

FONIX[®] 7000

Hearing Aid Test System

Operator's Manual

Version 1.62



FRYE ELECTRONICS, INC.

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

(503) 620-2722 • (800) 547-8209

Fax: (503) 639-0128

www.frye.com • e-mail: sales@frye.com

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Introduction & Setup

Welcome to the 7000 Hearing Aid Test System, the newest innovation in hearing aid testing technology! The 7000 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 7000 Hearing Aid Test System was designed to be a workhorse, capable of performing test after test, day after day, week after week, month after month, and year after year 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 7000 Hearing Aid Test System was also designed for accuracy 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 industry 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 into 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.

Indications for use

The FONIX 7000 Hearing Aid Test System allows the user to test the characteristics of a hearing aid using coupler and optional real-ear measurements. These characteristics include: Frequency response, harmonic distortion, equivalent input noise, battery current drain, and compression. Coupler measurements are performed inside a sound chamber. Real-ear measurements are performed with a small probe microphone inside the patient's ear. This manual provides detailed instructions on the measurement capabilities and user interface of the FONIX 7000.

1.1 History

The following is a brief history of the major changes and updates in the 7000 Hearing Aid Test System.

- September 2003: Initial release (v1.00).
- October 2004: Added RS232 support (v1.10)
- December 2004: Added JIS automated test sequence (v1.20)
- March 2005: Added ANSI S3.22-2003 automated test sequence (v1.30)
- March 2006: Added Battery, Attack & Release, I/O screens (v1.40)

- September 2006: Added NAL-NL1 fitting formula and Visible Speech screen (v1.50)
- February 2007: Added IEC 60118-7: 2005 automated test sequence. Improved Opening, Setup, and Calibration screens. (v1.60)

1.2 Basic Test Functions

The basic 7000 can perform the following coupler tests:

- Pure-tone signal measurements
- Composite and Digital Speech signal measurements
- 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

For both composite and pure tone measurements, the following are possible:

- Special CIC hearing aid coupler measurements
- Behind the ear (BTE), In the ear (ITE), in the canal (ITC), Open ear, and body hearing aid measurements
- Choice of IEC 60118-7:1994/2005, ANSI S3.22-2003/96/87/92, or JIS automated test sequences
(All tests can be installed as options)

An additional function that comes standard with the 7000 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 7000 Test System can also be performed through the computer.

1.3 Options

The 7000 test system has the following software (and hardware) options available:

Real-Ear Option

The 7000 test system can be ordered with the Real-Ear Option so that tests can be done on the hearing aid while it is in the client's ear. These measurements are also commonly called "probe measurements" because they are performed with a probe microphone. Using real-ear measurements makes it possible to individualize the fitting of a hearing aid since a coupler measurement can seldom tell the operator exactly how what sound is received by the client. Many factors affect the sound on its way to the ear drum. When measuring with a probe microphone, you will know what is happening in the "real-ear."

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 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.

OES Option

The Occluded Ear Simulator (OES) Option includes the MZ-1, MZ-2, and MZ-3 couplers and corresponding correction factors meant to simulate the results of a real-ear simulator (Zwislocki) coupler when simulating occluded ear measurements in the sound chamber. The results produced with the OES Option will not be an exact duplication of the results produced with a Zwislocki coupler.

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.

1.4 Accessories

The following are accessories that are standard and optional on your FONIX 7000 hearing aid analyzer.

1.4.1 Standard Accessories

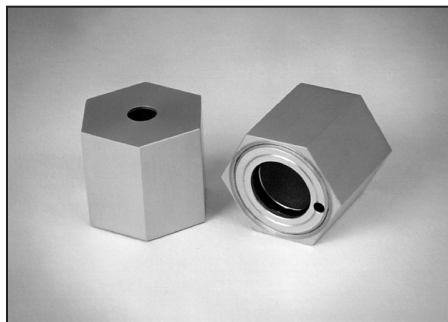
The following accessories come standard with each 7000 test system.



Coupler Microphone—M1950E

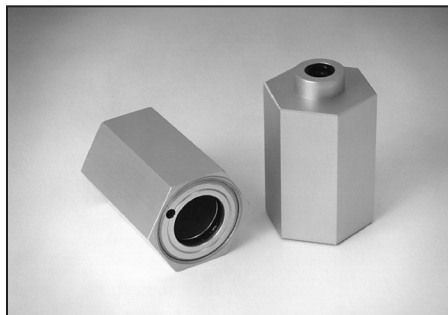
14 mm pressure-type electret instrumentation microphone.

Note: Older 7000 analyzers may use the M1750E microphone.



HA-1 2-cc Coupler

Dimensions per ANSI S3.7 for testing in-the-ear aids, canal aids, and aids fitted with earmolds.



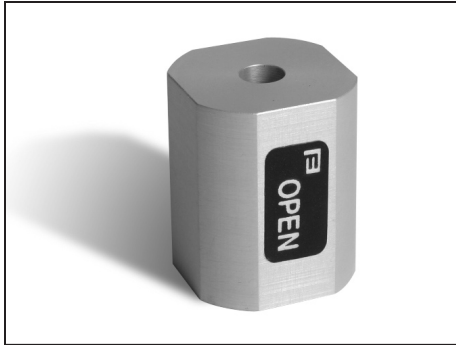
HA-2, 2-cc Coupler

Dimensions per ANSI S3.7 for testing behind-the-ear aids, eyeglass aids, and body aids.



Ear-Level Adapter (BTE)

Snap into the 1/4" (6.35 mm) diameter cavity of the HA-2 and MZ-2 couplers. Equipped with a 0.6" (15 mm) length of 0.076" (1.93 mm) ID tubing, the adapter allows ANSI S3.22 specified connection of an ear-level aid to the coupler.

**Open Fit Coupler**

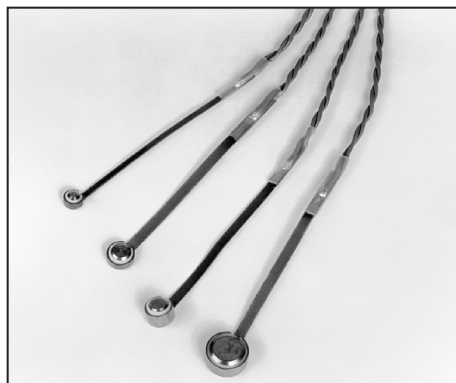
Non-standard coupler used for realistic testing of open ear hearing aids.

**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.

**Test Chamber Cable**

Connects the main module to the test chamber.

**Battery Substitution Pills**

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

675/76

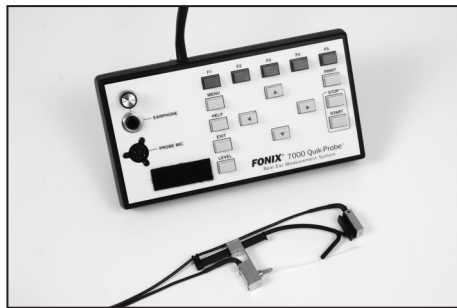
13

312

10A/230

Other Standard Accessories:**Thermal Paper****Fun-Tak****RS232 Cable****Dummy Microphone** (for testing to ANSI specifications)**Sound Chamber Replacement Feet****Operator's Manual****Maintenance Manual** (upon request at time of purchase)**1.4.2 Real-Ear Accessories**

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

**Remote Module and Microphones**

The remote module allows the user to control the analyzer while remaining close to the patient. The probe and reference microphones, used for performing real-ear measurements, are plugged into this module.

**Sound Field Speaker**

Produces the output for most real-ear measurements. The Real-Ear Option can be ordered with a floor stand, remote module shelf, or with a swing arm.

Loudspeaker Floor Stand

The lightweight, sturdy floor stand is adjustable and has a low-profile tripod base.

Remote Module Shelf

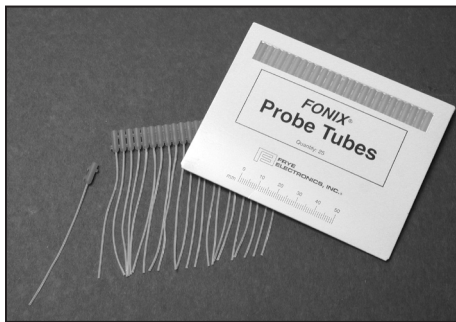
The shelf fits directly on the floor stand, providing a stable, convenient platform for operating and storing the remote module. This is the default configuration.

**Loudspeaker Swing Arm**

This swing arm may be substituted for the speaker floor stand & shelf. It is a convenient device that can be mounted to a wall or desktop. The four-piece arm swivels and extends along five different dimensions to allow precise placement and aiming of the loudspeaker. Spring tension and friction keep the loudspeaker exactly where you put it.

**Monitor Headset**

Plugs into the remote module, and allows the user to listen to the signal being measured by the probe microphone. Model of headset may differ from one shown.

**Probe Tubes**

Used for performing real-ear measurements. Probe tubes are not reusable.

1.4.3 Optional Accessories



Wedge-style Ear Hook

Standard Size. Holds probe and reference microphone during real-ear testing.



Infant/Child Headband

Includes infant, child, and adult headbands, six bendable earhooks, and two sets of “animal ears.”



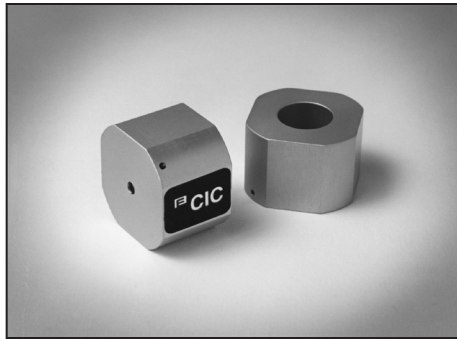
6-cc Coupler

Enables checking the response of standard audiometer headphones. It is designed around the NBS 9A coupler specifications.



MZ Couplers

MZ-3, MZ-2, and MZ-1 couplers are supplied with the OES Option.

**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

**#5 battery pill**

Provides battery current measurements for many CIC hearing aids.

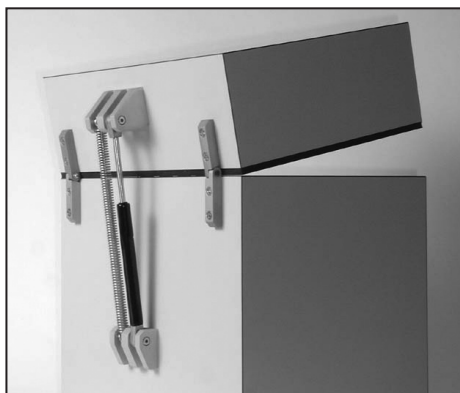
Also available:
#41 battery pill
AA



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 @1.40-1984 and IEC 942: 1988.

**Sound Chamber Stand**

A secure, steel-tube stand that improves sound isolation and brings the testing area of the test chamber to convenient table height. Color matches the electronics module.

**Sound Chamber Spring Damper**

Factory-installed or Assembly Kit. This spring assembly fits onto the back of the sound chamber, making it easier to open the sound chamber lid. Once the sound chamber is open past a certain point, the user can release the lid and let the spring open it the rest of the way. Great when performing repetitive coupler measurements.

**FM Kit**

Facilitates coupler and real-ear tests of FM systems. The kit includes a telescoping floor stand with a test platform and plenty of extra Fun-Tak and a 6-inch (15 cm) square foam pad for using the 2-cc coupler outside the test chamber.



RECD Earphone Package

Consists of one ER3A earphone with a 1/4 inch plug, a 72 inch cable, an assortment of ear tips, a calibration certificate, and a label clip. This package is suitable for performing an RECD measurement with the 7000 Test System.

1.5 Layout, Controls, and Safety

This section describes the basic layout of the front and rear panel of the 7000 test system, and special information pertaining to safety regulations.

1.5.1 Front Panel Layout

The front panel of the 7000 test system consists of 8 function keys, 4 arrow keys, and 9 other keys with varying operations. Together, all of these keys are used to control all the operations of the 7000 test system. A wide internal thermal printer is located to the right of the front panel. See Figure 1.5.1.

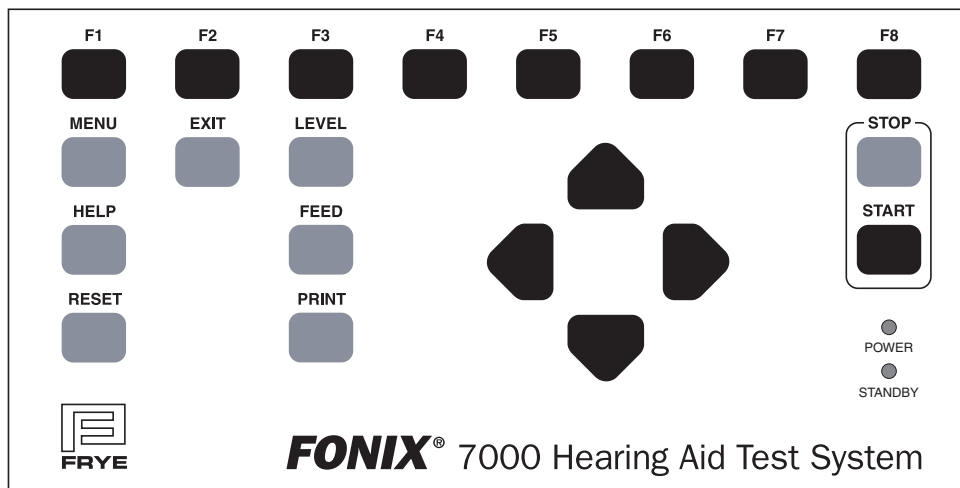


Figure 1.5.1—Front panel

FUNCTION KEYS:

The top row of buttons on the 7000 front panel consists of “function keys” labeled [F1] through [F8]. The function of these keys change from screen to screen, according to the need of 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]:	Brings up 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:	<p>Power: When green, this LED indicates that the 7000 Test System is powered on.</p> <p>Standby: When green, this LED indicates that the screensaver mode is engaged (screensaver not available at this time)</p>

1.5.2 Rear Panel Layout

The rear panel of the 7000 test system contains most of the external connections for the analyzer. See Figure 1.5.2 for a diagram of the back panel.

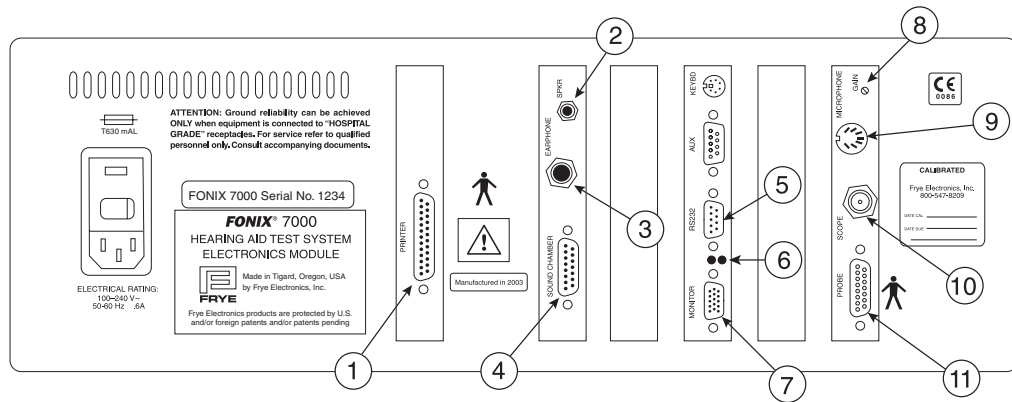


Figure 1.5.2—Back panel

1. **PRINTER:** Connects an external printer to the 7000 test system.
2. **SPKR:** Connects the sound field speaker for real-ear measurements.
3. **EARPHONE:** Connect a insert earphone to the analyzer for RECD measurements. A 50 ohm earphone should always be used, to avoid harm to the earphone.
4. **SOUND CHAMBER:** Connects the main module to the sound chamber.
5. **RS232:** Connects the 7000 test system to a personal computer.
6. **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.
7. **MONITOR:** Connects the main module to a video monitor.
8. **GAIN:** Adjusts the calibration of the M1950E microphone.
9. **MICROPHONE:** Connects the M1950E microphone.
10. **SCOPE:** Connects to an external scope for external measuring purposes.

11. PROBE:	Connects the main module to the remote module (used for real-ear measurements).
KEYBD:	Not currently active.
AUX:	Not currently active.

The following safety symbols can be found on the back of the 7000 hearing aid analyzer:



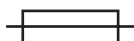
Type B Equipment. The probe microphone and insert earphone are type B applied parts, according to IEC 60601-1.



Read the accompanying documents. Please read this manual before operating the 7000 test system. A separate maintenance manual exists for the 7000 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 7000 test system to remain compliant.



Replace fuses only with the same type and rating.

1.5.3 Safety

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 7000 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.

Connection of peripheral equipment to the 7000

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

All electrical equipment attached to the 7000, 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 60601-1-1 must not be exceeded. IEC 60601-1-1 should be consulted when assembling such a system.

Electromagnetic compatibility

The 7000 complies with IEC 60601-1-2.

The 7000 generates and uses radio frequency energy. In some cases the 7000 could cause interference to radio or television reception. You can determine if the 7000 is the source of such interference by turning the unit off and on.

If you are experiencing interference caused by the 7000, 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 7000 and the receiver.
3. Connect the 7000 to a different outlet than the receiver.

In some cases radio transmitting devices, such as cellular telephones, may cause interference to the 7000. In this case try increasing the distance between the transmitter and the 7000.

Disposal of the 7000 and accessories

The 7000 and some of its accessories contain lead. At the end of its useful life, please recycle or dispose of the 7000 according to local regulations.

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

Siemens Hearing Instruments Ltd.
Alexandra House
Newton Road
Manor Royal
Crawley
West Sussex RH109TT
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 or (800) 547-8209
 Fax: (503) 639-0128
 email: support @frye.com
 sales@frye.com

ISO 13485



FM 77405

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 7000 test system. A description of the front and back panels is also included.

1.6.1 Unpacking the FONIX 7000

Remove the FONIX 7000 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 7000 test system and a labeling of its basic components.

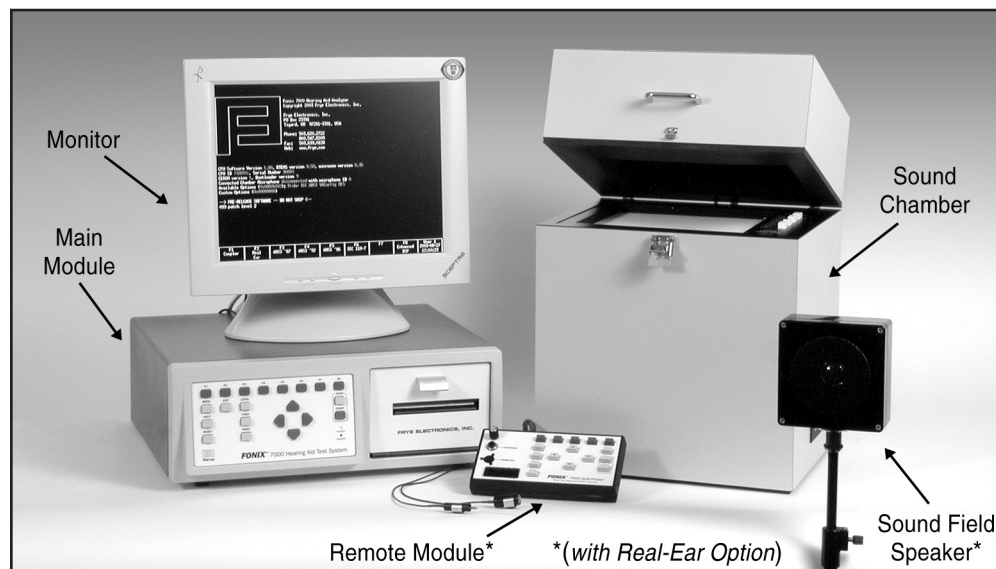


Figure 1.6.1. Caption: The 7000 Test system.

1.6.2 Locating and arranging the 7000 test system

Locate the 7000 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.

If your 7000 has the Real-ear Option, further consideration needs to be given to the placement of the sound field speaker. The speaker should be placed in a manner in which the sound will not reflect off walls, chairs, tables, or other objects. Such sound reflections could negatively affect test results.

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 “Monitor” on the back of the main module. Tighten the screws on the connector to secure the connection.
2. Plug the M1950E microphone into the connector marked “Microphone” located on the back of the main module.
3. Connect the sound chamber cable into the plug marked “sound chamber” on the back of the main module. Plug the other end of the cable into the sound chamber. This cable provides all the connections necessary for operating the internal loudspeaker, telecoil, and battery voltage supply of the 7020 test chamber. Tighten the screws of the plug at each end of the cable to secure the connection.
4. Plug the power cord into the three-pronged jack on the rear panel of the main module. Plug the power cords of both the main module and the video monitor into an AC outlet. We recommend using a switchable multiple outlet power strip. Any voltage between 100 and 240 VAC is acceptable, 50 or 60 Hz line frequency.

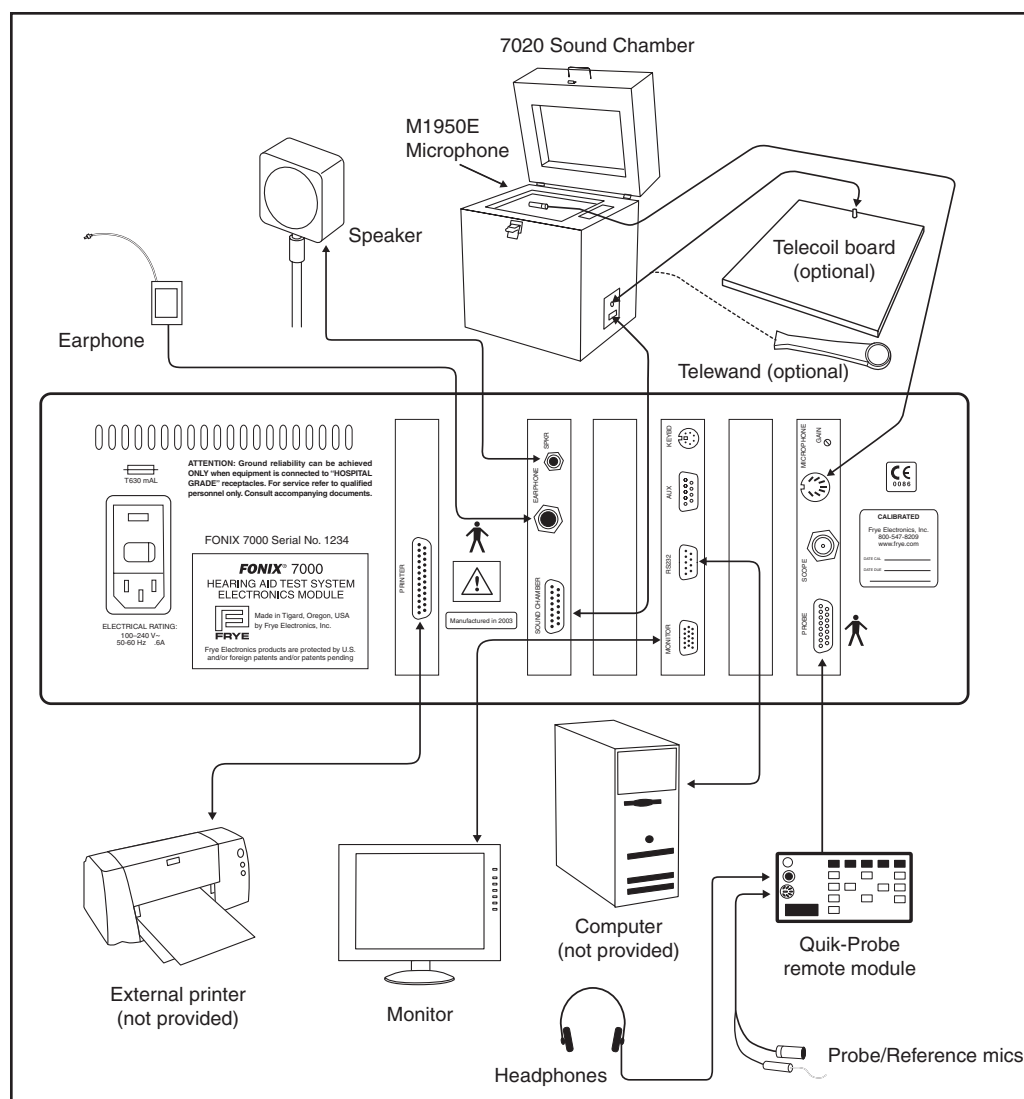


Figure 1.6.3 —7000 test system setup

1.6.4 Connecting the Real-Ear Equipment

If you ordered the Real-Ear Option, connect the real-ear equipment as follows. See Figure 1.6.3.

1. Plug the remote module cable into the jack labeled “Probe” on the back of the main module. Tighten the connector screw to secure the connection.
2. Plug the round, 8-pin connector of the dual microphone cable into the top surface of the remote module where it is marked “PROBE MIC.”
3. Plug the monitor headset into the remote module by attaching the ¼” adapter and plugging it into the jack marked “earphone,” if desired.

4. Depending on whether you have a floor stand or a swing arm, either (1) Unfold and extend the floor stand to the desired height, about the level of a seated client's ear, or (2) Mount the wall/desk bracket of the swing arm in a convenient location. Attach the loudspeaker to the stand or arm, using the threaded connection.
5. Plug the dual banana plug into the rear jacks of the loudspeaker. Then plug the other end of the cable into the main module where it is marked "SPKR."

1.6.5 Powering up the 7000 test system

1. Turn on the electronics module 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. See the video operator's manual for instructions, if necessary.

The Opening screen of the 7000 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 7000 test system.

1.7 Maintenance

In order to ensure accurate testing, we recommend yearly calibrations of your coupler microphone. For those units with the Real-ear Option, we also recommend yearly calibration of the probe & reference microphones and the sound field speaker. 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 7000 from mains power while cleaning. Wipe the 7000 with a slightly moist but not dripping cloth. Use plain water or water with mild dish washing detergent. Wipe away any detergent with a slightly moist cloth. Finally, use a soft dry cloth to eliminate any lingering moisture.

Never allow fluid to enter the 7000:

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

The 7000 microphones should be wiped with a dry cloth. Excess moisture may damage the microphones.

Solvents and abrasives will cause permanent damage to the 7000.

1.7.2 Care & Maintenance of your M1950E Coupler Microphone

Microphones are perhaps the most delicate of FONIX products. They require care and concern 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 you no good and the microphone 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 Fun-Tak on the grill of the microphone!

Fun-tak 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 will cause damage!

Overall, just be aware that your coupler microphone is a delicate instrument that needs to be treated with care and respect. If you do so, the two of you will be rewarded with a long, happy relationship.

1.7.3 Locating the serial number and software version

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

The serial number of your 7000 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 7000 test system.

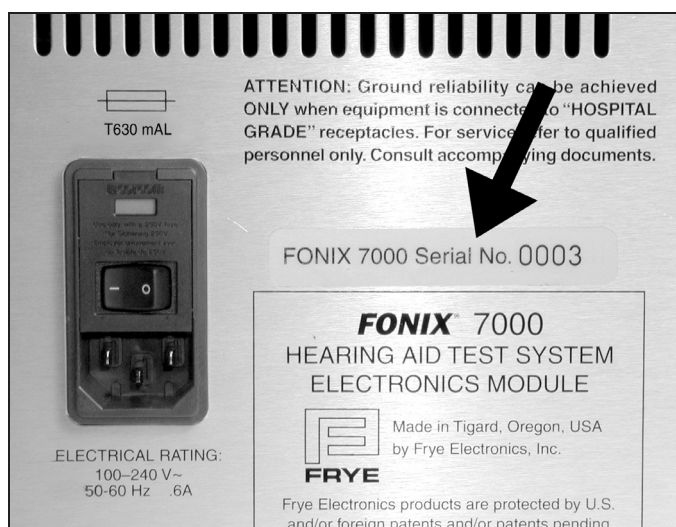


Figure 1.7.3A—Serial number location

The software version of your 7000 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.

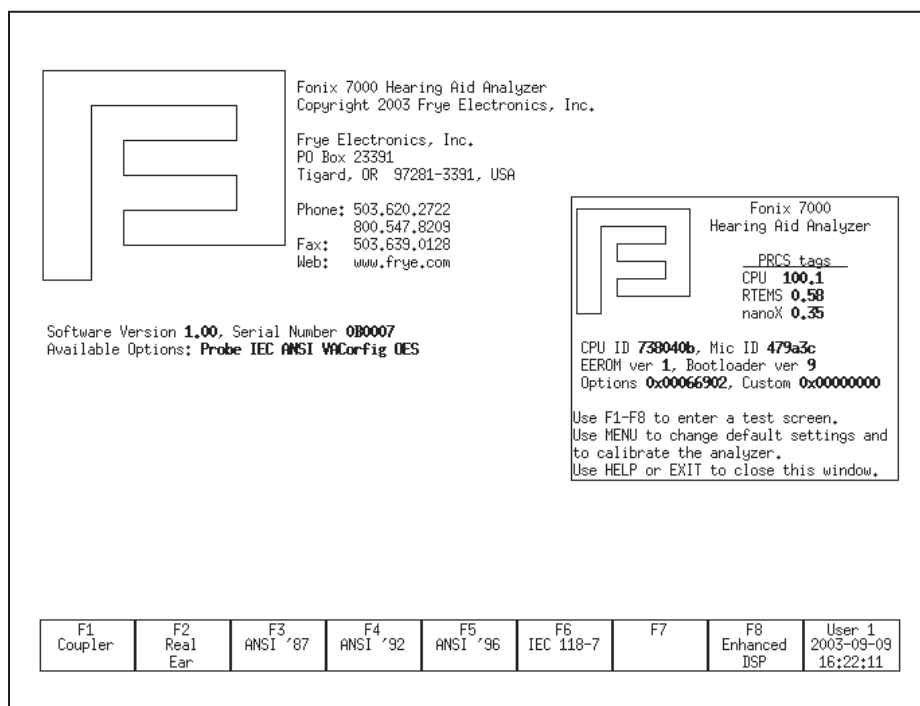


Figure 1.7.3B—Software version location

1.7.4 Contacting the Factory

If you have any questions regarding your instrument, have your serial number and software version ready (see Section 1.5.3), and contact us at:

Mailing address:

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

Shipping address:

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

Phone: (800) 547-8209 or (503) 620-2722

Fax: (503) 639-0128

Email: sales@frye.com (sales questions)

Support@frye.com (technical questions)

Service@frye.com (repair questions)

1.7.5 Warranty

The 7000 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 7000 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 7000 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 7000 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.

