamber measurements. Selections of CIC and MZ turn on corresponding software correction factors (see Sections 3.6 and 3.7). A selection of NONE or 2cc does not apply correction factors to the curve.

STATIC TONE: Status of individual frequency measurement. Choose SINGLE to emit a static tone in between composite measurements or pure-tone sweeps. Choose AVG to emit a three frequency average between other measurements. Choose OFF to turn off this measurement.

DISTORTION: Type of harmonic distortion used in a pure-tone measurement. Choose between 2nd, 3rd and TOTAL. See Section 2.3.1.3.

COMPOSITE FILTER: Filter used in Composite and Digital Speech measurements. Choose between ANSI, ICRA and FLAT.

AUTO MODE: Status of Auto Mode in the Coupler Multicurve screen. Choose between OFF, SEMI-AUTOMATIC and FULLY AUTOMATIC. See Section 3.8 for more details.

CURVE GROUP LOADED: Choose which curve group to load upon entry into the Coupler Multicurve screen. See Section 3.8 for details.

F7 and F8: Change the function of the F7 and F8 function keys in the Coupler Multicurve screen. This allows the user to create a shortcut to commonly used menu settings. Choose from: DISPLAY, COUPLER, BIAS AMPL, STATIC, BATT SIZE, AID TYPE, OFF/PREV, DATA/GRAPH. See Section 3.9.

EQUIV NOISE TEST: Status of the equivalent input noise measurement in the automated test sequences such as ANSI, JIS and IEC. Turns it ON or OFF.

TELECOIL: Status of the telecoil measurement in the ANSI, JIS and IEC automated test sequences. Turn it ON or OFF.

12 dB DIST: The status of the 12 dB harmonic distortion rule. When measuring harmonic distortion, if the amplitude of the response at the second harmonic of the frequency being measured is 12 dB greater than the amplitude of the primary frequency, the harmonic distortion measurement is ignored at the primary frequency. Turn this rule ON or OFF in the ANSI and IEC automated test sequences.

VA CORFIG: Software correction factors designed by the VA to produce a more realistic response curve than the normal ANSI response curve. This setting comes with the VA-CORFIG Option.

AGC 250, 500, 1000, 2000 and 4000: Turn ON or OFF the I/O and attack-and-release measurements at the indicated frequencies in ANSI S3.22-1996, ANSI S3.22-2003, IEC 60118-7 2005. Other automated test sequences do not offer this choice. Note that 2000 Hz is always measured in IEC 60118-7:2005 regardless of the AGC 2000 Hz setting here.

AGC SWITCHING: Status of compression switching during the ANSI S3.22-2003 and IEC 60118-7 2005 automated test sequences. These standards call for the hearing aid to be set with a high compression kneepoint during most of the test sequence, but for the compression kneepoint to be set to minimum (or as specified by the hearing aid manufacturer) during the I/O and attack and release measurements. Turning this setting ON allows the compression to be changed during the test sequence. Turning this setting OFF ignores this requirement and continues with the test sequence.

CD GROUP LOADED: This selects which, if any, group of settings for the Coupler Directional Screen are loaded.

Real-Ear Default Settings

FIT RULE: Fitting rule used to create real-ear targets. Choices include: NAL-NL1, MOD NAL, NAL-RP, POGO, BERGER, 1/3 GAIN, 1/2 GAIN, 2/3 GAIN, DIRECT.

CLIENT AGE: Age of the client being tested. This affects the real-ear targets when NAL-NL1 and MOD NAL are selected. Choices include ADULT, 0-2 MTHS, 3-6 MTHS, 7-12 MTHS, 1-2 YRS, 2-3 YRS, 3-4 YRS, 4-5 YRS, 5+ YRS.

COMPRESSION: Compression kneepoint of the hearing aid. If the hearing aid has multiple kneepoints of compression, choose the lowest frequency or the frequency in which the most significant compression occurs. This will affect the real-ear target when NAL-NL1 or MOD NAL is selected.

CHANNELS: Number of channels of the hearing aid. Choose from 1-18+. This will affect the real-ear target when NAL-NL1 or MOD NAL is selected.

AID LIMIT: Choose the type of output limiting used by the hearing aid. Choices are MULTICHANNEL, WIDEBAND or NONE. This will affect the real-ear target when NAL-NL1 or MOD NAL is selected.

FIT TYPE: Choose whether the client is being fitted with one hearing aid (UNILATERAL) or two hearing aids. (BILATERAL). This will affect the real-ear target when NAL-NL1 or MOD NAL is selected.

SOUND FIELD: Choose whether you are performing real-ear measurements using a sound field speaker placement at 0 degrees azimuth or 45 degrees (recommended). This will affect the real-ear target when NAL-NL1 or MOD NAL is selected.

REF POSITION: Choose whether or not you are performing sound field leveling with the patient in the sound field (HEAD SURFACE) or outside of the sound field (UNDISTURBED). This will affect the real-ear target when NAL-NL1 or MOD NAL is selected.

AUD TRANSDUCER: Choose the type of transducer used to perform the audiometric measurements. Choices include SOUND FIELD, ER3, TDH, or OFF. This will affect the real-ear target when NAL-NL1 or MOD NAL is selected.

RECD MODE: Choose whether the RECD is MEASURED, ENTERED, or OFF (RECD graph not displayed on Audiogram Entry screen).

RESET SOURCE: Source type selected by default. Choose from DIGSPEECH, TONE LONG, TONE NORM, TONE FAST, TONE SHORT, or COMPOSITE.

SOURCE FILTER: Choose the source weighting used with complex source signals. Options are ICRA, ANSI, ANSI 92, Flat or pink weighting. ANSI is recommended.

RESET EAR: Choose the default ear. LEFT or RIGHT.

REF MIC: Status of the reference microphone. ON or OFF.

OUTPUT LIMIT: Maximum measurement the probe microphone will read at any frequency before shutting off the test automatically. This is a safety feature to prevent the patient from being exposed to loud, amplified sounds. Choose from 80-140 dB in 5 dB increments. 120 is the recommended default. *Extreme care should be taken when raising this value above 120 dB.*

NOISE RED (TONE): Type of averaging used when performing pure-tone measurements. Choices are: OFF, 2X, 4X, 8X, 16X. When 2X is selected, two measurements are taken at each frequency in a puretone sweep and averaged together to obtain the final result. 4X, 8X and 16X work similarly.

NOISE RED (COMPLEX SOURCE): When A complex source signal is chosen, a running average is used when measuring the frequency response. Choices are OFF, 2X, 4X, 8X, 16X. When 2X is selected, the last two measurements are used to obtain the final result. 4X, 8X and 16X work similarly.

SMOOTHING: Choose whether or not to smooth the frequency response of the real-ear measurement. Smoothing makes the frequency response less peaky, but could also eliminate some information about the response, especially in the high frequencies. This can be turned on and off even after a measurement is taken, allowing you to see both the smoothed and unsmoothed result if desired.

APPROACH: This affects the default source type for curve 5 in the Insertion Gain and Real-ear SPL screens. When set to SPL, the default source type is TONE SHORT. When set to IG, the default source type is the RESET SOURCE used by the other four aided measurement curves.

UNAIDED: Choose whether or not use an AVG or CUSTOM unaided response. When the unaided response is measured, this is automatically set to CUSTOM.

REUR AUTO ADJUST: When this is enabled, the displayed unaided response will automatically adjust to the source level of the current selected aided curve.

That is, if the unaided curve was measured at 65 dB, but the 50 dB aided curve is selected, the unaided curve will automatically be adjusted linearly so that you can directly compare it to the 50 dB aided curve.

IG DISPLAY: This setting controls how curves are displayed in the bottom graph on the Insertion Gain screen. Choices are GAIN and SPL.

2.3 Source Types

At Frye Electronics, the acoustic signal used to test the hearing aid is called the source signal. In the past, two types of sources were available on the FONIX 8000 Test System: pure-tone and composite. With the introduction of real time digital signal processing, random noise and speech signals have been added to the list of available source signals.

Four methods of presenting pure-tone sweeps are available: long, normal, fast and short. Two types of composite signals are available: Composite and Digital Speech. The spectral content of the composite signal can also have your choice of speech weightings, including ANSI and ICRA.

Random noise with spectral weighting of flat or pink can now be used for testing hearing aids in coupler tests. Speech in the form of the ISTS signal is now available to be used in the ISTS option.

2.3.1 Understanding Pure-tone Signals

A pure-tone sweep is a test involving a progression of pure tone signals presented at a specified level. When the sweep is complete, the aid's frequency response at those frequencies is displayed on the graph (or data column).

There are four types of pure-tone signals: long, normal, fast and short.

- LONG: Contains 64 different frequencies and only does one sweep before ending the test.
- NORMAL: Contains 43 different frequencies and only does one sweep before ending the test.
- FAST: Contains 16 different frequencies and continually sweeps through them until you stop the test. The fast sweep is meant to be used as a real-time continuous signal convenient for use while adjusting hearing aids. It is an alternative to the composite signals.
- SHORT: Contains 10 different frequencies and only does one sweep. It is primarily used for testing loud levels in real-ear measurements.

2.3.1.1 Noise reduction

Noise reduction is used in noisy testing environments. Pure-tone noise reduction takes several measurements at each frequency and averages those measurements together. Larger noise reduction numbers lead to smoother curves but increase the amount of time it takes to complete a pure-tone sweep.

For example, if you select “4” as the pure-tone noise reduction setting, 172 measurements (43 x 4) will be taken with every normal pure-tone sweep.

2.3.1.2 Delay times

The FONIX 8000 Test System allows you to refine your pure-tone measurements with many different adjustments for delay times. This choice is allowed because some hearing aid circuits take a longer time than others to adjust to changes in amplitude or frequency. If the measurement is made too quickly, an artifact in testing will be created. If the measurement takes too long, the test is longer than necessary.

In determining the length of time needed for a proper measurement, a good rule is to use twice the published attack time of the hearing aid. If you are unsure of the attack time, you can experiment with longer times and shorter times and see if there is any difference in the test results. Linear aids can be tested very quickly, so a delay of 20 msec is usually fine. Other aids are quite variable.

The FONIX 8000 Test System has standard delay times that are determined by the aid type selection. When you set the delay settings to Default, the following delay times will be used:

Measurement	Linear	AGC	Adaptive
SWEEP START	100 ms	500 ms	2000 ms
SWEEP MEAS	20 ms	50 ms	100 ms
MISC START	100 ms	500 ms	2000 ms
MISC MEAS	20 ms	100 ms	200 ms
I/O START	100 ms	500 ms	2000 ms
I/O MEAS	20 ms	100 ms	200 ms

In addition to the delays, the aid type will also have an effect on the way some measurements are made. With a selection of ADAPTIVE, the analyzer will throw away the first three measurements of all averaging (including reference test gain) and harmonic distortion measurements. This will increase the amount of time it takes for the test, but it should increase the accuracy of the test for adaptive AGC aids.

Note: The “Adaptive” aid type category was created for a specific type of adaptive-AGC aid, such as the model created by Telex.

2.3.1.3 Harmonic distortion

When a pure tone is used for the test source, harmonic distortion can be measured by examining the multiples of the input source signal frequency.

Harmonic distortion occurs when a hearing aid amplifier modifies the shape of a pure-tone input signal, resulting in artifacts at harmonics (integer multiples)

of that input signal. For example, if you present a 500 Hz tone to the hearing aid, distortion artifacts could occur at 1000 Hz and 1500 Hz.

The harmonic distortion measurement is expressed as the percentage of the power of these distortion artifacts to the power of the input signal. All hearing aids will have some amount of distortion.

Usually, the strongest artifacts occur at the second and third harmonics of the frequency. With the FONIX 8000 Test System, you can test the amount of distortion available in the second harmonic, the third harmonic, or both harmonics (considered “total harmonic distortion”).

Definitions

2nd Harmonic: Energy of the second harmonic or twice the presented frequency.

3rd Harmonic: Energy of the third harmonic or three times the presented frequency.

TOTAL: Combined 2nd and 3rd harmonic distortion.

See Section 3.4.7 for instructions on performing the harmonic distortion measurement.

2.3.1.4 Pure-tone Filter

Pure-tone signals are usually flat-weighted. That is, in a pure-tone sweep, each tone usually has the same amplitude as every other tone in the sweep. In contrast, the wideband Composite and Digital Speech signals are usually speech-weighted. That is, the lower frequencies of the wideband signals have higher amplitudes than the higher frequencies, simulating the long-term average of speech.

2.3.2 Understanding Complex Signals

The 8000 now has the option of employing two types of complex source signals: composite waveforms and random noise.

There are two types of composite signals: Composite and Digital Speech. An additional complex signal, random noise, has been added to the choices enabled in the 8000's coupler mode of operation.

The Composite signal is a continuous broadband signal containing 79 different frequencies presented simultaneously. This signal is usually “speech weighted,” in which the lower frequencies are presented with a stronger emphasis than the higher frequencies. After the composite acoustic signal has been processed by the hearing aid microphone/amplifier/receiver and picked up by the 8000's microphone, the resulting signal is digitized and then analyzed by use of a mathematical algorithm called the Fourier transform. All 79 components of the composite signal are thus processed simultaneously.

Operationally, the Composite signal is both a faster and a more realistic signal than a pure-tone sweep because there is no waiting for a progression of tones to complete, and, like speech, a broad spectrum of frequencies is used simultaneously. The Composite signal typically repeats 100 times a second. A complete response can thus be generated in 10 milliseconds.

Random noise, on the other hand,, is a random signal, and does not repeat. In some ways, it is like speech, which also does not repeat. It is only over a period of time that all random signal or speech frequency components are produced. Thus it takes mathematical signal averaging over a much longer period of time to generate a reasonable display of an aid's response to a random noise or a speech signal.

"Digital Speech" is an interrupted version of the Composite signal used for testing modern digital hearing aids. Many of these digital aids (though not all) use a technology called "speech enhancement" or "noise reduction." These aids respond to any continuous signal as if it were noise, and lower the gain at those frequencies. Unfortunately, these aids regard the Composite signal or pure-tone sweeps as noise, making them difficult to test using traditional methods. Digital Speech was developed as a way to test these high-end hearing aids. Instead of presenting a continuous signal, it presents an interrupted signal that the aid interprets as speech instead of noise.

A further enhancement is seen in recent digital hearing aid algorithms. The phase of the high frequency portion of the amplified spectrum is randomized, so that the phase of the signal coming out of the aid cannot be predicted. The randomizing allows the hearing aid to provide as much as ten decibels more gain than a non randomized amplifier before feedback occurs. And since this portion of the amplified speech spectrum usually consists of noisy sounds as is produced with phonemes like "/s/" and "/t/", little intelligibility is lost when this algorithm is employed.

However, this HF signal randomizing destroys the ability of the analyzing instrument to use time domain averaging, since such an averaging process results in an answer of zero gain for the randomized frequency bands. The 8000 and other FONIX analyzers overcome this problem when digital speech is chosen as the source test signal by shifting averaging to the frequency domain. The averaging is done after the frequency content of the individual samples of the signal have been calculated.

Time domain averaging is still used with the Composite signal for noise reduction.

2.3.2.1 "FFT" and Fractional octave Complex signal analysis

An interesting property of pure tone signals is that if an analyzer system is working properly, a pure tone presented to either a Fast Fourier Transform method of analysis or a fractional octave band analyzer method, such as one third octave analyzer, the answer is always the same. The pure tone presents only one frequency component. The same cannot be said for a complex signal with a spread of frequency components.

Complex signals have spectra that spread over many frequency bands, and the width or composition of the frequencies in the bands differ between FFT and fractional octave analyzers. A third octave analyzer has a band spread of 1/3 octave, regardless of the center frequency of the band. The FFT, on the other hand, has a frequency band spread set by the basic time window of analysis; a FFT system like the 8000 uses has a window of 10 milliseconds, setting the individual analysis windows to 100 Hz, regardless of the frequency being analyzed.

When a complex signal with a “WHITE” or “FLAT” spectrum is analyzed by a FFT analyzer, the frequency response will be flat across the spectrum. The same signal analyzed by a fractional octave band analyzer will show a rise with frequency at the rate of 3 dB per octave. It is possible to employ a mathematical conversion to convert a FFT analysis to that of a 1/3 octave analyzer. The 8000 provides this conversion in the operation of the ISTS option. The use of the PINK spectrum test source filter will provide a flat appearing response with a fractional octave band analyzer. The 8000 does not provide this spectrum analysis method in the coupler test window.

2.3.2.2. Spectral weighting and “leveling” of complex source signals

Complex signals can be used with several different types of weightings: ANSI, ICRA, FLAT and PINK. Flat is generally only used for specific research purposes—it contains no speech weighting and is difficult for most hearing aid circuits to process. PINK is a recent introduction to FONIX analyzers.

The 8000 now uses real time digital signal processing (DSP) to “level” the response of the sound delivery system. All of the analog signals being routed to the speaker that delivers energy to the sound field are passed through a digital filter, the components of which have been set during the leveling process to adjust the spectrum to within a few tenths of a decibel of the level of the electrical input spectrum. The leveling process typically takes around one second. The DSP process is used in coupler and real ear sound generation.

2.3.2.3 Noise reduction

Complex noise reduction is a little different than pure-tone noise reduction (discussed in Section 2.3.1.1), even though both are used for noisy testing environments.

When a complex signal is running, the analyzer takes several different measurements a second and displays them on the screen. Composite noise reduction performs a “running average” of these composite measurements. This means it averages together several of the previous measurements with the current measurement to produce the next curve. If you select “2X” noise reduction, it will average the last two measurements together. A selection of “4X” averages the last four measurements together. When performing composite measurements, it will take several seconds for the actual noise reduction used to reach the set value. This is due to the nature of the running average.

Larger noise reduction numbers lead to smoother curves but increase the amount of time it takes the analyzer to update its composite measurements.

2.3.2.4 Intermodulation distortion

The complex signals are helpful for identifying intermodulation distortion (IM). IM distortion occurs when amplitudes at more than one frequency in a signal combine to create an amplitude at a frequency not present in the original signal. When viewing a graph run with a composite signal, look for points along the graph where the line “breaks up.” Such an appearance indicates the presence of IM distortion. See Figure 2.3.2.4 for an example of IM distortion.

This type of distortion is only apparent when a composite signal source is used because pure-tone sweeps do not present more than one frequency at a time.

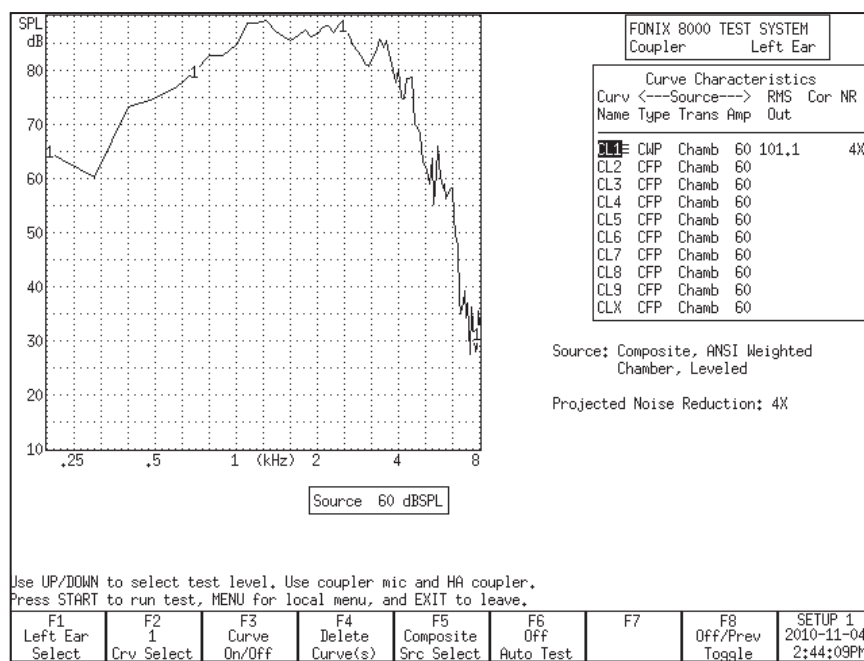


Figure 2.3.2.4—Example of IM distortion

2.3.2.5 Complex Signal filters

The spectral character of the Composite signal can be shaped with two main types of filters (also known as “speech weighting”): ICRA and ANSI. They differ in the speech spectrum they use.

The ANSI filter, taken from the ANSI S3.42 standard, rolls off the high frequencies at a rate of 6 dB per octave, starting with a 3 dB drop at 900 Hz. The ICRA filter uses the ICRA speech spectrum developed by the International Collegium of Rehabilitative Audiology. The ICRA spectrum is based on the Long Term Average Speech Spectrum (LTASS) and rolls off the high frequencies more rapidly than the ANSI spectrum. Figure 2.3.2.5 shows a comparison of the spectra.

In general, we recommend using the ANSI speech weighting for Composite and Digital Speech measurements.

Spectra of either FLAT or PINK may be selected when the Random Noise signal is used. The spectral weighting can be selected by use of the MENU in the coupler screen.

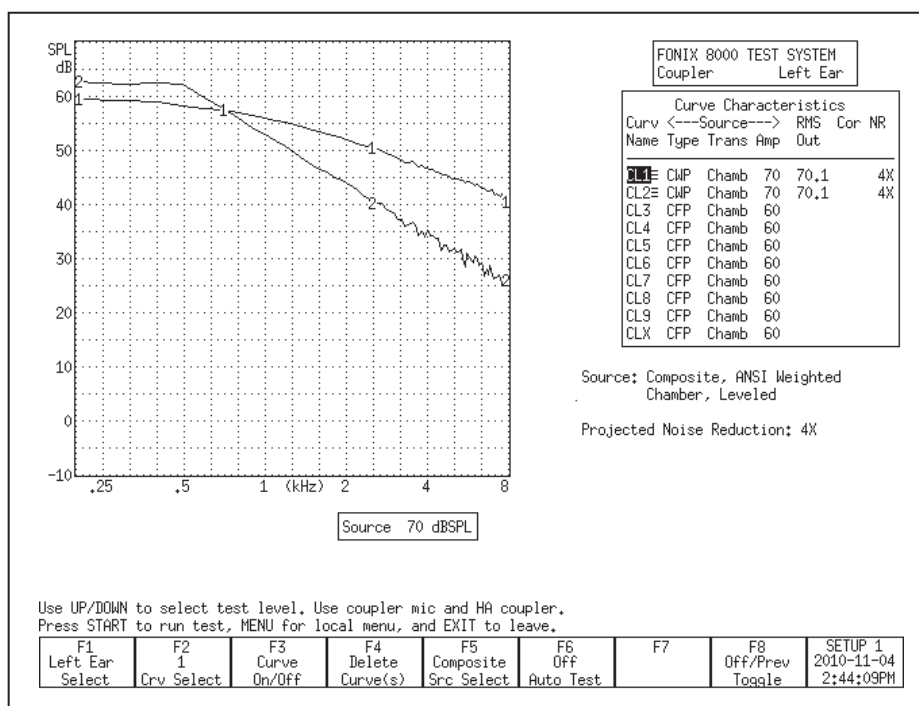


Figure 2.3.2.5—Comparison of the ICRA shape and the ANSI shape

2.3.2.6 Composite type

There are two types of the traditional Composite signal available on the FONIX 8000 Test System. They are known as “Standard” and “Chirp.” The two signals differ in the manner that their phase is generated, and this difference has an impact on the *crest factor* of the signals. The *crest factor* of a waveform is the ratio of its highest amplitude to its RMS amplitude. Human speech is often referred to as having a 12 dB crest factor.

For the needs of most clinicians, the Standard and Chirp Composite signals are virtually identical.

The Standard Composite signal is composed of 79 different individual frequencies that are each generated with a random phase pattern that results in the signal having a crest factor of 10 dB, close to the crest factor of human speech. (If the phase components were not randomized or otherwise changed, and if all the signal components were in phase, the crest factor of the signal would increase

to over 19 dB.) The Standard Composite signal is the standard signal used on the 7000 test system, the predecessor to the 8000.

The Chirp Composite signal is another type of composite signal, but with a lower crest factor. The phase of the individual frequency components of the Chirp Composite signal is determined in a way that makes the signal appear to be presented as a “chirp,” or very fast sweep. The Chirp has a crest factor of 6 dB. The Chirp Composite signal is the standard composite signal used on the FP40 and FP35 portable hearing aid test systems.

Although the Standard and Chirp Composite signals sound the same to most people, an analysis tool such as Tempus3D will show the difference between them. Both the Standard and the Chirp Composite signals are further speech-weighted to agree with the user-selected composite filter (described in Section 2.3.2.5.)

2.3.2.7 Complex source levels

The Composite signal (and its Digital Speech counterpart) is a complex signal consisting of 79 different frequency components. When you set the source level of a composite signal (50 dB, 60 dB, etc), you are actually setting its overall energy, known as the RMS (root-mean-square) of the signal; you are NOT setting the amplitude of the individual frequency components.

The actual amplitude of each of frequency of the Composite signal is less than the overall RMS of the signal. See Figure 2.3.2.7 for an example of the SPL levels of each frequency of the Composite signal with an RMS of 70 dB. Be aware of this difference, especially when viewing frequency response results in overall amplitude of dB SPL. The noise signal also has to be thought of in much the same way.

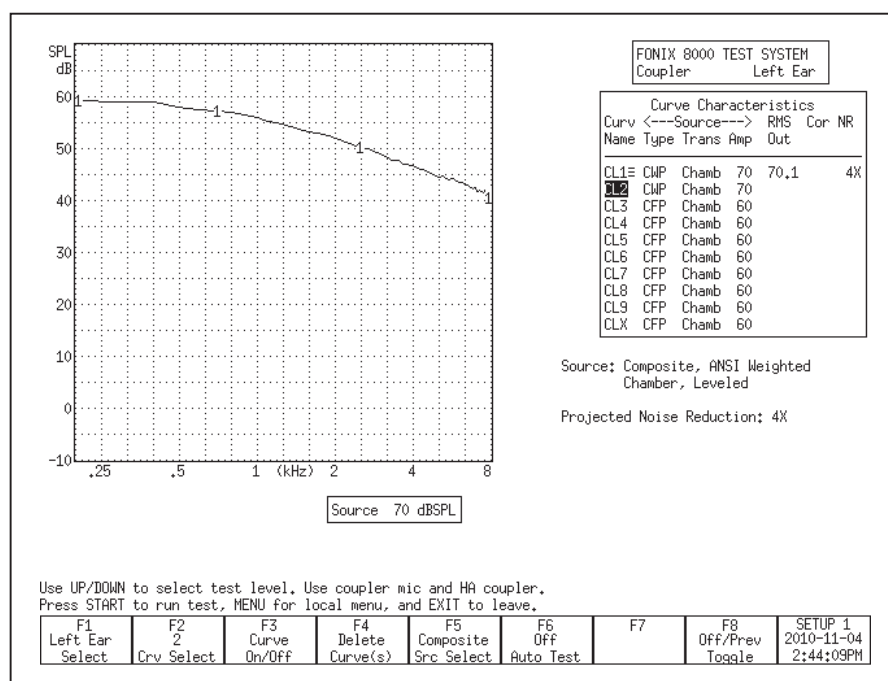


Figure 2.3.2.7: ANSI weighing of the Composite signal at 70 dB SPL RMS

2.3.2.8 Digital Speech technical details

The digital speech signal works by turning the composite signal on for a set period of time, taking a measurement, turning the signal off for a random period of time, and turning the signal back on again. This sequence is repeated until the test ends.

The signal “on” time takes a minimum of 60 milliseconds. This includes the time to turn the signal on, take the measurement, and turn the signal off. Some aids may require an additional delay before the measurement is taken in order to allow their circuits to settle. This additional delay time can be changed in the MISC MEAS delay setting that is available in the local menu of the measurement screens and in the Setup Menu. The MISC MEAS setting is automatically adjusted according to the aid type selected. This setting is added to the 60 ms minimum measurement time.

The default settings are:

Linear: 20 ms
AGC: 100 ms
ADAPTIVE: 200 ms

The signal “off” time is random between 100 and 300 milliseconds. This time is not controllable by the user.

Changing the White/Pink Noise

1. Use [F5] to choose the RANDOM NOISE signal source. (Press [F5]. Use [▼, ▲] to select the desired signal type. Press [►] to complete the selection and close the pop-up menu.) See Section 3.4.1 for details on signal types.
2. Press [MENU] in the Coupler screen.
3. Use [▼, ▲] to select Composite Filter under Measurement Settings. Use the [START] key to skip ahead sections, if necessary.
4. Use [◀, ▶] to select **Flat** or **Pink**.
5. Press [EXIT] to return to the Coupler screen.

2.3.3 Understanding the Frequency Shift Signal

The frequency shift signal generates a single puretone signal like in section 2.3.1, but analyzes it like a composite signal in section 2.3.2. This test is used to see how much the hearing aid shifts the input signal frequency.

2.4 Printing

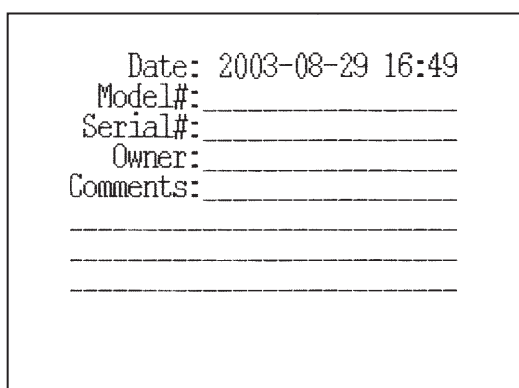
The FONIX 8000 Test System comes equipped with an internal thermal printer. The thermal printer prints a clear, easy-to-read image of the display. At this time, there is no support for external printing.

2.4.1 Adding a label

A label with your printout allows you to record useful information about the client and hearing aid to go along with the test results. See Figure 2.4.1.

If you are in the middle of a test, and you want to add a label for the printout in the local screen without changing the default setting, perform the following steps:

1. Press [MENU] from the measurement screen to open a local menu.
2. Use [▼, ▲] to select Print Label. You may want to use the [START] button to skip ahead sections in the local menu.
3. Use [►] to turn the label ON.
4. Press [EXIT] to return to the measurement screen. Any printout will now include a label until your turn off the analyzer.



```
Date: 2003-08-29 16:49
Model#:
Serial#:
Owner:
Comments:
-----
-----
-----
```

Figure 2.4.1—Label with printed result

If you want to include a label on all printouts by default:

1. Press [MENU] from the Opening screen to enter the Setup menu.
2. Use [▼, ▲] to select Print Label.
3. Use [►] to select ON.
4. Use [F8] to save the settings to a user setup. This will also save all the other selections in the Setup menu.
5. Press [EXIT] to return to the Opening screen.

2.4.2 Using the printer

The internal printer of the FONIX 8000 Test System is straight-forward to use. Make sure the internal printer is selected by following the instructions in the section above. Press [PRINT] to print any displayed screen. Press the [FEED] button to feed the thermal paper through the printer without printing.

General Information

The following is useful information to know about the internal printer:

- Raise “Head-Up” lever to the **up** position when paper is not loaded, or when the internal printer is not in use for extended periods of time.
- Frequently inspect the printer for any residue or foreign matter, and clean as required. Paper residue or foreign matter may shorten the life of the thermal printer head or platen.
- The 8000 printer mechanism is equipped with a paper back tension device. This feature is used to eliminate paper migration from side-to-side. If paper migrates too far to one side, the edge of the paper will “krinkle” and cause a paper jam. The white plastic, spring-loaded, back tension rod located at the rear of the printer mechanism provides the required tension on the outside of the paper roll. No adjustment is required for proper operation.

Error Messages:

In the event that an error occurs when printing with the 8000 analyzer, we’ve included some error codes in the lower right corner of the screen that should help a FONIX technician troubleshoot the problem. This section describes those error codes.

There are two categories of errors that can occur with the 8000 printer: initialization errors and printing errors. Initialization errors occur only when the 8000 analyzer is first powered up; this also initializes the printer. Here are the printer initialization error codes:

- Init failed 0: No memory available for the converted screen buffer
- Init failed 1: No memory available for the label bitmap
- Init failed 2: Printer driver unresponsive
- Init failed 3: Version number from printer board is unreadable

Errors that occur when actually printing have the following error codes:

- Print failed 0: Switching from internal to external printer failed
- Print failed 1: Copying the label bitmap to the printer board has failed
- Print failed 2: Converting the screen to printable version has failed
- Print failed 3: Copying the converted screen bitmap to the printer board has failed
- Print failed 4: Preparing to print; printer board is busy
- Disconnected: External printer is disconnected.
- No power: Internal or external printer is not powered.
- Offline External printer is offline.
- Head up: Internal printer has head raised.

If you are having a problem with the 8000 printer, contact the factory (Section 1.7.4) and be ready to provide the Frye technician with the error code. The printer software version, available in the help menu of the Opening screen, will also be helpful.

2.4.4 Loading the thermal paper for v2.91, (For v3.00 printer go to page 255)

Please read the entire instructions before loading paper. Refer to Fig. 2.4.2A for printer features. (see next page)

Step I: Installing the paper into the printer assembly

1. Open the printer door.
2. Remove the plastic paper roller from the printer mechanism. If you are replacing an empty paper roll, remove and discard the paper spool from the printer mechanism, but **do not discard the plastic roller**. The spring-loaded (white plastic) back tension rod, located directly behind the paper roller is not a removable part.
3. Insert the plastic roller into a new paper roll.
4. Install the plastic roller and paper roll into the printer mechanism, with paper facing out and feeding from the top of the roll. (See Fig. 2.4.2C) The paper roller will fit into the slots on the left and right side of the printer mechanism. The paper roller should drop into position without additional adjustment.

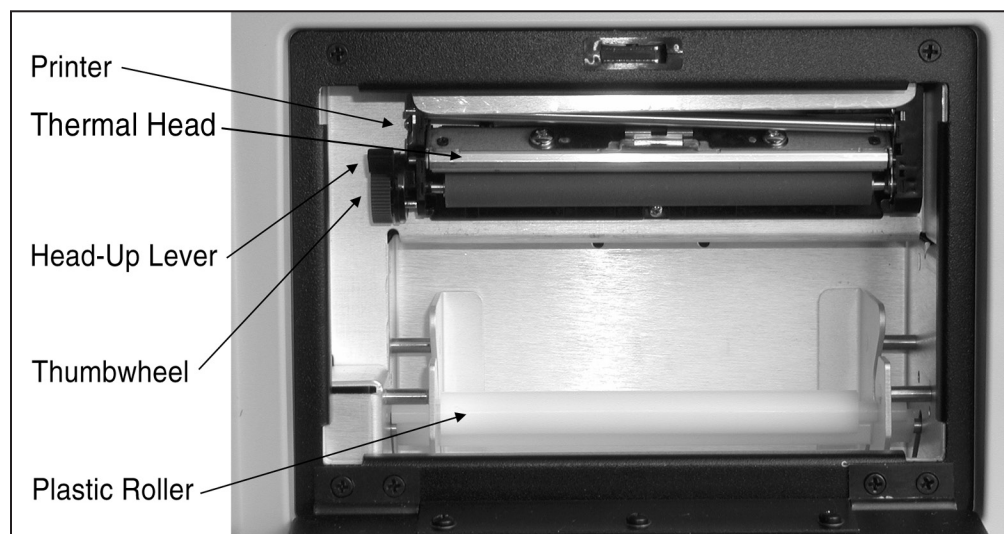


Figure 2.4.2A—The internal printer

Step II: Loading paper into the printer

1. Turn on the instrument.
2. Place the Head-Up lever into the **up** position. See Fig. 2.4.2B.

3. Unroll approximately six inches of paper from the roll, and insert the paper's leading edge into the bottom of the printer mechanism, directly beneath the rubber roller so the paper moves up behind the roller. See Fig. 2.4.2C.
4. While holding the paper in place behind the rubber roller, manually turn the thumbwheel to advance the paper approximately one inch. **Never press the [FEED] button** while the Head-Up lever is in the **up** position. See Note 2 at the end of this section.

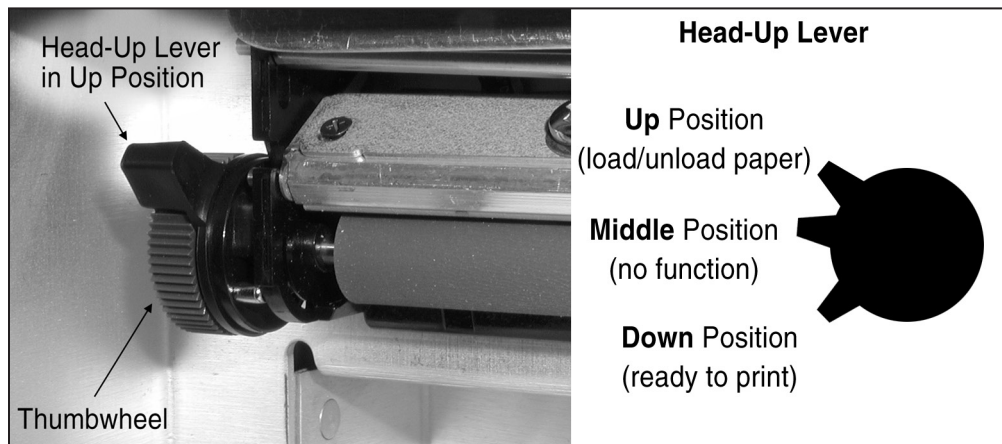


Figure 2.4.2B—Head-Up lever in up position.

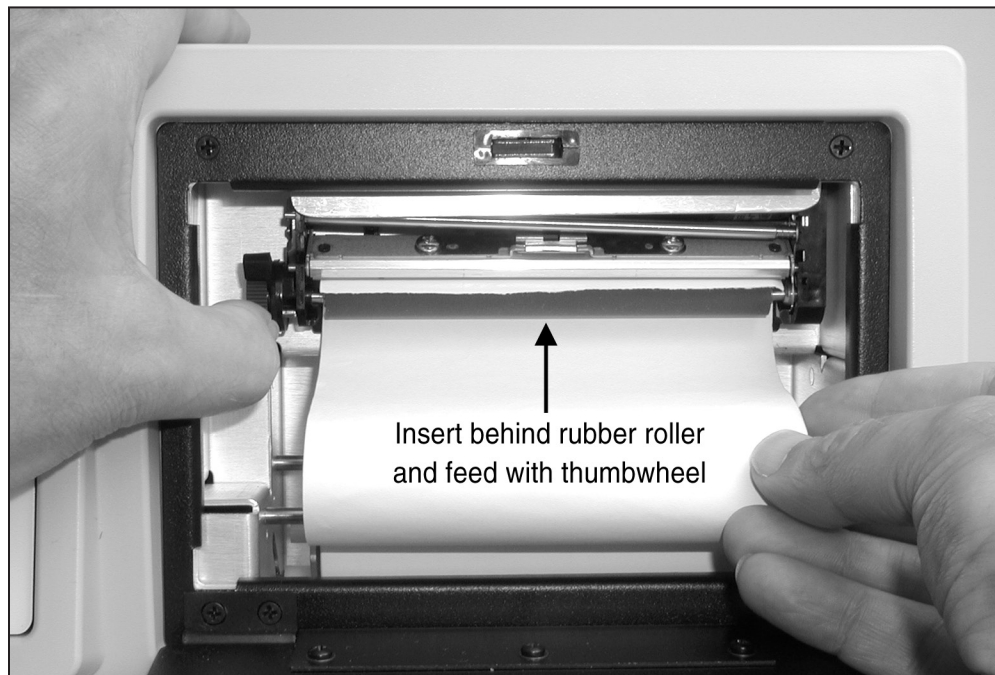


Figure 2.4.2C—Loading paper into the printer

5. Center the paper on the rubber roller. Visually inspect the paper path to ensure that the paper advances smoothly without hitting the edges of the printer. If necessary, manually pull on the end of the paper until the paper is centered and does not hit the edges of the printer.
6. Place the Head-Up lever into the **down** position.
7. *Please read the caution note below before proceeding.*

Press the [FEED] button to advance the paper. Continue pressing it until the paper advances smoothly. The back tension device should automatically correct a misaligned paper feed.

If the paper is not aligned properly, it may “krinkle” on one edge. If the paper continues to wrinkle after feeding 12 inches, place the Head-Up lever into the **up** position and repeat steps 5 through 6.

CAUTION—Do not allow the paper to feed back into the rubber roller. It may be necessary to use your fingers to guide paper out and away from the rubber roller. If the paper has a severe curl, it may have a tendency to roll back under the rubber roller and cause a paper jam. If this occurs, stop feeding the paper immediately, remove it from the roller, and reload the paper.

8. Tear off excess paper by pulling the paper against the thermal head at approximately a 45° angle.
9. Close the printer door. Press the [FEED] button to advance the paper through the printer door slot. You can tear off excess paper by pulling it upward against the tear strip (on top of the printer door opening) at approximately a 45° angle. You are now ready to print.

Note 1: Whenever the printer door is opened, you will need to repeat steps 8 and 9. **Closing the printer door without tearing the paper at the thermal head can cause a paper jam, which can damage the printer.**

Note 2: If the [FEED] or [PRINT] button is pressed while the Head-Up lever is in **up** or **middle** position, the printer may fail to respond to all subsequent key commands, even when the lever is returned to **down** position. If this happens, it will be necessary to power off the instrument and restart.

2.4.3 Unloading a partial roll of paper

1. Place the Head-Up lever in the **up** position.
2. Use the thumbwheel to unwind the paper from behind the rubber roller.
3. Push the roll of paper back and up, then lift it out.

2.5 Display & Data

This section describes the Curve Characteristics Box that is common to every measurement screen, and the data display that shows the numerical data of the response curves in the Coupler screen and the real-ear measurement screens.

2.5.1 Viewing the Curve Characteristics Box

Each measurement screen has a Curve Characteristics Box that tells you different information about each measured curve. It has several different columns of data: Curve Name, Curve Title (real-ear only), Source Type, Source Transducer, Source Amplitude, RMS Out, Correction Factors (COR, coupler only) and NR (Noise Reduction). Figure 2.5.1 shows an example.

FONIX 8000 TEST SYSTEM						
Coupler			Left Ear			
Curve Characteristics						
Curv	<---Source---			RMS	Cor	NR
Name	Type	Trans	Amp	Out		
CL1E	CMP	Chamb	70	70.1		4X
CL2E	CMP	Chamb	70	63.5	CIC	4X
CL3	CFP	Chamb	60			
CL4	CFP	Chamb	60			
CL5	CFP	Chamb	60			
CL6	CFP	Chamb	60			
CL7	CFP	Chamb	60			
CL8	CFP	Chamb	60			
CL9	CFP	Chamb	60			
CLX	CFP	Chamb	60			

Figure 2.5.1—Curve Characteristics Box

Curve Name: This identifies the name of each curve. The first letter is derived from its measurement type—coupler (C) or probe (P). The second letter is derived from its ear—left (L) or right (R). (Coupler curves can also be labeled A and B.) The third letter is the number of the curve. CR1 is the first coupler curve for the right ear. PL2 is the second probe curve for the left ear.

Curve Title: This identifies the title of the real-ear curve. It is only available in the real-ear measurement screens. Here are the possible titles: REUR (real-ear unaided response), REAR (real-ear aided response), REIG (real-ear insertion gain), TARG (real-ear target), HTL (hearing threshold level), UCL (uncomfortable level).

Source Type: This identifies the type of source used to make the curve. Each curve is identified by three letters.

First letter:

- C = Composite
- P = Pure-tone
- D = Digital Speech

Second letter:

For pure-tone:

- N = Normal pure-tone
- F = Fast pure-tone
- S = Short pure-tone

For Composite or Digital Speech:

W = Weighted composite
 F = Flat weighted
 S = Spectrum

Third letter:

P = SPL measurement (power)
 G = Gain measurement

Note: When it's possible to toggle between Gain and SPL in the local menu, the FONIX 8000 Test System will convert most curves back and forth between the two formats.

Source Transducer: This identifies the transducer used to make the measurement. "Chamb" means sound chamber. "S.F." means sound field. "Tcoil" refers to a telecoil board or telewand transducer.

Source Amplitude: This identifies the amplitude of the signal used to make the curve.

RMS Out: The root-mean-square of the measured curve.

Correction Factors (COR): The coupler correction factors used to make the measurement. Coupler screen only.

Noise Reduction: The noise reduction used to make the measurement. See Sections 2.3.1.1 and 2.3.2.1.

Lastly, just to the right of the Curve Name column, the FONIX 8000 Test System uses symbols to describe the display status of the curves. Here is the legend for those symbols:

- ≡ Curve is completely on the graph
- Curve is measured but turned off
- ↓ Curve is partially off the bottom of the graph
- ↑ Curve is partially off the top of the graph
- ▲ Curve is on, but is out of view above the graph
- ▼ Curve is on but is out of view below the graph
- ↕ Curve is partially off the graph in both directions

2.5.2 Viewing numerical data

You can display the numerical data of the response curves made in several test screens including the Coupler Multicurve screen.

To display numerical data:

1. Press [MENU] from the test screen.
2. Select Data/Graph using [▼, ▲]. (This selection is not available in the automated test screens such as ANSI 03.)
3. Use [◀, ▶] to select DATA.*
4. Press [EXIT] to return to the measurement screen.
5. Use [F2] to select the curve that you want to show. See Figure 2.5.2 for an example of the data display of a composite curve.

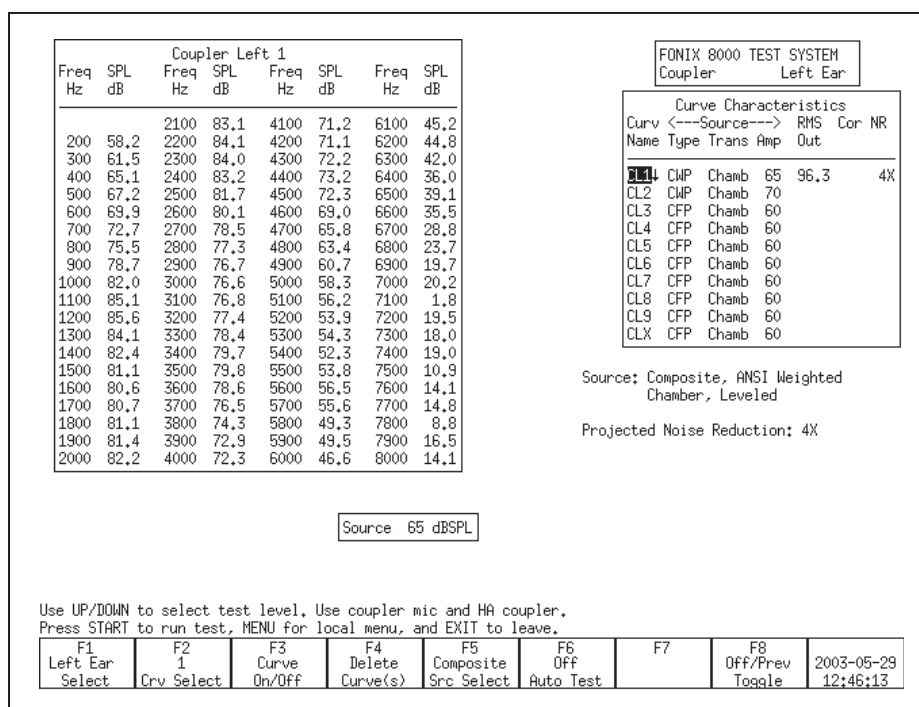


Figure 2.5.2—Data display of a composite measurement

2.6 Computer Connection

The FONIX 8000 Test System is equipped with an RS232 connection that will allow you to connect to a personal computer and exchange data. You will also need a software program, such as WinCHAP, on your Windows computer that can communicate with the analyzer. It is possible to make your own program using the FRYERS protocol. See www.frye.com for details.

2.7 Leveling

Leveling is the process by which the response of the sound chamber or sound field is measured and computer-corrected so that a flat sound field is achieved. Sound chamber leveling can be saved into permanent memory.

Here are some technical details on the leveling status messages.

- UNLEVELED: Leveling has not been attempted and sound is uncorrected.
- LEVEL_ERROR or LEVEL_FAILED: An error happened during leveling and source is uncorrected.
- LEVELED: Leveling has been achieved within ± 0.25 dB between 260–6000 Hz and ± 0.5 outside that frequency range for sound chamber leveling or within ± 1 dB between 260–6000 Hz and ± 2 dB outside that frequency range for real-ear leveling.
- SEMI_LEVELED: Leveling has been achieved between ± 0.25 dB and ± 0.5 dB between 260–6000 Hz and between ± 0.5 and ± 1.5 dB outside that frequency range for sound chamber leveling or between ± 1 dB and ± 2 dB between 260–6000 Hz and between ± 2 dB and ± 6 dB outside that frequency range for real-ear leveling.
- WEAK_LEVELED: Tolerances are the same as SEMI-LEVELED but the maximum output for the speaker is less than 100 dB for coupler measurements or 80 dB for real-ear measurements. To achieve a louder signal, the speaker needs to be moved closer to the analyzer microphone and re-leveled.

If a leveling error occurs during sound chamber leveling, check the connections of the sound chamber and the microphone, and make sure that you are getting noise out of your sound chamber. If those connections are good, your microphone is probably in need of calibration or it is damaged. It is also possible that your sound chamber speaker is damaged, but this is unlikely.

Contact the factory or your local FONIX distributor if you continue to have problems with leveling.

Basic Sound Chamber Tests

In the Coupler Multicurve screen, you can view measurement curves in dB SPL or dB Gain, and run them with Composite, Digital Speech, or pure-tone signals. You can display up to 10 curves on the Coupler screen at the same time.

From the Opening screen of the FONIX 8000 Test System, enter the Coupler Multicurve screen by pressing [F1].

The Coupler Multicurve screen can be set as the screen that appears when the FONIX 8000 Test System is powered or the [RESET] button is pressed. See Section 2.2.1 and 2.2.4 for details.

3.1 The Coupler Multicurve Screen Display

The display of the Coupler Multicurve Screen varies depending upon whether you have chosen a pure-tone source or a composite (including Digital Speech) source.

3.1.1 Viewing a Pure-tone Display

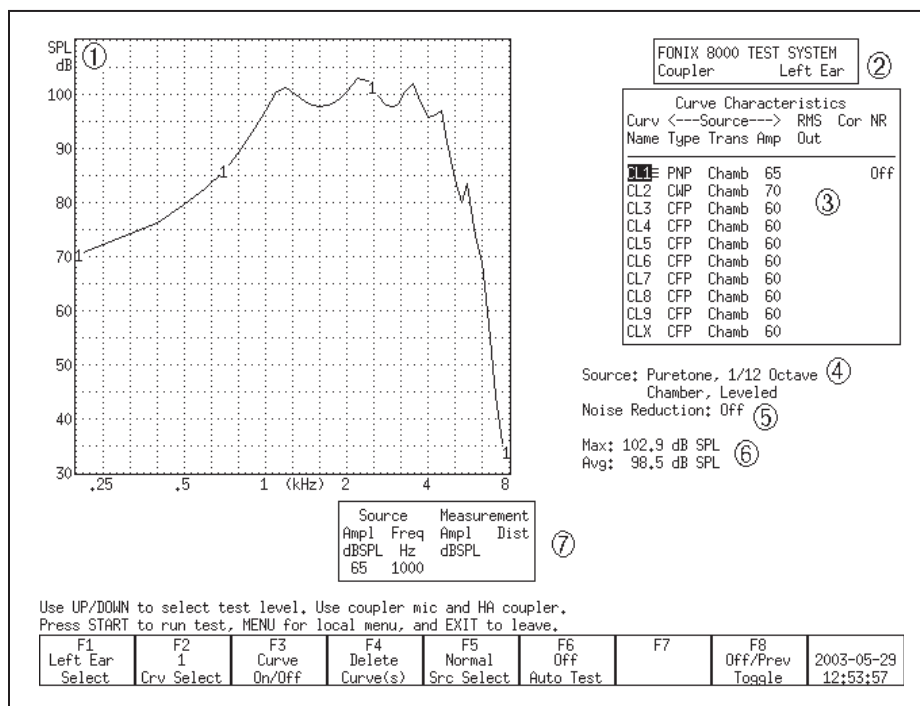


Figure 3.1.1—Coupler Multicurve Screen with pure-tone source

Refer to Figure 3.1.1 for the following explanation of the graphical display:

1. Type of display. This will be either dB SPL (coupler output) or dB Gain (coupler gain).
2. Selected ear.
3. Curve Characteristics box. See Section 2.5.1 for more details.
4. Signal type and leveling status.
5. Selected noise reduction.
6. Maximum output and three-frequency average of the selected curve.
7. Source Signal Statistics Box. Displays the source amplitude, frequency, distortion and output/gain.

3.1.2 Viewing a Composite Display

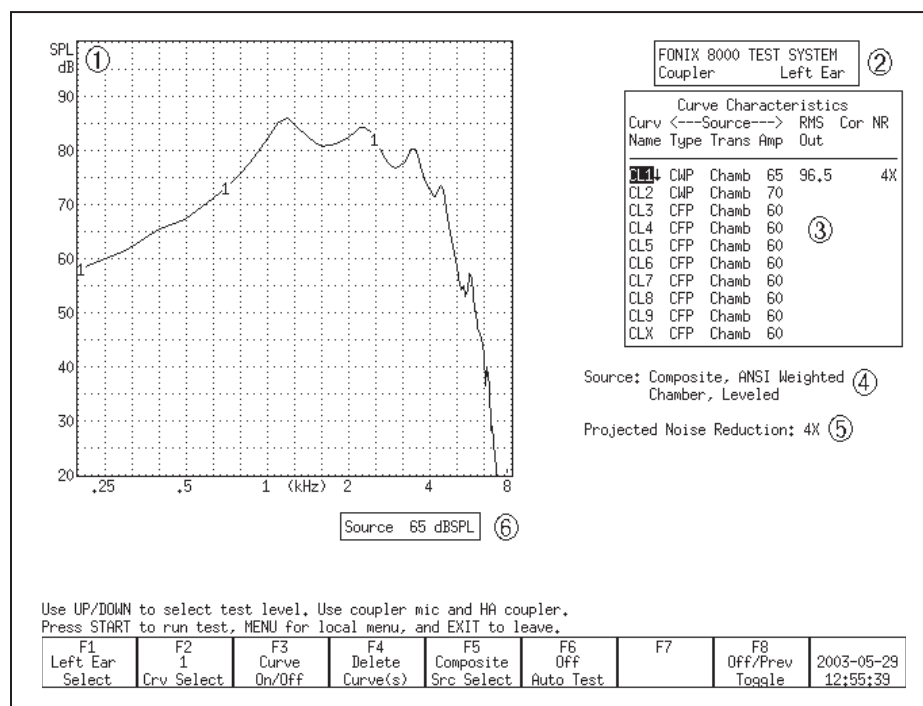


Figure 3.1.2—Coupler Multicurve screen with a Composite source

Refer to Figure 3.1.2 for the following explanation of the graphical display:

1. Type of display. This will be either dB SPL (coupler output) or dB Gain (coupler gain).
2. Selected ear.

3. Curve Characteristics box. See Section 2.5.1 for more details.
4. Signal type, speech weighting, leveling status, and bias status (Digital Speech only).
5. Selected noise reduction.
6. Source Signal Statistics Box. Displays the source amplitude.

3.2 The Leveling Process

Leveling is the process by which the response of the sound chamber is measured and computer-corrected so that a “flat” sound field is achieved. The leveling status can be saved into the FONIX 8000 Test System’s permanent memory so that you don’t have to level the analyzer every time you turn it on. However, if you get your analyzer calibrated, or if you get a software upgrade, you should always level the chamber again (and save the leveling).

To double-check the leveling status of the analyzer, place the microphone by itself in the sound chamber at the reference point and run a composite frequency response (Figure 3.2). You should get a smooth, flat curve.

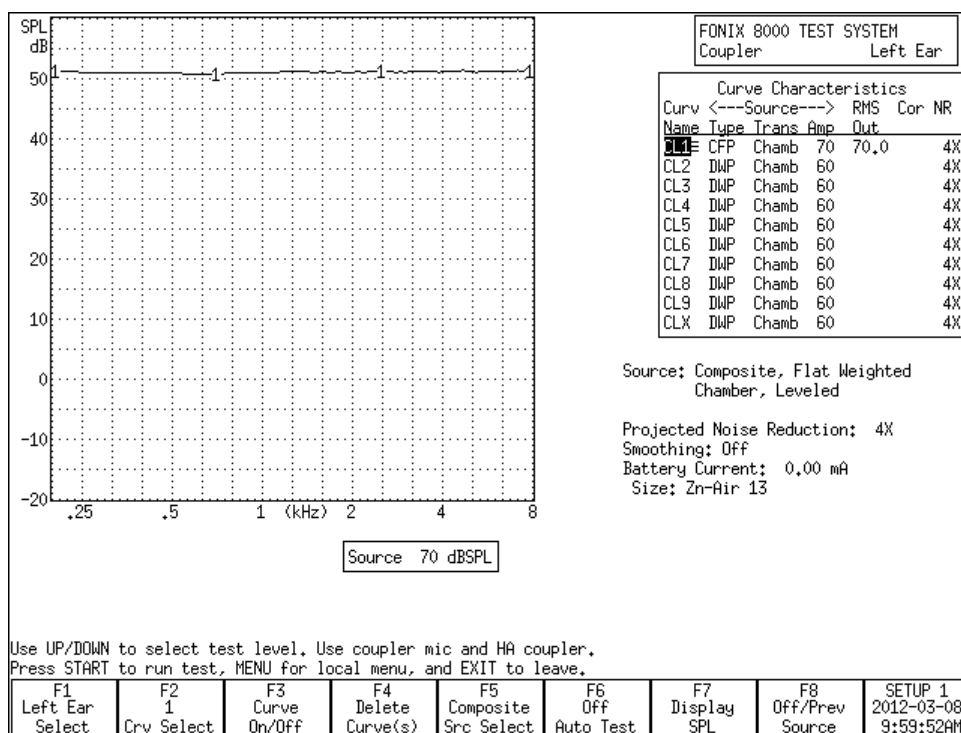


Figure 3.2

If you are getting bad coupler frequency responses that you suspect are the fault of the analyzer, rather than the fault of the hearing aid, the first step of troubleshooting is to level the sound chamber. Even if the screen says LEVELED, the

response of the measurement microphone may have altered since the analyzer was last leveled, invalidating the leveling. When in doubt, level the sound chamber again.

