FONIX® FP40/FP40D
PORTABLE HEARING AID ANALYZER

OPERATOR'S MANUAL

A Note on this Manual

The instructions in this manual are for software version 3.70 and above, with references to earlier software. However, you may contact Frye Electronics for a more appropriate manual if you have earlier software.

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

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Alexandra House
Newton Road
Manor Royal
Crawley
West Sussex RH109TT
England

Otherwise, please report all safety-related concerns to:

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P.O. Box 23391
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ISO 13485
FM 77405

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Chapter 1: Introduction

1.1 Description

Hearing aid analyzers are designed to give the user accurate information on how much amplification the aid provides, which frequencies it amplifies, how loud it can get, and how much distortion and noise are present. Information is displayed in both graphs and in number tables, and can be printed as desired.

The FP40 Hearing Aid Analyzer is the third generation of portable analyzers manufactured by Frye Electronics. It incorporates a tilt-up, wide-angle LCD (liquid crystal display), a quiet, fast thermal printer, and a convenient, optional battery pack for testing in places where it is not convenient to use electrical outlets. The lid holding accessories comes off so that the unit looks like a desk model in your office.

The following test sequences are currently available on the FP40: ANSI (American National Standards Institute); IEC (International Electrotechnical Commission); JIS (Japanese Industrial Standard) and ISI (Indian Standards Institute). Your choice of one of these is included in the standard price. Additional test sequences can be included at a modest cost. Instructions for the ANSI and IEC test sequences are found in Chapter 5. Instructions for the JIS automated test sequence are available upon request.

The FP40 comes standard with three types of pure-tone sweeps: normal, fast, and short. The Composite Options adds three real-time signals: the Composite signal, Digital Speech ANSI, and Digital Speech ICRA. These signals are described in more detail in Section 1.3.

Indications for use

The FONIX FP40 Hearing Aid Analyzer 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 FP40.

1.2 Hardware History

Here's some of the recent hardware changes to the FP40:

In 1994, we introduced the VGA Option that allowed the FP40 to be hooked up to an external color video monitor for a large, colorful display. (In 1999, this VGA Option became a standard feature.) At the same time, we introduced the Telecoil Option to allow telecoil testing. It requires separate hardware such as the ANSI 87 telecoil board or the ANSI 96 telewand.

Also in 1994, we introduced the FP40-D desk model analyzer. This unit is always equipped with the real ear testing function. In order to minimize costs, the Battery Pack Option is not available on this unit and some accessories (battery pills and monitor headset) that are standard on the FP40 are optional with the FP40-D. Since this unit does not have a lid, a separate soft carrying case is available for those who want to carry the unit from place to place.

In 1996, we improved the sound chamber significantly. The new sound box excludes much more ambient noise than the previous model did. It was designed to be taken out of the module and placed on a short pole for use as a speaker for real ear measurements. The speaker is then at a higher elevation than in the previous design and can be swiveled, allowing easy positioning for real ear measurements.

1.3 Features & Options

This section describes many of the different features and options available on the FP40 hearing aid analyzer

1.3.1 Composite/Digital Speech Option

In addition to pure-tone tests, the FP40 can be purchased with the Composite Option, providing real-time measurements of hearing aids. The Composite and Digital Speech signals are complex signals made up on 79 different frequencies presented simultaneously, updating about once a second.

Besides giving instant results, these test signals often provide more realistic test results of hearing aids than you can get using pure-tone sweeps. Aids with automatic gain control (AGC) technology can respond unexpectedly to pure-tone sweeps, providing more amplification in the low frequencies than would occur in a real-life situation. This artifact of pure-tone testing, known as “artificial blooming,” does not occur when a complex signal, such as the composite signal, is used.

Advanced digital hearing aids with “noise suppression” have different difficulties with testing. These aids were designed to lower their gain when in the presence of a continuous sound. Unfortunately, this generally includes conventional test signals such as pure-tone sweeps or the standard composite signal. Digital Speech was developed as a way to test these advanced hearing aids. Digital Speech is very similar to the composite signal except that instead of being a continuous signal, it is an interrupted signal that the aid responds to as it would respond to speech.

Digital Speech comes with two speech weightings: ANSI and ICRA. The ANSI speech weighting is from the ANSI S3.22-1992 standard – it is the same weighting used by the standard Composite signal. The ICRA speech weighing is from a CD of sounds from multiple languages developed by the International Collegium of Rehabilitative Audiology. It rolls off the high frequencies more rapidly than the ANSI weighting.

The use of the Composite or Digital Speech signals can uncover the presence of intermodulation distortion in a hearing aid. Intermodulation distortion is the distortion that results when two or more frequencies are delivered to the hearing aid simultaneously, resulting in the addition of frequencies to the output that were not present in the input. In other words, when you deliver a complex signal to the hearing aid, such as speech, the aid provides unexpected amplification to some of the frequencies, causing the entire signal to sound distorted.

Intermodulation distortion can be detected using the composite or digital speech signals and looking for jagged peaks and valleys in the response curve. The curve "breaks up" more and more as the amount of intermodulation distortion increases.

1.3.2 Probe Option (standard on the FP40-D)

(See Chapter 5 for details.)

The FP40 Hearing Aid Analyzer can be ordered with the Probe Option so that tests can be done on the hearing aid while it is in the client's ear. Probe measurements are also known as "real-ear" measurements. It is then possible to individualize the fitting of a hearing aid since a coupler measurement can seldom tell the operator exactly 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."

The probe microphone can also be used as a reference microphone while making coupler measurements.

Target 2-cc Prescription
The Target 2-cc screen on the FP40 converts real-ear targets to coupler targets. It can be used for ordering hearing aids from a manufacturer, and it can be used for adjusting the hearing aid to target when a real-ear measurement isn't possible. Further refinements of the coupler target are possible using a measured real-ear to coupler difference (RECD) measurement. This is explained in more detail in Chapter 5.

1.3.3 External Video Monitor

In September 1994, the VGA Color Option was introduced on the FP40. This allowed the FP40 to be hooked up to an external video monitor. In 1999, we made this a standard feature. When the VGA display mode is chosen, the LCD is blanked.

When purchasing a VGA monitor for your FP40, it is recommended that you get one with a 0.31 or 0.28mm dot pitch so that you get the resolution needed to take full advantage of the FP40 video resolution.

1.3.4 Battery Pack Option

Some users may find it convenient to operate their unit away from electrical outlets. These users can order the Battery Pack Option which will operate on its rechargeable batteries for up to three hours. (Not available on the FP40-D.)

1.3.5 ID Option

The ID Option personalizes the printout strips with the owner's name and address or phone number. Specify two lines of 27 characters each at time of purchase, and we will program them into your instrument. The ID can be changed for a modest fee with an exchange of PROMs (Programmable Read Only Memory).

1.3.6 RS232 Option

The RS232 Option allows you to hook your analyzer up to a computer so you can grab your analyzer data from your analyzer and save it on your computer. It includes internal FP40 software and external RS232 cables and connectors. In order for you to communicate with your analyzer, you will also need a corresponding program on your computer, such as WinCHAP. It is also possible to create your own custom program for communicating with your FP40.

1.3.7 OES (Occluded Ear Simulator) Option

The OES Option provides special couplers, (the MZ series) and correction factors to produce the same results as a real ear simulator (Zwislocki coupler) when simulating occluded ear measurements in the sound chamber. See Section 3.7 for more details.

1.3.8 CIC (Completely In the Canal) Option

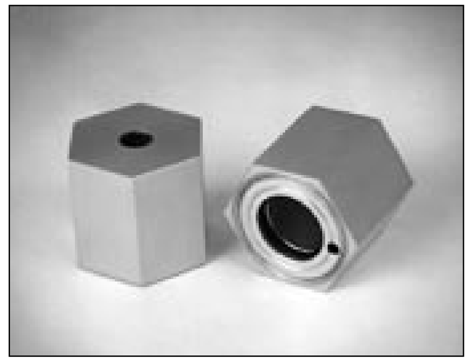
The CIC Option was designed as a realistic coupler test for CIC hearing aids. It uses a 0.4 cc coupler combined with software correction factors in order to create a response curve that is more like what you would expect to see in a person's ear than the response curve you will get using a stan dard HA-1 coupler. See Section 3.6 for more details.

1.4 Accessories

The standard and optional accessories available for the FP40 analyzer are described in this section.

1.4.1 Standard Accessories

Microphone Adapter
14 mm to ANSI 1" diameter microphone size. This is used for calibrating the FP40 microphones.

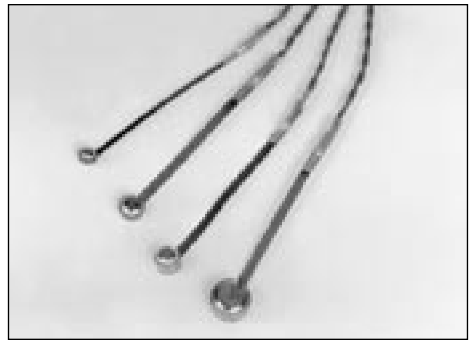


HA-1 2-cc Coupler
Dimensions per requirements of ANSI S3.7 for testing in-the-ear aids.

HA-2 2-cc Coupler
Dimensions per requirements of ANSI S3.7 for testing ear level, eyeglass and body aids.

Ear-Level (BTE) Adapter
Snaps into the 1/4" (6.35 mm) diameter cavity in the HA-2 2-cc coupler or the MZ-2 coupler. 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.

FM40 Microphone
Provided if the Real-Ear Option is not ordered.



Battery Pills
(With 12" [30 cm] cables — 24" [60 cm]) cables available upon request) #13, #675/65, #312, #10A/230. (All pills optional with FP40-D).

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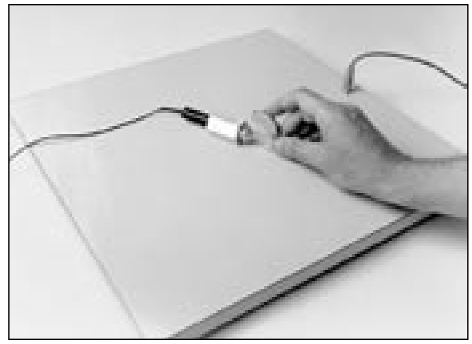
1.4.2 Optional Accessories

6-CC Coupler
Per ANSI S3.7 for NBS 9A—used to check output of audiometers.

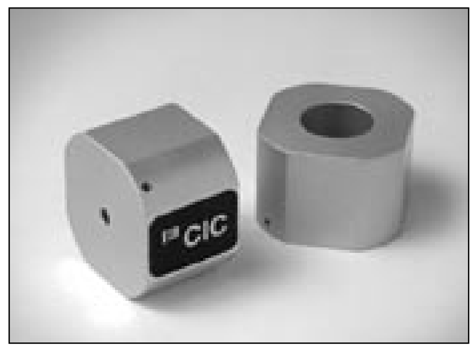
Sound Level Calibrator
For microphone calibration

6040 Sound Chamber
For control of external noises.



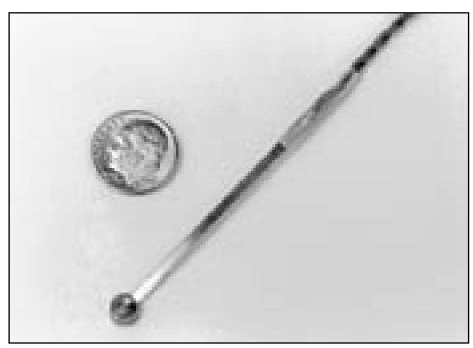
External Telecoil
For checking the response of aids in the “telephone” mode.

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



CIC Coupler
Required coupler for use with CIC Option.

RECD Earphone Package
Consists of one ER3A earphone with a phono plug, a 72 inch cable, an assortment of ear tips, a calibration certificate, and a lapel clip. This package is suitable for performing an RECD measurement with the FP40 analyzer.



#5 Battery Pill
12" or 24"
Needed for some CIC hearing aids.

Child Size Wedge Style Earhook
Holds probe and reference microphones during real ear testing.

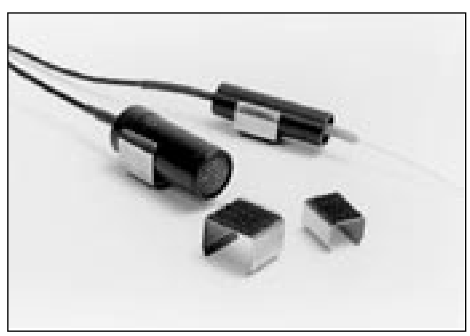
Telewand
For checking the telecoil response per ANSI-S3.22-1996

Other Optional Accessories

- RS232 Option—RS232 cable
- Probe Extension Cable for 6040 & FP40 w/o Probe
- 6040 Sound Chamber Cable
- External Printer Package: serial-to-parallel converter, printer cable and custom cable
- Y adapter for using both external printer and RS232
- Eartips for insert earphones:
  - Eartips, 3A medium, 50/pk
  - Eartips, 3B small, 50/pk
  - Eartips, 3C large, 25/pk
- Battery Pills, #AA, #41 (with 12" cables. 24" cables available upon request)
- Maintenance Manual (on request at time of purchase

1.4.3 Real-Ear Accessories

M200 Probe Microphone



Mounting Sleeves
(L) for reference mic
(R) for probe mic

Wedge Style Ear Hook
Standard size
Holds probe and reference microphones during real ear testing. Improved design eliminates need for Velcro headband.

Optional Swing Arm, Speaker, and Cable
Allows precise placement and aiming of the loudspeaker.

Monitor Headset, folding
(Optional with FP40-D)

Infant/Child Headband Package
Includes infant, child, and adult headbands, six flexible earhooks, and two sets of "animal ears."

Other Real Ear Accessories

Set of 25 Probe Tubes
Ear hook, standard size
Ear Hook, children's size
Velcro Headband
Calibration Clip
Felt Pen-dry erase
Probe Calibration Adapter

1.5 Layout & Controls

This section gives a short explanation of the layout of the FP40 analyzer, its controls, and its functions

1.5.1 LCD (Liquid Crystal Display)

The FP40 is equipped with an LCD screen that displays test results and operational instructions in both alphanumeric and graphical formats. This display is mounted on a swing-up door that can be adjusted for optimum viewing by the operator.

Hint: If no display appears on the LCD screen, turn the contrast knob in the upper right corner, or press any key.

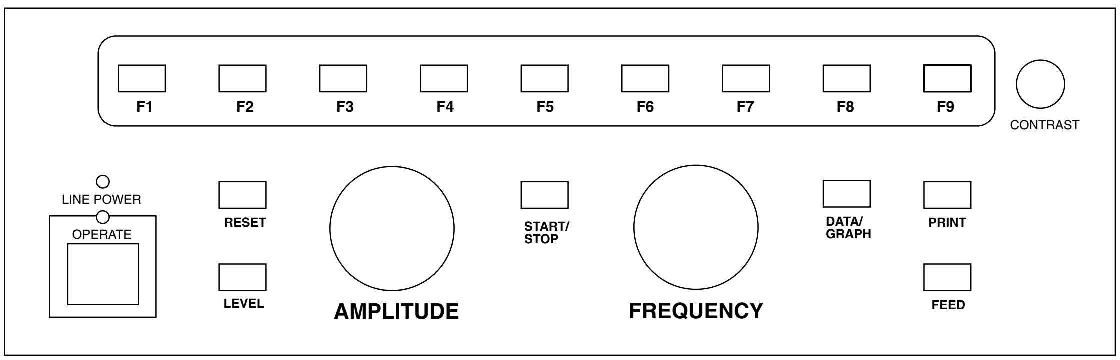


Figure 1.5.1A—FP40 Front Panel Function Buttons

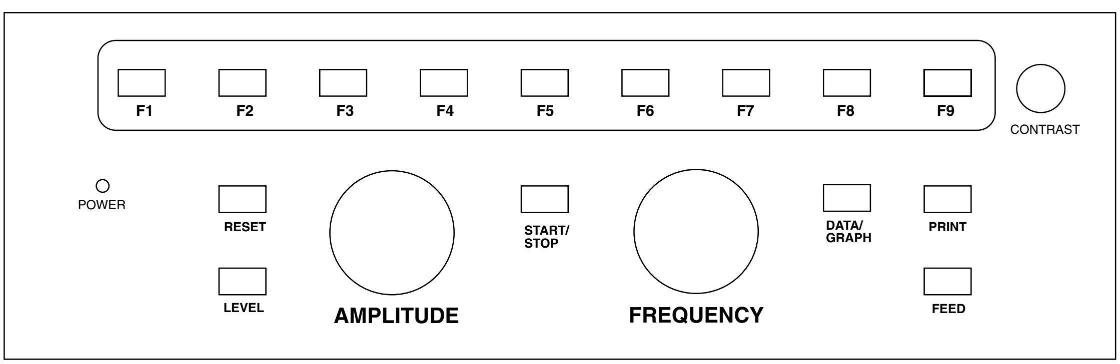


Figure 1.5.1B—FP40-D Front Panel Function Buttons

1.5.2 Front Panel Buttons

There are nine function key buttons in the top row of the FP40 front panel. The function of each of these keys changes as you move from screen to screen on the FP40.