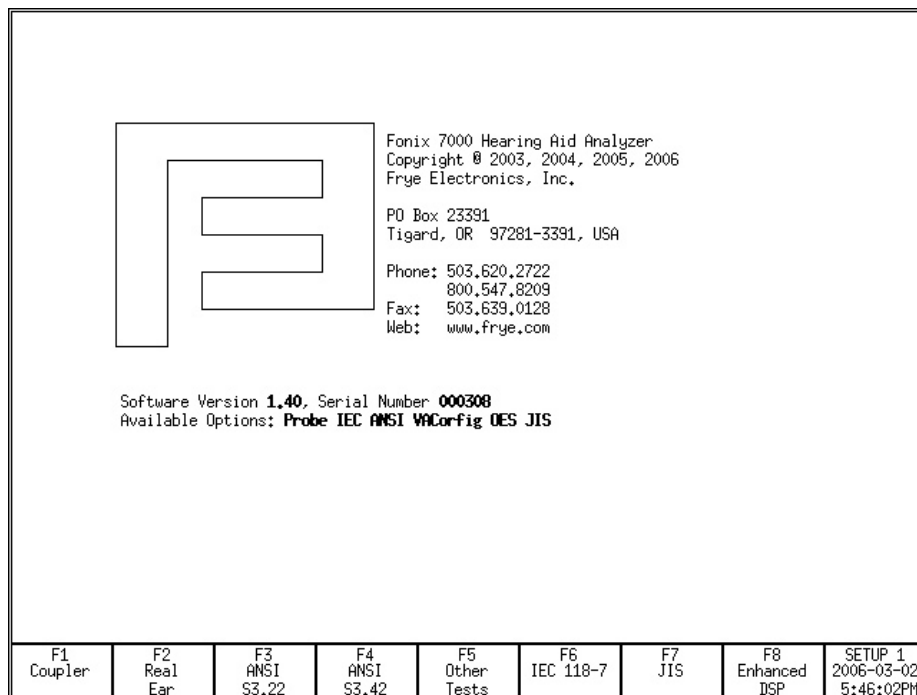


Figure 2.1—Function key display

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 tested will toggle between “left” and “right.” A red box will appear briefly around the function key box on the display. This box 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 bring up a pop-up menu. When this happens, use the [v, ^] keys to select the desired setting, and then use [>] to perform the actual selection.

For example, in the Coupler screen, pressing [F5] will bring up a selection of source types. To select the desired source, you would use [v, ^]. 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.

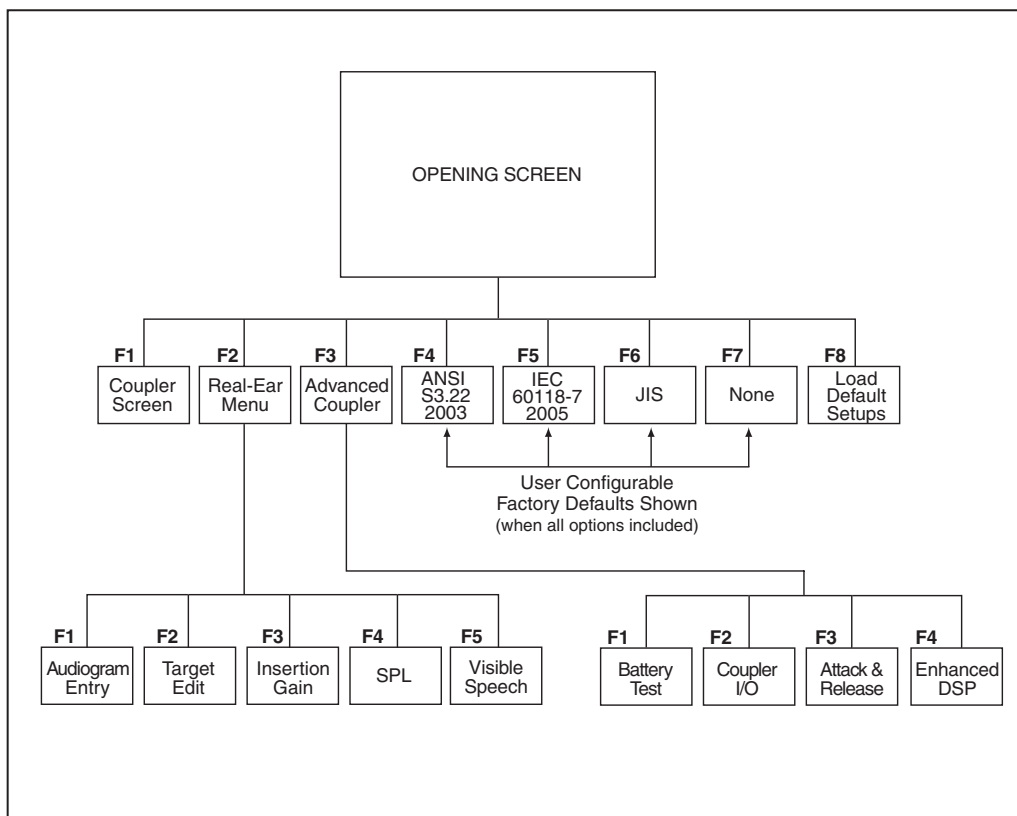


Figure 2.1.2—Navigation Flow Chart

2.1.3 Using the pop-up help windows

Each operational screen on the 7000 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 [v, ^] 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.

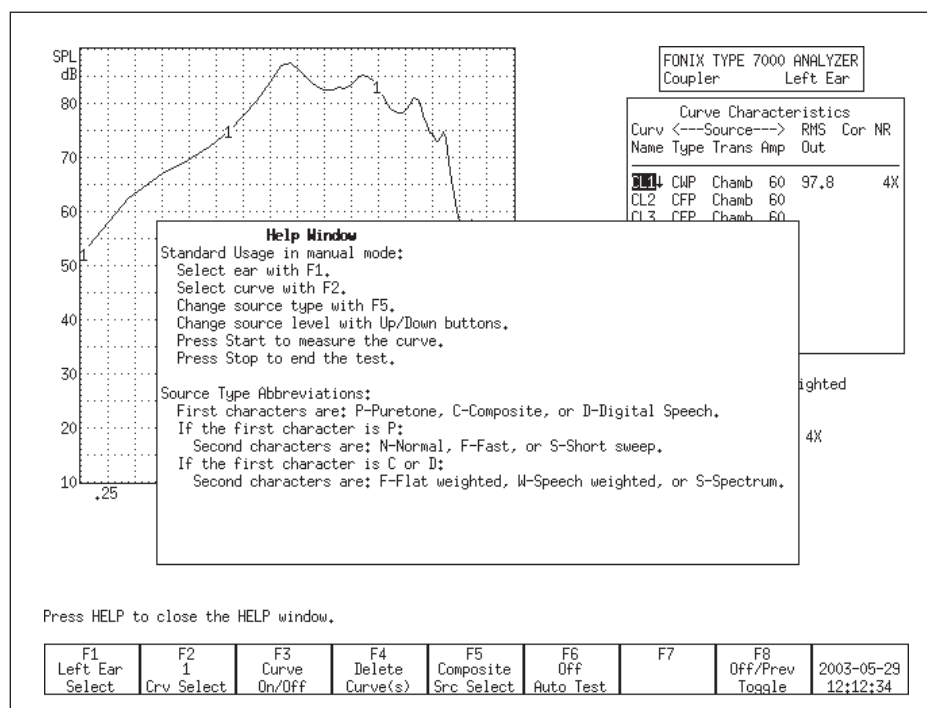


Figure 2.1.3—Pop-up help window

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.

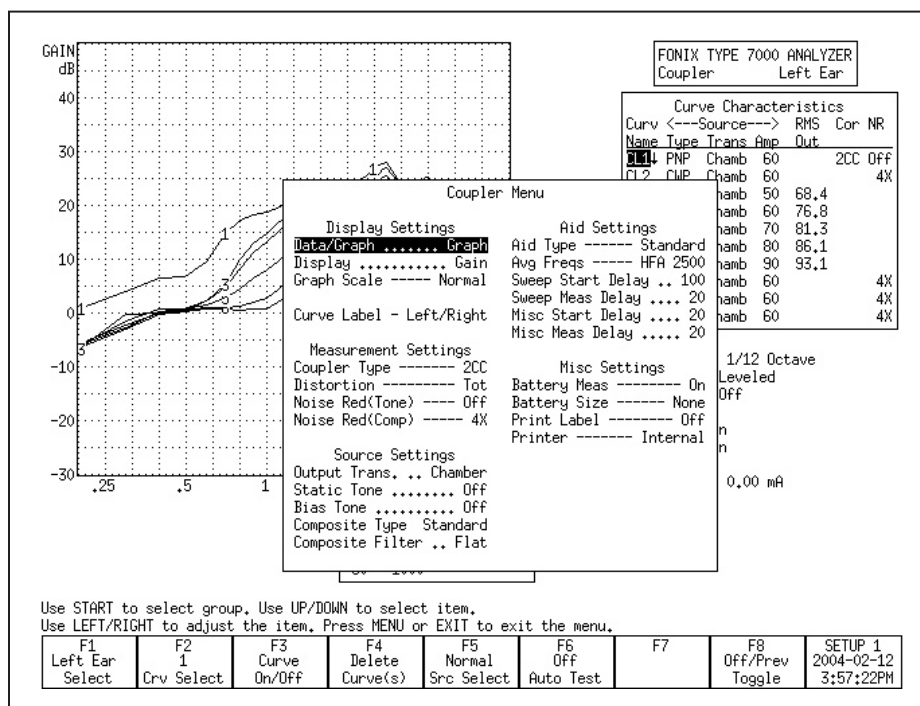


Figure 2.1.4—Local menu

Some local menu selections are common across screens. When this is the case, selections made in one local menu will usually carry across 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 S3.42, IEC 60118-7 1994, IEC 60118-7 2005, JIS, Audiogram Entry, Insertion Gain, Real-ear SPL, Visible Speech (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. In the Audiogram Entry and Target Edit screens, they are used to edit the audiogram and targets.

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, Coupler, and Real-ear 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. If the Real-ear Option is included, use F1 to select the Real-ear Default Settings Menu (if the Real-ear Option is included on your analyzer), and change the settings as desired.
5. Press [F8] to open the Save Setup Defaults pop-up menu.
6. Use [v, ^] to select the desired setup number. If you are only going to use one saved configuration, use Setup 1.
7. Use [>] to complete the selection and close the pop-up menu. This will save all settings in the General, Coupler, and Real-ear Default Settings windows. It will take a few seconds for the 7000 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 [v, ^] 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 that are 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 [v, ^] 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 7000 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, those 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 [v, ^] 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. 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 all the various settings

General Default Settings

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

PRINTER: Printer used for printouts. Choose INTERNAL or EXTERNAL. See Section 2.4.

EXT PRNT COLOR: Color used when an external printer is selected. Choose B&W (Black & White) or COLOR.

EXT PRNT LANGUAGE: Language used when the external printer is selected. Choose HPCL or EPSON.

EXT PRNT #SCRNS/PAGE: The number of screens printed on a page using an external printer. See Section 2.4.7.

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

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 S3.42, IEC 60118-7 1994, IEC 60118-7 2005, JIS, Audiogram Entry, Insertion Gain, Real-ear SPL, Visible Speech (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 S3.42, IEC 60118-7 1994, IEC 60118-7 2005, JIS, Audiogram Entry, Target Edit, Insertion Gain, Real-Ear SPL, Visible Speech, 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 7000 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 7000 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.

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.

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 require-

ment and continues with the test sequence.

Real-Ear (Only available with the Real-Ear Option)

FIT RULE: The selected real-ear fitting rule, also known as a real-ear target.

CLIENT AGE: The age of the patient being fitted with hearing aids. This will affect the NAL-NL1 real-ear target and the HL to SPL transform.

COMPRESSION: The compression kneepoint of the hearing aid being fit. This will affect the NAL-NL1 real-ear target.

CHANNELS: The number of channels available on the hearing aid. This will affect the NAL-NL1 real-ear target.

AID LIMIT: The type of output limiting employed by the hearing aid. Change this to MULTICHANNEL or WIDEBAND or NONE. This will affect the NAL-NL1 real-ear target.

FIT TYPE: The type of fitting. Choose between UNILATERAL and BILATERAL. This will affect the NAL-NL1 real-ear target.

SOUND FIELD: The position of the sound field speaker during real-ear measurements. Choose between 0 and 45 degree azimuth. This will affect the NAL-NL1 target, the average unaided response, the insertion gain to SPL transform, and the HL to SPL transform.

REF POSITION: The condition of the sound field during leveling. **HEAD SURFACE** means that the reference microphone is placed on the patient's head during the leveling process. **UNDISTURBED FIELD** means that the reference microphone is held in front of the speaker during leveling. This will affect the NAL-NL1 target, the average unaided response, the insertion gain to SPL transform, and the HL to SPL transform.

AUD TRANSDUCER: Select the type of transducer used to obtain the audiometric measurements. This will affect the NAL-NL1 real-ear targets and the HL to SPL transform.

RECD MODE: Real-ear to coupler difference used in real-ear conversions such as HL to SPL. When set to OFF, the RECD graph and table are removed from the Audiogram Entry Screen, and the average RECD is used. **CUSTOM ENTERED** will let you enter RECD values previously measured, and **CUSTOM MEASURED** will let you measure the RECD.

RESET SOURCE: The signal type selected in the real-ear measurement screens when the [RESET] button is pushed.

TONE FILTER: The weighting used for pure-tone sweeps in real-ear measurements. **FLAT** produces tones at each frequency with the same amount of amplification. **ANSI** and **ICRA** produce tones with higher amplification at lower fre-

quencies and lower amplification at higher frequencies, according to the ANSI and ICRA speech weighting, respectively.

COMPOSITE FILTER: Wide-band speech weighting used in the Composite and Digital Speech signals. See Section 2.3.2.3.

RESET EAR: The ear selected in the real-ear measurement screens when the [RESET] button is pushed.

REF MIC: Status of the reference microphone during real-ear measurements.

OUTPUT LIMIT: The maximum dB SPL value that the analyzer will allow when taking real-ear measurements. When this value is exceeded at any frequency, the measurement will automatically stop and the source will turn off in order to protect the patient.

NOISE RED (TONE): Pure-tone noise reduction for real-ear measurements. See Section 2.3.1.1.

NOISE RED (COMP): Composite noise reduction for real-ear measurements. See Section 2.3.2.1.

SMOOTHING: Status of smoothing, which rounds off real-ear curves and removes minor peaks. Turn it ON or OFF.

APPROACH: The approach set in the local menu of the Real-Ear Target screen. When set to Gain, the source type of REAR 5 in both the Real-Ear Insertion Gain and Real-Ear SPL screens will be set to the RESET SOURCE type. When set to SPL, the source type of this curve will be set to SHORT. This is done for performing a real-ear saturation measurement at 90 dB SPL.

UNAIDED: The type of unaided curve used in real-ear measurements. A selection of AVG will set the KEMAR average. A selection of CUSTOM will use the patient's measured unaided response.

REUR AUTO ADJUST: This function adjusts the real-ear unaided response to the current selected input level. This allows you to compare the REUR to an aided response made at a different input level. For instance, if the REUR was performed at 65 dB SPL, but the current aided source level is 50 dB SPL, the REUR will be adjusted to its probable response if measured at 50 dB SPL so that you can directly compare the 50 dB SPL aided response.

IG DISPLAY: Type of display used in the Insertion Gain screen. Choose between having the lower graph display in gain or SPL (output).

2.3 Source Types

There are two main types of sources available on the 7000 test system: pure-tone and composite. Four types of pure-tone sweeps are available: long, normal,

fast, and short. Two types of composite signals are available: Composite and Digital Speech. The composite signal can have your choice of speech weightings, including ANSI and ICRA.

The type of signal you should choose for a particular test or type of hearing aid depends upon the situation. Here is a description of each of the source types and when you would want to use them.

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 (43×4) will be taken with every normal pure-tone sweep.

2.3.1.2 Delay times

The 7000 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 7000 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

Harmonic distortion occurs when a hearing aid clips the peak 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 7000 Test System, you can test the amount of distortion available in the second harmonics, the third harmonics, 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.

When viewing measurements in output (dB SPL), the weighting of the signal is very important because the signal input is included with the measurement results of the output. This could cause some problems when comparing pure-tone sweeps with speech-weighted Composite or Digital Speech signals. For this reason, we have made it possible to “weight” the real-ear pure-tone sweeps on the 7000 hearing aid test system.

The TONE FILTER selection is available in the Setup Menu under Real-ear settings and in the local menus of the Real-Ear Insertion Gain and Real-Ear SPL measurements screens. It has the following settings:

- FLAT: Uses a flat weighted signal with equal amplitudes of all the tones in the sweep
- ANSI: Uses the ANSI weighting in the pure-tone sweep
- ICRA: Uses the ICRA weighting in the pure-tone sweep

Pure-tone measurements made in the coupler measurement screens are always flat weighted.

2.3.2 Understanding Composite Signals

There are two types of composite signals: Composite and Digital Speech. The Composite signal is a continuous broadband signal containing 79 different frequencies presented simultaneously. This signal is usually “speech weighted,” which means that the lower frequencies have a higher emphasis than the higher frequencies.

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 updates several times a second.

Digital Speech is an interrupted version of the Composite signal used for testing high-end digital hearing aids. Many high-end 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 the offending 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 regards as speech instead of noise.

The Composite and Digital Speech signals can be used with several different types of speech weightings: ANSI, ICRA, and FLAT. Flat is generally only used for specific research purposes—it contains no speech weighting and is difficult for most hearing aid circuits to process. See Section 2.3.2.3 for a discussion of the ANSI and ICRA speech weightings.

A significant advantage of using a composite signal is that each frequency present in the signal can be individually controlled in amplitude and phase. As the analyzer goes through the leveling process, each component is adjusted to produce a signal that is optimally accurate at the reference point where the leveling microphone is located. The 7000 test system is able to equalize the amplitudes to within 0.25 dB for coupler measurements made with the Composite signal. The spectrum limits are broadened to within 2 dB for real-ear measurements.

2.3.2.1 Noise reduction

Composite 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 composite 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.

2.3.2.2 Intermodulation distortion

The composite 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 2.3.2.2 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.

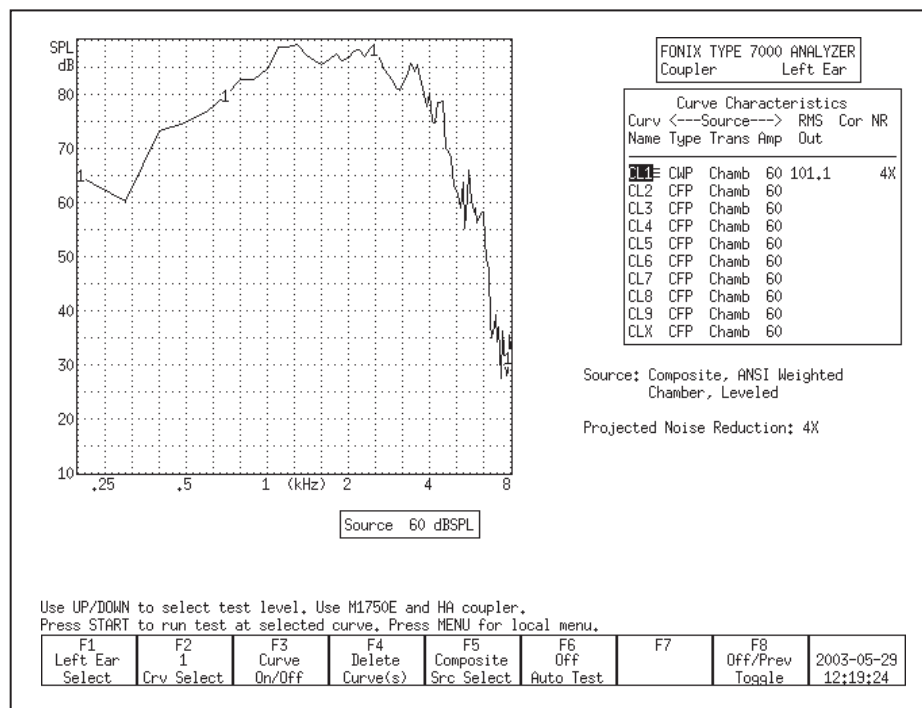


Figure 2.3.2.2—Example of IM distortion

2.3.2.3 Composite filter

There are two main types of composite 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 2.3.2.3 shows a comparison of the spectra.

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

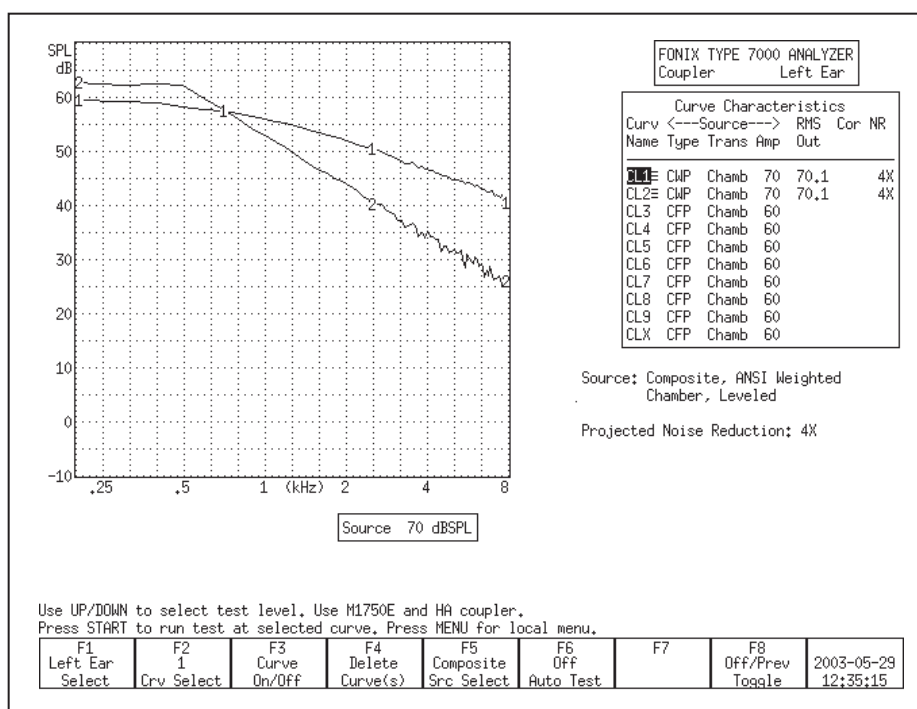


Figure 2.3.2.3—Comparison of the ICRA shape and the ANSI shape

2.3.2.4 Composite type

There are two types of the traditional Composite signal available on the 7000 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 signal 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 6500-CX test system, the predecessor to the 7000.

The Chirp Composite signal is another type of composite signal with a low 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 pre-

sented 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 2.3.2.3.)

2.3.2.5 Composite 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 2.3.2.5 for an example of the amplitudes 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.

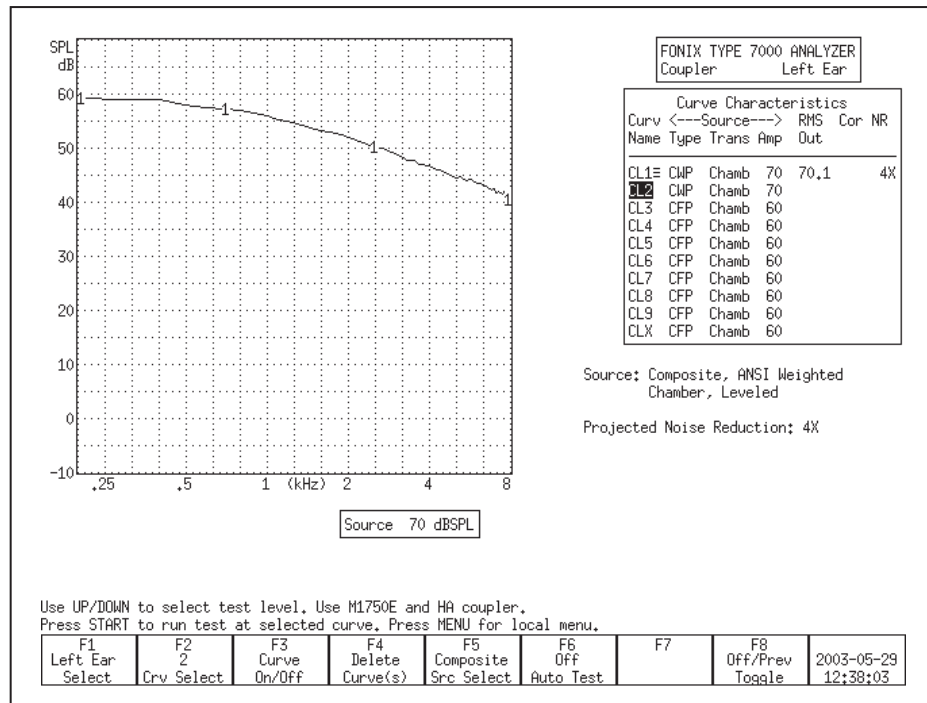


Figure 2.3.2.5

2.3.2.6 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.

2.4 Printing

The 7000 test system comes equipped with an internal thermal printer. The thermal printer prints a clear, easy-to-read image of the display. You can also hook up an external printer to print your results on normal office paper. You can use any external printer that supports HP PCL (Hewlett Packard Printer Computer Language) version 3.0 or the Epson ESC/P2 printer language.

2.4.1 Choosing a printer

You can set which printer to use in any local menu. (If you want to set the printer language or whether to print in color or black & white, you will need to use the Setup menu, shown in the next set of instructions.) To choose the printer in the local menu:

1. Press [MENU] from any measurement screen to open a local menu.
2. Use [v, ^] to select Printer. (You can use the [START] button to skip ahead sections in the local menu.)
3. Use [>] to make your printer selection (INTERNAL or EXTERNAL).
4. Press [EXIT] to return to the measurement screen.

To set the default printer, and/or to set the external printer language and color choice, use the Setup menu:

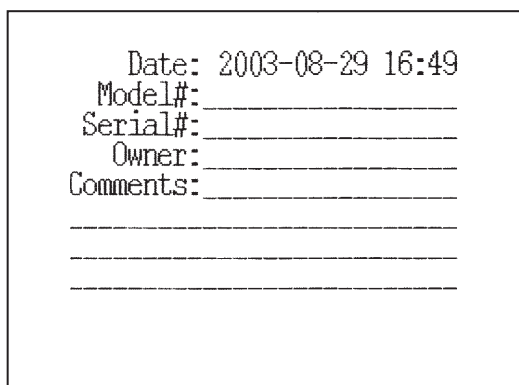
1. Press [MENU] from the Opening screen to open the Setup menu.
2. Use [v, ^] to select Printer.
3. Use [>] to make your printer selection (INTERNAL or EXTERNAL).
4. Use the arrow keys to make the desired selections for EXT PRNT COLOR and EXT PRNT LANGUAGE, if you are using an external printer.
5. Use [F8] to save the settings to a user setup. This will also save all the other selections in the Setup menu.
6. Press [EXIT] to return to the Opening screen.

2.4.2 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 2.4.2.

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:

1. Press [MENU] from the measurement screen to open a local menu.
2. Use [v, ^] 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 you turn off the analyzer.



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

Figure 2.4.2—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 [v, ^] 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.

2.4.3 Using the internal printer

The internal printer of the 7000 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:

- 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 7000 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 back of the printer mechanism provides the required tension onto 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 7000 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 7000 printer: initialization errors and printing errors. Initialization errors occur only when the 7000 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 of 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 7000 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

Please read the entire instructions before loading paper. Refer to Fig. 2.4.4A for printer features.

Step I: Installing the paper into the printer assembly

1. Open the printer door.
2. Remove the white 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 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.

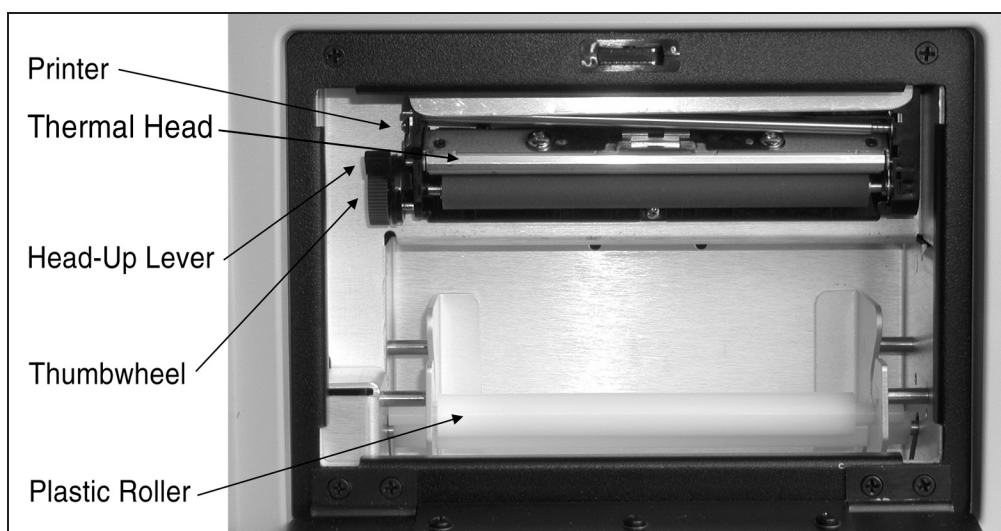


Figure 2.4.4A—The internal printer

Step II: Loading paper into the printer

1. Turn on the instrument.
2. Place the Head-Up lever into the **up** position. See Fig. 2.4.4B.
3. Unroll approximately six inches of paper from the roll, and insert the paper's leading edge into the bottom of the printer, directly behind the rubber roller. See Fig. 2.4.4C.