See Section 2.8 for details on the leveling status and troubleshooting the leveling process. See Section 5.1.1 for the ANSI standardized leveling procedures.

3.2.1 Leveling the 8050 & 8060 Sound Chambers

To level the 8050 & 8060 sound chambers:

1. **IMPORTANT:** Be sure nothing is plugged into the battery voltage supply.
 2. Place the microphone in the sound chamber with the microphone grill over the reference point at a 90° angle the speaker in the back of the chamber (Figure 3.2.1). Close and latch the sound chamber lid.
- Warning: Leveling is valid only when the microphone position is not changed after leveling. Each significant change in microphone location requires new leveling.**
3. Press [F1] to enter the Coupler Multicurve screen.
 4. Press [LEVEL] to start the leveling sequence. The system responds by presenting a complex composite signal consisting of tones from 100 to 8000 Hz. It measures the signal and stores correction factors, so that the sound field is flat for testing.
 5. Look at the display. After a few seconds, the video monitor should display a “Leveled” message under the Curve Characteristics box. If the FONIX 8000 Test System doesn’t level, it could be an indication that your microphone needs to be calibrated or replaced.

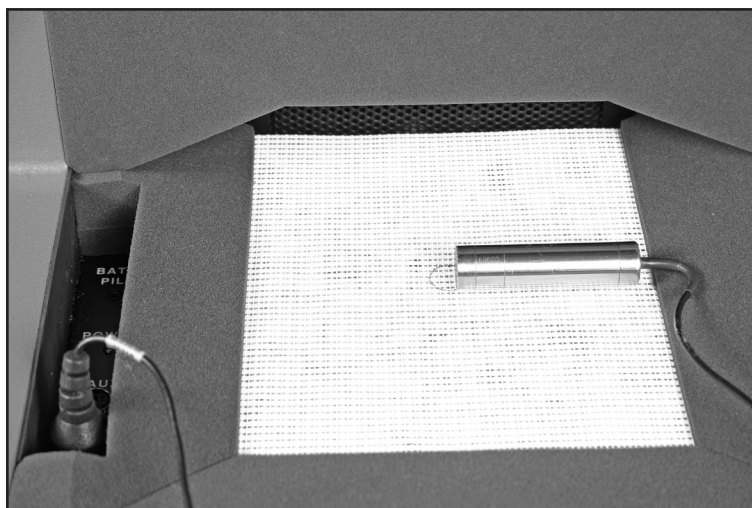


Figure 3.2.1—Leveling the 8050 & 8060 Sound Chambers

3.2.2 Leveling the 8120 Polar Plot Sound Chamber

When performing Coupler Multicurve or automated test sequence coupler measurements such as ANSI or IEC, it is not necessary to position the hearing aid in the 8120 Polar Plot chamber on the rotating shaft. If desired, you can place the 8120 Removable Test Surface over the cavity and perform the coupler measurements with the hearing aid placed on the basket. This procedure describes how to level the sound chamber for this type of testing. If you are going to measure the hearing aid with it placed on the rotating shaft, see Section 6.2 for leveling instructions.

1. Place the 8120 Removable Test Surface over the cavity containing the rotating shaft in the chamber.
2. Unplug any battery pill from the sound chamber.
3. Place the microphone on the test surface with the microphone grill over the reference point at a 90° angle to the speaker in the back of the chamber (Figure 3.2.2). Close and latch the sound chamber lid.

Warning: Leveling is valid only when the microphone position is not changed after leveling. Each significant change in microphone location requires new leveling. This includes positioning the hearing aid on the rotating shaft for Coupler Directional testing.

4. Press [F1] to enter the Coupler Multicurve screen.
5. Press [LEVEL] to start the leveling sequence. The system responds by presenting a complex composite signal consisting of tones from 100 to 8000 Hz. It measures the signal and stores correction factors, so that the sound field is flat for testing.
6. Look at the display. After a few seconds, the video monitor should display a “Leveled” message under the Curve Characteristics box. If the FONIX 8000 Test System doesn’t level, it could be an indication that your microphone needs to be calibrated or replaced.

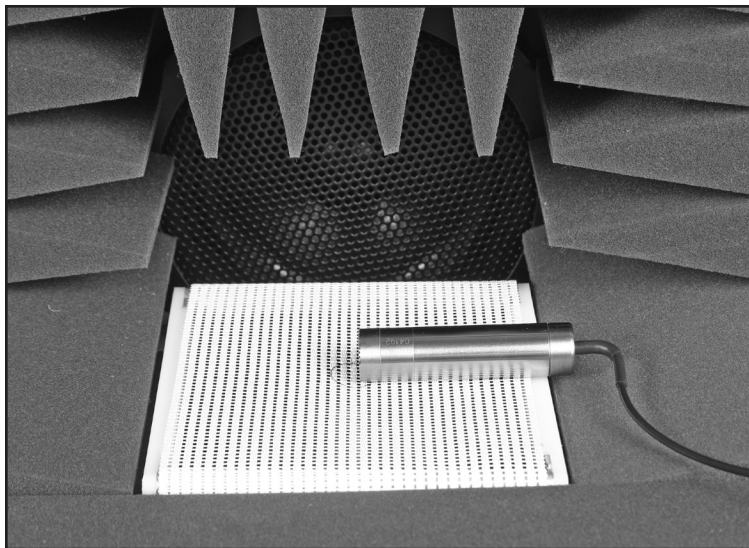


Figure 3.2.2—Leveling the 8120 Polar Plot Sound Chamber with the removable test surface

3.2.3 Removing the leveling of the sound chamber:

In some instances, you may want to look at the response of the sound chamber without the benefit of leveling. In order to do this, you will need to remove the leveling of the sound chamber. To do this:

1. Disconnect the microphone.
2. Push the [LEVEL] button. The leveling will be removed. If you don't save this new unleveled status, the analyzer will revert to its leveled status after it has been turned off and on again.

3.2.4 Saving the leveling information

To save the sound chamber leveling so that you won't have to re-level the sound chamber the next time the analyzer is turned on:

1. Follow the instructions in Section 3.2.1 or 3.2.2 to level the sound chamber.
2. Press [MENU] from the Opening screen. This will open the Setup menu.
3. Press [F5] to save the chamber leveling.
4. Press [EXIT] to return to the Opening screen.

3.3 Hearing Aid Setup

Coupler types and methods for attaching them to hearing aids are described in this chapter. This includes a description of the HA-1 coupler, HA-2 coupler, the ear-level adapter (used with the HA-2 coupler), the CIC coupler, and the Open Ear coupler.

Most FONIX couplers have an O-ring located deep within them that reduces pressure on the inserted microphone, thereby reducing damage to the microphone. When inserting the microphone into the coupler, you will feel a point of resistance when the microphone reaches the O-ring. You must continue to push the microphone into the coupler past that first resistance or incorrect data will be collected.

3.3.1 HA-1 Coupler

The HA-1 direct access coupler is used to test in-the-ear (ITE), in-the-canal (ITC), completely-in-canal (CIC), and other hearing aids with attached ear molds. In some cases, it may also be used to test Open Ear style hearing aids. Figure 3.3.1 illustrates a cross section of this coupler. The sound bore of the aid is sealed directly to the 2-cc cavity with putty.

The CIC coupler described in Section 3.3.3 can also be used to test CIC hearing aids for a more realistic frequency response, but in most cases the HA-1 coupler must be used to test to manufacturing specifications.

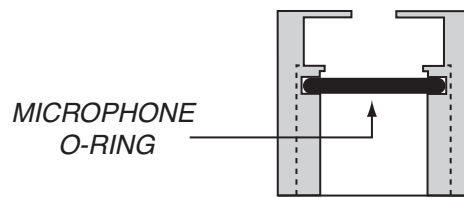
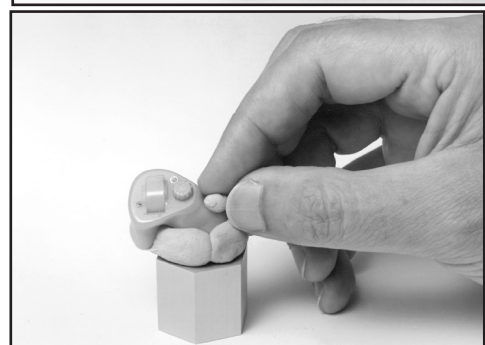
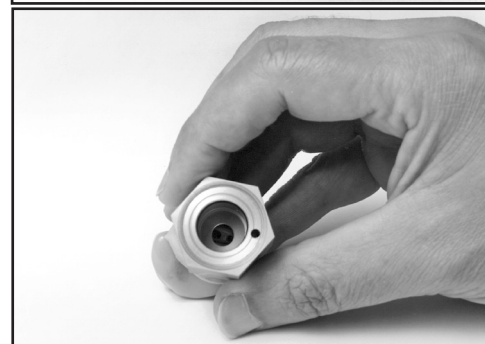
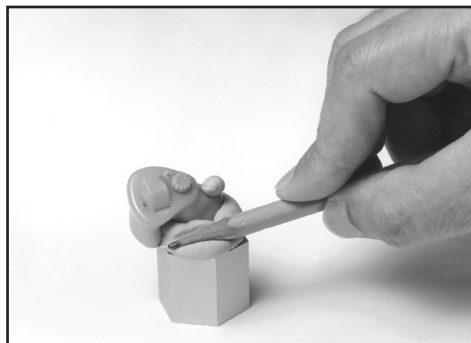


Figure 3.3.1—Direct access coupler (HA-1)

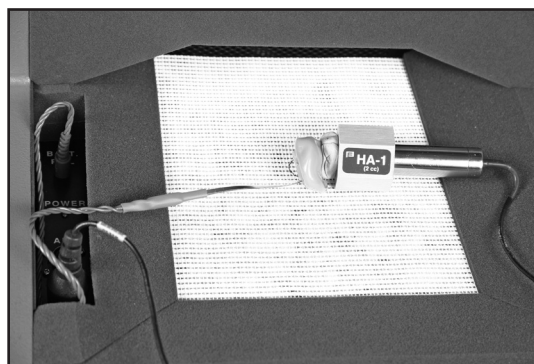
1. Roll the Fun-Tak, provided with each instrument, into a rod long enough to go around the transmitting end of the aid (approximately 2 inches). (Modeling clay can also be used, but it doesn't work as well.)
2. Bend the Fun-Tak rod around the canal of the aid, making the resulting "donut" flush with the end of the aid. (Some users choose to seal the vent opening at this end with a small amount of Fun-Tak.)
3. Align the sound opening of the aid to the hole at the conical end of the coupler. Look through the open end of the coupler to be sure the sound opening of the aid is clear of obstructions and correctly placed.
4. Seal any vent on the aid with a small kernel of Fun-Tak.



5. Complete the acoustical sealing of the aid to the coupler by using a pencil or finger. You may want to double-check the aid placement through the open end of the coupler at this point. **Slowly** reinsert the coupler microphone into its access opening.



6. Place the completed assembly at the reference position in the test chamber. With ITEs, the position of the aid can affect the frequency response. As a rule, point the faceplate of the aid toward the speaker in the back of the chamber, with the microphone opening in the reference circle.



If you are using a battery pill, be sure the metal conductor strip does not obstruct the sound path.

3.3.2 HA-2 Coupler

The HA-2 coupler approximates the human ear with an earmold attached. See Figure 3.3.2A. Note the tube that simulates the earmold. Button-type receivers connect directly to this coupler. Behind-the-Ear (BTE) hearing aids connect to this coupler by means of an ear-level adapter.

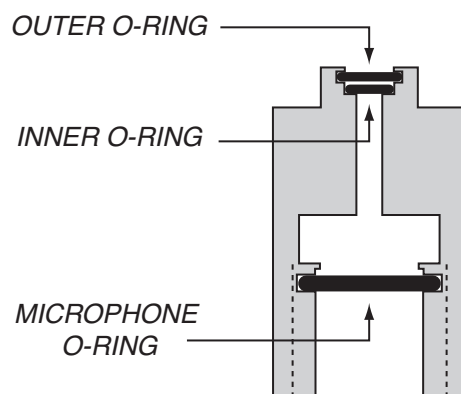


Figure 3.3.2A—Standard 2-cc Coupler (HA-2)

The length and thickness of the tubing of the ear-level adapter can have a significant effect on the frequency response of an aid. If an aid is being compared against the manufacturer's specifications, the tubing should be carefully chosen to duplicate that used by the manufacturer to obtain the original data. For ANSI tests, use #13 thick-walled tubing with a length of about 24 mm. See Figure 3.3.2B.

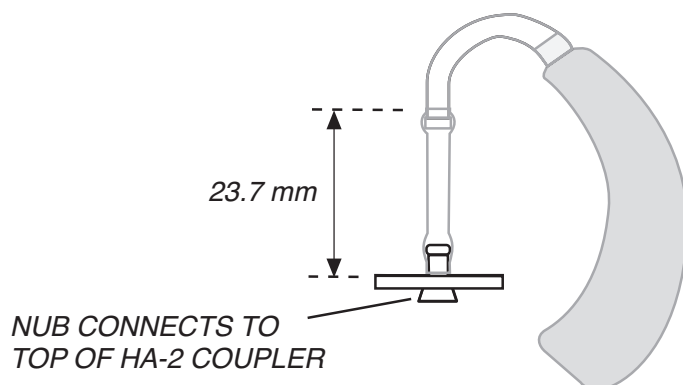


Figure 3.3.2B—Ear-level Adapter (used with HA-2)

To use the HA-2 coupler:

1. Insert the coupler microphone into the HA-2 2-cc coupler.
2. Couple the aid to the HA-2 coupler using the ear-level adapter. There should be about 24 mm of tubing between the nub of the ear-level adapter and the nub of the coupler adapter.
3. Place the microphone of the hearing aid at the reference point in the chamber, as shown in Figure 3.3.2C.
4. Close the lid and test as desired.

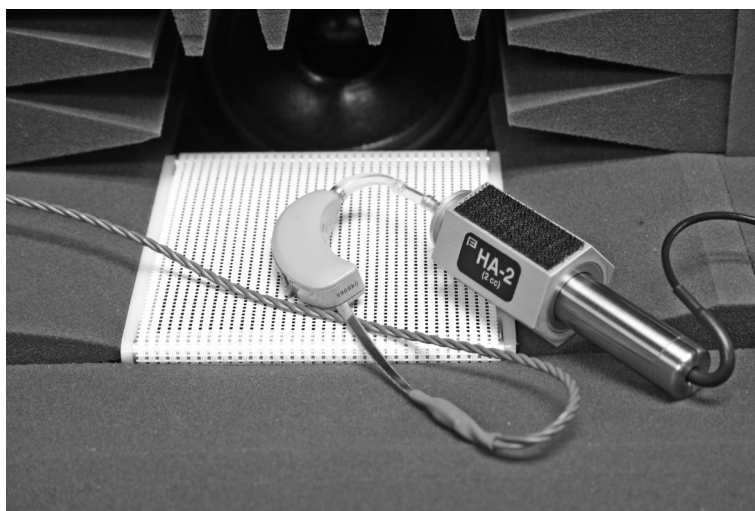


Figure 3.3.2C—Behind-the-Ear Aid with Ear-level Adapter

3.3.3 CIC Coupler

The CIC coupler is a non-standard coupler with a 0.4 cc coupler (as opposed to the 2 cc size used by the HA-1 coupler). Together with software correction factors, this coupler is used to produce a frequency response similar to the response actually found in the patient's ear. See Figure 3.3.3.

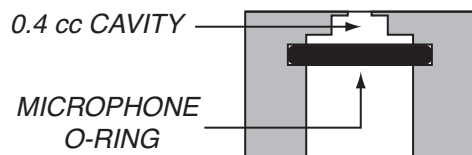


Figure 3.3.3—CIC Coupler

This coupler is recommended for use in obtaining a realistic frequency response of a CIC hearing aid when a real-ear measurement is not possible or practical. See Section 3.6 for details on measuring with the CIC coupler. CIC hearing aids are attached to the CIC coupler in the same fashion that hearing aids are attached to the HA-1 coupler (see Section 3.3.1).

The CIC coupler is not specified for use in the ANSI, IEC, or JIS standards. Therefore, to test exactly to the specification of one of these standards, the HA-1 coupler should be used instead of the CIC coupler.

3.3.4 Body Aids

1. Insert the coupler microphone into the HA-2 coupler. (The most consistent results for body aids can be obtained by locating the 2-cc coupler outside the test chamber, preferably on a foam pad to isolate it from vibration.)
2. Snap the earphone (receiver) of the body aid onto the 1/4" recessed-end of the coupler (Figure 3.3.5A).
3. Place the aid in the test chamber with its microphone opening as close to the reference point as possible. See Figure 3.3.5B.
4. Turn the gain (volume) control to the desired setting and set the switch for microphone operation (not telephone coil or "T").
5. Close the lid and test as desired.

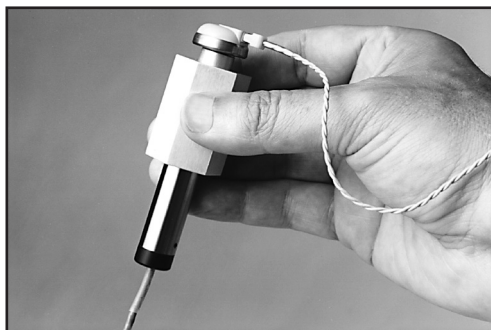


Figure 3.3.5A—Coupler setup



Figure 3.3.5B—Body Aid in test chamber

3.3.5 Eyeglass Aids

1. Follow the manufacturer's instructions for removing the hearing aid assembly or the temple piece from the eyeglass frame, if possible. Should you be unable to remove the aid assembly or temple from the frame, it is possible to place the entire frame in the test chamber for testing. Be sure to fold the glasses first.
2. Insert the coupler microphone into the HA-2 coupler.
3. Couple the aid to the 2-cc coupler using the BTE aid adapter and the appropriate tubing, as shown in Figure 3.3.6.

The length and thickness of the tubing have a significant effect on the frequency response of an aid, especially in the 500 to 1000 Hz region. If an aid is being compared against the manufacturer's specifications, the tubing should be carefully chosen to duplicate that used by the manufacturer to obtain the original data. For ANSI tests, use 0.6" (15 mm) of #13 thick-walled tubing (exposed portion).

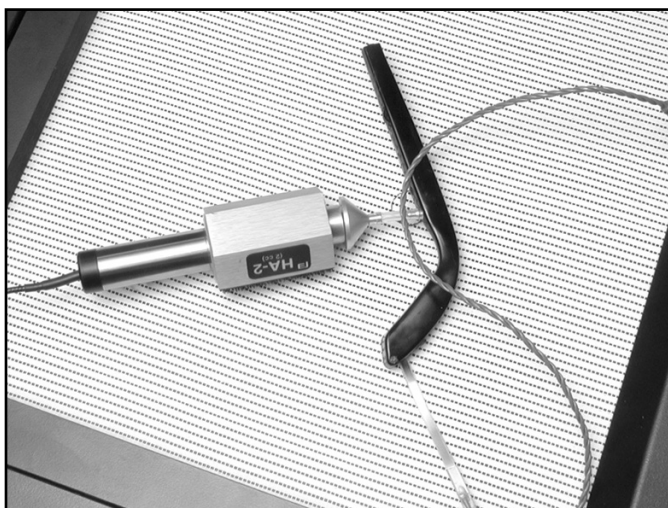


Figure 3.3.6—Eyeglass Aid Set-up

4. Position the microphone of the aid as close as possible to the reference point in the test chamber, as shown in Figure 3.3.6.
5. Close the lid, if possible, and then test as desired. If the lid can't be closed, measurements can be made with the lid open. But we recommend that you first re-level the chamber with the lid open, and use the quietest possible location.

3.3.6 Wireless CROS and BICROS Aids

The key to testing these aids is to get the proper amount of separation between the transmitter and the receiver. This separation may be vertical. The transmitter may be in the chamber while the receiver is on top of it.

If you are using a CRT monitor, it may be necessary to turn it off while testing these aids, because CRT monitors create magnetic fields which may interfere with testing. Either turn the monitor back on to view results, or push [PRINT] to print. LCD monitors should not cause interference.

Wireless CROS

A CROS (Contra-lateral Routing of Signal) aid consists of a transmitter and a receiver so that sound received on one side of the head can be transmitted to the other side without a wire connection. You can test these units in the test chamber of the FONIX 8000 Test System. See Figure 3.3.7.

1. Place the microphone of the transmitter at the reference point in the test chamber. Turn on the transmitter.
2. Close the lid of the test chamber.
3. Check the specification sheet of the aid under test to determine how far apart to place the transmitter and the receiver. About 6" (15 cm) is usually sufficient.

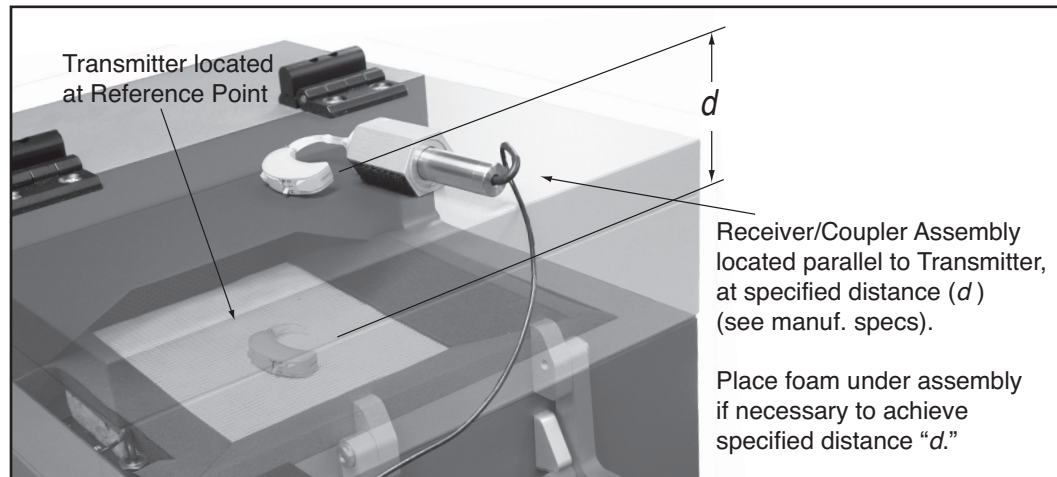


Figure 3.3.7—Testing Wireless CROS Hearing Aids

4. Place the receiver on top of the lid of the test chamber. The total depth of the lid of the test chamber is about 5 ½ inches (14 cm). To increase the total separation, place foam on the top of the test chamber until the total separation equals that recommended by the aid manufacturer.
5. Attach the coupler to the receiver just as you would for an ordinary BTE or eyeglass aid.

6. Align the receiver and coupler assembly on the top of the test chamber so that the receiver is exactly parallel to the transmitter in the test chamber.
7. Test as you would any ordinary hearing aid.

Wireless BICROS

BICROS systems have two microphones: one on the transmitter side and the other on the receiver side.

1. Test the receiver side as an ordinary hearing aid first.
2. Arrange the transmitter parallel to the receiver, but as far as possible from it while still in the chamber. You may have to unscrew the ear hooks one-quarter turn to accomplish this. Fun-Tak may help to keep the units in position, but be careful not to obstruct the sound paths to the microphones.
3. Test the hearing aid again. Adding the transmitter should increase the gain by the amount specified by the manufacturer. It is not possible to get exact measurements by this measure because at least one of the microphones will not be at the reference point.

Additional Notes for Testing Wireless Instruments

1. There must not be any metal objects between the transmitter and the receiver sides.
2. The two sides must be directly parallel as illustrated (See Figure 3.3.7).
3. The distance between the two sides should be as specified by the manufacturer.

THE GAIN OF THE AID INCREASES AS THE TRANSMITTER AND RECEIVER MOVE CLOSER TO EACH OTHER. EVENTUALLY, THE RECEIVER WILL OVERLOAD.

4. No other wireless CROS/BICROS/MultiCROS transmitters are to be turned on near the test box.
5. Calculators should be kept at least a foot (300 mm) from the test box.

3.3.7 Wire-Type CROS and BICROS aids

CROS

CROS aids are similar to ordinary hearing aids, except that the microphone and amplifier are separate units connected by a wire. Both units may be placed inside the test chamber during testing.

1. Place the orifice of the microphone unit at the reference position in the test chamber.
2. Connect the amplifier unit to the appropriate 2-cc coupler. (See earlier sections for details.)

3. Place the coupler with the amplifier unit at the left side of the test area.
4. Test as desired.

BICROS

Test wire-type BICROS aids just as you would wireless BICROS aids, except instead of separating the two units and keeping them parallel, place both units as close as possible to one another with the microphone openings as close as possible to the reference circle. (Otherwise, follow the steps given in Section 3.3.7 for BICROS aids.)

3.4 Basic Measurements

In the Coupler Multicurve screen of the FONIX 8000 Test System, you can perform the following measurements: response curves, single-frequency measurements, three-frequency averages, harmonic distortion, and intermodulation distortion.

3.4.1 Signal Types

The following signal types are available:

RANDOM NOISE—Two spectral shapes of random noise are commonly used. They are white and pink. The long term average spectral shape of white noise is flat when using a Fourier Analysis method of spectral analysis. The long term average spectral shape of pink noise is flat when using a fractional octave analysis method.

DIGITAL SPEECH—A randomly interrupted composite signal designed to mimic speech. This signal is for use with hearing aids with a “noise reduction” or “speech enhancing” feature that lowers the gain of the aid in the presence of a continuous signal (such as the regular composite signal).

COMPOSITE—A continuous, real-time, speech-weighted signal made up of 79 different frequencies. The composite signal gives you the advantage of seeing how an aid responds to noise that more closely simulates speech, and it lets you see immediately how the aid responds to any change in the amplitude of the signal.

FREQUENCY SHIFT—A pure tone source signal. The pure tone frequency and level can be set to just like a Single Tone source type. The source frequency is indicated on the graph by a vertical line cursor. The hearing aid output is displayed on a composite curve. The peak output frequency and level are also displayed. This source type is used to test a hearing aid that does frequency shifting.

TONE LONG—A detailed frequency response curve that gives you information on the amplification of 64 different pure-tone frequencies between 200 and 8000 Hz

TONE NORMAL—A detailed frequency response curve that gives you information on the amplification of 43 different pure-tone frequencies between 200 and 8000 Hz.

TONE FAST—A continuous pure-tone sweep that takes measurements at 16 different frequencies between 200 and 8000 Hz.

TONE SHORT—A single pure-tone sweep of 10 different frequencies.

3.4.2 Running a Test Curve

1. Press [MENU] to make any necessary selections. See Section 3.10 for details on available menu selections.
2. Set up the aid in the sound chamber as described in Section 3.3 and level if necessary.
3. Select signal type with [F5]. (Press [F5]. Use [▼, ▲] to select the desired signal type. Press [►] to complete the selection and close the pop-up menu.) See Section 3.4.1 for details on signal types.
4. Press [START] to initiate the frequency sweep. If you are using the LONG, NORMAL, or SHORT selections, the test will stop when the sweep is complete. The COMPOSITE, DIG SPEECH, RANDOM NOISE and FAST signals are continuous, making it necessary to press [STOP] when you want the signal to stop.
5. Use [F2] to select the next curve to be measured.
6. Repeat steps 3-5 to take additional measurements.

Figure 3.4.2 shows a completed normal pure-tone sweep.

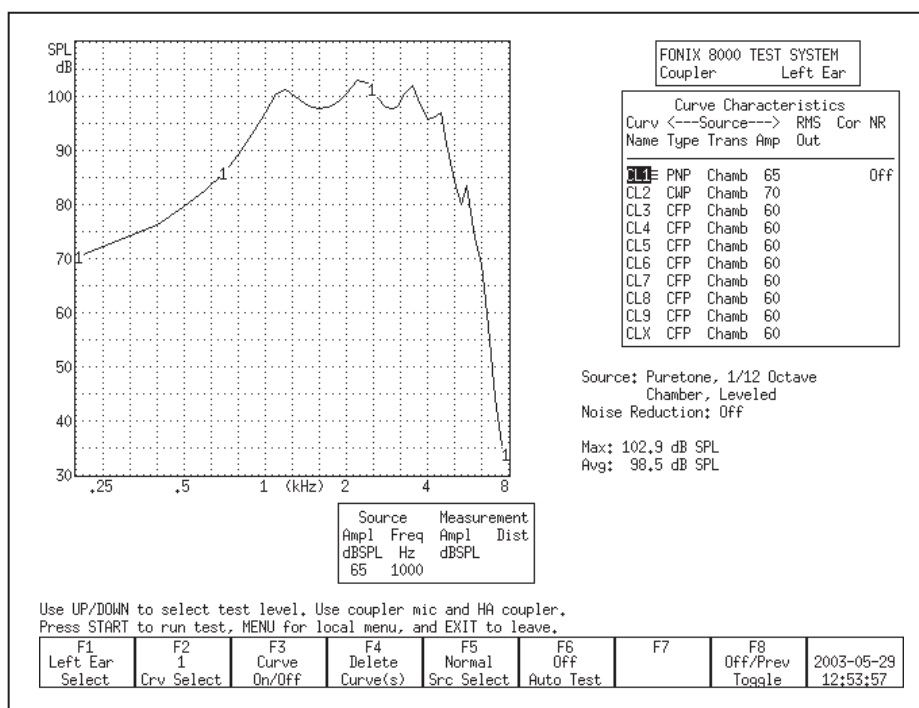


Figure 3.4.2—Pure-tone measurement

3.4.3 Examples

3.4.3.1 COMPOSITE Source Type Example

Following the instructions above, run 4 Gain curves using amplitudes 50, 60, 70, and 80 dB SPL. Use a signal source of COMPOSITE.

This scenario will provide you with a family of curves. Whenever the curves sit on top of each other, the gain of the aid is the same for the amplitudes of those curves. This indicates the aid is running linearly. If the curves provide progressively less gain as the input rises, then the aid has some sort of compression circuit. Figure 3.4.3 shows two examples of this scenario.

Here are the steps:

1. Look at the graph. If it has a display of SPL, press [MENU] and change the DISPLAY from SPL to GAIN, using the arrow keys. Press [EXIT] to return to the Coupler screen.
2. Use [F2] to select CRV 1. (Press [F2]. Use [▼, ▲] to select CRV1. Press [►] to complete the selection and close the pop-up window.)
3. Use [▼, ▲] to select a source level of 50 dB SPL.
4. Use [F5] to select a source type of COMPOSITE.
5. Press [START] to run the first measurement. Press [STOP] when the measurement has stabilized.
6. Use [F2] to select CRV 2.
7. Use [▲] to select a source level of 60 dB SPL.
8. Use [F5] to select a source type of COMPOSITE.
9. Press [START] to run the second measurement. Press [STOP] when the measurement has stabilized.
10. Use [F2] to select CRV 3.
11. Use [▲] to select a source level of 70 dB SPL.
12. Use [F5] to select a source type of COMPOSITE.
13. Press [START] to run the third measurement. Press [STOP] when the measurement has stabilized.
14. Use [F2] to select CRV 4.
15. Use [▲] to select a source level of 80 dB SPL.
16. Use [F5] to select a source type of COMPOSITE.
17. Press [START] to run the fourth measurement. Press [STOP] when the measurement has stabilized. You now have a family of curves.

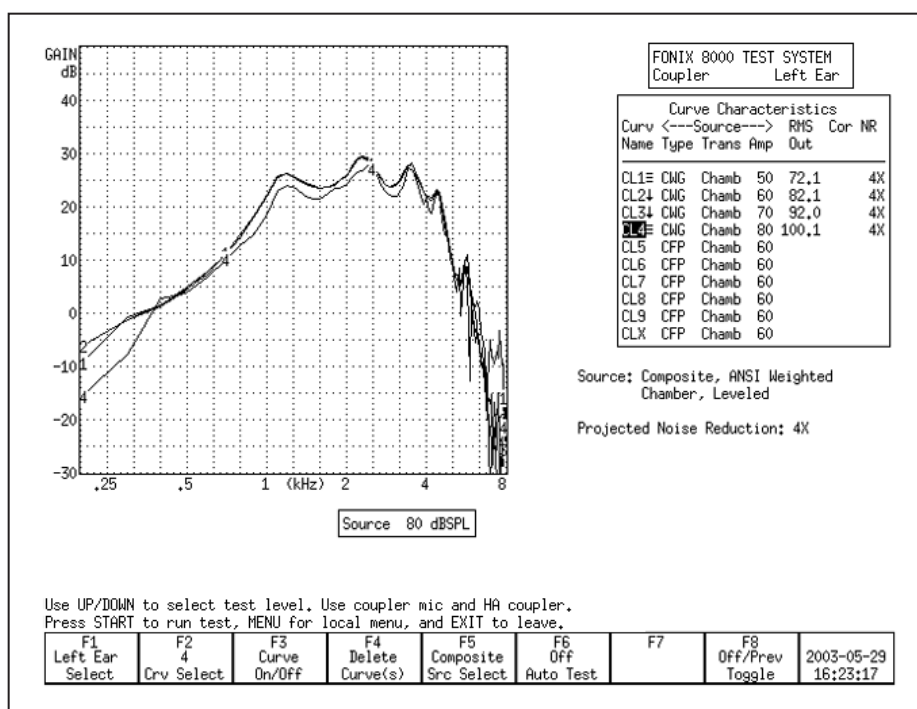


Figure 3.4.3.1A—Family of curves. Notice how all the curves are on top of each other. This aid has very little compression between 50 dB and 80 dB SPL.

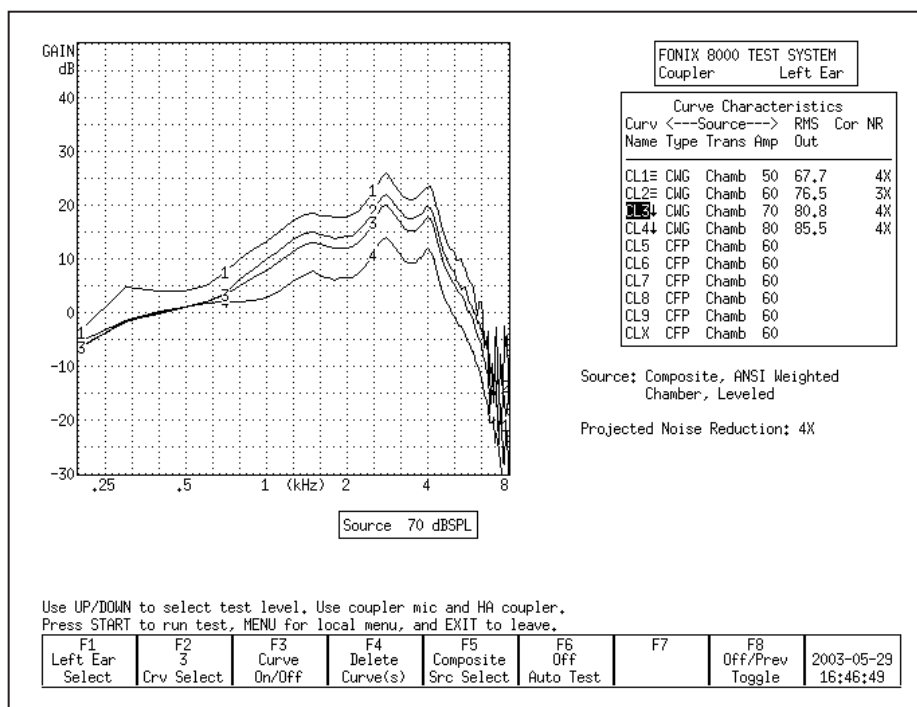


Figure 3.4.3.1B—Family of curves. Notice how the curves show less gain as the amplitude increases. This aid shows a great deal of compression between 50 dB and 80 dB.

3.4.3.2 Frequency Shift Source Type Example

1. Follow the instructions in section 3.4.2 except select the "Freq Shift" signal type. Only measure one curve. Select the source tone frequency with the left and right keys.
2. Look at the screen shot for the following discussion.
 - 2a. The dotted vertical line is the source frequency of the puretone that the 8000 is generating in the chamber speaker. The source frequency is also shown in the Curve information area as the "Source: Frequency:".
 - 2b. The curve on the graph is the hearing aid output in response to the tone the 8000 is producing. The highest point on the curve should be the shifted tone frequency. If it's at the same frequency as the dotted line, then the aid is not shifting the frequency.
 - 2c. The measured frequency in the aid output is also shown in the Curve information area as the "Measured Frequency:".

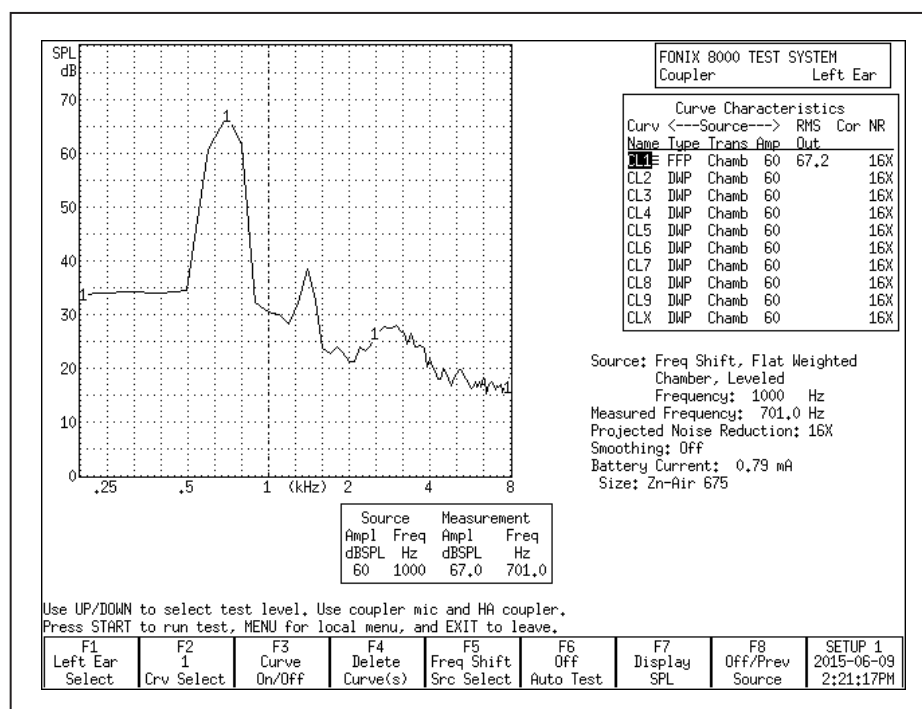


Figure 3.4.3.2—Frequency Shift Source Type curve.

3.4.4 Deleting measurements and settings

Use the [F4] key to permanently delete measurement curves. When you press it, there are four possible selections:

- Selected Curve: Delete only the selected curve, but keep the curve selections (usually source type and level).

- Sel Curve & Settings: Delete selected curve and return curve to analyzer default setting.
- All Curves: Delete all curves, but keep the curve selections.
- All Curves & Settings: Delete all curves and return them all to analyzer default settings.

To delete a curve:

1. Press [F4].
2. Use [▼, ▲] to make the desired deletion type.
3. Press [►] to perform the deletion and close the pop-up menu.

3.4.5 Running a Single Frequency Measurement

At times, you may want to find out what the frequency response of the hearing aid is to a single pure-tone signal. See Figure 3.4.5.

1. Press [MENU] from the Coupler screen.
2. Use [▼, ▲] to select Static Tone under Source Settings.
3. Use [◀, ▶] to choose SINGLE.
4. Press [EXIT] to return to the Coupler screen. The single tone will automatically be running.
5. Adjust the frequency using the [◀, ▶] buttons. Adjust the amplitude using the [▲, ▼] buttons.

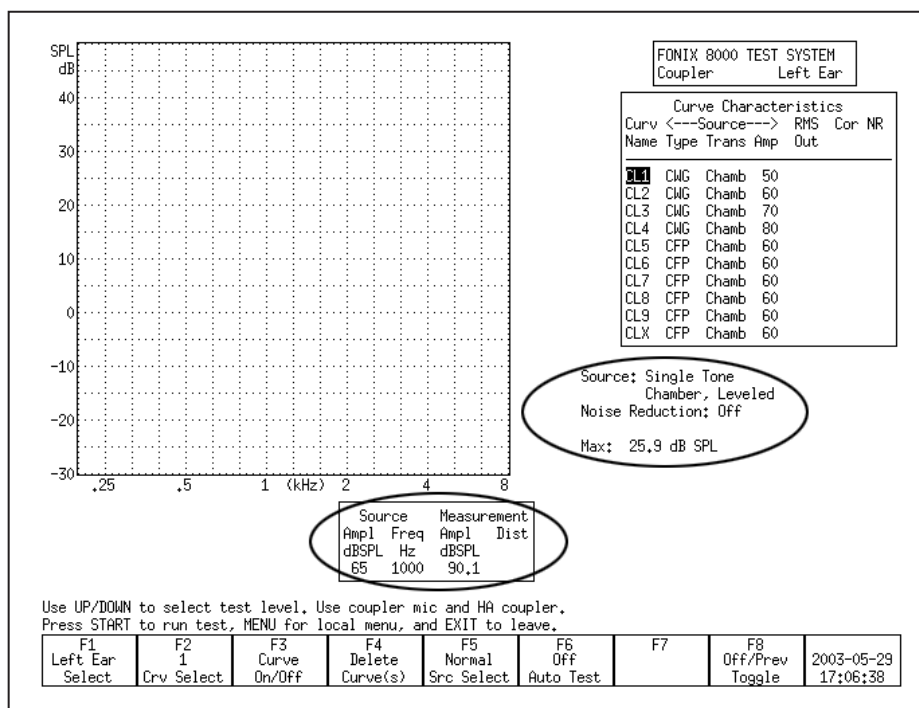


Figure 3.4.5—Measuring a single frequency

3.4.6 Running a Three-Frequency Average

The ANSI standard includes some three frequency average tests. You can run a three frequency average test (apart from the test sequence) in the Coupler screen. See Figure 3.4.6. To do this:

1. Press [MENU] from the Coupler screen.
2. Use [▼, ▲] to select Static Tone under Source Settings.
3. Use [◀, ▶] to choose AVERAGE.
4. Use [▼, ▲] to select Avg Freqs under Aid Settings.
5. Use [◀, ▶] to choose the highest frequency of the three frequency average. See Section 2.2.4 for a complete list of frequencies.
6. Press [EXIT] to return to the Coupler screen. The three frequency average will automatically be running.
7. Adjust the amplitude using the [▲, ▼] buttons.

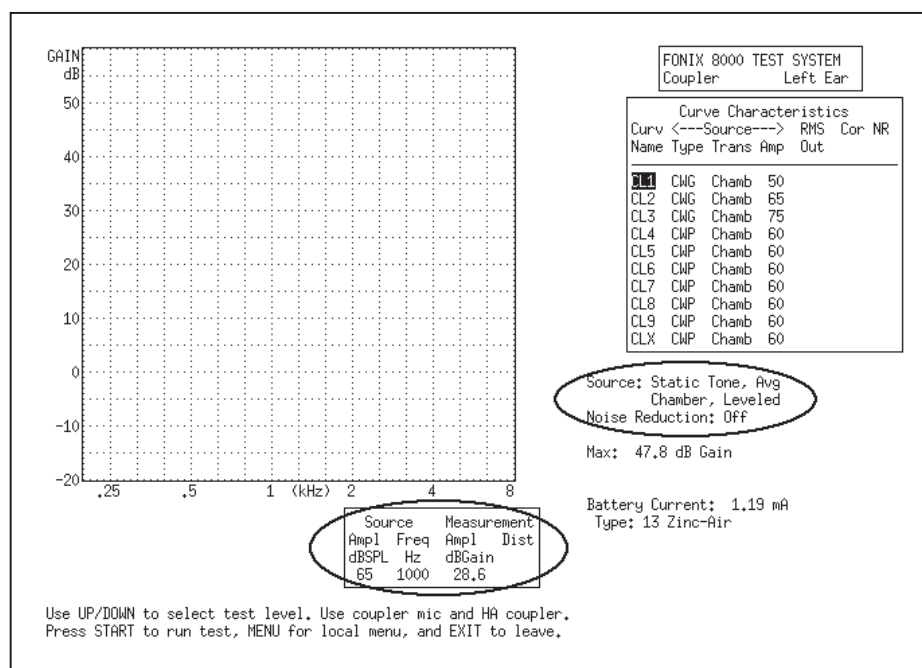


Figure 3.4.6—Measuring a three frequency average

3.4.7 Measuring Harmonic Distortion

Harmonic distortion is when the hearing aid returns energy at frequencies not present in the source signal. The FONIX 8000 Test System allows you test for this phenomenon very easily.

1. Press [MENU] from the Coupler screen.
2. Select Distortion under Measurement Settings using the [▼, ▲] buttons.

3. Select the distortion type desired by using the [◀, ▶] buttons.

The selections are:

2ND: Distortion present at the second harmonics, or twice the presented frequency.

3RD: Distortion present at the third harmonics, or three times the presented frequency.

TOTAL: Distortion present at the second and third harmonics.

4. Press [EXIT].
5. Use [F5] to select a signal type of TONE NORMAL. (Press [F5]. Use [▼, ▲] to select TONE NORMAL. Use [▶] to complete the selection and close the pop-up menu.)
6. Press [START] to run normal frequency sweep.

After running a normal sweep, the harmonic distortion data will appear on the measurement graph as a series of red bars. The scale for the bars is on the right side of the graph.

In general, you should ignore the harmonic distortion measurement when the amplitude of the response curve measurement at the second harmonic is more than 12 dB greater than the amplitude at the first harmonic. This is called the 12 dB rule and is part of the ANSI S3.22 standard.

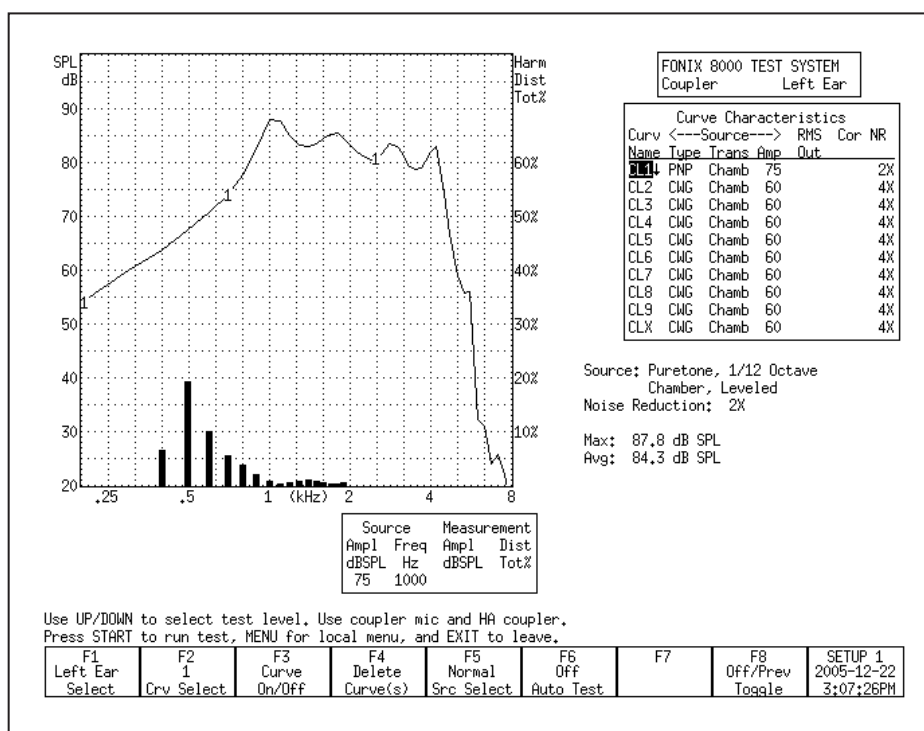


Figure 3.4.7—Measuring Harmonic Distortion

3.4.8 Intermodulation Distortion

The composite signal is helpful for identifying intermodulation distortion (IM), a type of distortion that sometimes occurs in a hearing aid response.

IM distortion occurs when more than one frequency is present in the source signal and those frequencies combine to create new frequencies not actually present in the source. IM distortion is disturbing to the client, often more so than harmonic distortion. When viewing a graph run with the composite signal, look for points along the graph where the line “breaks up.” Such an appearance indicates the presence of intermodulation distortion. As IM distortion increases, the curve becomes more disconnected. See Figure 3.4.8 for an example of IM distortion.

This type of distortion is only apparent when the composite signal source is used because pure-tone source types do not contain more than one frequency at the same time.

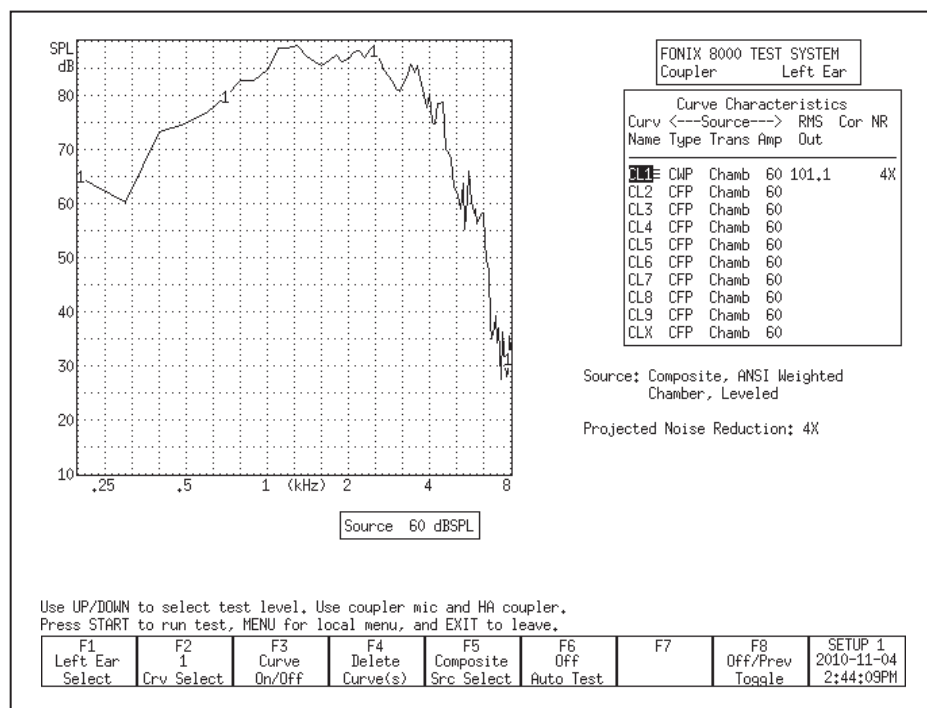


Figure 3.4.8—Measuring intermodulation distortion

3.4.9 Battery Current Drain

You can measure the battery current drain in the Coupler screen if you use battery pills (instead of regular batteries) in the hearing aid while performing

your measurements. To turn on the battery current drain measurement in the Coupler screen:

1. Set up the hearing aid in the sound chamber for testing. You must use a FONIX battery pill to test for current drain.
2. Close the lid of the sound chamber and latch it.
3. Press [MENU] in the Coupler screen.
4. Use [▼, ▲] to select Battery Meas under Misc Settings. (You can use [START] to skip between groups of selections.)
5. Use [▶] to turn ON the Battery Meas.
6. Use [▼] to select Battery Size and use [◀, ▶] to select the hearing aid's battery size.
7. Press [EXIT] to return to the Coupler screen. You should now see the battery current drain measurement below the Curve Characteristics box. See Figure 3.4.9.
8. Start a frequency response measurement to display the battery current drain.

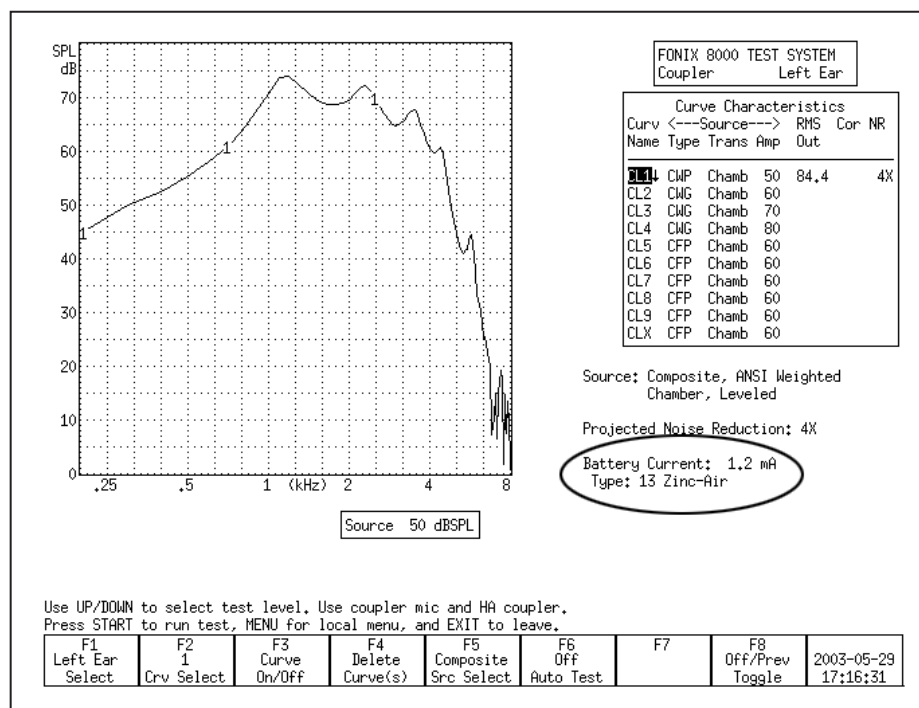


Figure 3.4.9—Battery Current Drain

3.4.10 Telecoil

Telecoil measurements can be performed in the Coupler screen using any of the source signals available on the 8000 Test System. During a telecoil measurement, a magnetic field is used that simulates the field of a telephone receiver. A telecoil capable of producing this field is built into every 8120 Polar Plot and 8050 & 8060 sound chambers. When the analyzer has the ANSI option, the external Telewand can also be used for the measurement.

Telecoil measurements can be performed with puretone, composite or digital speech signals. The filter of the signal is always set to flat. The resulting display is always in SPL (not gain).

Analyzer Setup

It is very important to pick a testing location that is free of magnetic disturbances, especially those caused by fluorescent lights and power lines. To do this:

1. Locate a wide-range linear hearing aid with good low frequency response and a telecoil switch.
2. Set the hearing aid to operate in the telecoil position and turn the gain control up to its full-on position.
3. Connect the hearing aid to a coupler. Don't insert the measurement microphone.
4. Walk around your possible testing location and listen for raspy humming sounds from the hearing aid. This will be the aid responding to magnetic fields in the room.
5. Pick a location that is as free of such sounds as possible. Rotate the aid in all directions when looking for a good site.

Testing with the Sound Chamber Telecoil board

Every 8120 Polar Plot Chamber and 8050 & 8060 Chambers has a built-in telecoil that can be used for telecoil testing.

1. Set up the hearing aid for testing in the usual way by connecting it to the appropriate coupler and inserting the measurement microphone.
2. Enter the Coupler screen by pressing [F1] in the Opening screen.
3. Press [MENU] in the Coupler screen to open the local menu. Set the TRANSDUCER to TELECOIL under Source Settings and press [EXIT] to close the local menu.
4. Use [F5] to set the Source Type to Composite.
5. Press [START] to start a composite measurement.
6. Look at the RMS OUT in the Curve Characteristics box. This shows the current output of the hearing aid to the magnetic field input.

7. Position the hearing aid for maximum output. For BTE hearing aids, this usually occurs when the body of the aid is in a vertical position. If necessary, use Fun Tak to help hold the aid in that position. See Figure 3.4.10A.
8. Use [▲, ▼] to change the intensity of the magnetic field. The choices are: OFF, 1.00, 1.78, 3.16, 5.62, 10.0, 17.8, 31.6, 56.2 and 100 mA/m. 31.6 is the default source intensity.
9. Press [STOP] to stop the measurement or continue to test, as desired.