The rest of the front panel buttons have specific functions that do not change with each new menu selection.

Feed Feeds the paper through the printer.

Print Produces a hard copy of the data and graphs displayed on the LCD screen or monitor screen.

Data/Graph Allows the screen presentation to be switched from graph to data table and back again.

Start/Stop Starts or continues or stops a measurement action, depending on the particular measurement task. When the instrument is running a continuous measurement, this button starts or freezes the measurement on the display. START/STOP is also used to activate a menu selection.

FP40s manufactured prior to 8/22/90 are marked START/CONTINUE.

Level Along with START/STOP button, initiates a leveling action that takes a response measurement and develops a set of frequency response corrections to adjust the signal so that it is at the correct level for each test frequency.

Reset Resets the test signal to the amplitude and frequency you have chosen in the SETUP MENU and interrupts current operation.

Operate Starts and terminates the measurement operation of the FP40. Use operate to turn the instrument on and off. (There is no operate button on the FP40-D.)

1.5.3 Front Panel Lamps

Line Power Signals that the FP40 is connected to the power line, and that the main rear panel-mounted power switch is switched “on.” If the Battery Option is installed, this lamp may also indicate that the battery is being charged.

Operate When lighted, signals that the instrument is active. (Not on the FP40-D).

1.5.4 Front Panel Knobs

Amplitude Controls the amplitude or loudness of the test signal. Is also used to move the cursor up and down in making menu selections.

Frequency Controls the frequency of the test signal in pure-tone mode. Is also used to move the cursor left and right when making menu selections. In the real-ear target screen, it selects the amplitude in the audiogram tables.

Contrast Control Controls the contrast of LCD display. If no display appears, check this control first.

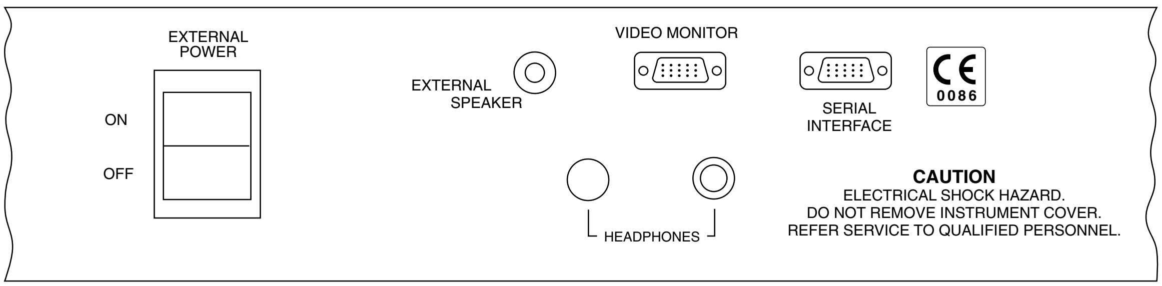


Figure 1.5.5—Rear Panel

1.5.5 Rear Panel Controls

External Speaker A miniature phone jack that allows an external sound field speaker or sound box (FONIX 6040) to be connected to the speaker drive from the FP40.

Headphones A standard 1/4 inch phone jack and volume control that allows the monitoring of the sound reaching the probe microphone.

Serial Interface Nine pin D jack for RS232 connection and laser printer connection.

CE Mark This symbol indicates that Frye Eelctronics conforms to the Medical Device Directive 93/42/EEC. If an external monitor or printer is used, it should also have a CE mark in order for the FP40 to remain compliant.

Video Monitor Units with serial numbers 940000 and above have VGA connectors. Older units have RCA jacks for composite monitors.

External Power Main power input switch. (On the portable version, operate button on front panel must also be pushed to activate the instrument.)

1.5.6 Right Side Mounted Jack and Module

Line input connector, IEC computer variety.
Dual “snap in” fuse holder.
Instrument will automatically choose the proper voltage.

1.5.7 Sound Chamber Mounted Jacks and Controls

Jacks Battery replacement pill jack. Microphone jack.

Controls Gain controls for microphones.
Found on the left side of the sound chamber, near te speaker.
Marked: Probe Gain and Ref. Gain.

1.5.8 Top of Instrument, Printer

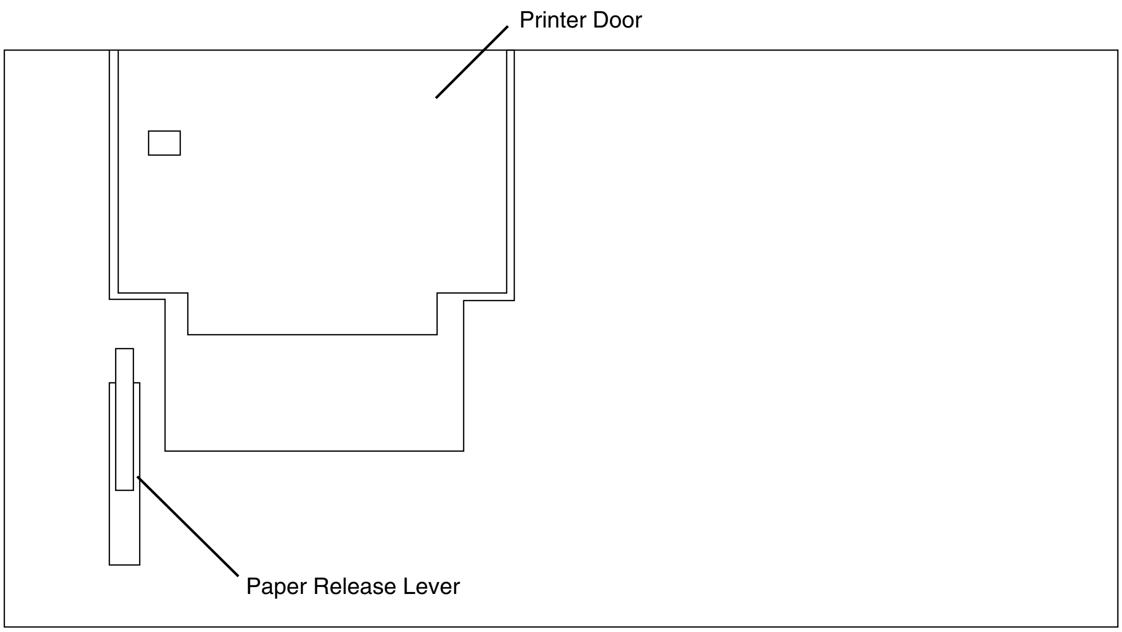


Figure 1.5.8—Electronics Module Top View

1.6 FP40 Setup

This section describes how to set up the FP40 analyzer and prepare it for testing.

1.6.1 Setting up the instrument

Unpack and locate all accessories (in the lid/FP40; in the boxes/FP40-D). Save the shipping box in case you need to send the unit in to us for repair or major upgrades. Choose a location for the FP40 which is relatively free of ambient sounds and vibrations. See Figure 1.5.5 for a drawing of the rear panel

1.6.2 Connecting equipment

If you want to connect an external printer, you must have the External Printer Kit. This kit consists of a special serial-to-parallel converter, a printer cable, a couple connectors, and an RJ11 cable. See Figure 1.6.2.

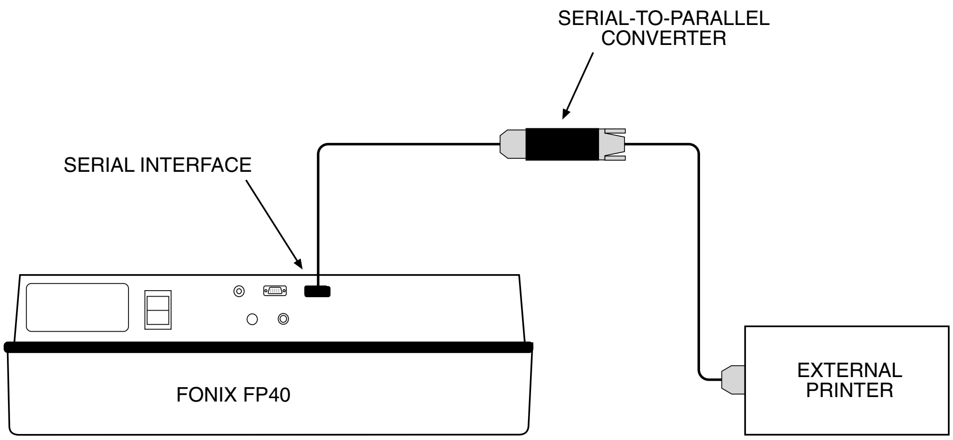


Figure 1.6.2—External printer setup

1. Make sure the FP40 is turned off.
2. Attach the connector labeled “FP40 Printer” to the serial interface connector on the back of the FP40.
3. Attach the RJ11 cable to the FP40 printer connector
4. Attach the connector labeled “Printer” to the other end of the RJ11 cable.
5. Attach the printer connector to the “RS232” side of the serial-to-parallel converter.
6. Attach the printer cable to the “Parallel” side of the serial-to-parallel converter.
7. Attach the other end of the printer cable to your external printer.

If desired, plug in an external video monitor to the connector labeled "Video Monitor" on the back of the FP40.

You can also plug in an external sound chamber or an external sound field speaker into the "external speaker" jack of the FP40.

Hint: When something is plugged into the external speaker jack, the sound source of the FP40 is always delivered to that external source, regardless of whether you are performing a coupler test or a real-ear test.

1.6.3 Connecting the line cord

Plug the line cord into the jack on the right side of the analyzer. Push the on-off rocker switch on the back of the unit. The green LED labeled "line power" (FP40) or "power" (FP40-D) will light up. This will turn on the analyzer if you have an FP40-D model. To fully turn on an FP40 model analyzer, push the square gray button marked OPERATE on the front panel.

1.7 Miscellaneous

This section describes how to clean and service your FP40 analyzer. Warranty information is also included.

1.7.1 Servicing Your FP40

Contact Frye Electronics, Inc., Box 23391, Tigard, Oregon 97281-3391 for service. Our toll-free number is 1-800-547-8209. Our regular number is (503) 620-2722, or you may contact your local Frye representative. We are also available on the internet. Our e-mail address is: service@frye.com, and our web site is http://www.frye.com.

Units may be returned to Frye Electronics, Inc., 9826 S.W. Tigard St., Tigard, Oregon 97223. It is advisable to contact the company or your local Frye representative first, since many problems can be fixed without returning the whole unit. Printed circuit boards, for instance, may be exchanged. If something must be returned, an RMA number will be issued.

When contacting the factory, please have the serial number of your instrument on hand. (Found on the rear panel of the instrument.) It will also be helpful for you to be able to tell us the software version installed on your machine. The software version and date of release are found on the LCD when you turn the unit on (FP40-D) or press OPERATE (FP40).

1.7.2 Cleaning the FP40 Display

Cleaning of the FP40 LCD screen should be kept to a minimum to avoid scratching the surface. To clean the LCD, first blow off any loose dust. Then wipe gently with a soft cloth moistened with glass cleaner. The surface of the LCD is waxed to minimize scratching.

1.7.3 Emergency Shutdown

If you find it impossible to turn off the instrument using the OPERATE button in units with a Battery Option, hold OPERATE down and then tap RESET twice. Or you can simply hold the OPERATE button down for five seconds.

1.7.4 Warranty

The FONIX FP40/FP40-D 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.

Battery pills are warranted for thirty days because they are necessarily fragile and can be damaged by careless handling.

This chapter discusses the general operation of the FP40 analyzer. You will learn how to navigate through the different screens, use the General Setup Menu, and change the function keys to suit your purposes. Other general operational topics will also be discussed such as source types, battery pills, printers, and other topics.

2.1 Screen Navigation

You move through the different screens of the FP40 by using the function keys. The function keys are the top row of buttons of the FP40 front panel labeled F1 through F9. Each button is labeled on the display screen just above the function keys.

For example, in most screens, F1 is labeled "MENU." This means that you get to the Menu by pressing F1.

Hint: Whenever a function key is labeled with large letters, it is a navigational key. That is, pressing it will take you to a different screen.

2.2 General Setup Menu

In the General Setup Menu, you can change most of the settings on the FP40. To enter the General Setup Menu, press F1 from almost any screen.

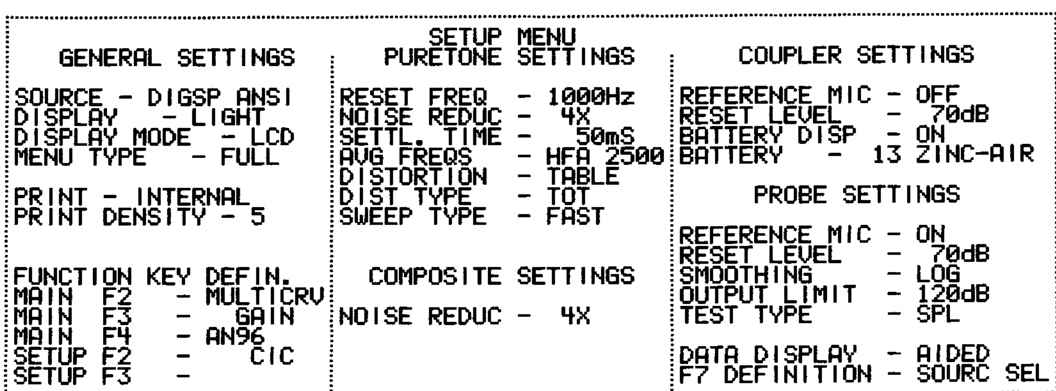


Figure 2.2—General Setup Menu

2.2.1 Making selections

Notice the three columns in the General Setup Menu. Move the selection indicator (lines above and below the selection) from one column to another using the FREQUENCY knob. Move the knob slowly. You will feel each position change. Move the selection indicator up and down within the columns with the AMPLITUDE knob.

Push the START/STOP button, found in the very center of the front panel, to switch between the available choices at the indicated position.

2.2.2 Saving changes

Unless you purposely make setup changes permanent, they will only be effective until you turn off the analyzer. When the analyzer is turned on again, it will revert to default settings. However, you can change the default settings to suit your own needs.

- To change the default setting of an individual item, highlight the item in the General Setup Menu, change it to the desired setting, and press F8. This will store the individual item setting.
- To set the default settings of the entire menu at once, make any desired changes in the General Setup Menu, and press F9. This will store the entire menu.

2.2.3 Switching between partial and full menus

Not all the items in the General Setup Menu will apply to every screen of the FP40. In order to avoid information overload, the FP40 has a "Partial Menu" mode.

If the FP40 is in PARTIAL Menu mode, it will only display the items of interest to the screen you just left. For instance, if you enter the General Setup Menu from the Main Coupler Screen, the partial menu will not display Probe Settings. Also, if you have selected a composite signal source, it will not display the pure-tone settings.