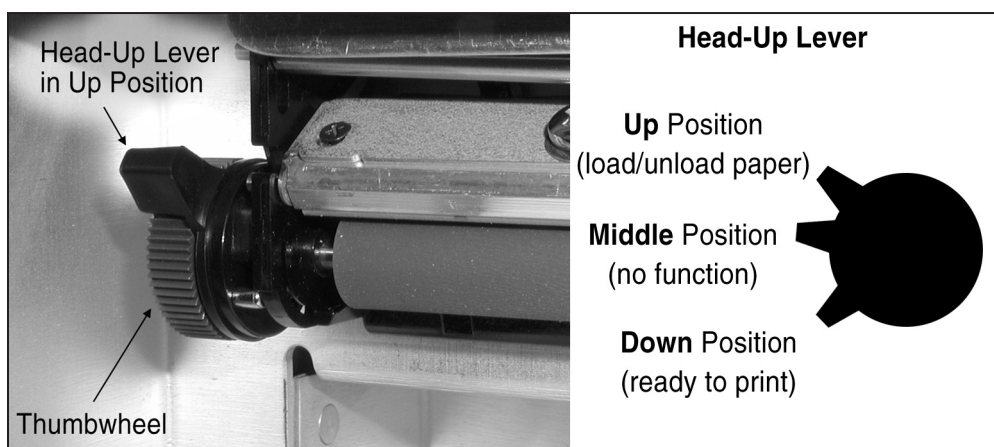


Figure 2.4.4B—Head-Up lever in up position.

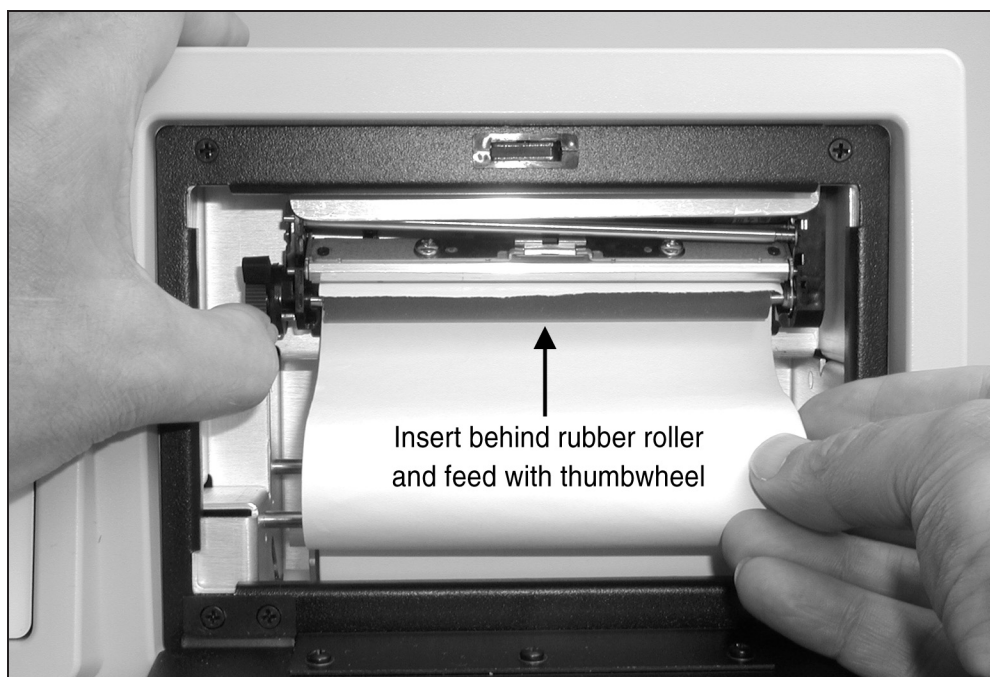


Figure 2.4.4C—Loading paper into the printer

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.
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 krinkle 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.

2.4.5 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 out.

2.4.6 Using an external printer

You can hook up an external printer to your 7000 test system to print your results on normal office paper. This eliminates the problem of fading associated with thermal printouts, and often makes it easier to store your test results.

You can use any external printer that supports HP PCL (Hewlett Packard Printer Control Language) version 3.0 or the Epson printer language ESC/P2. The printer should have a parallel interface. We keep a list of printers that work with our analyzer on our website:

<http://www.frye.com/products/analyzers/exprinter.html>.

1. Unplug the 7000 test system and the external printer from any power source.
2. Connect a standard printer cable to the external printer.
3. Connect the other end of the cable to the connector labeled PRINTER on the back of the main module of the 7000 test system.
4. Plug the 7000 test system and the external printer into their respective power sources.
5. Follow the directions found in Section 2.4.1 to select the external printer in the 7000 software. If you want to set the printer language or whether to print in color or black & white, you will need to use the Setup menu.

2.4.7 Putting multiple screens on a page

When printing with an external printer, it is possible to save paper by putting two screen prints on one piece of paper. This is done by printing the first screen on one half of the paper and leaving the paper halfway through the external printer until you choose to print the second screen. To do this:

1. Press [MENU] in the Opening screen to open the Setup menu.
2. Change Ext Prnt #Scrns/Page to 2. Make sure Printer is set to External.
3. Press [EXIT] to return to the Opening screen.
4. Go to the screen you want to print on the first half of the page.
5. Press [PRINT] to print the screen onto the first half of the paper. The paper will remain halfway through the external printer.
6. Go to the screen you want to print on the second half of the paper, or run another test.
7. Press [PRINT] to print the second screen and feed the paper the rest of the way through the printer.

Note: if you decide you don't want to take a second screen shot, press [FEED] to feed the second half of the paper through the external printer without printing.

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 TYPE 7000 ANALYZER						
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 7000 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 7000 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 the Coupler screen and the real-ear measurement screens.

To display numerical data:

1. Press [MENU] from the Coupler Multicurve screen or real-ear measurement screen.
2. Select Data/Graph using [v, ^].
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.

* Unlike the other measurement screens, the Insertion Gain screen offers the following selections: AIDED DATA and IG DATA. A selection of AIDED DATA will display the data from the aided curves that are normally displayed on the lower graph of the screen. A selection of IG DATA will display the data from the insertion gain curves that are normally displayed on the upper graph of the screen.

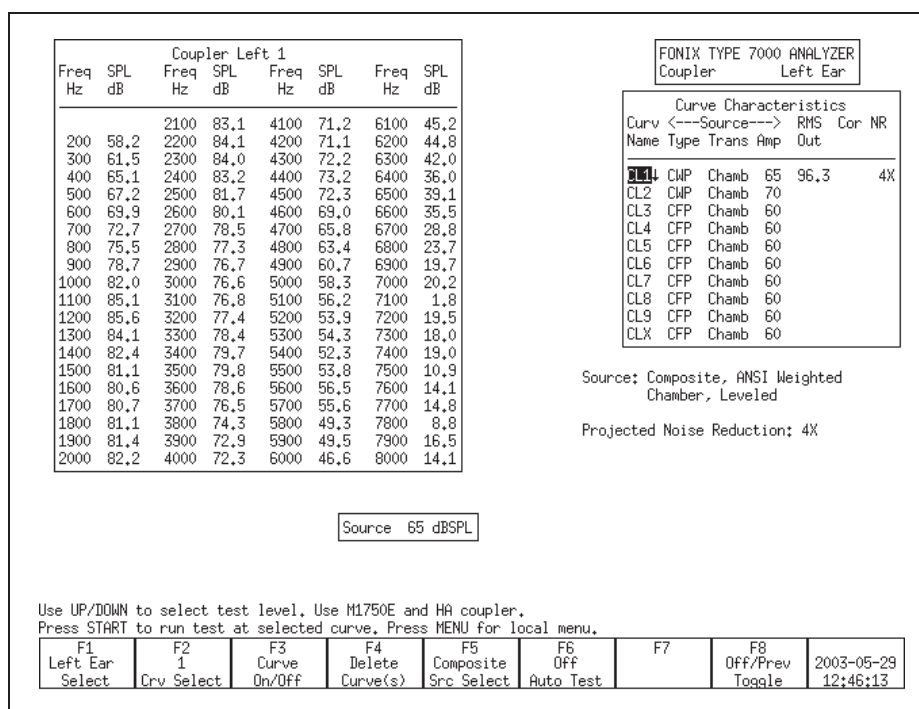


Figure 2.5.2—Data display of a composite measurement

2.6 Computer Connection

The 7000 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.

2.7 Remote Module

The remote module is a way of operating the 7000 away from the main module itself. This is especially helpful for performing real-ear measurements.

The keys of the remote module are a sub-set of the keys of the front panel of the main module. This means all functions performed with the remote module can also be performed in the same way with the front panel.

Since there are only five function keys on the remote module and eight function keys on the main module, there will be some operations, particularly in coupler mode, that will only be able to be performed with the front panel and its extra three function keys. However, we have made a special effort to ensure all real-ear functions can be performed with the remote module, allowing you to step away from the main module during the measurement process and make any necessary adjustments to your client and testing situation.



Figure 2.7—Remote Module

2.8 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, but sound field leveling for real-ear measurements must be done for every patient and every ear. See Section 3.2.1 and Section 6.2.4 for instructions on how to perform coupler and real-ear leveling, respectively.

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_LEVELLED:** Tolerances are the same as SEMI-LEVELLED 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 a much less common problem.

If you are having problems leveling the sound field speaker for real-ear measurements, check the connections of the microphones, remote module, and sound field speaker. If you have been able to successfully level the sound field speaker in the past, the most likely problem is the reference microphone needs calibration or is damaged, although sound field speakers have also been known to go bad.

Sound field leveling, however, is more prone to user error than sound chamber leveling. Make sure the sound field speaker isn't pointed at a wall or other surface that may cause the sound field to bounce and interfere with the leveling process (and measurements). The client should be 12-15 inches from the speaker; try moving him closer and see if that helps. For troubleshooting purposes, try leveling the sound field speaker by holding the microphone 6 inches from the speaker. If the sound field levels with this technique, then you probably have a positioning problem instead of a hardware problem. (This technique should NOT be used for leveling for actual real-ear measurements.)

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

Basic Sound Chamber Tests

In the Coupler 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 7000 test system, enter the Coupler screen by pressing [F1].

The Coupler Multicurve screen can be set as the screen that appears when the 7000 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 Screen Display

The display of the Main Coupler 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

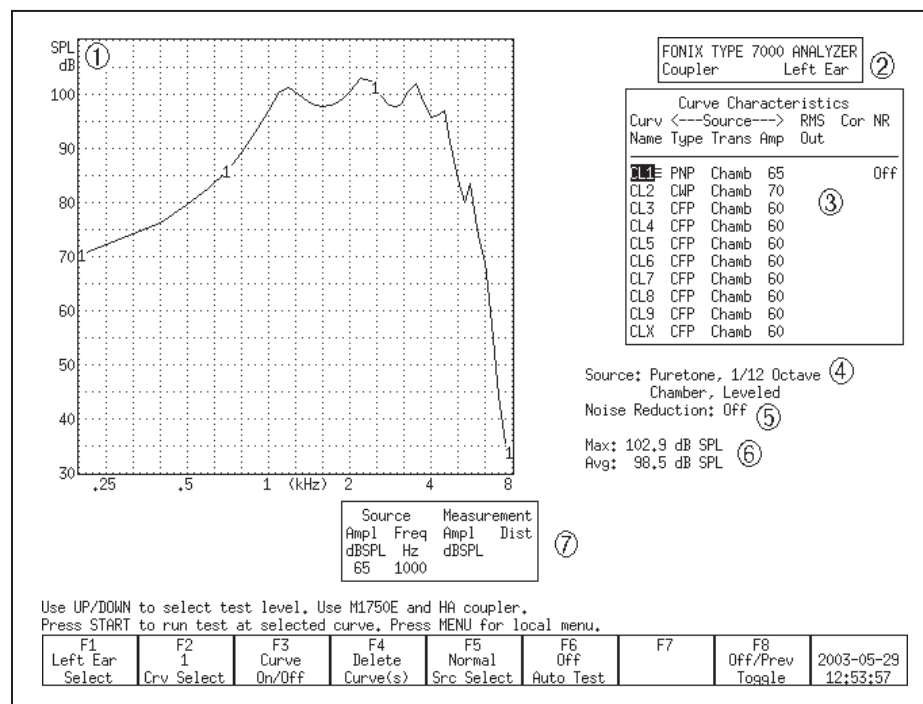


Figure 3.1.1—Coupler Screen with pure-tone source

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

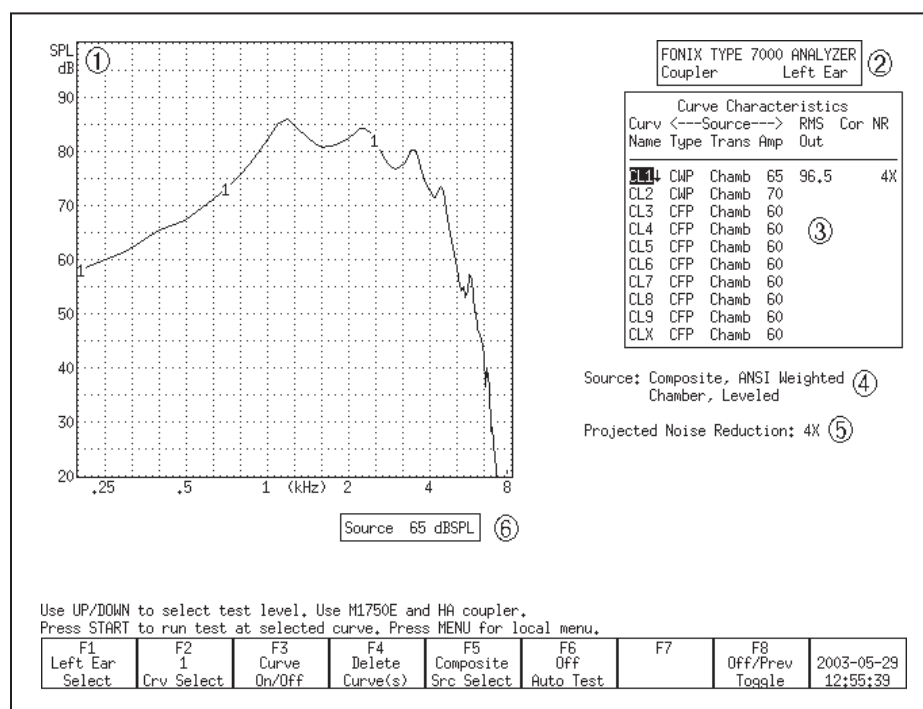


Figure 3.1.2—Coupler screen with a Composite source

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 7000 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 in the sound chamber at the reference point by itself and run a composite frequency response (see Section 3.4.2). You should get a smooth, flat curve.

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.

3.2.1 Leveling the sound chamber

To level the sound chamber:

1. **IMPORTANT:** Be sure nothing is plugged into the battery voltage supply.
2. Place the microphone on the left side of the sound chamber, with the microphone grill over the reference point (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 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 7000 doesn’t level, it could be an indication that your microphone needs to be calibrated or replaced.



Figure 3.2.1—Leveling the sound chamber

Note: See Section 5.1.1 for the ANSI standardized leveling procedures.

3.2.2 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 or the sound chamber.
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.

3.2.3 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 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.

All 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.

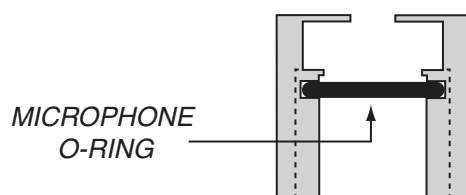


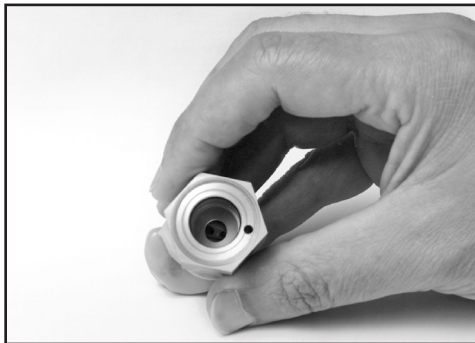
Figure 3.3.1—Direct access coupler (HA-1)



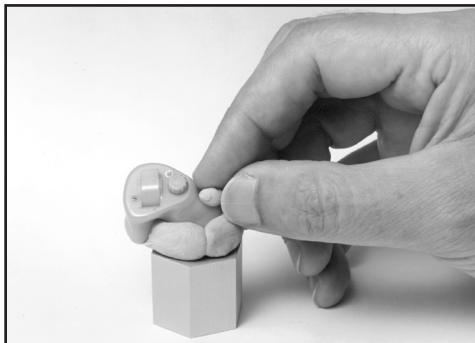
1. Roll the Fun-Tak, provided with each instrument, into a rod long enough to go around the transmitting end of the aid (approximately 2 inches). (Modeling clay can also be used, but it doesn't work as well.)



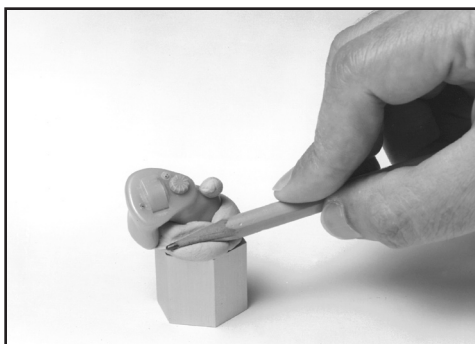
2. Bend the Fun-Tak rod around the canal of the aid, making the resulting “donut” flush with the end of the aid. (Some users choose to seal the vent opening at this end with a small amount of Fun-Tak.)



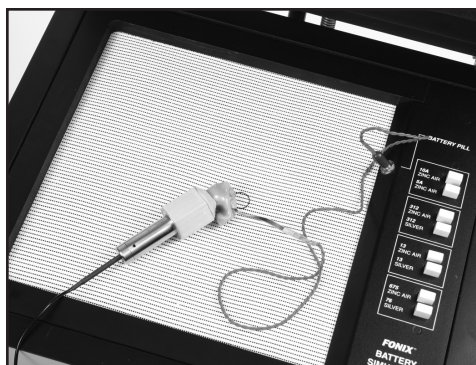
3. Align the sound opening of the aid to the hole at the conical end of the coupler. Look through the open end of the coupler to be sure the sound opening of the aid is clear of obstructions and correctly placed.



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 right, with the microphone opening as close as possible to the reference circle. It is best, when possible, to angle the faceplate upward instead of downward (see the photo at left).

For the sake of repeatability, you may elect to use a ninety degree angle of the faceplate to the reference circle, again with the microphone opening as close as possible to 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.

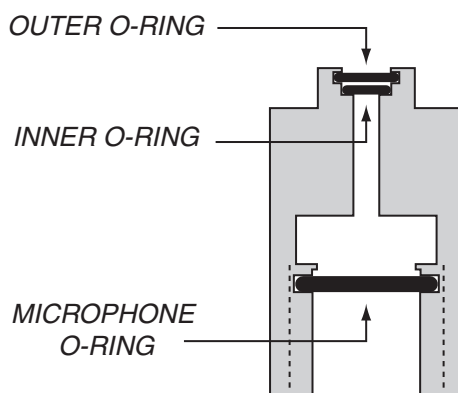


Figure 3.3.2A—Standard 2-cc Coupler (HA-2)

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 0.4 inches (10 mm). When cutting tubing to length, leave extra space at each end to go around the nubs of the ear-level adapter and the hearing aid hook. See Figure 3.3.2B.

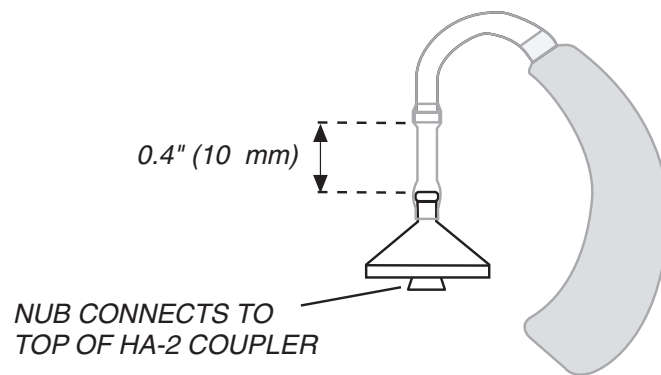


Figure 3.3.2B—Ear-level Adapter (used with HA-2)

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 0.4 inches (10 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.

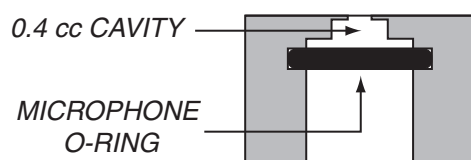


Figure 3.3.3—CIC Coupler

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 Open-Ear Hearing Aids

The Open Ear Coupler is a non-standard sized coupler used to produce a realistic frequency response of an open ear style hearing aid while providing an easy mechanism for attaching these hearing aids to the coupler. Figure 3.3.4A shows an illustration of the Open Ear coupler and how it is attached to a hearing aid. The speaker unit of the hearing aid is inserted into the coupler just as it would be inserted into the patient's ear. The connection, unlike that of an HA-1, HA-2, or CIC coupler, is not occluded.

Like the CIC coupler, the Open Ear coupler cannot be used to perform measurements to a standard such as ANSI, IEC, or JIS. Unfortunately, there is no standardized method of performing a coupler measurement on an open-ear style hearing aid.

Hearing aid manufacturers have independently developed different mechanisms for attaching an open-ear hearing aid to an HA-1 or HA-2 coupler. One such device, pictured in Figure 3.3.4B, is attached to the speaker unit of the open-ear hearing aid and to the tubing of an HA-2 coupler. Other connecting devices consist of a plate that attaches to an HA-1 coupler.

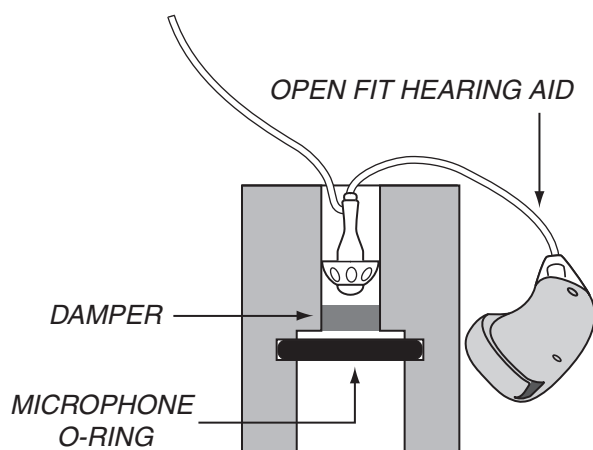


Figure 3.3.4A—Open-Ear Coupler

To perform a coupler measurement to the ANSI S3.22 standard, we recommend using Fun-Tak to connect the speaker unit of the open-ear hearing aid to an HA-1 coupler, as pictured in Figure 3.3.4C. The HA-1 coupler is better than the HA-2 coupler for open-ear hearing aids because, unlike the BTE aids for which the HA-2 was designed, open-ear hearing aids are not attached to an ear mold.



Figure 3.3.4B—HA-2 Coupler

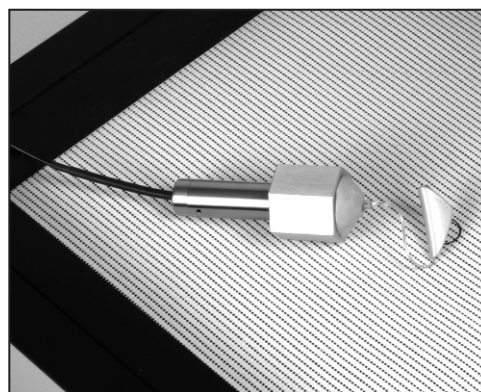


Figure 3.3.4C—HA-1 Coupler

Figure 3.3.4D contains an example of a comparison of an open-ear hearing aid tested with an open-ear coupler (Curve 1), an HA-1 coupler attached to the open-ear hearing aid with Fun-Tak (Curve 2), and an HA-2 coupler with an open-ear attachment (Curve 3). The dark line (Curve 4) in the graph represents the KEMAR real-ear gain response of the hearing aid. As illustrated, the open-ear coupler provides the measurement most like the real-ear response of the hearing aid.

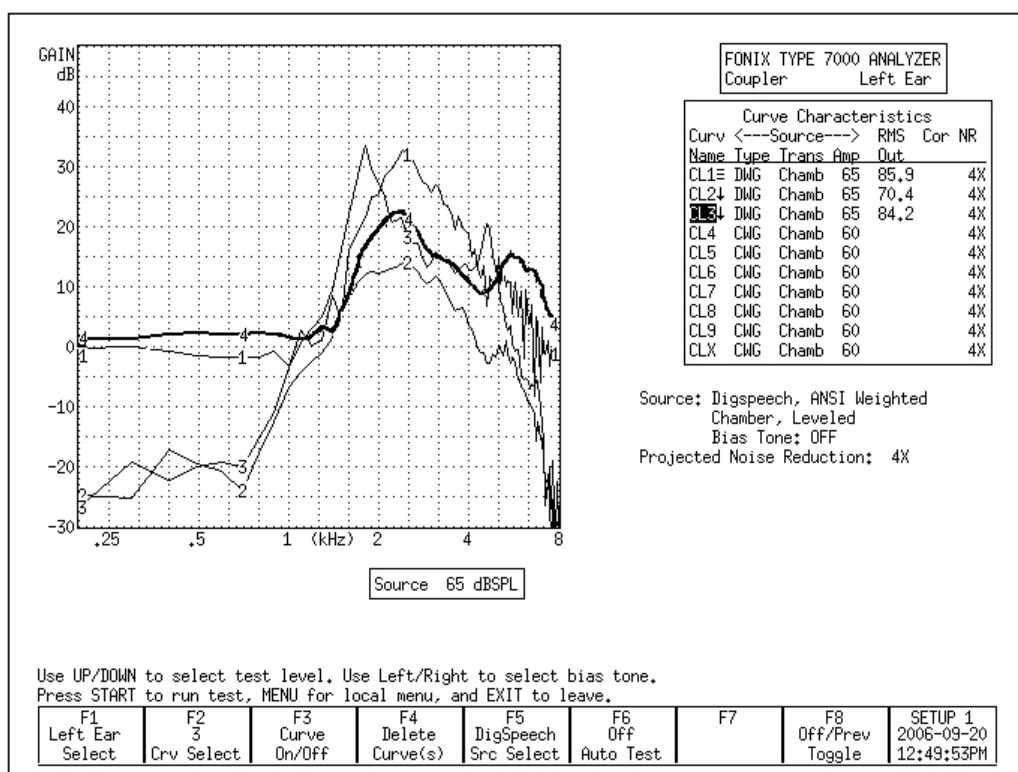


Figure 3.3.4D—Comparison of couplers with open-ear hearing aid. Curve 1 was measured using the Open Ear coupler, Curve 2 with an HA-1 coupler, Curve 3 with an HA-2 coupler, and Curve 4 is the KEMAR real-ear response.

3.3.5 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. (The aid's cord will not be damaged by closing and latching the test chamber lid.)

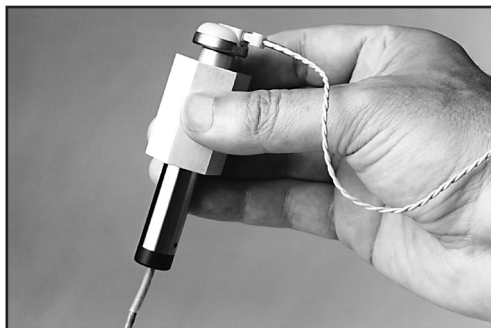


Figure 3.3.5A—Coupler setup



Figure 3.3.5B—Body Aid in test chamber

3.3.6 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).

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.

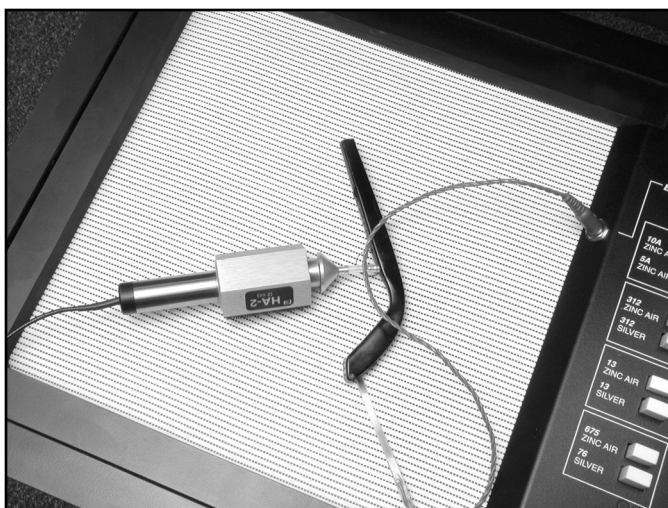


Figure 3.3.6—Eyeglass Aid Set-up

3.3.7 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 7000 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.