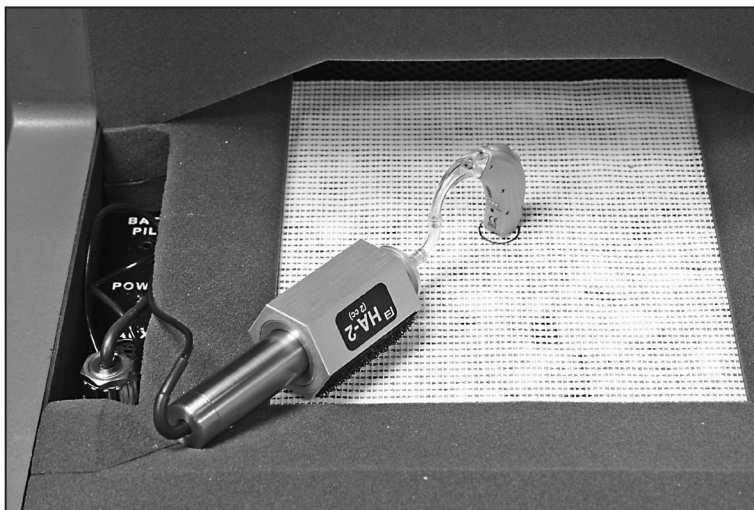


Figure 3.4.10A—Testing with the Sound Chamber Telecoil Board

Note: 8000 Version 2.50 is the first software version to support calibrated telecoil for the 8070 and TBS25 chambers. If you have an older Chamber Remote Module, it may need to be updated as well to use it with the 8070 and TBS25.

Testing with the Telewand

When the ANSI Option is ordered with the 8000 Hearing Aid Test System, the Telewand device is also included. Otherwise, you can order it from the factory as an optional accessory. The Telewand is supposed to provide a more realistic test of the telecoil features of a hearing aid than the built-in telecoil in the sound chamber because it more closely simulates the magnetic field produced by a telephone receiver.

1. Set up the hearing aid for testing in the usual way by connecting it to the appropriate coupler and inserting the measurement microphone.
2. Enter the Coupler Multicurve screen by pressing [F1] in the Opening screen.
3. Press [MENU] in the Coupler screen to open the local menu. Set the TRANSDUCER to TELEWAND under Source Settings and press [EXIT] to close the local menu.
4. Use [F5] to set the Source Type to Composite.

5. Press [START] to start a composite measurement.
6. Plug the Telewand into the Telecoil connector on the back of the 8120 Polar plot or 8050 & 8060 Sound Chambers.
7. Hold the hearing aid in one hand and the Telewand in the other hand. Position the Telewand as you would position the receiver of a telephone. That is, hold the Telewand a few millimeters next to the hearing aid, positioned parallel to the body of a BTE aid or against the faceplate of an ITE aid.
8. Look at the RMS OUT in the Curve Characteristics box. This shows the current output of the hearing aid to the magnetic field input.
9. Position the hearing aid (with the Telewand held against it) for maximum output. For BTE hearing aids, this usually occurs when the body of the aid is in a vertical position. If necessary, use Fun Tak to help hold the aid in that position. See Figure 3.4.10B.
10. Use [▲, ▼] to change the intensity of the magnetic field. The choices are: OFF, 1.00, 1.78, 3.16, 5.62, 10.0, 17.8, 31.6, 56.2 and 100 mA/m. 31.6 is the default source intensity.
11. Press [STOP] to stop the measurement or continue to test, as desired.



Figure 3.4.10B—Testing with the Telewand

3.4.11 Measuring directionality with the 8050 & 8060 Sound Chambers

Although directional hearing aids can have different types of polar plots and two or even three microphones, the basic concept is fairly simple: speech sound from in front of the hearing aid wearer is louder than noise from behind him. If you have purchased the Coupler Directional Option including the 8120 Polar Plot Sound Chamber and the Coupler Directional test screen, you can perform a polar plot measurement of a directional hearing aid. See Chapter 6 for details. If you do not have this option, however, you can still get a rough idea of directionality by using the 8050 & 8060 Sound Chambers.

The directional test with the 8050 & 8060 Sound Chambers takes advantage of the horizontal speaker placement and the flat testing surface that makes it easy to position the hearing aid for testing. There are two measurements: one where the hearing aid is positioned so that it is facing towards the sound chamber speaker, and one where the hearing aid is positioned so that it is facing away from the sound chamber speaker. You should use the same input signal for both measurements. The source amplitude used for this measurement should be greater than the noise floor of the testing environment, but less than the compression knee point of the hearing aid, if possible. 50 dB SPL is usually a good choice.

Speaker Placement

The speaker in the 8050 & 8060 Chambers is positioned horizontally in the back of the chamber. This makes it easy to visualize how the hearing aid should be positioned for the directional test.

Forward measurement

The first step in doing a directional test is to position the hearing aid in the sound chamber so that the front of the hearing aid is pointing towards the back of the chamber. See Figure 3.4.11A. Close the sound chamber lid and perform the following steps:

1. Enter the Coupler Multicurve screen by pressing [F1] from the Opening screen.
2. Use [F5] to set the source type to Digital Speech.
3. Use [▼, ▲] to set the source amplitude to 50 dB SPL.
4. Press [START]. After the measurement has stabilized, press [STOP]. The measured curve is the “forward” measurement of the directional test.

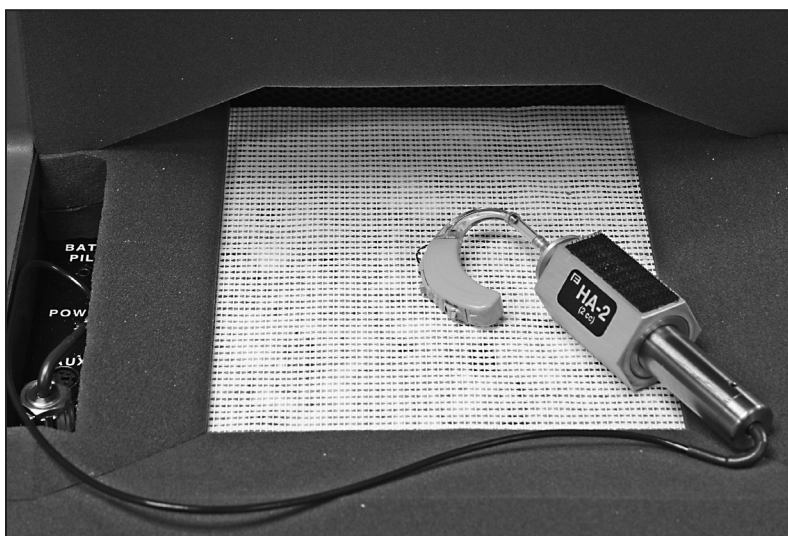


Figure 3.4.11A—Forward directional measurement.

Reverse measurement

Next, open the sound chamber and position the hearing aid so that the front of the hearing aid is pointing away from the back of the chamber. See Figure 3.4.11B. Different hearing aids have different null points so you will want to adjust the positioning so that the sound chamber speaker is pointing towards what should be the null point of the directional aid (this may be 135 degree instead of 180 degrees). Close the sound chamber lid when finished and perform the following steps:

1. Use [F2] to select the next curve.
2. Use [F5] to set the source type to Digital Speech.
3. Use [▼, ▲] to set the source amplitude to 50 dB SPL.
4. Press [START]. When the measurement has stabilized, press [STOP]. The measured curve is the “reverse” measurement of the directional test. If the directional microphones of the hearing aid are working properly, this curve should have less output or gain than the forward measurement.

The difference in the RMS Out of the two curves will give you the average overall advantage provided by the directional microphones. See Figure 3.4.11C. In this example, the hearing aid has an 8 dB average directional advantage.

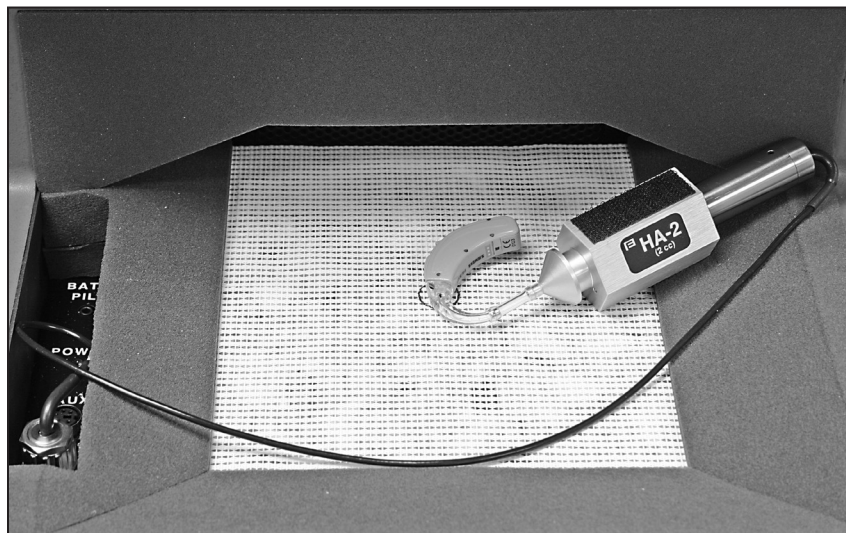


Figure 3.4.11B—Reverse directional measurement

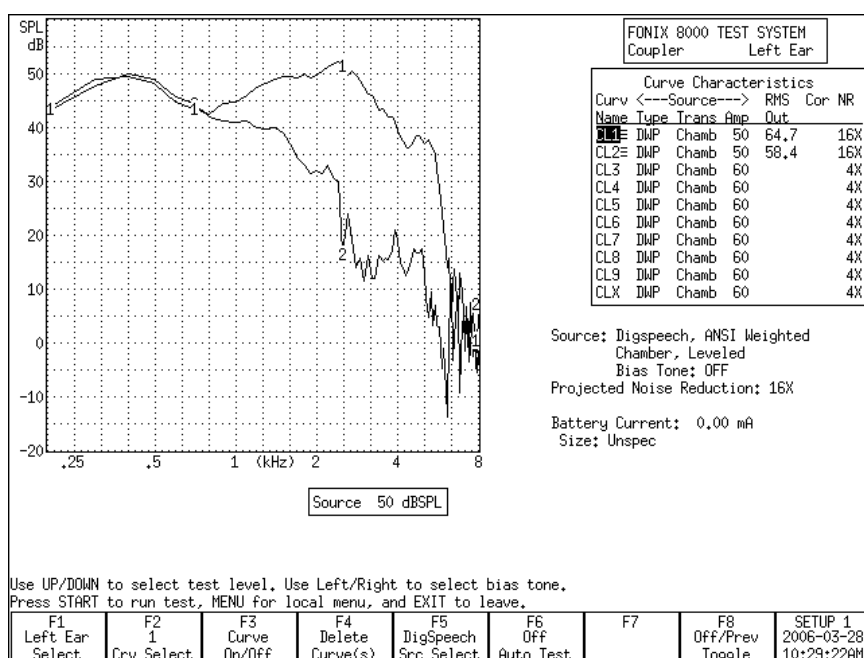


Figure 3.4.11C—Directional measurement screenshot

3.5 Digital hearing aids

All digital aids can be tested, but some of the high-end models require a little more thought and care; these aids have a “noise suppression” feature (also known as “speech enhancement”). This noise suppression, not to be confused with the automatic compression of AGC hearing aids, checks if the sound going into the hearing aid is a continuous signal that could be regarded as noise. If the aid decides that the sound is noise, it lowers the gain at the corresponding frequencies. Conventional testing techniques, such as a pure-tone sweep or the Composite signal, can cause the high-end digital aid to go into this noise reduction mode. This means that the gain or output you see on the analyzer’s display will not necessarily reflect the normal response of the aid in speech.

The Digital Speech signal was developed in order to test noise-reducing digital hearing aids without concerns of them going into noise suppression mode. It does this by taking the standard Composite signal and interrupting it randomly. The digital hearing aid responds to this modulated signal as it would respond to normal speech.

3.5.1 Using Digital Speech

The FONIX 8000 Test System seamlessly incorporates the testing of digital hearing aids into its normal testing procedures.

To test a digital hearing aid, follow the steps outlined in Section 3.4.2, choosing DIG SPEECH in Step 3. Digital Speech can be used to accurately test any hearing aid, so if you aren’t sure if the hearing aid is digital, you can always use Digital Speech and be assured that the frequency response is correct.

3.5.2 Changing the Speech Shape

By default, the Digital Speech (and Composite) signal use the ANSI S3.42 speech weighting. This speech weighting rolls off the high frequencies at a rate of 6 dB per octave, starting with 3 dB down at 900 Hz. Some clinicians, however, may prefer to use the ICRA speech weighting.

The ICRA speech weighting was taken from a CD of sounds developed by the International Collegium of Rehabilitative Audiologists (ICRA) and based on the long term average speech spectrum. The ICRA rolls off the high frequencies much more quickly than the ANSI spectrum. To switch to using ICRA:

1. Press [MENU] in the Coupler screen.
2. Use [▼, ▲] to select Composite Filter under Measurement Settings. Use the [START] key to skip ahead sections, if necessary.
3. Use [◀, ▶] to select ICRA.
4. Press [EXIT] to return to the Coupler screen.
5. Use [F5] to choose the DIG SPEECH signal source. It will now have the ICRA speech weighting. See Figure 3.5.2 for a comparison of an aid tested with the ANSI and ICRA speech weightings.

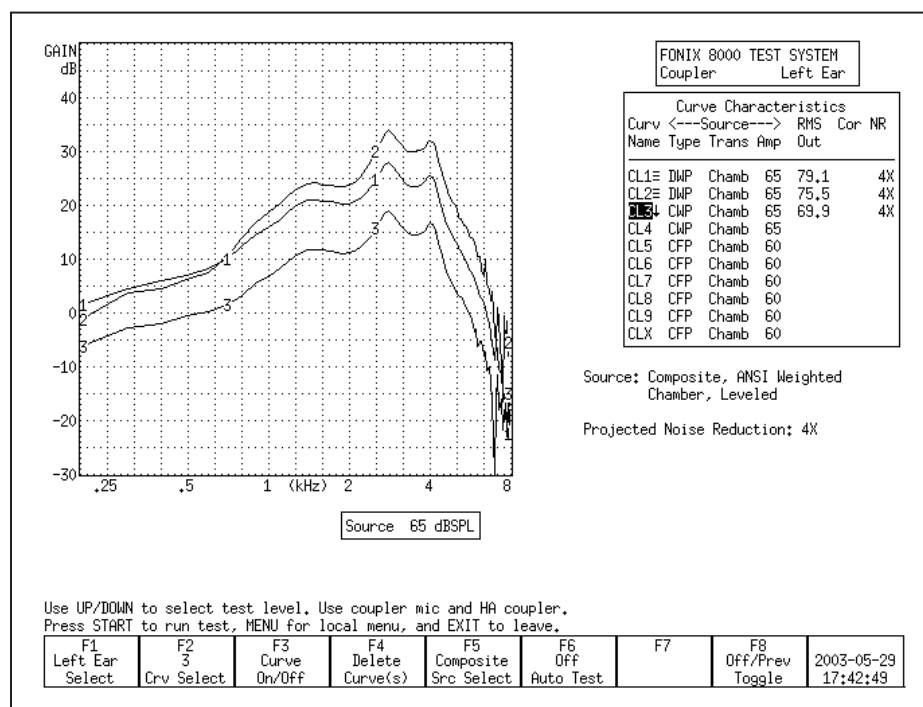


Figure 3.5.2—Comparison of a digital aid tested with Digital Speech ICRA (CRV1), Digital Speech ANSI (CRV2), and the Composite signal (CRV3).

3.5.3 Testing with Bias Signals

You can add a pure-tone bias signal to the Digital Speech signal, creating a continuous signal at the frequency of your choice. This will allow you to see how the aid reacts to the presence of noise at different frequencies. To add a bias signal:

1. Select the DIG SPEECH signal with [F5] in the Coupler screen.
2. Press [MENU] to enter the local menu.
3. Use [▼, ▲] to select Bias Tone under Source Settings. Use the [START] key to skip ahead sections, if necessary.
4. Use [◀, ▶] to select the bias amplitude.
5. Press [EXIT] to return to the Coupler screen.
6. Press [START] to start the frequency response measurement. The Digital Speech signal will include a bias signal at the amplitude you specified in Step 4.
7. Use [◀, ▶] to change the frequency of the bias signal. The current selected frequency will be displayed on the screen below the Curve Characteristics Box.
8. Press [STOP] when done with the measurement. See Figure 3.5.3 for an example of using the bias signal at several different frequencies.

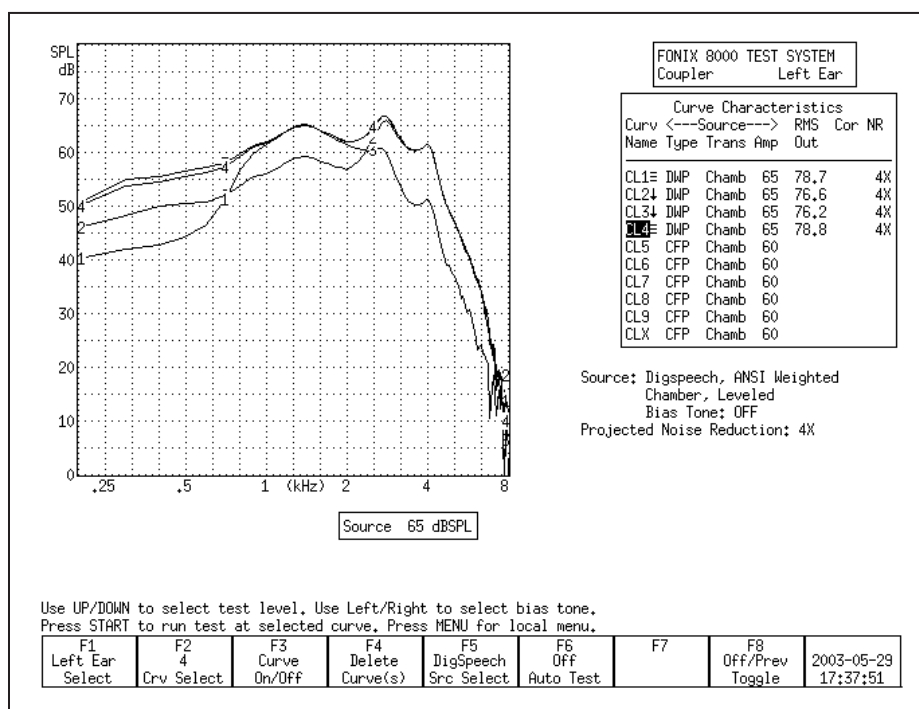


Figure 3.5.3—Using the bias signal with Digital Speech. CRV 1-3 have bias signals at 500 Hz, 1000 Hz, and 4000 Hz respectively. CRV 4 was performed with Digital Speech and no bias signal.

3.5.4 Checking Noise Suppression

When testing a digital hearing aid that is supposed to be programmed with a noise suppression or speech enhancement feature, it is useful to make sure the feature is working correctly. You can use a combination of Digital Speech and the Composite signal to test noise suppression.

1. Look at the top left corner of the graph on the Coupler screen. It should read “dB GAIN.” If it reads “dB SPL,” you will need to change the display to GAIN. To do this:
 - a. Press [MENU] from the Coupler screen to open the local menu.
 - b. Use [▼, ▲] to select Display under Display Settings.
 - c. Use [◀, ▶] to choose GAIN.
 - d. Press [EXIT] to return to the Coupler screen.
2. Use [F2] to select CRV 1. (Press [F2]. Use [▼, ▲] to select CRV 1. Use [▶] to complete the selection and close the pop-up menu.)
3. Use [F5] to select DIG SPEECH in the same manner as described above.
4. Use [▼, ▲] to select a normal speech amplitude, such as 65 dB SPL.
5. Make sure the digital noise suppression feature is enabled on the hearing aid, and set it up for testing in the sound chamber.
6. Press [START] to begin the measurement. When the response curve has stabilized, press [STOP] to stop the measurement.
7. Use [F2] to select CRV 2.
8. Use [F5] to select COMPOSITE.
9. Make sure the signal amplitude is the same as selected in Step 4.
10. Press [START] to begin the measurement. Leave the signal on for at least 15 seconds. This should allow the noise suppression feature time to activate. When the measurement has stabilized, press [STOP].
11. Compare CRV 1 and CRV 2. If the curves are right on top of each other, the aid is responding to the Digital Speech signal just as it would respond to the Composite signal. This could be an indication that the digital suppression feature is either not enabled or not present on the hearing aid. Figure 3.5.4 gives an example of a hearing aid that is amplifying the Digital Speech signal and suppressing the Composite signal.

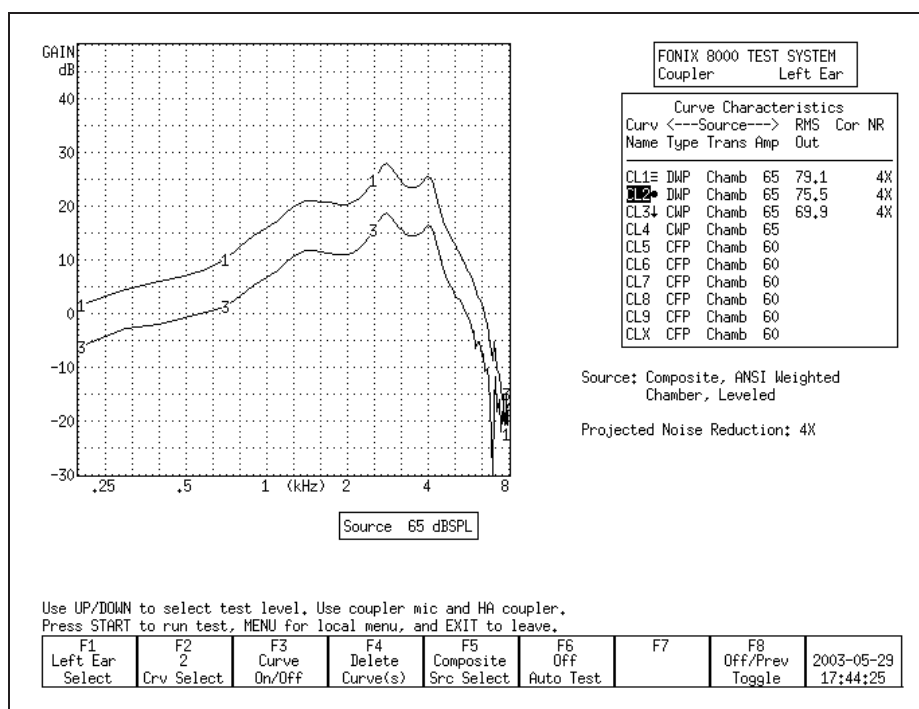


Figure 3.5.4—Digital Noise Suppression test. CRV 1 was measured with Digital Speech. CRV 2 was measured with the Composite signal.

3.5.5 Understanding Terminology

With the new testing terminology of hearing aid analyzers combined with the new technology of hearing aids, it's easy to get terminology confused. "Noise Reduction" is a term that Frye Electronics has always used to denote the averaging that the analyzer makes when analyzing data to achieve a smooth curve. This process is described in Section 2.3.1.1 and Section 2.3.2.1.

Some high-end digital hearings have digital signal processing features that try to detect noise in the environment and lower the gain at the frequencies in which it detects the noise. Different manufacturers have different terminology for these features, but they are most commonly called "Speech Enhancement," "Noise Suppression" or "Noise Reduction."

Just keep in mind that these are two separate applications of the phrase "Noise Reduction" that mean two completely different things. When you set the Noise Reduction on your FONIX 8000 Test System, you are setting the amount of averaging the analyzer does. When you set Noise Reduction on your hearing aid, you are usually setting the amount of noise suppression that the hearing aid does.

3.6 CIC Feature

The CIC Feature is a way of performing a coupler test of a CIC hearing aid that more accurately reflects the real-ear performance of that aid than a regular 2-cc coupler measurement. It is not a way to check the manufacturing specifications of CIC hearing aids because those specifications are based upon 2-cc coupler measurements.

The CIC Feature consists of a CIC coupler (0.4 cc) and software correction factors. Both need to be used in order to correctly perform the measurement.

To measure a CIC hearing aid:

1. Attach the CIC coupler to the CIC aid just as you would attach an HA-1 coupler to the aid, and set the hearing aid up for testing as shown in Section 3.3.2.
2. Press [MENU] in the Coupler screen.
3. Highlight Coupler Type under Measurement Settings with [▼, ▲].
4. Select CIC with [◀, ▶].
5. Press [EXIT].
6. Select the desired source type with [F5]. (Press [F5]. Use [▼, ▲] to select the desired source type. Press [▶] to complete the selection and close the pop-up menu.)
7. Select the desired source amplitude with [▼, ▲].
8. Press [START] to perform the measurement. You should see CIC appear in the Curve Characteristics box in the “Cor” column of the selected curve. If you are using the FAST, COMPOSITE, or DIG SPEECH signal, press [STOP] to end the measurement once it has stabilized.

Figure 3.6 shows the difference between a CIC hearing aid tested with an HA-1 coupler, and the same aid tested with a CIC coupler and correction factors.

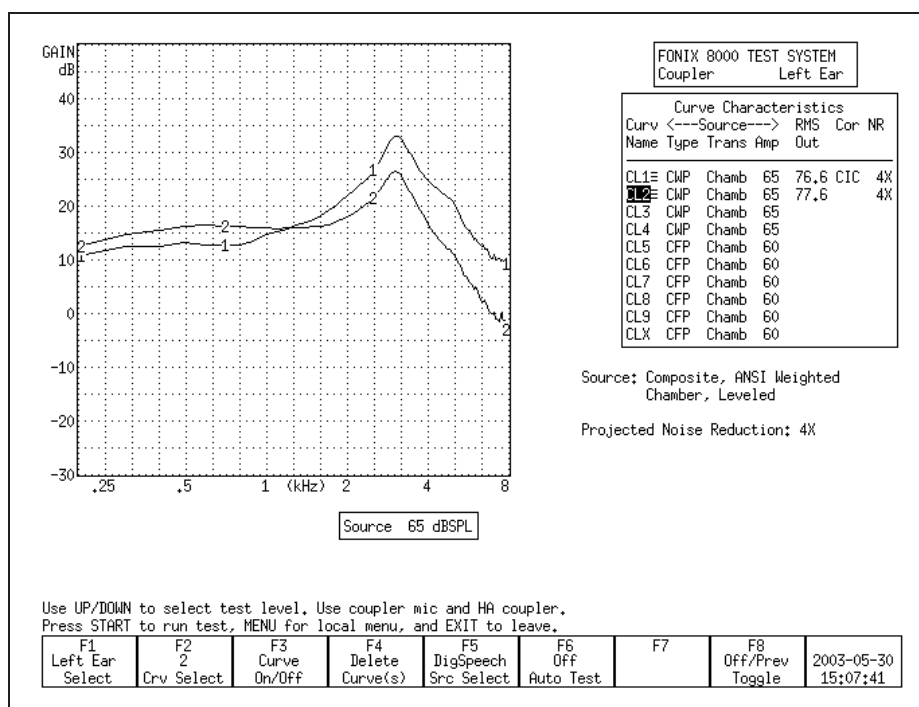


Figure 3.6—CURVE 1 uses CIC coupler + correction factors
CURVE 2 uses 2-cc HA-1 coupler

3.7 Automatic Testing—Loading & Saving Groups

You can use the FONIX 8000 Test System to program simple automated or semi-automated test sequences that will help you test hearing aids more efficiently. Each test sequence can contain up to 10 different response curves with your choice of source types, source levels, noise reduction, and other adjustments.

In automatic mode, the analyzer will quickly run through all designated tests without pausing. In semi-automatic mode, the analyzer will automatically advance to the next curve and stop. This curve will not be measured until you start the test, but you are saved the step of using F2 to select the next curve number.

Tests are programmed into the analyzer using the Program mode. In this mode, you set the source type, source level and noise reduction for each curve. You can program any of the available 10 curve slots in the Coupler screen. This is described in Section 3.7.1.

If there is a sequence of tests that you would like to perform frequently, you can save it into the FONIX 8000 Test System's permanent memory using the SAVE GROUP function. Three groups of up to 10 curves can be saved into SAVE GROUP 1, 2, and 3, respectively. The settings for both ears are saved when SAVE GROUP is used, so it is possible to program one set of settings for the left ear and an other set for the right ear.

When you want to manually load a group that has previously been saved, you use the LOAD GROUP function. It is also possible to have the FONIX 8000 Test System automatically load a saved group and put itself in Fully-Auto or Semi-Auto mode when the analyzer is first turned on or the [RESET] button is used. This is described in Section 3.7.2. When the "Factory" group is loaded, the factory default settings are loaded.

3.7.1 Setting up a test sequence

The first step in running your custom automated test sequence is deciding on the source types and levels of the frequency response curves. When finished, these selections can be stored into the analyzer's permanent memory.

1. Use [F4] to delete ALL CURVES & SETTINGS in the Coupler screen. (Press [F4]. Use [▼, ▲] to select ALL CURVES & SETTINGS. Use [►] to complete the selection and close the pop-up menu.)
2. Use [F6] to select PROGRAM. This will open a pop-up window with helpful programming instructions.
3. Use [F1] to select the ear.
4. Use [F2] to select the curve number.
5. Use [F5] to select the desired source type.
6. Use [▼, ▲] to select the desired source level.
7. Press [MENU] and use the arrow keys to change other menu settings, if desired. Press [EXIT] to return to the coupler screen.
8. Save and advance to the next curve. This can be done two ways:
 - Press [START] if you want the analyzer to be programmed to automatically advance to the next curve and start measuring it.
 - Press [STOP] if you want the analyzer to be programmed to advance to the next curve, but then pause and wait for user intervention before taking the next measurement. Use this if you want to make an adjustment to the aid before taking the next measurement. A horizontal line will be drawn across the Curve Characteristics box when a pause is inserted in this fashion.
9. Repeat steps 5-8 to select the desired source type and level for all the curves that you want to measure in the automated test sequence.
10. Press [STOP] after you have set up the last curve that you want to run in the test sequence. For instance, if you want to run only 4 curves, press [STOP] after setting up CRV 4. This will make the analyzer pause after the four measurements – the remaining 6 available curves will not be run.
11. Use [F6] to SAVE GROUP 1, 2 or 3, if desired. This will permanently save the automated sequence.

3.7.2 Loading a Saved Test Sequence

It is not necessary to permanently save a custom test sequence, but doing so allows you to bring it up in the Coupler screen at any time, even if you've turned off the analyzer between tests. There are two ways to load a saved group: manually and automatically. In both cases, you must first follow the directions in Section 3.7.1 to first create and save a group.

To manually load a saved group, use [F6] in the Coupler Multicurve screen to LOAD GROUP 1, 2, or 3. Choose the group you saved in Step 11 of Section 3.7.1. (Press [F6]. Use [▼, ▲] to select the correct LOAD GROUP number. Use [►] to complete the selection and close the pop-up menu.)

To automatically load a saved group when the analyzer is powered on or when the [RESET] button is used:

1. Press [MENU] from the Opening screen to open the Setup Menu.
2. Press F1. Use [▼, ▲] to select COUPLER. Use [►] to complete the selection and bring up the Coupler Default Settings.
3. Select the desired AUTO MODE setting. Choose from FULLY AUTO (see Section 3.7.3), SEMI AUTO (see Section 3.7.4), or OFF.
4. Select the desired CURVE GROUP LOADED. Choose the group you saved in Step 11 of Section 3.7.1.
5. Change any other desired settings.
6. Use F8 to save the settings to a Setup.
7. Press [EXIT] to close the Setup Menu and return to the Opening screen. Now, if you power on and off the unit, or if you use [RESET], the selected curve group will automatically be loaded and the analyzer placed in the selected auto mode when you enter the Coupler Multicurve screen.

3.7.3 Testing in Fully-Automatic Mode

The fully-automatic mode will automatically run through a programmed test sequence without the need of user intervention. The analyzer will pause only when it reaches a programmed pause, which allows the user to make adjustments to the hearing aid before proceeding with the rest of the test sequence. A programmed pause will be indicated by a horizontal line across the Curve Characteristics box.

1. Load a test sequence. You can do this by following the directions in Section 3.7.1 to create a new sequence, or by loading a previously saved sequence by following the directions in Section 3.7.2.
2. Use [F6] to select FULLY AUTOMATIC. (Press [F6]. Use [▼, ▲] to select FULLY AUTOMATIC. Use [►] to complete the selection and close the pop-up menu.)

3. Use [F2] to select the curve number to start the sequence.
4. Use [START] to begin the test sequence. The test sequence will continue until the analyzer reaches a programmed pause.
5. Adjust the hearing aid, if desired, and press [START] to continue the test sequence if there are more curves to measure after the programmed pause.

Use [F6] to turn the AUTO TEST OFF when you want to return to normal testing mode.

3.7.4 Testing in Semi-Automatic Mode

In semi-automatic mode, once you have finished a measurement by pressing the [STOP] button or allowing a pure-tone sweep to complete, the analyzer will automatically advance to the next curve. However, the next measurement will not be taken until you explicitly press the [START] button.

1. If desired, follow the instructions in Section 3.7.2 to load a test sequence. You can do this by following the directions in Section 3.8.1 to create a new sequence, or by loading a previously saved sequence by following the directions in Section 3.7.2.
2. Use [F6] to select SEMI-AUTOMATIC. (Press [F6]. Use [▼, ▲] to select SEMI-AUTOMATIC. Press [►] to complete the selection and close the pop-up menu.)
3. Use [START] to start the automated test sequence. If you are using a source of type COMPOSITE, DIG SPEECH or FAST, press [STOP] to stop the measurement when it has stabilized. The FONIX 8000 Test System will automatically advance the curve selection to the next curve.
4. Make any desired adjustments to the hearing aid and repeat Step 3 until you have measured all your curves.

Use [F6] to turn the AUTO TEST OFF when you want to return to normal testing mode.

3.8 Custom Functions for F7/F8

The [F7] and [F8] keys can be customized to perform many different functions. This allows you to quickly adjust settings without going into the local menu. The following functions are available:

- Display: Switch between Gain and SPL.
- Coupler: Change the coupler type (2cc, CIC).
- Bias Ampl: Change the amplitude of the bias signal (see Section 3.5.3)
- Static: Turn on/off single tone or three frequency average (see Sections 3.4.5 and 3.4.6).

- **Batt Size:** Change the battery size. This is used in battery current drain measurements.
- **Aid Type:** Change the aid type (Standard, AGC, Adaptive AGC). This affects the delay times used in pure-tone sweeps and Digital Speech.
- **Off/Prev:** Switch between the signal being in spectrum analysis mode (source off but measurement running) and at the previous selected amplitude level.
- **Data/Graph:** Switch between displaying test results in numerical format and graphical format.

The F7/F8 selections are set in the local menu. In the Coupler Multicurve screen, press [MENU] to open the local menu. Change the F7 and F8 selections using the arrow keys. The default selection for these settings can be changed in the Setup Menu. See Sections 2.2.1 and 2.2.4 for details.

3.9 Complete List of Menu Items

The function of all items in the local menu of the Coupler screen are described in this section. Enter the local menu by pressing [MENU] in the Coupler screen. Selections are made by using [▼, ▲] to choose an item and [◀, ▶] to change the setting.

There is a dotted or dashed line in between an item and its selection. If the line is dotted, the selection will only effect the Coupler screen. If the line is dashed, the selection is *global* and will have an effect on other measurement screens.

The local menu is divided into five main categories: Display, Measurement, Source, Aid and Misc Settings. To skip ahead to the next category, use the [START] button.

Display Settings

- **Data/Graph:** The method of data display. Choose between DATA (numerical data) and GRAPH.
- **Display:** Type of display. Choose between SPL (output) and Gain (difference between input and output).
- **Smoothing:** Choose whether or not to smooth the frequency response of the measurement. Smoothing makes the frequency response less peaky, but could also eliminate some information about the response, especially in the high frequencies. This can be turned on and off even after a measurement is taken, allowing you to see both the smoothed and unsmoothed result if desired.
- **Graph Scale:** Scaling used when making measurements. NORMAL scales to the upper-most curve. AUTO scales to the current selected curve.
- **Curve Label:** Label used for the two available “ears.” Choose between LEFT/RIGHT and A/B.

Measurement Settings

- **Coupler Type:** The type of coupler being used in making sound chamber measurements. A selection of CIC turns on corresponding software correction factors (see Sections 3.6). A selection of 2CC does not apply correction factors to the curve, but will note a 2-cc coupler was used in the COR column of the Curve Characteristics Box. The NONE selection will apply no corrections and leave the COR column blank.
- **Distortion:** Type of harmonic distortion used in a pure-tone measurement. Choose between 2nd, 3rd and TOTAL. See Section 2.3.1.3.
- **Noise Red (Tone):** Amount of pure-tone noise reduction used. See Section 2.3.1.1.
- **Noise Red (Comp):** Amount of composite noise reduction used. See Section 2.3.2.1.

Source Settings

- **Output Trans:** Transducer used for the measurement. CHAMBER uses the test box. TELECOIL uses the built-in telecoil. TELEWAND uses the external telecoil connector that connects to the Telewand.
- **Static Tone:** Status of individual measurement. Choose SINGLE to emit a static tone in between composite measurements or pure-tone sweeps. Choose AVG to emit a three frequency average between other measurements.
- **Bias Tone:** Amplitude of the bias tone used with Digital Speech. OFF turns the bias tone off entirely.
- **Composite Type:** Type of composite signal used. Choose between STANDARD and CHIRP. See Section 2.3.2.4.
- **Composite Filter:** Filter used in Composite and Digital Speech measurements. Choose between ANSI, ICRA and FLAT.

Aid Settings

- **Aid Type:** Type of hearing aid being measured. Choose between Linear, AGC and ADAPTIVE AGC.
- **Avg Freqs:** Selection of three frequencies used in a three frequency average. See Section 2.2.4.
- **Sweep Start Delay:** The amount of time the FONIX 8000 Test System presents the first tone in a pure-tone sweep. See Section 2.3.1.2.
- **Sweep Meas Delay:** The amount of time each subsequent tone is presented before the measurement is made in a pure-tone sweep. See Section 2.3.1.2.
- **Misc Start Delay:** The amount of time the FONIX 8000 Test System presents the first tone in one of the following measurements: reference test

gain measurements (in automated test sequences), averaging, harmonic distortion measurements, and equivalent input noise measurements. See Section 2.3.1.2.

- Misc Meas Delay: The amount of time each subsequent tone is presented before the measurements is made in one of the measurements listed above. See Section 2.3.1.2.

Misc Settings

- Battery Meas: Status of the battery current measurement. Choose ON or OFF.
- Battery Size: Size of battery used with the hearing aid being tested.
- Print Label: Status of the printing label. Choose ON or OFF.
- Printer: Printer used for printouts. Only INTERNAL is available at this time. See Section 2.4.
- F7/F8: Function of the F7 and F8 function keys in the Coupler Multicurve screen. See Section 3.8.

Advanced Coupler Tests

4.1 Enhanced DSP

The Enhanced DSP measurement screen was designed to give you more information about digital hearing aids. The new technology in digital hearing aids has added a great deal of capability, such as increased clarity and flexible programming. However, the same technology can also have its pitfalls. This test will tell you the *digital processing delay* (also known as group delay) and the *signal phase* of the hearing aid.

The digital processing delay measurement will help you determine whether or not a hearing aid is suitable for a monaural fitting. The phase measurement will help you determine whether custom binaural hearing aids are working properly together as a team.

4.1.1 Digital Processing Delay

One of the properties of digital technology not normally mentioned in the literature is that it always takes time to process digital data. Imagine the digital hearing aid as a miniature computer: it takes an analog sound wave, turns it into digital information, performs some kind of algorithm to amplify the signal, and turns it back into an analog sound wave for the ear to hear. All of this calculating takes precious time; it's never instantaneous. The processing delay for some hearing aids is so slight that it is imperceptible to the human ear. The processing delay for other aids can extend to several milliseconds.

Why is this a problem? Well, if you fit a client monaurally with an aid with a significant digital processing delay, that person might experience some confusion because his unaided ear will be hearing sounds slightly faster than his aided ear. Problems can also be predicted for patients with open canal fittings. However, if you fit the same patient with an occluded binaural set, then both ears will be listening with the same delay, and the confusion will be alleviated.

What is a significant delay? At what magnitude does this delay start to affect speech intelligibility? These are good questions. Unfortunately, we don't have an answer at this time; the field of digital hearing aids is still too young, and there has not yet been enough research done to establish necessary guidelines. A conservative approach would be to avoid monaural and open canal fittings with digital aids that have delays of more than 1 to 2 milliseconds.

For now, this measurement will give you more information about what's really going on in that digital hearing aid circuit, and, hopefully, it will help you troubleshoot why some aids work better than others with monaural or binaural fittings.

Technical details

The digital processing delay measurement is taken by sending a short impulse from the sound chamber speaker to the hearing aid. The FONIX 8000 Test System microphone collects information from the hearing aid for 20 milliseconds from the time the impulse is delivered. This information is a series of numbers of varying amplitudes.

The FONIX 8000 Test System finds the maximum peak amplitude of the resulting information. Since the impulse response of a hearing aid is not always simple, the analyzer also checks for any peaks occurring before this maximum peak. If a smaller peak exists, and it has an amplitude of at least 50% of the maximum peak, the time of the smaller peak will be considered the processing delay point. Otherwise, the time of the maximum peak will be considered the processing delay point. The 8000 Test System delay is subtracted from this delay point in order to form the actual aid processing delay time. (The 8000 Test System delay is determined during the sound chamber leveling process.)

The data collected in the digital processing delay measurement is displayed in graphical format as amplitude vs. time. A dashed vertical line is placed at the calculated delay point. The numerical value is also displayed. A second dotted vertical line shows the 8000 system delay for reference.

4.1.2 Signal Phase

The signal phase measurement is a test of the “pushing” and “pulling” of the amplified sound of the hearing aid. Vibrations in the air create sound—these vibrations can be thought of as air pushing and pulling against the ear. If sound goes through a hearing aid, the hearing aid might cause a phase shift, turning a “push” of the sound wave into a “pull.” This isn’t necessarily a bad thing; there may be good reasons for a phase shift of the sound wave.

The components of a custom hearing aid are usually wired by hand. The receiver is typically wired into the amplifier in such a way that it may or may not cause a phase shift of the signal. If care is not taken, it’s entirely possible to wire one hearing aid of a custom binaural set one way, and wire the other aid in the opposite way. This could cause one of the hearing aids to be “pulling” while the other aid is “pushing,” resulting in strange sound quality for the hearing aid wearer.

We propose that it could be very important to check the signal phase of the hearing aids when fitting a client with a binaural set in order to ensure that the aids are working together as a team.

Technical Details

The signal phase measurement works by generating a 1 kHz cosine wave, turning it into a test signal and delivering it to the aid. The cosine wave signal is offset at the time of generation so that it starts at the baseline (the zero point).

It then continues through a complete cycle and terminates when it reaches the baseline again. This signal, although consisting of only a single pulse, contains very few frequencies above 1 kHz and is one millisecond wide at its base.

The data collected from this measurement is displayed in a graphical format 20 milliseconds wide. The system delay and the digital processing delay are noted for reference on the phase graph in the form of vertical lines.

4.1.3 Procedure

1. Press [F3] in the Opening screen to enter the Advanced Coupler Navigation screen.
2. Press [F4] in the Advanced Coupler Navigation screen to enter the Enhanced DSP screen.
3. Set up the hearing aid for testing in the sound chamber. See Section 3.3. Make sure the sound chamber is leveled.
4. Use [F1] to select the desired ear.

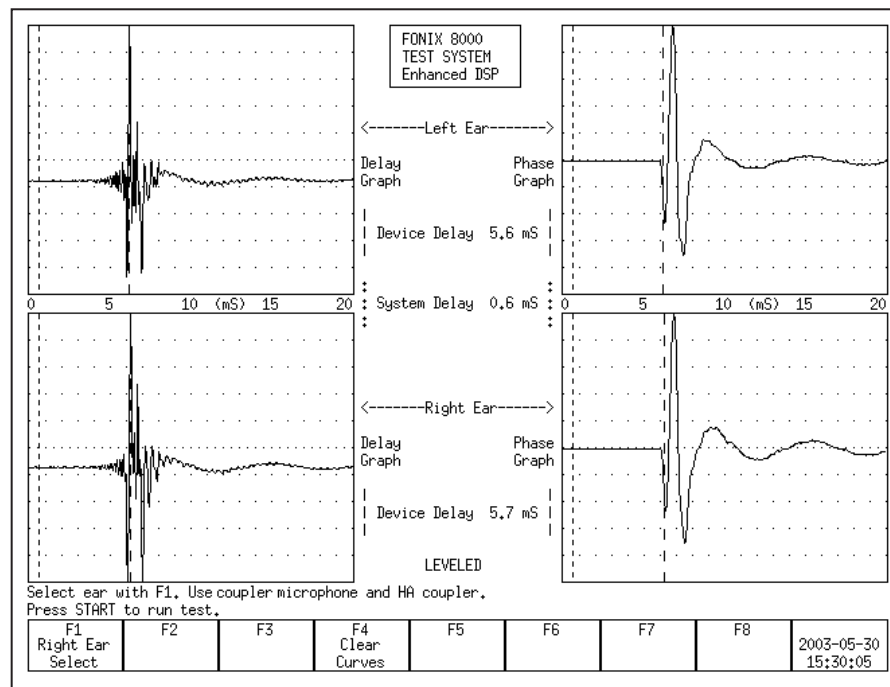


Figure 4.1.3—Enhanced DSP measurement results

5. Press [START] to perform the delay and phase tests for that hearing aid. If the left ear was designated in Step 4, the results will be shown in the upper two graphs. Otherwise, they will be shown in the lower two graphs.

6. Set up a second hearing aid in the sound chamber, if desired, and use [F1] to select the other ear. Press [START] to perform the measurements on this second aid. This will allow you to compare the results of the two hearing aids. See Figure 4.1.3.

When measuring a set of binaural hearing aids, both the phase and the delay graphs should match fairly closely.

4.2 Battery Current Test

The Battery screen lets you perform extensive tests on the amount of battery current that the hearing aid uses. These tests were designed to give you a complete picture of the amount of battery current that the hearing aid drains when exposed to different situations. There are three primary tests:

- **Static Test:** This test estimates the battery life of the hearing aid by presenting the hearing aid with a single static tone.
- **mA/Freq:** This test measures battery current drain as a function of frequency. This shows how the battery current varies as you present the hearing aid with different frequencies.
- **mA/Ampl:** This test measures battery current drain as a function of amplitude. This shows how the battery current varies as you present the hearing aid with different amplitudes.

To run these tests, toggle the test status with [F4], [F5] and [F6], respectively. Pressing [START] will run the mA/Freq and mA/Ampl tests. The tests will automatically stop when finished. The Static test is always on when its status has been toggled to On.

In order to perform these measurements, you need to insert a battery pill into the hearing aid, and plug the battery pill into the sound chamber.

To enter the Battery screen, first press [F3] from the Opening screen to enter the Advanced Coupler Navigation screen. Then press [F1] to enter the Battery Test screen.

A short list of the functions of this screen can be displayed by pressing [HELP].

Note: Many hearing aids do not vary when exposed to signals of varying frequency and amplitude. For those hearing aids, you will see a flat horizontal line when running both the mA/Freq and mA/Ampl measurements.

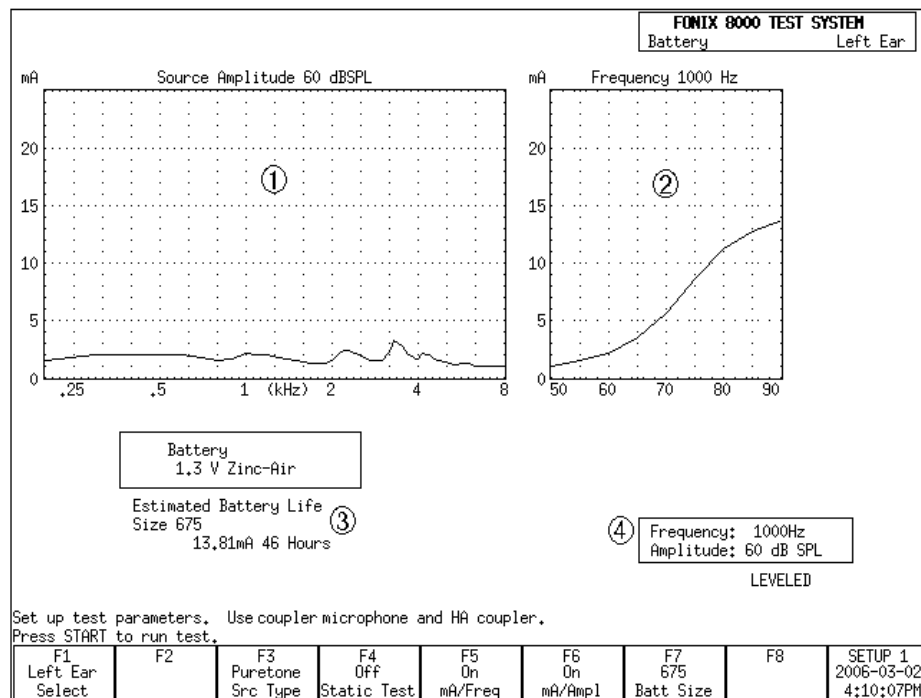


Figure 4.2—Battery Current Test

1. mA/Freq graph
2. mA/Ampl graph
3. Static test (estimated battery life)
4. Selected test settings.

4.2.1 Static Test (Estimated Battery Life)

The Static test estimates the battery life of the hearing aid. To turn on the test:

1. Enter the Battery screen (as described above).
2. Use [F7] to set the battery size: Press [F7]. Use [▼, ▲] to select the battery size of the hearing aid. Use [►] to complete the selection and close the pop-up menu.
3. Use [F4] to toggle the Static Tone to On. The estimated battery life should now be displayed below the ma/Freq graph. See Figure 4.2.

By default, this test uses a pure-tone stimulus of 1000 Hz at 60 dB SPL. The current source selections are shown in a box below the mA/Ampl graph on the right side of the screen. You can:

- Change the source Type by using [F3]. Toggle between Puretone and Composite,
- Change the source Amplitude by using [▼, ▲], and
- Change the source Frequency by using [◀, ▶]. This setting is only available when the soucre type is set to Puretone with [F3].

4.2.2 mA/Freq

The mA/Freq test shows how much battery current the hearing aid drains when exposed to different frequencies. By default, it runs a 60 dB SPL LONG pure-tone sweep. The selected amplitude is displayed below the mA/Ampl graph. This amplitude can be changed by using [▼, ▲].

Press [START] to run the test.

A few technical details about this test:

- The amplitude used for a test currently being displayed on the screen is shown above the mA/Freq graph.
- The source type selected with [F3] does NOT affect this test; this test always uses a pure-tone sweep.
- You can view the numerical data results by entering the local menu by pressing [MENU] and setting DATA/GRAPH to DATA by using the arrow keys. Close the local menu by using [EXIT] or [MENU] again. Test results will now be shown in tabular data format.
- You can turn this test off by toggling the test status with [F5]. If the mA/Freq graph is not displayed, it will not be measured when [Start] is pressed.
- Use [F1] to switch between left and right ear. Test results for each ear can be temporarily stored. (All data is lost when the analyzer is turned off or when the [RESET] button is pressed.)

4.2.3 mA/Ampl

The mA/Ampl test shows how much battery current the hearing aid will drain when exposed to different input level. A test very similar to the I/O measurement in the ANSI S3.22 test sequence is run. That is, the test begins with a stimulus being presented at 50 dB SPL. This amplitude increases in 5 dB steps until the final stimulus at 90 dB SPL is presented. This shows how the battery current drain varies as the aid is exposed to different amplitudes.

By default, the frequency of the stimulus is 1000 Hz. This can be changed by using [◀, ▶] buttons. The selected frequency is shown in a box below the mA/Ampl graph. You can also change the source type from Puretone to Composite by toggling [F3]. The [◀, ▶] buttons will not be active when Composite is selected.

Press [START] to run the test.

A few technical details about this test:

- The frequency used for a test currently being displayed on the screen is shown above the mA/Ampl graph.
- You can view the numerical data results by entering the local menu by pressing [MENU] and setting DATA/GRAPH to DATA by using the arrow

keys. Close the local menu by using [EXIT] or [MENU] again. Test results will now be shown in tabular data format.

- You can turn this test off by toggling the test status with [F6]. If the mA/Ampl graph is not displayed, it will not be measured when [Start] is pressed.
- Use [F1] to switch between left and right ear. Test results for each ear can be temporarily stored. (All data is lost when the analyzer is turned off or when the [RESET] button is pressed.)

4.3 Coupler I/O

The Coupler I/O Test measures the input/output of the hearing aid from 50 dB SPL to 90 dB SPL in 5 dB steps. Test results are shown in both graphical format and numerical format and can be displayed in either Gain or SPL (Output). See Figure 4.3.

To enter the Coupler I/O screen: press [F3] from the Opening screen to enter the Advanced Coupler Navigation screen. Then press [F2] to enter the Coupler I/O screen. Press [START] to run the I/O test.

By default, this test is done with a puretone stimulus at 2000 Hz. The frequency of this stimulus can be changed by using [◀, ▶]. You can also toggle the source type between Puretone and Composite by using [F5]. (The frequency selection is only available when the source type is set to Puretone.)

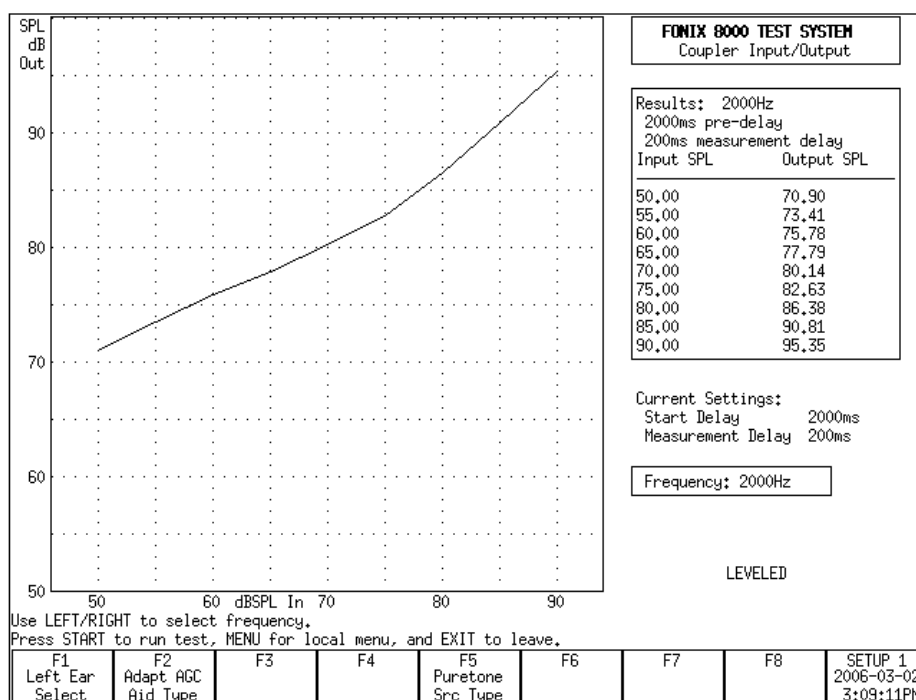


Figure 4.3—I/O Test

A few technical details about this test:

- Choose between showing test results in SPL (Output) and Gain in the local menu. (Use [MENU] to open the local menu, the arrow keys to adjust the selections, and [EXIT] or [MENU] again to close the local menu.)
- [F2] sets the aid type. This changes the length of time each stimulus is presented before the measurement is taken. Suitable default delay times are set when the aid type is selected. You can make further adjustments to the delay settings in the local menu. See Section 2.3.1.3 for details.
- The settings used for the test displayed on the graph are shown above the data results on the right side of the screen. The settings used when [START] is pressed are shown below the data under “Current Settings.”

4.4 Attack & Release

The Attack & Release test demonstrates how the hearing aid reacts to noise at different intensity levels. The test works by presenting a loud-soft-loud-soft stimulus sequence to the aid. The first loud-soft tones are done to prepare the analyzer and the hearing aid for the test. The second loud-soft tones are used for the actual measurements.

The loud stimulus demonstrates the hearing aid’s *attack* time. That is, how the hearing aid reacts to the test stimulus going from a soft level to a loud level. The last soft stimulus demonstrates the hearing aid’s *release* time. That is, how the hearing aid reacts to the test stimulus going from a loud level to a soft level.

To enter the Attack & Release screen: From the Opening screen, press [F3] to enter the Advanced Coupler Navigation screen. Then press [F3] to enter the Attack & Release screen.

Press [START] to run the Attack & Release test.

Measurement results are displayed in graphical and numeric format. See Figure 4.4. The top graph contains the response of the aid over time to the Attack test. The bottom graph shows the response of the aid over time to the Release test. These graphical displays let you see how the device performs over the attack and release phases. Erratic performance during these critical phases could result in effects that are audible to a hearing-impaired listener. These effects could be annoying or could even obscure parts of a conversation. The actual attack and release times determined by the analyzer are shown in a box to the right of the graph.