When the FP40 is in FULL Menu mode, it will display all available settings, regardless of the screen that you just left or the signal source you have chosen.

To switch between Partial Menu mode and Full Menu mode, select MENU TYPE in the General Setup Menu. Choose between FULL and PARTIAL.

2.3 Using Function Keys

The front panel of the FP40 analyzer contains nine function keys, F1 through F9. These keys control the navigation through the FP40 screens as well as some settings in each screen.

2.3.1 Hints

The first thing you need to understand when working with the FP40 is the concept of "function keys." In order to make it easier to add new functions and screens to the FP40, we made the function of keys F1 through F9 vary, depending upon the current screen and your current settings. Here are three simple things to remember about function keys:

- The function of the keys vary, depending upon the current screen
- The labels above the keys always indicate the function of that key. They are never labels for the current screen.
- Small labels indicate the function key toggles a setting. Large labels indicate the function key will take you to a different screen.

These three points are explained in more detail below.

Varying Function Keys
The function of the keys vary, depending upon the current screen. There are nine function keys used on the FP40 to toggle common settings and switch between screens. We've tried to make the function of each key be as consistent as possible when you switch from screen to screen.

For example,

- F1 is generally the "MENU" key. Pressing it will usually take you to the General Setup Menu.
- F4 in the Main Coupler Screen will take you to an automated test sequence such as ANSI. F4 in the ANSI Screen will exit you back to the Main Coupler Screen.

The function of each key for each screen is clearly labeled above the function key on the display.

Function Key Labels are NOT Screen Labels
As mentioned above, the function of each key is labeled on the display above the key. This label always denotes the function of the key. Function key labels are never labels for the current screen.

Sometimes it's easy to see "PROBE" above F5 and think that you are in the probe screen. Remember that the label above F5 actually means that you need to press F5 in order to enter the Probe Screen. The actual labels for the screens can usually be found in the top center of the screen.

Small Labels vs. Big Labels
There are two main types of function keys: setting keys that change a common setting in the current screen, and directional keys that take you to a different screen. In order to easily differentiate between the two types of keys, we generally use small letters to denote a setting key and large letters to denote a directional key. There are a couple of exceptions to this rule, but not many. Here's an example from the Main Coupler Screen:

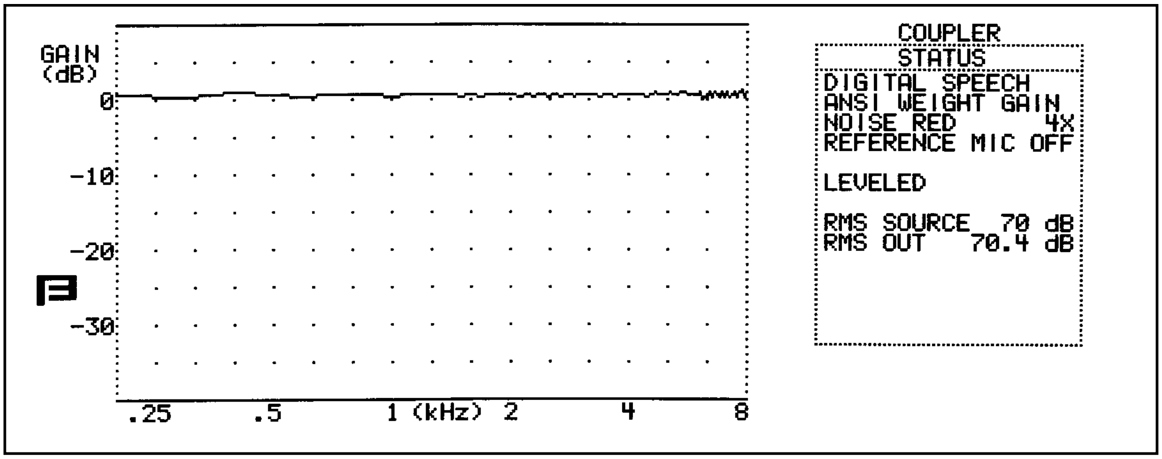


Figure 2.3.1—The Main Coupler Screen

Notice that F1, F4, and F5 are written in large letters. They take you to the Menu, ANSI 96, and Probe Screens, respectively. F2, F3, F6, F7, and F9 are all settings that pertain to the current Main Coupler Screen.

2.3.2 Customizing the function keys

As described in Section 2.3.1, the functions of F1 through F9 will vary, depending upon the current screen. Most of the time, the functions of these keys in each screen are set at the factory and cannot be changed. However, the FP40 does allow you to customize the function of several keys. This allows you to change the FP40 screen to fit your testing needs. Most of these are set in the FUNCTION KEY DEFIN section of the General Setup Menu.

MAIN F2 & MAIN F3: These settings change the function of F2 and F3 in the Main Coupler Screen. Usually, you can select from AVG, GAIN, MULTICURVE, and TELECOIL. (These options are explained in Chapter 3.) The available settings are dependent upon the options on your FP40, so you may have some additional functions available.

MAIN F4: This setting changes the automated coupler test sequence available from the Main Coupler Screen. Depending upon the options you purchased with your FP40, you may have only one choice for this key, or you may have multiple choices. See Chapter 4 for more information on automated test sequences.

SETUP F2 & SETUP F3: These selections allow you to customize the function of F2 and F3 in the General Setup Menu. This allows you to adjust functions used in the Main Coupler Screen that you might not need to change often.

For instance, if you always want to have Multi-Curve turned on in the Main Coupler Screen, you can have it set to ON in the General Setup Menu, freeing up either F2 or F3 in the Main Coupler Screen for a more commonly changed function, such as CIC.

Note: If you toggle a function with SETUP F2 or SETUP F3, that function will remain in that setting until you explicitly change it back or turn off the analyzer. For example, if you were to: 1) Choose MULTICURVE for SETUP F2, 2) Turn MULTICURVE ON using the F2 button in the General Setup Menu, 3) Choose CIC for SETUP F2, then Multi-Curve would remain ON in the Main Coupler Screen even though it would no longer be the selection for SETUP F2.

F7 DEFINITION: This selection is in a different section in the General Setup Menu than the previously described selections. This is because MAIN F2-F4 and SETUP F2-F3 all affect the Main Coupler Screen. F7 DEFINITION, located in the PROBE SETTINGS section of the General Setup Menu, affects the F7 key in the Main Probe Screen. A setting of SOURC SEL will make F7 in the Main Probe Screen toggle between the different source types available on your FP40. This is handy when you're doing a real-ear test, and you need to be able to quickly switch your source type. For example, you may want to switch between a composite signal and a digital speech signal. A setting of SNGL TONE allows you to present a single pure-tone signal to the aid (instead of running an entire pure-tone sweep).

2.4 Source Types

There are two main types of sources available on the FP40 analyzer: pure-tone and composite. Three kinds of pure-tone sweeps come standard with the FP40: normal, fast, and short. When you purchase the Composite Option, you will receive the Composite, Digital Speech ANSI, and Digital Speech ICRA signals.

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

2.4.1 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 three types of pure-tone signals: normal, fast, and short.

- 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 signal.
- SHORT: Contains 10 different frequencies and only does one sweep. It is primarily used for testing loud levels in real-ear measurements.

2.4.1.1 Pure-tone settings

There are several different settings available in the General Setup Menu for pure-tone signals. Here is an explanation of those settings.

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

NOISE REDUC: The amount of noise reduction used in pure-tone measurements. See Section 2.4.1.2.

SETTL. TIME: The amount of time each tone is presented before the measurement is made. See Section 2.4.1.3.

AVG FREQS: The frequencies used with the AVG function that averages the responses of three different frequencies. 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 Aids)	- 800, 1250, 2000
SPA	- 1250, 2000, 3150
“ “	- 1600, 2500, 4000
“ “	- 2000, 3150, 5000
IEC– (HAIC)	- 500, 1000, 2000

DISTORTION: The type of harmonic distortion display.

DIST TYPE: Type of harmonic distortion tested. See Section 2.4.1.4.

SWEEP TYPE: Type of pure-tone sweep used in measurements. Choose NORMAL, FAST, or SHORT.

2.4.1.2 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. You can select the amount of measurements and averaging in the General Setup Menu, in the PURETONE SETTINGS section, under NOISE REDUC.

Larger noise reduction numbers lead to smoother curves but increase the amount of time it takes to complete a pure-tone sweep.

2.4.1.3 Settling Time

When you are measuring with pure-tone sweeps, you are offered a choice of settling times. By this we mean that the tone source will be continued for a chosen amount of time before the measurement is made. 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 the 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 mS is usually fine. Other aids are quite variable.

2.4.1.4 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 FP40 analyzer, you can test the amount of distortion available in the second harmonics, the third harmonics, or both harmonics (considered “total harmonic distortion”). This is selectable in the General Setup Menu.

2.4.2 Understanding Composite signals

There are three types of composite signals: Composite, Digital Speech ANSI, Digital Speech ICRA. The Composite signal is a continuous broadband signal containing 79 different frequencies presented simultaneously. This makes it much faster than a pure-tone because there is no waiting for a progression of tones to complete – instead, you get the entire frequency response instantly, updating about twice a second.

The digital speech signals are interrupted versions of the Composite signal that are 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.

The Digital Speech signals were developed as a way to test these high end hearing aids. Instead of presenting a continuous signal, they present an interrupted signal that the aid regards as speech instead of noise. There are two varieties: Digital Speech ANSI and Digital Speech ICRA.

2.4.2.1 ICRA vs. ANSI

There are two types of Digital Speech signals: Digital Speech ICRA and Digital Speech ANSI. Both are interrupted composite signals for testing digital hearing aids. They differ in the speech spectrum they use.

Digital Speech ANSI uses the same speech spectrum as the Composite signal. This speech spectrum, taken from the ANSI S3.42 standard, rolls off the high frequencies starting with 3 dB down at 900 Hz and continuing at a rate of 9 dB per octave. Digital Speech ICRA 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 2.4.2.1 shows a comparison of the spectra.

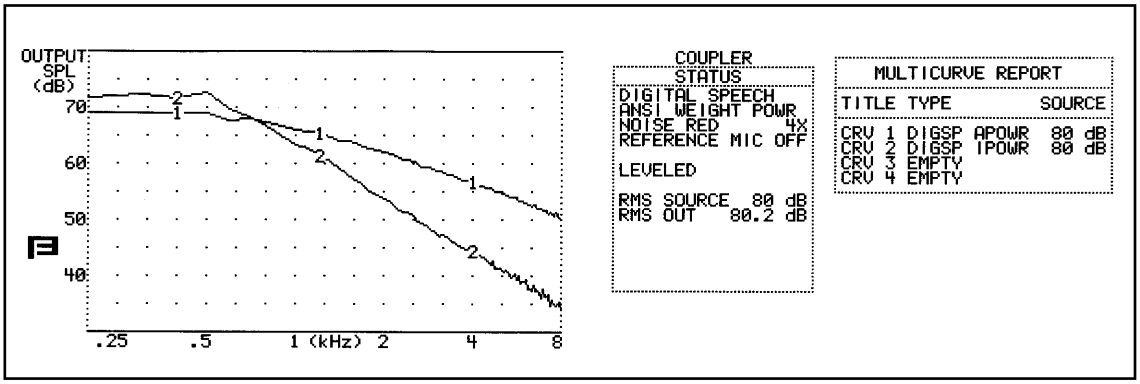


Figure 2.4.2.1—Comparison of Digital Speech ICRA (CRV 1) and Digital Speech ANSI (CRV 2)

2.4.2.2 Noise Reduction

There is only one setting for the composite signals in the General Setup Menu: NOISE RED. Composite noise reduction is a little different than pure-tone noise reduction, even though both are used for noisy testing environments.

When a composite signal is running, the analyzer takes several different measurements a second 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.

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

2.4.2.3 Intermodulation Distortion

The composite signals are helpful for identifying intermodulation (IM) distortion. 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 2.4.2.3 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.

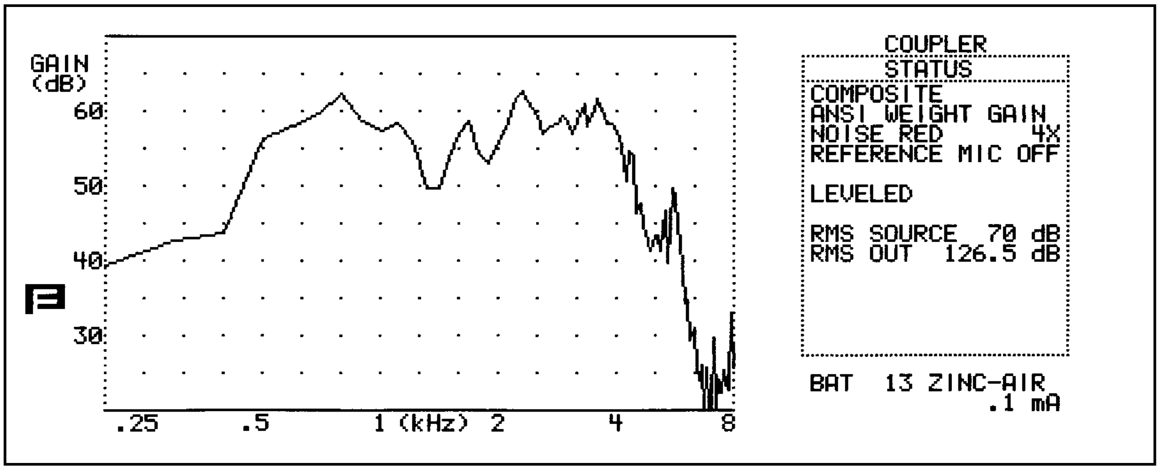


Figure 2.4.2.3—IM distortion

2.4.2.4 Composite source levels

When you adjust the amplitude of a composite signal, you are adjusting the root-mean-square (RMS) of the signal, not the amplitude of the individual frequency components. None of the amplitudes individual frequency components will be as high as the amplitude of the overall signal.

This is particularly noticeable when you view the test signal in dB SPL because this allows you to see the actual power of each frequency component. See Figure 2.4.2.4 as an example of this phenomenon. In this figure, the displayed curve has a 70 dB SPL RMS amplitude. Notice that the level at each frequency varies from –10 dB to –30 dB from the overall amplitude.

The amplitude differences in the individual components of the composite signal will be reflected in the frequency response of a hearing aid. Keep this in mind when viewing results in dB SPL.

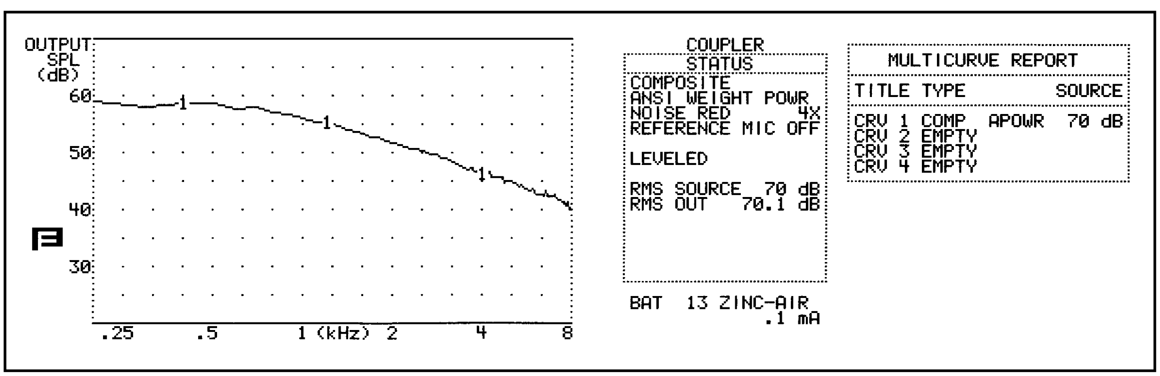


Figure 2.4.2.4—Composite signal with an amplitude of 70 dB SPL RMS

2.5 Display Mode

Although the FP40 comes standard with an LCD screen, it is easy to hook up an external monitor for a larger, more colorful display.