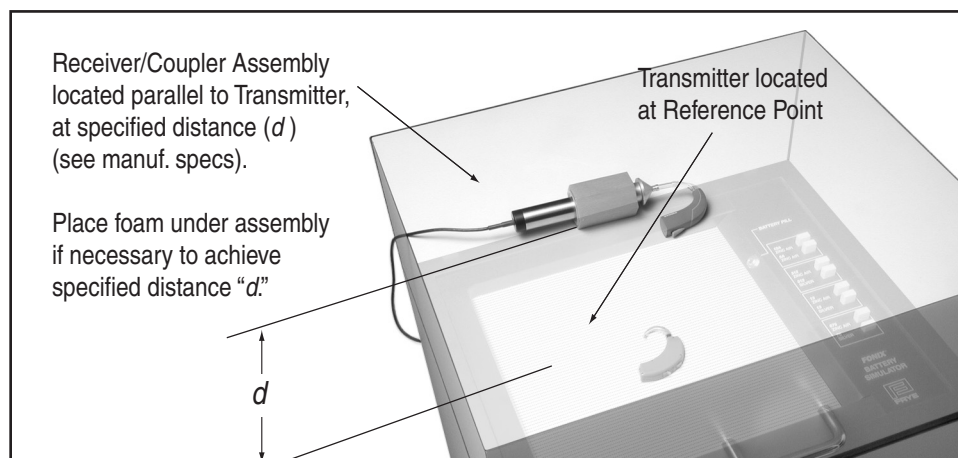


Figure 3.3.7—Testing Wireless CROS Hearing Aids

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.

3.3.8 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 screen of the 7000 analyzer, 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:

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.

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 [v, ^] 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, 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.

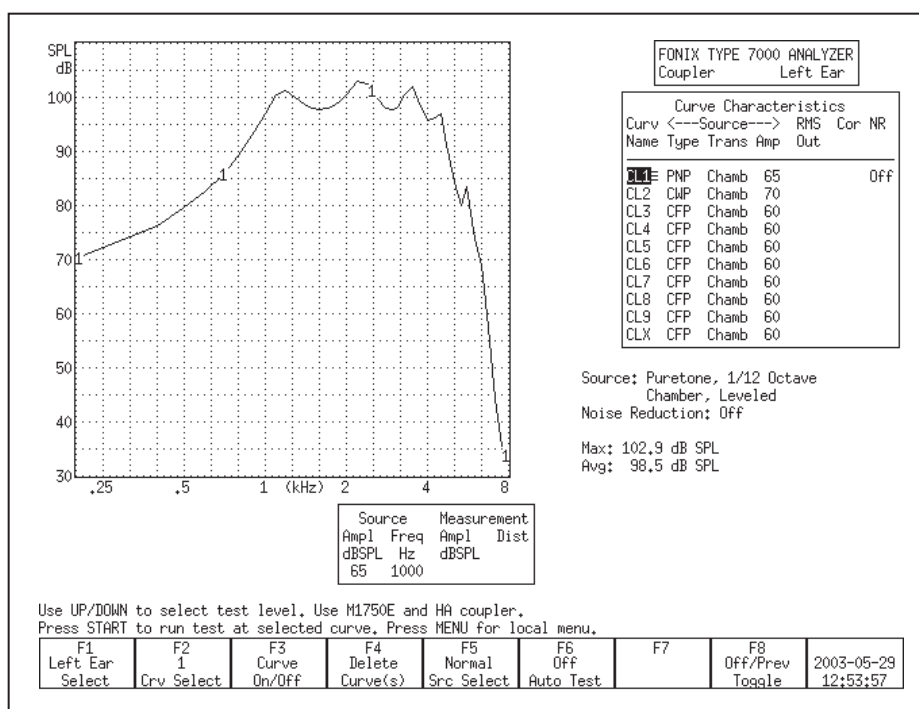


Figure 3.4.2—Pure-tone measurement

3.4.3 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 [v, ^] to select CRV1. Press [>] to complete the selection and close the pop-up window.)
3. Use [v, ^] 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. Press [START] to run the second measurement. Press [STOP] when the measurement has stabilized.
9. Use [F2] to select CRV 3.
10. Use [^] to select a source level of 70 dB SPL.
11. Press [START] to run the third measurement. Press [STOP] when the measurement has stabilized.
12. Use [F2] to select CRV 4.
13. Use [^] to select a source level of 80 dB SPL.
14. Press [START] to run the fourth measurement. Press [STOP] when the measurement has stabilized. You now have a family of curves.

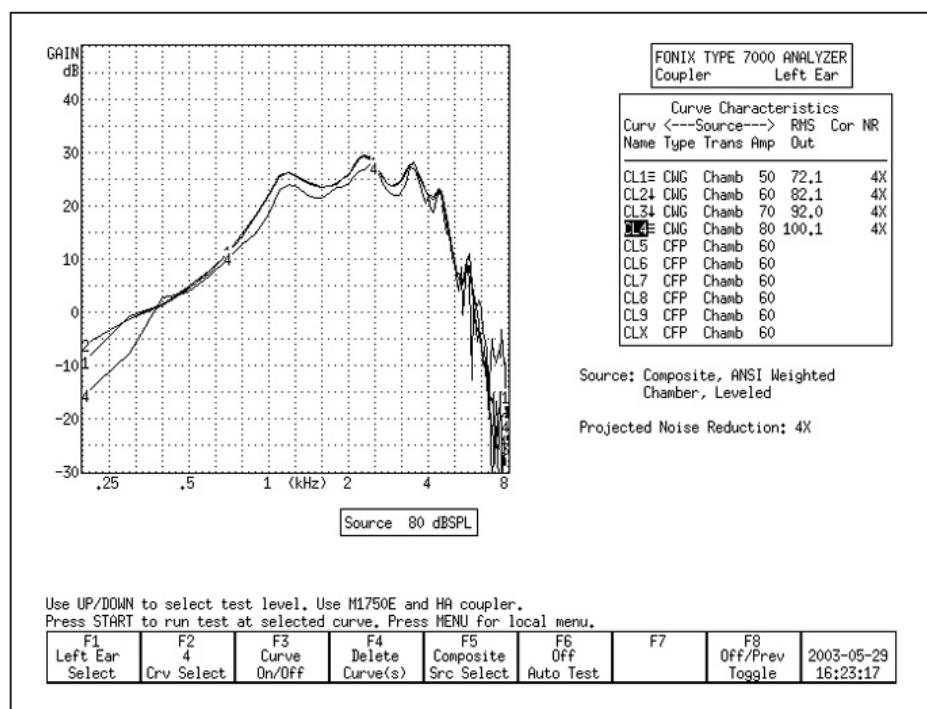


Figure 3.4.3A—Family of curves. Notice how all the curves are on top of each other. This aid has very little compression between 50 dB and 80 dB SPL.

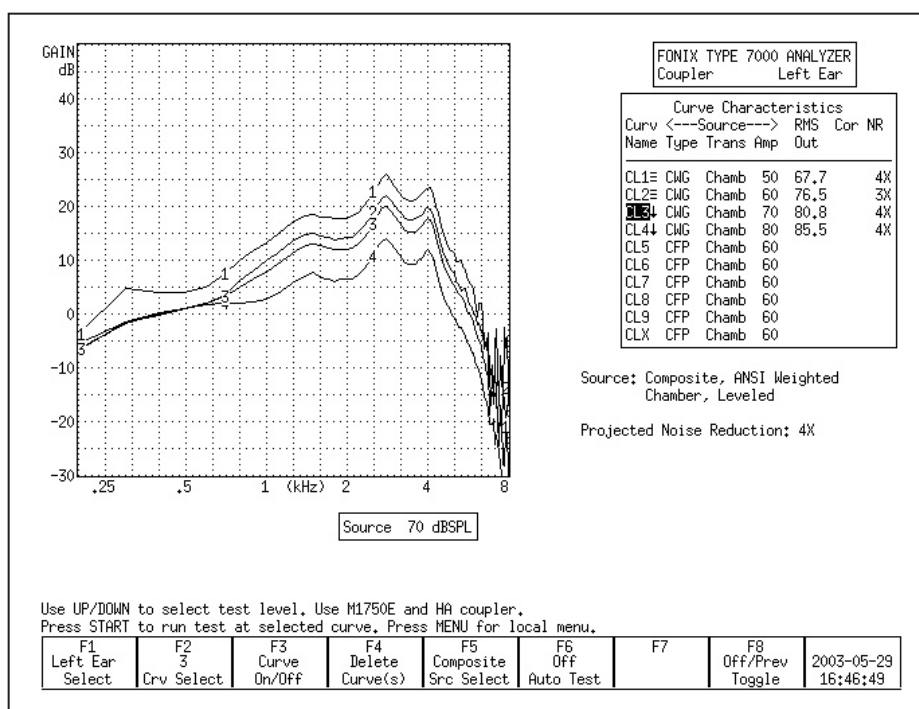


Figure 3.4.3B—Family of curves. Notice how the curves show less gain as the amplitude increases. This aid shows a great deal of compression between 50 dB and 80 dB.

3.4.4 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 [v, ^] 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 [v, ^] 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 [^, v] buttons.

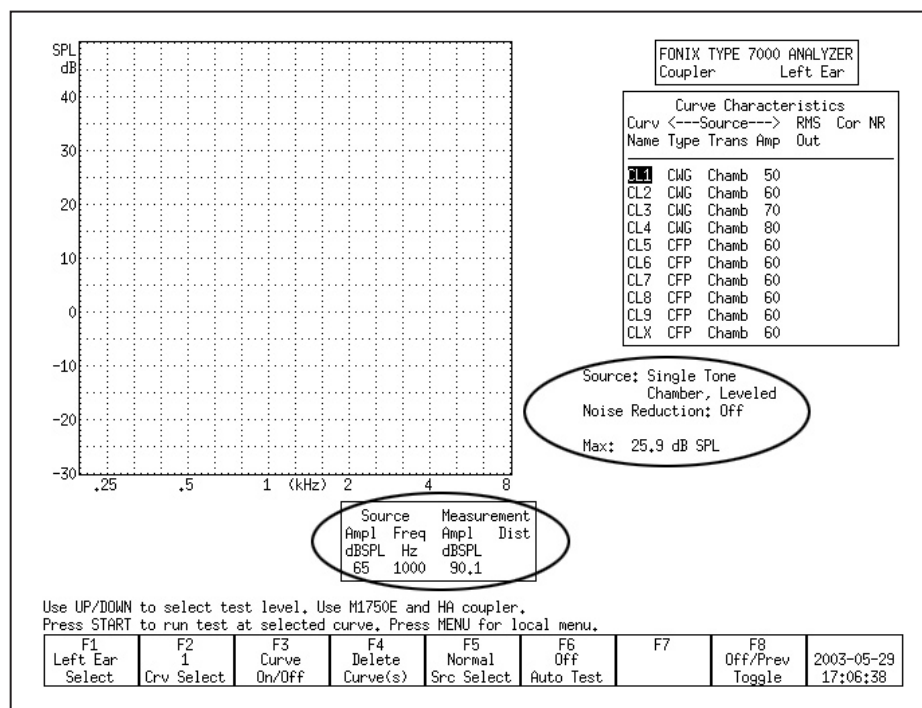


Figure 3.4.5—Measuring a single frequency

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 [v, ^] to select Static Tone under Source Settings.

3. Use [\leftarrow , \rightarrow] to choose AVERAGE.
4. Use [\vee , \wedge] to select Avg Freqs under Aid Settings.
5. Use [\leftarrow , \rightarrow] 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 [\wedge , \vee] buttons.

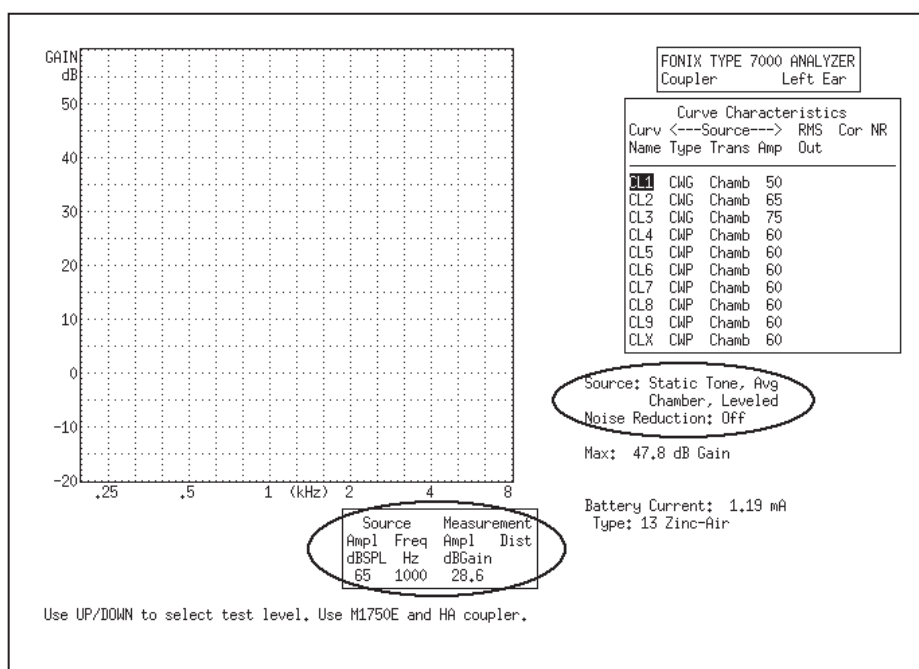


Figure 3.4.6—Measuring a three frequency average

3.4.7 Measuring Harmonic Distortion

Harmonic distortion is when the hearing aid returns energy at frequencies not present in the source signal. The 7000 analyzer allows you test for this phenomenon very easily.

1. Press [MENU] from the Coupler screen.
2. Select Distortion under Measurement Settings using the [\vee , \wedge] buttons.
3. Select the distortion type desired by using the [\leftarrow , \rightarrow] 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 [v, ^] 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.

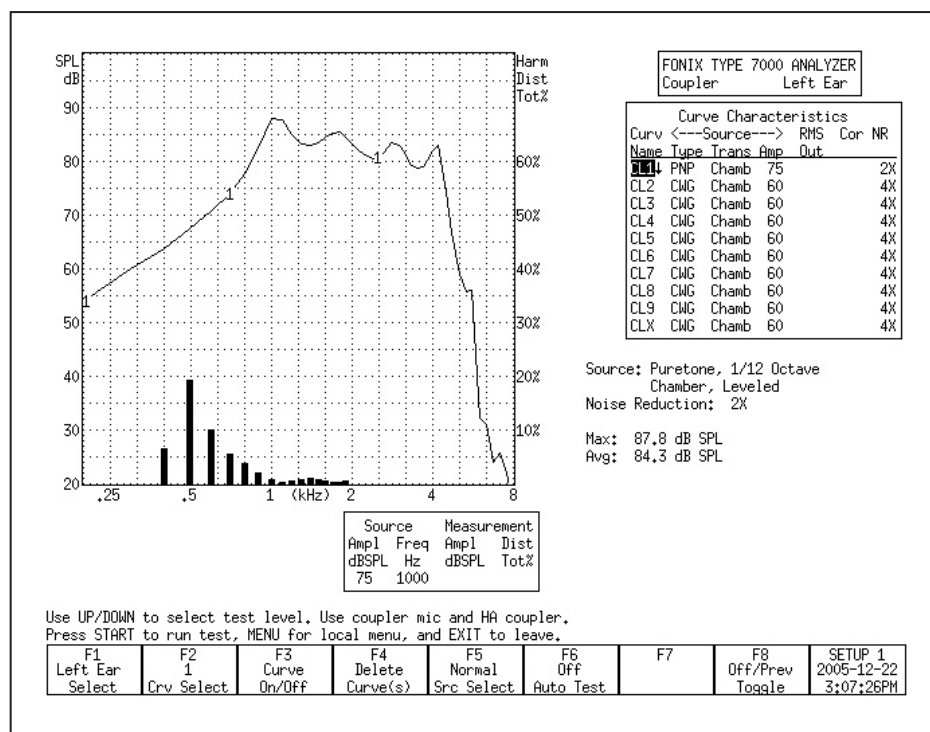


Figure 3.4.7—Measuring Harmonic Distortion

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.

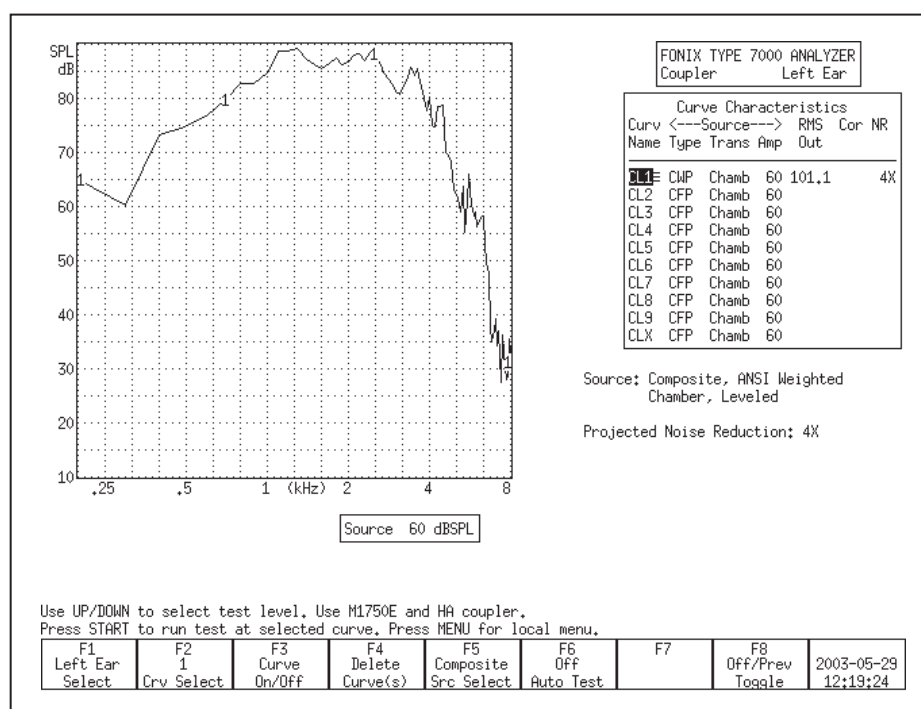


Figure 3.4.8—Measuring intermodulation distortion

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. Press the appropriate battery button inside the sound chamber.
3. Close the lid of the sound chamber and latch it.
4. Press [MENU] in the Coupler screen.
5. Use [v, ^] to select Battery Meas under Misc Settings. (You can use [START] to skip between groups of selections.)
6. Use [>] to turn ON the Battery Meas.
7. Use [v] to select Battery Size and use [<, >] to select the hearing aid's battery size.
8. 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.
9. Start a frequency response measurement to display the battery current drain.

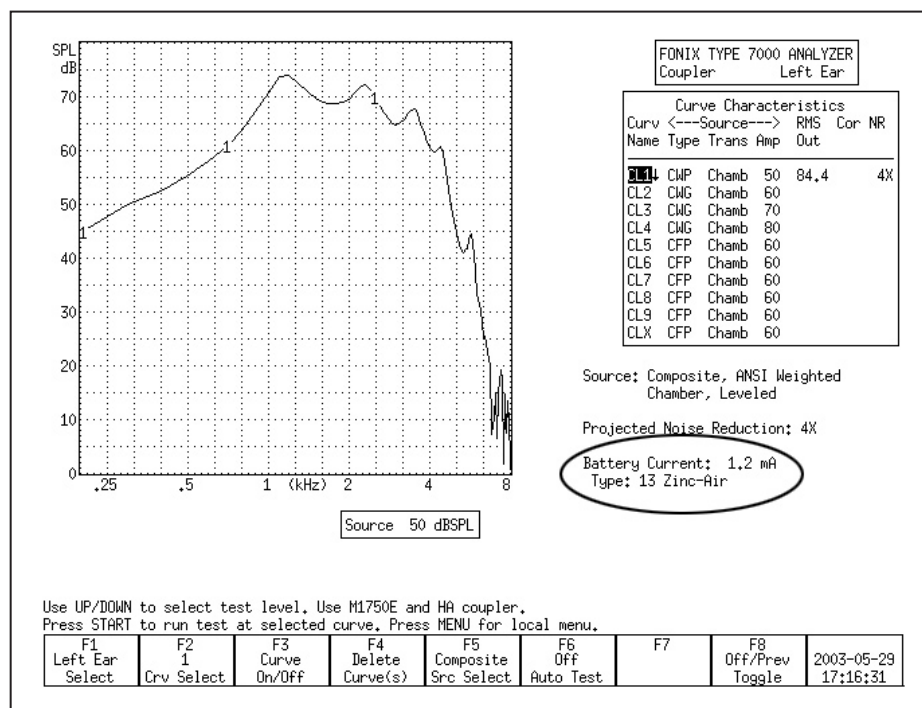


Figure 3.4.9—Battery Current Drain

3.4.10 Telecoil

Telecoil measurements can be performed in the Coupler screen using any of the source signals available on the 7000 Hearing Aid Test System. During a telecoil measurement, a magnetic field is used that is supposed to simulate the field of a telephone receiver. A telecoil board capable of producing this field is built into every 7000 sound chamber. When the analyzer has the ANSI option, the external Telewand can also be used for the measurement.

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 7000 sound chamber has a built-in telecoil board 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 [Λ, v] 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

Testing with the Telewand

When the ANSI Option is ordered with the 7000 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 board in the sound chamber because it more closely simulates the magnetic field produced by a telephone receiver.

1. Follow steps 1-5 in the section above.
2. 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 hearing aid. 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.
3. Look at the RMS OUT in the Curve Characteristics box. This shows the current output of the hearing aid to the magnetic field input.
4. 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.

5. Use [\wedge , \vee] 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.
6. 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

Although directional hearing aids can have different types of polar maps 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. The FONIX 7000 hearing aid test system cannot give you a polar plot of the directional hearing aid response, but it can provide you with the basic information of how much directional benefit the hearing aid wearer is receiving and at which frequencies.

The directional test takes advantage of the speaker placement in the large sound chamber 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 7000 sound chamber is positioned on the right side of the chamber at a 45° angle, as illustrated in Figure 3.4.11A. It is important to keep this in mind when positioning the directional hearing aid for measurements.



Figure 3.4.11A—7000 sound chamber speaker placement

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 right side of the chamber. See Figure 3.4.11B. 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 [v, ^] 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.

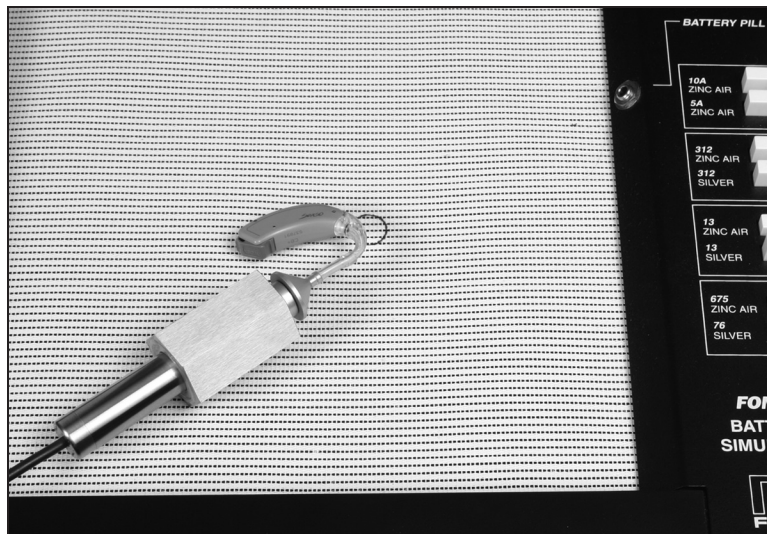


Figure 3.4.11B—Forward directional measurement.

Reverse measurement

Next, open the sound chamber and position the hearing aid so that the front of the hearing aid is pointing towards the left side of the chamber. See Figure 3.4.11C. 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. 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 [v, ^] 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 3.4.11D. In this example, the hearing aid has an 8 dB average directional advantage.

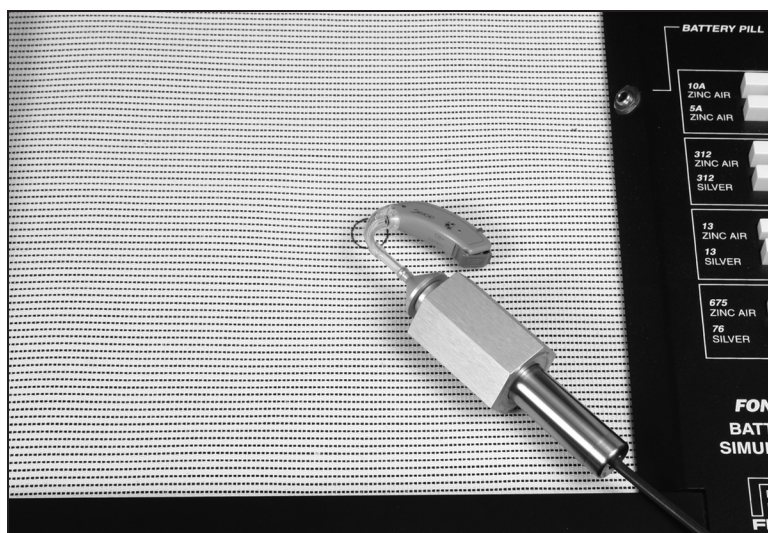


Figure 3.4.11C—Reverse directional measurement

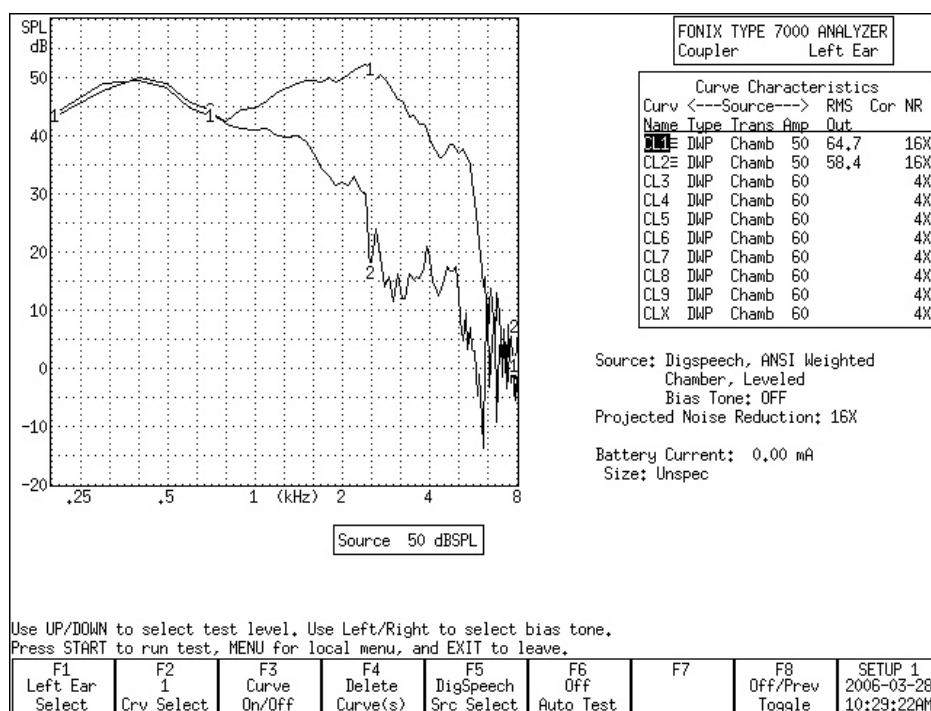


Figure 3.4.11D—Directional measurement screenshot

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 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 respond to normal speech.

3.5.1 Using Digital Speech

The 7000 analyzer 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 [v, ^] 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.
6. 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.

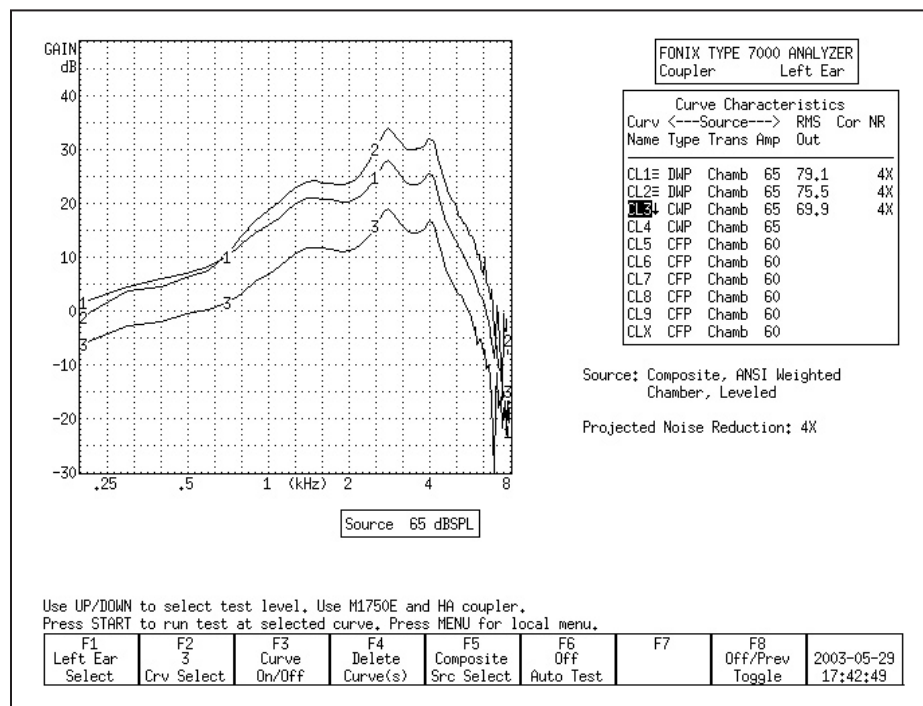


Figure 3.5.2—Comparison of a digital aid tested with Digital Speech ICRA (CRV1), Digital Speech ANSI (CRV2), and the Composite signal (CRV3).

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 [v, ^] 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.