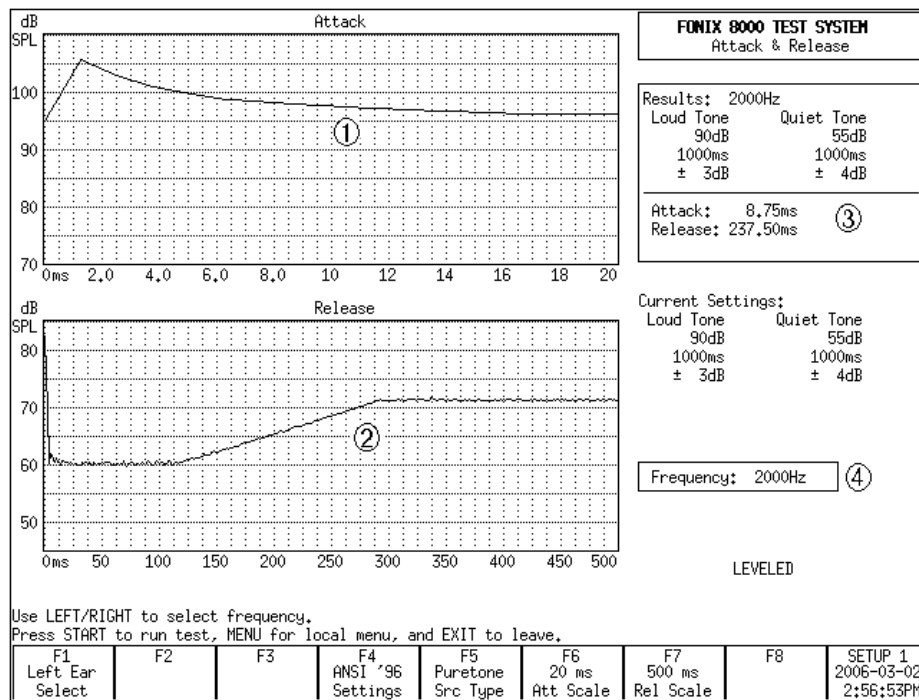


Figure 4.4—Attack & Release Test

1. Attack graph
2. Release graph
3. Measured Attack & Release times and test settings.
4. Current Attack & Release settings

By default, the Attack & Release test uses the settings specified by the ANSI 96 test sequence at 2000 Hz. If you want to perform attack and release measurements using a different standard, use the [F4] key. The available test selections are: IEC Loud, IEC Speech, JIS, IEC and ANSI 96. (The ANSI 03 test sequence uses settings identical to ANSI 96.) This changes the test settings to those specified by the selected standard.

You can further customize the test settings by pressing [MENU] to open the local menu. Use the arrow keys to make the desired adjustments, and use [MENU] again or [EXIT] to close the menu. See the Technical Details section below for more information.

In addition to the settings adjustable in the local menu, you can also change the frequency and the source type of the test. Use [F5] to toggle between Puretone and Composite. Use the [◀, ▶] keys to change the selected frequency. (You can only change the frequency when the Source Type is set to Puretone with [F5].) Please note that manufacturer specifications normally assume a puretone source type.

For most hearing aids, the most interesting part of the attack and release measurements occurs at the beginning of each test. After the aid reaches its settling amplitude, the test result just records a rather uninteresting flat line. The user can zoom in on the beginning of the test by using [F6] and [F7]. These keys re-scale the test results to show only the selected time interval. The beginning of the interval is always the beginning of the test. The end of the interval is the time selected by the user with [F6] and [F7] for the Attack and the Release tests, respectively. The available time intervals range from 10 ms to 2000 ms. These settings do NOT change the duration of the test.

Technical Details

- In order to determine the attack and the release times of the hearing aid, the 8000 analyzer calculates the settling amplitude of each measurement and uses the tolerance setting to achieve the final test result. The settling amplitude is calculated by averaging the last 16 measurements of the test. The attack (or release) time is the first time the aid reaches this amplitude within the set tolerance. The tolerance is one of the settings that is changeable in the local menu.
- Use [F1] to select ears. The 8000 analyzer can temporarily store one Attack & Release test per ear. This data is erased by measuring over it, pressing [RESET], or turning off the analyzer.
- The settings used for a displayed test are shown in a box to the right of the attack graph. The settings that will be used when [START] is pressed are shown below this box.

Automated Test Sequences

There are several automated coupler test sequences available for the FONIX 8000 Test System. The test sequences present on your analyzer are dependent upon the features purchased when you ordered your unit. If you would like access to a test sequence not present on your unit, you can always order an upgrade. Call the factory or your local distributor for more information.

The following test sequences are available:

- ANSI S3.22-2009
- ANSI S3.22-2003 (ANSI 03)
- ANSI S3.22-1996 (ANSI 96)
- ANSI S3.22-1987 (ANSI 87)
- ANSI S3.42-1992 (ANSI 92)
- IEC 60118-7-1994 (IEC 94)
- IEC 60118-7-2005 (IEC 05)
- JIS
- Profiler

5.1 ANSI S3.22

The ANSI S3.22 automated test sequences allow you to test hearing aids according to the ANSI S3.22 standards. You can use the ANSI tests to control the quality of the hearing aids that you dispense. Compare the manufacturer's specifications with your own ANSI measurements of an aid. If they do not conform within expected tolerances, you can contact the manufacturer.

There are four different versions of the ANSI S3.22 standard: ANSI 09, ANSI 03, ANSI 96, and ANSI 87. This is because the standard periodically gets upgraded by the ANSI standards committee. After the ANSI S3.22 standard has been updated, the FDA reviews it and eventually approves it to be used for labeling the specifications of all hearing aids manufactured in the United States.

The ANSI 96 standard was officially approved by the FDA on March 17, 2000. This means that any hearing aid designed after this date must be labeled to the ANSI 96 standard. However, if a manufacturer designed a hearing aid before this date, they can continue labeling newly manufactured aids of the same design to the older ANSI 87 standard.

ANSI 03, which was approved by the FDA in November of 2005, is the newest version of the ANSI S3.22 standard.

ANSI 09 has been approved by the FDA for use in manufacturing facilities in the United States, but it has not yet been required. Therefore hearing aids can be labeled to either the ANSI 03 or ANSI 09 standard.

Here are the main differences between ANSI 87 and ANSI 96:

- AGC aids are tested at reduced reference test gain in ANSI 96, but tested at full-on gain in ANSI 87. This will have an effect on nearly all measurement results in the ANSI test sequence.
- The input/output and attack & release measurements are performed at up to five different frequencies in ANSI 96. ANSI 87 only measures those functions at 2000 Hz.
- ANSI 96 measures the telecoil function of all aids using a telecoil device with a stronger magnetic field than the telecoil device used by ANSI 87, and a whole frequency sweep of measurements is performed in ANSI 96, instead of only one measurement at a single frequency in ANSI 87.

Here are the main differences between ANSI 96 and ANSI 03:

- In ANSI 03, the frequency response curve is always measured at 60 dB SPL. In ANSI 96, AGC aids are tested at 50 dB SPL.
- At the beginning of an ANSI 03 test, AGC aids should be set to have minimum compression. Just before the I/O and attack and release measurements, the analyzer will pause to let you turn on the compression controls to maximum.
- The EIN measurement uses a 50 dB SPL input instead of a 60 dB SPL input. This should give better results for AGC aids with knee points between 50 and 60 dB SPL.
- In ANSI 96, full-on gain is measured at 50 or 60 dB SPL for linear aids and 50 dB SPL for AGC aids. In ANSI 03, full-on gain is always measured at 50 dB SPL.
- The ANSI 96 Simulated Telephone Sensitivity (STS) measurement is called Relative Simulated Equivalent Telephone Sensitivity (RSETS) in ANSI 03.

Here are the main differences between ANSI 03 and ANSI 09:

- In ANSI 09, the response curve is displayed in dB Gain instead of dB SPL. In ANSI 03, the response curve was displayed in dB SPL.
- In ANSI 09, the response curve can be measured with either a pure-tone sweep or a composite curve. In ANSI 03, the response curve was always measured with a pure-tone sweep.
- In ANSI 03, when the hearing aid is set to AGC or Adaptive AGC, I/O and attack and release measurements were made. In ANSI 09, these measurements are no longer taken.
- In ANSI 03, an entire frequency response was made of the telecoil functionality. In ANSI 09, only a single measurement of the telecoil response is displayed.

5.1.1 Entering/Exiting the ANSI S3.22 Screens

By factory default, the [F4] key in the Opening screen will immediately open the ANSI 03 test screen. You can verify this operation by looking at the label for [F4] in the Opening screen. However, the [F4] through [F7] keys are user configurable and may have been changed. If this is the case, or if you want to enter the ANSI 09, ANSI 96 or ANSI 87 test screen, you may have to assign one of these keys to your desired ANSI test.

To configure the F4-F7 keys:

1. Press [MENU] in the Opening screen.
2. Change one of the F4-F7 selections in the General Default Settings window under Opening Screen to the desired ANSI S3.22 test. You can even assign one key to one test sequence (such as F4 to ANSI 03) and another key to another test sequence (such as F5 to ANSI 96).
3. Use [F8] to save the setting (and all other settings in the Setup Menus) as default selections. See Sections 2.2.1 and 2.2.4 for details.
4. Press [EXIT] to return to the Opening screen. Your new selection for the F4-F7 keys should be displayed in the function key list at the bottom of the screen.
5. Press the function key you selected in Step 2 to enter the ANSI screen.

When inside the ANSI screen, the [EXIT] button is used to leave the screen. This will take you to the ANSI navigation screen, which contains function keys selections pointing to all of the available ANSI S3.22 test selections. Use one of those function keys to enter a different ANSI test screen, or press [EXIT] again to return to the Opening screen.

5.1.2 Leveling for ANSI

Before you run an ANSI test, you should make sure the sound chamber is leveled. Even if the screen says that the chamber is leveled, it is a good idea to periodically re-level it to account for any differences that might have entered into the testing environment.

The ANSI standard requires that you do a special leveling that accounts for everything that will be in the chamber during the test. (For most practical office settings, the leveling procedure explained in Section 3.2 is adequate. If you are using the 8120 Polar Plot Chamber, you will need to place the 8120 basket cover over the cavity inside the chamber.

1. Place the dummy microphone (a black cylinder, provided when ANSI Option is ordered) into the coupler.
2. Attach the hearing aid to the coupler in the way appropriate for the type of aid under test. See Section 3.3.
3. Position the hearing aid/coupler assembly in the test chamber with the microphone of the aid at the reference point of the chamber.

4. Place the test microphone as close as practical to the hearing aid microphone (3-5 mm). See Figure 5.1.2A.

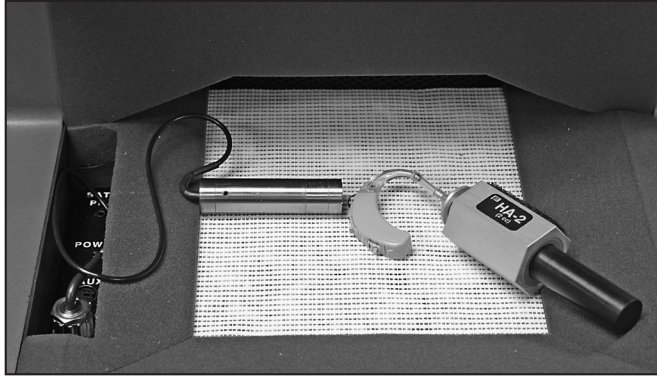


Figure 5.1.2A—Setup for leveling

5. Close the lid of the sound chamber.
6. Press the [LEVEL] button. The sound chamber will level.
7. Exchange the position of the dummy microphone and the test microphone and plug the battery pill into the battery voltage supply. See Figure 5.1.2B.

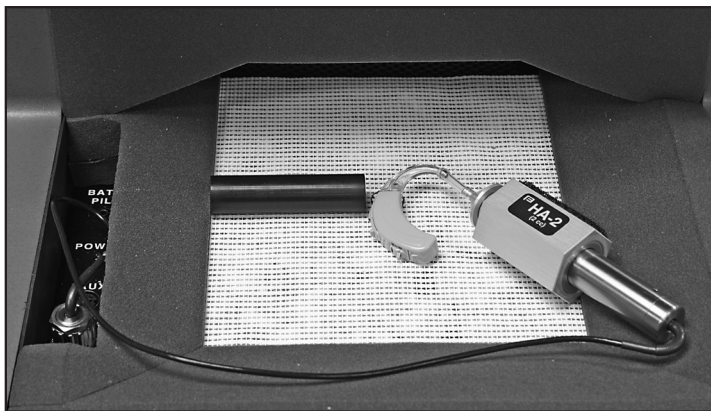


Figure 5.1.2B—Setup for aid testing/ equivalent substitution method

5.1.3 Setting up the hearing aid for ANSI

The hearing aid controls must be set to conform with ANSI requirements for the test results to be valid.

1. Set the controls on the aid (except for the compression controls) to give the greatest possible output and gain.
2. Set the aid for the widest frequency response range.

3. For ANSI 87 and ANSI 96, set AGC aids to achieve the greatest possible compression or as otherwise specified by the manufacturer. For ANSI 09 or ANSI 03, set AGC aids to have the minimum compression possible or as otherwise specified by the manufacturer.
4. Put the hearing aid in “test mode,” if applicable. All noise suppression and feedback cancellation features should be turned off.
5. Set the gain control of the aid to the full-on position.
6. Set the aid up in the sound chamber as described in Section 3.3.

5.1.4 Setting up the analyzer for ANSI

1. Enter the ANSI test screen as described in Section 5.1.1.
2. Use [F1] to select LEFT or RIGHT ear.
3. Use [F2] to select the aid type: LINEAR, AGC or ADAPTIVE AGC. (Press [F2]. Use [▼,▲] to choose the selection. Press [►] to complete the selection and close the pop-up menu.)
4. Use [F3] to select the full-on gain (FOG) amplitude used in the test sequence. We recommend setting this to AUTO, which will automatically use the appropriate amplitude. This step does not apply for ANSI 03 or ANSI 09.
5. Use [F5] to select whether or not to perform a telecoil measurement.
6. Press [MENU] to enter the local menu and make any desired selections. See Section 5.1.10.

Use [F7] to return all ANSI settings to their power-on default conditions.
Use [F8] to display all selected ANSI settings.

5.1.5 Running an ANSI 09, ANSI 03, or ANSI 96 Test

After leveling the sound chamber as described in Section 5.1.2, setting up the aid as described in Section 5.1.3, and setting up the analyzer as described in Section 5.1.4, follow these instructions:

1. Press [START] to begin the test. Usually the 8000 test system will pause during the measurement process in order to let you adjust the gain of the hearing aid to the reference test position.
 - a. Lift the sound chamber lid and adjust the gain control of the aid until the RTG MEASURED gain matches RTG TARGET.
 - b. Close the sound chamber lid when finished.
 - c. Look at the display again. The MEASURED gain should be within 1 dB of the TARGET gain for ANSI 96, or 1.5 dB for ANSI 03 or ANSI 09.
2. Push [START] to continue the test.

- 3A. If you chose to perform a telecoil measurement, do the following steps when the analyzer pauses. If you are running an ANSI 03 test of an AGC aid and are not performing a telecoil measurement, skip to step 3B. Otherwise, just wait for the test sequence to complete.
- Open the lid of the sound chamber.
 - Switch the aid to telecoil mode.
 - Plug the telewand into the side of the sound chamber, just above the cable that connects the sound chamber to the Frye box.
 - Hold the telewand over the aid as if it were the ear piece on a phone. That is, hold the telewand parallel to the body of a BTE or against the faceplate of an ITE. It's also usually best to position the hearing aid vertically to get the best telecoil response. See Figure 5.1.5.
 - Press [START] to measure the telecoil response. The analyzer will pause after the telecoil measurements are complete.
 - Return the aid to the normal microphone mode, set the AGC controls to max (ANSI 03 and AGC aids only), reposition the hearing aid in the sound chamber, close the lid, and press [START] to complete the test sequence.
- 3B. If you're running an ANSI 03 test of an AGC aid without a telecoil measurement, the analyzer will run several measurements and then pause to allow you to set the AGC controls of your aid to maximum. Do so, close the lid of the chamber, and press [START] to complete the test sequence.



Figure 5.1.5—Holding telewand parallel to the body of a BTE

5.1.6 Running an ANSI 87 Test

After leveling the sound chamber as described in Section 5.1.2, setting up the aid as described in Section 5.1.3, and setting up the analyzer as described in Section 5.1.4, follow these instructions:

1. Press [START] from the ANSI 87 screen to start the test.
2. If you have enabled the telecoil test, do the following when the sequence stops for the telecoil measurement. Otherwise, skip to step 3.
 - a. Open the lid of the sound chamber.
 - b. Switch the aid to telecoil mode.
 - c. While viewing TCOIL 10 mA/m near the upper right corner of the screen, try many positions for the hearing aid, near the reference point, until you find the position that gives the highest output with the least variability. Usually the best position is with the hearing aid held in the vertical position.
 - d. Hold that position and press [START]. This measures the telecoil output.
 - e. Switch the aid back to normal, microphone mode.
 - f. Press [START] to resume testing.
3. Depending on the aid type selected and the gain of the hearing aid, the ANSI sequence may stop for you to adjust the gain control to the reference-test. If the sequence stops:
 - a. Open the lid of the sound chamber.
 - b. While viewing the HF AVG readings in the lower center of the screen, turn the gain control on the aid down until the MEASURED value matches the TARGET value within 1 dB.
 - c. Close the lid. If the MEASURED number is still correct, press [START] to complete the test sequence.

5.1.7 Viewing ANSI Results

The test results for ANSI 03, ANSI 96 and ANSI 87 have a similar display. See Figure 5.1.7A for an explanation of ANSI 03 results. See Figure 5.1.7B for an explanation of ANSI 09 results.

1. OSPL 90 curve: Full-on gain frequency sweep taken at 90 dB SPL.
2. RESP 60 curve: Reference test gain frequency sweep taken at 60 dB SPL.
3. SPLITS curve: Frequency response of the telecoil.
4. Aid type (selected with F2)
5. OSPL 90 MAX: Amplitude and frequency of the maximum output of the aid.
6. OSPL 90 HFA/SPA: Three-frequency response of the OSPL 90 curve.
7. HFA/SPA FOG: Full-on gain three frequency average and the amplitude at which it was taken.
8. RTG Target: Target reference test gain
9. RTG Measured: Measured reference test gain
10. EQ Inp Noise: Equivalent input noise measurement

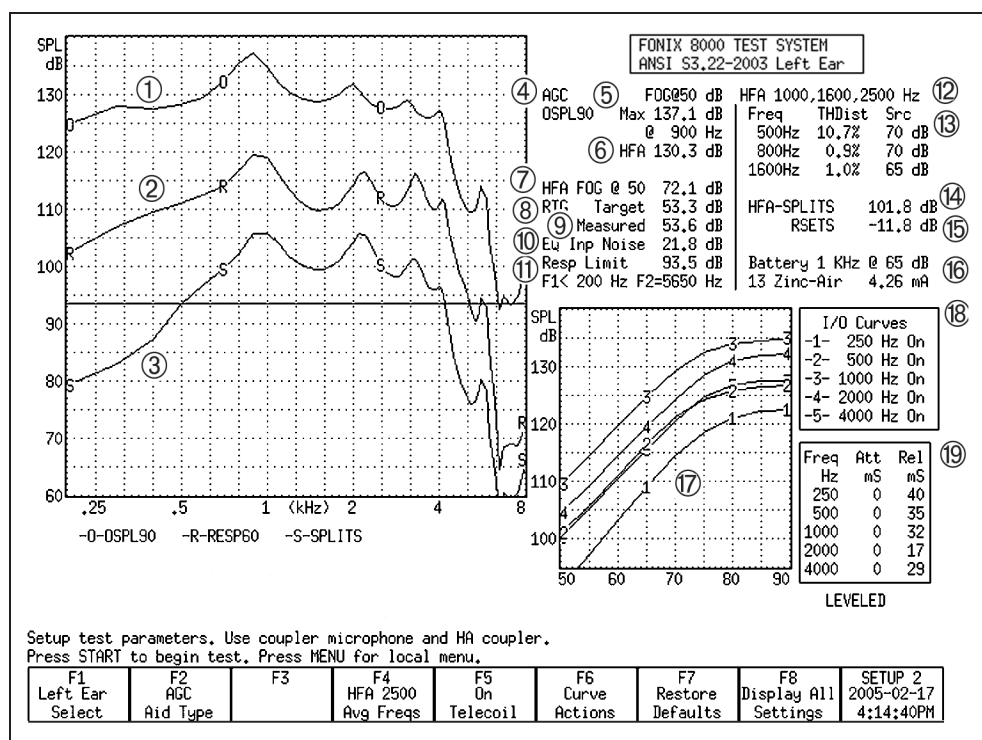


Figure 5.1.7A—ANSI 03 test results, Frequency Response Screen

11. Resp Limit: The response limit level is determined by taking the three frequency average of the RESP 50 curve and subtracting 20 dB.
F1 is where the RESP 50 curve crosses the response limit level on the way up.
F2 is where the RESP 50 curve crosses the response limit level on the way down.
12. HFA/SPA: Three frequency average chosen in the MENU.
13. TDH: total harmonic distortion measurements and the frequencies and amplitudes at which they are taken.
14. HFA/SPA-SPLITS: Three-frequency average of the telecoil frequency response curve.
15. RSETS: The difference between the HFA/SPA of the microphone response curve and the telecoil response curve.
16. Battery Current measurement
17. I/O curves: the input/output measurements taken of AGC aids. Only selected frequencies are tested.
18. I/O curve selection box: the key to the I/O graph, listing which frequencies go with which curve.
19. Attack and release measurements, including the frequencies at which they were measured.

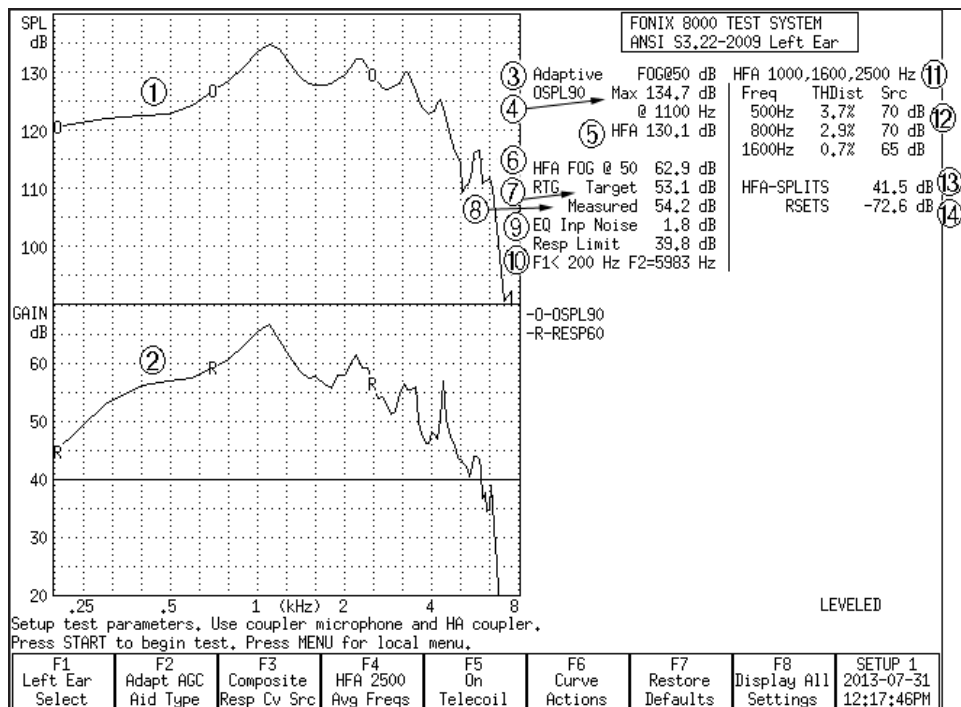


Figure 5.1.7B—ANSI 09 test results

1. OSPL 90 curve: Full-on gain frequency sweep taken at 90 dB SPL.
2. RESP 60 curve: Reference test gain measurement curve taken at 60 dB SPL with either a Composite or Pure-tone source type.
3. Aid type (selected with F2)
4. OSPL 90 MAX: Amplitude and frequency of the maximum output of the aid.
5. OSPL 90 HFA/SPA: Three-frequency response of the OSPL 90 curve.
6. HFA/SPA FOG: Full-on gain three frequency average and the amplitude at which it was taken.
7. RTG Target: Target reference test gain
8. RTG Measured: Measured reference test gain
9. EQ Inp Noise: Equivalent input noise measurement
10. Resp Limit: The response limit level is determined by taking the three frequency average of the RESP 60 curve and subtracting 20 dB.
F1 is where the RESP 60 curve crosses the response limit level on the way up.
F2 is where the RESP 50 curve crosses the response limit level on the way down.
11. HFA/SPA: Three frequency average chosen in the MENU.

12. TDH: total harmonic distortion measurements and the frequencies and amplitudes at which they are taken.
13. HFA/SPA-SPLITS: Three-frequency average of the telecoil frequency response curve.
14. RSETS: The difference between the HFA/SPA of the microphone response curve and the telecoil response curve.
15. (not shown) Battery current drain measurement

Test Result Differences with ANSI 96 and ANSI 87

- In ANSI 87 and ANSI 96, the response curve (2) is sometimes measured at 50 dB SPL
- In ANSI 87, I/O (17) is only measured at 2000 Hz
- In ANSI 87, attack and release (19) is only measured at 2000 Hz
- In ANSI 87, AGC aids are measured at full-on gain for the entire test sequence
- In ANSI 87, the OSPL90 curve is called SSPL90
- In ANSI 96, RSETS (15) is called STS-SPLITS
- In ANSI 87, the telecoil measurement (3, 14, 15) is much different. There is only one measurement called “TCOIL 10 mA/m”

To delete the displayed results, press [F6] and use [▼,▲] to select DELETE ALL CRVS. Press [►] to perform the deletion.

5.1.8 Testing Digital Hearing Aids

The ANSI S3.22 “labeling” standard for hearing aids was not designed with digital hearing aids in mind. In fact, most of the testing methods employed by ANSI have been around since the 1970s. However, since ANSI is a standard, in order to conform to that standard, it must use only the testing techniques outlined in the standard. For this reason, **the 8000 test system has no provisions for incorporating composite or digital speech into the ANSI test sequences.**

In order to test digital hearing aids with “noise reduction” or “speech enhancement” features to the ANSI standards, put the aid in “test” mode via its programming software and do the steps outlined in Section 5.1.5. Contact your manufacturer to get further suggestions on performing an ANSI specification test.

In order to get an accurate picture of the aid’s actual performance when it goes home with your client, put the aid in the mode you will use for that client, and perform response curve measurements in the coupler and in the real-ear via the procedures described in Chapter 3 and Chapter 6 using the digital speech (DIG SPEECH) signal source.

5.1.9 Viewing ANSI measurements in the Coupler screen

It's possible to copy ANSI response curves to the Coupler screen where they can be compared to other response curves. To do this:

1. Run the ANSI test sequence.
2. Press [F6].
3. Use [▼] to select Store Crvs Coup, if necessary.
4. Press [►] to store the curves and close the menu. The following is a list of where the curves are stored in the Coupler screen. Any previous measurements stored in these curve locations will be overwritten.
 - SPLITS – CRV 4
 - VA CORFIG – CRV 5
 - Response – CRV 6
 - OSPL90 – CRV 7
5. Press [EXIT] and [F1] to enter the Coupler screen and view the ANSI response curves.

5.1.10 Explaining the Menu Settings

The following is an explanation of all the ANSI menu selections:

Measurement Settings

- Noise Red (Tone)—The amount of noise reduction used in the pure-tone measurements. See Section 2.3.1.1 for details.
- Battery Meas—The status of the battery current measurement. Turns it ON or OFF. (Battery pill required for this measurement.)
- Battery Size—The size of the battery for the hearing aid being tested.
- 12 dB Dist—The status of the 12 dB harmonic distortion rule. When measuring harmonic distortion, if the amplitude of the response at the second harmonic of the frequency being measured is 12 dB greater than the amplitude of that primary frequency, the harmonic distortion measurement should be ignored at the primary frequency. Turn this rule ON or OFF.
- Equiv Noise Test—Status of the EIN measurement. Turns it ON or OFF. In ANSI 87 and ANSI 96, this should probably be turned off for compression aids with a knee point below 60 dB SPL.
- Option—Used with the test sequence. This can be CIC, which adds CIC correction factors, (make sure to use the CIC coupler with this option), or VA-CORFIG, which includes software correction factors designed by the VA to produce a more realistic response curve than the normal ANSI response curve.

ANSI Settings

- OSPL90 Sweep Start Delay—The delay after the first tone is presented in the OSPL90 sweep and before the first measurement is taken.
- OSPL90 Sweep Meas Delay—The delay between frequencies in the OSPL90 sweep.
- Res Crv Sweep Start Delay—The delay after the first tone is presented in the response curve (at 50 or 60 dB SPL) sweep and before the first measurement is taken.
- Res Crv Sweep Meas Delay—The delay between frequencies in the response curve (at 50 or 60 dB SPL) sweep.
- Misc Start Delay—The delay after the first tone is presented and before the first measurement is taken in the HFA/SPA, reference test gain, equivalent input noise, and harmonic distortion measurements.
- Misc Meas Delay—The delay between frequencies in the measurements mentioned above.

Note: ANSI 87 combines the “OSPL90” and “Res Crv” delays into the “Sweep Start” delay settings.

AGC Settings

The purpose of the following settings is identical for each I/O frequency.

- AGC frequency—Status of the I/O test at the selected frequency. Turn the test ON or OFF.
- I/O Start—The delay after the first tone is presented in the I/O sweep and before the first measurement is taken.
- I/O Meas—The delay between frequencies in the I/O sweep.
- Attack Window—The amount of time the analyzer measures the attack time of the hearing aid. Select a time that is at least twice as long as the attack time specified by the manufacturer.
- Release Window—The amount of time the analyzer measures the release time of the hearing aid. Select a time that is at least twice as long as the release time specified by the manufacturer.

Note: ANSI 87 only measures I/O at 2000 Hz, and the Attack and Release window settings are not available.

Misc Settings

- Print Label—Status of the printing label. Choose ON or OFF.
- Printer—Printer used for printouts. Only INTERNAL is available at this time. See Section 2.4.
- AGC Switching—Pause during the test sequence that allows the user to change the compression setting of AGC aids according to the IEC standard. Turn ON or OFF.

5.2 ANSI S3.42-1992 (ANSI 92)

The ANSI Option includes a test sequence based on the ANSI S3.42-1992 standard. This standard has been developed to test non-linear hearing aids with a broadband noise signal. The need for this standard stems from the importance of evaluating the performance of these circuits in a more real-world environment. ANSI 92 gives you: noise saturation sound pressure level, noise gain, a family of frequency responses, and a noise input/output curve.

5.2.1 Understanding ANSI 92

The original signal used in the 8000 test system is that of a speech-weighted set of pure tones starting at 200 Hz and ending at 8000 Hz, with a gradual high frequency roll off of 6 dB per octave. The knee point of the roll off is placed at 900 Hz. The spectrum was developed from data supplied by the National Bureau of Standards, and is the signal used for the testing of hearing aids submitted for use in the Veterans Administration hearing aid program.

In 1992, the ANSI standards committee for hearing aid test standards published S3.42-1992. This standard describes a noise signal that is very similar to the one we use in the 8000 test system. There are some differences, mostly in the low frequencies and in the way that the signal spectral shape is specified. The committee wanted a system that could be built easily by anyone, and assumed that a manufacturer who would develop equipment to make tests for this standard would use a white noise signal to produce the roll off above the 900 Hz knee point.

In order to produce a signal that met with the provisions of the S3.42 standard, Frye Electronics decided to slightly modify the Composite signal for use in this ANSI 1992 test sequence. This modified signal is not used in the normal composite operation of the 8000 test system.

Only the most observant operator will see any significant difference in the hearing aid performance between the two signals. The ANSI S3.42 signal may result in an increase in noise gain by about 1 dB.

5.2.2 Entering the ANSI 92 Screen

To enter the ANSI 92 test screen, you must configure one of the function keys in the Opening screen to point to that test screen.

To configure the F4-F7 keys in the Opening screen:

1. Press [MENU] in the Opening screen.
2. Change one of the F4-F7 selections in the General Default Settings window under Opening Screen to ANSI S3.42.
3. Use [F8] to save the setting (and all other settings in the Setup Menus) as default selections. See Sections 2.2.1 and 2.2.4 for details.

4. Press [EXIT] to return to the Opening screen. Your new selection for the F4-F7 keys should be displayed in the function key list at the bottom of the screen.
5. Press the function key you selected in Step 2 to enter the ANSI 92 screen.

5.2.3 Running ANSI 92.

1. Level the sound chamber and set up the hearing aid to full on gain as specified in Section 5.1.2 and 5.1.3.
2. Press [F4] in the Opening screen to enter the ANSI 92 screen.
3. Use [F1] to select the desired ear.
4. Use [F2] to select the settle time used for the test.
5. Use [F3] to set the noise reduction used for the test. See Section 2.3.2.1 for more information on composite noise reduction.
6. Press [START] to begin the test sequence.

For some aids, the analyzer will pause the test and tell you to turn the aid down to reference test gain. Adjust the volume of the aid until it comes within 1 dB of the target gain. Take care not to move the aid from its position. If you must move it in order to adjust the gain control, replace the aid as close as possible to its original position. Push [START] to complete the test.

To delete the displayed results, press [F4] and use [▼, ▲] to select DELETE ALL CRVS. Press [►] to perform the deletion.

5.2.4 Viewing ANSI 92 Results

1. Family of composite gain curves made at 50, 60, 70, 80 and 90 dB SPL,
2. NSPL90—Maximum RMS output sound pressure level (SPL) produced with a 90dB RMS speech-weighted noise input SPL signal.
3. Full-On Noise Gain—Maximum RMS gain with a 60dB SPL noise input signal. (Note: This test may not elicit a true reading of maximum gain for hearing aids with an onset of non-linear operation below 60dB.)
4. Target Reference Gain—This information is only displayed when the actual gain is greater than the calculated desired setting of gain. This target is used to adjust the hearing aid's actual gain to a level of ± 1 dB of the target. The figure is calculated by adding the 60dB SPL input + 17dB and subtracting it from the NSPL90 RMS output. (NSPL90 D-77 = desired setting of gain)
5. Actual Reference Gain—The measured amount of gain when the hearing aid is set to the reference test position.
6. Noise I/O Curve—This demonstrates the compression or limiting of the non-linear circuit.

For a more detailed explanation of these terms, consult the ANSI S3.42-1992 standard.

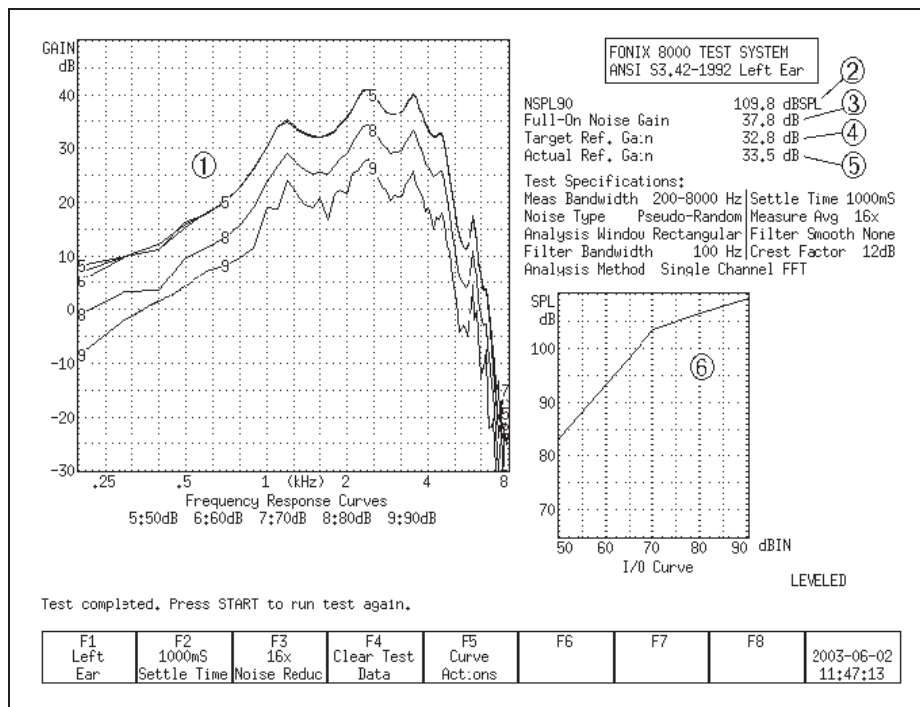


Figure 5.2.4—ANSI 92 test results

5.2.5 Viewing ANSI measurements in the Coupler screen

It's possible to copy ANSI response curves to the Coupler screen where they can be compared to other response curves. To do this:

1. Run the ANSI 92 test sequence.
2. Press [F6].
3. Use [▼] to select Store Crvs Coup, if necessary.
4. Press [►] to store the curves and close the menu. The following is a list of where the curves are stored in the Coupler screen. Any previous measurements stored in these curve locations will be overwritten.
 - 50 dB SPL—CRV3
 - 60 dB SPL—CRV4
 - 70 dB SPL—CRV5
 - 80 dB SPL—CRV6
 - 90 dB SPL—CRV7
5. Press [EXIT] and [F1] to enter the Coupler screen and view the ANSI response curves.

5.2.6 Explaining the Menu Settings

There are only a couple of menu settings in the local menu of the ANSI 92 screen.

Misc. Settings

- Print Label—Status of the printing label. Choose ON or OFF.
- Printer—Printer used for printouts. Only INTERNAL is available at this time. See Section 2.4.

5.3 IEC

The International Electro-technical Commission (IEC) 60118-7 standard in the international community is analogous to the ANSI standard in the United States.

There are two versions of the IEC standard in common use: IEC 60118-7 1994 (IEC 94) and IEC 60118-7 2005 (IEC 05). IEC 05 is very similar to the ANSI 03 standard.

Technical note for IEC 94:

Most of the IEC 94 measurements are made with the aid set to reference test gain. You can either set the aid to the reference test gain calculated by the 8000 analyzer, or you can set it to the reference test gain specified by the manufacturer.

We calculate the reference test gain used by IEC 94 with the following method:

The reference frequency is measured at 90 dB SPL (value A) and 60 dB SPL (value B).

- If $B \geq A - 68$, the calculated reference test gain is $A - 75$
- Otherwise, the calculated reference test gain is $B - 7$.

5.3.1 Entering the IEC 94 or IEC 05 Test Screen

By factory default, the [F5] key in the Opening screen will immediately open the IEC 05 test screen when the IEC Option is included. You can verify this operation by looking at the label for [F5] in the Opening screen. However, the [F4] through [F7] keys are user configurable and may have been changed. If this is the case, you may have to assign one of these keys to IEC 94 or IEC 05. Once inside one of the IEC test screens, you can change the standard version in the local menu.

To configure the F4-F7 keys:

1. Press [MENU] in the Opening screen.
2. Change one of the F4-F7 selections in the General Default Settings window under Opening Screen to the desired IEC 60118-7 test. You can even assign one key to one test sequence (such as F4 to IEC 94) and another key to another test sequence (such as F5 to IEC 05).

3. Use [F8] to save the setting (and all other settings in the Setup Menus) as default selections. See Sections 2.2.1 and 2.2.4 for details.
4. Press [EXIT] to return to the Opening screen. Your new selection for the F4-F7 keys should be displayed in the function key list at the bottom of the screen.
5. Press the function key you selected in Step 2 to enter the IEC screen.

Once inside the IEC test screen, press [MENU] to open the local menu. Use the IEC Standard selection to change the test version between IEC 94 and IEC 05, if desired.

5.3.2 Setting up the hearing aid for IEC

The hearing aid controls must be set to conform with IEC requirements for the test results to be valid.

1. Set the controls on the aid (except for the compression controls) to give the greatest possible output and gain.
2. Set the aid for the widest frequency response range.
3. Set AGC aids to have the minimum compression possible or as otherwise specified by the manufacturer.
4. Put the hearing aid in “test mode,” if applicable. All noise suppression and feedback cancellation features should be turned off.
5. Set the gain control of the aid to the full-on position.
6. Set the aid up in the sound chamber as described in Section 3.3.

5.3.3 Setting up the analyzer for IEC

1. Enter the IEC test screen as described in Section 5.3.1.
2. Use [F1] to select LEFT or RIGHT ear.
3. Use [F2] to select the aid type: LINEAR, AGC, or ADAPTIVE AGC. (Press [F2]. Use [▼, ▲] to choose the selection. Press [►] to complete the selection and close the pop-up menu.)
4. If testing to IEC 94, use [F3] to select the full-on gain (FOG) amplitude used in the test sequence. Choose 50 or 60 dB SPL. This step does not apply for IEC 05.
5. If testing to IEC 94, use [F4] to select the reference frequency to use for the test sequence (1600 or 2500 Hz), and use [F5] to choose the distortion frequency (400, 500, 650, 800, 1000, 1250, 1600 Hz). If testing to IEC 05, use [F4] to choose the three frequency average used for the test, and use [F5] to select whether or not to perform a telecoil measurement.
6. Press [MENU] to enter the local menu and make any desired selections. See Section 5.3.7.

5.3.4 Running an IEC 05 Test

After leveling the sound chamber as described in Section 5.1.2, setting up the aid as described in Section 5.3.2, and setting up the analyzer as described in Section 5.3.3, follow these instructions:

1. Press [START] to begin the test.
2. If you choose to perform a telecoil measurement, do the following steps when the analyzer pauses. Otherwise, skip to Step 3.
 - a. Open the sound chamber.
 - b. Switch the aid to telecoil mode.
 - c. Position the hearing aid vertically in the sound chamber as shown in Figure 3.4.10A. Move the aid around in the chamber until the Telecoil running measurement shows the maximum amount of gain. This may not be the reference position in the sound chamber.
 - d. Press [START] to perform the telecoil measurement. The sound chamber lid does not need to be closed for this test. The analyzer will pause after the telecoil measurement is complete.
 - e. Return the aid to normal microphone mode and reposition in the sound chamber for normal testing.
3. Usually the 8000 test system will pause during the measurement process in order to let you adjust the gain of the hearing aid to the reference test position.
 - a. Lift the sound chamber lid and adjust the gain control of the aid until the Reference Test Gain Measured gain matches Reference Test Gain Target.
 - b. Close the sound chamber lid when finished.
 - c. Look at the display again. The MEASURED gain should be within 1.5 dB of the TARGET gain.
4. Push [START] to continue the test sequence.
- 5A. If you chose to perform a telecoil measurement, do the following steps when the analyzer pauses. If you are testing an AGC aid and are not performing a telecoil measurement, skip to step 5B. Otherwise, just wait for the test sequence to complete.
 - a. Open the lid of the sound chamber.
 - b. Switch the aid to telecoil mode.
 - c. Position the hearing aid as it was positioned in Step 2.
 - d. Press [START] to perform the telecoil measurement. The sound chamber lid does not need to be closed for this test. The analyzer will pause after the telecoil measurement is complete.
 - e. Return the aid to the normal microphone mode, set the AGC controls to max (AGC aids only), reposition the hearing aid in the sound chamber, close the lid, and press [START] to complete the test sequence.
- 5B. If you're running an IEC 05 test of an AGC aid without a telecoil measurement, the analyzer will run several measurements and then pause to allow you to set the AGC controls of your aid to maximum. Do so, close the lid of the chamber, and press [START] to complete the test sequence.

5.3.5 Running an IEC 94 Test

After leveling the sound chamber as described in Section 5.1.2, setting up the aid as described in Section 5.3.2, and setting up the analyzer as described in Section 5.3.3, follow these instructions:

1. Press [START] from the IEC 94 screen. The instrument will run a measurement and then pause.
2. Turn the gain of the aid down to the reference test position. Match the target value within 1 dB.
3. Press [START] to complete the test sequence.
4. Press [PRINT] to print test results.

5.3.6 Viewing IEC 05 Results

1. OSPL 90 response curve
2. RESP curve measured at reference test gain with a 60 dB SPL input
3. Full-on gain (FOG) curve with a 50 dB SPL input
4. Maximum output and its frequency
5. Three frequency average of OSPL90
6. Maximum gain of the FOG curve and its frequency
7. Three frequency average of FOG curve
8. Reference test gain calculated (target) and measured (actual)

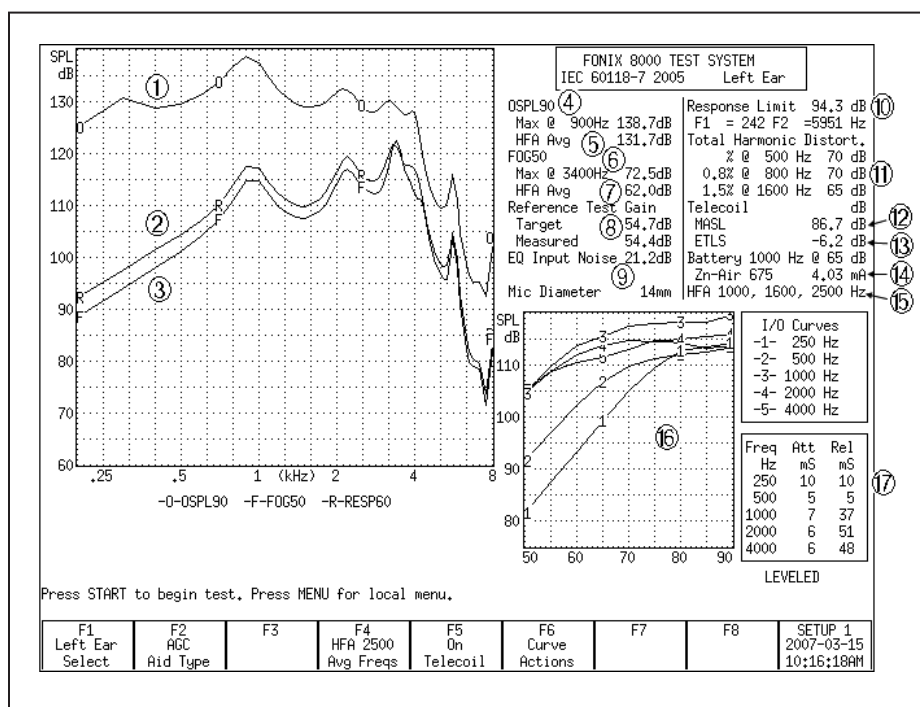


Figure 5.3.6—IEC test results

9. Equivalent input noise
10. Response limit and its maximum and minimum frequencies
11. Total harmonic distortion
12. Maximum HFA magneto-acoustical sensitivity level (HFA MASL) of induction pick-up coil: three frequency average of the telecoil measurement made at full-on gain with a magnetic input of 1 mA/m
13. Equivalent test loop sensitivity (ETLS): three frequency average of the telecoil measurement made at the reference test position with a magnetic input of 31.6 mA/m.
14. Battery current drain
15. Frequencies used in three frequency average measurements
16. I/O curve(s) measured at specified frequencies (2000 Hz is always measured)
17. Attack & release measurements at specified frequencies (2000 Hz is always measured)

5.3.7 Understanding the Menu Settings

The following menu settings are available in the local menu of the IEC screen.

General Settings

- User – FONIX user type. Beginner mode provides extra help messages and eliminates menu settings unnecessary for most users. Advanced mode eliminates some help messages and adds extra menu settings.
- IEC Standard – Selected version of the IEC 60118-7 standard. Choose from 1994 (IEC 94) and 2005 (IEC 05).
- Noise Red (Tone) – The amount of noise reduction used in the IEC measurements. See Section 2.3.1.1 for more details.
- Battery Meas. – The status of the battery current measurement. Turns it ON or OFF. (Battery pill required for this measurement.)
- Battery Size – The size of the battery of the hearing aid being tested.
- 12 dB Dist – The status of the 12 dB harmonic distortion rule. When measuring harmonic distortion, if the amplitude of the response at the second harmonic of the frequency being measured is 12 dB greater than the amplitude of that primary frequency, the harmonic distortion measurement should be ignored at the primary frequency. Turn this rule ON or OFF.
- Equiv Noise Test – Status of the EIN measurement. Turns it ON or OFF.

Printer Settings

- Print Label – Status of the printing label. Choose ON or OFF.
- Printer – Printer used for printouts. Only INTERNAL is available at this time. See Section 2.4.

AGC Settings

These settings only appear when the IEC 2005 test is selected in the IEC Standard setting above.

- AGC Switching – Pause during the test sequence that allows the user to change the compression setting of AGC aids according to the IEC standard. Turn ON or OFF.
- AGC 250, 500, 1000, 4000 – Status of the AGC measurements at the specified frequency. Turn ON or OFF the I/O and attack-and-release measurements at each frequency. 2000 Hz is always measured, so it is not selectable.

Delays

The following settings only appear when the User mode is set to Advanced.

- OSPL90 Sweep Start Delay – The delay after the first tone is presented in the OSPL90 sweep and before the first measurement is taken.
- OSPL90 Sweep Meas Delay – The delay between frequencies in the OSPL90 sweep.
- Res Crv Sweep Start Delay – The delay after the first tone is presented in the response curve and FOG sweeps and before the first measurement is taken.
- Res Crv Sweep Meas Delay – The delay between frequencies in the response curve and FOG sweeps.
- Misc Start Delay – The delay after the first tone is presented and before the first measurement is taken in the HFA/SPA, reference test gain, equivalent input noise, and harmonic distortion measurements.
- Misc Meas Delay – The delay between frequencies in the measurements mentioned above.
- I/O Start Delay – The delay after the first tone is presented in the I/O sweep and before the first measurement is taken. This is settable for each I/O frequency.
- I/O Meas. Delay – The delay between frequencies in the I/O sweep. This is settable for each I/O frequency.
- Attack Window – The amount of time the analyzer measures the attack time of the hearing aid. Select a time that is at least twice as long as the attack time specified by the manufacturer. This is settable for each frequency at which attack time is measured.
- Release Window – The amount of time the analyzer measures the release time of the hearing aid. Select a time that is at least twice as long as the release time specified by the manufacturer. This is settable for each frequency at which release time is measured.

5.4 JIS

The JIS 2000 automated test sequence allows you to testing hearing aids according to the Japanese Instrument Standard.

5.4.1 Entering the JIS Screen

By factory default, the [F6] key in the Opening screen will immediately open the JIS test screen when the JIS Option is included. You can verify this operation by looking at the label for [F6] in the Opening screen. However, the [F4] through [F7] keys are user configurable and may have been changed. If this is the case, you may have to assign one of these keys to JIS.

To configure the F4-F7 keys in the Opening screen:

1. Press [MENU] in the Opening screen.
2. Change one of the F4–F7 selections in the General Default Settings window under Opening Screen to JIS.
3. Use [F8] to save the setting (and all other settings in the Setup Menus) as default selections. See Sections 2.2.1 and 2.2.4 for details.
4. Press [EXIT] to return to the Opening screen. Your new selection for the F4–F7 keys should be displayed in the function key list at the bottom of the screen.
5. Press the function key you selected in Step 2 to enter the JIS screen.

5.4.2 Running JIS

Follow these instructions to run a JIS automated test sequence.

1. Enter the JIS test screen as described in Section 5.4.1.
2. Use [F1] to select the ear.
3. Use [F2] to select the aid type: Press [F2], use [▼, ▲] to make your selection, and [►] to complete the selection and close the pop-up menu.
4. Use [F3] to select the amplitude of the full-on gain measurement.
5. Use [F4] to select the test frequency that you want to use.
6. Use [F5] to select the type of coupler you are using for the test. The 2-cc selection is used for the HA-1 and HA-2 coupler. The MZ selection is used for the MZ couplers.
7. Press [MENU] and use the arrow keys to make any desired changes to the menu items. See Section 5.4.5 for more details. Press [EXIT] to close the local menu.
8. Press [START] to start the test sequence. The instrument will run a measurement and then pause.
9. Turn the gain of the aid down to the reference test position. Match the target value within 1 dB.

10. Press [START] to complete the test sequence.

11. Press [PRINT] to print test results.

5.4.3 Viewing JIS Results

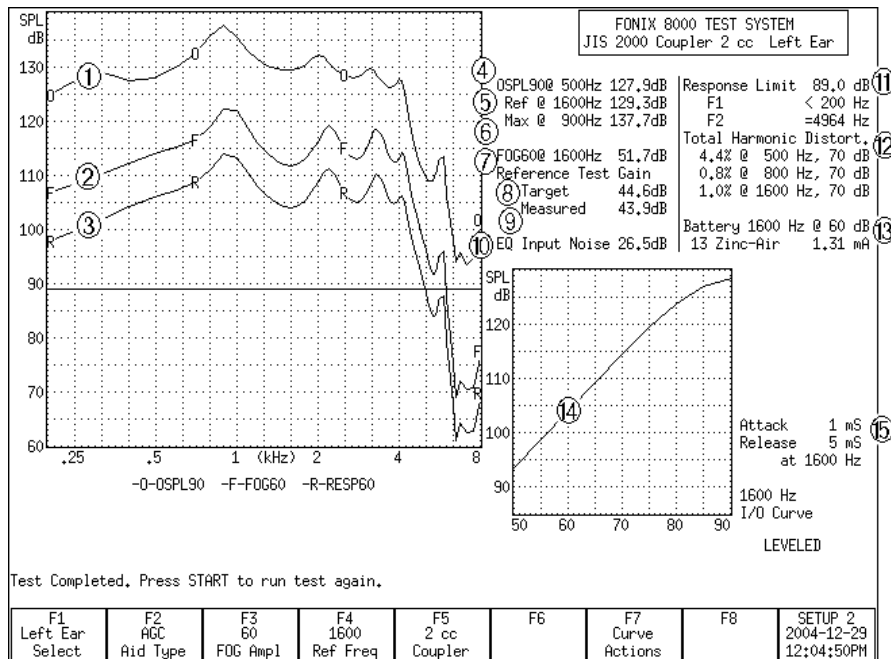


Figure 5.4.3—JIS test results

See Figure 5.4.3 for the following explanation of test results.

1. OSPL90 response curve
2. Full-on gain response curve measured at 50 or 60 dB SPL
3. Response curve measured at reference test gain at 60 dB SPL
4. Output with a 90 dB input at 500 Hz
5. Output with a 90 dB input at the reference frequency
6. Maximum output and the frequency at which it was measured
7. Gain of the FOG curve at the reference frequency
8. Reference test gain calculated (target)
9. Reference test gain measured (actual)
10. Equivalent input noise
11. Response limit and the two frequencies (F1 and F2) at which the response curve crosses its horizontal line.
12. Total harmonic distortion at 500, 800, and 1600 Hz

13. Battery current drain with 60 dB input at the reference frequency
14. I/O curve measured at the reference frequency.
15. Attack & release measurements at the reference frequency

5.4.4 Viewing JIS measurements in the Coupler screen

It is possible to copy JIS response curves to the Coupler screen where they can be compared to other response curves. To do this:

1. Run the JIS test sequence.
2. Press [F7].
3. Use [▲] to select Store Crvs Coup, if necessary.
4. Use [►] to “store” the curves (that is, copy them to the Coupler screen) and close the pop-up menu. The following is a list of where the curves are copied in the Coupler screen. Any previous measurements stored in those curve locations will be overwritten.
 - Full-on Gain—CRV 5
 - Response—CRV 6
 - OSPL90—CRV 6
5. Press [EXIT] and [F1] to enter the Coupler screen and view the JIS response curves.

5.4.5 Understanding the menu settings

The following menu settings are available in the local menu of the JIS screen.

Measurement Settings

- Noise Red (Tone) – The amount of noise reduction used in the JIS measurements. See Section 2.3.1.1 for more details.
- Battery Meas. – The status of the battery current measurement. Turns it ON or OFF. (Battery pill required for this measurement.)
- Battery Size – The size of the battery of the hearing aid being tested.

Aid Settings

- Sweep Start Delay – The delay after the first tone is presented in a pure-tone frequency sweep and before the first measurement is taken.
- Sweep Meas. Delay – The delay between frequencies in a pure-tone frequency sweep.
- Misc. Start Delay – The delay after the first tone is presented and before the first measurement is taken in the HFA/SPA, reference test gain, equivalent input noise, and harmonic distortion measurements.
- Misc. Meas. Delay – The delay between frequencies in the measurements mentioned above.

- I/O Start Delay – The delay after the first tone is presented in the I/O sweep and before the first measurement is taken.
- I/O Meas. Delay – The delay between frequencies in the I/O sweep.

JIS Settings

- Equiv Noise Test – Status of the EIN measurement. Turns it ON or OFF.

Misc. Settings

- Print Label – Status of the printing label. Choose ON or OFF.
- Printer – Printer used for printouts. Only INTERNAL is available at this time. See Section 2.4.

5.5 Profiler

The Profiler is a comprehensive, diagnostic tool. It includes ten tests, each selected because of its potential to identify common customer complaints. The tests included are an OSPL 90 test, a total harmonic distortion test, a maximum output reading, an equivalent input noise measurement, the RMS gain of the medium speech curve, a battery current drain measurement, three speech curves run at soft, medium, and loud levels, and a reserve gain test.

The sequence is performed in a very short period of time, and, with the exception of the reserve gain measurement, it is done with the hearing aid set at the user gain and settings.