To attach the video monitor:

Hook a standard computer monitor to the port labeled "Video Monitor" on the back of the FP40 analyzer.

To view with the video monitor:

- Press F5 from the Opening Screen of the FP40 analyzer. This is the screen that appears only when you first turn on the analyzer.

  — or —

- Highlight DISPLAY MODE in the General Setup Menu by using the Amplitude and Frequency knobs. Select VGA by pressing the START/STOP button. You can also use this selection to switch back to LCD mode.

2.6 Battery Current Drain

You can measure the battery current drain of hearing aids in the Main Coupler Screen and in any of the screens of the automated test sequences (such as ANSI '96). To do this, you must insert the appropriate battery pill into the hearing aid, and plug the battery pill into the jack located on the left side of the internal sound chamber. See Figure 2.6A.

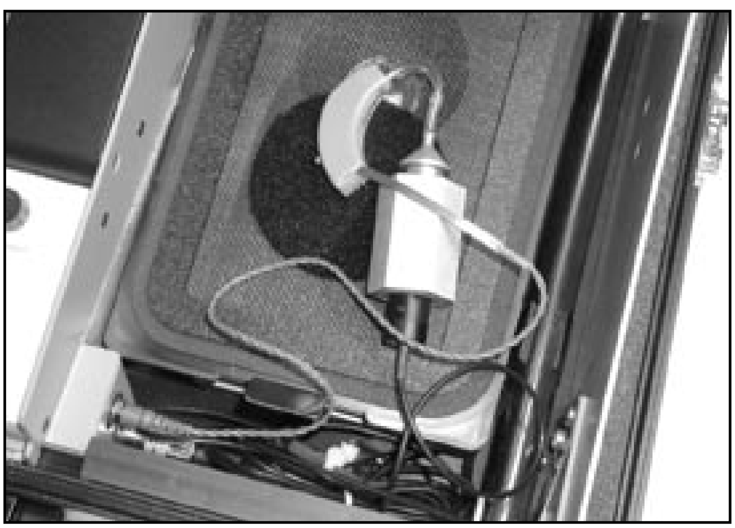


Figure 2.6A—Using a battery pill to measure the battery current drain

To turn on the battery current drain measurement in the Main Coupler Screen:

1. Press F1, MENU, from the Main Coupler Screen.
2. Select BATTERY DISP in the third column of the screen, under COUPLER SETTINGS.
3. Press START/STOP to toggle ON.
4. Press F1 to exit back to the Main Coupler Screen. You should now see a battery current reading under the Status Box. See Figure 2.6B.
5. Press F7 to select the battery pill that you are using.

To set the default battery pill:

1. Press F1, MENU, from the Main Coupler Screen.
2. Select BATTERY in the third column on the screen, under COUPLER SETTINGS.
3. Press START/STOP to toggle the desired selection.
4. Press F8 to store that selection as the default.

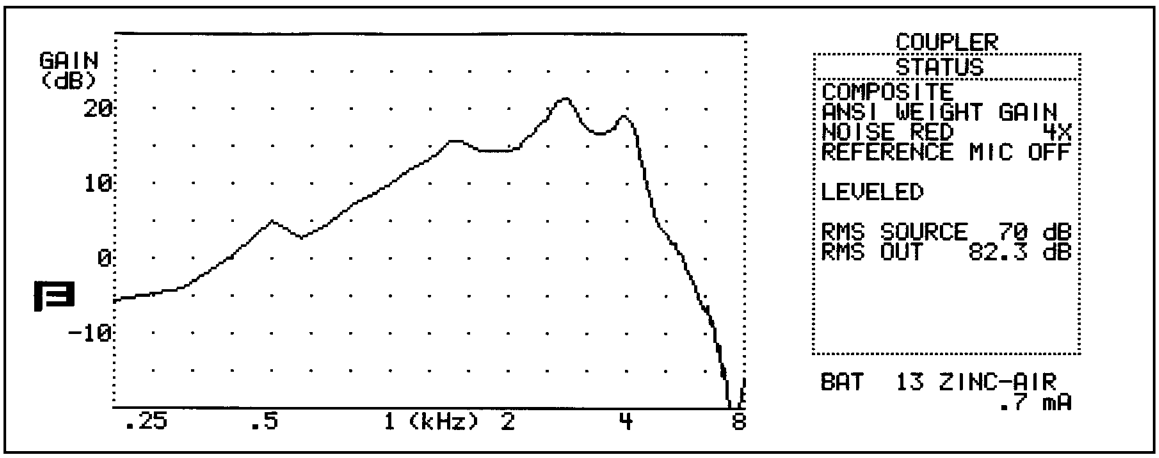


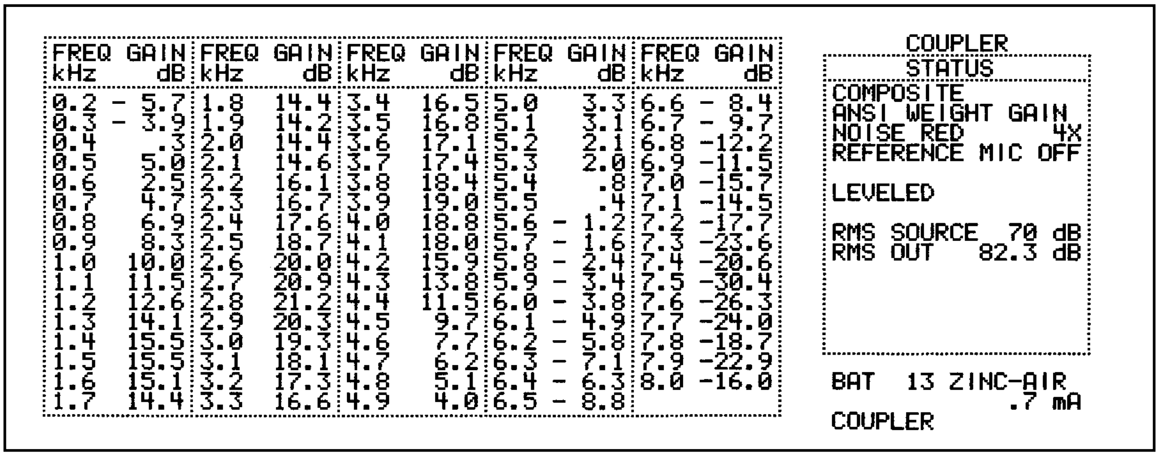
Figure 2.6B—Coupler screen with battery drain

Note: You must use a pure-tone or composite source for the battery current drain to function. It will not work with the Digital Speech source types.

2.7 Using the DATA button

Although it's usually more useful to display test results in the familiar graph format, it can often be useful to look at the actual numerical data. You can do this in the Main Coupler Screen or in the real-ear measurement screens.

To switch back and forth between graphical and numerical data format, press the DATA/GRAPH button on the FP40 main panel. See Figure 2.7.



FREQ kHz	GAIN dB	FREQ kHz	GAIN dB	FREQ kHz	GAIN dB	FREQ kHz	GAIN dB	FREQ kHz	GAIN dB
0.2	- 5.7	1.8	14.4	3.4	16.5	5.0	3.3	6.6	- 8.4
0.3	- 3.9	1.9	14.2	3.5	16.8	5.1	3.1	6.7	- 9.7
0.4	.3	2.0	14.4	3.6	17.1	5.2	2.1	6.8	-12.2
0.5	5.0	2.1	14.6	3.7	17.4	5.3	2.0	6.9	-11.5
0.6	2.5	2.2	16.1	3.8	18.4	5.4	.8	7.0	-15.7
0.7	4.7	2.3	16.7	3.9	19.0	5.5	.4	7.1	-14.5
0.8	6.9	2.4	17.6	4.0	18.8	5.6	- 1.2	7.2	-17.7
0.9	8.3	2.5	18.7	4.1	18.0	5.7	- 1.6	7.3	-23.6
1.0	10.0	2.6	20.0	4.2	15.9	5.8	- 2.4	7.4	-20.6
1.1	11.5	2.7	20.9	4.3	13.8	5.9	- 3.4	7.5	-30.4
1.2	12.6	2.8	21.2	4.4	11.5	6.0	- 3.8	7.6	-26.3
1.3	14.1	2.9	20.3	4.5	9.7	6.1	- 4.9	7.7	-24.0
1.4	15.5	3.0	19.3	4.6	7.7	6.2	- 5.8	7.8	-18.7
1.5	15.5	3.1	18.1	4.7	6.2	6.3	- 7.1	7.9	-22.9
1.6	15.1	3.2	17.3	4.8	5.1	6.4	- 6.3	8.0	-16.0
1.7	14.4	3.3	16.6	4.9	4.0	6.5	- 8.8		

COUPLER
STATUS
COMPOSITE
ANSI WEIGHT GAIN
NOISE RED 4X
REFERENCE MIC OFF
LEVELED
RMS SOURCE 70 dB
RMS OUT 82.3 dB
BAT 13 ZINC-AIR
.7 mA
COUPLER

Figure 2.7—DATA coupler screen

Notes:

- Only one measurement curve can be displayed in numerical format at a time. When working with multiple measurement curves, select the curve you want to view with F6 in the Main Coupler Screen and F3 in a real-ear measurement screen.
- The DATA/GRAPH button only works in the Main Coupler Screen and the real-ear measurement screens. You can't use it to view numerical data in an automated test sequence screen.

2.8 External Sound Chamber or Speaker

If you are in a noisy testing environment, it might be useful to have an external sound chamber. The 6040 sound chamber has better sound isolation than the standard internal sound chamber of the FP40. It also has a larger work space in the chamber, which makes it easier to take aids in and out of the chamber.

When performing real-ear measurements, it's often more convenient to have an external speaker on a swing arm or a floor stand so you can move the speaker around the patient, rather than the patient around the speaker. This makes external speakers convenient for clinicians who don't move their analyzers around often.

To use an external sound chamber or an external speaker, plug it into the jack labeled "external speaker" on the back of the FP40.

Hint: Whenever you have an external sound source plugged into the external speaker jack on the FP40 analyzer, all sound from the analyzer goes to the external sound source, no matter what operational screen you are viewing. To avoid confusion, unplug the external sound source when it's not in use.

2.9 Printing

You can print the screen display either by using the internal thermal printer, or by using the External Printer Kit to connect an external printer. In either case, printing performs a screen dump of the current screen on your display. (Help messages and function key labels will not print.)

Here are some general instructions:

- Press PRINT to start printing. Press PRINT again to stop printing.
- Press FEED to feed the paper.

2.9.1 Selecting the printer

1. Press F1 from almost any screen to enter the General Setup Menu.
2. Select PRINT in the GENERAL SETTINGS column using the frequency and amplitude knobs.
3. Press START/STOP to cycle through your choices. They are:
    - INTERNAL for the thermal printer,
    - HPCL MONO for an external black and white HP-style printer,
    - HPCD COLOR for an external color HP-style printer,
    - EPSON 9 MONO for an external black and white Epson printer,
    - EPSON 9 COLOR for an external color Epson printer.
4. Press F1 to exit from the General Setup Menu.

2.9.2 Using the thermal printer

To use the thermal printer, just follow the directions found in Section 2.8.1 to make sure that INTERNAL is selected for PRINT in the General Setup Menu, and push the PRINT button.

Possible errors:

- If the printer is out of paper, it won't function, and you will see the message "PLEASE INSTALL NEW ROLL OF PAPER IN THE PRINTER" on the bottom of your screen.

- If the print head is up, you will see the message PLEASE PUSH LEVER NEXT TO THE PRINTER. To correct this, push the black lever to the left of the thermal printer.

To change the paper:

1. Remove the printer door by pushing the small black knob on the printer door to the right.
2. Remove the paper roller.
3. Place the new paper roll on the roller and insert it into the paper slot. Refer to the drawing on the inside of the printer door.
4. Pull the black lever to the left of the printer to raise the print head.
5. Thread the paper through the printer.
6. Push the black lever to the left of the printer to lower the print head again.
7. Press FEED and PRINT to test the operation.
8. Replace the printer door.

To change the print density:

The print density controls the darkness of the printout. There are five degrees of darkness with 0 being the lightest and 5 being the darkest. (It is not adjustable on the FP40-D analyzer.)

Select the PRINT DENSITY in the General Setup Menu.

To save printouts:

Although the paper we use with the FP40 is a good quality thermal paper, any thermal printing can eventually fade over time. To minimize fading, store away from the light in a cool, dry place. Do not store the strips in plastic or put cellophane tape on them, and avoid fingerprints.

If you want to be absolutely certain that you will have the data for many years, use a regular copier to duplicate the printed results.

2.9.3 Using an external printer

Follow the directions found in Section 1.6.2 for instructions on hooking up an external printer.

Note: When you use an external printer and an external monitor, it will print in the format shown on the video monitor. If you use an external printer and the FP40's LCD display, it will print in the format shown on the LCD display.

Will your printer work?

Some external printers, both black & white and color, may be used with the FP40 and FP40-D. Both Epson nine-pin dot-matrix printers, and HP printers which support HP PCL (Hewlett Packard Printer Computer Language) version 3.0 or higher are compatible. To use these printers, you must purchase the External Printer Package from Frye Electronics containing a custom cable (PN 119-0312-00), a series-to-parallel converter, and a printer cable.

The FP40 will work with all new HP LaserJet printers, and with many Deskjet printers (check language specifications in the printer manual). Also, the Epson FX-870, FX-880, and FX-1170 printers are compatible. If the printer uses PPA (Printer Performance Architecture) it will be incompatible with FONIX instruments. Examples are the Deskjet printers from the 720, 820, and 1000 series. A list of compatible printers is maintained on our web site, www.frye.com, under the “Support” menu.

Some notes on using an external printer

- Although the FP40 has only one serial port, it is possible to have both the external printer and a computer hooked up at the same time to the analyzer. You will need a special Y adapter. It is not possible to use the computer to control the FP40 while printing.
- You can change the SPEED of the connection between the FP40 and the external printer in the General Setup Menu. Choose 9600, 19200, 38400, or 57600 baud.

2.9.4 Printing a label

If a label is desired to identify the measurements taken, you can toggle the creation of a label with all printouts by pressing the F9 buton in most screens. Here is a sample label:

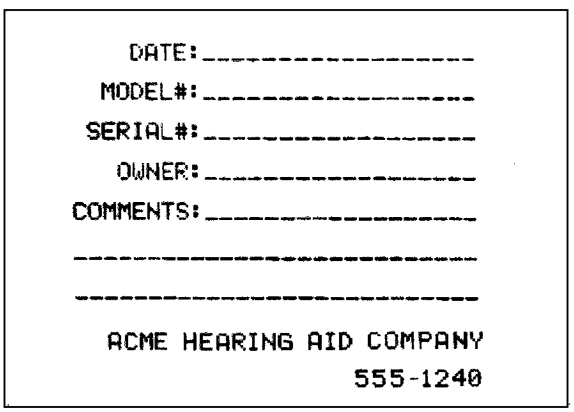

DATE:__________________
MODEL#:__________________
SERIAL#:__________________
OWNER:__________________
COMMENTS:__________________
____
____
ACME HEARING AID COMPANY
555-1240

Figure 2.9.4—Label

2.10 The Opening Screen

The Opening Screen of the FP40 (Figure 2.10) contains some useful information including:

- Software version of your analyzer,
- Option code of your analyzer,
- RS232 availability,
- Frye Electronics contact information.

In the Opening Screen, you can turn on and off the screensaver, and switch from LCD to VGA display mode. The screensaver turns off the LCD backlighting if the unit hasn't been used in 15 minutes. You can deactivate it by pressing any key.