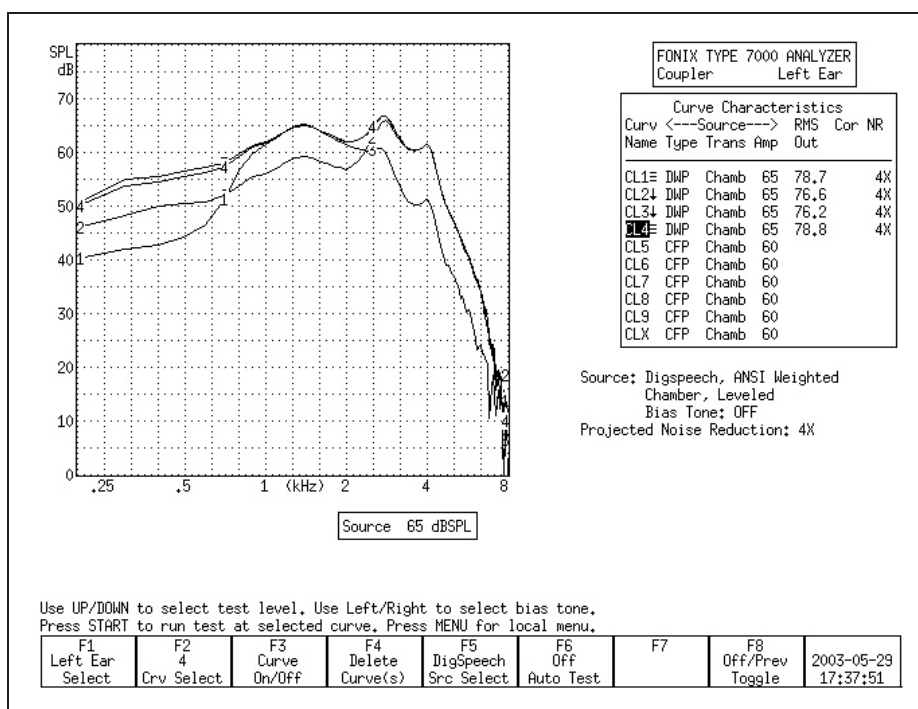


Figure 3.5.3—Using the bias signal with Digital Speech. CRV 1-3 have bias signals at 500 Hz, 1000 Hz, and 4000 Hz respectively. CRV 4 was performed with Digital Speech and no bias signal.

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.

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 [\vee , \wedge] 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 [v, ^] 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 [v, ^] 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.

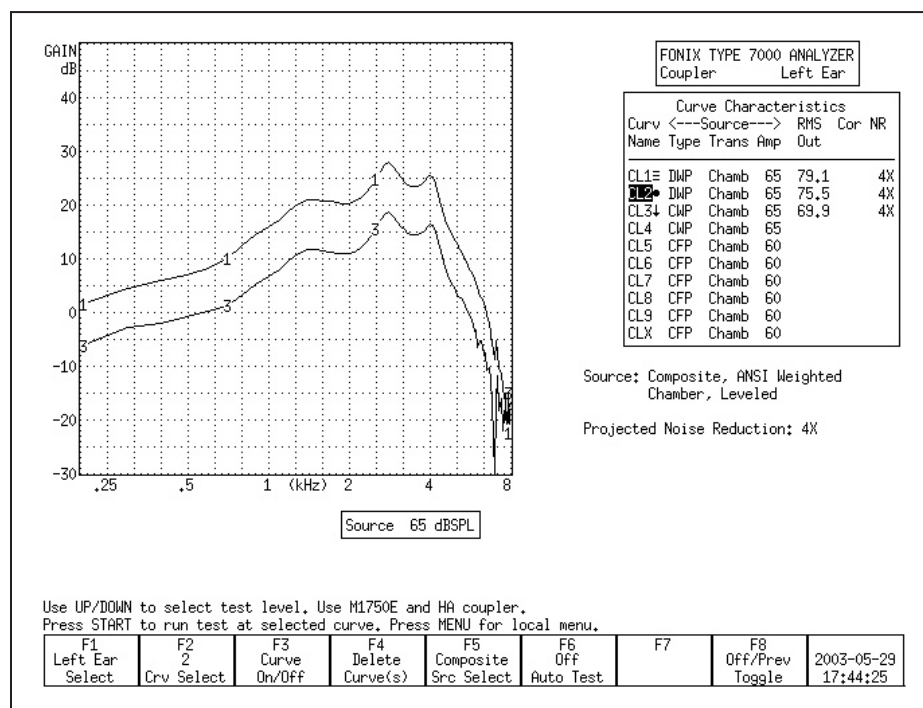


Figure 3.5.4—Digital Noise Suppression test. CRV 1 was measured with Digital Speech. CRV 2 was measured with the Composite signal.

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 7000 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 reduction 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 [v, ^].
4. Select CIC with [<, >].
5. Press [EXIT].
6. Select the desired source type with [F5]. (Press [F5]. Use [v, ^] to select the desired source type. Press [>] to complete the selection and close the pop-up menu.)
7. Select the desired source amplitude with [v, ^].

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.

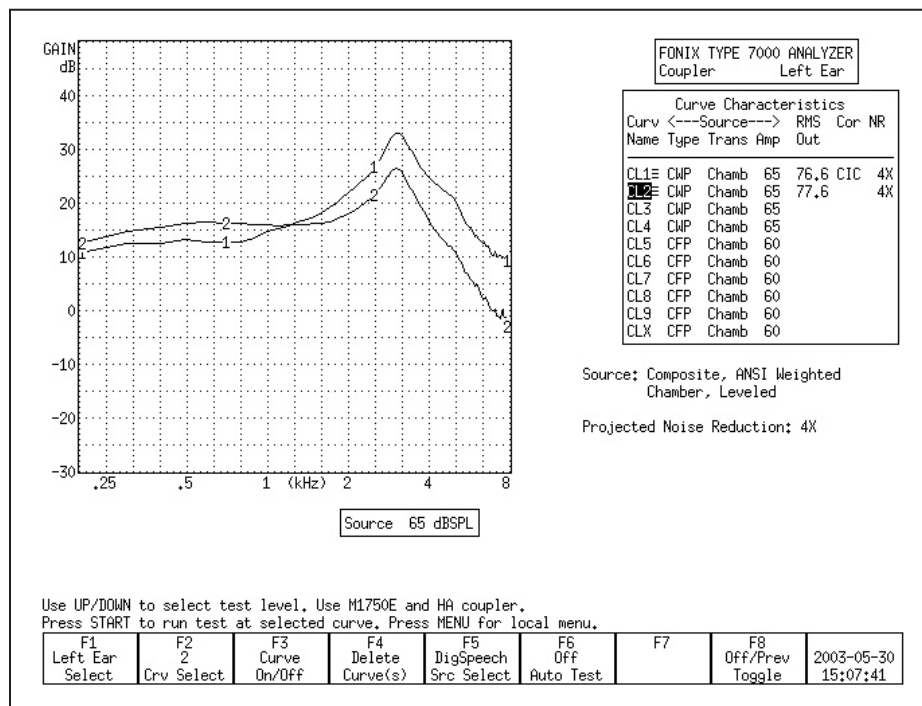


Figure 3.6—CURVE 2 uses CIC coupler + correction factors

CURVE 1 uses 2-cc HA-1 coupler

3.7 Occluded Ear Simulator Option

The Occluded Ear Simulator (OES) Option consists of software correction factors and three special (MZ) couplers. Together, they allow you to simulate the data you would get with a standard ear simulator (IEC 711 or Zwislocki coupler), providing the hearing aid or mold being tested is not vented. This should give you a coupler measurement that more accurately reflects a real-ear response of an occluded ear than a 2-cc coupler.

Note: The data results from the OES coupler will not be an exact duplicate for results performed with a Zwislocki coupler.

To use the OES Option:

1. Attach the MZ coupler to the aid. See Table 3.7 for details on choosing the correct MZ coupler.
2. Set up the hearing aid for testing as described in Section 3.3.
3. Press [MENU] in the Coupler screen.
4. Highlight Coupler Type under Measurement Settings with [v, ^].
5. Select MZ with [<, >].
6. Press [EXIT].
7. Select the desired source type with [F5]. (Press [F5]. Use [v, ^] to select the desired source type. Press [>] to complete the selection and close the pop-up menu.)
8. Select the desired source amplitude with [v, ^].
9. Press [START] to perform the measurement. You should see OES 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.

See Figure 3.7 for a comparison of a BTE tested with an MZ coupler as opposed to a 2-cc coupler.

Table 3.7—Which is the Correct MZ Coupler to use?

TYPE OF AID	COUPLER	COMMENT
ITE, ITC	MZ-1	
BTE, or EYEGLASS	MZ-1	<u>With</u> custom earmold attached. (NOTE: Vents must be plugged.)
	MZ-2	<u>Without</u> custom earmold attached, when a 3 mm horn earmold is planned, use with the Ear-Level Hearing Aid Adaptor that normally snaps onto the HA-2, 2-cc coupler.
	MZ-3	<u>Without</u> custom earmold attached, when a conventional (#13 tubing) earmold is planned, attach a length of #13 tubing that corresponds to the length of the sound channel of the wearer's earmold.
BODY	MZ-2	With snap-on receivers, use the MZ-2 without the Ear-Level Hearing Aid Adapter attached.

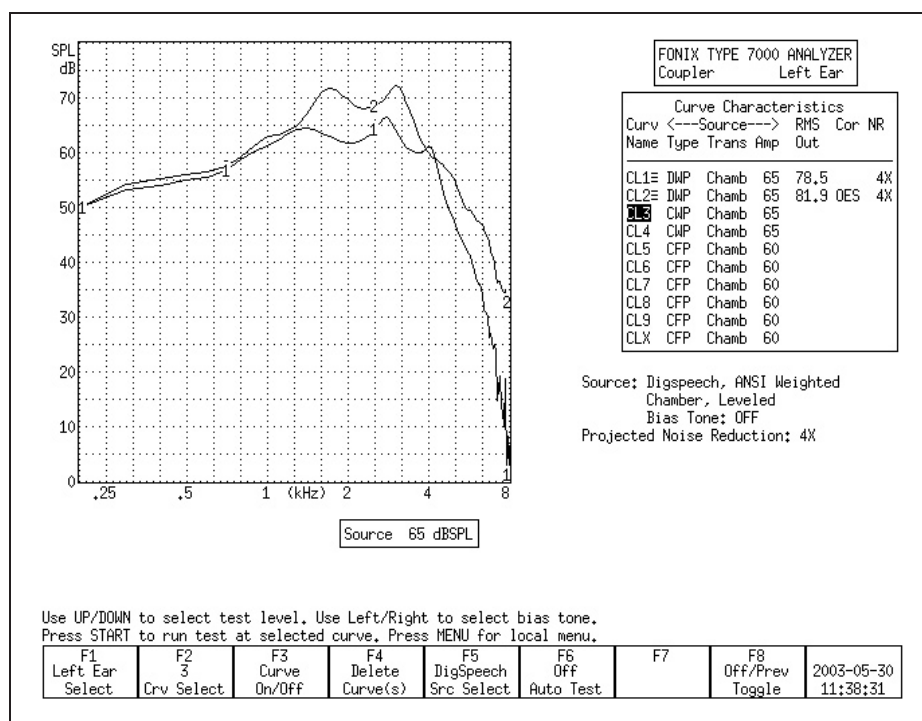


Figure 3.7—Comparison of the responses with the MZ and HA-2 couplers. Curve 2 was measured with an MZ coupler and OES correction factors. Curve 1 was measured using a standard 2-cc coupler.

3.8 Automatic Testing—Loading & Saving Groups

You can use the 7000 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 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 3.8.1.

If there is a sequence of tests that you would like to perform frequently, you can save it into the 7000 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 other set from 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 7000 analyzer 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 3.8.2. When the "Factory" group is loaded, the factory default settings are loaded.

3.8.1 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 [v, ^] 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 [v, ^] 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.

3.8.2 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 and on the analyzer. There are two ways to load a saved group: manually and automatically. In both cases, you must first follow the directions in Section 3.8.1 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 3.8.1. (Press [F6]. Use [v, ^] 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 [v, ^] 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 3.8.3), SEMI AUTO (see Section 3.8.4), or OFF.
4. Select the desired CURVE GROUP LOADED. Choose the group you saved in Step 11 of Section 3.8.1.
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.

3.8.3 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 3.8.1 to create a new sequence, or by loading a previously saved sequence by following the directions in Section 3.8.2.
2. Use [F6] to select FULLY AUTOMATIC. (Press [F6]. Use [v, ^] 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.

3.8.4 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 3.8.2 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 3.8.2.
2. Use [F6] to select SEMI-AUTOMATIC. (Press [F6]. Use [v, ^] 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 7000 analyzer 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.

3.9 Custom Functions for F7/F8

The [F7] and [F8] keys can be customized to perform many various 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, MZ).
- 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. These default selection for these settings can be changed in the Setup Menu. See Sections 2.2.1 and 2.2.4 for details.

3.10 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 [v, ^] 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).
- 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. Selections of CIC and MZ turn on corresponding software correction factors (see Sections 3.6 and 3.7). 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 or the ANSI 96 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 off the bias tone 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 7000 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 7000 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. Choose INTERNAL or EXTERNAL. See Section 2.4.
- F7/F8: Function of the F7 and F8 function keys in the Coupler Multicurve screen. See Section 3.9.

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 very 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 other aids 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 7000 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 7000 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 7000 Test System delay is subtracted from this delay point in order to form the actual aid processing delay time. (The 7000 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 dotted vertical line is placed at the calculated delay point. The numerical value is also displayed. A second dotted vertical line shows the 7000 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.

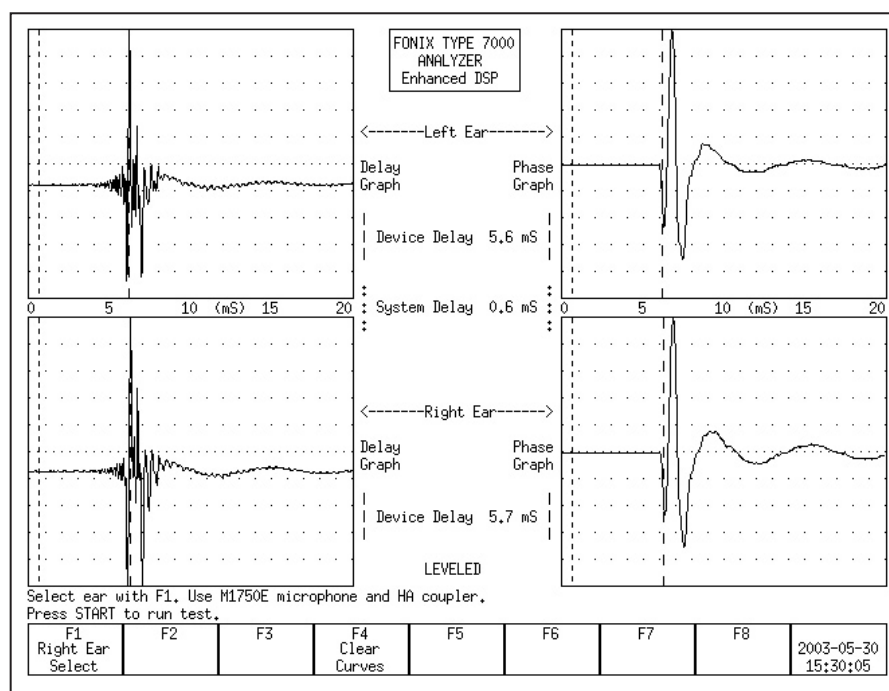


Figure 4.1.3—Enhanced DSP measurement results

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, plug the battery pill into the sound chamber, and push the applicable button in the chamber.

To enter the Battery screen, 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.

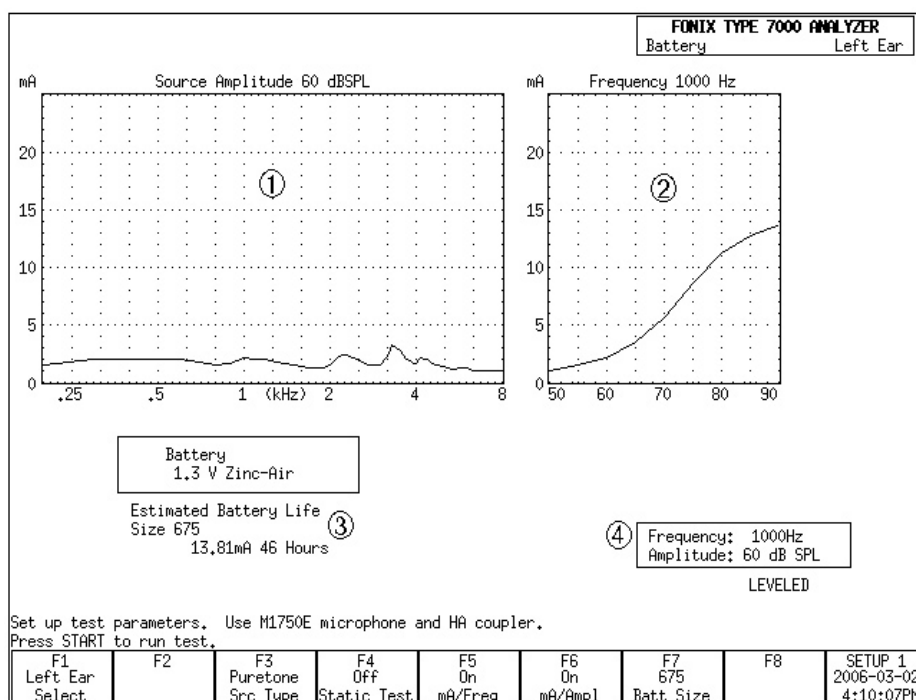


Figure 4.2—Battery Current Test

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 [\downarrow , \uparrow] 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 [\downarrow , \uparrow], and
- Change the source Frequency by using [<, >]. This setting is only available when the source 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 [v, ^].

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.)

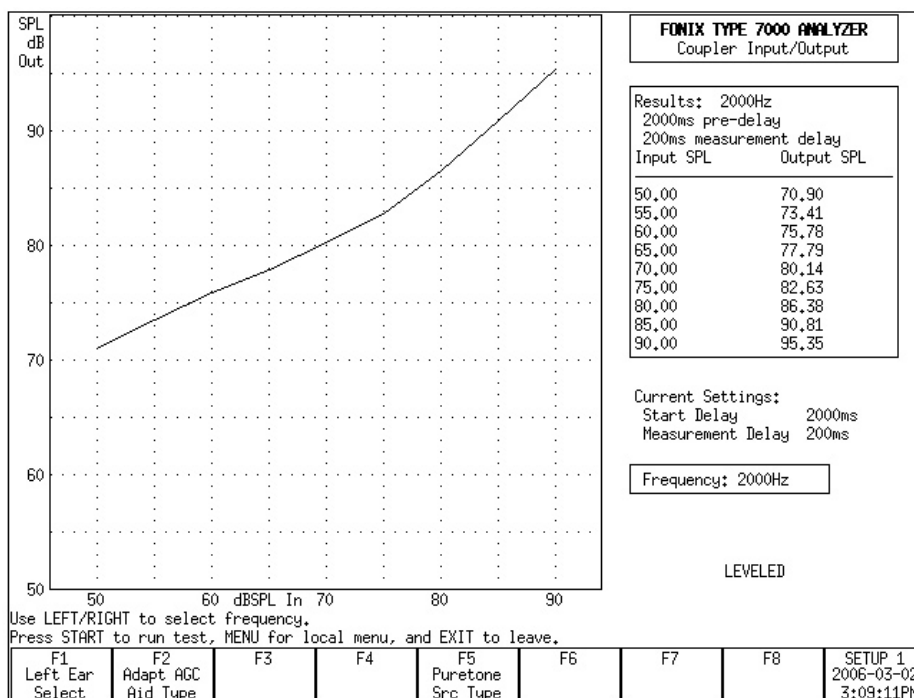


Figure 4.3—I/O Test

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 that will be 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 stimuli 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 even could 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.

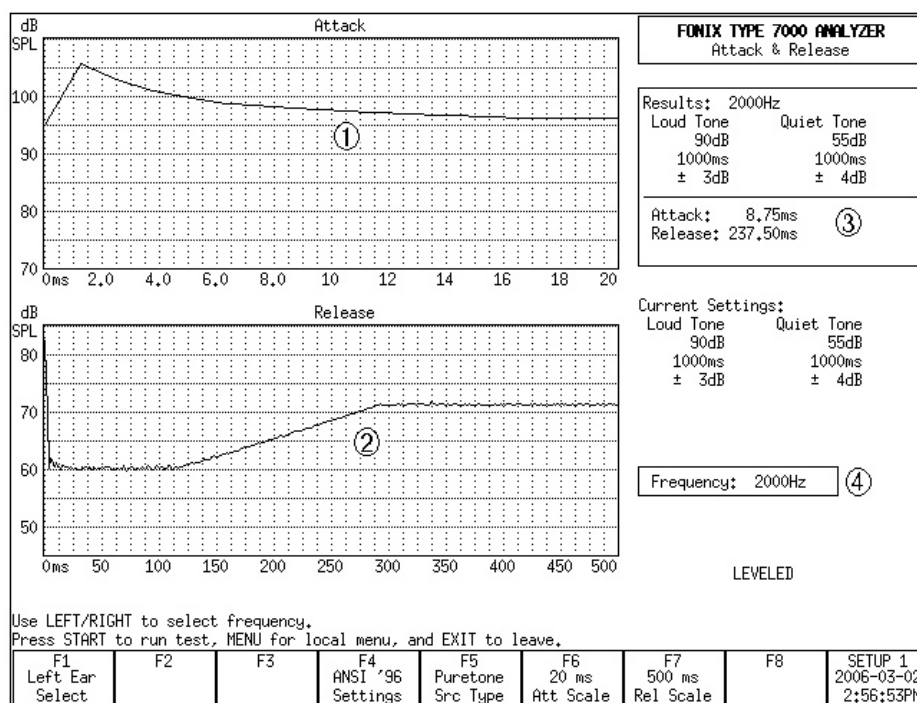


Figure 4.4—Attack & Release Test

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 7000 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 7000 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 7000 hearing aid analyzer. 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 S3.22-2003 (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

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 three different versions of the ANSI S3.22 standard: 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.

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 of 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.

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 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).

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.

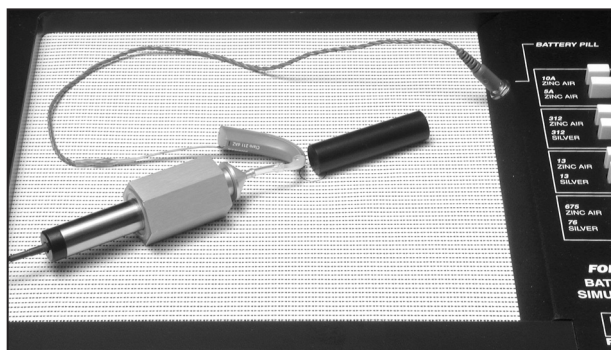


Figure 5.1.2B—Setup for aid testing/ equivalent substitution method

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 03, set AGC aids to have the most 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 [v, ^] 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.
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 96 or an ANSI 03 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 7000 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.
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.
 - a. Open the lid of the sound chamber.
 - b. Switch the aid to telecoil mode.
 - c. Plug the telewand into the side of the sound chamber, just above the cable that connects the sound chamber to the Frye box.
 - d. 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.
 - e. Press [START] to measure the telecoil response. The analyzer will pause after the telecoil measurements are complete.
 - f. 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:

- Open the lid of the sound chamber.
- 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.
- 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. Here is an explanation of the ANSI 03 results (Figure 5.1.7):

- OSPL 90 curve: Full-on gain frequency sweep taken at 90 dB SPL.
- RESP 60 curve: Reference test gain frequency sweep taken at 60 dB SPL.
- SPLITS curve: Frequency response of the telecoil.
- Aid type (selected with F2)
- OSPL 90 MAX: Amplitude and frequency of the maximum output of the aid.
- OSPL 90 HFA/SPA: Three-frequency response of the OSPL 90 curve.
- HFA/SPA FOG: Full-on gain three frequency average and the amplitude at which it was taken.
- RTG Target: Target reference test gain

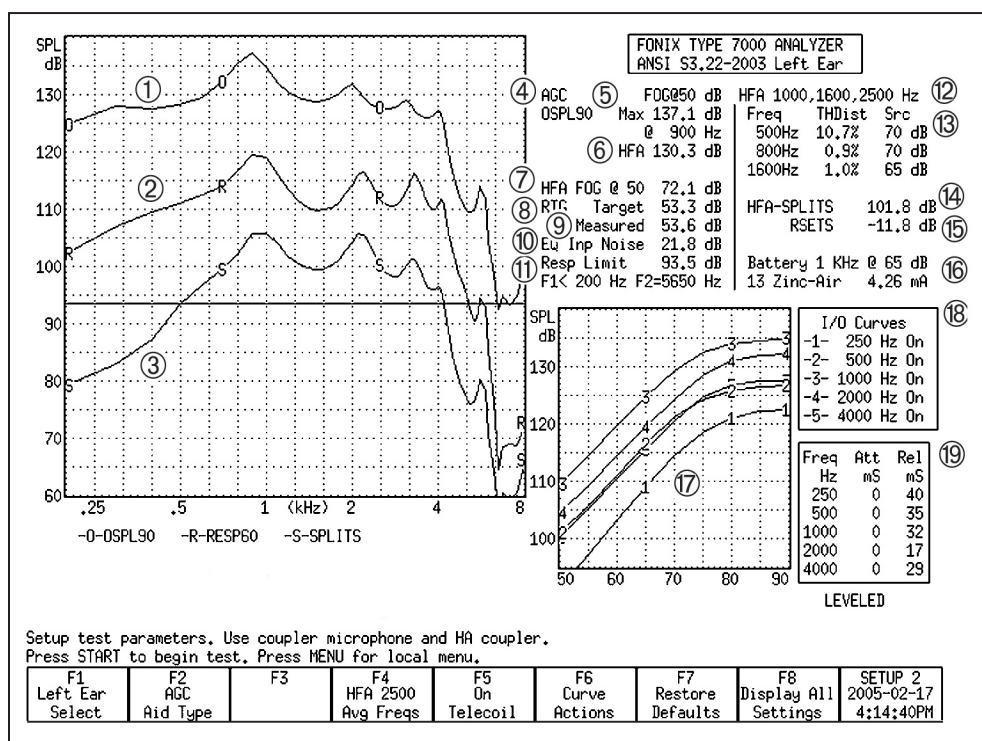


Figure 5.1.7—ANSI 03 test results, Frequency Response Screen

9. RTG Measured: Measured reference test gain
10. EQ Inp Noise: Equivalent input noise measurement
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.

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 [v, ^] 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 7000 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 [v] 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 those 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—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—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 measured 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. Choose INTERNAL or EXTERNAL. 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 7000 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 7000 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 7000 test system.

Only the most critical 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 as close as possible to its original position. Push [START] to complete the test.

To delete the displayed results, press [F4] and use [v, ^] 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.

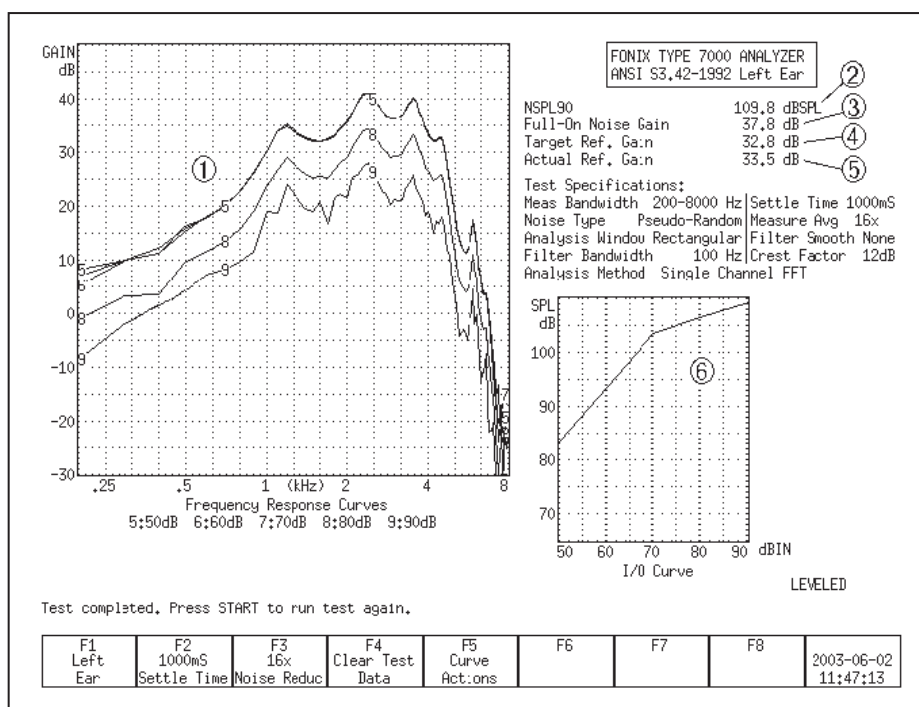


Figure 5.2.4—ANSI 92 test results

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 [v] 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 those 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. Choose INTERNAL or EXTERNAL. 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 7000 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 $B > A - 68$, 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 most 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 [v, ^] 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 7000 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)

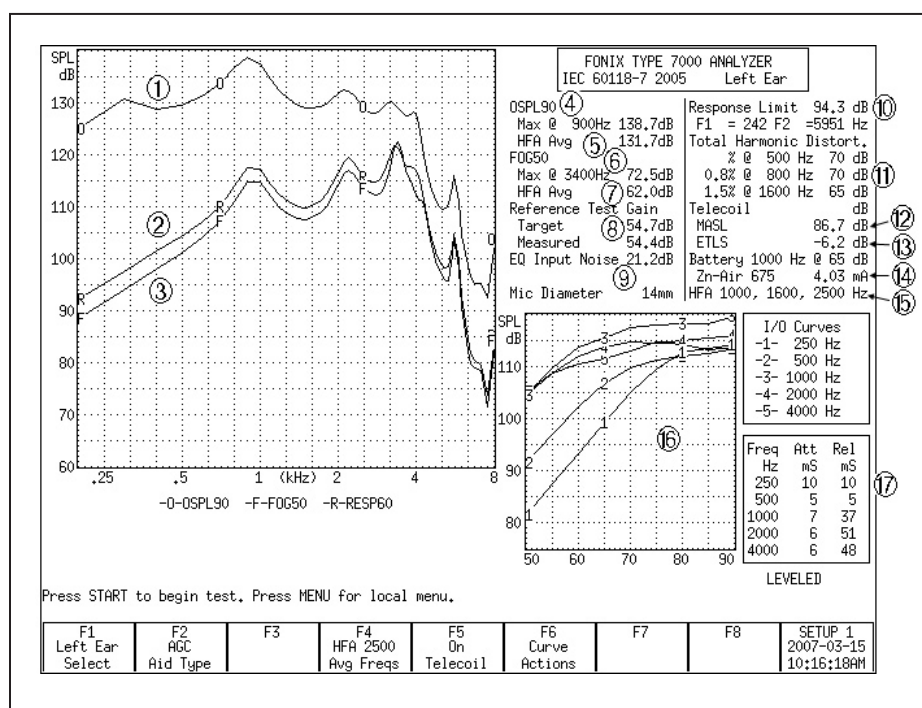


Figure 5.3.6—IEC test results

9. Equivalent input noise
10. Three frequency average frequencies
11. Response limit and its minimum and maximum frequencies
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. 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.