5.5.1 Running Profiler Test

1. Make sure Profiler is a test sequence selected for navigation from the Opening Screen:
 - a. Press [MENU] in the Opening Screen.
 - b. Use the up-down arrow keys to select one of the function key settings [F4] through [F7].
 - c. Use the right-left arrow keys to change the selection to Profiler
 - d. Press [EXIT]. Profiler will now be displayed as an option under the function key selected above.
2. Press the function key indicating the Profiler test sequence in the Opening Screen.
3. Select the Source Type with [F5]. Normally, this should be Digsp ANSI. This is the digital speech signal with an ANSI filter.
4. Select the Digital Speech Duration with [F2]. This is the amount of time the signal will be presented to the hearing aid when measuring a response curve. This time should depend on how long it takes for the hearing aid to settle in response to an input signal. Some hearing aids require up to ten seconds whereas other hearing aids respond very quickly. This setting will greatly effect the length of the test sequence.

5. Select whether or not to test the battery current with [F7]. The battery current test requires the hearing aid be connected to a battery pill. If you are testing the hearing aid with a normal battery, you can leave the battery current test off (this will not affect other measurements.)
6. Select whether or not you want to perform an EIN (equivalent input noise) test. If the hearing aid is not set to have completely linear amplification below 60 dB SPL, the EIN test results will be artificially high as a result of a test artifact. Keep this in mind when deciding whether to perform the EIN test and in interpreting test results.
7. Press [START] to perform the Profiler test sequence.

5.5.2 Viewing Profiler Test Results

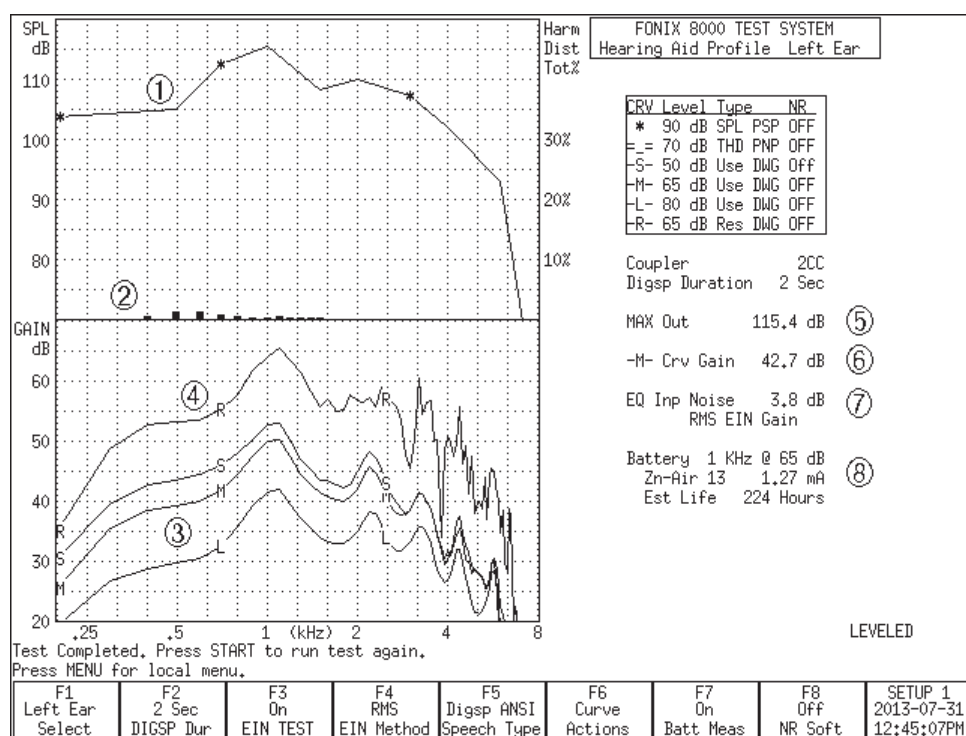


Figure 5.5.2: Completed Profiler Test Sequence

See Figure 5.5.2 for the following explanation of test results.

1. OSPL90 curve: Pure-tone curve measured at 90 dB SPL and displayed in output
2. Harmonic distortion tested at 70 dB SPL and displayed as a series of vertical bars. The scaling for these bars is located on the right side of the graph.
3. Soft (S), Medium (M), and Loud (L) curves measured with the source selected with [F5] at 50, 65, and 80 dB SPL respectively. Results are displayed in dB Gain, allowing the clinician to quickly determine the overall compression characteristics of the hearing aid.

4. Reserve gain curve. While every other measurement in this test sequence is performed with the hearing aid set to normal user gain, this measurement is performed with the hearing aid set to full-on gain. This shows the clinician how much “headroom” the hearing aid has.
5. Maximum Output: This is the maximum output of the hearing aid as measured during the OSPL90 curve.
6. M Curve Gain: This is the RMS of the medium speech curve measured at 65 dB SPL. This is the overall gain of the hearing aid when tested at normal speech levels.
7. Equivalent Input Noise and the method used to measure it (RMS vs HFA/SPA).
8. Battery current drain and the estimated battery life of the hearing aid.

5.6 IS: 16127-2013

The IS: 16127-2013 automated test sequence allows you to test BTE type hearing aids according to the Indian standard.

5.6.1 Running an IS: 16127-2013 Test

After leveling the sound chamber as described in Section 5.1.2, setting up the aid as described in Section 5.3.2, and setting up the analyzer as described in Section 5.3.3, follow these instructions:

1. Press [START] to begin the test. The 8000 will now run the OSPL90 and Full On Gain microphone curves.
2. If you choose to perform a telecoil measurement, do the following steps when the analyzer pauses. Otherwise, skip to Step 3.
 - a. Open the sound chamber.
 - b. Switch the aid to telecoil mode.
 - c. Position the hearing aid vertically in the sound chamber as shown in Figure 3.4.10A. Move the aid around in the chamber until the Telecoil running measurement shows the maximum amount of output. This may not be the reference position in the sound chamber.
 - d. Press [START] to perform the Full on Gain Telecoil curve measurement. The sound chamber lid does not need to be closed for this test. The analyzer will pause after the telecoil measurement is complete.
 - e. Return the aid to normal microphone mode and reposition in the sound chamber for normal testing.
3. Usually the 8000 test system will pause during the measurement process in order to let you adjust the gain of the hearing aid to the reference test position.
 - a. Lift the sound chamber lid and adjust the gain control of the aid until the Reference Test Gain Measured gain matches Reference Test Gain Target.
 - b. Close the sound chamber lid when finished.

- c. Look at the display again. The MEASURED gain should be within 1.5 dB of the TARGET gain.
4. Push [START] to continue the test sequence. The 8000 will then measure the Response curve, the distortion, the Battery Current, and the Equivalent Input Noise.

If you're running a test of an AGC aid with AGC switching turned on, the analyzer will pause to allow you to set the AGC controls of your aid to maximum. Do so, close the lid of the chamber, and press [START] to complete the test sequence.

If you're running a test of an AGC aid, the I/O curves and Release and Attack measurements are now made.

5.6.2 Viewing IS: 16127-2013 Results

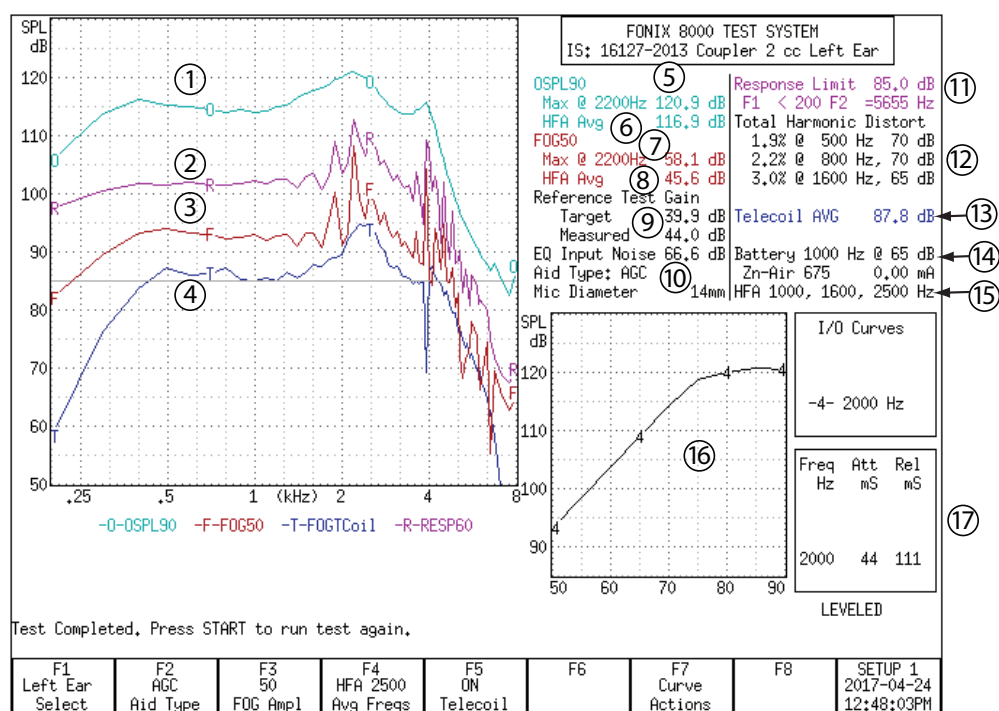


Figure 5.6—IS: 17127-2013 test results

1. OSPL 90 response curve
2. RESP curve measured at reference test gain with a 60 dB SPL input
3. Full-on gain (FOG) curve with a 50 or 60 dB SPL input
4. FOG Telecoil curve.
5. Maximum output and its frequency
6. Three frequency average of OSPL90

7. Maximum gain of the FOG curve and its frequency
8. Three frequency average of FOG curve
9. Reference test gain calculated (target) and measured (actual)
10. Equivalent input noise
11. Response limit and its maximum and minimum frequencies
12. Total harmonic distortion
13. Maximum HFA magneto-acoustical sensitivity level of induction pick-up coil: three frequency average of the telecoil measurement made at full-on gain with a magnetic input of 10 mA/m
14. Battery current drain
15. Frequencies used in three frequency average measurements
16. I/O curve(s) measured at specified frequencies.
17. Attack & release measurements at specified frequencies.

5.6.3 Understanding the Menu Settings

The following menu settings are available in the local menu of the IS: 16127-2013 screen.

Measurements Settings

- Noise Red (Tone) – The amount of noise reduction used in the measurements. See Section 2.3.1.1 for more details.
- Battery Meas. – The status of the battery current measurement. Turns it ON or OFF. (Battery pill required for this measurement.)
- Battery Size – The size of the battery of the hearing aid being tested.
- Battery Chemistry – The chemistry of the battery of the hearing aid being tested.

Aid Settings

- Sweep Start Delay – The delay after the first tone is presented in each sweep and before the first measurement is taken.
- Sweep Meas Delay – The delay between frequencies in the each sweep.
- I/O Start Delay – The delay after the first tone is presented in the I/O sweep and before the first measurement is taken.
- I/O Meas. Delay – The delay between frequencies in the I/O sweep.
- Misc Start Delay – The delay after the first tone is presented and before the first measurement is taken in the HFA/SPA, reference test gain, equivalent input noise, and harmonic distortion measurements.
- Misc Meas Delay – The delay between frequencies in the measurements-mentioned above.

- Attack Window – The amount of time the analyzer measures the attack time of the hearing aid. Select a time that is at least twice as long as the attack time specified by the manufacturer.
- Release Window – The amount of time the analyzer measures the release time of the hearing aid. Select a time that is at least twice as long as the release time specified by the manufacturer.

IS Settings

- Equiv Noise Test – Status of the EIN measurement. Turns it ON or OFF.
- 12 dB Dist Rule – The status of the 12 dB harmonic distortion rule. When measuring harmonic distortion, if the amplitude of the response at the second harmonic of the frequency being measured is 12 dB greater than the amplitude of that primary frequency, the harmonic distortion measurement should be ignored at the primary frequency. Turn this rule ON or OFF.
- AGC Switching – Pause during the test sequence that allows the user to change the compression setting of AGC aids according to the IEC standard. Turn ON or OFF.
- AGC 250, 500, 1000, 2000, 4000 – Status of the AGC measurements at the specified frequency. Turn ON or OFF the I/O and attack-and-release measurements at each frequency.

Misc Settings

- Print Label – Status of the printing label. Choose ON or OFF.
- Printer – Printer used for printouts. Only INTERNAL is available at this time. See Section 2.4.

Coupler Directional Testing

6.1 Introduction

The Directional Polar and the Directional Difference screens are used with the FONIX 8120 Polar Plot Chamber to perform directional hearing aid testing, providing the hearing health clinician with a valuable tool used to verify that the hearing aid is providing a directional benefit and the nature of its directionality. The low-reflection design of the 8120 Polar Plot chamber and its automatic rotational features combined with the software in the Directional Polar and Directional Difference screens provide a clinical tool that was previously missing from the marketplace.

Although the 8120 Polar Plot Chamber was designed to approximate laboratory testing results made in a large anechoic chamber, there are some design considerations that make an exact replication of those results unlikely. Here are some things to keep in mind when examining directional measurements made in the Directional Polar and Directional Difference screens:

- The speaker inside the sound chamber is very close to the aid being tested. In a large laboratory anechoic chamber, the speaker will typically be a much larger distance away from the hearing aid.
- The short distance between the hearing aid and the walls inside the 8120 Polar Plot chamber do not allow the greater attenuation of reflected sound that is present in a large laboratory anechoic chamber.
- ITE hearing aids must be positioned in the 8120 Polar Plot Chamber with the faceplate perpendicular to the speaker. If a person were to be wearing an aid rotated in this manner, he would be rotated head over heels. This obviously isn't desirable, but the 8120 Polar Plot Chamber would have to be considerable larger to accommodate a more realistic horizontal rotation.
- The head shadow effect is not taken into consideration in Directional Polar and Directional Difference measurements.

6.1.1 Features of the 8120 Polar Plot Chamber

The 8120 Polar Plot Chamber is a desktop box that was designed to be small enough to be practical in a clinical environment but large enough to accommodate the special foam configuration (designed to minimize sound reflections) and the Rotating system used to mount and position the directional hearing aid for polar plot and difference testing.

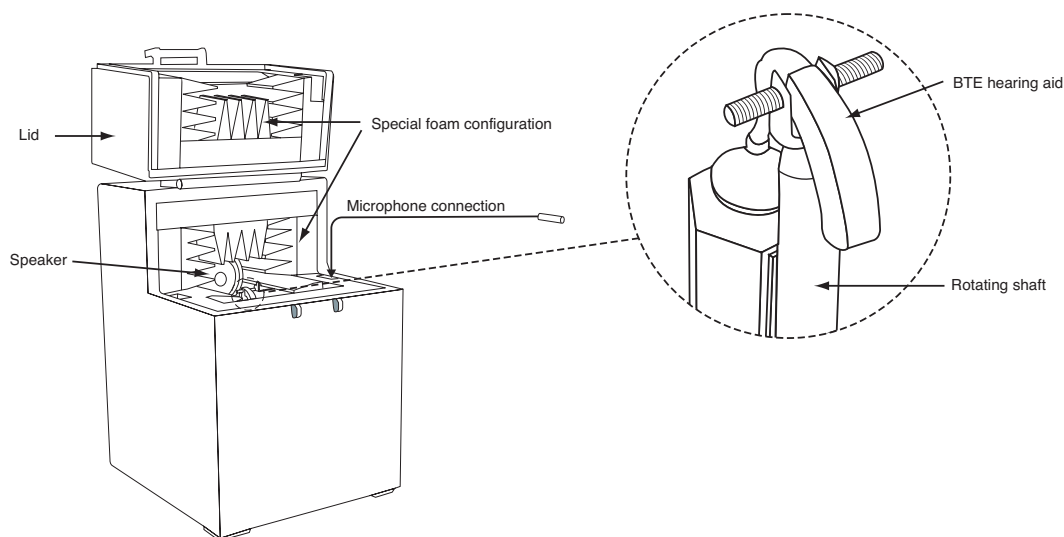


Figure 6.1.1—8120 Polar Plot Chamber

The hearing aid is attached to the coupler and measurement microphone and placed on the rotating shaft inside the cavity of the chamber. The shaft itself can be easily removed by pulling it firmly upward from the base. Two types of hearing aid rotation shafts are provided:

- **BTE Rotating Shaft:** This shaft (shown in Figure 6.1.1) is nearly cylindrical with a flatted surface on one side containing four small magnets. A fifth magnet is located on the top of the shaft for attachment of the Positioning Saddle that is used to hold the BTE hearing aid in place during testing. The HA2 coupler has a steel plate that is held by the magnets to the flatted portion of the shaft.
- **ITE Rotating Shaft:** This shaft contains a flat steel bar fitted with four magnets. The matching HA-1 coupler has a flat steel plate that attaches to these magnets.

See Section 6.3 for information on setting up the hearing aid in the 8120 Polar Plot Sound Chamber.

The foam surrounding the cavity inside the 8120 Polar Plot Chamber is designed to provide low levels of reflected sound over a wide band of acoustic frequencies.

At the beginning of the test, the hearing aid is positioned so that it is pointed towards the speaker at the back of the chamber. During the test, the shaft will automatically rotate the hearing aid in a 360° circle counterclockwise, stopping periodically to collect measurement data. When the test is completed, this rotation will automatically reverse and return the hearing aid to the starting position to prevent the microphone cord from tangling around the shaft.

The coupler microphone uses a connector placed inside the chamber in order to eliminate the need for cords to exit the chamber and possibly break the chamber seal. If it is necessary to connect the hearing aid to an external cable, it is recommended that the cable exit the sound chamber at the front or at the rounded corner near the rear of the lid. This will minimize the chance of damage to the cable due to the sheer force applied by the chamber seals.

When the clinician wants to perform “normal” hearing aid testing, such as ANSI or IEC automated test sequences or Coupler Multicurve measurements, the removable Chamber Basket can be placed over the cavity to create a horizontal, flat test surface. See Section 3.2.2 for more details.

6.2 Leveling

Leveling is the process by which the response of the sound chamber is measured and computer-corrected so that a “flat” sound field is achieved. When performing a polar plot or difference measurement, the hearing aid is positioned on the rotating shaft inside the 8120 Polar Plot chamber. This positioning is different than during a typical hearing aid test in which the 8120 Removable Test Surface is used and the hearing aid is positioned on the horizontal surface. It is important to level the sound chamber in the setup that you are going to use for the coupler measurements. This section describes how to level the sound chamber for polar plot and difference measurements. See Section 3.2.2 for leveling instructions for measuring the hearing aid using the 8120 Removable Test Surface and horizontal positioning.

1. Unplug the battery pill and remove the hearing aid, coupler and 8120 Removable Test Surface from the sound chamber. The Rotating Shaft should remain in place inside the cavity of the chamber.
2. Place the coupler microphone on top of the Rotating Shaft at a 90° angle from the speaker. The magnetic surface of the shaft will hold the microphone securely in place. See Figure 6.2.
3. Enter the Directional Polar or Directional Difference screen. (From the Opening screen with the Frye logo, press [F3] to enter the Advanced Coupler Navigation Screen and [F5] to enter the Directional Polar screen or [F6] to enter the Directional Difference screen.)
4. Press [LEVEL] to start the leveling sequence.
5. Look at the display. After a few seconds, the video monitor should display a “Leveled” message in the lower left corner of the screen. If the FONIX 8000 Test System doesn’t level, it could be an indication that your microphone needs to be calibrated or replaced.

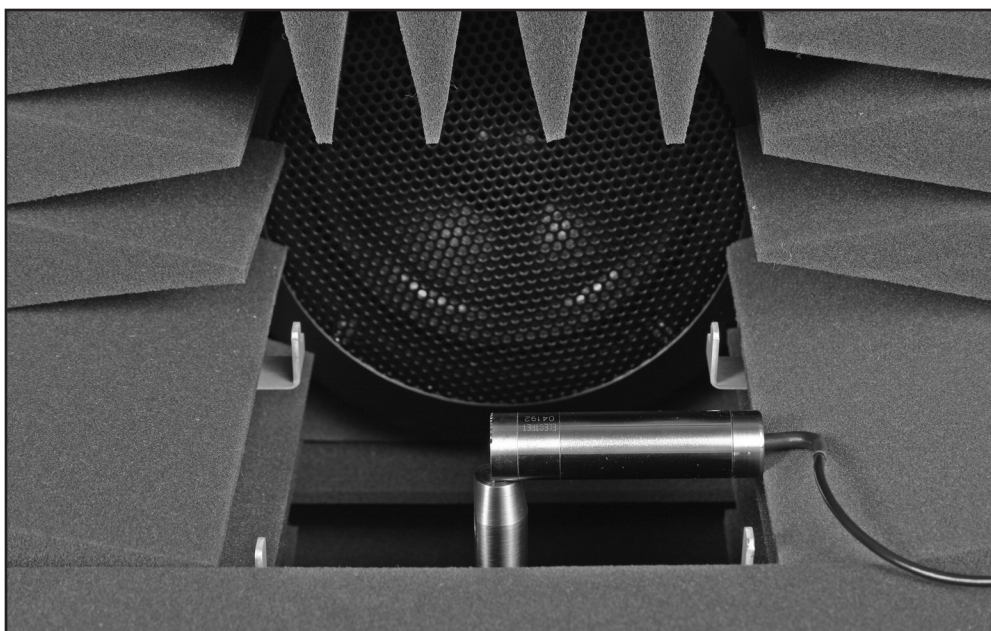


Figure 6.2: Leveling setup for the 8120 Polar Plot Chamber

6.3 Hearing Aid Setup

This section describes how to set up the hearing aid for testing on the rotating shaft. There are two main categories of directional hearing aid body styles: BTEs and other types of hearing aids that fit behind the ear, and ITE style hearing aids with faceplates. Please note that open fit hearing aids with the receivers that fit into the ear will typically use an HA-1 coupler (or Open Fit coupler) for testing, but will be arranged in the chamber as a BTE.

For best directional measurements, the AGC characteristics of the hearing aid should be set to minimum and any noise suppression features should be disabled. This will ensure that any reductions in hearing aid amplification during the polar plot or difference test will be due to the hearing aid's directional characteristics instead of its AGC or noise suppression technology. It is often useful to test at a level that is below the AGC threshold and above the expansion threshold such as 50-60 dB SPL RMS. If the hearing aid has a noise reduction feature, a better polar plot result may be obtained by setting **Polar Plot Signal** to Auto in the local menu. This turns the input signal off while the hearing aid is rotating and may prevent the hearing aid from activating its noise reduction technology. (This setting does not apply during the Directional Difference test.)

6.3.1 Testing Directional BTEs

The BTE Rotating Shaft, shown in Figure 6.3.1A with the attached Positioning Saddle, is used for testing BTE and over-the-ear-style Open Fit directional hearing aids.

1. Place the Positioning Saddle on the top of the shaft as shown in Figure 6.3.1A. The two thumb screws of the saddle should be positioned to either side of the flat surface on the shaft. (A removable paper shim keeps the hearing aid body from being scratched during positioning.)
2. Place a fresh battery in the hearing aid and attach it to the coupler in the usual fashion. (We do not recommend using a battery pill for measurements in the Coupler Directional screen.)
3. Attach the magnetic strip on the coupler to the flat side on the rotating shaft and slide the body of the hearing aid through the opening of the Positioning Saddle. The area between the two microphones of the hearing aid should form a line perpendicular to the vertical surface of the post. See Figure 6.3.1B.
4. Tighten the thumb screws of the Positioning Saddle to hold the hearing aid in place.
5. Insert the coupler microphone, turn on the hearing aid, and set it for directional testing.
6. Insert the rotating post into the 8120 Polar Plot Chamber. Just slide the narrow end into the small hole at the bottom of the chamber cavity and apply pressure until the post snaps into place as shown in figure 6.3.1C. Check to see that the measurement microphone has not been dislodged from the HA-2 coupler.
7. Manually rotate the hearing aid (attached to the shaft) in a clockwise manner so that the hearing aid is facing towards the speaker in the back of the sound chamber. See Figure 6.3.1D. During testing, the hearing aid is rotated counter-clockwise, so this type of positioning should ensure that the microphone cord does not get tangled during testing.

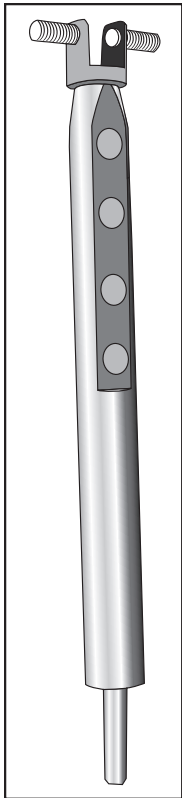


Figure 6.3.1A: The BTE Rotating Shaft and Positioning Saddle

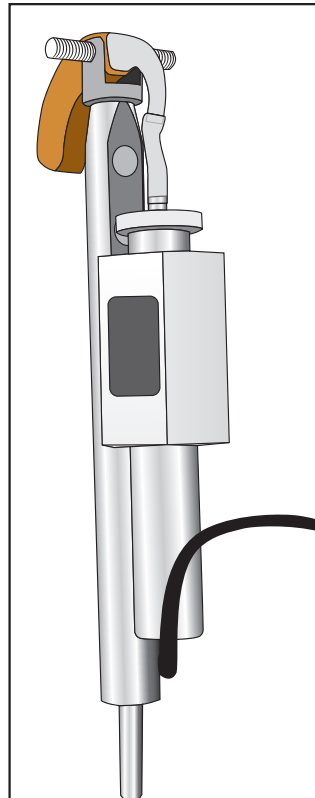


Figure 6.3.1B: BTE hearing aid positioned on Rotating Shaft and Positioning Saddle

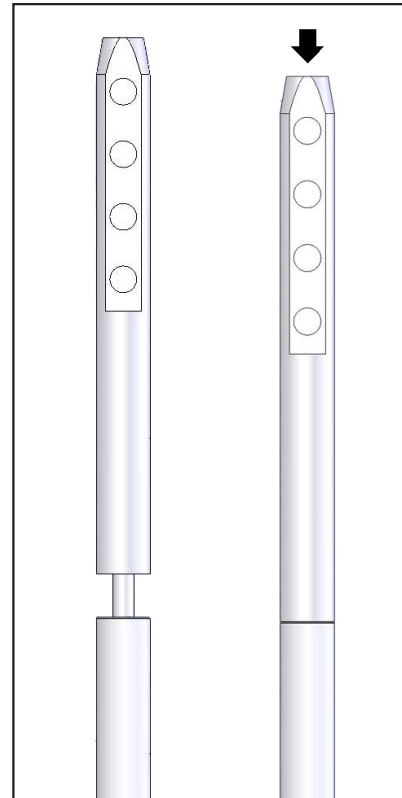


Figure 6.3.1C: Fully insert the shaft into the sound chamber



Figure 6.3.1D: Setting up a BTE hearing aid in the 8120 Polar Plot Chamber

6.3.2 Testing Directional ITEs

The ITE Rotating Shaft, shown in Figure 6.3.2A, is used for positioning directional ITE hearing aids.

1. If already in place, firmly grip the rotating shaft and pull it straight up out of 8120 Polar Plot chamber. (You can also position the hearing aid with the rotating shaft in place, if desired.)
2. Place a fresh battery in the hearing aid and attach it to the coupler with blue adhesive putty. (We do not recommend using a battery pill for measurements in the Coupler Directional screen.)
3. Attach the magnetic strip on the coupler to the magnetic side of the ITE rotating shaft. The faceplate of the hearing aid should be positioned in a horizontal plane perpendicular to the vertical surface of the shaft. Use more adhesive putty and rotate the coupler if necessary. See Figure 6.3.2B.

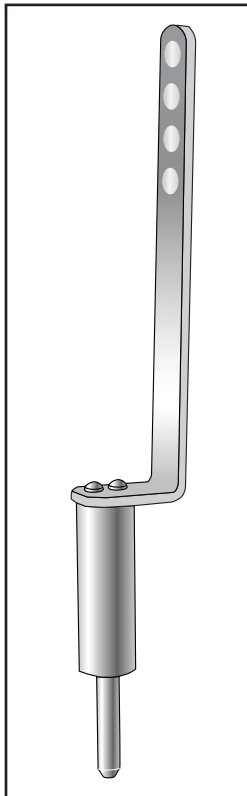


Figure 6.3.2A: The ITE Rotating Shaft



Figure 6.3.2B: Positioning the ITE hearing aid on the Rotating Shaft.

4. Insert the coupler microphone, turn on the hearing aid, and set it for directional testing.
5. Insert the rotating post into the 8120 Polar Plot Chamber. Just slide the tapered end into the small hole at the bottom of the chamber cavity and apply pressure until the post snaps into place. Check to see that the measurement microphone has not been dislodged from the HA-1 coupler.

6. Manually rotate the hearing aid (attached to the shaft) in a clockwise manner so that a line made between the two microphones of the hearing aid point directly towards the speaker in the back of the chamber. The forward microphone of the hearing aid should be closest to the speaker, and the point half-way between the two microphone should be over the part of the rotating shaft that plug into the sound chamber (the axis of rotation). The faceplate of the hearing aid should be perpendicular to the speaker. See Figure 6.3.2C. During testing, the hearing aid is rotated counter-clockwise, so this type of positioning should ensure the microphone cord is not tangled during testing.



Figure 6.3.2C: Setting up an ITE hearing aid in the 8120 Polar Plot Chamber

6.4 The Directional Polar Test

You can perform polar plot testing of directional hearing aids in the Directional Polar test screen. The polar plot is a display of the gain or SPL at a single frequency of the hearing aid response as a function of its angular position with respect to the sound source. Eleven different polar plots can be displayed on the Polar Plot graph at any one time. Each plot can also be displayed in tabular format with the level (gain or SPL) and the angle of each measurement.

6.4.1 Viewing the Directional Polar Display

The Directional Polar test display consists of a polar plot graph, a Curve Characteristics box displaying information about the source frequency and the Directivity Index (2D-DI) of each polar plot curve, and a Settings box displaying the test conditions and signal characteristics used for the selected curve and the current test configuration.

See Figure 6.4 for the screen items being described below.

Graph:

1. Display type: SPL or Gain
2. Reference levels used to determine gain or SPL of the plots
3. Reference angles of 0°, 90°, 180° and 270°
4. Example of a polar plot curve. Curves are marked with a number corresponding to information in the Curve Characteristics box.

Curve Characteristics box:

6. Curve designations: PL1-PLI or PR1-PRI. The current selected curve is highlighted
7. Frequency at which each polar plot curve was measured. When the Comp DSP signal is selected, the frequency will be displayed as CMPD. When the Composite signal is selected, the frequency will be displayed as COMP.
8. 2D-DI: The two-dimensional directivity index of the hearing aid. This gives you a quantitative measurement of the directionality of the hearing aid.
9. Avg 2D-DI: The arithmetic mean of the directivity index of all measured curves.

Settings box: The test settings used to measure the current selected curve are displayed here. This box is also used to show the test settings used for the next curve to be measured. The [F8] key toggles between showing the settings used for the selected measurement curve and the settings that will be used in the next measurement curve.

10. Test Mode: Manual or Simultaneous. Measurements made when the analyzer is set to Semi-Automatic or Fully-Automatic modes are shown as "Manual."
11. Ang Resolution: Number of degrees between each point of the polar plot test. For instance, when this is set to 15, measurements are taken every 15 degrees.
12. Source: Source type used for the measurement curve. Choices are Inter Composite (interrupted Composite), Cont Composite (continuous Composite), Inter Pure Tone (interrupted Pure Tone), Cont Pure Tone (continuous Pure Tone). (Choose between Comp DSP, Composite, and Tone with [F5]. Choose between Continuous and Interrupted in the local menu.)
13. Filter: Broadband filter used for performing measurements made with the Comp DSP or Composite source types.
14. Analysis: This is shown as FFT when the source type is set to Comp DSP or Composite. This is shown as DFT when the source type is set to Tone.
15. Avg: This shows the type of averaging used with the measurement curve and is controlled in the local menu with the Noise Red (Comp) and Noise Red (Tone) settings. When the source type is set to Composite or Tone, the measurement averaging is performed in the time domain. When the source type is set to Comp DSP, the averaging is performed in the frequency domain. (This is the difference between Composite and Comp DSP.)

16. Amplitude: This is the test level used to measure the curve.
17. Frequency: This is the frequency used to measure the curve. When the source type is set to Composite, this is shown as COMP. When the source type is set to COMP DSP, this is shown as CMPD.
18. Leveling status. This is the status of leveling when the measurement was taken.

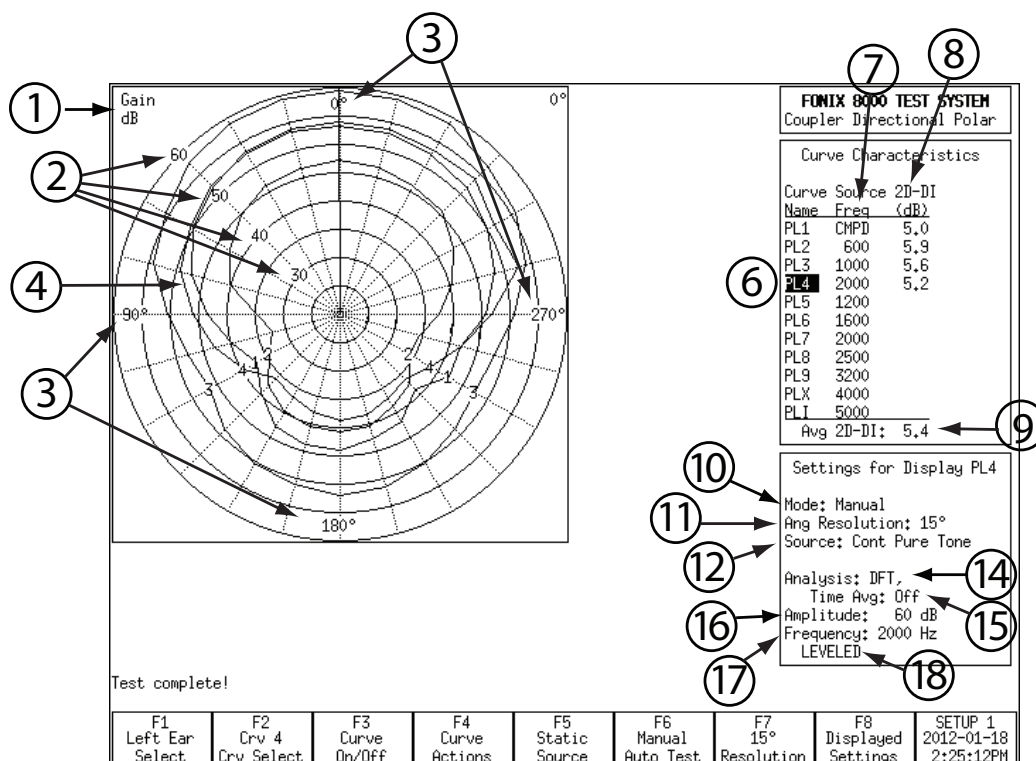


Figure 6.4—Directional Polar display

6.4.2 Testing in Simultaneous Mode

By default, when you enter the Directional Polar screen, you will be in “Simultaneous Mode.” Simultaneous mode was designed as a fast test that tells you the polar plot response of the hearing aid at eleven important frequencies using only one rotation of the hearing aid.

Simultaneous mode uses the broadband Composite signal (with the ANSI filter) at 60 dB SPL by default, although the user can adjust these characteristics by using the arrow keys to change the input level and the local menu to change the signal settings. (It is important to test the hearing aid below its compression kneepoint and above its expansion kneepoint to ensure any reductions in amplification are from its directional characteristics instead of its AGC functionality.) If the tested hearing aid is open fit, you may need to switch to the COMP DSP signal. The COMP DSP signal uses a different type of signal averaging that works better for hearing aids with advanced processing. Use the [F5] key to change the signal type to COMP DSP if desired.

A full frequency response is measured after each partial aid rotation. The level (either in Gain or SPL) is recorded for each of the frequencies in the Curve Characteristics box. The polar plot results of all frequencies are plotted simultaneously.

If you have switched to another test mode and want to return to Simultaneous Mode, use [F6] to open the function key menu. Use the up-down arrow keys to select “Simultaneous” and the right arrow key to complete the selection.

6.4.2.1 To Start a Test in Simultaneous Mode

1. Use the [F6] key, if necessary, to enter Simultaneous mode. (Press [F6]. Use the up-down arrow keys to select “Simultaneous.” Press the right arrow key to complete the selection.)
2. Select the input level using the up-down arrow keys. (The default level is 60 dB SPL).
3. Use [F5] to change the source type to “Composite” or “Comp DSP.” The “Tone” selection will not work in Simultaneous Mode, and the Composite signal will be substituted automatically.
4. Use [F7] to choose the test resolution. Choose between 5, 10, 15, 20, 24, 30, 36, 40 and 45 degrees. Smaller numbers will create a higher-resolution test but will take longer to perform. Larger numbers will create a lower-resolution test that will take less time to perform.
5. Press [START]. The test will run and the results will be displayed in Polar Plot graph. See Figure 6.4.2.1.

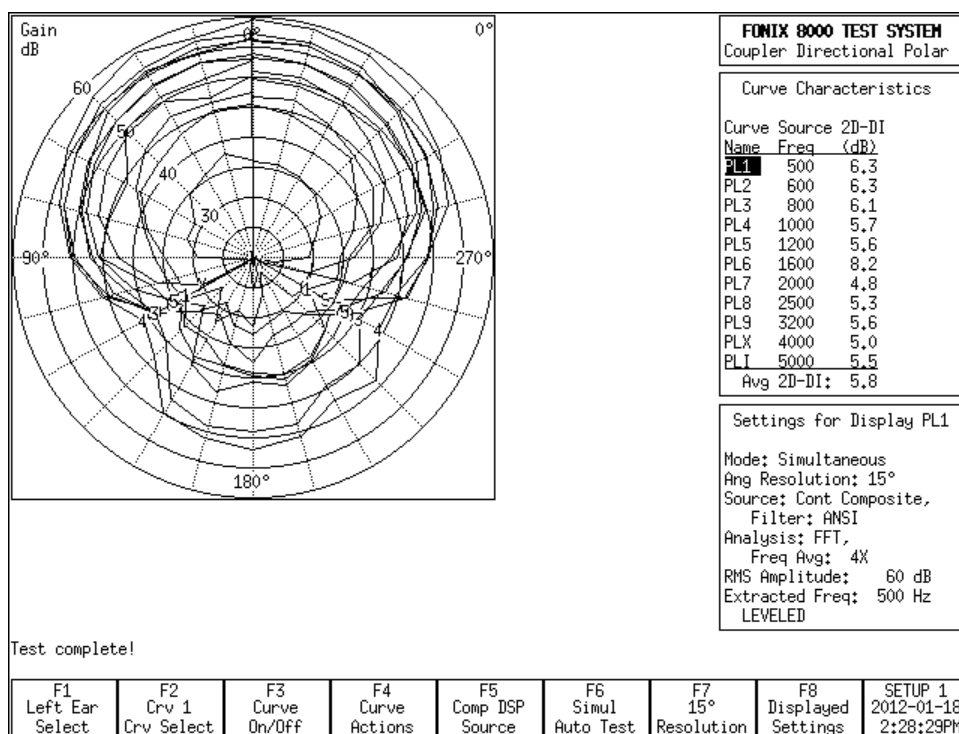


Figure 6.4.2.1

6.4.2.2 To Change the Test Frequencies

By default, the test frequencies are measured at 500, 600, 800, 1000, 1200, 1600, 2000, 2500, 3200, 4000 and 5000 Hz. To change these frequencies:

1. Use the [F4] key to delete the current test results.
2. Select the desired curve with the [F2] key.
3. Use the left-right arrow keys to adjust the frequency shown in the Curve Characteristics box.
4. Repeat steps 1-2 to select each polar plot curve and adjust its frequency.
5. Press [START]. This will run a new Simultaneous test using the selected frequencies.

6.4.3 Testing in Manual Mode

In Manual Mode, the user performs the polar plot measurements one curve at a time using a choice of input signals and input levels. Usually pure-tone signals are used for these measurements, although you can also perform a polar plot of the RMS of a Composite signal response.

To perform a manual test:

1. Use [F4] to delete any existing test results.
2. Use [F6] to select Manual Mode (Press [F6]. Use the up-down arrow keys to select "Manual." Use the right arrow key to complete the selection.)
3. Use [F2] to select curve 1.
4. Use [F5] to choose the source type. Usually this will be Tone.
5. Use the left-right arrow keys to choose the frequency to be tested.
6. Use [F7] to select the number of angles between each point of the polar plot test. Choose between 5, 10, 15, 20, 24, 30, 36, 40 and 45 degrees. Smaller numbers will create a higher-resolution test but will take longer to perform. Larger numbers will create a lower-resolution test that will take less time to perform.
7. Press [START]. When the test is completed, the analyzer will automatically reset the hearing aid to its original position and finish the test.
8. Repeat steps 3-7 for additional measurements.

6.4.4 Semi-Automatic Mode

When the analyzer is in Semi-Automatic mode, after a measurement is made, the next curve is automatically chosen. That is, if Curve 1 is measured, after the test has been completed, the analyzer will automatically advanced to Curve 2. However, no measurement will be made for this next curve until the user presses the [START] key.

6.4.5 Automatic & Program Mode

In Automatic Mode, the user can program in a test sequence and save it into permanent memory. Afterwards, that test sequence can be loaded and run at any time. This is useful if the clinician always wants to run the same sequence of polar plot measurements for every hearing aid tested.

6.4.5.1 To Program the Test Sequence

1. Use the [F6] key to select Program Mode. (Press [F6]. Use the up-down arrow keys to select "Program." Press the right arrow key to complete the selection.)
2. Use [F4] to delete any existing measurements.
3. Use [F2] to select curve 1.
4. Use [F5] to choose the source type.
5. Use the left-right arrow keys to change the frequency if the Tone source type is selected.
6. Use the up-down arrow keys to select the input level.
7. Press [MENU]. Select the desired settings and press [MENU] again to close the menu when finished.
8. Press [START]. This will program the first curve and select curve 2.
9. Repeat steps 3-7 to program each desired measurement curve. If you do not wish to measure all eleven available curves, press [STOP] after the final desired curve. This will place a horizontal line across the Curve Characteristics box, indicating that an automatic test sequence will not advance any further.
10. Use [F6] to save the test sequence to Group 1, 2 or 3. This saves it into the analyzer's permanent memory.

6.4.5.2 To Run an Automatic Test Sequence

1. Use [F6] to enter Automatic Mode. (Press [F6]. Use the up-down arrow keys to select "Automatic." Use the right-arrow key to complete the selection.)
2. Use [F2] to select Curve 1.
3. (optional) Use [F6] to load the saved test sequence from Group 1, 2 or 3. If the desired test sequence is already displayed in the Curve Characteristics box, this step is unnecessary.
4. Press [START]. This will run through the test curves until reaching a pause, indicated by a horizontal line across the Curve Characteristics box. If no such line is displayed, all eleven curves will be measured.

6.4.6 Directivity Index

The Directional Polar screen plots the directivity index (2D-DI) for each polar plot measurement as well as the average 2D-DI value for all measured curves.

The 2D-DI formula is taken from the ANSI S3.35-2010 standard. Since the FONIX 8000 measures in 100 Hz intervals instead of third octave, we are using the 100 Hz intervals closest to the specified third octave frequencies between 500 and 5000 Hz (inclusive) for the calculations.

The average directivity index is the arithmetic mean of the calculated directivity indices.

6.4.7 Test Settings

There are many ways to refine the settings in the Directional Polar test screen. Press [MENU] to open the local menu for a list of test settings.

Display Settings

- Data/Graph: The method of data display. Choose between DATA (numerical data) and GRAPH.
- Display: Type of display. Choose between SPL (output) and Gain (difference between input and output).

Measurement Settings

- Noise Red (Comp): Amount of composite noise reduction used. See Section 2.3.2.1.
- Noise Red (Tone): Amount of pure-tone noise reduction used. See Section 2.3.1.1.
- Aid Type: Type of hearing aid being measured. Choose between Linear, AGC, and ADAPTIVE AGC. This affects the delay settings used in the measurements.
- Signal Presentation: Choose whether to have the test signal on continuously during the polar plot test (Continuous) or whether to turn it off while the hearing aid is rotating for the test and turn it on only for the actual measurements (Interrupted).

Misc Settings

- User: Sets the User mode. See Section 2.3.3. In the Directional Polar screen, this setting controls whether the Advanced menu items are displayed.
- Print Label: Status of the printing label. Choose ON or OFF.

Advanced Settings

- Start Delay: The amount of time the FONIX 8000 Test System presents the first tone in a polar plot test. See Section 2.3.1.2.
- Meas Delay: The amount of time each subsequent tone is presented before the measurement is made in a polar plot test. See Section 2.3.1.2.
- Composite Filter: Filter used in Composite or Comp DSP measurements. Choose between ANSI, ANSI 92, ICRA and FLAT.

6.5 The Directional Difference Test

The Directional Difference Test shows the difference between the frequency response of the hearing aid when it is pointed towards the speaker and the frequency response when it is pointed away from the speaker. The reverse angles used can be specified by the user (the forward angle is always zero). Results are given as a function of frequency.

6.5.1 Viewing the Directional Difference Test

The following items are shown in Figure 6.5.1:

1. Directional Difference graph. This is always displayed in dB Gain.
2. Curve Characteristics box displaying the input level, forward angle, and reverse angle to make each difference curve.

Settings Box

3. Mode used for the measurement curve. This will either be Simultaneous or Manual. If the mode is set to Semi-Automatic or Fully-Automatic mode, this will be displayed as "Manual."
4. Source Type: Source used for the measurement curve. Choose from Tone Long, Tone Normal, Cont Composite (Continuous Composite), Inter Composite (Interrupted Composite).
5. Broadband filter used with the Composite or Comp DSP signals. This can be set to ANSI, ICRA, ANSI92 or FLAT.
6. Analysis: This is shown as FFT when the source type is set to Comp DSP or Composite. This is shown as DFT when the source type is set to Tone Normal or Tone Long.
7. Avg: This shows the type of averaging used with the measurement curve and is controlled in the local menu with the Noise Red (Comp) and Noise Red (Tone) settings. When the source type is set to Composite or Tone, the measurement averaging is performed in the time domain. When the source type is set to Comp DSP, the averaging is performed in the frequency domain. (This is the difference between Composite and Comp DSP.)
8. Angle: The forward angle (always zero) and the reverse angle used in the selected measurement curve. The Reverse Angle can be changed in the local menu.
9. Smoothing: Smoothing can be used to smooth out the final measurement curve. Care should be taken in its use because important test information might also be thrown away when smoothing is turned on.
10. Amplitude: Source level used with the selected measurement curve.
11. Leveling status: Status of leveling on the analyzer when the selected measurement curve was measured.

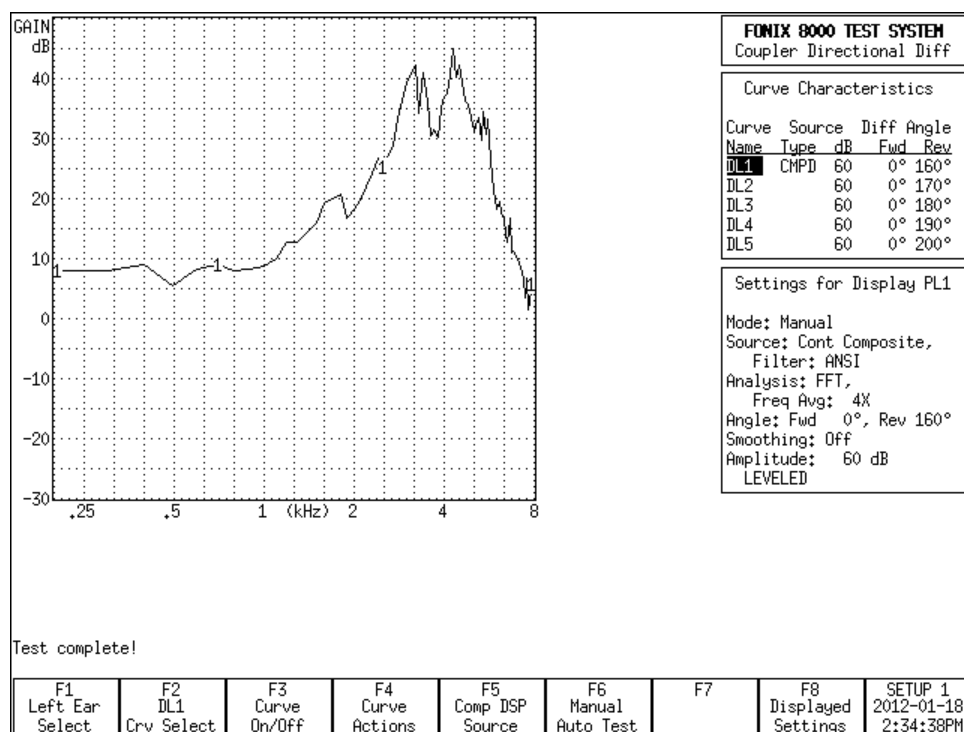


Figure 6.5.1

6.5.2 Testing in Simultaneous Mode

By default, when you first enter the Directional Difference test screen, you are in Simultaneous Mode. In Simultaneous Mode, all five difference curves are taken in one test sequence. A single zero degree “forward” measurement is used when calculating all five difference curves taken with potentially different reverse angles.

To test in Simultaneous Mode:

1. Use the [F6] key, if necessary, to enter Simultaneous mode. (Press [F6]. Use the up-down arrow keys to select “Simultaneous.” Press the right arrow key to complete the selection.)
2. Select the input level using the up-down arrow keys. (The default level is 60 dB SPL).
3. Use [F5] to change the source type to “Composite” or “Comp DSP.” The “Tone” selection will not work in Simultaneous Mode, and the Composite signal will be substituted automatically.
4. Press [START]. The test will run and the results will be displayed in Difference graph.

6.5.3 Testing in Manual Mode

If desired, you can perform one measurement at a time in Manual Mode in the Directional Different test screen. Use the [F6] to key select Manual Mode. (Press [F6], use the up-down arrow keys to select Manual, use the right-arrow key to complete the selection.)

To test in Manual Mode:

1. Use the [F6] key to enter Manual Mode.
2. Use the up-down arrow keys to change the source level to the desired selection. This is 60 dB SPL by default.
3. Use [F5] to change the source type. Choose between Composite, Comp DSP, Tone Normal, and Tone Long.
4. Press [MENU] to open the local menu and change the Reverse Pos, if desired. This is the angle used to perform the “reverse” measurement in the difference test. If desired, you can also change the Signal Presentation setting. This controls whether or not the Composite signal will be presented during the entire time of the test (Continuous) or only when a measurement is being actually taken (Interrupted). Close the local menu by pressing the [MENU] key again.
5. Position the hearing aid in the sound chamber for a directional test (see Section 6.3).
6. Press [START] to perform the difference test.

6.5.4 Automatic & Program Mode

In Automatic Mode, the user can program in a test sequence and save it into permanent memory. Afterwards, that test sequence can be loaded and run at any time. This is useful if the clinician always wants to run the same sequence of polar plot measurements for every hearing aid tested.

6.5.4.1 To Program the Test Sequence

1. Use the [F6] key to select Program Mode. (Press [F6]. Use the up-down arrow keys to select “Program.” Press the right arrow key to complete the selection.)
2. Use [F4] to delete any existing measurements.
3. Use [F2] to select curve 1.
4. Use [F5] to choose the source type.
5. Use the up-down arrow keys to select the input level.
6. Press [MENU]. Select the desired settings and press [MENU] again to close the menu when finished.
7. Press [START]. This will program the first curve and select curve 2.

8. Repeat steps 3-7 to program each desired measurement curve. If you do not wish to measure all five available curves, press [STOP] after the final desired curve. This will place a horizontal line across the Curve Characteristics box, indicating that an automatic test sequence will not advance any further.
9. Use [F6] to save the test sequence to Group 1, 2 or 3. This saves it into the analyzer's permanent memory.

6.5.4.2 To Run an Automatic Test Sequence

1. Use [F6] to enter Automatic Mode. (Press [F6]. Use the up-down arrow keys to select "Automatic." Use the right-arrow key to complete the selection.)
2. Use [F2] to select Curve 1.
3. (optional) Use [F6] to load the saved test sequence from Group 1, 2 or 3. If the desired test sequence is already displayed in the Curve Characteristics box, this step is unnecessary.
4. Press [START]. This will run through the test curves until reaching a pause, indicated by a horizontal line across the Curve Characteristics box. If no such line is displayed, all five curves will be measured.

6.5.5 Test Settings

There are many ways to refine the settings in the Directional Difference test screen. Press [MENU] to open the local menu for a list of test settings.

Display Settings

- Data/Graph: The method of data display. Choose between DATA (numerical data) and GRAPH.
- Smoothing: Choose whether or not to apply smoothing to the measurement curves. This smooths out the curve but may also eliminate some important test information. No actual data is deleted when smoothing is turned on. You can switch back and forth between smoothed and unsmoothed curves without needing to rerun the measurement curves.

Measurement Settings

- Noise Red (Comp): Amount of composite noise reduction used. See Section 2.3.2.1.
- Noise Red (Tone): Amount of pure-tone noise reduction used. See Section 2.3.1.1.
- Aid Type: Type of hearing aid being measured. Choose between Linear, AGC, and ADAPTIVE AGC. This affects the delay settings used in the measurements.
- Signal Presentation: Choose whether to have the test signal on continuously during the difference test (Continuous) or whether to turn it off

while the hearing aid is rotating for the test and turn it on only for the actual measurements (Interrupted).

- Reverse Pos: Angle used for the “reverse” part of the difference test. The forward angle is always set to zero.

Misc Settings

- User: Sets the User mode. See Section 2.3.3. In the Directional Difference test screen, this setting controls whether the Advanced menu items are displayed.
- Print Label: Status of the printing label. Choose ON or OFF.

Advanced Settings

- Start Delay: The amount of time the FONIX 8000 Test System presents the first tone in a difference test (only used for a pure-tone source type). See Section 2.3.1.2.
- Meas Delay: The amount of time each subsequent tone is presented before the measurement is made in a difference test (only used for a pure-tone source type). See Section 2.3.1.2.
- Composite Filter: Filter used in Composite or Comp DSP measurements. Choose between ANSI, ANSI 92, ICRA and FLAT.

The ISTS Test

The ISTS Test screen performs coupler measurements to the upcoming IEC 60118-15 standard titled, “Electroacoustics – Hearing Aids – Part 15: Methods for characterizing signal processing in hearing aids with a speech-like signal.” The ISTS is part of a new way of performing coupler measurements on advanced digital hearing aids, representing a major departure from the traditional ANSI method of evaluating hearing aid performance.

The acronym ISTS actually refers to the speech-like signal that is used as part of the test. It stands for “International Speech Test Signal,” and was developed by the European Hearing Instrument Manufacturers Association which holds the copyright. This signal was developed from recordings of female speakers of Arabic, English, French, German, Mandarin and Spanish. The recordings were cut into short segments and recomposed in random order.

During the test, third octave analysis is performed on the hearing aid response to the ISTS signal for a choice of 10, 20 or 45 seconds (actual test times are slightly longer). When the test is complete, the results are displayed as the long-term speech spectrum (LTASS), and the 30%, 65% and 99% of the distribution of sound pressure level.

See Figure 7.0 for a screenshot of a completed ISTS Test. Notice that the results are shown as a series of connected horizontal segments. These segments represent the third octave intervals used for the measurements. That is, each segment shows the frequency response across the entire third octave interval. In all other respects, however, they can be interpreted similarly to any hearing aid frequency response curve.

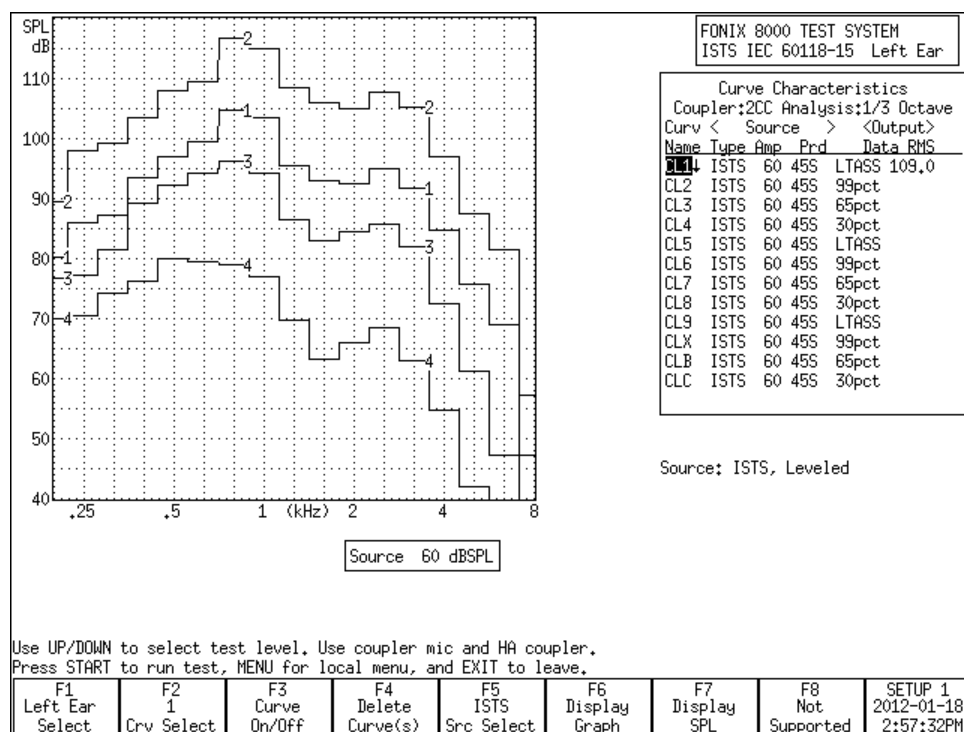


Figure 7.0: A Completed ISTS Test

7.1 Hearing Aid Setup

This section describes how the hearing aid should be programmed and set up in the sound chamber.