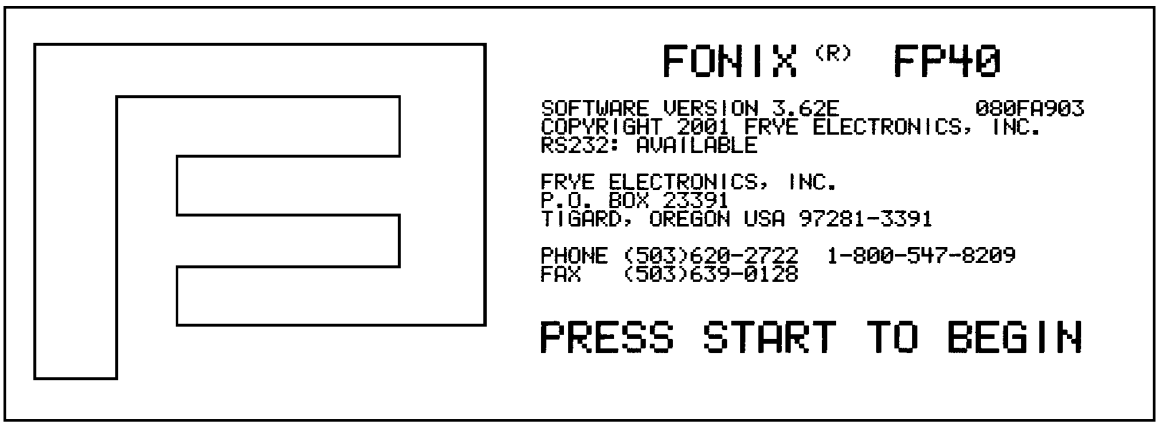


Figure 2.10—Opening Screen of the FP40

2.11 The Battery Option (not available on FP40-D)

FP40s that have a battery pack will have a "fuel gauge" on the main display reporting the state of charge of the battery.

The reading on the fuel gauge will be accurate in a minute or two after pushing the OPERATE button. A new, fully charged battery will operate the instrument for approximately three hours. The fuel gauge will be accurate plus and minus 20%. There is no way to completely predict how long a charge will last because of all the variables of temperature, battery condition, power supply variance, and load.

Close examination of the fuel gauge will reveal an arrow pointing to the right when the battery is being charged, while an inverse arrow pointing to the left will be displayed when the battery is being discharged. If the fuel gauge is halfway between E and F, you have approximately half the battery time left, and so on.

You may still be able to operate when the gauge shows empty, but you are on reserve. Battery operation shuts down when the battery voltage reaches approximately 10 volts.

If the software fails and the battery discharges to 9.2V, there is an automatic hardware shutdown to protect the batteries.

Be sure to recharge the batteries within 24 hours if the instrument shuts down (having reached 10V), to prevent damage to the batteries.

Replace the batteries when you are dissatisfied with the longevity of the charge, or when the battery does not hold a charge for more than an hour.

If you find it impossible to turn off the instrument using the OPERATE button in units with a Battery Option, hold OPERATE down and then push RESET twice.

The Main Coupler Screen is the first operational screen you encounter when using the FP40. In it, you can take coupler frequency response curves and view them in either dB GAIN or dB SPL. By default, the FP40 comes with three different types of pure-tone sweeps that you can use as signals to generate the response curves. You can also add the Composite and Digital Speech signals for testing AGC and digital hearing aids.

3.1 The Main Coupler Screen

The display of the Main Coupler Screen varies depending upon whether you have chosen a pure-tone source (available on all FP40 analyzers) or a Composite/Digital Speech source (optional).

3.1.1 Viewing a Pure-tone display

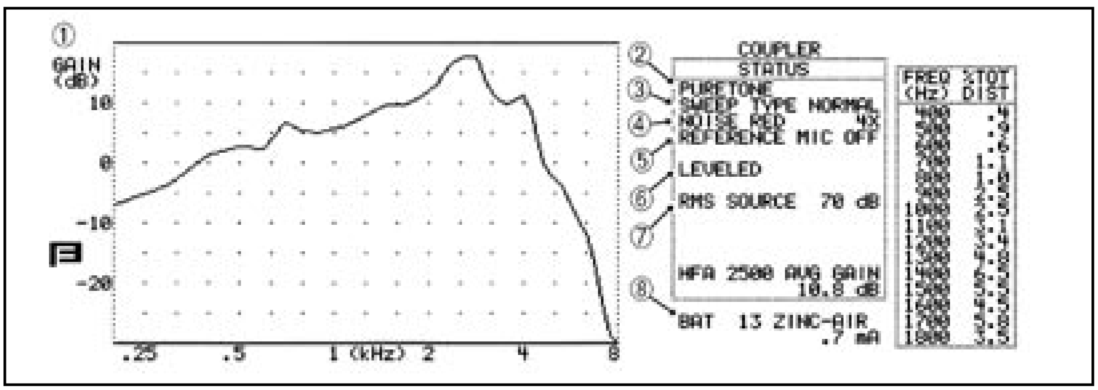


Figure 3.1.1—Pure-tone coupler screen

1. Display type: dB GAIN or dB SPL
2. Signal type
3. Pure-tone sweep type
4. Amount of noise reduction used (see Section 2.4.1.2)
5. Status of reference microphone
6. Leveling status
7. Source level of signal used in graph
8. Battery current drain (only if turned on)

3.1.2 Viewing a Composite display

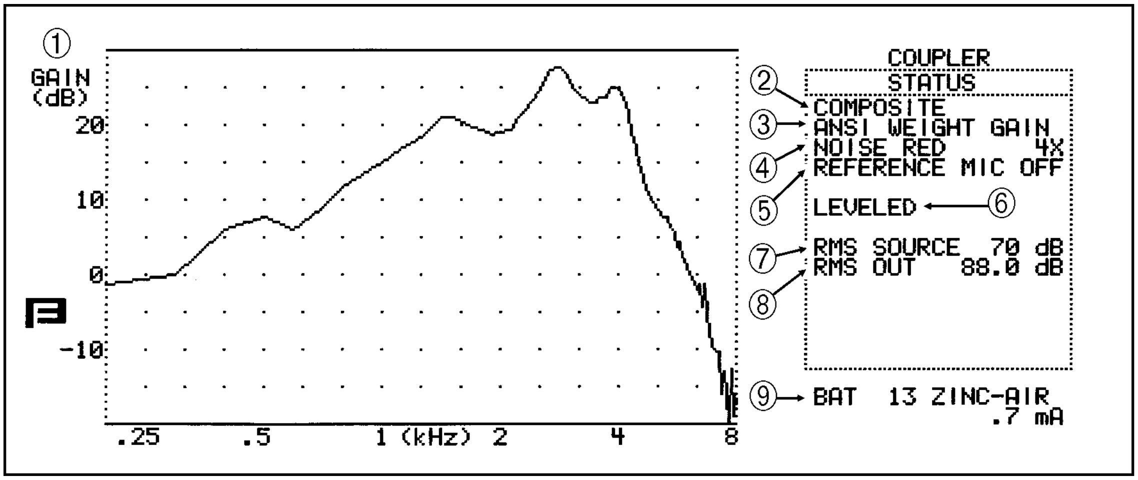


Figure 3.1.2—Composite coupler screen

1. Display type: dB GAIN or dB SPL
2. Signal type
3. Composite weighting
4. Amount of noise reduction used (see Section 2.4.1.2)
5. Status of reference microphone
6. Leveling status
7. Source level of signal
8. RMS out measured by analyzer of current graph
9. Battery current drain (only if turned on)

3.2 Leveling

Leveling is the process by which the response of the sound chamber is measured and computer-corrected so that a "flat" sound field is achieved. The leveling status can be saved into the FP40 analyzer's permanent memory so 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).

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.

3.2.1 Leveling without the reference microphone (standard)

The leveling process described here is adequate for most testing situations. If you have the Probe Option, you can also level the sound chamber using the reference (probe) microphone. That method is described in Section 3.2.2.

1. Look in the Coupler Status Box. Make sure it says "REFERENCE MIC OFF." If the reference microphone is ON, turn it off in the General Setup Menu.
2. Open the sound chamber.
3. Place the measurement microphone at the center of the speaker cone in the sound chamber. See Figure 3.2.1.

Figure 3.2.1—Leveling without the reference microphone.

4. Close the chamber lid.
5. Press LEVEL.
6. Press START/STOP.

To save the leveling information so it will be used the next time you turn on the analyzer, go to Section 3.2.3.

3.2.2 Leveling with the reference microphone

If your unit has the Probe Option, you can use the probe microphone as a reference microphone in leveling. This method is more exact than the leveling method described in Section 3.2.1, but you must level the chamber every time you change the hearing aid.

1. Set up the aid for testing as described in Section 3.3. If you are using a battery pill for testing, don't plug it in yet. If you are using a regular battery for testing, do not turn on the hearing aid.
2. Insert the measurement microphone into the coupler.
3. Place the reference (probe) microphone next to the measurement microphone. Use some Fun-Tak to secure the probe tube next to the microphone of the hearing aid. See Figure 3.2.2.
4. Press F1 from a coupler measurement screen.
5. Use the AMPLITUDE and FREQUENCY knobs to select REFERENCE MIC under COUPLER SETTINGS.
6. Press [START/STOP] to toggle on.
7. Press F1 to return to the coupler measurement screen.
8. Press the LEVEL button.
9. Press the START/STOP button. This will level the sound chamber.

When you want to test a different aid, you must level the sound chamber again to account for the difference in the size of the hearing aid. (If the hearing aid is an identical model, you won't have to re-level.)

Figure 3.2.2—Leveling with reference microphone

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. Press MENU to enter the General Setup Menu.
2. Press F5 to store the coupler leveling.
3. Press F1 to return to the testing screen.

3.3 Hearing Aid Setup

To set up the analyzer and the hearing aid for testing, you connect the hearing aid to a coupler. The standard couplers of the FP40 analyzer are the HA-1 and HA-2 couplers. These couplers contain 2 cc of space, simulating the amount of space in a person's ear canal.

Other available couplers include the MZ-series couplers (used in the OES and JIS Options), and the CIC coupler.

3.3.1 Setting up a BTE

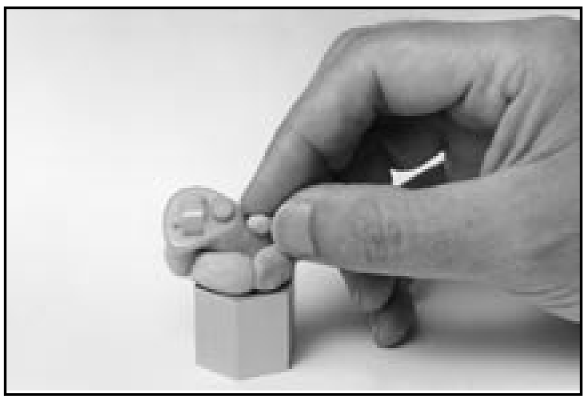
1. Adjust the tone and gain controls of the aid to the desired positions. If desired, insert a battery pill into the aid.
2. Insert the end of the earhook of the hearing aid into the plastic tubing of the ear level adapter.
3. Insert the measurement microphone into the HA-2 2-cc coupler.
4. Snap the ear level adapter onto the end of the coupler.
5. Place the hearing aid/coupler combination into the sound chamber so that the microphone of the aid is directly over the center of the speaker.

3.3.2 Setting up an ITE/ITC/CIC

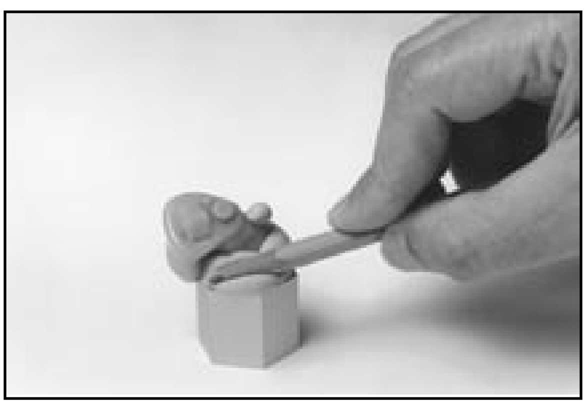
1. Roll some Fun-Tak into a rod long enough to go around the transmitting end of the aid. Modeling clay can also be used, but it doesn't work as well.

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 with 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.



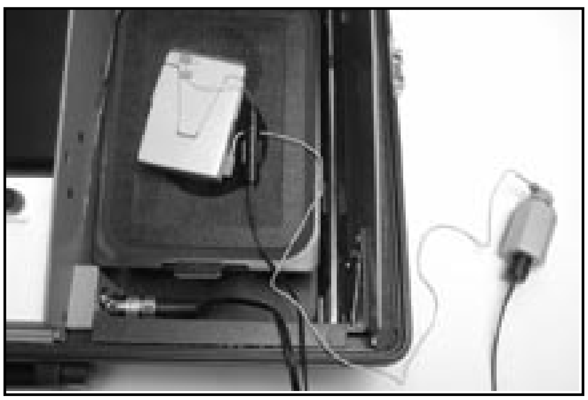
4. Seal the outside opening of any vent on the aid with a small kernel of Fun-Tak.



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.

6. Slowly insert the microphone into the coupler. You may feel an initial resistance when the mic reaches the O-ring. Continue to push the microphone until it stops.
7. Place the completed assembly over the center of the speaker in the test chamber. With ITEs, the position of the aid can affect the frequency response. If possible, point the faceplate of the aid toward the right or the left.
8. If you are using a battery pill, be sure the metal conductor strip does not obstruct the sound path.

3.3.3 Setting up a body aid



1. Adjust the tone and gain controls of the aid to the desired positions.
2. Place the hearing aid into the sound chamber so that the microphone of the aid is centered over the speaker.
3. Insert the FP40 microphone into the HA-2 coupler and then snap the receiver onto the end of the coupler.
4. Place the coupler outside of the sound chamber and close the lid.

3.3.4 Setting up an eyeglass aid

1. If possible, remove the ear piece containing the hearing aid from the glasses.
2. Attach the receiver nub of the aid to the ear level adapter on the HA-2 coupler.
3. Place the assembly in the sound chamber with the microphone of the aid at the center of the speaker.
4. If it is not possible to disassemble the eye glass aid, you must fold it on itself and get as close as possible to the setup just described.

3.4 Frequency responses

The Main Coupler Screen lets you take the frequency response of the hearing aid. You can:

- Use a variety of signal sources
- View multiple responses at once
- Find the single frequency response of the aid
- Take a three frequency average
- View the harmonic distortion in bars or in a separate table
- Switch between viewing curves in output and gain
- Test with or without the reference microphone

This section will tell you how to do all of these things.

3.4.1 Choosing a source type

The first step in taking a frequency response is to choose the signal you will be using as a source. The sources available on the FP40 analyzer are described in Section 2.4.

To select a pure-tone source:

1. Press F1—MENU to enter the General Setup Menu.
2. If you have the Composite signal, you will see the item SOURCE as the first item in the left column. If you don't see this selection, skip to step 3.
    a. Select SOURCE with the FREQUENCY and AMPLITUDE knobs.
    b. Push START/STOP to select TONE.
3. Select SWEEP TYPE with the FREQUENCY and AMPLITUDE knobs in the middle column of the screen. See Figure 3.4.1.
4. Select the desired pure-tone sweep type using START/STOP. In general, select NORM to perform a single sweep containing many frequencies. Select FAST to perform continuous sweeps containing fewer frequencies.
5. Press F1—EXIT to return to the Main Coupler Screen.