15. Battery current drain
- 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. Expert 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. Choose INTERNAL or EXTERNAL. 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 Expert.

- 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. Press [F7] from the Opening screen to enter the JIS test screen.

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 [v, ^] 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

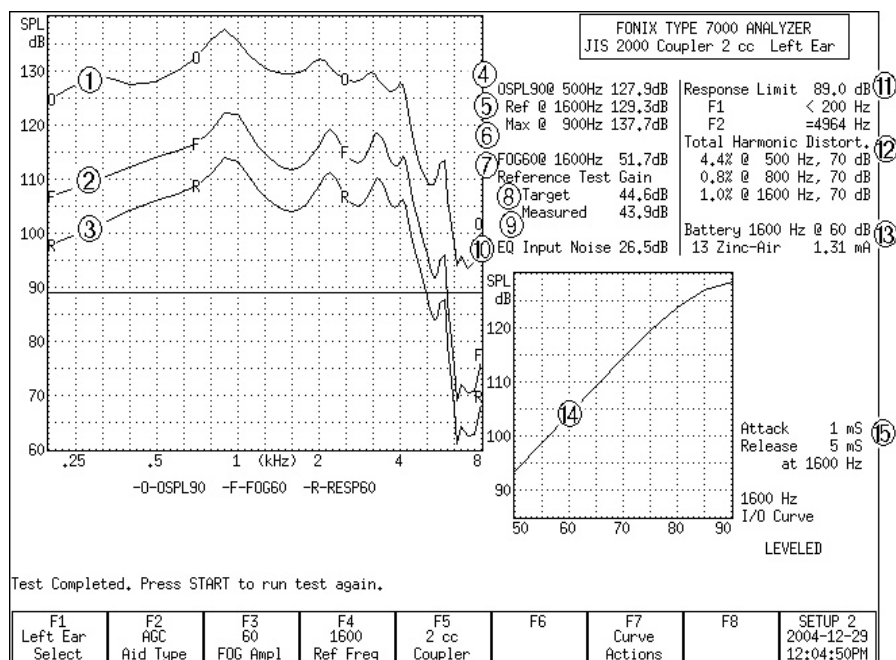


Figure 5.4.3

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. Choose INTERNAL or EXTERNAL.
See Section 2.4.

Real-Ear Measurements

6.1 Introduction

The Real-Ear Option gives you the capability to make probe microphone measurements inside your client's ear. You can:

- Input audiograms
- Create targets
- Perform insertion gain measurements
- Perform SPL measurements
- Perform Visible Speech measurements
- Perform RECD measurements

6.1.1 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 6.1.1.

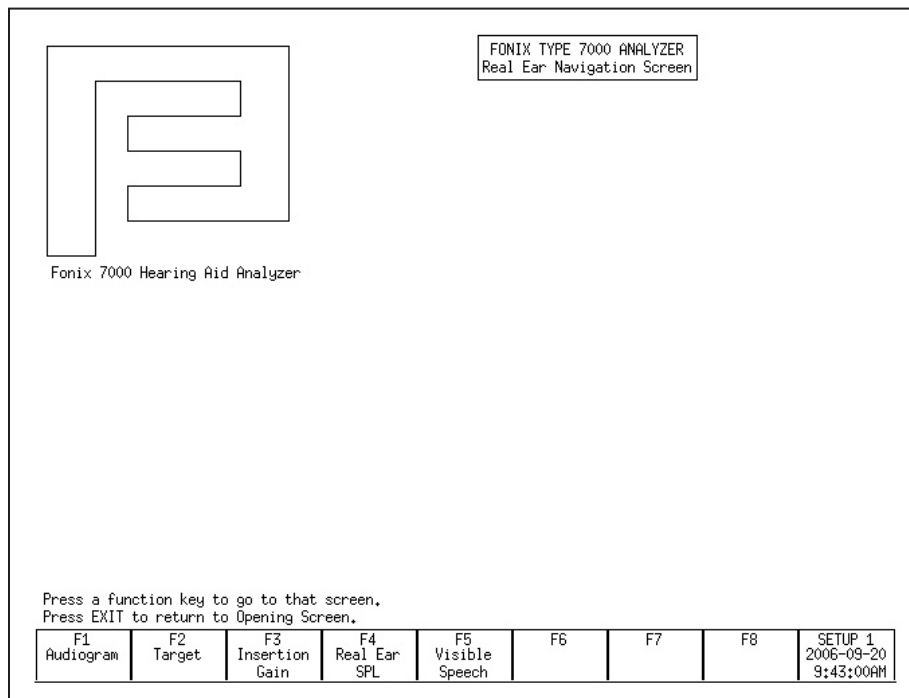


Figure 6.1.1—Real-Ear Navigation Screen

These screens are:

- Audiogram Entry screen [F1]
- Target screen [F2]
- Insertion Gain screen [F3]
- SPL screen [F4]
- Visible Speech [F5]

6.1.2 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. You can use the function buttons found on the front panel of the 7000 test system or on the remote module.
- To exit from any of the real-ear measurement screens, press the [EXIT] button on either the front panel of the 7000 analyzer or the remote module. This will return you to the Real-Ear Navigation screen.

6.2 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.

6.2.1 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 6.2.1.

NOTE: It is especially important for accuracy that the speaker is within 12" if you are using a 90-dB signal.

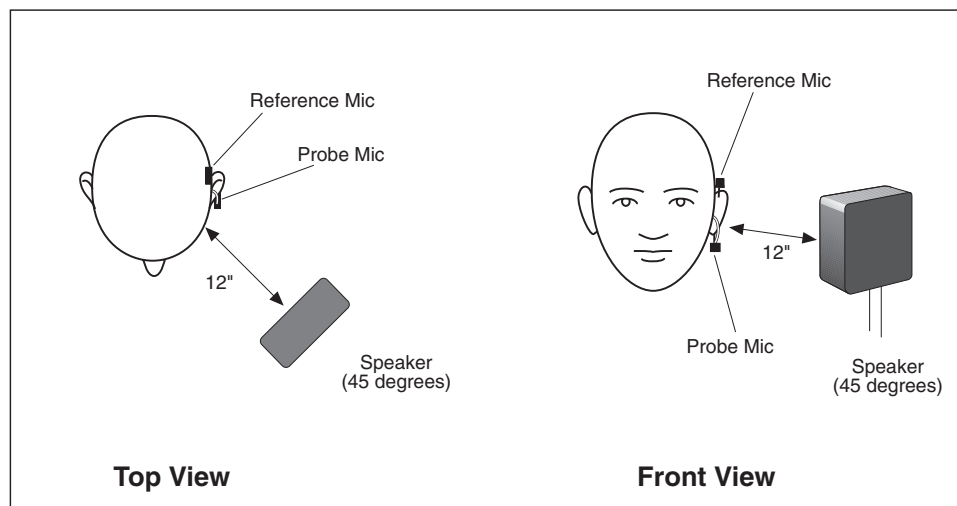


Figure 6.2.1—Sound field speaker setup

6.2.2 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.

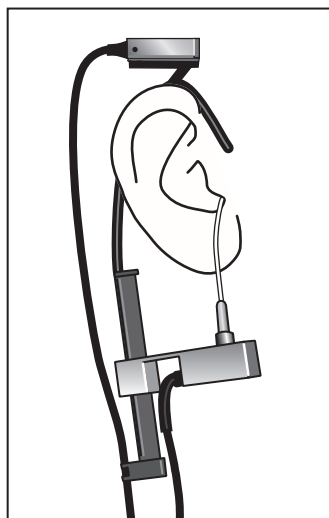


Figure 6.2.2—Placing the reference and probe microphones

6.2.3 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 6.2.3A.
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.

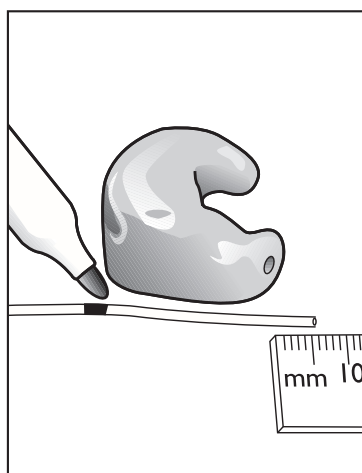


Figure 6.2.3A—Marking the probe tube

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 6 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.

WARNING

Choose OUTPUT LIMITING carefully (see procedure below). You don't want to damage your clients' hearing or to cause them discomfort during testing. To ensure safety and comfort, the 7000 Test System reacts automatically when the OUTPUT LIMITING level is exceeded at the Probe Microphone. When the level measured at the Probe Microphone exceeds the pre-set limit, the words "OUTPUT OVER LIMIT" appear on the screen, and the signal source is automatically turned off and the measurement stopped.

The default setting for OUTPUT LIMITING is 120 dB SPL. You can set the OUTPUT LIMITING to any level between 90 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 [v, ^] to select OUTPUT LIMIT under Measurements.
3. Use [<, >] to choose the desired limit.
4. Return to the measurement screen by pressing [EXIT].

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.

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 6 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 6 kHz and 8 kHz. See Figure 6.2.3B.
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.

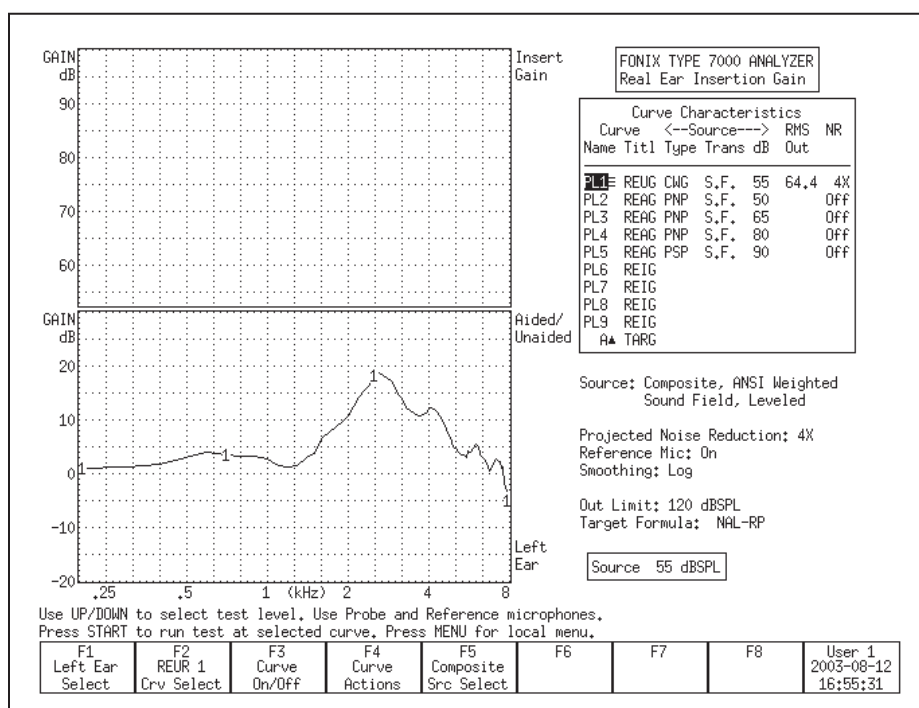


Figure 6.2.3B—Unaided response with correct insertion of the probe tube

6.2.4 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 6.2.4. **You must re-level the sound field for every client and every ear.**

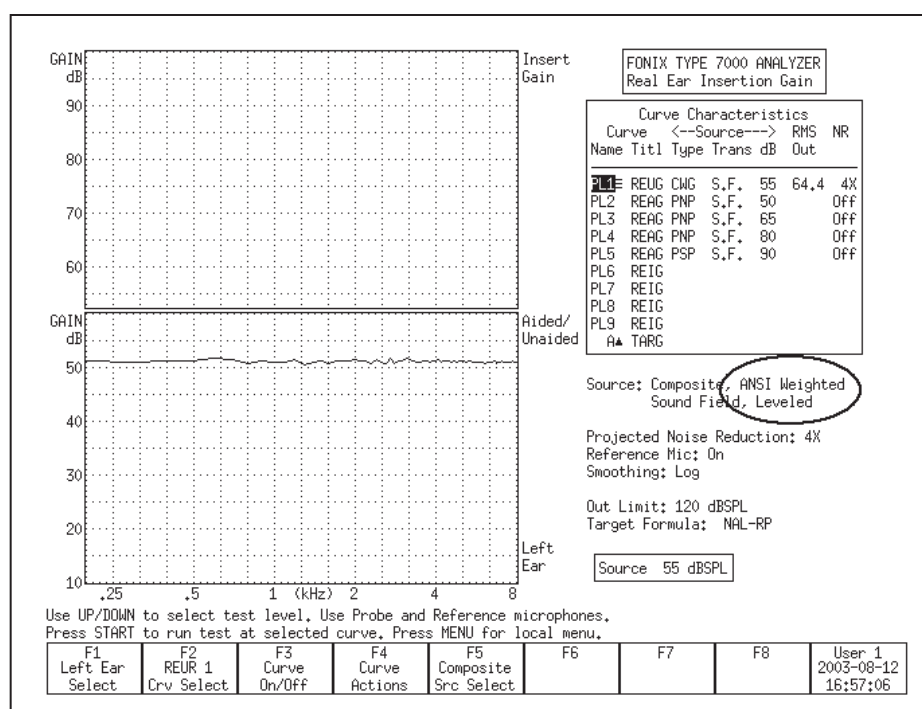


Figure 6.2.4—Leveling the sound field speaker

- Follow the instructions found in Sections 6.2.1 and 6.2.2 to position the client, sound field speaker, and microphones for testing. Only the larger 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 in the client's ear (described in Section 6.2.3) before the leveling process.
- Press [F2] from the Opening screen to enter the Real-Ear Navigation screen.
- Press [F3] or [F4] from the Real-Ear Navigation screen to enter either the Insertion Gain screen, or the SPL screen, respectively.
- Press [LEVEL].
- The instrument will attempt to level the sound field speaker. There are three leveling statuses:
 - LEVELED—This indicates the leveling process was correct within 1 dB.
 - LEVEL-FAILED—This indicates that the leveling process is incorrect by at least 6 dB.
 - SEMI-LEVELED—This indicates that the leveling process was correct between 1 dB and 2 dB.
 - 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.

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.

6.2.5 Setting up Body Aids

The setup below is recommended for Body aids.

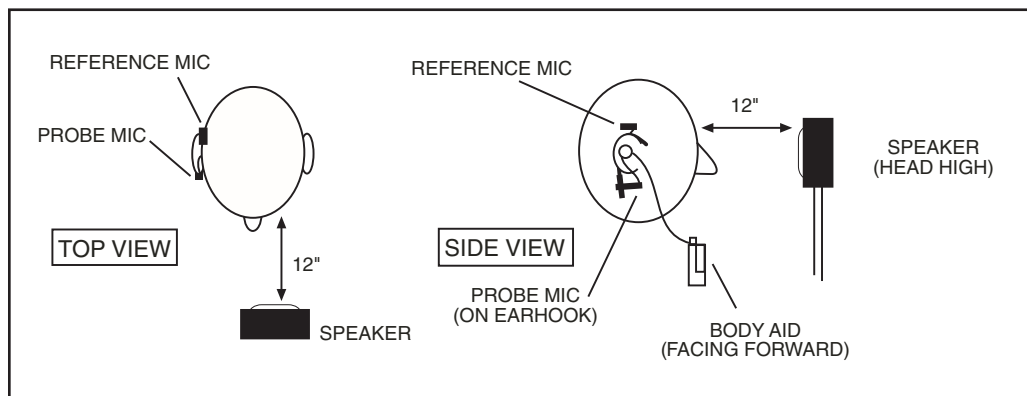


Figure 6.2.5—Setting up a body aid for real-ear testing

6.3 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.

6.3.1 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 6.3.1.
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 [v, ^] to select the frequency.
6. Use [F5] to select the client's age. (Press [F5]. Use [v, ^] to make the selection. Press [>] to complete the selection and close the pop-up window.)
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 [v, ^] 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.

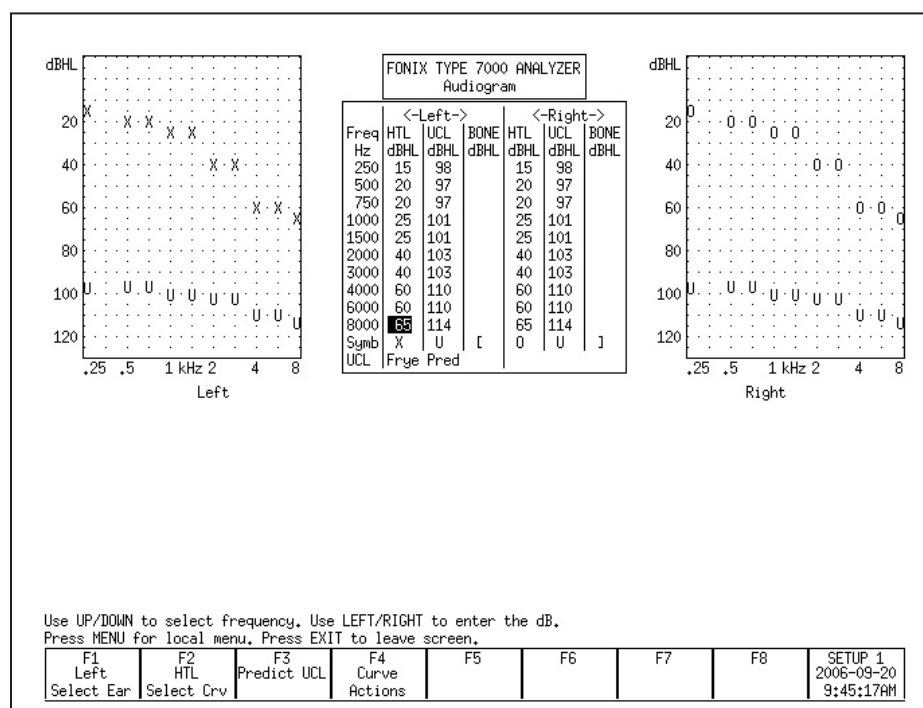


Figure 6.3.1—Audiogram Entry screen

To specify the transducer used to take the audiometric measurements, press [MENU] and use the arrow keys to specify the Aud. Transducer under Targets.

6.3.2 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 [v, ^] 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.

6.3.3 Creating a Target

Once you input an audiogram (Section 6.3.1), 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 [v, ^].
3. Use [<, >] to select the desired fitting rule.
4. Use [v, ^] to select Client Age, and use [<, >] to input the desired selection.
5. If you have selected NAL-NL1, 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 limited 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.

6.3.4 Entering Bone Data

The NAL-NL1 target uses bone data in its calculations. If the patient's bone thresholds are not entered, it 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.

6.3.5 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. The 7000 Test System will eventually support an RECD method using a linear hearing aid, but that feature is not yet implemented.

To perform the coupler measurement:

1. Insert the 50 ohm insert earphone into the jack on the back of the 7000 test system 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 6.3.5A.
3. Insert a probe tube through the black probe microphone adapter as shown in Figure 6.3.5B. Attach a dab of Fun-tak to the adapter to keep the probe tube from slipping.
4. Attach the probe tube to the probe microphone.
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 6.3.5A
Insert earphone attached to coupler



Figure 6.3.5B
Probe tube in probe mic adapter

To perform the real-ear measurement:

1. Insert the 50 ohm insert earphone into the jack on the back of the 7000 test system labeled "EARPHONE."
2. Insert the probe microphone into the client's ear, as described in Section 6.2.3. See Figure 6.3.5C.
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 6.3.5D.
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 [v, ^] to select RECD Mode under Misc, and use [<, >] to choose Custom Measured.
8. Use [v, ^] to select RECD Transducer and use [<, >] to choose ER3.

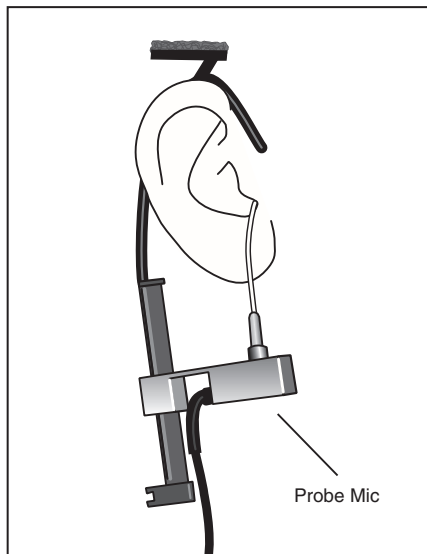


Figure 6.3.5C—Insert probe microphone

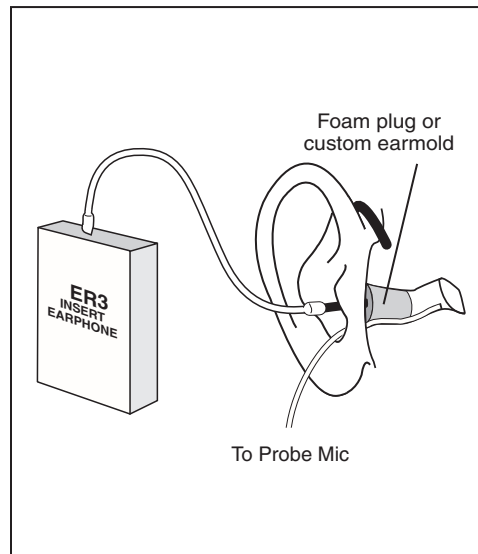


Figure 6.3.5D—Insert foam eartip connected to insert microphone.

9. Press [EXIT] to close the menu.
10. Use [F2] in the Audiogram Entry screen to select RECD. You may have to push the button several times.
11. Press [START] to take the measurement. The results will appear in both graphical and numeric format. See Figure 6.3.5.E

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.

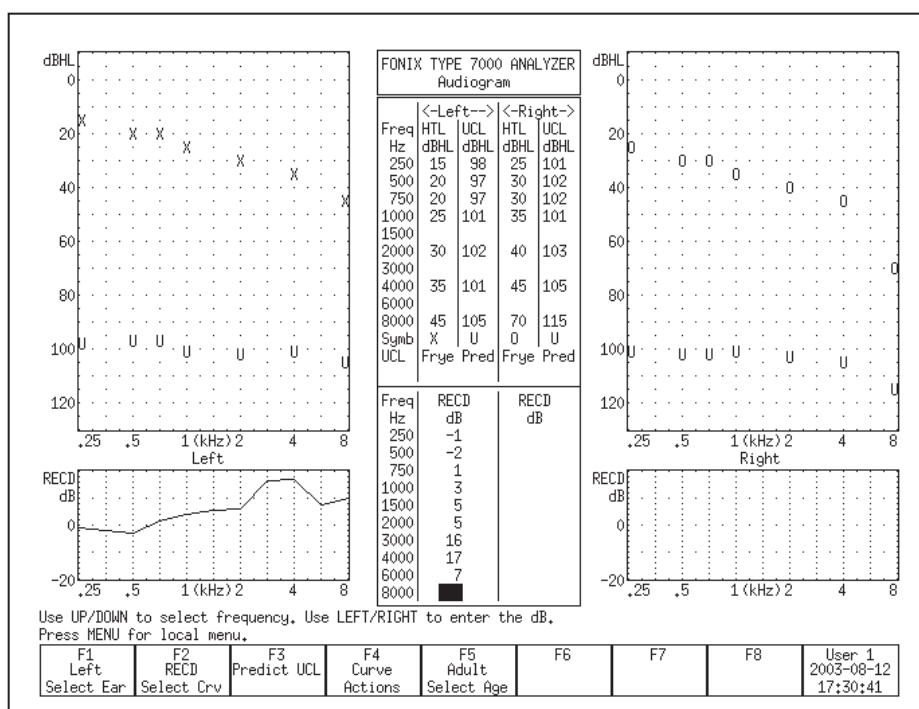


Figure 6.3.5E—Taking an RECD Measurement

6.3.6 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 6.3.6. If you have input an audiogram as described in Section 6.3.1, 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
 - TARG SPL: 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)
 - TARG 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 [v, ^] 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.

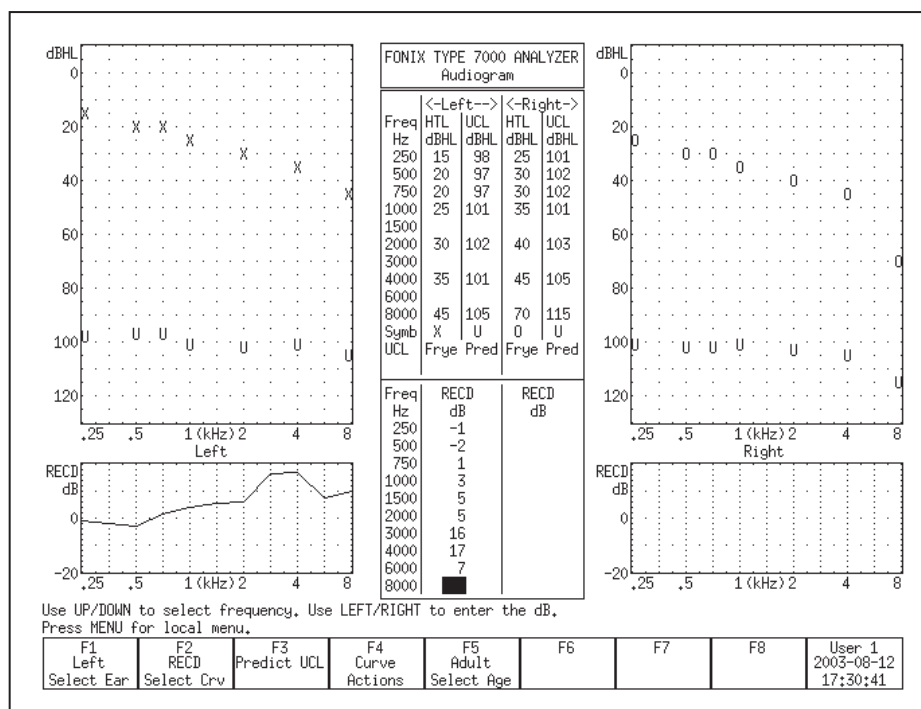


Figure 6.3.6—The Real-Ear Target screen

6.3.7 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 [v, ^].
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. You may have to press [F2] repeatedly. The REDD column for the selected ear will now be highlighted.
9. Use the arrow keys to input the REDD transform. The [v, ^] keys select the frequency. The [<, >] keys select the amplitude.

6.4 Real-Ear Measurements

The 7000 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 6.7 for operation of the Visible Speech screen.

6.4.1 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 6.2.3)
2. The sound field speaker is leveled. (Section 6.2.4)
3. The unaided response is measured. (Section 6.4.3)
4. The hearing aid is carefully inserted into the ear.
5. The aided response is measured. (Section 6.4.4)
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 6.4.1.) 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 7000 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].

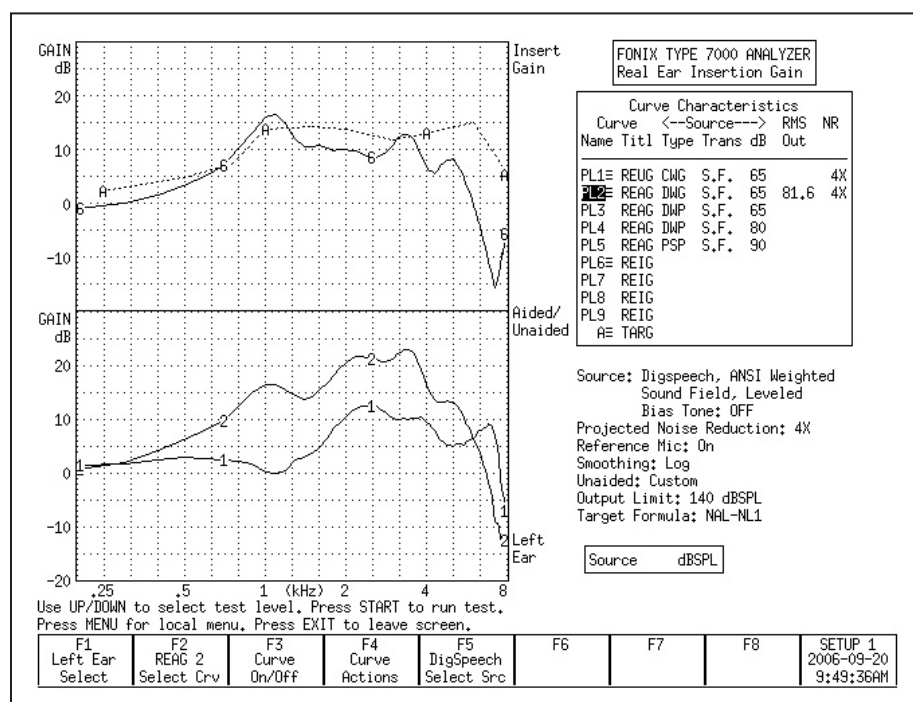


Figure 6.4.1—Real-ear Insertion Gain screen. Curve 1 is an REUG (unaided) measurement. Curve 2 is an REAG (aided) measurement. Curve 6 is the REIG (insertion gain) curve. Curve A is the real-ear prescription target.