The sound chamber should be leveled (Section 3.2), and the hearing aid should be arranged in the test chamber in the usual way (Section 3.3). BTE hearing aids should be tested with the HA-2 coupler and canal hearing aids with the HA-1 coupler. The IEC 60118-15 standard specifies that hearing aids with the receiver in the canal or using thin coupling tubes should use the HA-1 coupler.

All settings of the hearing aid should be set to end-user settings, including noise reduction algorithms, feedback suppression systems, echo cancellation, etc. Features like frequency transposition should be disabled since they may give measurement results that are difficult to interpret.

It is recommended to program the hearing aid for a closed vent since actual measurements will take place using a coupler and no venting. Directional hearing aids should be set to omni-directional mode.

The hearing aid should be programmed for the patient's measured audiogram. However, if there is no patient yet, you can use one of the following audiograms found in Table 7.1 for flat and moderately sloping audiograms or Table 7.2 for steeply sloping audiograms. Make sure you make a note of which audiogram you used to program the hearing aid for reference purposes later.

No	HL	250 Hz	375 Hz	500 Hz	750 Hz	1000 Hz	1500 Hz	2000 Hz	3000 Hz	4000 Hz	6000 Hz
N1	16	10	10	10	10	10	10	15	20	30	40
N2	31	20	20	20	22.5	25	30	35	40	45	50
N3	46	35	35	35	35	40	45	50	55	60	65
N4	63	55	55	55	55	55	60	65	70	75	80
N5	76	65	67.5	70	72.5	75	80	80	80	80	80
N6	89	75	77.5	80	82.5	85	90	90	95	100	100
N7	103	90	92.5	95	100	105	105	105	105	105	105

Table 7.1: Standard audiograms for flat and moderately sloping group

No	HL	250 Hz	375 Hz	500 Hz	750 Hz	1000 Hz	1500 Hz	2000 Hz	3000 Hz	4000 Hz	6000 Hz
S1	23	10	10	10	10	10	10	15	30	55	70
S2	49	20	20	20	22.5	25	35	55	75	95	95
S3	63	30	30	35	47.5	60	70	75	80	80	85

Table 7.2: Standard audiogram for the steep sloping group

7.2 The ISTS Test

Performing the ISTS Test is very straightforward.

1. Enter the ISTS Test screen by selecting [F3] Advanced Coupler from the Opening Screen and then pressing [F7] ISTS Noise.
2. Set up the hearing aid for testing as described in Section 7.1.
3. Use the up-down arrow keys to adjust the source level, if desired. The default is 60 dB SPL.
4. Use the [F5] key to choose the source type. Normally, this will be the ISTS Wave, but you can also choose Pink Noise or White Noise.
5. Press [MENU] and adjust the Test Period, if desired. This changes the measurement time for the test. Choose between 10, 20 and 45 seconds. Keep in mind actual test time is longer. Press [MENU] again to close the local menu.
6. Press [START]. The ISTS test will run and four curves will be displayed when the test is complete. These curves represent the LTASS (long term average speech spectrum), the 99, 65 and 30 percentile curves. This means that in the 99 percentile curve, 99 percent of the measured response is below this line. In the 65 percentile curve, 65 percent of the measured response is below this line. Similarly, in the 30 percentile curve, 30 percent of the measured response is below this line.
7. Use [F2] to select Crv 4 and repeat if desired. Three separate tests can be measured and displayed together using a total of 12 different curves.

Real-Ear Measurements

8.1 Introduction

The Real-Ear Option gives you the capability to make probe microphone measurements inside your client's ear. You can:

- Input audiograms (Section 8.3.1)
- Create targets (Section 8.3.3)
- Perform insertion gain measurements (Section 8.4.1)
- Perform SPL measurements (Section 8.4.2)
- Perform Visible Speech measurements (Section 8.8)
- Perform RECD measurements (Section 8.3.5)

8.1.1 Understanding the Real-Ear Screens

There are several different screens associated with real-ear measurements. You access each of these screens from the Real-Ear Navigation screen shown in Figure 8.1.1.

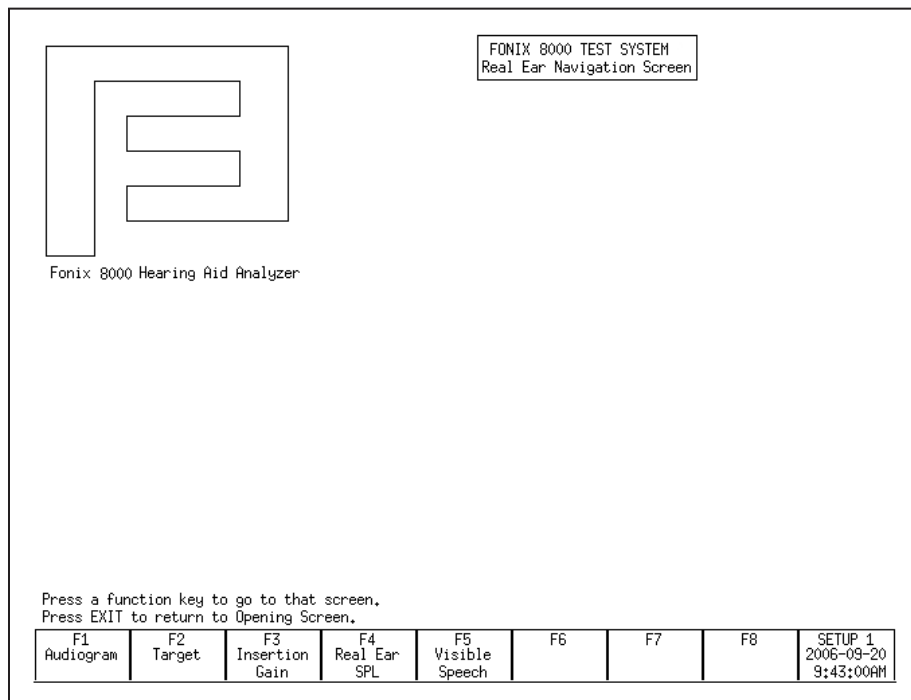


Figure 8.1.1—Real-Ear Navigation Screen

These screens are:

- Audiogram Entry screen [F1]
- Target screen [F2]
- Insertion Gain screen [F3]
- SPL screen [F4]
- Visible Speech [F5]

8.1.2 Navigating through the Real-Ear Screens

The Real-Ear Navigation screen is the key to moving through the different real-ear screens.

- To enter the Real-Ear Navigation screen from the Opening screen, press [F2].
- To enter any of the real-ear screens, press the appropriate function key button from the Real-Ear Navigation screen.
- To exit from any of the real-ear measurement screens, press the [EXIT] button. This will return you to the Real-Ear Navigation screen.

8.2 Real-Ear Setup

This section describes how to set up your client and your analyzer for real-ear measurements. It is important to follow these instructions carefully since your setup will have a direct impact on the accuracy of your measurements.

The dual ear functionality of the FONIX 8000 Hearing Aid Test System allows you to set up the probe microphone for each ear and then switch back and forth between them for measurements. (At this time, the FONIX 8000 does not support simultaneous dual probe measurements.)

For instructions on physically connecting the real-ear measurement components, see Section 1.6.4.

8.2.1 Placing the Sound Field Speaker

For the most accurate, repeatable measurements, we recommend a sound field speaker placement of approximately 12 inches from the client's head and pointing towards the ear to be tested. The speaker should be at an azimuth angle of 45 degrees (halfway between the client's nose and ear). The height of the loudspeaker should be level with, or a little above the ear. See Figure 8.2.1A.

If you wish to use the dual ear functionality of the 8000 Hearing Aid Test System, it may be more convenient to use a zero degree azimuth as shown in Figure 8.2.1B. This will allow you to more easily switch back and forth between ears. The zero degree azimuth may be slightly less repeatable than the 45 degree azimuth, but within the margin of error for clinical use. The most important thing is to be consistent in your speaker placement.

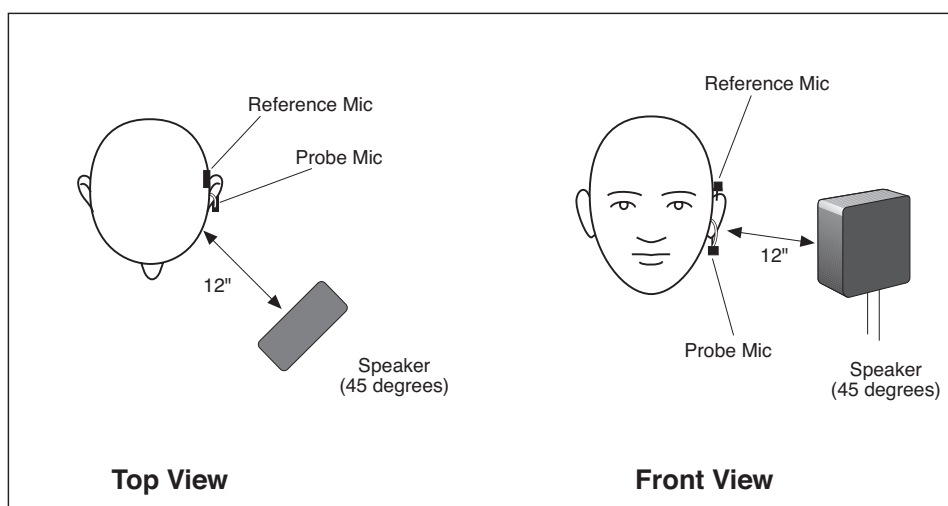


Figure 8.2.1A—Sound field speaker setup using a 45 degree azimuth

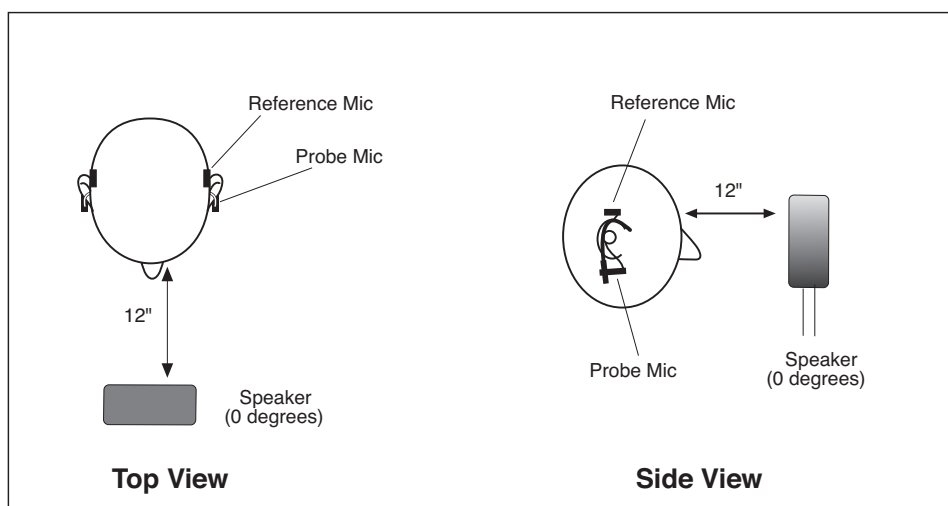


Figure 8.2.1B—Sound field speaker setup using a 0 degree azimuth

8.2.2 Placing the earhook and reference microphone

1. Place the integrated probe microphone set on the patient's ear.
2. Make sure the small reference microphone is secured on the earhook above the ear.
3. Adjust the earhook slider up or down for optimal positioning of the probe tube into the patient's ear.
4. After the probe tube has been inserted (see next section), the probe microphone body can be pivoted towards the ear to help hold the probe tube in place.
5. Repeat for the other ear, if desired.

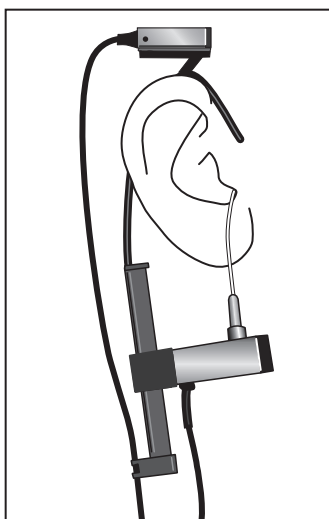


Figure 8.2.2—Placing the reference and probe microphones

8.2.3 Inserting the probe tube

There are several different methods used for properly inserting the probe tube. Here are two easy methods.

Method 1

1. Place an unattached probe tube on a flat surface along with the client's earmold or shell.
2. Place or hold the ear mold next to the probe tube, so that the tube rests along the bottom of the canal part of the earmold with the tube extending at least 5 mm past the canal opening. If there is a large vent, you can slide the tube down the vent until it protrudes at least 5 mm past the canal opening.
3. Mark the probe tube where it meets the outside surface of the earmold with a marking pen. See Figure 8.2.3A.
4. Attach the probe tube to the body of the probe microphone.
5. Attach the probe microphone to the round Velcro pad on the earhook.
6. Insert the probe tube (without the earmold or aid) into the client's ear so that the mark is at the location where the bottom of the outer surface of the earmold will be, once the earmold is in place.

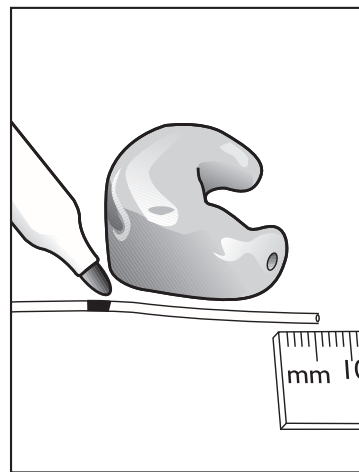


Figure 7.2.3A—Marking the probe tube

WARNING

Choose OUTPUT LIMIT carefully (see procedure below). You don't want to damage your clients' hearing or cause them discomfort during testing. To ensure safety and comfort, the 8000 Test System reacts automatically when the OUTPUT LIMIT level is exceeded at the Probe Microphone. When the level measured at the Probe Microphone exceeds the pre-set limit, the words "Over Range has occurred" appear on the screen, and the signal source is automatically turned off and the measurement stopped.

The default setting for OUTPUT LIMIT is 120 dB SPL. You can set the OUTPUT LIMIT to any level between 80 and 140 dB SPL in 5-dB increments (see procedure below). In special cases, when you select 130 or 140 dB SPL, be aware that extra care is necessary with any output that may exceed 132 dB SPL.

Keep in mind that the sound pressure level at the eardrum can be higher than that measured at the mid-ear canal position, especially at high frequencies. For this reason, EXTREME CAUTION is advised when performing real-ear SSPL measurements.

When using pure tones, set Noise Red (Tone) to OFF in the local menu of the real-ear measurement screen to increase the test speed. The pure-tone SHORT signal is recommended when testing output levels at 90 dB SPL.

1. Push [MENU] from the real-ear measurement screen to enter the local menu.
2. Use [▼, ▲] to select OUTPUT LIMIT under Measurements.
3. Use [◀, ▶] to choose the desired limit.
4. Return to the measurement screen by pressing [EXIT].

Monitor Headset

If you are using the monitor headset to listen to the probe microphone measurements at the probe tip, make sure you plug the monitor headset into the MONITOR connector jack. Plugging the monitor headset into SPKR A or SPKR B could cause loud output through the monitor headset and damage your hearing. Use the monitor headset with the MONITOR connector jack **ONLY**.

SANITATION NOTICE

DO NOT REUSE PROBE TUBES.

Use a new probe tube for each ear to prevent the possible spread of infection. Sterilization of probe tubes is not possible, and germicidal solutions can leave a residue inside the tubing which can result in errors. Do not cut off any portion of the tube.

DO NOT REUSE INSERT EARPHONE EARTIPS.

Insert earphone eartips are used primarily for performing RECD and audiometric measurements. Sterilization of these eartips is not possible. When performing these measurements, make sure to use a new ear tip for each patient. You may spread infections if you reuse insert earphone eartips.

Method 2

This method uses the Composite signal and the fact that there is a dip in gain inside the ear caused by a standing wave created by the 7 kHz frequency reflecting off the eardrum.

1. Press [F2] to enter the Real-Ear Navigation screen from the Opening screen.
2. Press [F3] to enter the Insertion Gain screen.
3. Press [F5] to select the Composite signal as the source type.
4. Press [START] to start a measurement.
5. Insert the probe tube carefully, looking at the composite measurement. At some point, there will be a large dip below the 0 dB level at 7 kHz caused by the standing wave inside the ear. Keep inserting the probe tube until that dip goes away and the unaided response is above 0 dB gain between 7 kHz and 8 kHz. See Figure 8.2.3B.
6. Press [EXIT] to return to the Real-Ear Navigation screen.

Hints: To help keep the probe tube in place, position the tube so that it runs through the tragal notch, resting against the lower edge of the tragus. If necessary, reposition the body of the probe microphone lower on the Velcro button of the ear hanger. If desired, use surgical tape to hold the tube in position.

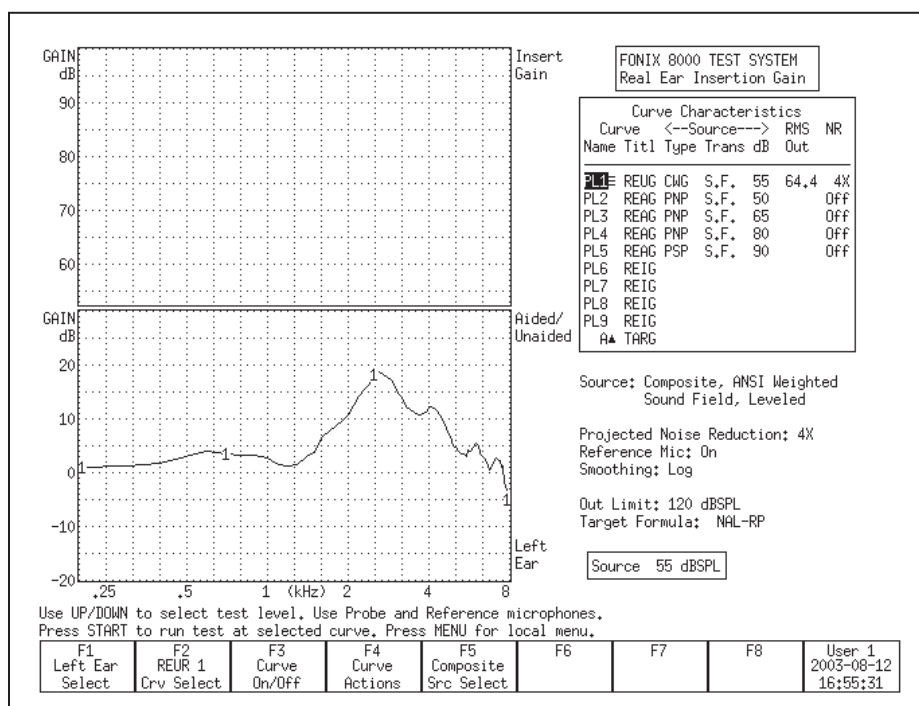


Figure 8.2.3B—Unaided response with correct insertion of the probe tube

8.2.4 Leveling the Sound Field Speaker

The first step in making real-ear measurements is to level the sound field speaker. The sound field includes the room and everything in it: the operator, the client, and any ambient noise that may penetrate the room. Leveling is important so that the input to the hearing aid is properly controlled across the frequency spectrum. See Figure 8.2.4. **You must re-level the sound field for every client and every ear.**

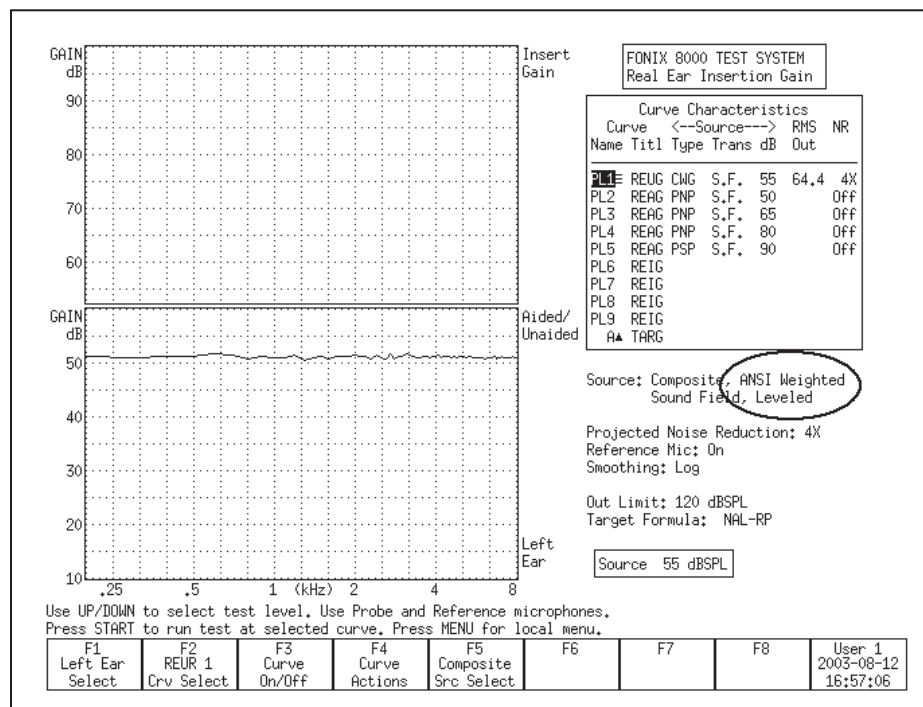


Figure 8.2.4—Leveling the sound field speaker

1. Follow the instructions found in Sections 8.2.1 and 8.2.2 to position the client, sound field speaker, and microphones for testing. Only the reference microphone is used for leveling. However, to speed things up and ensure the client is in the same position for leveling as he is for measuring, it is recommended that you insert the probe microphone tube into the client's ear (described in Section 8.2.3) before the leveling process.
2. Press [F2] from the Opening screen to enter the Real-Ear Navigation screen.
3. Press [F3] or [F4] from the Real-Ear Navigation screen to enter either the Insertion Gain screen, or the SPL screen, respectively.
4. Press [LEVEL].
5. The instrument will attempt to level the sound field speaker. There are four leveling statuses:

- a. **LEVELED**—This indicates the leveling process was correct within 1 dB.
 - b. **LEVEL-FAILED**—This indicates that the leveling process is incorrect by at least 7 dB.
 - c. **SEMI-LEVELED**—This indicates that the leveling process was correct between 1 dB and 2 dB.
 - d. **WEAK-LEVELED**—This indicates that the leveling process was correct between 1 dB and 2 dB, but that the maximum output that the speaker can produce is less than 80 dB SPL. To produce a louder signal, move the speaker closer to the patient and re-level.
6. Press [F1] to switch to the other ear and press [LEVEL] again to level the other ear, if desired.

If the instrument didn't successfully level, there are several things you can try.

- Check the position of the sound field speaker. It should be 12 to 15 inches from the client's head.
- Make sure the microphone set is securely plugged into the remote module.
- Check the calibration of the loudspeaker and microphones. See Appendix B.
- Check the noise level in the room. It may be necessary to change or correct the sound field environment.
- Make sure the remote module and speaker cable are securely plugged into the main electronic module.

See Section 2.8 for details on the leveling status and troubleshooting the leveling process.

8.2.5 Setting up Body Aids

The setup below is recommended for Body aids.

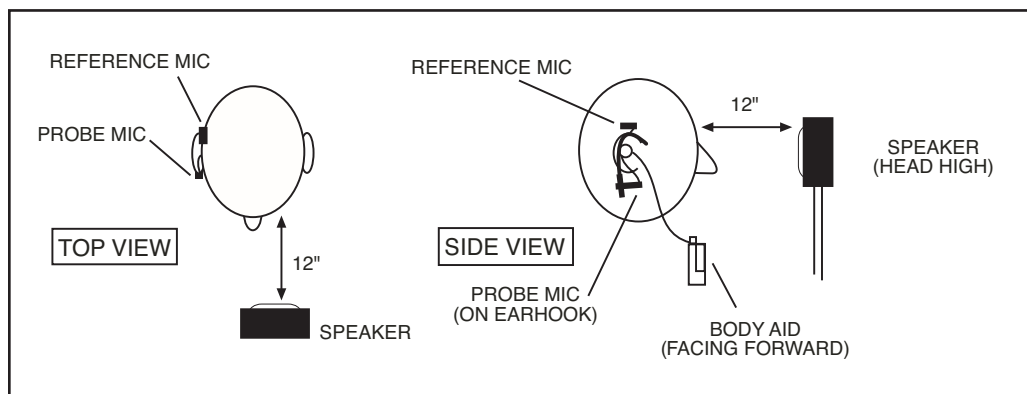


Figure 8.2.5—Setting up a body aid for real-ear testing

8.2.6 Using the Monitor Headset

The 8000 Real-ear Option comes with a set of headphones that can be used to listen to the real-ear measurement at the tip of the probe tube. This can be useful for determining if the probe tube is blocked or if the patient is receiving amplification. To use the monitor headset, plug it into the jack labeled MONITOR, and listen to the headphones during the probe measurements.

Warning: Make sure you do not plug the monitor headset into the SPKR A or SPKR B connector jacks. This could result in very loud sound from the sound field speaker, which could damage your hearing if you are listening to the headphones. Use the MONITOR connector jack **ONLY** when using the monitor headset.

8.3 Real-Ear Targets

This section describes how to enter a real-ear audiogram, enter or measure a real-ear to coupler difference (RECD), and create or modify a real-ear target.

8.3.1 Entering an Audiogram

1. Enter the Real-Ear Navigation screen by pressing [F2] from the Opening screen or [EXIT] from any real-ear screen.
2. Press [F1] to enter the Audiogram Entry screen. See Figure 8.3.1.
3. Press [F1] to select the desired ear.
4. Make sure HTL is selected above F2. You should see a cursor in the HTL column for the selected ear in the middle of the display. If the cursor is in a different column, press [F2] to select HTL.
5. Use the arrow keys to input the client's HTL (hearing threshold level) values. Use [◀, ▶] to input the amplitude. Use [▼, ▲] to select the frequency.
6. Use [MENU] to open the local menu and adjust the patient's age. Press [EXIT] to close the menu.
7. Use [F2] to select Bone in order to input the patient's bone conduction values if that is desired. You can copy the HTL values to the Bone column by using F4 and selecting HTL to Bone. Bone values only affect the NAL-NL1 target.
8. Use [F2] to select UCL if you would like to input your client's measured uncomfortable levels. Press [F3] if you would like to predict the UCL values. (Pascoe [1988] is used for calculating UCL values.)
9. Press [F4] and select COPY EAR with [▼, ▲] if you would like to copy the data from the selected ear into the other ear. Press [▶] to make the selection. This is useful if your client has a similar loss in both ears.
10. Use [F1] to switch ears and repeat steps 4-8.

To specify the transducer used to take the audiometric measurements, press [MENU] and use the arrow keys to specify the Aud. Transducer under Targets.

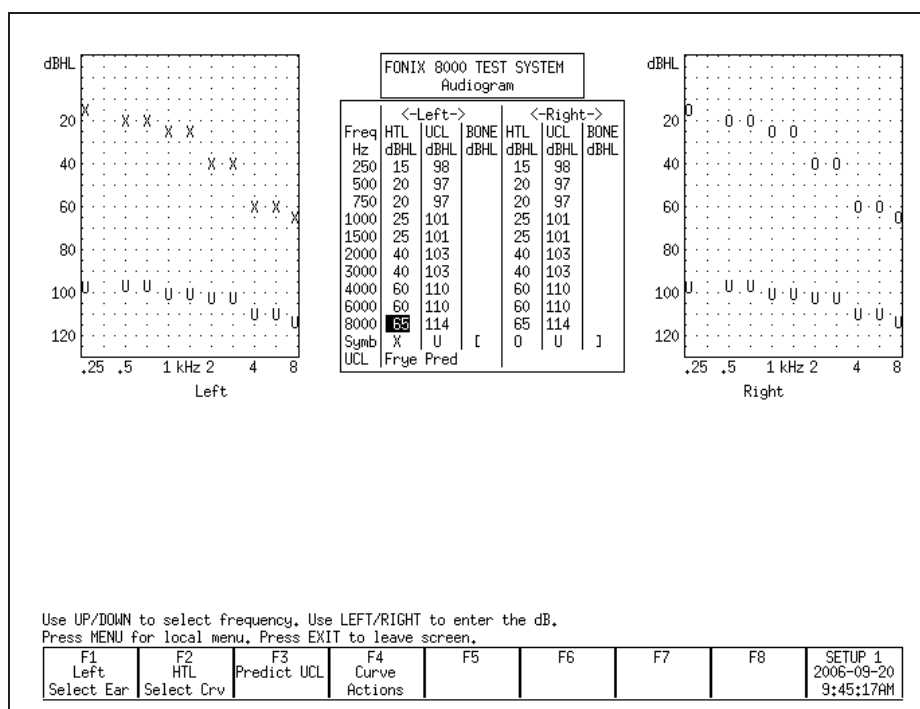


Figure 8.3.1—Audiogram Entry screen

8.3.2 Deleting Audiometric Information

If you make a mistake, it's often useful to be able to delete all or part of the inputted audiometric data. To do this:

1. Press [F4] and use [▼, ▲] to select the data you would like to delete. You can delete the client's HTL, UCL, Bone and RECD. Selecting "This Ear" will delete all data in the selected ear. Selecting "New Client" will delete all data in both ears.
2. Press [►] to perform the action.

8.3.3 Creating a Target

Once you input an audiogram (Section 8.3.1), a target will automatically be created when you enter a real-ear measurement screen.

To change a fitting rule:

1. Press [MENU] from the real-ear measurement screen or the Audiogram Entry screen.
2. Select Fitting Rule under Targets with [▼, ▲].
3. Use [◀, ▶] to select the desired fitting rule.
4. Use [▼, ▲] to select Client Age, and use [◀, ▶] to input the desired selection.

5. If you have selected NAL-NL1, or MOD NAL, the following menu settings are also available:
 - Compression: The compression kneepoint of the hearing aid. If the hearing aid has multiple compression kneepoints, use the first one.
 - No. of Channels: The number of channels of the hearing aid.
 - Aid Limit: Type of output limit employed by the aid. Choose from Multichannel or Wideband.
 - Fit Type: Type of hearing aid fitting used by the patient. Choose Unilateral or Bilateral.
 - Sound Field: Position of the sound field speaker during real-ear measurements. If the patient's threshold values were measured with a sound field speaker, the same angle used for the audiometric measurements should be used for the real-ear measurements.
 - Ref. Position: Type of leveling used for the real-ear measurement. Head surface includes the patient inside the sound field (recommended for best accuracy). Undisturbed Field indicates leveling was done by holding the reference microphone in front of the sound field speaker.
6. Press [EXIT] to close the menu. If you are in a real-ear measurement screen, you should see the new selected fitting rule noted under the Curve Characteristics box.

8.3.4 Entering Bone Data

The NAL-NL1 and MOD NAL targets use bone data in their calculations. If the patient's bone thresholds are not entered, they will assume average values. No other fitting rules use the bone data. To enter this data:

1. Press [MENU] in the Audiogram Entry screen to open the local menu.
2. Set the FITTING RULE to NAL-NL1 using the arrow keys.
3. Press [EXIT] to exit the local menu.
4. Press [F2] repeatedly until BONE is selected.
5. Use the arrow keys to enter the bone values into the appropriate column of data.

8.3.5 Performing an RECD measurement

The real-ear to coupler difference (RECD) is the acoustical difference between a 2-cc coupler and the real-ear occluded response of an individual. It involves a coupler measurement and a real-ear measurement. Both measurements are usually performed with an insert earphone as the transducer.

It's also possible to use a linear hearing aid, instead of an insert earphone, to perform the RECD test. In this case, you would use the same hearing aid, set with identical volume control and/or other settings, for both the coupler and real-ear portions of the test. *The DSL Method does NOT recommend using a hearing aid as the RECD transducer.*

Coupler Measurement

The coupler part of the RECD is performed when you “calibrate” the insert earphone used in the measurement. When this calibration is performed, the coupler measurement is stored into permanent memory. This saves a lot of time because, after the coupler measurement is made once, you will only have to perform the real-ear part of the RECD for each patient. If you change the transducer or calibrate your microphones, make sure to perform the coupler measurement again.

The following instructions assume you are using an ER3 insert earphone for performing the RECD measurement.

To perform the coupler measurement:

1. Insert the 50 ohm insert earphone into the jack on the probe module labeled “EARPHONE.”
2. Plug the other end of the insert earphone into the tubing of the ear level adapter attached to an HA-2 coupler. See Figure 8.3.5A.
3. Insert a probe tube through the black probe microphone adapter as shown in Figure 8.3.5B. Attach a dab of Fun-tak to the adapter to keep the probe tube from slipping.
4. Attach the probe tube to the left probe microphone. The right probe microphone is not used for this measurement. The left microphone coupler measurement is used for both the left and right RECD measurements.
5. Insert the adapter into the HA-2 coupler.
6. Press [MENU] from the Opening screen to open the Setup menu.
7. Press [F4] to perform the coupler measurement. This also saves the coupler measurement in permanent memory.
8. Press [EXIT] to return to the Opening screen.



Figure 8.3.5A
Insert earphone attached to coupler



Figure 8.3.5B
Probe tube in probe mic adapter

To perform the real-ear measurement:

Note: When testing infants and small children, we recommend using the infant/child headband set. This is an optional accessory.

1. Insert the 50 ohm insert earphone into the earphone jack on the probe module.
2. Insert the probe microphone into the client's ear, as described in Section 8.2.3. See Figure 8.3.5C.
3. Insert the foam eartip connected to the insert earphone into the client's ear, or attach the earphone directly to the client's earmold, and insert the earmold into the client's ear. See Figure 8.3.5D.
4. Press [F2] from the Opening screen to enter the Real-Ear Navigation screen.
5. Press [F1] from the Real-Ear Navigation screen to enter the Audiogram Entry screen.
6. Press [MENU] from the Audiogram Entry screen to enter the local menu.
7. Use [▼, ▲] to select RECD Mode under Misc, and use [◀, ▶] to choose Custom Measured.
8. Press [EXIT] to close the menu.
9. Use [F2] in the Audiogram Entry screen to select RECD.
10. Press [START] to take the measurement. The results will appear in both graphical and numeric format. See Figure 8.3.5.E

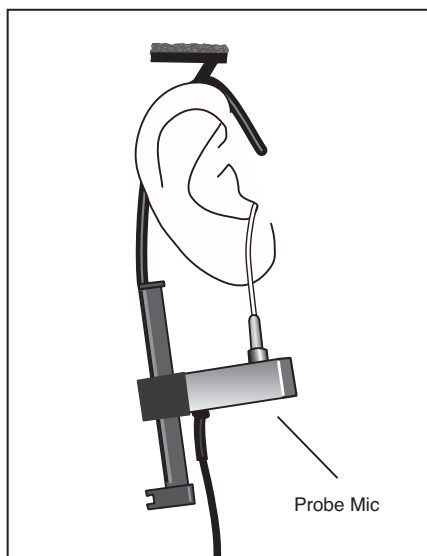


Figure 8.3.5C—Insert probe microphone

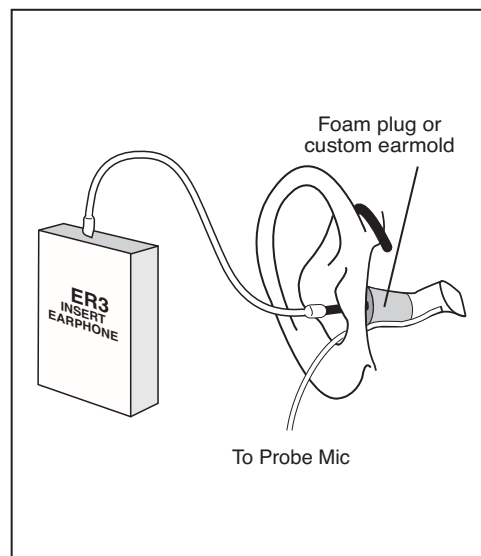


Figure 8.3.5D—Insert foam eartip connected to insert microphone.

If you have previously taken an RECD measurement, you can input it (without measuring it) by selecting RECD with [F2] and using the arrow keys as you would to input HTL values.

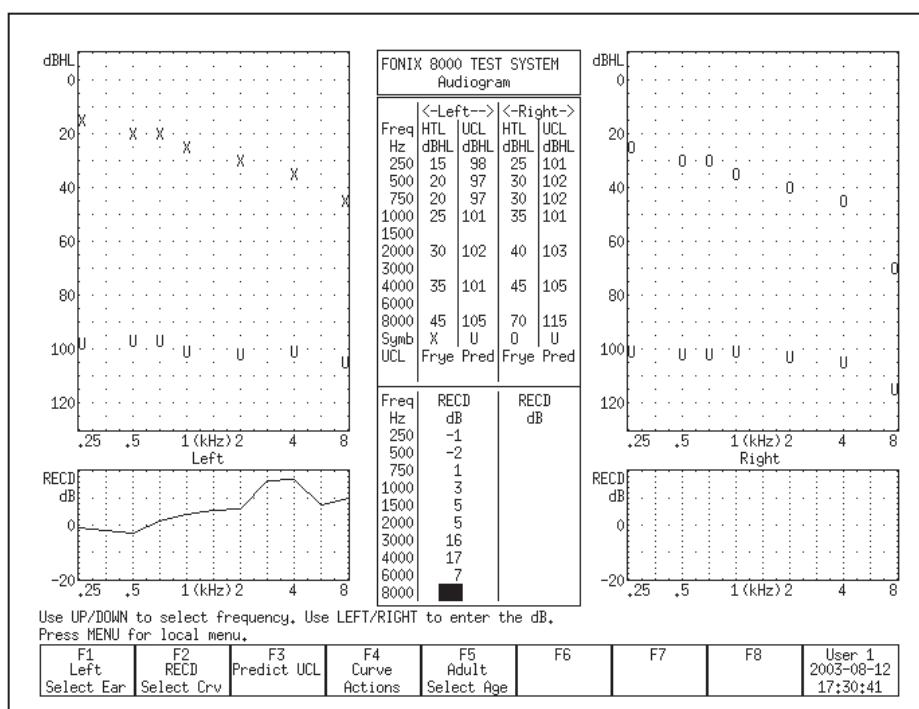


Figure 8.3.5E—Taking an RECD Measurement

8.3.6 Modifying a Target

Once you input an audiogram in the Audiogram Entry screen, a target will automatically appear on the real-ear measurement screens. You can use the Real-Ear Target screen to modify a target or to input your own target in dB insertion gain or dB SPL, edit your client's HTL and UCL values in dB SPL, and input a custom real-ear to dial difference (REDD).

1. Enter the Real-Ear Navigation screen by pressing [F2] from the Opening screen or [EXIT] from a real-ear screen (such as the Audiogram Entry screen).
2. Press [F2] to enter the Real-Ear Target screen. See Figure 8.3.6. If you have input an audiogram as described in Section 8.3.1, you should see targets in both the SPL and gain graphs.
3. Select the desired ear with [F1].
4. Use [F3] to select the desired fitting rule.
5. Use [F2] to select the data you want to edit. The choices are:
 - HTL (re): The client's audiogram in dB SPL
 - Target (re): The mid-level target in dB SPL
 - UCL (re): The client's uncomfortable levels in dB SPL

- REDD: The real-ear to dial difference (only selectable when REDD is set to CUSTOM)
 - Target IG: The mid-level target in dB insertion gain
- Use [F5] to select the signal source if you are modifying the SPL target:
 - Select the Source Type. Choose between Tone and Composite. Press [START] to make your selection without closing the pop-up window.
 - Select the Source Level. Choose between 40 through 90 dB SPL. Press [►] to make your selection and close the pop-up window.
 - Use the arrow keys to make your modifications to the target. The [▼, ▲] keys select the desired frequency, and the [◀, ▶] keys modify the amplitude 1 dB at a time.

Note: When you edit the Target IG, the Target SPL will also be updated. However, when you edit the Target SPL directly, it will not have an effect on the Target IG.

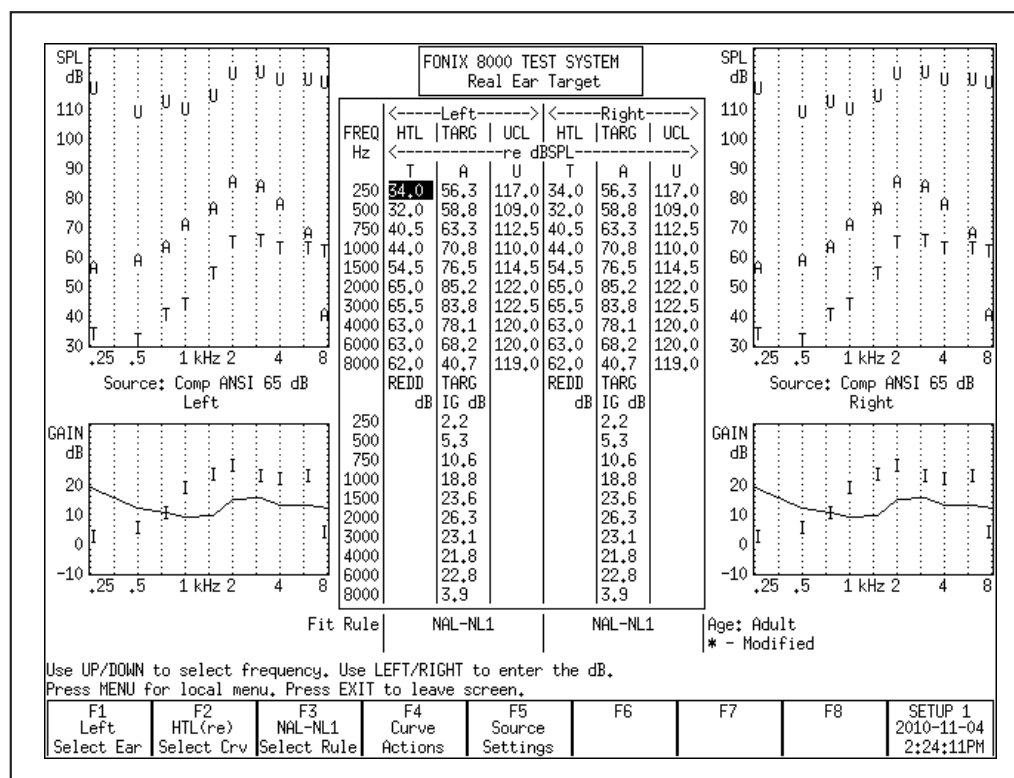


Figure 8.3.6—The Real-Ear Target screen

8.3.7 Entering an REDD transform

The REDD transform affects how dB HL values are converted to dB SPL.

To enter a measured REDD value:

1. Enter the Real-Ear Navigation screen by pressing [F2] from the Opening screen or [EXIT] from a real-ear screen (such as the Audiogram Entry screen).
2. Press [F2] to enter the Real-Ear Target screen.
3. Press [MENU] in the Real-Ear Target screen.
4. Select REDD using [▼, ▲].
5. Choose CUSTOM using [◀, ▶].
6. Press [EXIT] to return to the Real-Ear Target screen.
7. Use [F1] to select the desired ear.
8. Use [F2] to select REDD. The REDD column for the selected ear will now be highlighted.
9. Use the arrow keys to input the REDD transform. The [▼, ▲] keys select the frequency. The [◀, ▶] keys select the amplitude.

8.4 Real-Ear Measurements

The 8000 Hearing Aid Test System has three real-ear measurement test screens: Insertion Gain, Real-ear SPL, and Visible Speech. The Insertion Gain and Real-ear SPL screens are explained in this section. See Section 8.7 for operation of the Visible Speech screen.

8.4.1 Measuring in the Insertion Gain screen

Insertion Gain is the most conventional method used for performing real-ear measurements. In the typical insertion gain procedure:

1. The probe tube is inserted into the ear canal. (Section 8.2.3)
2. The sound field speaker is leveled. (Section 8.2.4)
3. The unaided response is measured. (Section 8.4.3)
4. The hearing aid is carefully inserted into the ear.
5. The aided response is measured. (Section 8.4.4)
6. The insertion gain response is compared to the prescribed insertion gain target and any necessary adjustments are made to the hearing aid in order for the response to better match the target.

The Insertion Gain screen itself consists of two graphs. (See Figure 8.4.1.) The bottom graph displays an unaided response and up to four aided responses in dB Gain or dB SPL. The top graph displays a prescribed insertion gain target and up to four insertion gain curves. Insertion gain is the difference between the patient's aided and the unaided responses.

In other words, the bottom graph of the insertion gain screen shows the difference between the sound field measured by the reference microphone outside of the ear and the probe microphone in the ear canal. (When the reference microphone is disabled, the estimated sound field is subtracted.) The top graph shows the insertion gain, which are the values obtained when the unaided response is subtracted from the aided response.

Target Curve A, displayed in the top graph in the Real-ear Insertion Gain screen, is automatically adjusted to the source type and amplitude of the current selected curve when REAG 2-5 are selected. When REUG 1 is selected, Target Curve A uses the source settings of REAG 3. (This only applies when the NAL-NL1 fitting rule is selected. All other fitting rules on the 8000 are linear, which means the target does not change with respect to the source type and amplitude of the signal.)

Most of the operations of the Insertion Gain screen are identical to the operations of the Real-ear SPL screen. Therefore, most of the instructions found in this section apply to measurements performed in both screens. Any differences between operations in the two screens are noted.

To enter the Insertion Gain screen, press [F2] from the Opening screen to enter the Real-ear Navigation screen. Then press [F3].

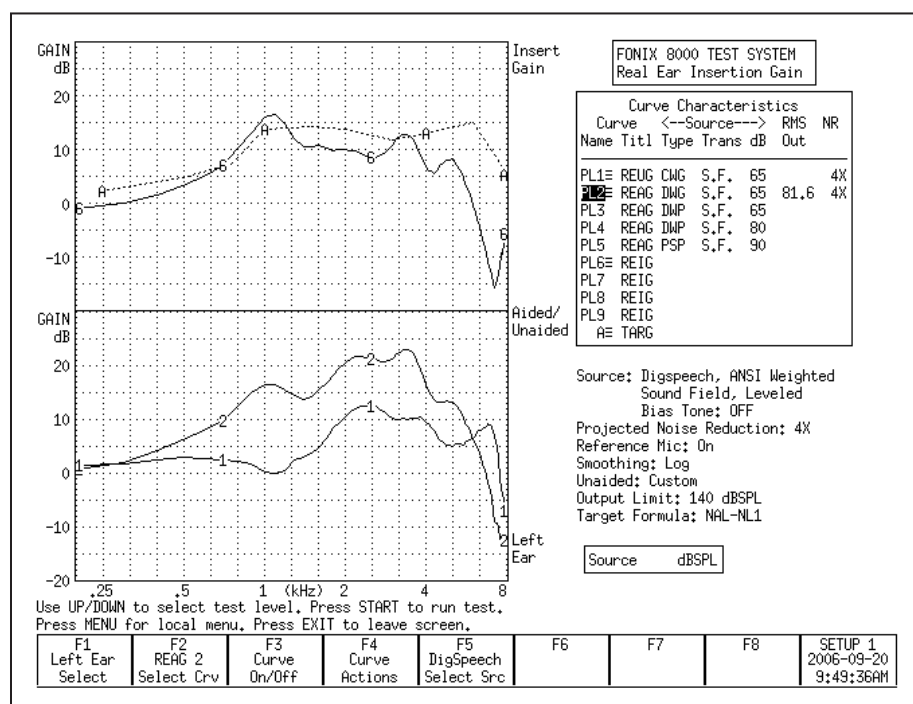


Figure 8.4.1—Real-ear Insertion Gain screen. Curve 1 is an REUG (unaided) measurement. Curve 2 is an REAG (aided) measurement. Curve 6 is the REIG (insertion gain) curve. Curve A is the real-ear prescription target.

8.4.2 Measuring in the Real-ear SPL screen

In the past ten years, the SPL method of performing real-ear measurement has increased in popularity. In the SPL method, the patient's hearing threshold levels (HTLs), uncomfortable levels (UCLs), real-ear target, and real-ear measurements are displayed together on one graph in terms of dB SPL. This allows for a direct comparison of audiometric measurements and real-ear measurements.

The goal in the SPL method is to ensure the response of the hearing aid to soft signals (50 dB SPL) reach above the patient's HTLs, the response to average signals (65-80 dB SPL) meet the target, and the response to loud signals (90 dB SPL) are below the UCLs.

In the Real-ear SPL screen (Figure 8.4.2), the patient's HTLs and UCLs are displayed on one large graph together with up to three real-ear targets and five real-ear measurements. The three targets (L, M and H) are matched to the source type and amplitude of REAR 2, REAR 3 and REAR 4 respectively. That is, Target Curve L is appropriate for the settings used in REAR 2, M is appropriate for REAR 3, and H is appropriate for REAR 4. When changing the source type or amplitude of any of these three measurement curves, the target will automatically adjust. These curves are color coded to make it easier to match the measurement curve to the appropriate target. Target L and REAR 2 are blue, Target M and REAR 3 are green, and Target H and REAR 4 are red.

The long term average speech spectrum (LTASS) can also be displayed as three dotted "l", "m" and "h" curves. The LTASS is the average real-ear unaided response. The "m" curve is the real-ear unaided response at 70 dB SPL. The "h" curve is 12 dB above this curve, and the "l" curve is 18 dB below it. The three curves of the LTASS are used as a comparison tool to the aided measurement curves to demonstrate the amplification advantage provided by the hearing aid. Use [F3] to turn this feature ON.

During a typical real-ear measurement using the SPL method:

1. The probe tube AND hearing aid are inserted into the ear canal. (Section 8.2.3)
2. The sound field speaker is leveled. (Section 8.2.4)
3. The hearing aid is carefully inserted into the ear.
4. The aided response is measured (Section 8.4.4) with an input signal of 50 dB SPL and compared to the patient's HTLs.
5. The aided response is measured with an input signal of 65 dB SPL and compared to the real-ear target.
6. The aided response is measured with an input signal of 90 dB SPL and compared to the patient's UCLs

Most of the operations of the Real-ear SPL screen are identical to the operations of the Insertion Gain screen. Therefore, most of the instructions found in this section apply to measurements performed in both screens. Any differences between operations in the two screens are noted.

To enter the Real-ear SPL screen, press [F2] from the Opening screen to enter the Real-ear Navigation screen. Then press [F4].

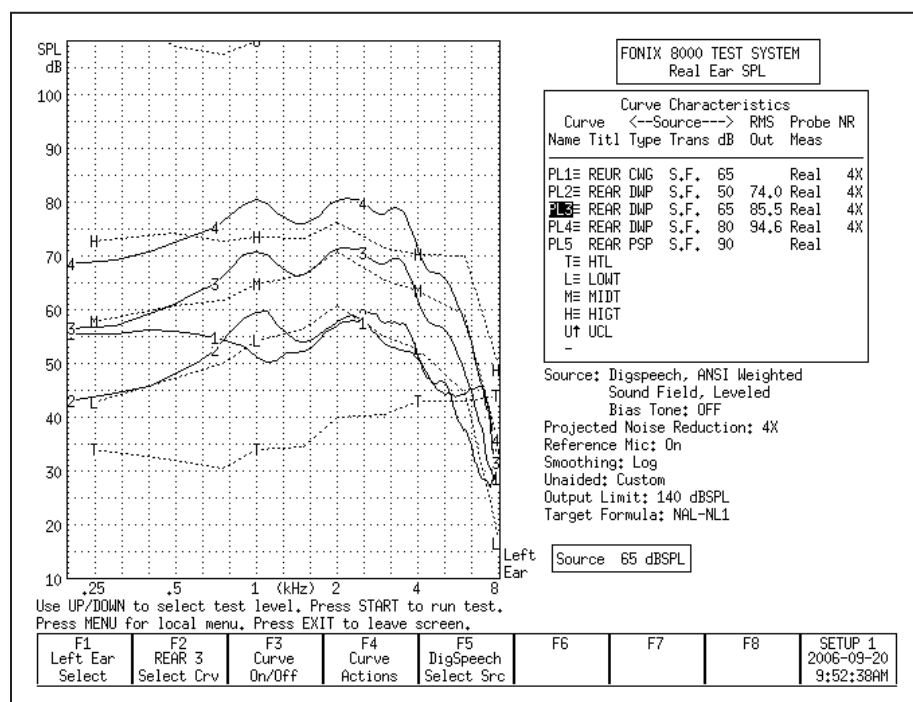


Figure 8.4.2—Rear-ear SPL screen. The T curve represents the patient's thresholds, the L, M, and H curves represent the NAL-NL1 targets. Curve 1 shows the unaided response. Curves 2, 3, and 4 show the aided response at 50, 65, and 80 dB SPL. The patient's UCLs are just off the top of the graph.

8.4.3 Measuring the Unaided Response (REUG/REUR)

The REUG/REUR is a measurement of the unaided response of the patient's ear canal. It can be measured in either the Real-ear Insertion Gain screen or the Real-ear SPL screen, and any measurement performed in one of these screens will be automatically displayed in the other screen.

To measure the unaided response:

1. Position the patient in front of the sound field speaker and place the earhook and reference microphone on the ear. See Sections 8.2.1 and 8.2.2.
2. Insert the probe tube into the patient's ear canal. See Section 8.2.3.
3. Input the patient's audiogram to generate a target, if desired. See Section 8.3.
4. Press [EXIT] in the Audiogram Entry screen to return to the Real-ear Navigation screen.

5. Enter the Insertion Gain or Real-ear SPL screen by using [F3] or [F4] in the Real-ear Navigation screen, respectively.
6. Select the desired ear with [F1].
7. Level the sound field speaker. See Section 8.2.4.
8. Use [F2] to select REUR 1. (Press [F2]. Use [▼, ▲] to select REUR 1. Press [►] to complete the selection and close the pop-up menu.)
9. Use [F5] to select Composite.
10. Use [▼, ▲] to select the desired amplitude for the measurement. We recommend 65 dB SPL.
11. Press [START] to start the measurement.
12. Press [STOP] when the unaided response has stabilized. Curve 1 in the bottom graph of Figure 8.4.1 shows an example of the unaided response using the Gain display in the Insertion Gain screen.
13. If desired, use [F1] to switch to the other ear, and repeat steps 7-12.

To choose between Gain and SPL (Output):

In the Real-ear Insertion Gain screen, the bottom graph contains the unaided and aided measurement curves as a function of gain (REUG/REAG) or of output SPL (REUR/REAR). The “SPL” display includes the input signal in the measurement. The “gain” display subtracts the input signal in the measurement.

1. Enter the Real-ear Insertion Gain screen.
2. Press [MENU] to open the local menu.
3. Select Display using the up-down arrow keys.
4. Use the right arrow key to choose between Gain and SPL.
5. Press [EXIT] to return to the Real-ear Insertion Gain screen. The bottom graph should now match your selection.

The Real-ear SPL screen cannot display measurements in Gain. All measurements are displayed in SPL (output). Therefore, the Display selection in the local menu is disabled.

To use an average unaided response:

It is also possible to display an average unaided response on the measurement screen instead of a measured response. This allows the clinician to skip the unaided response measurement. When the unaided response is set to average, the REAR 2 curve is automatically selected at the first measurement curve instead of the REUR 1 curve.

To use an average unaided curve, press [MENU] in the Insertion Gain or Real-ear SPL screen. Use the arrow keys to set Unaided to Avg. Press [EXIT] to close the local menu. The average unaided response will now be displayed on the measurement graph.

To auto-adjust the unaided response:

When using the SPL display in the Insertion Gain screen, or when measuring in the Real-ear SPL screen (in other words, when the unaided response is displayed in terms of SPL and not gain), the unaided response includes the input signal used in the measurement.

In order to directly compare the unaided response to the aided response in an SPL graph, it is important that the speech weighting and input level of the input signal are the same for both the unaided and the aided response. For example, if the unaided response is measured at 65 dB SPL, it is difficult to directly compare it to the measured aided response at 80 dB SPL when viewing the data in an SPL graph. However, a direct comparison of the unaided and aided response can be desirable in ensuring the hearing aid amplifies above the unaided response. Therefore, the 8000 Hearing Aid Test System has an “REUR Auto Adjust” feature.

When the REUR Auto Adjust is enabled, the unaided response is automatically adjusted according to the speech weighting and input level of the selected aided measurement. This allows the clinician to measure the unaided response at one level and directly compare it to aided measurement curves measured at another level.

To enable the REUR Auto Adjust, press [MENU] in the Real-ear Insertion Gain or Real-ear SPL screen to open the local menu. Use the arrow keys to select REUR Auto Adjust under Measurements and change its setting to On.

The REUR Auto Adjust is automatically enabled when Unaided is set to Average in the local menu.