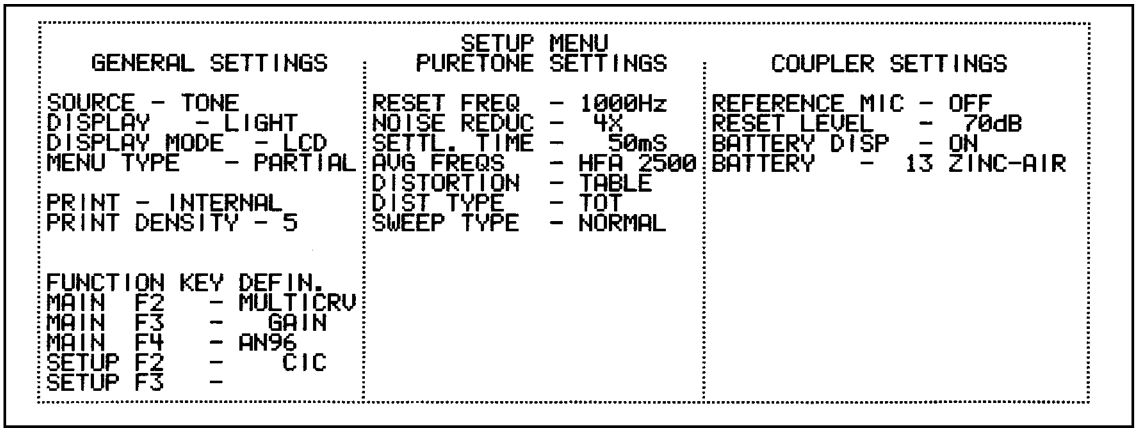


Figure 3.4.1—Selecting a pure-tone sweep

To select a Composite/Digital Speech source:

1. Press F1—MENU to enter the General Setup Menu.
2. Select SOURCE with the FREQUENCY and AMPLITUDE knobs.
3. Press [START/STOP] to cycle through your choices. To select the Composite signal, choose COMPOSITE. If you have the Digital Speech Option, you will also have access to DIGSP ANSI (Digital Speech ANSI) and DIGSP ICRA (Digital Speech ICRA).
4. Press F1—EXIT to return to the Main Coupler Screen.

3.4.2 Taking the measurement

1. Make sure the sound chamber is leveled, as described in Section 3.2. You don't need to level the sound chamber every time you turn it on, but it's a good idea to level the chamber (and save the leveling) about once a week.
2. Set up the hearing aid in the sound chamber as described in Section 3.3.
3. Choose a source type as described in Section 3.4.1.
4. Adjust the source to the desired level by using the AMPLITUDE knob. If you are using a composite/digital speech signal, you will see the RMS SOURCE in the STATUS box change as you adjust the knob. If you are using a pure-tone signal, you will see the SOURCE change in the lower right hand corner of the screen.
5. Press START/STOP. This will start the measurement. If you are using a NORM (or SHORT) pure-tone source signal, the analyzer will perform one pure-tone sweep measurement and stop automatically. Otherwise, wait for the measurement to stabilize, and press START/STOP to stop the measurement.

3.4.3 Viewing multiple measurements

It's often useful to view several different frequencies responses together on the same screen. This is especially important when testing AGC hearing aids. To do this, use the Multi-curve function.

To take multiple measurements:

1. Look at the screen just above F2 and F3. If one of them is "OFF MULTICRV," press the corresponding function button (F2 or F3) to turn it on. Skip to step 6. Otherwise, proceed to step 2 for instructions on selecting Multi-curve for F2 or F3.
2. Press F1 to enter the General Setup Menu.
3. Use the AMPLITUDE and FREQUENCY knobs to select MAIN F2 or MAIN F3. Press START/STOP repeatedly to select MULTICRV.
4. Press F1 to return to the Main Coupler Screen.
5. Press the function key (F2 or F3) that says "OFF MULTICRV" to turn it on.
6. Look at the screen. In the upper right hand corner of the screen, you will see a MULTICURVE REPORT box that will contain a legend for four curves. This will give you data about each curve.
7. Press F6 to select the curve you want to use for the measurement.
8. Follow the directions found in Section 3.4.2 for instructions on how to take a frequency response measurement.
9. Repeat steps 6-8 to take up to four distinct measurements. If you select a curve that already contains a frequency response, the old frequency response will be erased when you take a new response.

To turn off the display of a curve:

1. Press F6 to select the desired curve.
2. Press F7 to turn off the display of that curve. This will not erase the curve.
3. Press F7 to redisplay the curve.

To erase a curve:

There are two ways to erase a curve.

- Press F8. This will erase all four curves in the Multi-curve buffer.
- Press F6 to select the desired curve, and take a new measurement. This will replace the old curve with the new curve.

3.4.4 Taking a single frequency response

1. Look at the first line in the STATUS box in the Main Coupler Screen. If it says PURE-TONE or BURST, skip to step 6. Otherwise, proceed to step 2.

2. Press F1 to enter the General Setup Menu.
3. Select SOURCE with the AMPLITUDE and FREQUENCY knobs.
4. Press START/STOP to select TONE.
5. Press F1 to return to the Main Coupler Screen.
6. Open the sound chamber and listen to the signal. You will hear a continuous pure-tone signal. Close the sound chamber.
7. Look at the lower right side of the screen. You will see a box listing the SOURCE, FREQ, and MIC GAIN (or MIC SPL) of the signal.
8. Adjust the amplitude and frequency of the signal using the AMPLITUDE and FREQUENCY knobs.
9. Watch the MIC GAIN (or MIC SPL) in the lower right side of the screen change as you adjust the amplitude and frequency of the signal.

3.4.5 Taking a three frequency average

To take the three frequency average of a hearing aid, you use the AVG feature.

1. Press F1 to enter the General Setup Menu.
2. Select TONE for the SOURCE type, if necessary. If you don't have the Composite signal on your analyzer, you won't see a selection for SOURCE type.
3. Use the FREQUENCY and AMPLITUDE knobs to select MAIN F2 or MAIN F3.
4. Press START/STOP repeatedly until you select AVG.
5. Use the FREQUENCY and AMPLITUDE knobs to select AVG FREQS under PURE-TONE SETTINGS.
6. Press START/STOP to toggle the desired three frequency average, represented by the highest of the frequencies. See Section 2.4.1 for a list of those frequencies.
7. Press F1 to return to the Main Coupler Screen.
8. Look at the lower right side of the screen. You will see a box listing the SOURCE, FREQ, and MIC GAIN (or MIC SPL) of the signal. FREQ will be changing rapidly as the analyzer switches between the three frequencies.
9. Adjust the amplitude of the signal using the AMPLITUDE knob. Watch the MIC GAIN (or MIC SPL) in the lower right side of the screen change as you adjust the knob.

3.4.6 Viewing harmonic distortion

1. Press F1 to enter the General Setup Menu.
2. Select TONE for the SOURCE type, if necessary. If you don't have the Composite signal on your analyzer, you won't see a selection for SOURCE type.

3. Use the FREQUENCY and AMPLITUDE knobs to select DISTORTION under PURE-TONE SETTINGS.
4. Press START/STOP to toggle between displaying the harmonic distortion in “bar” format on the graph or “table” format next to the graph.
5. Use the AMPLITUDE to select DIST TYPE.
6. Press START/STOP to select the type of harmonic distortion measurement to make. See Section 2.4.1.4 for more details.
7. Press F1 to return to the Main Coupler Screen.
8. Run a pure-tone frequency response by following the directions found in Section 3.4.2. The harmonic distortion results will appear either as bars on the graph or as a separate table.

3.4.7 Viewing battery current drain

Follow the directions in Section 2.6 for instructions on turning on the battery drain display and selecting the appropriate battery pill. You must use a composite or pure-tone sweep source.

You must use a battery pill to view battery current drain.

3.4.8 Switching between gain and output

Look at the screen just above F2 and F3. If one of the function button labels reads “ON GAIN” or “OFF GAIN,” press the corresponding function button (F2 or F3) to toggle the selection. This will switch between viewing the response graph in dB GAIN or dB SPL.

When you view the graph in dB GAIN, you are looking at the difference between the input (the source signal) and the output (measured by the analyzer’s microphone). This is nice because you are seeing only what the hearing aid is amplifying.

When you view the graph in dB SPL, you are viewing everything that is measured by the analyzer’s microphone. The source signal is not subtracted.

3.4.9 Testing with the reference microphone

You can use the FP40 to perform coupler measurements with or without the reference microphone. We generally recommend to test without the reference microphone when performing coupler measurements because it’s easier, faster, and almost as accurate. However, testing with the reference microphone, when done correctly, is slightly more accurate than testing without it. See Figure 3.4.9 for pictures of aids tested with the reference microphone.

Things to keep in mind when testing with the reference microphone:

- You must relevel the sound chamber with the reference microphone every time you switch hearing aids. See Section 3.2.2 for instructions.

- You must position the reference microphone properly. If you don't have the reference microphone positioned next to the microphone of the hearing aid, you will get inaccurate results. Worse, if you leave the reference microphone outside the chamber when it is turned on, you will get wildly inaccurate test results.

To turn on the reference microphone:

1. Press F1 to enter the General Setup Menu.
2. Use the AMPLITUDE and FREQUENCY knobs to select REFERENCE MIC under COUPLER SETTINGS.
3. Press START/STOP to toggle the selection from OFF to ON.
4. Press F1 to return to the Main Coupler Screen. You will read REFEENCE MIC ON in the STATUS box.

Figure 3.4.9A—Test setup for BTE aid using reference microphone.

3.4.9B—Test setup for ITE aid using reference microphone

3.5 Digital Aids

All digital aids can be tested, but some of the high-end models requires a little more thought and care; these aids have a "noise suppression" (or "speech enhancement") feature. This noise suppression feature, not to be confused 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 a Composite signal, can cause the high-end digital aid to go into this noise suppression 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 to speech.

3.5.1 Testing with Digital Speech

To test digital aids with noise suppression, we have taken our standard continuous Composite signal and interrupted it at intervals just long enough to trick the hearing aid into thinking it is hearing speech instead of noise. This program is called “Digital Speech” and comes equipped with two different speech spectra: the ANSI S3.42 spectrum that is similar to the Composite signal spectrum, and the ICRA spectrum that was used in the creation of some high end digital hearing aids.

The nice thing about Digital Speech on the FP40 is that it works the same way as any other type of signal works. You don’t have to learn any new button pushes, and you can treat the digital aid just as you would any other hearing aid. In fact, there’s no reason that you can’t use the Digital Speech signal for testing an analog hearing aid.

To use digital speech:

Follow the instructions from Section 3.4.1 to choose a Digital Speech source (DIGSP ANSI or DIGSP ICRA), and test the aid according to Section 3.4.2. You can present the signal to the aid as long as you need to, without worrying about the aid going into its “noise suppression” mode.

To understand ICRA vs. ANSI:

There are two Digital Speech signals available: Digital Speech ICRA (DIGSP ICRA) and Digital Speech ANSI (DIGSP ANSI). They have different speech weightings. DIGSP ANSI rolls off the high frequencies of the broadband signal at the same rate as the Composite Signal. DIGSP ICRA rolls off the high frequencies of the broadband signal more quickly. Figure 3.5.1 shows a comparison of the two speech spectra.

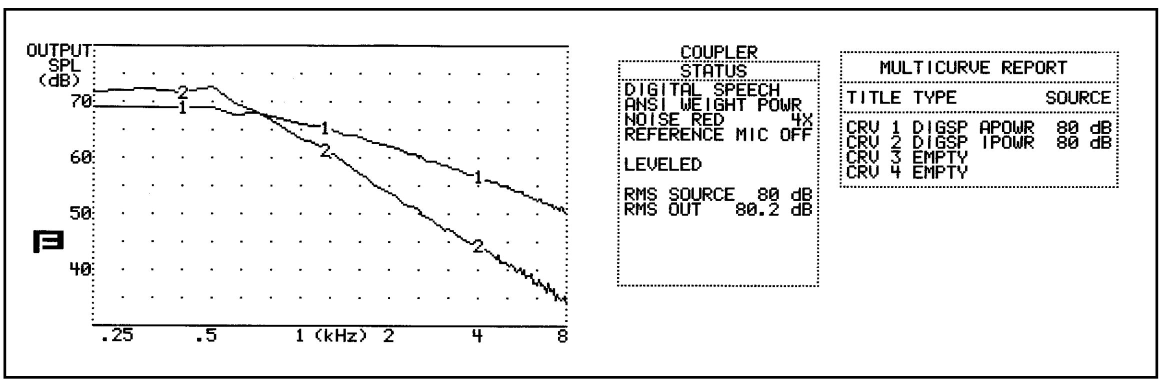


Figure 3.5.1—Comparison of DIGSP ANSI (CRV 1) and DIGSP ICRA (CRV 2)

3.5.2 Testing with the Composite Signal

If you don’t have Digital Speech on your analyzer, you can still perform accurate measurements of the hearing aid using the Composite signal. Most noise suppression features on high end digital aids will accept a continuous signal for several seconds before decreasing the gain of the hearing aid.

To use the Composite signal to test high end digital aids, you first need to figure out how long you can present the signal before the aid's noise suppression goes into effect.

Follow these instructions:

1. Follow the instructions from Section 3.4.1 to select the Composite signal as the source type.
2. Use the AMPLITUDE knob to select 65 dB.
3. Press START/STOP and watch the response curve carefully. If the noise suppression of the aid is working properly, you should see the amplitude of the curve drop after several seconds. Some aids might take 3-5 seconds while other aids will take 10-15 seconds. Press START/STOP again when finished.
4. Estimate the amount of time it took for the noise suppression to "kick in." If you don't see any noticeable difference in the response of the aid after 15 seconds, either the aid's noise suppression isn't working, or it's not the type of aid that requires special consideration when testing.

Now test normally using the Composite signal. Make sure to turn off the signal (by pressing START/STOP again) before the time you estimated in step 4 passes. This will allow you to get an accurate measurement before the aid goes into noise suppression mode.

3.5.3 Testing with pure-tone sweeps

Unfortunately, the only way to test a high-end digital hearing aid using only a pure-tone sweep is to put the aid in "test" mode and turn off the noise suppression feature of the hearing aid. Most digital hearing aids have a way to do this in their programming software. Contact your hearing aid manufacturer for details.

3.6 Directional Hearing Aids

When fitting a directional aid, it is very important to make sure the microphones of the hearing aid are providing a directional benefit. This is typically done by measuring the response of the hearing aid when the source is in front of the patient—the forward response—and the response of the hearing aid when the source is behind the patient—the reverse response.

When testing a directional aid in the sound chamber, it is important to position the aid correctly in order to test the forward and reverse responses. After the measurements have been completed, compare the forward and reverse responses to each other.

Since the FP40 analyzer has a small sound chamber, directional testing is best done with the chamber in the upright position that is usually associated with real-ear measurements. The hearing aid, connected to the coupler, can positioned in front of the speaker on a stand or the back of a chair. In a pinch, the operator can stand to the side of the sound field and just hold the aid at a fixed distance from the speaker. If you have the FP40 portable model without the real-ear option, you will need the microphone extension cord (072-0300-00) for the folowing procedure.

The reference microphone should be OFF for these measurements.

3.6.1 Preparing for the measurement

1. Set up your analyzer so that the speaker is in the upright position. See Section 5.1.1.2.
2. Position the stand or chair you are going to use to set up the hearing aid. If you are using a chair, face the chair to the side, so that the sound field will not bounce against the large flat surface of the back of the chair. The testing surface should be about 12 inches from the speaker.
3. Use Fun-Tak to affix the large measurement microphone to the testing surface. If you are going to be holding the aid during the test, then hold the measurement microphone about 12 inches from the speaker while standing to the side of the sound field. See Figure 3.6.1.
4. Push the LEVEL button on your analyzer from the coupler measurement screen. This will level the sound field.
5. Attach the hearing aid to the coupler and insert the measurement microphone, as usual. You are now ready to test.

Figure 3.6.1—Preparing for a coupler directional measurement

3.6.2 Taking the Forward Measurement

1. Position the hearing aid on the testing surface so that it is facing forward. Use Fun-Tak to hold the assembly in place. Alternately, hold the hearing aid in place while standing to the side of the sound field. See Figure 3.6.2.
2. Make sure you are in the Main Coupler screen.
3. Make sure MULTICURVE is turned ON. See Section 3.4.3 for details.
4. Select a Composite or Digital Speech signal source, if available. Otherwise, use the pure-tone FAST signal. See Section 3.4.1 for details.