6.4.2 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 6.4.2), 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) is also 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.

During a typical real-ear measurement using the SPL method:

1. The probe tube AND hearing aid are inserted into the ear canal. (Section 6.2.3)
2. The sound field speaker is leveled. (Section 6.2.4)
3. The hearing aid is carefully inserted into the ear.
4. The aided response is measured (Section 6.4.4) 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].

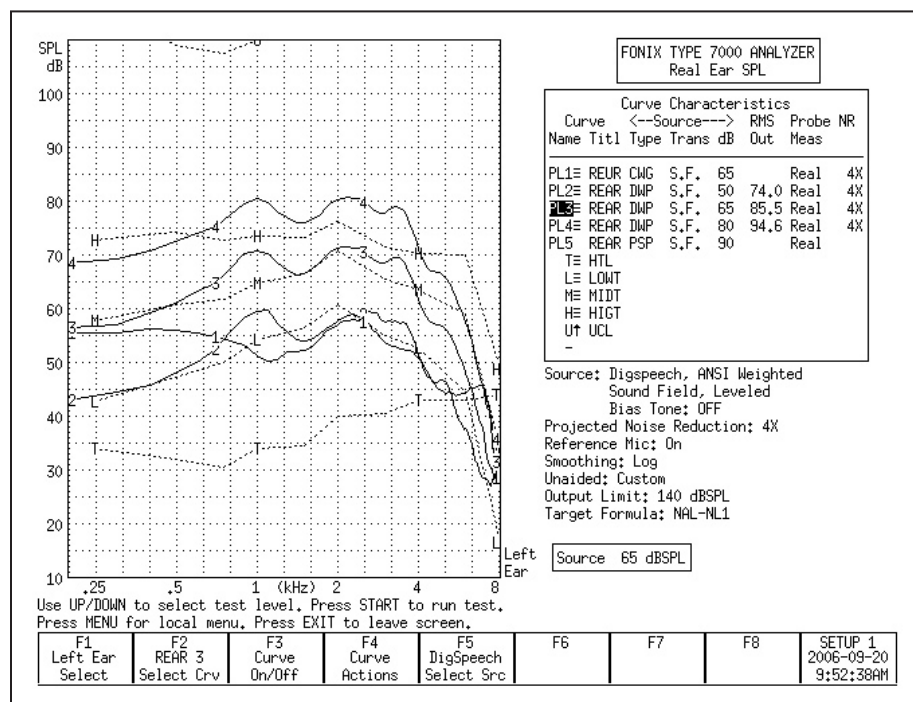


Figure 6.4.2—Rear-ear SPL screen. The T curve represents the patient's thresholds, the L, M, and H curves represent the NAL-NL1 targets. Curve 1 shows the unaided response. Curves 2, 3, and 4 show the aided response at 50, 65, and 80 dB SPL. The patient's UCLs are just off the top of the graph.

6.4.3 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 6.2.1 and 6.2.2..
2. Insert the probe tube into the patient's ear canal. See Section 6.2.3.
3. Input the patient's audiogram to generate a target, if desired. See Section 6.3.
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. Level the sound field speaker. See Section 6.2.4.
7. Select the desired ear with [F1].
8. Look at the [F2] setting to see which curve is selected. If necessary, use [F2] to select REUR 1. (Press [F2]. Use [v, ^] to select REUR 1. Press [>] to complete the selection and close the pop-up menu.)
9. Use [F5] to select Composite.
10. Use [v, ^] 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 6.4.1 shows an example of the unaided response using the Gain display in the Insertion Gain screen.

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 7000 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.

6.4.4 Measuring the Aided Response (REAG/REAR)

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. Follow the instructions found in Section 6.4.3 to measure the unaided response, if desired. Even if you don't want to measure the unaided response, follow the instructions in Steps 1-7 in Section 6.4.3 to enter an audiogram, enter the measurement screen, insert the probe tube, and level the sound field speaker.
2. Insert the hearing aid into the ear, being careful not to move the probe tube.
3. 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.)

4. Use [F2] to select REAG 2. By default, this curve is set to 50 dB SPL (i.e., soft speech). To perform a medium speech curve measurement, use the up arrow key to increase the source level to 65 dB SPL.
5. Press [START] to take the measurement. When the frequency response has stabilized, press [STOP] to stop the measurement.

Measuring in the Real-ear Insertion Gain screen:

For a description of the Real-ear Insertion Gain screen, see Section 6.4.1. In Figure 6.4.1, Curve 2 in the bottom graph shows the aided response, Curve 6 in the top graph shows the real-ear insertion gain (REIG), and Curve A shows the REIG prescription 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 5 above to make another measurement.

If desired, use [F2] to select REAG 3-5. It is recommended to perform real-ear measurements as 50, 65, 80, and 90 dB SPL. For this reason, the default source levels of REAG 2-5 are set accordingly. Use the up-down arrow keys to change the selected source amplitude at any time. Target Curve A is always adjusted to the source type and amplitude of the current selected aided curve.

Measuring in the Real-ear SPL screen:

For a description of the Real-ear SPL screen, see Section 6.4.2. In Figure 6.4.2, Curve 2 is displayed as a solid (blue) curve on the SPL graph. When the NAL-NL1 target is selected, a (blue) dotted Curve L is the prescription target for the source type and amplitude used for Curve 2. To match the frequency response to target, match Curve 2 to Curve L.

When using the NAL-NL1 fitting rule, Target Curve L should be used for REAR 2, Target Curve M should be used for REAR 3, and Target Curve H should be used for REAR 4. REAR 5 can be compared to the displayed “U”s, representing the patient’s uncomfortable levels to make sure that the response at 90 dB SPL does not exceed them.

When using a target other than NAL-NL1, only the M target will be displayed in the Real-ear SPL screen, which uses the source settings of REAR 3. Therefore, to match the frequency response to a non-NAL-NL1 target, use [F2] to select REAR 3, and perform the measurement. REAR 3 can be compared to the M target.

Make any necessary adjustments to the hearing aid fitting, and use the [START] and [STOP] keys to make another measurement. If desired, use [F2] to select

another measurement curve. It is recommended to perform real-ear measurements as 50, 65, 80, and 90 dB SPL. For this reason, the default source levels of REAG 2-5 are set accordingly. Use the up-down arrow keys to change the selected source amplitude at any time.

6.4.5 Working with prescription targets

The 7000 Hearing Aid Test System has the following fitting rules available: NAL-NL1, NAL-RP, 1/3 Gain, 1/2 Gain, 2/3 Gain, Berger, and POGO. The NAL-NL1 fitting rule is non-linear and changes 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 6.3.1. Values must be entered at 500, 1000, 2000, and 4000 Hz or the target will not be displayed.

The NAL-NL1 target has 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 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 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 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 non-linear target, the shape of the linear target will not change as the input level of the input signal changes.

6.4.6 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 advanced 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 [v, ^]. 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 does not work 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 [v, ^]. 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.

6.4.7 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 [∇ , \blacktriangle]. 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 [∇ , \blacktriangle] to adjust the amplitude of the test signal.
8. Press [STOP] when the measurement is complete.

6.4.8 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 [∇ , \blacktriangle] under Measurements.
4. Use [$<$, $>$] to choose ON or OFF.
5. Press [EXIT] to return to the measurement screen.

6.4.9 Viewing numerical curve data

The frequency response curves measured by the 7000 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 [∇ , \wedge].
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 6.4.9.
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.

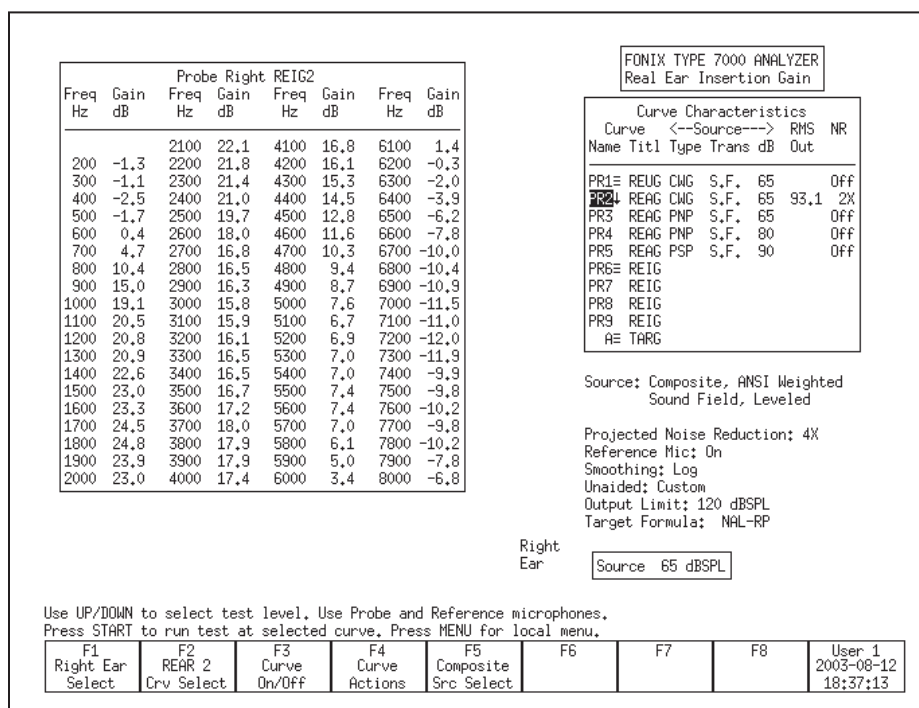


Figure 6.4.9—Insertion Gain data format display

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 [∇ , \wedge].

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.

6.4.10 Deleting and un-displaying measurements

It is often convenient to temporarily clear one or more of the measurement curves without deleting them.

To turn off/on the display of a curve without deleting it:

1. Press [F3] to open the pop-up menu with the curve selections.
2. Use [\vee , \wedge] 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.

6.4.11 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 6.4.11 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.
1. Press [MENU] to enter the local menu.
2. Use [v, ^] to select Smoothing under Display.
3. Use [<, >] to choose LOG or OFF.
4. Press [EXIT] to return to the measurement screen. All measurements will have the chosen smoothing status.

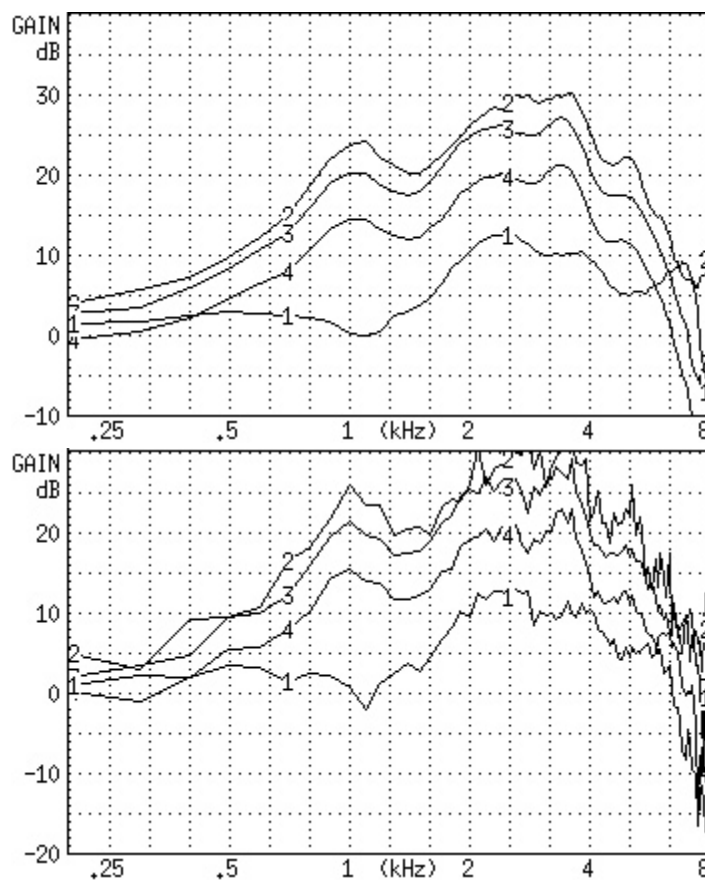


Figure 6.4.11—A comparison of a smoothed (top) and unsmoothed (bottom) curve.

6.4.12 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 7000 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 between 90 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.

To change the output limit:

1. Press [MENU] to enter the real-ear measurement menu.
2. Press [v, ^] to select Output Limit under Measurements.
3. Use [<, >] to choose the desired limit.
4. Press [EXIT] to return to the real-ear measurement screen.

6.4.13 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 6.2.3 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 [v, ^] 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 [v] 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 [v] 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.

6.5 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.

6.5.1 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 7000 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.

6.5.2 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 7000 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 6.5.2 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 [v, ^] 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.

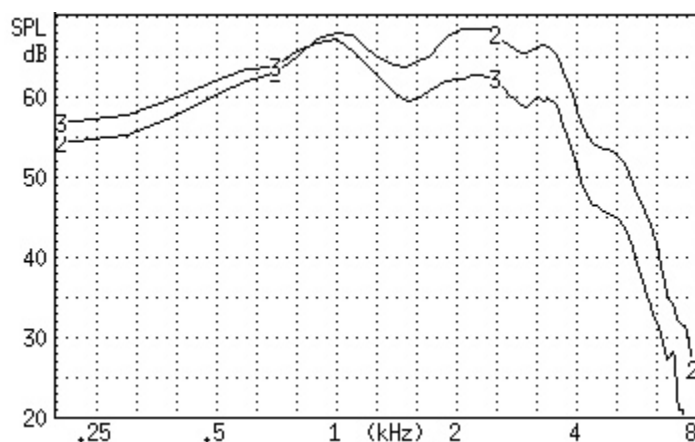


Figure 6.5.2—A comparison of an aid being tested with Digital Speech using the ICRA (CRV 3) and the ANSI S3.42 (CRV 2) speech weightings

6.5.3 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 [\vee , \wedge].
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 6.5.3.
9. Press [STOP] when done with testing. Go back into the menu to turn the bias signal OFF again.

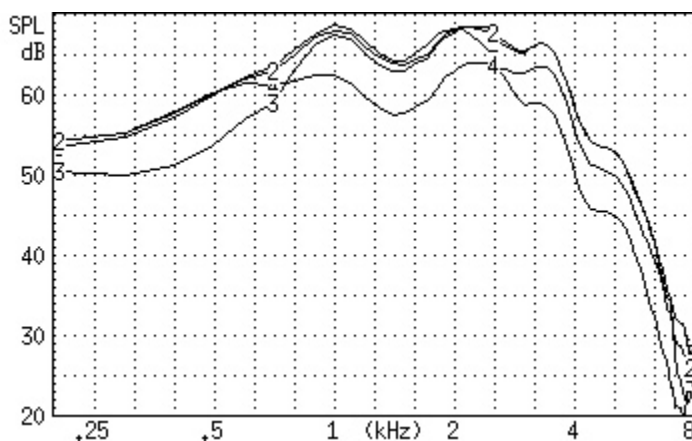


Figure 6.5.3—Using the bias signal in real-ear measurements. CRV 2–5 were measured using bias signal frequencies of no bias, 500 Hz, 2000 Hz, and 4000 Hz respectively

6.5.4 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 [\vee , \wedge] to select REAR 2. Press [$>$] to complete the selection and close the menu.)
3. Use [F5] to select Digital Speech.
4. Use [\vee , \wedge] 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 [v, ^] 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 6.5.4 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. .

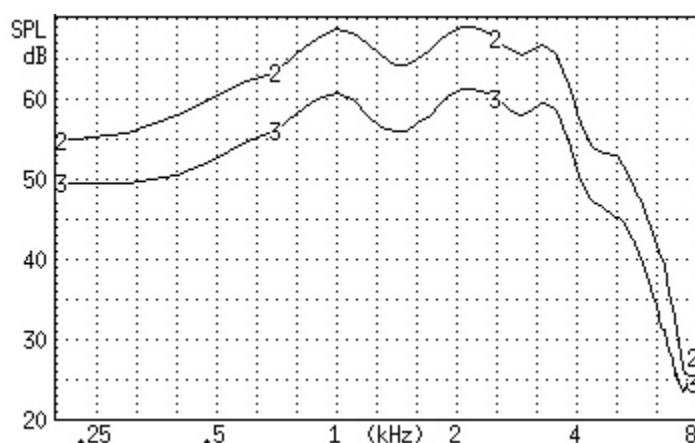


Figure 6.5.4—Testing noise suppression of a digital hearing aid. REAR 2 was tested using Digital Speech. REAR 3 was tested using the Composite Signal.

6.6 Directional Hearing Aids

The directional advantage provided by a hearing aid can be easily measured with real-ear measurements. This section describes a method of measuring directionality using the Real-ear Insertion Gain screen.

6.6.1 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 [v, ^] 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 [v, ^] 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 [v, ^] to set the source amplitude to 50 dB SPL.

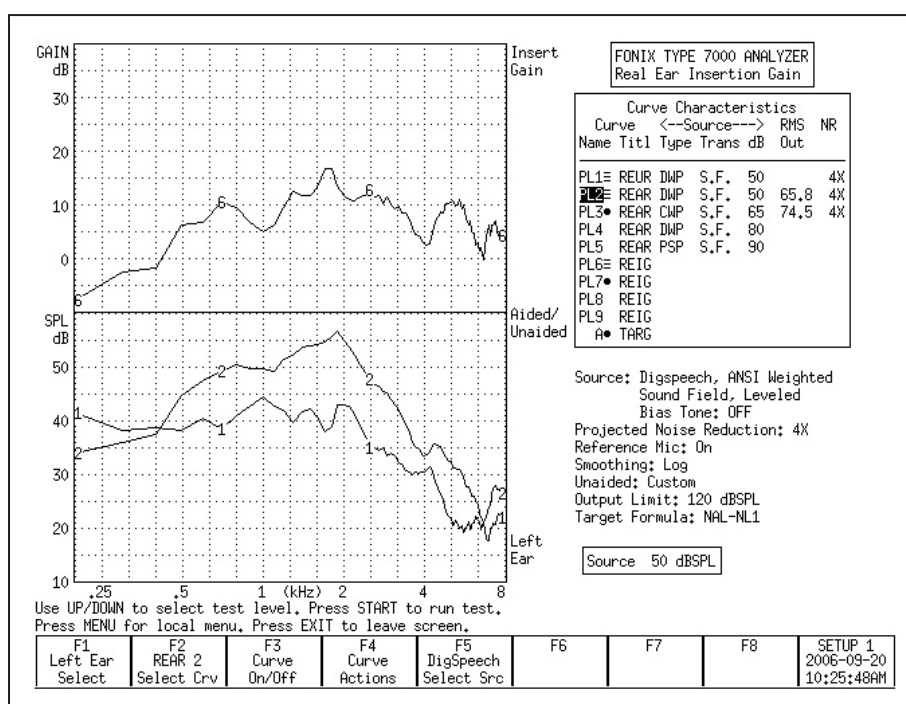


Figure 6.6.1—Testing directionality. REUR 1 was tested with the source at 135° azimuth. REAR 2 was tested with the source at 45° azimuth. Curve 6 illustrates the directional advantage of the hearing aid.

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 6.6.1). 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.

6.6.2 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 6.6.1 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 equal distance 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.

6.7 Open Ear Hearing Aids

Open ear 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-ear hearing aid, the reference microphone of the 7000 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 [v, ^].
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.

6.8 Visible Speech

The Visible Speech screen, shown in Figure 6.8, is a special screen used for performing real-ear measurements with live speech or other external source types. Visible Speech was designed to demonstrate the real-time response of the hearing aid to the speech 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 6.8.5 for more technical details on SII and how it is calculated on the 7000 Hearing Aid Test System.

When first entering the Visible Speech screen (Figure 6.8), the following is displayed:

- Shaded areas below and above the patient's 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 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.

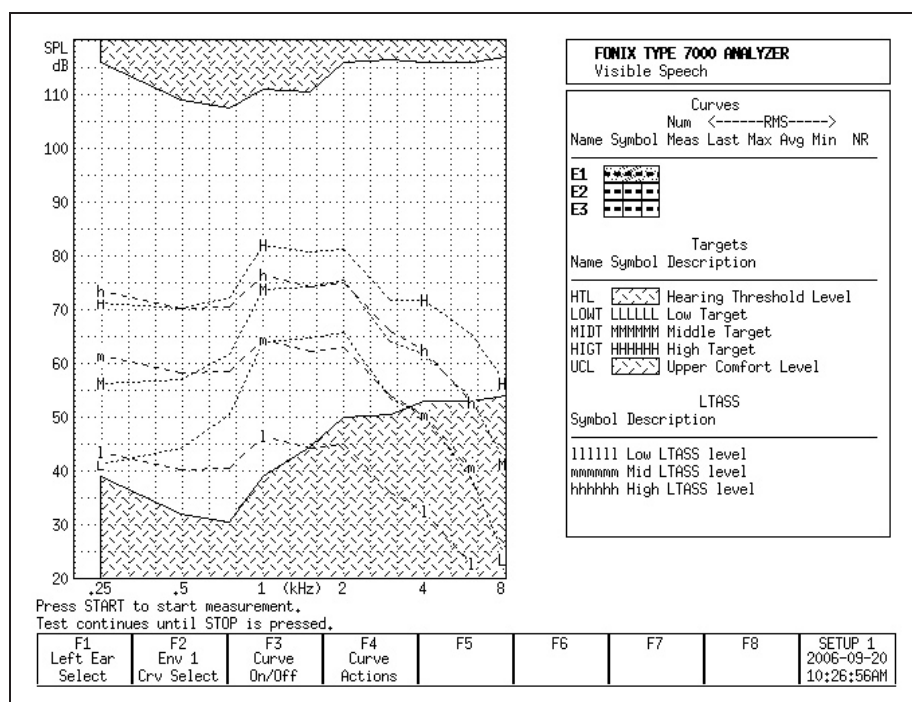


Figure 6.8—Visible Speech screen before a measurement is taken. The shaded regions are below and above the patient's thresholds and uncomfortable levels. The L, M, and H lines represent the real-ear targets at 50, 65, and 80 dB SPL. The l, m, and h lines represent the region of unamplified speech.

6.8.1 Performing Visible Speech measurement

1. Enter the patient's audiogram into the analyzer, as described in Section 6.3.1.
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 as described in Section 6.2.3. The reference microphone is not used in this measurement. It can be placed on the earhook as normal, or left hanging behind the patient's back
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. Have the person start talking, or start the external signal. It is useful to have a handheld sound level to monitor the input level of the signal at the patient's ear.
8. Press [START] on the 7000 analyzer. This will start the Visible Speech measurement. (There is no need to level the sound field speaker for this test.)

6.8.2 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)

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.

6.8.3 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 6.8.3 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.

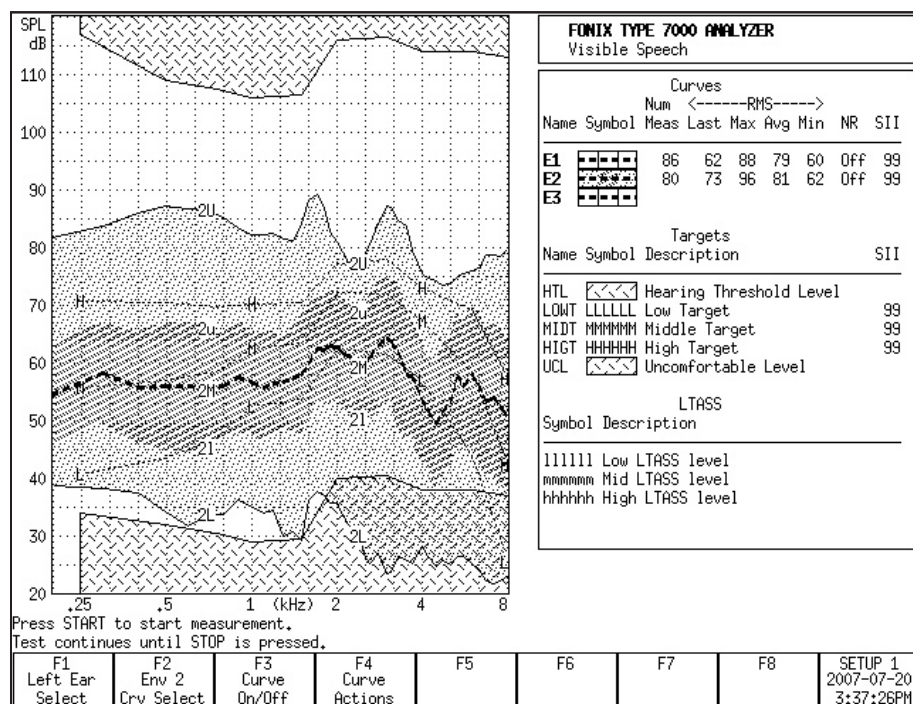


Figure 6.8.3—Completed Visible Speech test.

6.8.4 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 [v, ^] 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.

6.8.5 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 7000, 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 7000. 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 7000 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 7000 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.

6.9 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:

6.9.1—Measuring the Head Baffle Effect

6.9.2—Measuring the Overcoming of the Head Baffle Effect

6.9.3—Measuring the Overall Insertion Gain

6.9.4—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 6.4.1.2. For measurements labeled “Aided” (even if they aren’t aided) follow the instructions in Section 6.4.1.3.

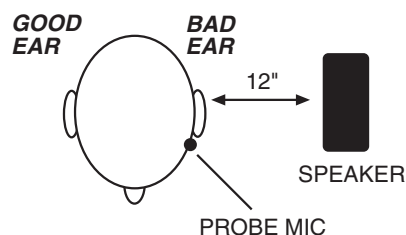
6.9.1 Measuring the Head-Baffle Effect

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 7000 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

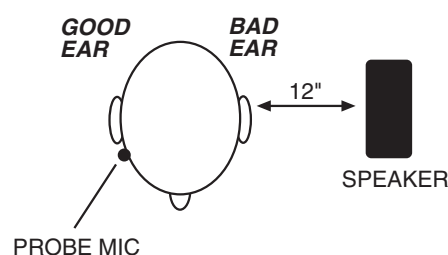


Aided—Real Ear response on “good” ear side

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 7000 test system to be UNLEVELED with the reference microphone OFF, the rest of the measurements in this section call for the 7000 test system to be LEVELED with the reference microphone ON.

6.9.2 Measuring the Overcoming of the Head-Baffle Effect

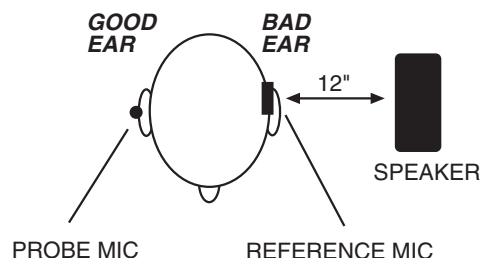
This section describes how to measure how well the hearing aid overcomes the head-baffle effect. The methods are different for CROS hearing aids than they are for BICROS hearing aids.

6.9.2.1 CROS

Unaided—Measurement of “good” ear canal (baffled by head)

Set up the 7000 test system as follows.

- Reference microphone ON
- Sound field LEVELED
- Unaided CUSTOM
- Reference microphone over pinna of bad ear
- Probe microphone 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.

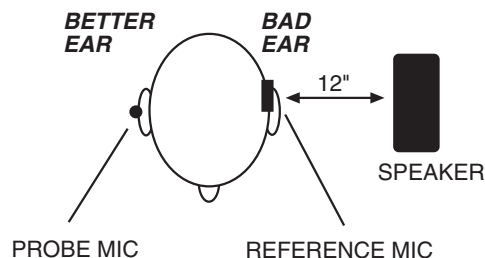
The difference curve, labeled “Insertion Gain” on the screen, shows the benefit the aid gives for sound arriving from the “bad” side.

6.9.2.2 BI-CROS

Unaided—Measurement of “better” ear canal (baffled by head)

Set up the 7000 test system as follows.

- Reference microphone ON
- Sound field LEVELED
- Unaided set to CUSTOM
- Reference microphone over pinna of “bad” ear
- Probe microphone 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.

6.9.3 Measuring Overall Insertion Gain

The methods for measuring the overall insertion gain of CROS and BICROS aids are described in this section.

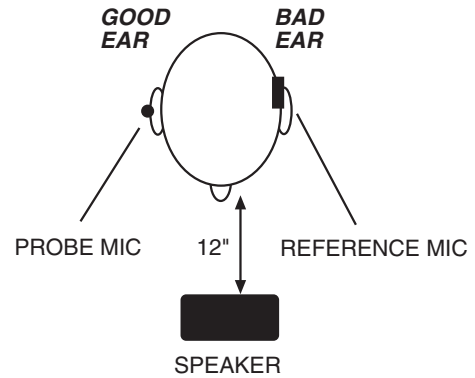
Since it has not been shown for CROS and BI-CROS instruments that a 45° position of the loudspeaker improves the reliability of insertion gain measurements, we recommend a 45° position of the loudspeaker only for monaural instruments, and a 0° position for CROS and BI-CROS instruments.