8.4.4 Measuring the Aided Gain in the Insertion Gain Screen

Up to four different aided curves can be measured and displayed together in the Real-ear Insertion Gain and Real-ear SPL screens. Any measurement made in one of these screens will automatically be displayed in the other screen.

To measure the aided response:

1. Position the patient in front of the sound field speaker and place the earhook and reference microphone on the ear. See Sections 8.2.1 and 8.2.2.
2. Insert the probe tube into the patient's ear canal. See Section 8.2.3.
3. Input the patient's audiogram to generate a target, if desired. See Section 8.3.
4. Press [EXIT] in the Audiogram Entry screen to return to the Real-ear Navigation screen.
5. Enter the Insertion Gain screen by using [F3] in the Real-ear Navigation screen.

6. Select the desired ear with [F1].
7. Level the sound field speaker. See Section 8.2.4.
8. Measure the unaided gain, if desired. See Section 8.4.3 for details.
9. Insert the hearing aid into the ear, being careful not to move the probe tube.
10. Use [F2] to select REAG 2. By default, this curve is set to 50 dB SPL (i.e., soft speech). To adjust the input level, use the up-down arrow keys.
11. Select the signal source with the [F5] button. Digital Speech is a good source type to use when measuring most hearing aids. (Press [F5] to open the pop-up selection menu. Use the up-down arrow keys to make the desired selection. Press the right arrow key to complete the selection and close the menu.)
12. Press [START] to take the measurement. When the frequency response has stabilized, press [STOP] to stop the measurement.
13. Compare the measurement curve (Curve “6”) in the top graph to the “A” target. When fitting to the prescription target, the Curve 6 should be within 5 dB of Curve A. Make any necessary adjustments to the hearing aid fitting, and repeat Step 12 above to make another measurement.
14. Use [F2] to select REAG 3, if desired, and repeat steps 11-13 to perform a measurement at a different input level (default is 65 dB SPL) and compare Curve 7 to Target Curve A. (If you are using the NAL-NL1 or MOD NAL fitting formula, the target curve automatically adjusts to the selected input level and source type.) Repeat for REAG 4 and REAG 5, if desired.
15. Use [F1] to switch ears, if desired, and repeat the entire process for the other ear.

8.4.5 Measuring the Aided Gain in the Real-ear SPL Screen

1. Position the patient in front of the sound field speaker and place the earhook and reference microphone on the ear. See Sections 8.2.1 and 8.2.2.
2. Insert the probe tube into the patient’s ear canal. See Section 8.2.3.
3. Input the patient’s audiogram to generate a target, if desired. See Section 8.3.
4. Press [EXIT] in the Audiogram Entry screen to return to the Real-ear Navigation screen.
5. Enter the Real-ear SPL screen by using [F4] in the Real-ear Navigation screen.
6. Select the desired ear with [F1].
7. Level the sound field speaker. See Section 8.2.4.
8. Measure the unaided response, if desired. See Section 8.4.3 for details.
9. Insert the hearing aid into the ear, being careful not to move the probe tube.
10. Use [F2] to select REAR 2. By default, this curve is set to 50 dB SPL (i.e., soft speech). To adjust the input level, use the up-down arrow keys.
11. Select the signal source with the [F5] button. Digital Speech is a good source type to use when measuring most hearing aids. (Press [F5] to open the pop-up

- selection menu. Use the up-down arrow keys to make the desired selection. Press the right arrow key to complete the selection and close the menu.)
12. Press [START] to take the measurement. When the frequency response has stabilized, press [STOP] to stop the measurement.
 13. Compare the measurement curve (Curve “2”) to the “L” target. When fitting to the prescription target, the Curve 2 should be within 5 dB of Curve L. Make any necessary adjustments to the hearing aid fitting, and repeat Step 12 above to make another measurement.
 14. Use [F2] to select REAR 3, if desired, and repeat steps 11-13 to perform a measurement at a different input level (default is 65 dB SPL) and compare Curve 3 to Target Curve M.
 15. Use [F2] to select REAR 4, if desired, and repeat steps 11-13 to perform a measurement at a different input level (default is 80 dB SPL) and compare Curve 4 to Target Curve H.
 16. Use [F2] to select REAR 5. By default, this measurement uses a puretone SHORT input signal with a 90 dB SPL level. Press [START] to perform the short pure-tone sweep and compare Curve 5 to the patient’s UCLs.
 17. Use [F1] to switch ears, if desired, and repeat the entire process for the other ear.

Note: When a linear target is selected, the L and H targets are automatically hidden. You should normally only perform measurements with these targets using REAR 3 at a medium speech level such as 65 or 70 dB SPL.

8.4.6 Working with prescription targets

The 8000 Hearing Aid Test System has the following fitting rules available: NAL-NL1, MOD NAL, NAL-RP, 1/3 Gain, 1/2 Gain, 2/3 Gain, Berger, and POGO. The NAL-NL1 and MOD NAL fitting rules are non-linear and change depending upon the amplitude of the input signal. The other fitting rules are linear and provide the same amount of gain regardless of the input level.

To display a target, the clinician must enter the patient’s audiogram in the Audiogram Entry screen. See Section 8.3.1. Values must be entered at 500, 1000, 2000, and 4000 Hz or the target will not be displayed.

The NAL-NL1 and MOD NAL targets have a number of settings associated with it that will change the prescription. Press [MENU] in the Audiogram Entry screen, Insertion Gain, or Real-ear SPL screen to change the current settings. Press [EXIT] to close the local menu when the changes are complete.

In the Insertion Gain screen, one insertion gain target is displayed in the top graph. If the NAL-NL1 or MOD NAL fitting rule is selected, this target adjusts according to the input level setting of the current selected curve. That is, if the amplitude of the source is set to 50 dB SPL, the displayed target is for a 50 dB

SPL input level. If the clinician changes the input level to 80 dB SPL, the target will decrease, showing the prescription for that input level. When the unaided (REUG 1) is selected, the target curve uses the source settings for REAR 3.

In the Real-ear SPL screen, up to three SPL targets are displayed on the screen. When NAL-NL1 or MOD NAL is the selected fitting rule, all three targets are automatically displayed. They are labeled L, M and H. The L target is tied to the input level and speech weighting selected for REAR 2. The M target is tied to the input level and speech weighting selected for REAR 3. The H target is tied to the input level and speech weighting selected for REAR 4. That is, if the clinician changes the input level or speech weighting of REAR 2, 3 or 4, the corresponding SPL target will also adjust.

If a fitting rule other than NAL-NL1 or MOD NAL is selected, only the M target is displayed, which is tied to REAR 3. If desired, the clinician can turn on the display of the other two targets using [F3], but these targets will be linearly related to each other. That is, unlike with the NAL-NL1 or MOD NAL non-linear targets, the shape of the linear target will not change as the input level of the input signal changes.

8.4.7 Using Semi-Auto and Fully-Auto Mode

The Real-ear Insertion Gain and Real-ear SPL screens have basic implementations of Semi-Automatic and Fully-Automatic test modes. In Semi-Automatic mode, the analyzer automatically advances to the next measurement curve when the measurement is stopped. That is, if the user selects REUR 1 and takes a measurement, the analyzer will automatically advance the curve selection to REAR 2. This eliminates the need for the clinician to press [F2] and manually advance to the next curve. Semi-automatic mode is available in both the Real-ear Insertion Gain and Real-ear SPL screens.

To activate semi-automatic mode:

1. Enter the Real-ear Insertion Gain or Real-ear SPL screen.
2. Press [MENU] to open the local menu.
3. Select Auto Test under Measurements [▼, ▲]. Pressing [START] will jump to the beginning of the next section in the local menu.
4. Choose Semi-Auto using [◀, ▶].
5. Press [EXIT] to return to the real-ear measurement screen. The analyzer will now be in Semi-Automatic mode.

Fully automatic mode automatically measures REAR 2, REAR 3, REAR 4, and REAR 5 in quick succession. When REUR 1 is selected, after pressing [START] to perform the unaided measurement, the user must still press [STOP] to stop the test. This will automatically advance the curve selection to REAR 2, but no measurement will be taken until the [START] button is pressed again.

Fully-automatic mode is only available in the Real-ear SPL screen. It is not an option in the Real-ear Insertion Gain screen.

To activate fully-automatic mode:

1. Enter the Real-ear SPL screen.
2. Press [MENU] to open the local menu.
3. Select Auto Test under Measurements [▼, ▲]. Pressing [START] will jump to the beginning of the next section in the local menu.
4. Choose Fully-Auto using [◀, ▶].
5. Press [EXIT] to return to the Real-ear SPL screen. The analyzer will now be in Fully-Automatic mode.

8.4.8 Testing with a single tone or three frequency average

It is sometimes useful to be able to look at a hearing aid's response to a single frequency or to a repeating three-frequency sequence. To measure with one of these selections:

1. Enter the Real-ear Insertion Gain or Real-ear SPL screen.
2. Press [MENU] to enter the local menu.
3. Select Static Tone under Source using [▼, ▲]. Pressing [START] will jump ahead to the beginning of the next section in the local menu.
4. Choose Single or Avg using [◀, ▶]. If choosing Avg for a three-frequency average, use the Avg Freqs setting to select the highest frequency of the three frequency average. See Section 2.3.1.1 for more details on the available frequencies.
5. Press [EXIT] to return to the measurement screen.
6. Press [START] to start the test. If performing a SINGLE test, use [◀, ▶] to adjust the frequency of the tone.
7. Use [▼, ▲] to adjust the amplitude of the test signal.
8. Press [STOP] when the measurement is complete.

8.4.9 Using the reference microphone

When determining the gain of a hearing aid, the analyzer normally subtracts the response measured by the probe tube from the sound field measured by the reference microphone positioned outside the ear. This occurs when the reference microphone is ON. If you are in a particularly noisy environment or if you are testing an open fit hearing aid, the reference microphone measurement could introduce unwanted artifacts into your testing.

When the reference microphone is disabled, the analyzer uses the information determined during the leveling process to determine the signal outside the ear during the measurement. It is very important that the patient remain still after leveling and that the sound field is undisturbed, particularly if the reference microphone has been disabled.

To enable/disable the reference microphone:

1. Enter the Real-ear Insertion Gain or Real-ear SPL screen.
2. Press [MENU] to enter the local menu.
3. Select Reference Mic using [▼, ▲] under Measurements.
4. Use [◀, ▶] to choose ON or OFF.
5. Press [EXIT] to return to the measurement screen.

8.4.10 Viewing numerical curve data

The frequency response curves measured by the 8000 test system can be viewed in either the standard graphical format or in data format, allowing the clinician to take a look at the actual numerical values of the measurements.

To view curve data in the Real-ear Insertion Gain screen:

1. Enter the Real-ear Insertion Gain:
2. Press [MENU] to enter the local menu.
3. Select Data/Graph under Display using [▼, ▲].
4. Use [◀, ▶] to choose:
 - AIDED DATA: To view selected aided curve.
 - IG DATA: To view selected insertion gain curve.
 - GRAPH: To view in standard graphical (non-numeric) format.
5. Press [EXIT] to return to the Insertion Gain screen. Instead of the measurement graphs, you will now see tables of numerical data. See Figure 8.4.9.
6. Use [F2] to select the curve you want to view. Depending upon your selection in Step 3, you will either see the insertion gain or the aided gain results.

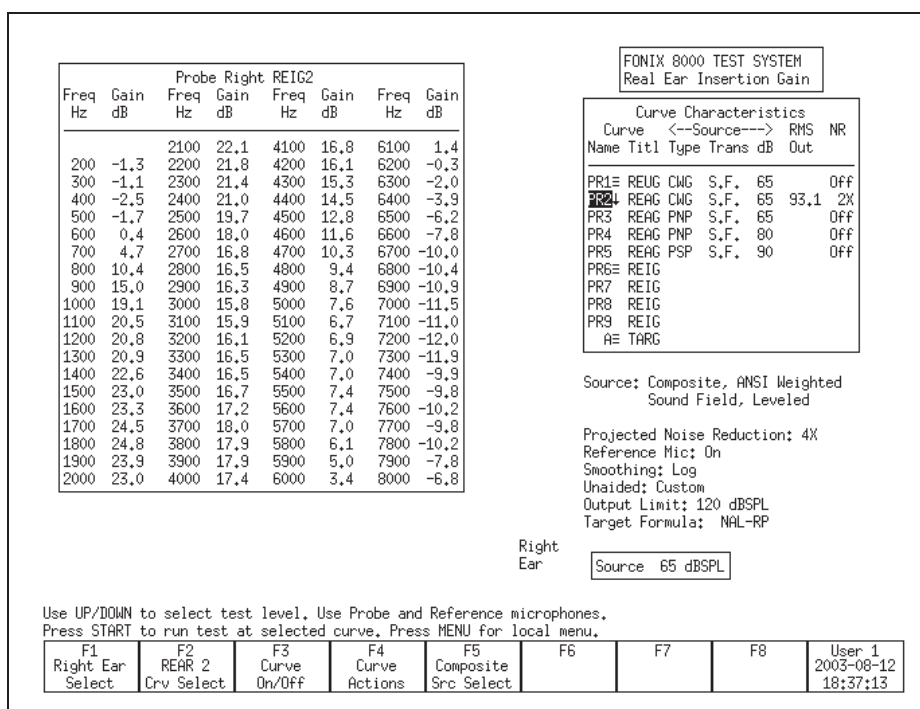


Figure 8.4.9—Insertion Gain data format display

To view curve data in the Real-ear SPL screen:

1. Enter the Real-ear SPL screen:
2. Press [MENU] to enter the local menu.
3. Select Data/Graph under Display using [▼, ▲].
4. Use [◀, ▶] to select DATA.
5. Press [EXIT] to return to the Real-ear SPL screen. The numerical data display will be shown.
6. Use [F2] to select the curve data you want to display.

8.4.11 Temporarily Clearing the display and Deleting measurements

It is often convenient to temporarily clear one or more of the measurement curves without deleting them.

To turn the display of a curve on/off without deleting it:

1. Press [F3] to open the pop-up menu with the curve selections.
2. Use [▼, ▲] to select the curve you want to turn off or on.
3. Use [▶] to toggle the display of the selected curve and close the menu. Alternately, press [START] to toggle the display but leave the pop-up menu open. This will allow you to quickly make another display change without closing the menu. Press [F3] to close the menu.

Note: The status of each curve is displayed in the Curve ON/OFF menu. ON means the curve is measured and displayed. OFF means the curve is measured and not displayed. NO means the curve has not been measured.

To permanently delete a curve:

1. Press [F2] to select the curve you want to delete.
2. Use [F4] to delete the selected curve. The following selections are available:
 - DELETE SELECTED CURVE: Deletes the curve but retains the curve settings such as the source type and source level.
 - DELETE SELECTED CURVE AND SETTINGS: Deletes the curve and return the source type and level to their default settings.
 - DELETE ALL CURVES: Deletes all curves but retains the curve settings.
 - DELETE ALL CURVES AND SETTINGS: Deletes all curves and returns curve settings to their default selections.

8.4.12 Using Smoothing in measurement curves

Smoothing averages together points in a response measurement in order to achieve a smoother response curve. This is useful for reducing artifacts that might be introduced in a noisy testing environment, but it can also decrease the accuracy of the curve. See Figure 8.4.11 for a comparison of a measurement curve with and without smoothing.

In composite log smoothing:

- From 200 Hz - 2000 Hz, measured data points from three consecutive frequencies 100 Hz apart are averaged to get the curve point at the center frequency.
- From 2000 Hz - 3000 Hz, measured data points from five consecutive frequencies 100 Hz apart are averaged to get the curve point at the center frequency.
- From 3000 Hz - 8000 Hz, measured data points from seven consecutive frequencies 100 Hz apart are averaged to get the curve point at the center frequency.

In normal pure-tone log smoothing:

- Each center frequency is smoothed by averaging it together with the outputs from the next upper and lower 12th octave frequency.

To turn on/off log smoothing:

1. Enter the measurement screen.
2. Press [MENU] to enter the local menu.
3. Use [▼, ▲] to select Smoothing under Display.

4. Use [◀, ▶] to choose LOG or OFF.
5. Press [EXIT] to return to the measurement screen. All measurements will have the chosen smoothing status.

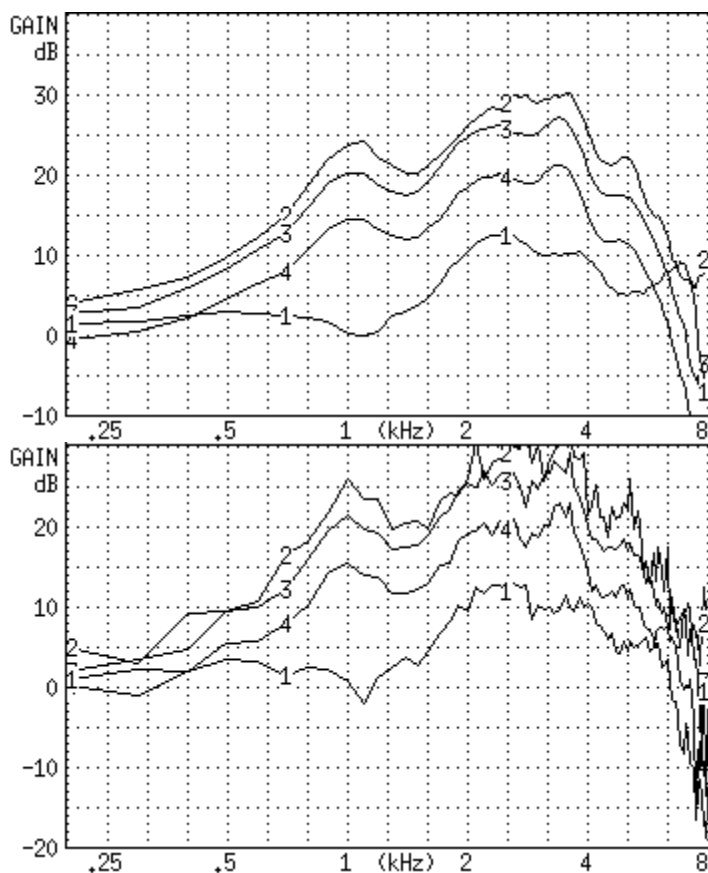


Figure 8.4.11—A comparison of a smoothed (top) and unsmoothed (bottom) curve.

8.4.13 Using Output Limiting

When performing real-ear measurements, it is very important not to expose your client to noises that could conceivably further damage his hearing. For this reason, the 8000 test system has built-in *output limiting*. When the probe microphone reads a value above the output limit at any frequency, the test will automatically stop.

The default setting for the output limit is 120 dB SPL. In the real-ear measurement menu, you can change this limit to any value from 80 dB SPL to 140 dB SPL in 5 dB steps.

Be aware that extra care is necessary with any output that may exceed 132 dB SPL. Also, keep in mind that the sound pressure level at the eardrum can be higher than that measured at the mid-ear canal position, especially at high frequencies. For this reason, extreme caution is advised when performing real-ear measurements with a source level of 90 dB SPL or higher.

To change the output limit:

1. Press [MENU] to enter the real-ear measurement menu.
2. Press [▼, ▲] to select Output Limit under Measurements.
3. Use [◀, ▶] to choose the desired limit.
4. Press [EXIT] to return to the real-ear measurement screen.

8.4.14 Measuring the occlusion effect

You can use the Insertion Gain screen in order to measure the “occlusion effect” of a hearing aid. By analyzing the spectrum of your client’s own voice, you can judge whether the occlusion effect will make the hearing aid uncomfortable, and you can measure an improvement (lessening) of the occlusion effect after adjusting the vent opening.

To measure the occlusion effect:

1. Enter the Real-Ear Navigation screen by pressing [F2] from the Opening screen.
2. Follow the instructions in Section 8.2.3 to insert the probe tube into the client’s ear. You do **not** have to level the sound field speaker for this measurement.
3. Insert the hearing aid in the client’s ear, being careful not to move the probe tube. The hearing aid can be turned on or off.
4. Enter the Insertion Gain screen by pressing [F3] from the Real-Ear Navigation screen.
5. Use [F2] to select the REUR 1 curve. (Press [F2]. Use [▼, ▲] to select REUR 1. Press [▶] to complete the selection and close the pop-up menu.)
6. Use [F5] to select a source type of COMPOSITE.
7. Press [▼] repeatedly until the chosen source is OFF.
8. Press [START] to start the measurement.
9. Instruct your client to sustain the vowel sound “eee.”
10. Press [STOP] while the “eee” is still sounding, and the curve has stabilized. The client can now stop vocalizing.
11. Look at the amplification in the low frequencies. If it seems high, you may consider adjusting the vent to a more open condition, to prevent occlusion-effect discomfort.

12. Press [F2] to select the REAR 2 curve. Make sure that COMPOSITE is the selected source type, and that the source is turned OFF. Use [F5] and [▼] to make these selections, if necessary.
13. Press [START] to start a second measurement
14. Ask the client to sustain an “eee” sound again. Press [STOP] during the vocalization when the measurement has stabilized. (You can then tell your client to stop.)
15. Examine the REAR 2 curve in the lower graph and the corresponding REIR curve in the upper graph. REAR 2 is a measurement of the occlusion effect with the adjusted vents. The REIR curve in the upper graph is a measurement of the difference between the two vent configurations.

8.5 Digital Hearing Aids

All digital aids can be tested, but some of the high-end models require a little more thought and care; these aids have a “noise suppression” feature (also known as “speech enhancement”). This noise suppression, not to be confused with the automatic compression of AGC hearing aids, checks if the sound going into the hearing aid is a continuous signal that could be regarded as noise. If the aid decides that the sound is noise, it lowers the gain at the corresponding frequencies. Conventional testing techniques, such as a pure-tone sweep or the Composite signal, can cause the high-end digital aid to go into this noise reduction mode. This means that the gain or output you see on the analyzer’s display will not necessarily reflect the normal response of the aid in speech.

8.5.1 Using Digital Speech

The Digital Speech signal was developed in order to test noise-reducing digital hearing aids without fear of them going into noise suppression mode. It does this by taking the standard Composite signal and interrupting it randomly. The digital hearing aid responds to this modulated signal as it would response to normal speech.

The advantage of Digital Speech is that the 8000 analyzer treats it just as another signal source. You don’t have to test the digital hearing aid any differently than you would test a normal analog hearing aid. Just choose Digital Speech as your testing signal using the [F5] function key in one of the real-ear testing screens.

8.5.2 Choosing a speech weighting

By default, the Digital Speech (and Composite) signal uses the ANSI S3.42 speech weighting. Some clinicians, however, prefer to test using the ICRA speech weighting, which was used in the development of some digital hearing aids. The ICRA weighting available on the 8000 analyzer is based on the ICRA CD track #1, “unmodulated moderate male weighted artificial speech,” developed by the International Collegium of Rehabilitative Audiologists (ICRA). See Figure 8.5.2 for a comparison of an aid being tested with the ANSI and the ICRA speech weightings.

To change the speech weighting:

1. Press [MENU] from a real-ear measurement screen.
2. Use [▼, ▲] to select Composite Filter under Source.
3. Use [◀, ▶] to choose ANSI or ICRA.
4. Press [EXIT] to return to the real-ear measurement screen. Any Digital Speech or Composite signal will use the new selected speech weighting.

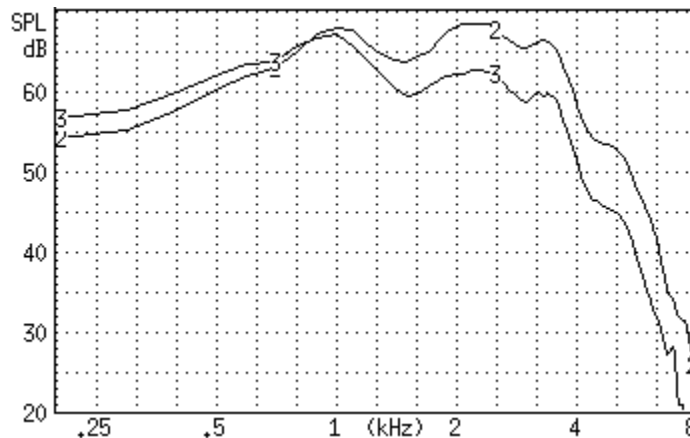


Figure 8.5.2—A comparison of an aid being tested with Digital Speech using the ICRA (CRV 3) and the ANSI S3.42 (CRV 2) speech weightings

8.5.3 Testing the digital filters

It is possible to add a bias tone to the Digital Speech signal in order to see how the aid responds in the presence of noise at different frequencies. This is useful for checking the filters of the hearing aid and determining how one channel of the hearing aid reacts to noise in a different channel of the aid.

To introduce a bias signal in a measurement screen:

1. Enter the Real-ear Insertion Gain or Real-ear SPL screen, set up the patient for real-ear measurements, and level the sound field speaker.
2. Select the Digital Speech signal source with [F5].
3. Press [MENU] to enter the local menu.
4. Select Bias Tone under Source using [▼, ▲].
5. Use [◀, ▶] to select the level of the bias signal. Choose from 40-90 dB SPL in 5 dB steps.
6. Press [EXIT] to return to the measurement screen. The Digital Speech signal will now include the pure-tone bias signal.
7. Press [START] to start the measurement.
8. Use [◀, ▶] to change the frequency of the bias signal. Notice how the aid reacts when the bias frequency is changed. Some hearing aids don't react at all to the bias while other aids react dramatically. See Figure 8.5.3.

9. Press [STOP] when done with testing. Go back into the menu to turn the bias signal OFF again.

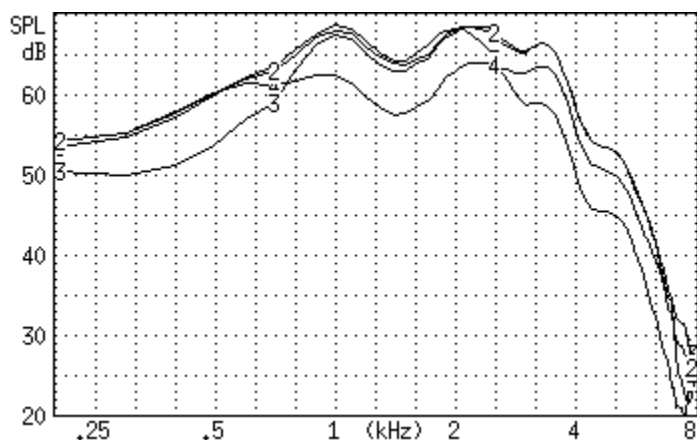


Figure 8.5.3—Using the bias signal in real-ear measurements. CRV 2–5 were measured using bias signal frequencies of no bias, 500 Hz, 2000 Hz, and 4000 Hz respectively

8.5.4 Testing digital noise suppression

The comparison of the frequency response using the Composite signal and the Digital Speech signal can be used to see how much the aid lowers its gain when subjected to a noisy signal. This is a test of the noise suppression technology on the hearing aid.

1. Enter the Real-ear Insertion Gain or Real-ear SPL screen, set up the patient for real-ear measurements, and level the sound field speaker.
2. Use [F2] to select REAR 2. (Press [F2]. Use [▼, ▲] to select REAR 2. Press [►] to complete the selection and close the menu.)
3. Use [F5] to select Digital Speech.
4. Use [▼, ▲] to set the source amplitude to 65 dB SPL.
5. Press [START] to measure the frequency response of the hearing aid. Press [STOP] when the measurement has stabilized.
6. Use [F2] to select the REAR 3.
7. Use [F5] to select Composite.
8. Use [▼, ▲] to set the source amplitude to 65 dB SPL.
9. Press [START] to start the measurement. After the measurement has stabilized, press [STOP] to stop the measurement. Figure 8.5.4 illustrates an example of a digital hearing aid with noise suppression. Curve 2 shows the response of the aid to the Digital Speech curve, and Curve 3 shows the response of the aid to the Composite signal.

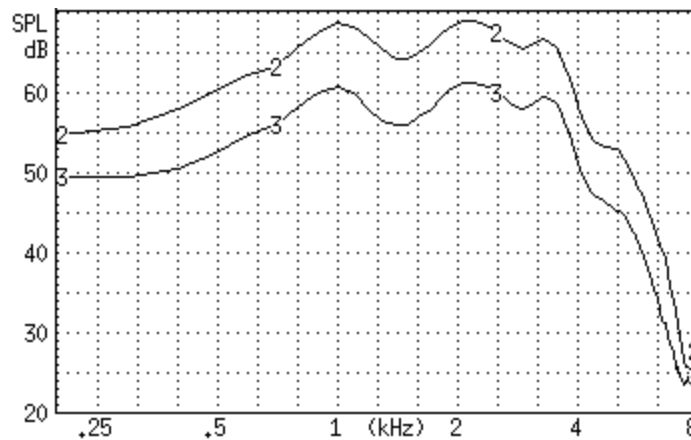


Figure 8.5.4—Testing noise suppression of a digital hearing aid. REAR 2 was tested using Digital Speech. REAR 3 was tested using the Composite Signal.

8.6 Directional Hearing Aids

A hearing aid directional response pattern can be directly measured with the 8120 sound chamber, using the coupler directional test screen. The anechoic environment of this small chamber, coupled with a mechanical rotator system, can inform the operator exactly where the optimal gain and the attenuation angles occur.

The real ear test system, using the insertion gain screen, can give additional information on the aid's directional pattern while it is worn by the actual patient. It should be realized that the ear and head structure by itself has directional characteristics, sometimes called the head shadow effect. An aid which is considered omnidirectional can display directional characteristics because of this effect. A good directional aid should show very strong directional characteristics when using the real ear insertion gain approach described in this section.

8.6.1 Using the insertion gain technique

The Real-ear Insertion Gain screen is ideal for performing real-ear measurements of hearing aid directionality.

To test directionality:

1. Set up the patient for real-ear measurements by inserting the probe microphone and hearing aid.
2. Place the sound field speaker behind the patient at 180° or 135° azimuth. Point the reference microphone of the probe microphone set towards the sound field speaker.
3. Enter the Real-ear Insertion Gain screen.
4. Press [LEVEL] to level the sound field speaker.

5. Use [F2] to select REUG 1. (Press [F2] to open the pop-up selection menu. Use [▼, ▲] to select REUG 1. Press [►] to complete the selection and close the menu.)
6. Use [F5] to set the source type to DIG SPEECH.
7. Use [▼, ▲] to set the source amplitude to 50 dB SPL.
8. Press [START] to start the frequency response measurement. When the measurement has stabilized, press [STOP]. This is the “reverse” measurement curve.
9. Use [F2] to select REAG 2.
10. Use [F5] to set the source type to DIG SPEECH.
11. Use [▼, ▲] to set the source amplitude to 50 dB SPL.

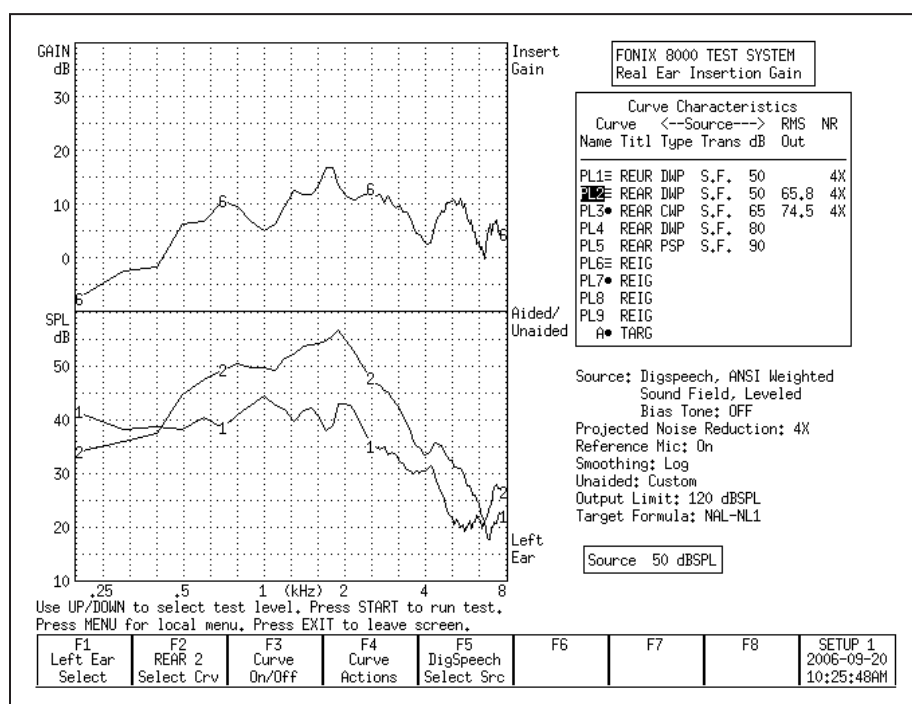


Figure 8.6.1—Testing directionality. REUR 1 was tested with the source at 135° azimuth. REAR 2 was tested with the source at 45° azimuth. Curve 7 illustrates the directional advantage of the hearing aid.

12. Reposition the patient so that the sound field speaker is placed at 0° or 45° azimuth. The reference microphone should be repositioned so that it is facing towards the sound field speaker.
13. Press [LEVEL] to re-level the sound field speaker. This will temporarily clear (but not erase) the reverse measurement.
14. Press [START] to start the frequency response measurement. (The “reverse” measurement will reappear when the measurement starts.) When the “forward” measurement has stabilized, press [STOP].

15. Look at the difference between the “forward” (REAG 2) and the “reverse” (REUG 1) frequency responses (Figure 8.6.1). The “forward” frequency response should show more amplification than the reverse frequency response. Take note of the differences in the RMS OUT of the two curves. This will tell you the average amount of amplification advantage that the directional microphones provide.

8.6.2 Determining the “null”

When performing a directional test, the position of the sound field speaker can be used to determine the “null” of the directional microphones. The “null” is the azimuth at which the directional hearing aid provides the least amount of amplification.

To determine the null, follow Steps 1-8 in Section 8.6.1 to measure the reverse curve. While performing this measurement, move the sound field speaker around the patient (this is easier using a speaker on a swing arm than a floor stand). Try to keep the speaker equidistant from the patient while moving the speaker in a semi-circle behind him.

Look at the frequency response as the speaker is moved. If the aid is directional, its frequency response will decrease as the speaker is moved from the front of the patient to the back of the patient. The angle at which the frequency response is at its lowest is the “null” of the directional hearing aid.

8.7 Open Fit Hearing Aids

Open fit hearing aids require additional consideration during real-ear measurements because of the special technology used by these aids to eliminate feedback. This feedback suppression technology can interfere with the sound field measured by the reference microphone outside the ear. Therefore, in order to get an accurate real-ear measurement of an open-fit hearing aid, the reference microphone of the 8000 Hearing Aid Test System should be disabled.

To set up the analyzer for open fit real-ear testing:

1. Enter the Real-ear Insertion Gain or Real-ear SPL screen.
2. Press [MENU] to open the local menu.
3. Select Reference Mic under Measurements with [▼, ▲].
4. Choose Off with [►].
5. Press [EXIT] to close the local menu.
6. Level the sound field speaker as usual (even though the reference microphone is disabled for measurements, it will still be used for leveling).
7. Test as usual. With the reference microphone disabled, it is even more critical than usual that the patient not move after leveling and that the sound field be undisturbed during testing.

8.8 Visible Speech

The Visible Speech screen, shown in Figure 8.8, is a special screen used for performing real-ear measurements with pre-recorded speech, live speech, or several other broadband signals. Visible Speech was designed to demonstrate the real-time response of the hearing aid to the signal, the average response of the aid over the time of the test, and the minimum and maximum amplitudes of each frequency. These measurements can be compared to the patient's thresholds, uncomfortable levels, real-ear target(s), and the long-term average speech spectrum.

The Speech Intelligibility Index (SII) is calculated for each test. In general terms, SII represents an indexed value in the range 0-100 representing the proportion of all cues carried in verbal speech that are available to a particular listener. See Section 8.8.5 for more technical details on SII and how it is calculated on the 8000 Hearing Aid Test System.

When first entering the Visible Speech screen (Figure 8.8), the following is displayed:

- Shaded areas below and above the patient's threshold and uncomfortable values, respectively. The non-shaded area in the center of the graph represents that patient's dynamic range of hearing.
- **L, M, H** dotted lines indicating the real-ear prescriptive targets at 50, 65, and 80 dB SPL. When NAL-NL1 or MOD NAL is not the selected fitting rule, only the M target (65 dB SPL) will be displayed.
- **l, m, h** dotted lines indicating the region of average unamplified speech. These lines are called collectively the LTASS (long term average speech spectrum). They can be used as a comparison against the amplified speech response.

There are several different broadband signals available in the visible speech screen:

- Visible: external signal. The FONIX 8000 will not generate the input signal.
- ISTS: International Speech Test Signal. Please see Chapter 7 for more details.
- Eng Male: Pre-recorded male speaker
- Eng Female: Pre-recorded female speaker
- White Noise: Broadband signal with equal power at all frequencies
- Pink Noise: Broadband speech-weighted signal

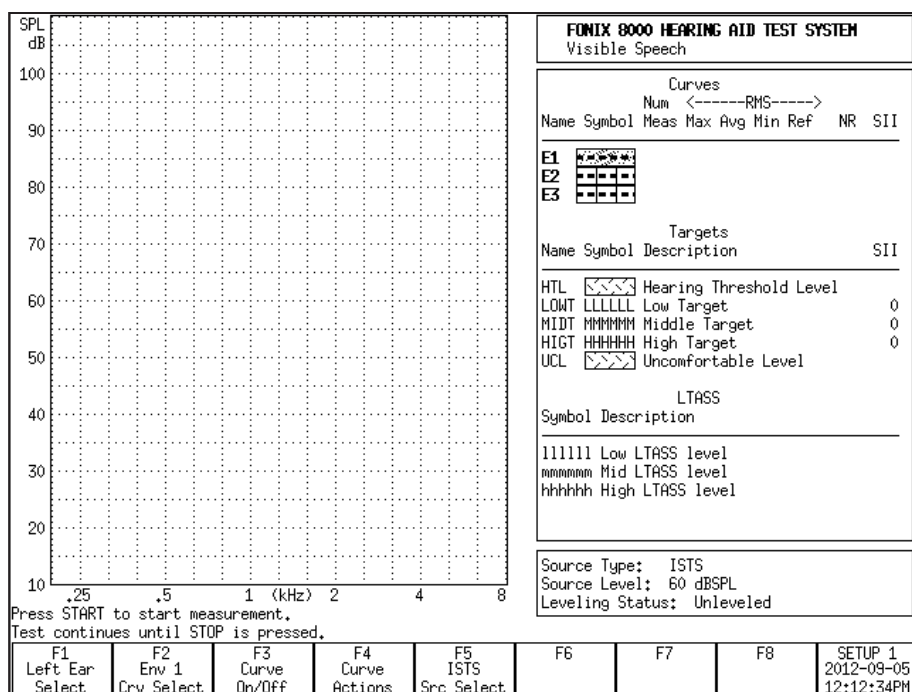


Figure 8.8—Visible Speech screen before a measurement is taken. The shaded regions are below and above the patient's thresholds and uncomfortable levels. The L, M and H lines represent the real-ear targets at 50, 65 and 80 dB SPL. The l, m and h lines represent the region of unamplified speech.

8.8.1 Performing Visible Speech measurement

1. Enter the patient's audiogram into the analyzer, as described in Section 8.3.1.
2. Press [EXIT] from the Audiogram Entry screen to return to the Real-ear Navigation screen.
3. Press [F5] to enter the Visible Speech screen.
4. Insert the probe microphone into the patient's ear with the reference microphone above the ear, as described in Sections 8.2.2 and 8.2.3.
5. Insert the hearing aid into the ear, being careful not to move the probe tube.
6. Situate the patient in front of the person who will be providing the live speech stimulus, or the loudspeaker providing the external signal.
7. Select the source type with [F5].
8. Select the input level by using the up-down arrow keys.
9. Level the sound field speaker with the [LEVEL] button (not needed when the external "visual" source type is selected)
10. Press [START] on the 8000 analyzer. This will start the Visible Speech measurement.

8.8.2 Viewing the Real-time Visible Speech Display

During the Visible Speech test, the analyzer displays four changing measurement curves:

- Real-time measurement curve showing the immediate response of the hearing aid
- Average frequency response of the hearing aid over the time of the test
- Maximum amplitude of the response per frequency (optional)
- Minimum amplitude of the response per frequency (optional)
- Reference microphone frequency response measured outside of the ear (optional)

These measurements together give the clinician both the real-time response of the hearing aid and information about its response over the time of the test.

Press [STOP] when the average response curve has stabilized. This may take 30-60 seconds.

The minimum and maximum amplitude curves can be turned off by adjusting the Min/Max setting in the local menu.

8.8.3 Viewing Completed Test Results

When the Visible Speech measurement is stopped, the following changes occur:

- The region around the average frequency response curve is darkly shaded. This region represents the standard deviation of the average response curve. That is, the area containing most of the frequency response curves measured during the test.
- The real-time measurement curve disappears. Since this curve represents the latest measurement of an ever-changing speech signal, it is not relevant to the overall test results displayed upon test completion.
- The region between the minimum and maximum response curves is lightly shaded. This indicates the entire region of the frequency response of the hearing aid over the time of the test. If desired, you can turn off this part of the display by adjusting the Min/Max setting in the local menu.

See Figure 8.8.3 for an example of a completed Visible Speech measurement. The curves consisting of Envelope 2 are labeled:

- 2U—Represents the maximum response per frequency over the time of the test.
- 2u—Represents the upper boundary of the standard deviation around the average frequency response.
- 2M—Represents the average frequency response of the test.
- 2l—Represents the lower boundary of the standard deviation around the average frequency response.
- 2L—Represents the minimum response per frequency over the time of the test.

Other Visible Speech envelope measurements are labeled similarly using the number of the envelope.

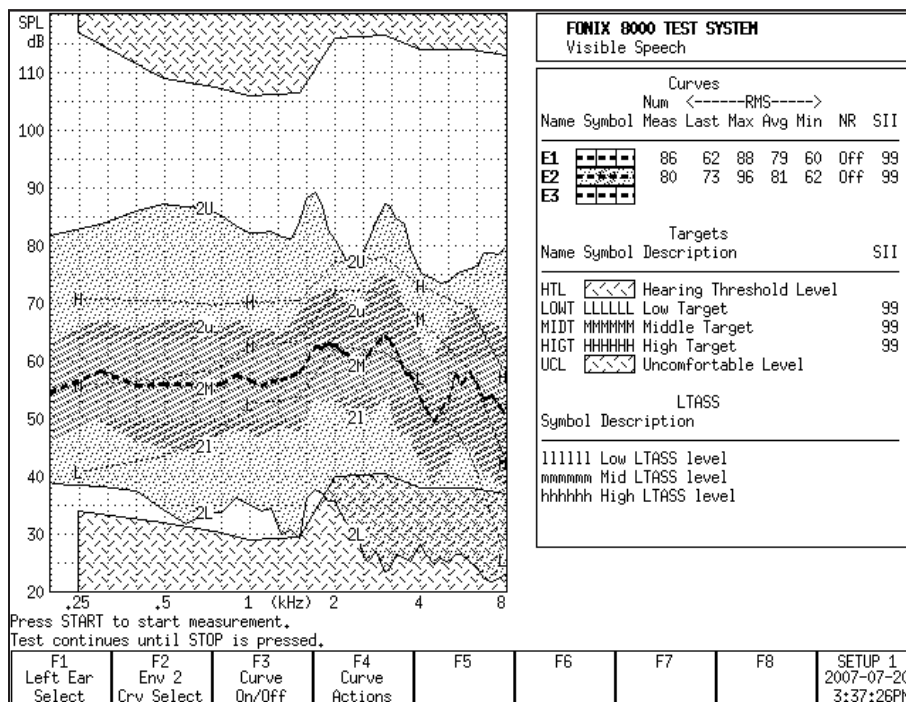


Figure 8.8.3—Completed Visible Speech test.

8.8.4 Measuring multiple envelopes

The clinician can measure up to three different Visible Speech envelopes. For example, it may be beneficial to perform measurements of the different programs on the hearing aid.

Another example of the usefulness of multiple measurements is when using the voice of the spouse of the patient. Have the spouse stand a few feet from the patient when measuring Visible Speech Envelope 1. Then use [F2] to select Visible Speech Envelope 2. (Press [F2]. Use [▼, ▲] to select the desired envelope. Press [►] to complete the selection and close the pop-up menu.) Repeat the test with the spouse standing across the room from the patient. A comparison of the two envelopes can demonstrate to the patient and the spouse how close they need to be to each other in order for speech to be easily audible.

When multiple envelopes have been measured, the selected envelope measurements are brighter and more visible than measurements of the other envelopes. To view a different Visible Speech envelope, use [F2] to select it, or use [F3] to temporarily turn off the display of the other envelopes.

If the screen looks too busy, you can turn off the minimum and maximum

curves by adjusting the Min/Max setting in the local menu. This disables the minimum and maximum curves for all envelopes.

8.8.5 Using the Reference Microphone

When the reference microphone is enabled in the local menu, the RMS measurement of the reference microphone is displayed in the Curve Characteristics box. This number represents the average energy of the signal before it enters the ear canal. By comparing this measurement to the RMS of the average curve, the clinician can determine the average amount of gain provided by the hearing aid during the test.

To enable the reference microphone:

1. Press [MENU] in the Visible Speech screen.
2. Select Reference Mic with [▼, ▲].
3. Use [▶] to select On.
4. Press [MENU] to close the local menu and return to the Visible Speech screen.

The entire frequency response of the reference microphone can also be displayed while the test is running. This allows the clinician to compare the frequency response of the input signal to the response of the output signal measured by the probe microphone. This curve is NOT displayed when the test is not running. To enable this curve, use [F3] and toggle on the Ref Mic curve.

8.8.6 Technical Information about the Speech Intelligibility Index

The Visible Speech screen contains the Speech Intelligibility Index for the measured curves and the target. The Speech Intelligibility Index is derived from the ANSI S3.5-1997 standard, "Methods for Calculation of the Speech Intelligibility Index."

Theory

In general terms, SII represents an indexed value in the range 0-100 representing the proportion of all cues carried in verbal speech that are available to a particular listener. This does NOT equal the proportion of verbal speech that is correctly understood by the listener, although the proportion of speech correctly understood can often be deduced from the SII score with reasonable accuracy.

In the calculation of SII, it is generally held that speech cues occur equally distributed in amplitude through the loudest 30 dB of SPL of the speech, and unequally distributed in frequency in a range from approximately 100 Hz to 9500 Hz, with a concentration of cues in the range from roughly 400 Hz to 4000 Hz. When various factors combine for a given listener such that, for at least some portion of the frequency range, the effective SPL range from the noise floor to the peak SPL is less than 30 dB, that listener will perceive fewer speech

cues than are available in the totality of the speech. While in general such factors include sound reverberations, echoes, interference, and background noise, we have a particular interest in the effect of hearing loss.

Hearing loss is treated in this calculation as an effective raising of the noise floor of the listener, and is generally measured as such. The audiogram method of measurement determines, for particular pure frequencies, the amplitude at which sound becomes perceptible by a subject listener. To the extent that this level is greater than the average such level across listeners considered to have good hearing, the subject listener has a higher than normal effective noise floor. The SII value is an attempt to quantify the effect of this higher effective noise floor on the reception of speech cues.

In an ideal world, in which continuous measurements may be made at arbitrary granularity and precision, the SII would be calculated as the integral across frequency of the peak SPL observed during speech less the effective noise floor, weighted according to the relative importance of each frequency. In practice, SII is calculated as the sum of values observed in relatively few non-overlapping frequency bands, with weighting coefficients determined experimentally. Within each frequency band, the peak speech SPL is determined, and the noise floor subtracted from this peak. The result is then truncated to a range of 30 dB to 0 dB.

This value is a SPL value representing the available signal space from noise floor to peak, within that frequency band. This value is then divided by 30 dB, the theoretical maximum signal space for speech across all frequencies, to obtain a value in the range 0.0 to 1.0 representing the proportion of the theoretical maximum signal space that is available in this frequency band. This operation is performed for all frequency bands.

Then, in each frequency band, the proportion available value is multiplied by the weighting factor for the band, and the results are summed. Weighting factors account for the relative importance, or speech cue density, of the various frequency bands, and are scaled such that the resulting sum is 1.0 when the full 30 dB of signal space is available in all bands. This sum is then multiplied by 100 to yield an SII value in the range 0-100.

Historically, determination of speech peaks has been by indirect means. Early researchers measured average SPL across an extended period, and assumed that the 30 dB range of speech cues was distributed from 12 dB above this average to 18 dB below it. Consequently, early researchers determined speech peaks as 12 dB plus the average measured SPL in each frequency band. Subsequent research has tended to shift the range a bit higher, and most recent work (including the current ANSI standard) places the range from 15 dB above to 15 dB below the measured average SPL in each band. These approaches of adding an offset to an observed average stem from limitations of measurement tools that only allow analysis on time windows of 125ms or longer, a time resolution much longer than the duration of fast, loud components of speech, such as plosives.

With the 8000, we offer an additional option for the speech peak: the actual measured peak. Since we are recording and analyzing 10 ms time slices of speech, we may be reasonably confident of capturing plosives and accurately capturing the actual peak SPL of a speech sample.

Implementation:

SII is implemented in the Visible Speech screen of the 8000. Within this screen, the user has a menu choice of using the measured peak for speech peaks, or using the measured average plus 12 dB, or using the measured average plus 15 dB. Pre-existing logic within the 8000 converts the entered audiogram into the perception threshold (the HTL values expressed in SPL).

Once speech peak values are available (which generally means once measurement has been started), for each plotted frequency, the difference between the speech peak and the HTL is taken, trimmed to the 0-30dB range, and scaled by the weighting factor for the range. The resultant values are summed, and then result is scaled to the appropriate 0-100 range. This resulting SII value is displayed in the curve characteristics box in the rightmost column.

The frequency weights used were derived from values given in “Derivation of primary parameters and procedures for use in speech intelligibility predictions”, Chaslav V. Pavlovic, J. Acoust. Soc. Am 82(2), August 1987. These weights are obtainable from the 8000 via RS232 using the Get List command when in the Visible Speech major mode. The frequencies used for the frequency bins are obtainable via the same command. The Set List command may be used to send arbitrary weights to the instrument for use in SII calculation. When the weights in use differ from those supplied by default, an asterisk (*) appears next to the SII value on screen.

For calculating SII values for targets, each target is treated as if it were the mean value of a speech envelope. When peaks are set as mean+12 dB or mean+15 dB, target peaks are similarly calculated as target+12 dB or target+15 dB. When the speech peak is set as the measured peak, the target peak is calculated as the target plus the difference between the measured peak and the measured mean. In other words, if the entire measured envelope were shifted in each frequency band, up or down as necessary, until the measured mean was right on the target, the shifted measured peak would define the values used for the target peak. Otherwise, the SII measurement proceeds in the same manner as for a measured envelope.

Settings:

The following settings are available in the Visible Speech local menu. You can reach the local menu by pressing [MENU] while in the Visible Speech screen.

- Noise Reduction (Comp): 0, 2X, 4X, 8X, 16X. This determines how much averaging the real-time measurement curve does while the test is running. Larger numbers do more averaging. Lower numbers do less.

- **SII Peaks:** Measured, Mean+15dB, Mean+12dB. This setting determines how the SII is calculated. The Measured setting uses the actual measured peak values in the calculation. The Mean settings use the average measurement curve and add the specified value to determine the peak value used in the SII calculation.
- **Smoothing:** Off, Log. This setting controls the smoothing used by the Visible Speech curves. Turning smoothing off shows more accurate measurement data. Turning smoothing on gives a nicer presentation.
- **Min/Max:** Off, On. This setting controls the display of the minimum and maximum curves in the Visible Speech display.
- **Reference Mic:** Off, On. This setting enables the reference microphone RMS measurement in the Curve Characteristics box and allows the user to enable the Reference Microphone curve with [F3].

8.9 CROS/BICROS Aids

When performing real-ear measurements on a Body aid, CROS, or Bi-CROS aid, we suggest the following setups and procedures.

Four Goals:

8.9.1—Measuring the Head Baffle Effect

8.9.2—Measuring the Overcoming of the Head Baffle Effect

8.9.3—Measuring the Overall Insertion Gain

8.9.4—Measuring the Insertion Loss to the “Good” Ear

Each of these measurements uses the insertion gain measurement technique, taking advantage of the fact that the insertion gain is a difference curve between two measured curves (usually the unaided and aided response). The techniques assign the label of “unaided” to one measurement and a label of “aided” to another measurement.

Take all measurements in the Insertion Gain Screen. For measurements labeled “Unaided” (even if they aren’t unaided) follow the instructions in Section 8.4.1.2. For measurements labeled “Aided” (even if they aren’t aided) follow the instructions in Section 8.4.1.3.

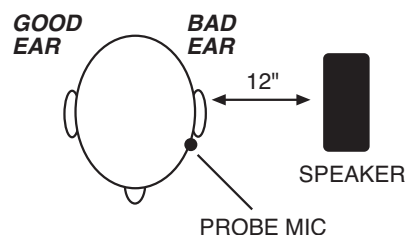
8.9.1 Measuring the Head-Baffle Effect

The measurements described in this section are for both CROS and BI-CROS hearing aids.

Unaided—Real Ear response on “bad ear” side

Set up the 8000 test system as follows.

- System UNLEVELED
- Reference microphone OFF
- Unaided CUSTOM
- Probe microphone over the bad ear, tube jutting just slightly forward of pinna
- Loudspeaker at 90°, 12 inches from bad ear

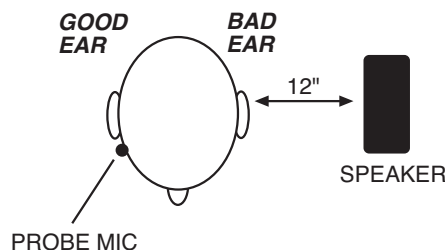


Aided—Real Ear response on “good” ear side

Same setup as above except:

- Probe microphone over the good ear

The difference curve, labeled “Insertion Gain” on the screen, shows the attenuation of sound arriving at the good ear from the bad ear side. Since this measurement excludes the external ear, differences across individuals should be minimal.



NOTE: Although the above two measurements call for the 8000 test system to be UNLEVELED with the reference microphone OFF, the rest of the measurements in this section call for the 8000 test system to be LEVELED with the reference microphone ON.

8.9.2 Measuring the Overcoming of the Head-Baffle Effect

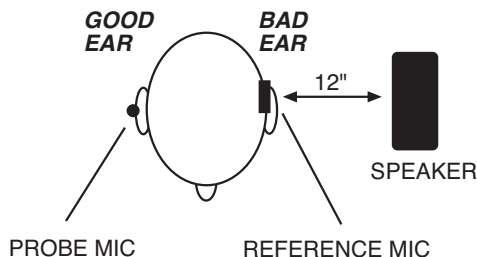
This section describes measuring how well the hearing aid overcomes the head-baffle effect. The methods are different for CROS hearing aids than they are for BICROS hearing aids.

8.9.2.1 CROS

Unaided—Measurement of “good” ear canal (baffled by head)

Set up the 8000 test system as follows.

- Reference microphone ON
- Sound field LEVELED
- Unaided CUSTOM
- Reference microphone over pinna of bad ear
- Probe microphone tube inside unoccluded ear canal of good ear
- Loudspeaker at 90°, 12 inches from bad ear



Aided—Measurement of “good” ear canal (baffle overcome by aid)

Same setup as above, except:

- Aid in place in good ear and set to normal user gain.

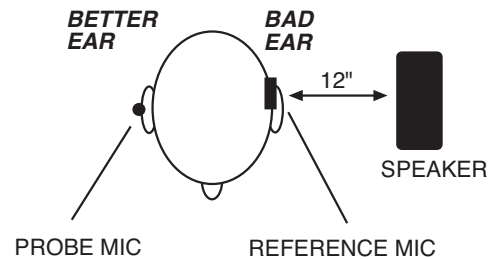
The difference curve, labeled “Insertion Gain” on the screen, shows the benefit the aid gives for sound arriving from the “bad” side.

8.9.2.2 BI-CROS

Unaided—Measurement of “better” ear canal (baffled by head)

Set up the 8000 test system as follows.

- Reference microphone ON
- Sound field **LEVELED**
- Unaided set to **CUSTOM**
- Reference microphone over pinna of “bad” ear
- Probe microphone tube inside ear canal of better ear
- Hearing aid in better ear, on, set at use gain
- Transmitter on bad side turned off
- Loudspeaker at 90°, 12 inches from bad ear



Aided—Measurement of “better” ear canal (baffle overcome by aid)

Same setup as above, except

- Transmitter on bad side turned on

The difference curve, labeled “Insertion Gain” on screen, shows the benefit of adding the second microphone for sound arriving from the “bad” side.

8.9.3 Measuring Overall Insertion Gain

The methods for measuring the overall insertion gain of CROS and BICROS aids are described in this section.

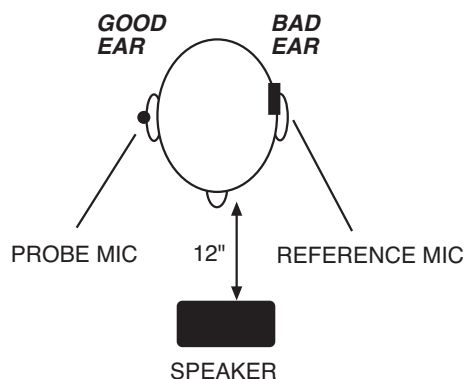
Since it has not been shown for CROS and BI-CROS instruments that a 45° position of the loudspeaker improves the reliability of insertion gain measurements, we recommend a 45° position of the loudspeaker only for monaural instruments, and a 0° position for CROS and BI-CROS instruments.