5. Use the AMPLITUDE knob to select an appropriate source level. Typically this measurement should be done so that it is above the noise floor of the testing environment, but below the compression knee point of the aid, if possible. If you have a quiet testing environment, use 50 dB SPL. Noisier testing environments may require you to use a higher source level to get a good measurement.
6. Press START/STOP to start the measurement. Press it again to stop the measurement once it has stabilized.

Figure 3.6.2—Testing the forward coupler response of a directional aid

3.6.3. Taking the Reverse Measurement

1. Position the hearing aid so that it is faced away from the sound field speaker. Different hearing aids have different null points, so you will want to adjust the positioning so that the sound field speaker is pointing towards what should be the null point of the directional aid. See Figure 3.6.3.
2. Make sure the aid is the same distance from the speaker that you used for the forward measurement.
3. Press F6 to select CURVE 2.
4. Make sure the source type and level are selected that you used for the forward measurement.
5. Press START/STOP to start the measurement. If you are using a Digital Speech or Composite source, you can actually rotate the hearing aid while the measurement is running to determine the null spot of the directional microphones – look for when the response drops the most.

6. Press START/STOP once the measurement has stabilized. Compare the reverse measurement to the forward measurement to see the directional advantage that the aid provides.

Figure 3.6.3 —Testing the reverse coupler response of a directional aid

3.7 The CIC Option

The CIC Option 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 aid because those specifications are based upon 2-cc coupler measurements.

The CIC Option consists of a CIC coupler 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 F1 to enter the General Setup Menu.
3. Use the AMPLITUDE and FREQUENCY knobs to select MAIN F2 or MAIN F3.
4. Press START/STOP repeatedly to select CIC.
5. Press F1 to return to the Main Coupler Screen.

6. Press F2 or F3 (selected in step 3) to turn the CIC correction factors ON.
7. Test as usual. See Section 3.4.2.

See Figure 3.7 for a comparison of a CIC aid tested with an HA-1 coupler and the same aid tested with a CIC coupler and correction factors.

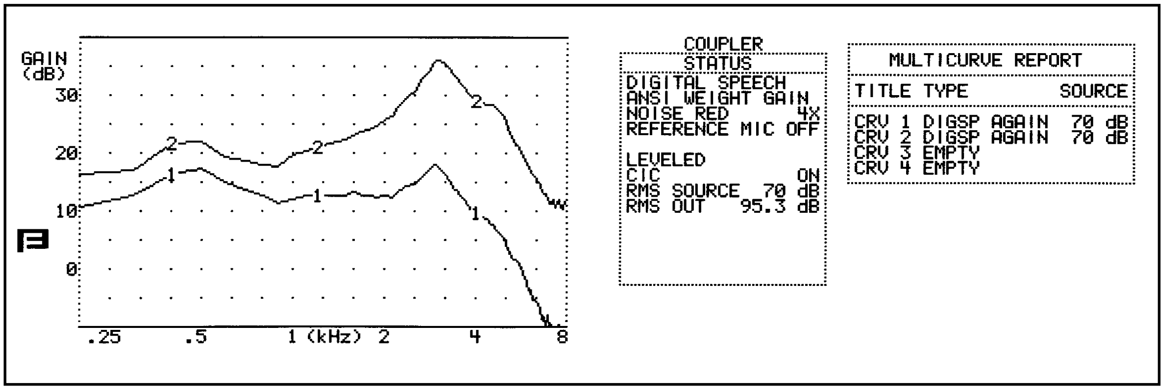


Figure 3.7—CIC vs. HA-2 comparison

3.8 The OES Option

The OES (Occluded Ear Simulator) Option allows you to simulate the test results you would get using a standard ear simulator (IEC 711 or Zwislocki coupler), provided the hearing aid or mold being tested in not vented. It consists of three MZ couplers (MZ-1, MZ-2, and MZ-3) and corresponding correction factors.

To use the OES Option:

1. Use the proper MZ coupler and connect the aid as usual. See Figure 3.8A.
2. Press F1 to enter the General Setup Menu.
3. Use the AMPLITUDE and FREQUENCY knobs to select MAIN F2 or MAIN F3.
4. Press START/STOP repeatedly to select OES.
5. Press F1 to return to the Main Coupler Screen.
6. Press F2 or F3 (selected in step 3) to turn the OES correction factors ON.
7. Test as usual. See Section 3.4.2.

Corrections will be made to all measurement curves, data displays, and individual measurements. See Figure 3.8B for a comparison of an aid tested with an HA-2 coupler, and the same aid tested with an MZ-3 coupler and OES correction factors.

TYPE OF AID	COUPLER	COMMENT
ITE, ITC	MZ-1	
BTE, or EYEGLASS	MZ-1	With custom earmold attached. (NOTE: Vents must be plugged.)
	MZ-2	Without custom earmold attached, **when a 3-mm horn earmold is planned**, use with the Ear-Level Hearing Aid Adapter that normally snaps onto the HA-2, 2cc coupler.
	MZ-3	Without 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 attaced.

Figure 3.8A—Choosing the proper MZ coupler

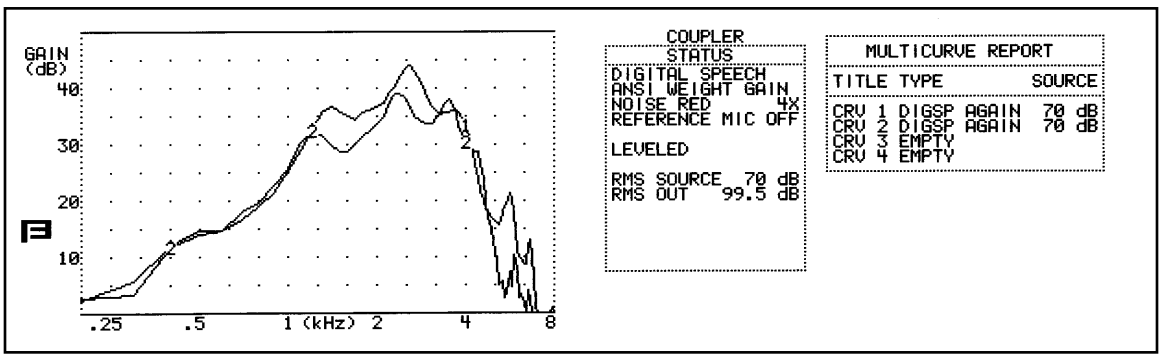


Figure 3.8B—MZ-3 vs HA-2 comparison

Chapter 4: Automated Test Sequences

There are several different automated test sequences available on the FP40 analyzer:

- ANSI S3.22-2003
- ANSI S3.22-1996
- ANSI S3.22-1987
- ANSI S3.42-1992
- ACIC
- JIS
- ISI
- Profiler
- IEC

The ANSI S3.22 is the FDA's hearing aid "labeling" standard. All hearing aids manufactured in the United States are labeled to this standard. ANSI 03, ANSI 96, and ANSI 87 are three versions of the same labeling standard. See Section 4.1, 4.2, and 4.3 for more information. ACIC is ANSI 87 with the CIC correction factors. It is meant to be used with the CIC coupler, and is for informational purposes only.

The ANSI S3.42-1992 is a voluntary standard for non-linear hearing aids. It uses the composite signal to take a series of frequency responses at different input levels so you can make sure the aid is compressing correctly. It is not directly related to ANSI 03, ANSI 96, or ANSI 03. See Section 4.4 for more information.

The IEC, JIS, and ISI are automated test sequences designed for the international hearing aid industry. IEC is used primarily in Europe, JIS is used primarily in Japan, and ISI is used primarily in India. See Section 4.5 for more information on the IEC automated test sequence. Instructions on the JIS and ISI test sequences are available upon request.

The Profiler was designed as a fast way of determining all the important characteristics of a hearing aid in a very short amount of time. It is used to quickly identify aids that need repair or replacement, and to validate new hearing aid fittings. See Section 4.6 for more information.

4.1 ANSI S3.22-2003

The ANSI S3.22 standard is the FDA's hearing aid "labeling" standard. All hearing aids sold in the United States must be labeled to this standard. The ANSI 03 automated test sequence performs all the measurements specified in the 2003 revision of the standard.

As of the publishing of this manual, the FDA has indicated that it will publish this standard in the federal registry in Fall 2005. After this happens, there will be a period of comment before the standard is officially adopted by the FDA and put into use. When this occurs, all newly designed hearing aids will be labeled to the 2003 standard. It is not known at this time whether previously designed hearing aids will also be labeled to this standard.

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

- When you set up an AGC aid for an ANSI 03 test sequence, you will start with its compression controls set to minimum (with the compression knee point set as high as possible). Just before the input/output measurements, the test sequence will pause to allow you to set the compression controls of the aid to maximum (with the compression knee point set as low as possible). In ANSI 96, AGC aids are tested with their compression controls set to maximum for all measurements.
- When you adjust the gain control of the hearing aid midway through the ANSI 03 automated test sequence, the measured reference test gain value needs to be within 1.5 dB of the target value. In ANSI 96, the measured valued needs to be instead of within 1 dB of the target value.
- The EIN formula in ANSI 03 uses a 50 dB SPL input instead of the 60 dB SPL input used in ANSI 03. With ANSI 96, any aid with a compression knee point below 60 dB SPL showed artificially high EIN results. This means that ANSI 03 EIN test results should be better (lower) for AGC aids.

4.1.1 Setting up the aid for testing

When possible, follow the procedure recommended by the hearing aid manufacturer when setting up the aid to perform an ANSI test sequence. Otherwise, use the following guidelines:

- Set the controls of the aid (except the compression controls) to give the greatest possible output and gain.
- Set the aid for the widest frequency response range.
- Set AGC aids to achieve minimum possible compression.
- Make sure the gain control of the aid is full-on.

Follow the instructions from Section 3.3 to set up the aid in the test box for testing.

4.1.2 Setting up the analyzer for testing

To enter the ANSI 03 screen:

1. From the Main Coupler Screen, look at the FP40's display above the F4 function key. If it says "AN03," skip to step 6.
2. Press F1 – Menu.
3. Use the AMPLITUDE and FREQUENCY knobs to select MAIN F4 under FUNCTION KEY DEFIN.
4. Press START/STOP to choose AN03. This will let you use the F4 function key to enter the ANSI 03 screen from the Main Coupler Screen.
5. Press F1 to return to the Main Coupler Screen.
6. Press F4 to enter the ANSI 03 screen.

To change the ANSI 03 settings:

1. From the ANSI 03 screen, press F1 to enter the General Setup Menu.
2. Use the AMPLITUDE and FREQUENCY knobs to select MENU TYPE.
3. Press START/STOP to choose PARTIAL. The menu will now only display the selections applicable to ANSI 03.
4. Use the AMPLITUDE and FREQUENCY knobs in conjunction with the START/STOP button to choose the settings for NOISE REDUC, SETTL. TIME, and AVG FREQS under PURETONE SETTINGS. These settings are explained in Section 2.4.1.
5. Use the AMPLITUDE and FREQUENCY knobs in conjunction with the START/STOP button to select whether or not you will use the REFERENCE MIC for testing. We generally recommend selecting OFF. See Section 3.4.9.
6. Use the AMPLITUDE and FREQUENCY knobs in conjunction with the START/STOP button to select the type of battery pill used in the measurement. This is used in testing battery current drain.
7. Press F1 to return to the ANSI 03 screen.
8. Press F2 to choose the type of aid you are testing. The selections are AGC, ADAPTIVE AGC, and LINEAR 50.
   - Choose LINEAR 50 for linear aids.
   - Choose AGC for most AGC aids.
   - Choose ADAPTIVE AGC if the aid has adaptive release times. This is also a suitable selection for digital aids that require extra time to adjust to input signals.
9. Use F5 to turn ON or OFF the telecoil measurement. The ANSI 03 telecoil measurement requires the Telewand.
10. Press DATA/GRAPH. If you are testing a linear hearing aid, skip to step 15.
11. Press F2 to choose a frequency and press F3 to select whether or not you want to run an input/output (I/O) curve at this frequency. Repeat this for each of the five available frequencies.
12. Use F5 to select the amount of time the first frequency of each I/O curve is presented before the measurement is made.
13. Use F6 to select the amount of time each subsequent frequency is presented before a measurement is made. This should be at least twice as long as the manufacturer specified attack time.
14. Use F8 to SET AGC ON or OFF. SET AGC ON will cause the test sequence to pause in order to allow you to adjust the AGC controls of the aid before running the input/output curves as required by ANSI 03. If it is not possible for you to adjust these controls, SET AGC to OFF, but be advised that test results may vary from manufacturing specifications.
15. Use F9 if you would like to identify the ear tested.
16. Return to the main function button selections by pressing DATA/GRAPH.
17. Press F8 to save your settings, if desired.

4.1.3 Running the test sequence

1. Level the sound chamber if necessary. See Section 3.2 for details.
2. Set up the aid for testing. See Section 4.1.1.
3. Close the sound chamber.
4. Press START/STOP when you are ready to begin the test.
5. Wait for several tests to be run. For most aids, the analyzer will pause after performing several measurements in order for you to turn down the gain of the aid.
6. If the analyzer pauses, open the sound chamber and adjust the gain control of the aid until the MEASURED gain matches the TARGET gain to within 1.5 dB when the sound chamber is closed.
7. Press START/STOP to resume testing.
8. The analyzer will pause again, if you are performing a telecoil measurement, and instruct you to put the aid in telecoil mode. Do so. Otherwise, skip to step 13.
9. Plug the Telewand into the External Speaker jack on the back of the FP40 and hold the wand over the aid as you would hold a telephone receiver to your ear. That is, for BTE aids, hold the wand flat against the body of the aid. For ITE/ITC/CIC aids, hold the wand against the faceplate of the aid. The aid should be positioned vertically, as it would be worn, in order to produce the best telecoil response.
10. Press START/STOP to take the telecoil measurements.
11. Put the aid back into microphone mode when the analyzer instructs you to.
12. Unplug the telewand from the External Speaker jack on the back of the FP40.
13. If you have set the aid type to AGC or ADAPTIVE, as described in step 8 of Section 4.1.2, and if the SET AGC is ON, as described in step 14, the analyzer will pause to allow you to adjust the AGC controls. Set the compression to maximum, or as recommended by the hearing aid manufacturer. Otherwise, wait for the test sequence to complete.
14. Press START/STOP to complete the test sequence.

4.1.4 Viewing the results

See Figure 4.1.4 for an example of an ANSI 03 test sequence (including the telecoil measurement).