6.9.3.1 CROS

Unaided—Measurement of “good” ear

Set up the 7000 test system as follows.

- Reference microphone ON
- Sound field LEVELED
- Reference microphone over pinna of bad ear
- Probe microphone inside unoccluded 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.

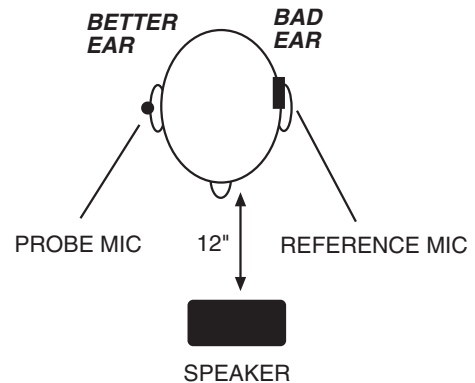
The difference curve, labeled “Insertion Gain” on the screen, shows the overall benefit of inserting the hearing aid.

6.9.3.2 BI-CROS

Unaided—Measurement of “better” ear

Set up the 7000 test system as follows:

- Reference microphone ON
- Sound field LEVELED
- Unaided response CUSTOM
- Reference microphone over pinna of bad ear
- Probe microphone inside unoccluded 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.

6.9.4 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.

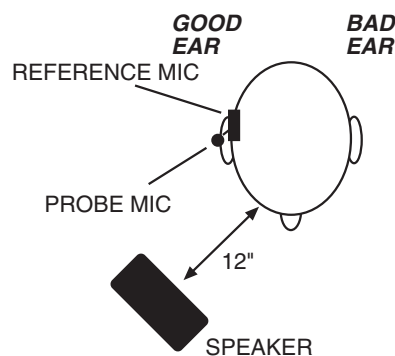
When a CROS aid has been prescribed to overcome a severe unilateral high-frequency loss, you may want to ensure that inserting an open ear mold into the good ear has not significantly attenuated the acoustic transmission to the good ear.

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 7000 test system as follows.

- Reference microphone ON
- Sound field LEVELED
- Unaided CUSTOM
- Reference microphone over pinna of good ear
- Probe microphone 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

ACOUSTIC DRIVE SIGNAL

Frequencies:	Composite: 200 to 8000 Hz in 100 Hz intervals SINE: 200 to 8000 Hz 1/12 oct, nearest 100 Hz intervals
Frequency Accuracy:	1%
Amplitude (RMS 5-dB steps)	
Chamber	COMPOSITE: 40 to 100 dBSPL; SINE: 40 to 100 dBSPL
Sound Field	COMPOSITE: 40 to 90 dBSPL; SINE: 40 to 90 dBSPL
Amplitude Accuracy	Within 1 dB from 300 to 5000 Hz, all others within
(All Modes, M1950E only)	3 dB; after leveling

CREST FACTOR

Composite Mode Signal: Less than 12 dB (4 to 1 ratio of peak to RMS value).

TELECOIL DRIVE

1, 1.78, 3.16, 5.62, 10, 17.8, 31.6, 56.2, 100 mA/meter. ANSI S3.22-1996

DIGITAL READOUT OF SOUND PRESSURE LEVEL

Frequency Range:	200 through 8000 Hz.
Amplitude Range:	From 0 through 150 dB (–90 through +110 dB gain).
Resolution:	0.1 dB.
Type:	True RMS
Accuracy (M1950E):	Within 1 dB plus or minus 1 digit from 300 to 5000 Hz; within 2 dB plus or minus 1 digit for all other frequencies.
SPL Equivalent Input Noise:	Less than 50 dB RMS (M1950E)
Noise Reduction:	Averages the measured signal in synchronism with the signal generator by the factor chosen. Factors of 2, 4, 8, and 16 available. Random noise will be reduced by an amount equal to the inverse of the square root of the factor chosen.

BATTERY CURRENT MEASUREMENT

Range:	0 to 20 mA.
Accuracy:	Within $\pm 5\%$ of reading plus or minus 0.01 mA.
Resolution:	0.01 mA.
Voltages supplied:	1.5 (silver), 1.3 (zinc air). See Appendix B, ANSI S3.22-1996.

Note: The above accuracy applies only if the battery pill is disconnected during the leveling operation.

SPECTRUM MODE AVERAGING

Spectral : off, 2,4,8 and 16.

HARMONIC DISTORTION ANALYZER

Type: Selectable for 2nd, 3rd, Total (2nd plus 3rd), or none.
Resolution: 0.1 percent.
Reading: Percent (%) with respect to fundamental. Single frequency readings made at 100-Hz intervals from 200 through 2600 Hz. Sweep readings made at 100 Hz intervals from 400 through 1900 Hz.

ATTACK/RELEASE TIME

Range: 1.25 to 5000 mSec.
Accuracy: $\pm 10\%$ or 2 mSec + Resolution, whichever is larger.
Resolution: 2000-8000 Hz: 1.25 mSec;
800-1600 Hz: 2.5 mSec;
400, 500 Hz: 5 mSec.
100 to 300 Hz and Composite: 10 mSec.
Available Test Modes: ANSI 96, ANSI 87
Signal Durations: ANSI 87: 2000 mSec
ANSI 96: variable (500 to 5000 mSec)

TEST SEQUENCES

Choose ANSI or IEC as part of standard package. Additional charge for the second test sequence.
ANSI 3.22 (87/92/96)
IEC EN60118-7 1993

FEATURES

Group Delay and Phase Measurement
Battery Current Measurement
Coupler Multi-Curve
RS232 Function

AVAILABLE SIGNALS

Composite, Sine, Digital Speech (ICRA & ANSI)

OPTIONS

Real Ear Measurement (7000 Quik-Probe), 2nd Test Sequence, VA CORFIG, MZ coupler.

PRIMARY POWER

100-240 VAC 50/60 Hz. Power requirement is 50 VA.

ELECTRONICS MODULE

Color:	Blue module case, white front panel and gray bezel
Size:	17.4"W x 6.5"H x 14.6"D (44.2 x 16.5 x 37.1 cm).
Weight:	17 lbs.(7.7 kg).

PRINTER, INTERNAL

Type:	High speed line thermal printer
Paper width:	4.41" (112 mm)
Print speed:	80 mm/ s

PRINTER, EXTERNAL (PRINTER NOT PROVIDED)

Port:	25 pin D, female
Type:	HP compatible, Epson Stylus series
Language:	HPCL3 and ESC-P/2

TEST CHAMBER

Type:	FONIX FC 7020
Test Area:	7"x 7.5"x 1.5 deep (17.8 x 19.1 x 3.8cm).
Internal Acoustic	SPL at test point will change less than 3 dB above
Reflections:	1 kHz, when lid is raised (w/o feedback compensation).
Ambient Noise Isolation:	45 dB at 1 kHz (allows THD measurement to within 3% at 60 dB source level and a 60 dB ambient).
Color:	Gray with black trim. Black and white test area.
Size:	13.5"W x 18"H x 11.5"D (34.3 x 45.7 x 29.2cm).
Weight:	36 lbs. (16.3 kg).

SHIPPING, INTERNATIONAL

Total Shipping Weight with Quik-Probe Option:	97 lbs. (45 kg)
Total Shipping Weight without Quik-Probe Option:	77 lbs. (35 kg)

STANDARD ACCESSORIES

FONIX M1950E Low Noise 14 mm diameter, pressure type Electret	
Microphone:	with add-only memory chip. 149 dB maximum SPL.
Microphone Adapter:	(044-1006-01) 14mm to 1" (25 mm).
HA-1 Coupler:	(044-1003-03) Dimensions per requirements of ANSI S3.7-1995 for testing all-in-the-ear aids and earmolds.
HA-2 Coupler:	(044-1001-04) Dimensions per requirements of ANSI S3.7-1995 for testing ear level, eyeglass and body aids.

Ear Level Adapter:	(044-1007-00) Per requirements of ANSI S3.22-1996 for adapting ear level aids to the HA-2 coupler.
Sound Chamber Cable:	(119-0204-07)
Battery Pills	#13: (059-2005-02) #675/76: (059-2004-02) #312: (059-2006-02) #10A/230: (059-2010-01). All with 12" cables—24" cables available on request.
Roll of Printer Paper	(026-0006-00)
Operator's Manual:	(010-0019-00)

OPTIONAL ACCESSORIES

Video Display Monitor:	(058-0077-00) VGA, flat panel, 15", color. Shipping weight: 21 lbs (10 kg).
6 cc Coupler:	(044-1004-03) NBS 9A, for checking audiometer headphones.
Test Chamber Stand:	(030-1002-04) Tubular steel stand which brings the testing area or the test chamber to convenient table height. Blue color.
Quest QC-10 Sound Level Calibrator:	(030-0004-00) For calibration of microphone. amplifier. 1 kHz, 114 dB SPL.
Telewand:	(043-1053-00) For checking response of aids in "telephone" mode. ANSI S3.22-1996.
Telecoil Induction Loop:	(120-1002-00) For checking hearing aid response to a magnetic loop field.
Battery Pills:	#AA: (059-1011-00); #41: (059-2009-02); #5: (059-2008-01). All with 12" cables—24" cables available on request.
Maintenance Manual:	(010-0020-00) On request at time of purchase.

SAFETY

Electronics module conforms to IEC 60601-1

GUARANTEE

The FONIX 7000 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.

Calibration

B.1 Calibrating the microphones

To calibrate the 7000 Test System's microphones, you will need a sound level calibrator such as the Quest CA-12, the 14mm-to-1 inch microphone adapter provided with your 7000 Test System, and a small flathead screwdriver. If you are calibrating the probe microphone, you will also need the probe microphone adapter and a Phillips-head screwdriver.



Figure B.1A—Equipment for calibrating the 7000 microphones.

To calibrate the M1950E coupler microphone:

1. Press [MENU] from the Opening screen to open the Setup Menu.
2. Press [F6] to open the Microphone Calibration window.
3. Insert the 14mm-to-1 inch adapter into the sound level calibrator.
4. Insert the M1950E coupler microphone into the adapter.
5. Turn on the sound level calibrator and look at the “Coupler Mic” level in the Microphone Calibration window. It should match the calibrated tone emitted by the sound field calibrator. This is usually 110 dB SPL or 114 dB SPL. Check your calibrator for details.

6. If necessary, adjust the gain of the 1950E microphone by using the flathead screwdriver to adjust the “gain” pot on the back of the 7000 Test System next to the microphone connector. Match the levels as close as possible. If you are unable to adjust the gain of the microphone to the level emitted by the calibrator, you probably have a faulty microphone and should contact your local FONIX distributor or the Frye factory.

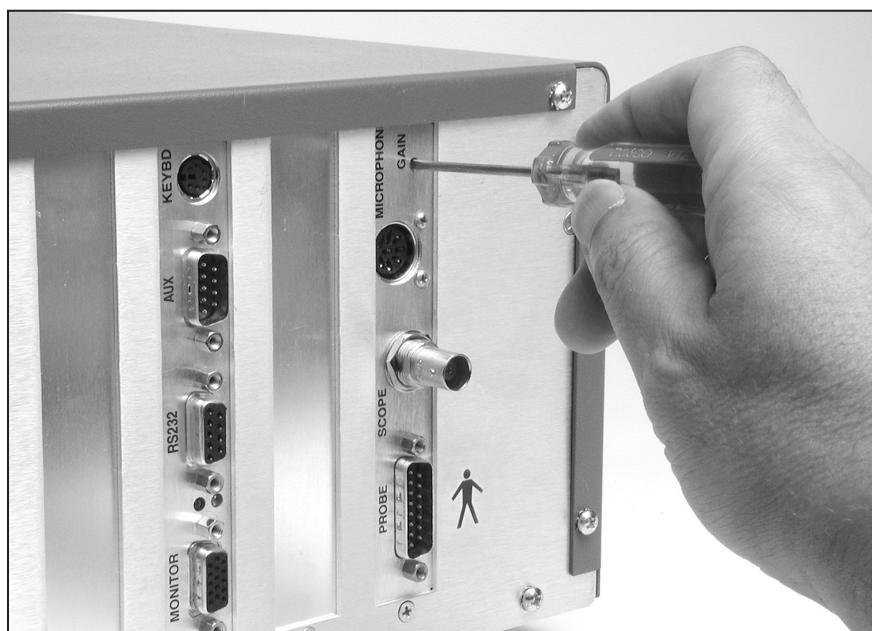


Figure B.1B—Adjusting the gain pot with a flat head screwdriver

To calibrate the real-ear probe and reference microphones:

1. Follow steps 1-3 above to set up the 7000 Hearing Aid Test System for calibration.
2. Use the down arrow on the 7000 keyboard to select “Probe Microphone” in the Microphone Calibration window.
3. Attach a new probe tube to the probe microphone.
4. Thread the probe tube through the edged side of the probe microphone adapter so that the probe tube sticks out a couple of millimeters from the other end of the adapter. See Figure B.1D.
5. Secure the probe tube in place by putting a dab of Fun-Tak on the edged end of the adapter.
6. Insert the probe microphone adapter with the attached probe microphone into the calibrator.



Figure B.1.C—Adjusting the reference pot with a Phillips-head screwdriver.

7. Turn on the sound level calibrator and look at the “Probe Mic” level in the Microphone Calibration window. It should match the calibrated tone emitted by the sound field calibrator.
8. If necessary, adjust the gain of the probe microphone by using the Phillips-head screwdriver to adjust the “probe” pot on the back of the remote module. Match the levels as close as possible. If you are unable to adjust the gain of the microphone to the level emitted by the calibrator, you probably have a faulty microphone and should contact your local FONIX distributor or the Frye factory.

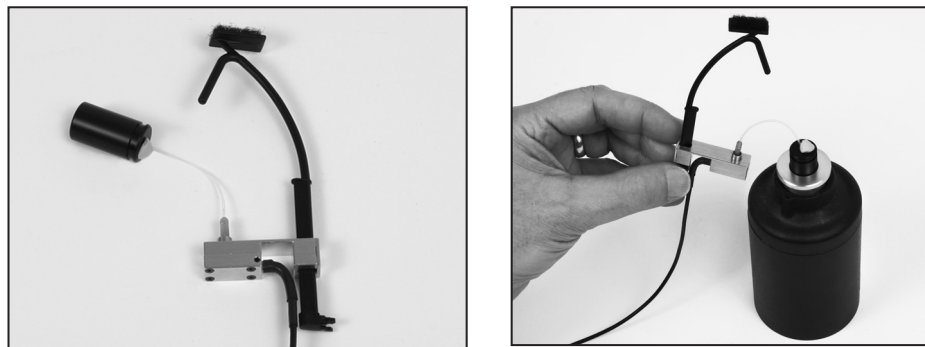


Figure B.1D—Calibrating the real-ear probe microphone

9. Press [EXIT] twice to return to the Opening screen.
10. Press [F2] to enter the Real-ear Navigation screen.
11. Press [F3] to enter the Real-ear Insertion Gain screen.
12. Press [MENU] to open the local menu.
13. Use the arrow keys to select Display and change its setting to Gain. Also use the arrow keys to select Composite Filter and change it to FLAT.
14. Press [EXIT] to close the local menu.
15. Use [F5] to select Composite.
16. Place the end of the probe tube at the opening of the reference microphone using a small dab of Fun Tak. You will need to remove the reference microphone from the Velcro wedge. See Figure B.1E.
17. Hold the integrated microphone six inches from the sound field speaker.
18. Press [START] to start a measurement and press [STOP] after a few seconds.
19. The displayed curve should be centered around the 0 dB line in the bottom graph on the screen. If necessary, adjust the gain of the reference microphone by using the Phillips-head screwdriver to adjust the “reference” pot on the back of the remote module, and repeat the measurement.
20. When finished, press [RESET] to delete all measurement curves on the analyzer and return the settings to their default conditions.

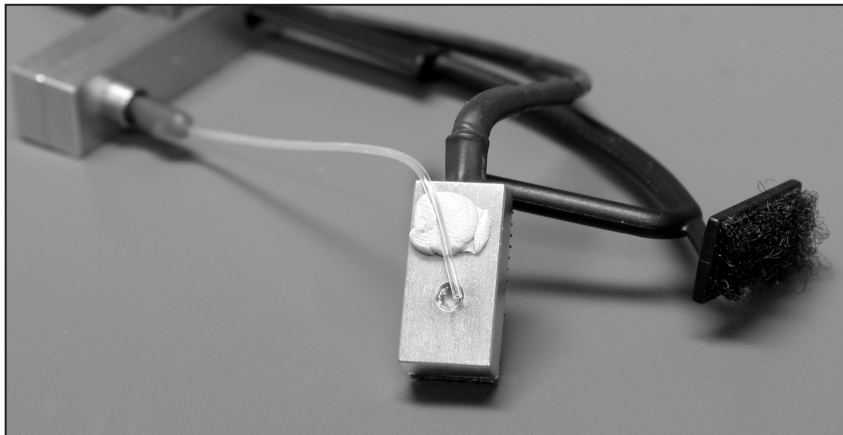


Figure B.1E—Attach probe microphone to reference microphone

B.2 Calibrating the insert earphone for the RECD

The real-ear to coupler difference (RECD) is a measurement that can be performed when you have the Real-Ear Option (Quik Probe). There are two parts to the RECD: a coupler measurement and a real-ear measurement. The coupler measurement is considered a calibration procedure and needs to be done only when the probe and reference microphones are calibrated.

The RECD measurement is usually done with a 50-ohm insert earphone. Eventually, the 7000 Test System will also support an RECD method performed with a linear hearing aid, but that has not yet been implemented.

1. Insert the earphone connector into the ¼ inch “Earphone” jack on the back of the 7000 Test System.
2. Plug the other end of the earphone into the tubing of the ear level adapter attached to an HA-2 coupler.
3. Attach a new probe tube to the probe microphone.
4. Thread the probe tube through the edged side of the probe microphone adapter so that the probe tube sticks out a couple of millimeters from the other end of the adapter. See the setup for calibrating the probe microphone in the previous section. The probe microphone adapter is used in the same manner.
5. Secure the probe tube in place by putting a dab of Fun-Tak on the edged end of the adapter.
6. Insert the adapter into the HA-2 coupler.
7. Press [MENU] from the Opening screen to open the Setup Menu.
8. Press [F4] to perform the measurement. The screen will briefly display that the measurement is being taken and saved. No further action is necessary.
9. Press [EXIT] to return to the Opening screen.

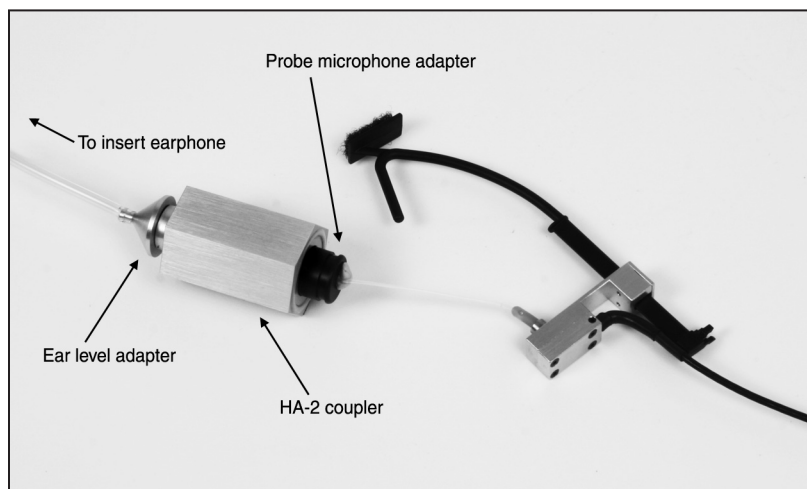


Figure B.2—Calibrating the insert earphone

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 switch(s).
- b. Make sure the power cable is plugged into a working wall outlet.
- c. Check the fuse in the power entry module.

CRT/VGA/LCD display monitor is not working

- a. Check the ON switch.
- b. Make sure the power cable is plugged into working wall 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 probe keyboard or main panel 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: 0.6" (15mm).

2. Test microphone is difficult to get into coupler or the ear level adapter does not easily seal to the other end of the 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 Fun-Tak the vent.
- b. There may be a coupler vent leak.
- c. The #13 coupler tubing could be cracked or broken.

Probe Problems:**1. Probe Reference Mic does not Level.**

- a. Check the reference mic calibration. (See Appendix B)
- b. Be sure the reference mic is properly plugged into the instrument.
- c. Are all connections clean and tight?
- d. Are the mic cables loose, broken, cut, worn or frayed?
- e. Is the Leveling signal coming out of the speaker? If not, check cable and connections.
- f. Make sure the distance from the speaker to the ref. mic during leveling is about 12" (max. 18").

2. Cleaning probe tubes

DO NOT REUSE probe tubes. There is NO recommended cleaning procedure. Germicidal solutions can leave a residue inside the tubing which can cause test result errors. DO NOT cut off any portion of the tube.

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 a significant amount more gain. Further, its response can be expected to 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 can be 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 that which 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	7000
-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 7000 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.

Probe SPL Mode Description

The Target IG is converted to the Target SPL in the following steps:

(Conversion tables appear on the following pages.)

1. Add the source level for Aided curve 2.
2. Interpolate from 10 frequency to 79 frequency curve frame.
3. Add the AVG Unaided ear response REUR in Table 1.
4. If Aided 2 is composite, subtract 10.7 dB from each frequency. If Aided 2 is Speech Weighted tone, add 2.1 dB to each frequency.
5. If Aided 2 is Speech Weighted, subtract the Speech Weighting in Table 2.

The complete formula is then:

$$\begin{aligned} \text{Target SPL} = & \text{Target IG} + \text{CRV2 source} + \text{AVG REUR} \\ & (\text{If Aided2 is composite}) - 10.7 \text{ dB} - \text{Speech Weighting.} \\ & (\text{If Aided2 is speech tone}) - \text{Speech Weighting.} \end{aligned}$$

- To convert the HTL and UCL from HL to SPL:
Add the corrections in Table 3.
- To predict UCL's (HL) given the HTL (HL):
Use Table 4 to convert from HTL to UCL.

TABLE 1

Average Real-Ear Unaided Response (REUR)

FREQ (Hz)	GAIN dB	FREQ (Hz)	GAIN dB	FREQ (Hz)	GAIN dB	FREQ (Hz)	GAIN dB
		2100	13.9	4100	12.7	6100	7.7
200	1.6	2200	14.7	4200	12.4	6200	7.5
300	2.1	2300	15.1	4300	12.2	6300	7.3
400	2.7	2400	15.0	4400	12.0	6400	7.2
500	2.9	2500	15.1	4500	11.9	6500	7.1
600	2.9	2600	15.0	4600	11.7	6600	6.9
700	3.1	2700	14.6	4700	11.6	6700	6.8
800	3.3	2800	14.1	4800	11.2	6800	6.6
900	3.6	2900	13.6	4900	10.7	6900	6.5
1000	3.4	3000	13.7	5000	10.3	7000	6.4
1100	3.1	3100	13.8	5100	9.9	7100	6.2
1200	3.6	3200	14.1	5200	9.5	7200	6.1
1300	4.2	3300	14.5	5300	9.2	7300	6.0
1400	4.4	3400	14.8	5400	8.9	7400	5.7
1500	5.6	3500	14.9	5500	8.7	7500	5.4
1600	7.0	3600	14.7	5600	8.5	7600	5.1
1700	8.1	3700	14.3	5700	8.3	7700	4.8
1800	9.3	3800	13.9	5800	8.2	7800	4.6
1900	10.9	3900	13.5	5900	8.0	7900	4.4
2000	12.6	4000	13.1	6000	7.8	8000	4.2

TABLE 2

Speech Weighting

FREQ (Hz)	dB	FREQ (Hz)	dB	FREQ (Hz)	dB	FREQ (Hz)	dB
		2100	8.1	4100	13.4	6100	16.7
200	0.2	2200	8.4	4200	13.6	6200	16.9
300	0.5	2300	8.8	4300	13.8	6300	17.0
400	0.8	2400	9.1	4400	14.0	6400	17.1
500	1.2	2500	9.4	4500	14.1	6500	17.3
600	1.6	2600	9.7	4600	14.3	6600	17.4
700	2.1	2700	10.0	4700	14.5	6700	17.5
800	2.5	2800	10.3	4800	14.7	6800	17.6
900	3.0	2900	10.6	4900	14.9	6900	17.8
1000	3.5	3000	10.8	5000	15.0	7000	17.9
1100	4.0	3100	11.1	5100	15.2	7100	18.0
1200	4.4	3200	11.3	5200	15.4	7200	18.1
1300	4.9	3300	11.6	5300	15.5	7300	18.2
1400	5.3	3400	11.8	5400	15.7	7400	18.4
1500	5.8	3500	12.1	5500	15.8	7500	18.5
1600	6.2	3600	12.3	5600	16.0	7600	18.6
1700	6.6	3700	12.5	5700	16.1	7700	18.7
1800	7.0	3800	12.7	5800	16.3	7800	18.8
1900	7.4	3900	13.0	5900	16.4	7900	18.9
2000	7.7	4000	13.2	6000	16.6	8000	19.0

TABLE 3

HL to real-ear SPL (or SPL to HL) conversion
table from ANSI S3.6-1989 Table G.1

FREQ (Hz)	dB
250	19.0
500	12.0
750	10.5
1000	9.0
1500	9.5
2000	15.0
3000	15.5
4000	13.0
6000	13.0
8000	14.0

TABLE 4

HTL(HL) to UCL(HL)
prediction table from Pascoe(1988) Table 4

HTL dBHL	UCL HL	HTL dBHL	UCL HL
0	97	65	114
5	99	70	115
10	99	75	117
15	98	80	120
20	97	85	120
25	101	90	124
30	102	95	130
35	101	100	127
40	103	105	133
45	105	110	134
50	107	115	137
55	108	120	140
60	110		

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.”
AIDED RESPONSE	The response of a hearing aid in place on the ear. (Also called “In-situ Response.”) Subtract the “Unaided Response” from the “Aided Response” to get the Insertion Gain Response. When the Aided Response is measured in a real ear (as opposed to a manikin), it is called the “Real Ear Aided Response” (or “REAR”).
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. An option on the 7000 Test System that uses three pure tones and averages them for the screen display.
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.
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.
EXTERNAL EAR EFFECT	See Unaided Response.
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.
FUN-TAK	A brand name for a modeling clay-like substance used to attach and seal hearing aids to couplers.
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.
INSERT EARPHONE	Earphone whose transducer is joined to the ear by means of a tube attached to a foam eartip that is placed into the outer ear canal; used in finding Real Ear to Coupler Difference (RECD) measurements.
INSERTION GAIN RESPONSE	A measure of the acoustic benefit of a hearing aid, measured in a patient’s ear. The insertion gain is the difference, at any particular frequency, between the Aided Response and the Unaided Response. When considered across a range of frequencies, the measure is called the “Insertion-gain Response.” When measured in a real ear (as opposed to a manikin), the insertion-gain response is called the “Real Ear Insertion-gain Response” (or “REIR”).
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.
INVALID	In the Multi-Curve Option, this word appears when there is no curve stored in a selected memory location.
JIS	Japanese Industrial Standard. The organization which sets standards for measurements in Japan.
KEMAR	Knowles Electronics Manikin for Acoustic Research. 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 pilot 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.
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 7000’s method of producing a more stable reading by averaging many samples.
OCCLUDED RESPONSE	A frequency response measured inside the ear canal with the hearing aid earpiece in place, but with the hearing aid turned off. This is a measure of how much unamplified sound leaks into the ear through the earpiece (such as with an open fitting). When measured in a real ear (as opposed to a manikin), it is called the “Real Ear Occluded Response” (or “REOR”).
OCCLUSION 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 7000, 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.
PROBE MICROPHONE	A miniature microphone with a thin, flexible tube that is inserted into an ear canal to measure sound.
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 EAR MEASUREMENT	A special test procedure using a probe microphone and a special instrument capable of measuring sound levels inside an ear canal.
REAL-TIME TESTING	The ability to view <u>instantly</u> the results of hearing aid tests.
RECD	Real Ear to Coupler Difference. Measurement of the difference in decibels between the output of a hearing aid found with a probe microphone in the ear canal and the output of the aid found in a 2-cc coupler.
REFERENCE MICROPHONE	With the QUIK-PROBE Option, the microphone, placed above the ear, which provides a reference measurement that is compared to that of the probe microphone placed in the ear canal.
REFERENCE POINT	The location in a test chamber where the microphone of a hearing aid must be placed for accurate testing. In the 7000, it is the small circle in the center of the test chamber.
REAR	Real Ear Aided Response. See "Aided Response."
REDD	Real-Ear to Dial Difference. This is the difference of the output of an audiometer, in dB HL, and the measured dB SPL value measured with a probe microphone in the ear.
REIR	Real Ear Insertion-gain Response. See "Insertion Gain."
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.
REOR	Real Ear Occluded Response. See "Occluded Response."
RESPONSE LIMIT	The high and low points of the frequency range found in the ANSI test sequence conditions.
RESR	Real Ear Saturation Response. A special case of the REAR for which the hearing aid is operated at its saturation level. This is akin to the coupler measurement known as the "SSPL-90."
REUR	Real Ear Unaided Response. See "Unaided Response."

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.
SINE TONE	A testing tone consisting of only one frequency. Same as Pure tone.
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.
SOFTWARE	The programming part of a computer system.
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.
TARGET	A curve, based on an audiogram and a prescription strategy, presenting the theoretically optimum response that a hearing aid should have for a particular hearing loss.
TELECOIL	Same as COIL. In the 7000, 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 7020 sound chamber.
UNAIDED RESPONSE	A frequency response measured inside the ear canal without a hearing aid in place. Also known as “External Ear Effect,” the Unaided Response consists of the combined acoustic affects of the head, torso, pinna, and ear canal. When measured in a real ear (as opposed to a manikin), it is called the “Real Ear Unaided Response” (or “REUR”).
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.

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