8.9.3.1 CROS

Unaided—Measurement of “good” ear

Set up the 8000 test system as follows.

- Reference microphone ON
- Sound field LEVELED
- Reference microphone over pinna of bad ear
- Probe microphone tube inside un-occluded ear canal of good ear
- Loudspeaker at 0°, 12 inches from bridge of nose



Aided—Measurement of “good” ear

Same setup as above, except:

- Aid in place in good ear and set to user gain.

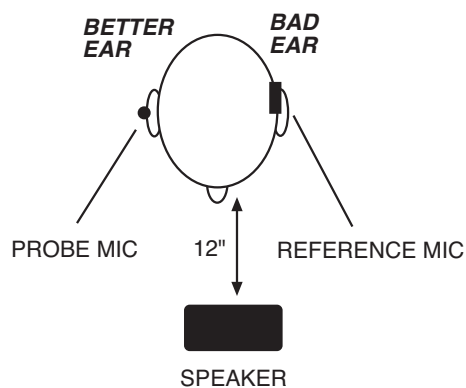
The difference curve, labeled “Insertion Gain” on the screen, shows the overall benefit of inserting the hearing aid.

8.9.3.2 BI-CROS

Unaided—Measurement of “better” ear

Set up the 8000 test system as follows:

- Reference microphone ON
- Sound field LEVELED
- Unaided response CUSTOM
- Reference microphone over pinna of bad ear
- Probe microphone tube inside un-occluded ear canal of better ear
- Loudspeaker at 0°, 12 inches from bridge of nose



Aided—Measurement of “better” ear

Same setup as above, except—

- Complete aid in place in better ear and set at use gain
- Both transmitters on

The difference curve, labeled “Insertion Gain” on the screen, shows the overall benefit of inserting the hearing aid.

8.9.4 Measuring Insertion Loss to the “Good” Ear (CROS)

The method for measuring insertion loss in the patient’s “good” ear is described in this section. They are the same for CROS and BICROS hearing aids.

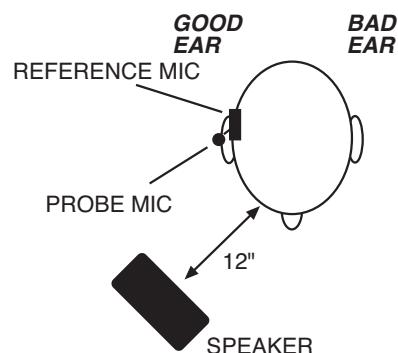
When a CROS aid has been prescribed to overcome a severe unilateral high-frequency loss, you may want to ensure that inserting an open ear mold into the good ear has not significantly attenuated the acoustic transmission to the good ear.

Since this is a monaural measurement, a 45° position of the loudspeaker is recommended.

Unaided—Unoccluded Ear canal Response of “good” ear

Set up the 8000 test system as follows.

- Reference microphone ON
- Sound field LEVELED
- Unaided CUSTOM
- Reference microphone over pinna of good ear
- Probe microphone tube inside unoccluded ear canal of good ear
- Loudspeaker at 45° toward good ear, 12 inches from surface of head



Aided—Occluded Response of “good” ear.

Same setup as above except

- Earmold in place in good ear
- Hearing aid is turned off

The difference curve, labeled “Insertion Gain” on screen, shows insertion loss, if any, caused by inserting the earmold into the good ear.

Specifications

ACOUSTICAL OUTPUTS

Frequencies:	200-8000 Hz in 100 Hz intervals (user interface) 200-8000 Hz in 50 Hz intervals (RS232)
Frequency Accuracy:	1%
Amplitudes:	40-100 dB in 5 dB intervals coupler, 40-90 dB in 5 dB intervals real-ear (user interface) 40-100 dB in 0.01 dB intervals coupler, 40-90 dB in 0.01 dB intervals real-ear (RS232)
Accuracy	Coupler: ± 1 dB from 300 to 5000 Hz, all others ± 3 dB (after leveling) Real-ear: ± 3 dB, 200-8000 Hz (after leveling)
Distortion (at 70 dB SPL):	Puretone: $< 0.5\%$, 400-2500 Hz

TELECOIL OUTPUTS

Field Strength:	1, 1.78, 3.16, 5.62, 10, 17.8, 31.6, 56.2, 100 mA/m (user interface) 0-180 mA/m in 0.01 mA/m specified intervals (RS232)
Accuracy:	± 2 dB

BATTERY CURRENT

Readout Range:	0.00-25.00 mA
Available Current:	greater than 50 milliamps
Accuracy:	$\pm 5\%$ of reading $\pm$ one digit
Resolution:	8 μ A
Voltages supplied:	1.5 (silver), 1.3 (zinc air)
Voltage Accuracy:	± 15 millivolts. (open circuit)
Resistance accuracy:	($\pm 6\% \pm 0.5$ ohm)

DIGITAL READOUT OF SOUND PRESSURE LEVEL

Frequency Range:	200-8000 Hz
Amplitude Range:	0-150 dB SPL
Resolution:	0.1 dB
Accuracy:	Coupler mic: ± 1.0 dB ± 1 digit, 300-5000 Hz, ± 2 dB ± 1 digit all other frequencies Probe mic: ± 2.5 dB ± 1 digit, 250-8000 Hz Ref mic: ± 3 dB ± 1 digit, 100-8000 Hz

HARMONIC DISTORTION ANALYZER

Type: 2nd, 3rd, Total (2nd plus 3rd)
Resolution: 0.1%

ATTACK/RELEASE

Range: 1.25 to 5000 mSec.
Accuracy: Accuracy: $\pm 10\%$ or ± 2 ms, whichever is larger
Signals: Puretone: 200-8000 Hz, in 100 Hz intervals (user interface), 50 Hz intervals (RS232), Composite

AVAILABLE TESTS

Automated Test Sequences: ANSI S3.22-1987, ANSI S3.22-1996, ANSI S3.22-2003, ANSI S3.22-2009, IEC 60118-7:1994, IEC 60118-7:2005, ANSI S3.42-1992, JIS:2000
Additional Coupler Tests: Profiler, ISTS, Enhanced DSP, Input/Output, Attack & Release, Battery Current, Coupler Multicurve
Real-Ear: Audiogram Entry, Target Edit, Insertion Gain, Real-ear SPL, Visible Speech
Optional: Coupler Directional (requires 8120 Polar Plot Chamber)

POWER

Source voltage: 100-240 volt AC.
Frequency Range: 50-60 Hz.
Power Requirement: 0.6 A.
Fuse: T 630mA, 0.63A / 250 V~, Type T, IEC 60127-2 Sheet III (Slo-Blo Type, Glass, 5mm x 20mm). Qty 2.

ELECTRONICS MODULE

Size: 17.3"W x 10.8"D x 6.5"H (43.9 x 27.4 x 16.5 cm).
Weight: 14.3 lbs.(6.49 kg).

PRINTER, INTERNAL

Type: High speed line thermal printer
Paper width: 4.41" (112 mm)

TEST CHAMBER: 8050 COMPACT

Test Area: 5"W x 6"D x 1.5"H (12.7 x 15.2 x 3.8 cm).
Ambient Noise Isolation: 45 dB at 1 kHz (allows THD measurement to within 3% at 60 dB source level and a 60 dB ambient).

Size: 11.5"W x 13.5"D x 9.2"H (29.2 x 34.3 x 23.4cm).
Weight: 21.8 lbs. (9.9 kg).

TEST CHAMBER: 8120 POLAR PLOT

Test Area: 4"W x 4"D x 1.75"H (10.2 x 10.2 x 4.4cm) with Removable Test Surface
4"W x 4"D x 1.75"H + 5.38" cavity height (10.2 x 10.2 x 4.4 + 13.7cm)
with Rotating Shaft
Ambient Noise Isolation: 45 dB at 1 kHz (allows THD measurement to within 3% at 60 dB
source level and a 60 dB ambient).
Size: 13.5"W x 19"H x 14.5"D (34.3 x 48.3 x 36.8cm).
Latch protrudes another 2.25" (5.7 cm) out the front.
Weight: 40.4 lbs. (18.3 kg).

ENVIRONMENTAL CONDITIONS

Shipping/Storage Humidity: 5 to 95 percent relative humidity (non-condensing)
Shipping/Storage Temperature: -20 to 60 degrees Celsius (-4 to 140 degrees Fahrenheit)
Operating Relative Humidity: 5 to 90 percent relative humidity (non-condensing)
Operating Temperature: 15 to 35 degrees Celsius

MONITOR HEADSET

Monitored channel: Probe microphone
Headphone type: Stereo 3.5mm
Usable headphone impedance: 32 ohms to 600 ohms (intended for Walkman style headphones)

GUARANTEE

The FONIX 8000 and its accessories are guaranteed to be free from manufacturing defects which would prevent the products from meeting these specifications for a period of one year from date of purchase.

8000 Software Upgrades

As new features and options become available on the 8000 analyzer, you may need to upgrade your instrument. The 8000 analyzer is upgraded using computer software.

It is recommended that you close any open programs on your computer before executing the software upgrade. It is particularly important to close any other programs that are Frye programs. It is also recommended that you disable your screensaver.

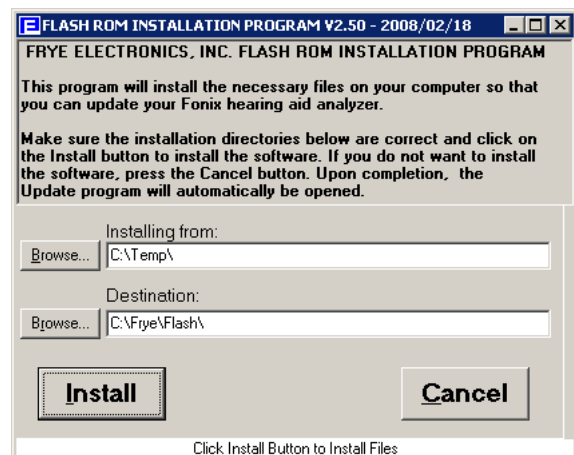
Software upgrades are usually delivered via email in a .zip file. **These instructions assume that you have unzipped this file.** Ask your local computer technician for help, if needed.

Important Note: Your computer will not be available for other programs during the software upgrade due to the intensive nature of the RS232 communications. The upgrade may take approximately 45 minutes to complete if you use the FastLoad option within the update program.

B.1 Installing the Update Software

The software used to update your hearing aid analyzer needs to be installed on a Windows computer that is connected to your analyzer.

1. Open setup.exe in the directory where you unzipped your emailed software. This will open the Flash ROM Installation Program. Please note that your version of Windows may intentionally hide known file extensions such as “exe”. The file name “setup.exe” maybe displayed as just “setup”.
2. Click **Install** to begin the installation. Do not alter the installation directory unless you are an expert computer user.
3. Click **OK** to acknowledge when the Installation is complete. The Flash Rom Update Program will automatically start.



B.2 Connecting the 8000 to the Computer

If you regularly use your computer to connect to your FONIX hearing aid analyzer (for instance, when using the NOAH Real-ear Module or WinCHAP), then close those programs and skip this section; your analyzer should already be connected to your computer. Otherwise, you will need to establish a connection between your hearing aid analyzer and your computer by using a USB port. Contact a local computer technician for computer support if necessary.

USB Computer Connection

The best way to connect your FONIX hearing aid analyzer to your computer is to use the USB cable supplied to you with your 8000. This is a standard High Speed USB cable. The two photos below show the cable alone and when it is connected to the back of a computer.



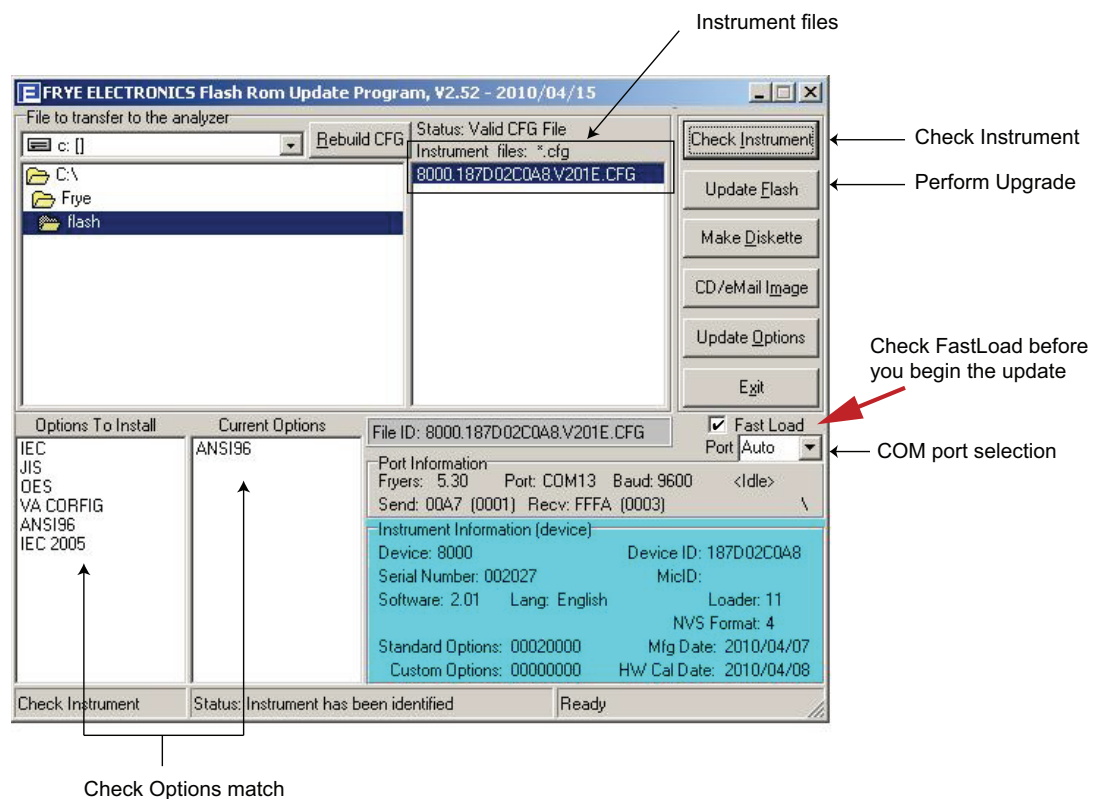
High Speed USB Cable

All FONIX 8000 hearing aid analyzers are provided with a USB cable at the time of shipment. Please retrieve this cable and associated USB driver disk. The cable and driver installation disk come with instructions. Make sure to install this cable on your computer and the 8000 (The hardware installation wizard for the USB cable normally runs twice as noted on the instruction).



B.3 Updating the FONIX 8000 Analyzer

If the Flash Rom Update Program is not already open, open the file:
C:\frye\flash\update.exe.



1. If necessary, click the Instrument File that matches the Instrument ID found on the Opening Screen of your FONIX analyzer. In most cases, there will be only one file and it will already be highlighted.
2. The update screen shot shown above is installing the options such as IEC, JIS, OES, VA Corfig, and IEC 2005. If you are only upgrading the firmware and the installed options are not changing, check that the Options to Install column matches the Current Options column. These two columns are intended to be self-explanatory.
3. Check the FastLoad checkbox to increase the transfer speed and reduce the time needed to update.
4. Click Update Flash to perform the flash ROM update. The computer will then proceed to rewrite the flash memory on your FONIX analyzer. This process may take up to 120 minutes. Do not use the computer for other activities while this transfer is in process. Options will also be transferred together with the new software upgrade.
5. During the 120 minute upgrade process, the monitor on your instrument 8000 may go blank. This is a normal screen saver process within the boot loader of the 8000. Do not be alarmed. Do not take any action.
6. When the Fonix 8000 opening screen logo is displayed, verify the desired software version or new options are installed.
7. Click Exit to close the FlashRom Update Program.

Troubleshooting the Update

Important Note: You may experience errors such as “Port Not Found”, “Response Error”, “No Poll”, or “Command Error” after the upgrade is complete because the 8000 is rebooting after the upgrade. Click the **OK** button to exit Error window, the “Exiting Transfer Mode” window should close automatically. Click **Exit** button in the Flash Rom Update Program.

- If your computer crashes during the upgrade process, or if the transfer is interrupted in any way, take the following steps:
 - a. Please be patient. Wait at least five minutes for the system to repair itself (transfer may take up to 45 minutes.)
 - b. Reboot the 8000 by turning off the power switch then turning it on.
 - c. Reboot your computer if it is locked up. Close all computer screen savers, virus protection programs or any power saver feature that may be interrupting the upgrade.
 - d. Before attempting to upgrade the analyzer again, ensure that all programs are closed, all screensavers and power management functions are turned off, all desktop programs such as Office toolbar are closed, all programs running in the Tray are closed.

- The Flash ROM Update program automatically detects the communications port used in connecting to the 8000 analyzer. However, if you are having trouble connecting, you might try specifying the COM port that the Update program should use. Contact a local computer technician for computer support if necessary.
- When using a USB cable, the computer turns the USB port into a COM port. In your Windows Device Manager, make sure the USB Cable is using COM 1-9. If it is using a higher COM port, the installation may not work. You may need to ask your local computer technician for help if necessary.
- The lower right corner of the screen displays instrument information. If you want to display information currently on the connected analyzer, click **Check Instrument**.
- Sometimes the instrument configuration file name can be damaged. This can happen if the package was copied through a computer system or program that does not understand long file names. If the name does not look right, or the Status says that the selected CFG file is not valid, try clicking on the Rebuild CFG button just above and to the left of the software CFG file selection. Normally that will correct a corrupted CFG file. If it does not, you will need to obtain a replacement file from Frye Electronics.

Calibration

There are few calibration adjustments on the 8000, both external and internal to the instrument. Those available are covered in this section.

C.1 Microphones

A sound level calibrator, such as the Quest QC-10 (with the supplied adapter), is used to generate a signal level at a calibrated intensity.

From the Opening Screen, press [MENU] to enter the setup menu. Then press F6 to enter the microphone calibration screen. Place the M1958E in a sound level calibrator. Position the cursor with the left/right key till the selected level matches the calibrator level. Press the Start key to make the calibration.

There are three possible microphones on the FONIX 8000 analyzer:

- Coupler microphone (M1950E or M1958E)
- Probe microphone
- Reference microphone

All 8000 analyzers include a coupler microphone. The procedure for calibrating this microphone is described in Section C.1.1. 8000 analyzers that do not include the Real-ear Option will only have the coupler microphone.

8000 analyzers with the Real-ear Option have an integrated probe microphone set in addition to the coupler microphone. This consists of a probe microphone integrated into the earhook and a rectangular reference microphone that attaches to the top of the earhook. The procedure for calibrating the integrated probe microphone is described in Section C.1.2. The procedure for calibrating the rectangular reference microphone is described in Section C.1.3.

To perform the microphone calibrations, you will need the following equipment, depending on what type of microphones you are calibrating. The adapters come standard with the analyzer. You can purchase additional adapters and a sound calibrator from the factory. (Sound calibrators are special orders and may not be immediately available for purchase.)

- Sound calibrator such as a QC-10 (all calibrations)
- 14 mm-to-1 inch microphone adapter (coupler and old-style reference microphone calibration)
- Probe microphone adapter (probe microphone calibration)
- Rectangular reference microphone adapter (rectangular reference microphone on integrated probe microphone)

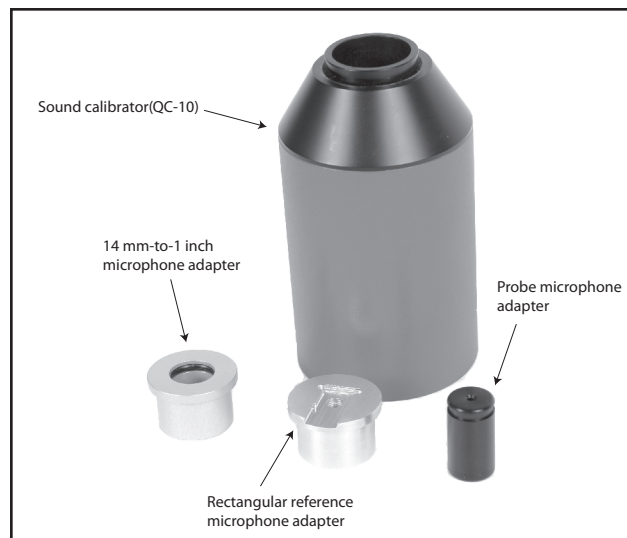


Figure C-1: Calibration equipment

C.1.1 Calibrating the Coupler Microphone

This procedure describes how to calibrate the coupler microphone.

1. From the Opening Screen, press [MENU] to enter the Setup Menu.
2. Press [F6] to enter the Microphone Calibration screen.
3. Put the 14-mm-to-1 inch microphone adapter into the sound level calibrator.
4. Place the coupler microphone in the adapter.
5. Turn on the sound level calibrator.
6. Position the cursor with left/right keys till the selected level matches the calibrator level. Press the [START] key to make the calibration.



Figure C-2: Coupler microphone inserted into sound calibrator.

C.1.2 Calibrating the Probe Microphone

1. From the Opening Screen, press [MENU] to enter the Setup Menu.
2. Press [F6] to enter the Microphone Calibration screen.
3. Use the down arrow key to select “Probe Left or Right”, “Probe”
4. Put the 14-mm-to-1 inch microphone adapter into the sound level calibrator.
5. Attach a new probe tube to the probe microphone.

6. Thread the probe microphone through the edged side of the probe microphone adapter so that the probe tube sticks out a coupler of millimeters from the other side of the adapter.
7. Secure the probe tube in place by putting a dab of Fun-Tak (Blue Stik) on the edged end of the adapter.
8. Insert the probe microphone adapter with the attached probe microphone into the calibrator. See Figure C-3.
9. Turn on the calibrator.
10. Position the cursor with left/right keys till the selected level matches the calibrator level. Press the [START] key to make the calibration.

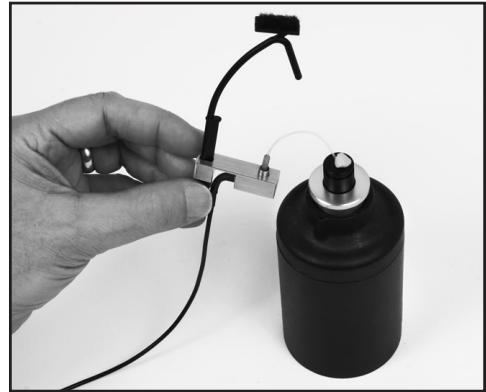


Figure C-3: Integrated probe microphone inserted into sound calibrator.

C.1.3 Calibrating the Rectangular Reference Microphone

This procedure describes how to calibrate the rectangular reference microphone that is part of the integrated probe microphone set.

1. From the Opening Screen, press [MENU] to enter the Setup Menu.
2. Press [F6] to enter the Microphone Calibration screen.
3. Use the down arrow key to select “Probe Left or Right”, “Ref”
4. Insert the rectangular reference microphone adaptor into the sound calibrator.
5. Remove the reference microphone from the integrated ear hook and insert it into the calibration adapter with the opening of the reference microphone pointing into the calibrator. See Figure C-4. You can use a rubber band to hold the microphone onto the calibrator, if necessary.
6. Turn on the sound calibrator.
7. Position the cursor with left/right keys till the selected level matches the calibrator level. Press the [START] key to make the calibration.



Figure C-4: Rectangular reference microphone inserted into sound calibrator.

Troubleshooting Guide

These are the most common problems that typically cause instrument failure. Please check these troubleshooting suggestions and follow the procedures outlined in this manual before contacting your local service representative or Frye Electronics.

General Problems:

No power

- a. Check ON/OFF switch(s).
- b. Make sure the power cable is plugged into a working outlet.
- c. Check the fuse in the power entry module.

CRT/VGA/LCD display monitor is not working

- a. Check the ON/OFF switch.
- b. Make sure the power cable is plugged into working outlet.
- c. Check the monitor brightness and contrast controls.
- d. Check the cable between the monitor and instrument.
- e. Make sure nothing is resting against the keyboard and causing a stuck button.

Test Chamber Problems:

Test Chamber Microphone does not Level

- a. Check your mic calibration. (See Appendix B)
- b. Is the mic properly plugged into the instrument?
- c. Are all connections clean and tight?
- d. Is the mic head (element) screwed on tightly?
- e. Is the mic cable loose, broken, cut, worn or frayed?
- f. Make sure everything is out of the test chamber (except the mic) when trying to level.
- g. Open the test chamber and listen for the leveling signal.
- h. Check the test chamber cable connections.
- i. Is there an unusual amount of background noise in the test area? (air conditioning/heating fans, street noise, people talking, computer fans, etc.)

Coupler Problems:

1. **HA-2 Coupler (BTE) adapter tubing is missing, loose or cracked**
Replace with #13 thickwall tubing. Length: 23.7 mm.
2. **Test microphone is difficult to get into coupler or the ear level adapter does not easily seal to the other end of the HA-2 coupler**
Lubricate the black “O” ring with light petroleum-type lubricant.
3. **A bump or peak in the low frequency response curve**
 - a. There may be a hearing aid vent leak. Be sure to close the vent with adhesive putty.
 - b. There may be a coupler vent leak.
 - c. The #13 coupler tubing could be cracked or broken.

Printer Problems:

1. **Printer does not work**
 - a. Check for a paper jam.
 - b. Press the FEED Button.
 - c. Make sure the print head lock-down lever is down.
2. **Test results do not print on paper**

Make sure you are using thermal paper. To check it, take a hard object, e.g. a car key, and scratch the surface of the paper on both sides. If a black mark appears it is thermal paper. If not, it is plain paper and will not work.

The FONIX CIC Feature

Background

Zwislocki built an ear simulator coupler years ago to better approximate the real ear's impedance variation with frequency. The ear's volume appears to get larger at lower frequencies. Mahlon Burkhard at Industrial Research Products agreed with this approach, especially when they built the KEMAR, and designed an ear simulator that had impedance changes that matched the Zwislocki figures. This ear simulator was later standardized by the publication of American National Standards Association standard, S3.25. Another ear simulator that has similar characteristics was introduced in Europe a few years later by Bruel and Kjaer, and is characterized in the standard IEC 711.

Frye Electronics introduced a slightly different approach in the 1980's when it came out with the INSITU option (and later, the OES option) for its 5500-Z hearing aid Analyzer. Realizing that ear simulators which contain frequency sensitive elements are somewhat fragile and can be damaged as they are handled in every day use, Frye made a coupler which it labeled the MZ (for Modified Zwislocki). This coupler had a central volume very similar to the standardized Zwislocki, but had no frequency sensitive elements. Instead, an analyzer program was used with the coupler to apply correction factors to the measured curves from the hearing aid so that the output was very similar to that which would be obtained if the aid were tested on a standardized ear simulator as built by Knowles or B&K.

These software corrections work well for most regions in the frequency response of the aid. In low frequency areas up to about 1500 Hz, if the aid has a response peak that is influenced by the volume of the cavity, the peak will be slightly higher in amplitude and slightly higher in frequency than that peak would be if the aid were measured in a standardized ear simulator. The CIC hearing aid is not usually affected by this problem.

The Need for a CIC Coupler

The introduction of the CIC hearing aids has made it desirable to be able to test them with a coupler that more closely approximates the actual volume and frequency response characteristics of the real ear. The CIC aid fits so close to the tympanic membrane (TM) of the ear that the volume of the cavity is reduced greatly and the aid produces significantly more gain. Further, its response can be substantially influenced by the frequency-dependent impedance variations of the TM.

Frye Electronics felt that the use of a CIC coupler with a proper response correction would give better data to a hearing professional than the use of the standard 2 cc coupler or even a Zwislocki ear simulator when attempting to produce

a good hearing aid fitting. It also felt that the approach taken in the use of the MZ coupler has been well accepted by professionals throughout the world and that the new CIC coupler should use a similar approach, with response corrections modified to take the smaller CIC volume into account.

The Basic Problem

The ear is not a simple structure. It is a biological coupling device that converts sound energy to nerve impulses. It also has a pinna that helps to direct higher frequency sounds into the external canal. The part of the structure we are concerned with is the external ear canal, or cavity, which is terminated by the TM. The ear canal can be considered to be fairly rigid when it is compared to the TM. In the lower frequencies below 2000 to 3000 Hz, the frequency-related changes in impedance that we see in an ear are thought to be mostly caused by the TM. When we reduce the volume of the cavity between the hearing aid and the TM by moving the aid closer to it, we should expect to see the TM play a more important part in determining the response of the aid.

For more shallow standard earmolds, the volume of the central cavity of the ear reduces the effect of the TM's frequency impedance changes. This is because the volume of the cavity is added to the equivalent volume of the TM. If the cavity volume is large and does not change with frequency, then the large changes in impedance of the TM are swamped by the large volume of the ear canal. If, on the other hand, the TM is working into a very small volume, then it would affect a large change in impedance across the frequency range.

CIC Hearing Aid—Gain and Frequency Response Changes

From the above discussion we see that we can expect that the frequency response of the CIC hearing aid will be greatly influenced by the frequency dependent impedance changes of the TM. What is the magnitude of these changes? A fairly typical ear fitted with a standard hearing aid and earmold should have characteristics that would normally be predicted by a KEMAR manikin and standardized ear simulator. When that ear is fitted with a CIC aid, what is the volume between the hearing aid and the TM? Because of the tilt of the TM, most professionals probably don't fit the aid right next to the TM. A reasonable figure may be 0.25 cubic centimeters. It should be realized that this number could be higher or lower, depending on circumstances. 0.2 to 0.4 cc may be a reasonable range.

Now, how much response variation will be introduced because of the smaller volume of 0.25 cc? This variation is what is used in the frequency response correction table used with the CIC coupler. One assumption that we make in calculations of volumes is that the simulator is small as compared to the wavelength of sound at the frequency we are examining. In the case of the standard ear simulator, the length of the cavity begins to affect its response to sound at frequencies above about 3000 Hz.

Knowing the physical volume of the occluded ear canal and its frequency response variations, it is possible to calculate the equivalent volume of the TM itself at each frequency and to apply this figure to the response of the 0.25 cc cavity between the hearing aid and the TM.

When the calculated volume variation of the TM is applied to the smaller volume of the CIC coupler, the total response variation comes out to be from -8.6 dB at 200 Hz to +5.5 dB at 8000 Hz for a total variation of 14.1dB.

Summary

Using the CIC coupler with its software option gives the dispenser an immediate idea of how much gain that this new type of hearing instrument is going to give the hearing impaired individual. It is nice to see that the CIC hearing aid can really produce significant amounts of gain in spite of its apparently poor performance in the 2cc world of the ANSI standard test.

The user must remember that an actual ear may produce differences from the predicted values.

Acknowledgment

Mead Killion, Mahlon Burkhard and Elmer Carlson are to be thanked for helping assemble the data from which the CIC corrections were derived.

CIC CORRECTION FACTORS

dB	Hz	dB	Hz	dB	Hz	dB	Hz
-8.7	200	-0.95	2200	3.2	4200	4.54	6200
-8.6	300	-0.5	2300	3.3	4300	4.55	6300
-8.7	400	-0.2	2400	3.5	4400	4.6	6400
-8.75	500	0	2500	3.6	4500	4.65	6500
-9	600	0.3	2600	3.7	4600	4.7	6600
-8.9	700	0.5	2700	3.8	4700	4.75	6700
-8.8	800	0.7	2800	3.85	4800	4.8	6800
-8.2	900	1	2900	3.95	4900	4.85	6900
-6.55	1000	1.2	3000	4	5000	4.9	8000
-6	1100	1.4	3100	4.07	5100	4.95	7100
-5.4	1200	1.65	3200	4.12	5200	5	7200
-4.95	1300	1.9	3300	4.18	5300	5.05	7300
-4.2	1400	2.1	3400	4.2	5400	5.1	7400
-3.6	1500	2.2	3500	4.25	5500	5.15	7500
-3.3	1600	2.4	3600	4.3	5600	5.2	7600
-2.8	1700	2.5	3700	4.35	5700	5.25	7700
-2.3	1800	2.7	3800	4.4	5800	5.3	7800
-2	1900	2.85	3900	4.45	5900	5.4	7900
-1.7	2000	2.91	4000	4.5	6000	5.5	8000
-1.2	2100	3	4100	4.52	6100		

Fitting Formula Tables

The conversions used by the FONIX 8000 Test System to convert audiograms to target gain curves are the following:

NAL-RP FITTING FORMULA CALCULATION

The insertion gains at each frequency are calculated according to the following formulas:

Freq (Hz)	Insertion Gain (dB)
250	$X + .31 \text{ HTL} - 17\text{dB} + S$
500	$X + .31 \text{ HTL} - 8\text{dB} + S$
750	$X + .31 \text{ HTL} - 3\text{dB} + S$
1000	$X + .31 \text{ HTL} + 1\text{dB} + S$
1500	$X + .31 \text{ HTL} + 1\text{dB} + S$
2000	$X + .31 \text{ HTL} - 1\text{dB} + S$
3000	$X + .31 \text{ HTL} - 2\text{dB} + S$
4000	$X + .31 \text{ HTL} - 2\text{dB} + S$
6000	$X + .31 \text{ HTL} - 2\text{dB} + S$
8000	$X + .31 \text{ HTL} - 2\text{dB} + S$

Where you calculate X and S (Slope correction values) as follows:

- $T = (\text{HTL @ } 500\text{Hz}) + (\text{HTL @ } 1000\text{Hz}) + (\text{HTL @ } 2000\text{Hz})$
- If T is less than or equal to 180dB, then
 $X = .05 \times T$
 If T is greater than 180dB, then
 $X = (.05 \times 180\text{dB}) + (.116 \times (T - 180\text{dB}))$
- If the HTL at 2000 Hz is less than 95dB, $S = 0$
 If the HTL at 2000 Hz is greater than or equal to 95dB, then
 apply the following slope correction factors at each frequency
 based on the 2000Hz measurement:

2000Hz HTL (dB)	250	500	750	1000	1500	2k	3k	4k	6k	8k
95	4	3	1	0	-1	-2	-2	-2	-2	-2
100	6	4	2	0	-2	-3	-3	-3	-3	-3
105	8	5	2	0	-3	-5	-5	-5	-5	-5
110	11	7	3	0	-3	-6	-6	-6	-6	-6
115	13	8	4	0	-4	-8	-8	-8	-8	-8
120	15	9	4	0	-5	-9	-9	-9	-9	-9

POGO

Prescription of Gain/Output (POGO) for Hearing Aids

by: Geary A. McCandless, PhD,
& Poul Erik Lyregaard, MSc
Hearing Instruments vol 34 #1, 1983

Required insertion gain is calculated as follows:

Frequency (Hz)	Insertion Gain (dB)
250	1/2 HTL - 10 dB
500	1/2 HTL - 5 dB
* 750	1/2 HTL - 2.5 dB
1000	1/2 HTL
* 1500	1/2 HTL
2000	1/2 HTL
3000	1/2 HTL
4000	1/2 HTL
* 6000	1/2 HTL
* 8000	1/2 HTL

Note: Frequencies preceded by an asterisk (*) are interpolated because the article does not reference them.

BERGER

A Method of Hearing Aid Prescription

by: Kenneth W. Berger, PhD, Eric N. Hagberg, M.A.,
& Robert L. Rane, PhD
Hearing Instruments July 1978

Required insertion gain is calculated as follows:

Frequency (Hz)	Insertion Gain (dB)
* 250	1/2 HTL
500	1/2 HTL
* 750	1/2 HTL
1000	1/1.6 HTL
* 1500	1/1.5 HTL
2000	1/1.5 HTL
3000	1/1.7 HTL
4000	1/2 HTL
* 6000	1/2 HTL
* 8000	1/2 HTL

Note: Frequencies preceded by an asterisk (*) are interpolated because the article does not reference them.

1/3, 1/2, 2/3 Gain

The 1/3-2/3 Insertion Gain Hearing Aid Selection Guide

by: Robert Libby

Hearing Instruments vol 37 #3, 1986

Required insertion gain is calculated as follows:

FREQ. (Hz)	INS GAIN (dB) (2/3 rule)	INS GAIN (dB) (1/3 rule)	INS GAIN (dB) (1/2 rule)
250	2/3 HTL - 5 dB	1/3 HTL - 5 dB	1/2 HTL -5 dB
500	2/3 HTL - 3 dB	1/3 HTL - 3 dB	1/2 HTL -3 dB
750*	2/3 HTL	1/3 HTL	1/2 HTL
1000	2/3 HTL	1/3 HTL	1/2 HTL
1500*	2/3 HTL	1/3 HTL	1/2 HTL
2000	2/3 HTL	1/3 HTL	1/2 HTL
3000	2/3 HTL	1/3 HTL	1/2 HTL
4000	2/3 HTL	1/3 HTL	1/2 HTL
6000	2/3 HTL - 5 dB	1/3 HTL - 5 dB	1/2 HTL -5 dB
8000*	2/3 HTL - 5 dB	1/3 HTL - 5 dB	1/2 HTL -5 dB

Note: Frequencies marked by an asterisk (*) are interpolated because the article does not reference them.

Glossary of Terms

AGC	Automatic Gain Control (or Automatic Volume Control). A feature on a hearing aid that automatically adjusts the gain, depending either on the input level (AGC-I) or the output level (AGC-O). Also known as “Compression.”
AMBIENT NOISE	The environmental sounds in a testing area.
ANECHOIC CHAMBER	A room with little sound reverberation; a room constructed to be acoustically absorptive.
AMPLITUDE	A measure of the magnitude of a signal.
ANSI	American National Standards Institute. A national organization that determines standards for testing equipment. A section number and date (year) following the initials “ANSI,” designate the standard referred to.
ARTIFACT	A false reading.
ASP	Automatic Signal Processing. A feature on a hearing aid intended to overcome the effects of background noise, making it easier to understand speech when noise is present. The term ASP is not standardized, and may refer to various forms of signal processing. Usually, however, ASP refers to a reduction in low-frequency gain in the presence of ongoing background noise.
AVG	Short for Averaging. A feature on the 8000 Test System that uses three pure tones and averages them for the final measurement.
BATTERY SUBSTITUTION PILL	A battery simulator that conforms to the size and shape of a battery used in a hearing aid. It connects to the Battery Voltage Supply, providing the proper voltage to the hearing aid.
BERGER	A prescription formula developed by Kenneth W. Berger.
BIAS FREQUENCY	The background frequency, acting as noise, when using the Digital-Speech-in-Noise test.
BIAS AMPL	The amplitude of the background frequency used in the Digital-Speech-in-Noise test.
BICROS	A CROS aid that has two microphones, one at each ear, sending both signals to one ear.
BLOOMING EFFECT	A characteristic of pure tone testing at high levels, that typically shows low frequencies being amplified more than they are under normal use conditions.

BLUE ADHESIVE PUTTY	A modeling clay-like substance used to attach and seal hearing aids to couplers.
CALIBRATOR	A sound generator that produces a tone at a precisely controlled frequency and amplitude.
CHAP	Computer Hearing Aid Program. A program designed to interface with Fonix instruments in order to make the storage of information in computer files quick and easy. The current version is known as WinCHAP.
CIC COUPLER	Completely-in-the-Canal Coupler. A coupler designed to better handle the unique acoustic qualities of completely-in-the-canal aids. Included with the CIC Coupler is internal software which provides corrections to increase the accuracy of CIC measurements even further.
CONCHA RESONANCE	The major part of the acoustic effect of the pinna, contributing significant energy to the External Ear Effect in the region of 5000 Hz.
COIL	Abbreviation for telephone pickup coil.
COMPOSITE	The FONIX test signal consisting of 79 pure tones presented simultaneously.
CONVERSION FORMULA	A hearing aid prescription formula, used to convert an audiogram to a target curve. Common formulas are the NAL, Berger, POGO, and the 1/2, 1/3 or 2/3 Gain rules.
CORFIG	Coupler Response for Flat Insertion Gain (or “correction figure”). This is the transformation that, when added to a target insertion-gain response, will give the target coupler response. The inverse of “CORFIG” is “GIFROC.”
COUPLER	A device that connects a test microphone to a hearing aid to provide an accurate testing situation.
CROS	Contralateral Routing of Signal. A type of hearing aid that uses a wired or wireless system to send a signal to the opposite ear.
CRT	Cathode Ray Tube. The device in a computer system that projects information onto a display screen.
CURVE	A visual diagram of a measurement using two variables. In testing hearing aids, one variable may be frequency, shown on the horizontal axis of the curve, and the other variable amplitude, shown on the vertical axis of the curve.
DATA	In FONIX analyzers, the word “data” refers to displaying curve information as a table of numbers.
DEFAULT	A choice automatically made by a computer program.

DIN CONNECTOR	A European-standard connector with pins surrounded by a round metal shell.
DISTORTION	Elements of a reproduced sound that deviate from the original.
DSIN	Digital speech-in noise. The source signal used for testing digital aids. The ANSI and ICRA speech weightings are available.
EAR CANAL RESONANCE	An acoustic property of the ear canal, often characterized by a peak at or near 3000 Hz. Along with the acoustic properties of the head, torso and pinna, the Ear canal Resonance contributes significantly to the External Ear Effect.
EIN	Equivalent Input Noise. The amplitude of internal noise created by a hearing aid.
ERROR	The latitude of inaccuracy in a testing system. It usually is expressed in +/- units and/or percent.
FAST FOURIER ANALYSIS	A computer “short-cut” of the FOURIER TRANSFORM method for determining the frequency content of a signal.
FLAT WEIGHTED	Same as UNWEIGHTED, referring to a signal that has equal amplitude at every frequency.
FOURIER TRANSFORM	A mathematical procedure that changes “time” information into “frequency” information.
FREQUENCY	The number of vibrations, or cycles, per second of a periodic wave. The unit of measurement is Hertz (Hz).
FREQUENCY RESPONSE	A measure of the output or gain of a device across a range of frequencies of the input signal.
FUNDAMENTAL FREQUENCY	The lowest frequency in a harmonic complex tone, such as the FONIX Composite signal. The fundamental frequency determines the “pitch” of a tone.
GAIN	The amplification or increase in sound power in a hearing aid. In testing, it results from subtracting the level of the input from the level of the output of the aid.
GIFROC	The inverse of “CORFIG.” GIFROC is the transformation that, when added to a coupler response, will give the estimated insertion-gain response.
GRAPH	A grid of lines, with the vertical lines representing one set of information and the horizontal lines representing another. A “Curve” superimposed on a graph grid, gives information about test results.
HAIC	Hearing Aid Industry Conference.

HARMONICS	Integral multiples of a pure tone. The tone itself is the 1st harmonic, or fundamental frequency; twice the frequency of the tone is the 2nd harmonic; three times the frequency of the tone is the 3rd harmonic; etc.
HARMONIC DISTORTION	The presence of harmonics in a reproduced signal that are not present in the original signal.
HFA	High frequency average: according ANSI S3.22-1987, the averaged response at 1000, 1600 and 2500 Hz.
HEAD BAFFLE EFFECT	Refers to the comparative augmentation of high-frequency sound caused by the acoustic diffraction of low-frequency sound by the head and pinna blending to produce a baffle.
HL	Hearing Level. The amount of decibels above audiometric zero at which a measured ear barely hears a sound.
Hz	Hertz. Unit of frequency, referring to cycles per second.
ICRA	International Collegium of Rehabilitative Audiology.
IEC	International Electrotechnical Commission. An international organization that sets standards for measurements.
IN-SITU	Latin for “in position.” In audiometry, it designates measurements taken with the hearing aid “in place” in the ear.
INTER-MODULATION DISTORTION	Distortion generated by the faulty mixture of different input frequencies. This is a primary cause of harshness and lack of intelligibility in a hearing aid.
JIS	Japanese Industrial Standard. The organization which sets standards for measurements in Japan.
KEMAR	Knowles Electronics Manikin for Acoustic Research. A model, which nearly reproduces the acoustic qualities of an average adult head and torso, that is utilized in the assessment of hearing aid performance.
LED	Light Emitting Diode. A small light on an instrument panel.
LEVELING	An automatic calibration procedure, establishing a “zero line” for measurements, taking into account all the acoustic properties of the test chamber or the testing room.
MENU	A list of choices offered by a computer software program.
MULTI-CROS	A hearing aid system that has a switch to select either a CROS, a BI-CROS, or a Monaural arrangement.
MZ COUPLERS	Modified Zwislocki Couplers. Three couplers based on the Zwislocki design, but sturdier; provided with the OES option.

NAL	National Acoustic Laboratories of Australia.
NBS	National Bureau of Standards (U.S.), now known as National Institute of Standards and Technology.
NOISE REDUCTION	The 8000's method of producing a more stable reading by averaging many samples.
OCCCLUSION EFFECT	Low-frequency intensification in the loudness level of bone-conducted signals resulting from the blocking of the ear canal.
OES	Occluded Ear Simulator. An option on the 8000, using three special couplers, that provides the same data obtained with a standard ear simulator.
POGO	Prescription Of Gain and Output. A hearing aid prescription formula.
POWER	The output of an aid, in dB SPL.
PT BURST	A burst of ten pure tones corresponding to standard audiometric frequencies. The entire signal lasts for less than two seconds.
PURE TONE	A testing tone consisting of only one frequency.
REAL-TIME TESTING	The ability to view <i>instantly</i> the results of hearing aid tests.
REFERENCE POINT	The location in a test chamber where the microphone of a hearing aid must be placed for accurate testing. In the 8000, it is the small circle in the center of the test chamber.
RESONANCE	The tendency of an acoustic system to reinforce sounds of a certain frequency, the frequency determined by the shapes and sizes of the components of the system.
RESPONSE LIMIT	The high and low points of the frequency range found in the ANSI test sequence conditions.
RMS	Root Mean Square. An overall measurement of the signal going in or coming out of a hearing aid. When measuring with Pure tones, the RMS level at each individual frequency will be the same as the level shown at each frequency on a response curve. When measuring with a Composite Tone, the (overall) RMS level will be several dB higher than the level at each frequency on a response curve, since all the frequencies are presented at once.
SATURATION	The condition where any further increase in input level will yield no further increase in output level.
SMOOTHING	A "rounding-off" of a curve, removing minor peaks and valleys, to create a more readable curve, using a method that is equivalent to warbling the input signal.

SPA	Special purpose average: according to ANSI S3.22, the averaged response at specially designated frequencies.
SPL	Sound Pressure Level. Expressed in decibels (dB), a logarithmic measure of the energy (amplitude) of a particular sound as compared to the energy of a specified reference sound.
SSPL (OSPL)	Saturation Sound Pressure Level. The greatest SPL that a given amplifier can produce.
SSPL-90 (OSPL-90)	Saturated Sound Pressure Level for an input of 90 dB SPL.
SWEEP	A sequence of pure tone frequencies, which generates a frequency response curve.
TELECOIL	Same as COIL. In the 8000, it is an accessory that generates a magnetic field for testing the telephone pickup of a hearing aid. The telecoil is a standard feature with the 8050 & 8060 and 8120 sound chambers.
UNWEIGHTED GAIN	A measurement of the amplification (gain) of an aid using an input signal (source) that has equal power across all test frequencies.
WARBLE TONE	A pure tone with slight, but rapid, frequency variations.
WEIGHTED GAIN	A measure of the amplification (gain) of an aid, using an input signal (source) that has a spectral shape similar to that of the long term average of speech.
WEIGHTED POWER	The measurement of amplitude, in SPL, of the output of an aid, using an input signal (source) that has a spectral shape similar to that of the long term average of speech.
WHITE NOISE	A signal composed of all frequencies, which vary randomly in phase, each frequency having equal long-term energy levels.
WINCHAP	Windows® Computer Hearing Aid Program used for storing hearing aid tests and client information on a personal computer.

The FONIX Keyboard App

The FONIX 8000 Hearing Aid Test System can be controlled wirelessly from an Android tablet using the FONIX keyboard app. When the Android Tablet Package is purchased, this app is pre-installed on the tablet. However, you can also install the FONIX keyboard app on any Android tablet with Bluetooth® technology. You will need the wireless dongle that you can purchase from the Frye factory. The FONIX Keyboard App can be purchased from the Android Marketplace.

H.1 Configuring the FONIX Keyboard App

1. Make sure the wireless dongle is installed on the FONIX 8000. See Figure 1 - 3.

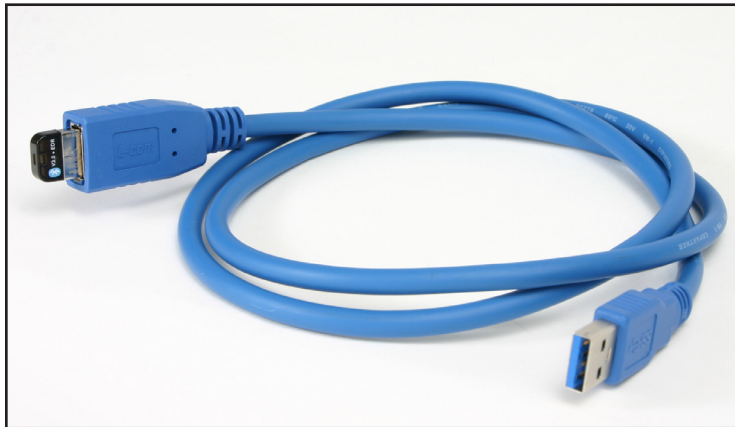


Figure 1: Wireless dongle & USB cable



Figure 2: Plug USB cable into 8000



Figure 3: Place the wireless dongle in clear sight

2. Turn on your 8000 and then turn on Android tablet (or phone).
3. Select "Settings."

4. Select “Wireless and network.”
5. Select “Bluetooth settings.”
6. Make sure Bluetooth is enabled on the tablet (or phone).
7. Select “Scan devices.”
8. Look for a Bluetooth device with the name “Fonix-8000-” and the serial number of your 8000. Select that device.
9. Type “1234” into the “Enter PIN” to Pair with the 8000. Press “OK”. The FONIX keyboard should now be configured correctly.

H.2 Running the Android FONIX Keyboard App

1. Select the “Fonix Remote Keyboard” app icon on the Android device.
2. Press the Android Menu key (NOT the [MENU] key on the FONIX Android keyboard, but the standard Android menu key that is used to change settings on many different Android apps) and select “Connect a device”.
3. Select your FONIX 8000 device. In the upper right corner of the keyboard application, you should get a message confirming the connection.
4. Press an 8000 key on the tablet and verify the FONIX 8000 responds accordingly. You can now run your FONIX 8000 from the Android app.

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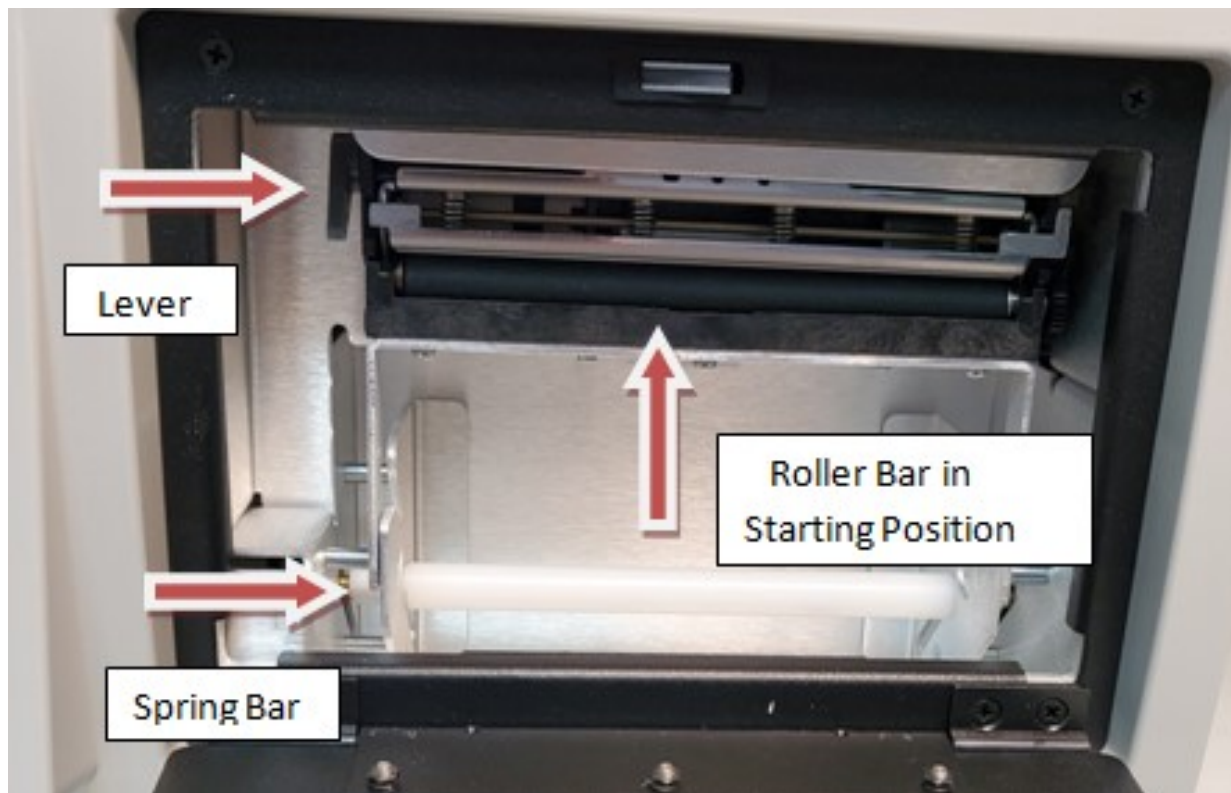
W

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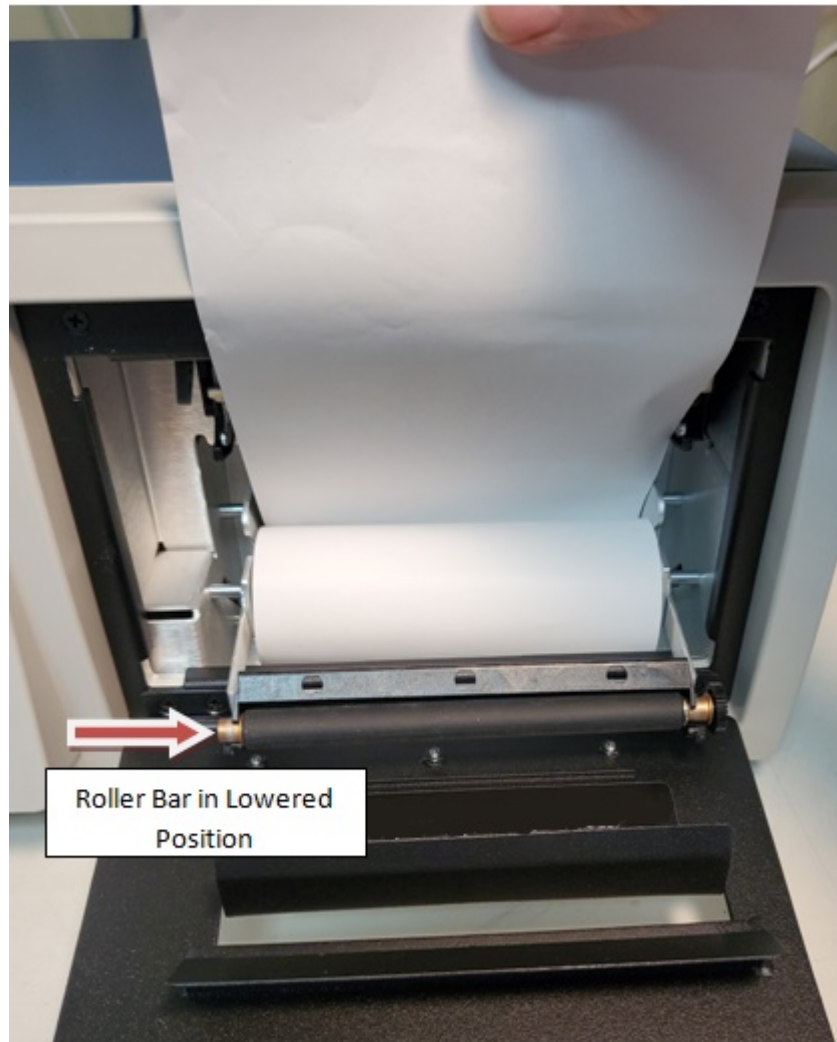
3.0v Load Fonix 8000 Printer Paper

2.4.4 Loading the thermal paper

1. Open the printer door.
2. Press Lever back till Roller Bar pops loose and drops into lower position against open door.
3. Remove the plastic paper roller from the printer mechanism. If you are replacing an empty paper roll, remove and discard the paper spool from the printer mechanism, but **do not discard the plastic spindle**. The spring bar (white plastic back tension rod), located directly behind the paper roller is not a removable part.
4. Insert the plastic roller into a new paper roll.
5. Install the plastic roller and paper roll into the printer mechanism, with paper facing out and feeding from the top of the roll. The paper roller will fit into the slots on the left and right side of the printer mechanism. The paper roller should drop into position without additional adjustment.



6. Load paper roll so it come off the back of the spindle and drop into the slots on either side of the white bottom spring bar



7. Move roller Bar back up and push until it clicks back in to starting position with paper behind it.



8. Feed Paper through door slot, close printer door and tear off extra paper.