1. OSPL90: Output measurement at 90 dB SPL
2. RESP60: Response measurement at 60 db SPL at reference test gain
3. SPLITS: Telecoil response curve measurement
4. NR: Noise reduction used in tests
5. SPA/HFA: Frequencies used for the three frequency average
6. MAX: Maximum frequency response measured and the frequency at which it occurred
7. SPA/HFA OSPL90: Three frequency average of the OSPL90 curve

8. SPA/HFA FOG: Three frequency average of a full-on gain measurement at 50 dB SPL
9. REFTG TARGET and MEASURED: The calculated reference test gain and the actual measured reference test gain
10. EQ INP NOISE: Equivalent input noise
11. RESP LIMIT and F1 and F2: The response limit level and the two frequencies where the response curve crossed over this level
12. THD: The total harmonic distortion measurements
13. HFA-SPLITS: The three frequency average of the telecoil SPLITS curve
14. RSETS: The difference between the high frequency average of the response curve and the SPLITS curve
15. BATTERY: Battery current drain
16. I/O CURVES: Input/output measurements at up to five different frequencies

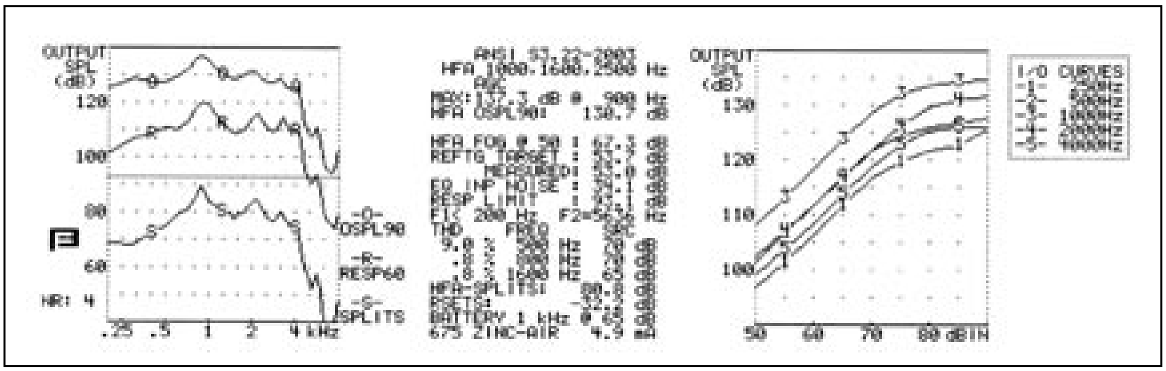


Figure 4.1.4—ANSI 03 results

4.2 ANSI S3.22-1996

Although the ANSI S3.22 was revised in 1996, the FDA did not adopt this new version of the standard until March 2000. As a result, all hearing aids designed (or with significant design changes) after March 17, 2000 must be labeled to the ANSI S3.22-1996 standard. All hearing aids manufactured today, but with no significant design changes since March 17, 2000, can continue to be labeled to the ANSI S3.22-1987. See Section 4.3 for more details on ANSI 87.

4.2.1 Setting up the aid for testing

When possible, follow the procedure recommended by the hearing aid manufacturer when setting up the aid to perform an ANSI test sequence. Otherwise, use the following guidelines:

- Set the controls of the aid (except the compression controls) to give the greatest possible output and gain.

- Set the aid for the widest frequency response range.
- Set AGC aids to achieve greatest possible compression.
- Make sure the gain control of the aid is full-on.

Follow the instructions from Section 3.3 to set up the aid in the test box for testing.

4.2.2 Setting up the analyzer for testing

To enter the ANSI 96 screen:

1. From the Main Coupler Screen, look at the FP40's display above the F4 function key. If it says "AN96," skip to step 6.
2. Press F1 – Menu.
3. Use the AMPLITUDE and FREQUENCY knobs to select MAIN F4 under FUNCTION KEY DEFIN.
4. Press START/STOP to choose AN96. This will let you use the F4 function key to enter the ANSI 96 screen from the Main Coupler Screen.
5. Press F1 to return to the Main Coupler Screen.
6. Press F4 to enter the ANSI 96 screen.

To change the ANSI 96 settings:

1. From the ANSI 96 screen, press F1 to enter the General Setup Menu.
2. Use the AMPLITUDE and FREQUENCY knobs to select MENU TYPE.
3. Press START/STOP to choose PARTIAL. The menu will now only display the selections applicable to ANSI 96.
4. Use the AMPLITUDE and FREQUENCY knobs in conjunction with the START/STOP button to choose the settings for NOISE REDUC, SETTL. TIME, and AVG FREQS under PURETONE SETTINGS. These settings are explained in Section 2.4.1.
5. Use the AMPLITUDE and FREQUENCY knobs in conjunction with the START/STOP button to select whether or not you will use the REFERENCE MIC for testing. We generally recommend selecting OFF. See Section 3.4.9.
6. Use the AMPLITUDE and FREQUENCY knobs in conjunction with the START/STOP button to select the type of battery pill used in the measurement. This is used in testing battery current drain.
7. Press F1 to return to the ANSI 96 screen.
8. Press F2 to choose the type of aid you are testing. The selections are AGC, ADAPTIVE AGC, LINEAR 50, LINEAR 60.
   - Choose LINEAR 60 for most linear aids.
   - Choose LINEAR 50 for high-gain aids.
   - Choose AGC for most AGC aids.
   - Choose ADAPTIVE AGC if the aid has adaptive release times.

9. Use F5 to turn ON or OFF the telecoil measurement. The ANSI 96 telecoil measurement requires the Telewand.
10. Press DATA/GRAPH if you are testing an AGC aid. This will change the function key labels. Otherwise, skip to step 14.
11. Press F2 to choose a frequency and press F3 to select whether or not you want to run an input/output (I/O) curve at this frequency. Repeat this for each of the five available frequencies.
12. Use F5 to select the amount of time the first frequency of each I/O curve is presented before the measurement is made.
13. Use F6 to select the amount of time each subsequent frequency is presented before a measurement is made. This should be at least twice as long as the manufacturer specified attack time.
14. Use F9 if you would like to identify the ear tested.
15. Return to the main function button selections by pressing DATA/GRAPH.
16. Press F8 to save your settings, if desired.

4.2.3 Running the test sequence

1. Level the sound chamber if necessary. See Section 3.2 for details.
2. Set up the aid for testing. See Section 4.2.1.
3. Close the sound chamber.
4. Press START/STOP when you are ready to begin the test.
5. Wait for several tests to be run. For most aids, the analyzer will pause after performing several measurements in order for you to turn down the gain of the aid.
6. If the analyzer pauses, open the sound chamber and adjust the gain control of the aid until the MEASURED gain matches the TARGET gain to within 1 dB when the sound chamber is closed.
7. Press START/STOP to resume testing.
8. The analyzer will pause again, if you are performing a telecoil measurement, and instruct you to put the aid in telecoil mode. Do so. Otherwise, wait for the test sequence to finish.
9. Plug the Telewand into the External Speaker jack on the back of the FP40 and hold the wand over the aid as you would hold a telephone receiver to your ear. That is, for BTE aids, hold the wand flat against the body of the aid. For ITE/ITC/CIC aids, hold the wand against the faceplate of the aid.
10. Press START/STOP to take the telecoil measurements.
11. Put the aid back into microphone mode when the analyzer instructs you to.
12. Unplug the telewand from the External Speaker jack on the back of the FP40.
13. Press START/STOP to complete the test sequence.

4.2.4 Viewing the results

See Figure 4.2.4 for an example of an ANSI 96 test sequence (including the telecoil measurement).

1. OSPL90: Output measurement at 90 dB SPL
2. RESP50 (or 60): Response measurement at 50 (or 60) db SPL at reference test gain
3. SPLITS: Telecoil response curve measurement
4. NR: Noise reduction used in tests
5. SPA/HFA: Frequencies used for the three frequency average
6. MAX: Maximum frequency response measured and the frequency at which it occurred
7. SPA/HFA OSPL90: Three frequency average of the OSPL90 curve
8. SPA/HFA FOG: Three frequency average of a full-on gain measurement at 50 (or 60) dB SPL
9. REFTG TARGET and MEASURED: The calculated reference test gain and the actual measured reference test gain
10. EQ INP NOISE: Equivalent input noise
11. RESP LIMIT and F1 and F2: The response limit level and the two frequencies where the response curve crossed over this level
12. THD: The total harmonic distortion measurements
13. HFA-SPLITS: The three frequency average of the telecoil SPLITS curve
14. STS-SPLITS: The difference between the high frequency average of the response curve and the SPLITS curve
15. BATTERY: Battery current drain
16. I/O CURVES: Input/output measurements at up to five different frequencies

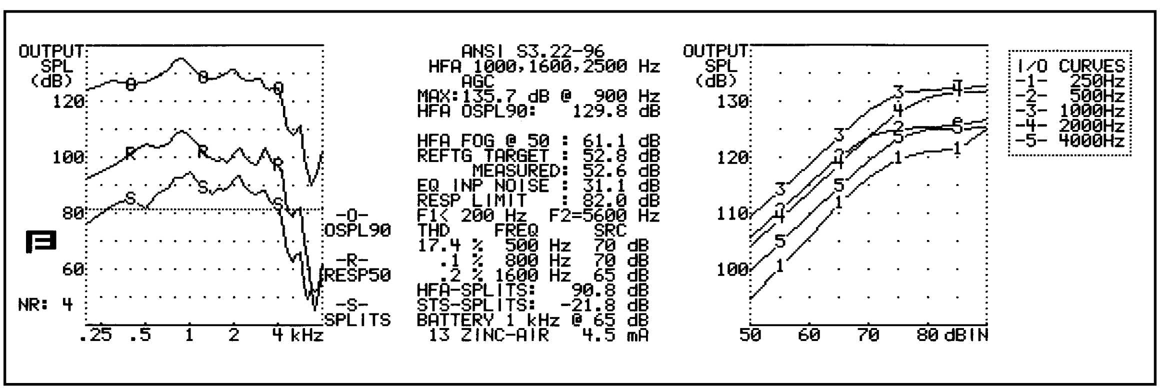


Figure 4.2.4—ANSI 96 results

4.3 ANSI S3.22-1987

The ANSI S3.22-1987 standard is an older version of the ANSI S3.22-1996 standard, discussed in Section 4.2. It is still used, however, in the labeling of hearing aids designed before March 17, 2000.

In ANSI 87, AGC aids are set at full-on gain for all measurements instead of being reduced to reference test gain, as they are in ANSI 96, and input/output measurements are only taken at 2000 Hz, as opposed to the five different frequencies offered with ANSI 96.

4.3.1 Setting up for the test

Follow the instructions found in Section 4.2.1 for instructions on setting up the aid for testing.

To enter the ANSI 87 screen:

1. From the Main Coupler Screen, look at the FP40's display above the F4 function key. If it says "AN87" (or ANSI for units with older software versions), skip to step 6.
2. Press F1 – Menu.
3. Use the AMPLITUDE and FREQUENCY knobs to select MAIN F4 under FUNCTION KEY DEFIN.
4. Press START/STOP to choose AN87 (or ANSI for units with older software versions). This will let you use the F4 function key to enter the ANSI 87 screen from the Main Coupler Screen.
5. Press F1 to return to the Main Coupler Screen.
6. Press F4 to enter the ANSI 87 screen.

To change the ANSI 87 settings:

1. Press F2 to choose the type of aid you are testing. The selections are AGC 50, LINEAR 50, LINEAR 60.
   - Choose LINEAR 60 for most linear aids.
   - Choose LINEAR 50 for high-gain aids.
   - Choose AGC for AGC aids.

   Note: If you are testing a digital aid, you should usually select AGC for this setting. However, ask the hearing aid manufacturer for guidance.
2. Press F3 to select the last frequency of the three frequency average used in the test sequence. See Section 2.4.1 for details.
3. Press F5 to turn the telecoil test off and on. The telecoil test requires the external telecoil board.
4. Press F6 to select the noise reduction used in the measurements.

5. Press F7 to select the battery type used in the measurements.
6. Press F8 to select whether or not you want to perform an equivalent input noise (EQIN also known as EIN) measurement.

   Note: The equivalent input noise measurement is difficult without a very quiet environment, especially with low gain aids.
7. Decide whether you want to test with or without the reference microphone. See Section 3.4.9 for instructions on the reference microphone.

4.3.2 Running the test sequence

1. Level the sound chamber, if necessary. See Section 3.2 for details.
2. Set up the aid for testing. See Section 4.2.1.
3. Close the sound chamber.
4. Press START/STOP when you are ready to begin the test.
5. If you turned on the telecoil test:
   a. Plug the external telecoil board into the external speaker jack on the back of the FP40.
   b. Set the aid to receive telecoil signals
   c. Position the aid and coupler on the telecoil board so that the TCOIL reading on the display is as large as possible.
   d. Press START/STOP to take the measurement.
   e. Return the aid and coupler assembly to the sound chamber, and put the aid back to microphone mode.
   f. Unplug the telecoil board.
   g. Press START/STOP to resume the test.
6. Wait for several tests to be run. For most linear aids, the analyzer will pause after performing several measurements in order for you to turn down the gain of the aid.
7. If the analyzer pauses, open the sound chamber and adjust the gain control of the aid until the HFA (or SPA) MEASURED gain matches the HFA (or SPA) TARGET gain to within 1 dB when the sound chamber is closed.
8. Press START/STOP to complete the test sequence.

4.3.3 Viewing the results

See Figure 4.3.3 for an example of ANSI 87 results

1. SSPL90: Output measurement at 90 dB SPL
2. RESP50 (or 60): Response measurement at 50 (or 60) db SPL
3. NR: Noise reduction used in tests
4. SPA/HFA: Frequencies used for the three frequency average

5. MAX: Maximum frequency response measured and the frequency at which it occurred
6. SPA/HFA SSPL90: Three frequency average of the OSPL90 curve
7. SPA/HFA FOG: Three frequency average of a full-on gain measurement at 50 (or 60) dB SPL
8. REF TEST GAIN: The measured reference test gain
9. EQ INP NOISE: Equivalent input noise
10. RESP LIMIT and F1 and F2: The response limit level and the two frequencies where the response curve crossed over this level
11. THD: The total harmonic distortion measurements
12. BATTERY: Battery current drain
13. I/O CURVE: Input/output measurement at 2000 Hz

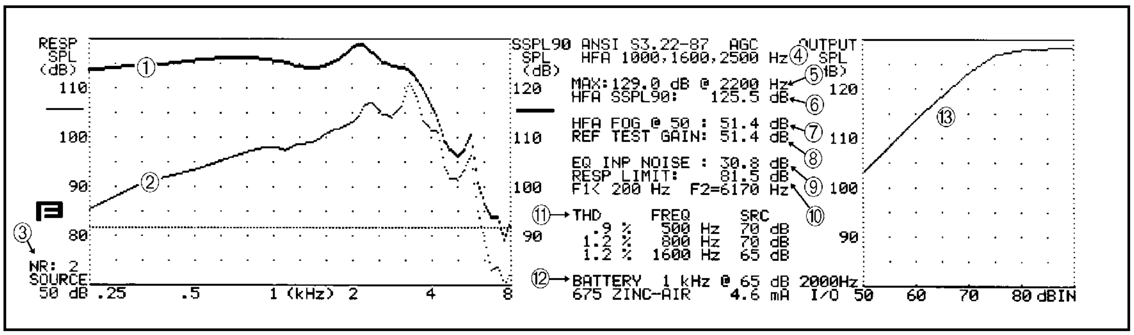


Figure 4.3.3—ANSI 87 results

4.4 ANSI S3.42-1992

The ANSI 92 test sequence is a series of tests designed for non-linear hearing aids. Although it is not used by manufacturers to label hearing aids, it can give you valuable information not present in the ANSI S3.22 labeling standard. ANSI 92 is only available if you have the Composite Option on your analyzer.

ANSI 92 uses the Composite signal to run a family of frequency responses at different input levels. The Composite signal is critical for accurate testing of non-linear hearing aids because of a well-known effect associated with pure-tone sweeps known as “artificial blooming.” When a pure-tone sweep is presented to a non-linear hearing aid, the aid’s AGC circuits can sometimes react by inflating their gain at low frequencies. This can result in inaccurate frequency response curves. This artificial blooming of the low frequencies does not occur when a broadband signal, such as the Composite signal, is used.

4.4.1 Setting up for the test

Follow the instructions found in Section 4.2.1 for instructions on setting up the aid for testing.

To enter the ANSI 92 screen:

1. From the Main Coupler Screen, look at the FP40's display above the F4 function key. If it says "AN92" , skip to step 6.
2. Press F1—Menu.
3. Use the AMPLITUDE and FREQUENCY knobs to select MAIN F4 under FUNCTION KEY DEFIN.
4. Press START/STOP to choose AN92. This will let you use the F4 function key to enter the ANSI 92 screen from the Main Coupler Screen.
5. Press F1 to return to the Main Coupler Screen.
6. Press F4 to enter the ANSI 92 screen.

To change the ANSI 92 settings:

1. Press F2 to select the desired range of input levels for the frequency response curves.
2. Press F3 to select the settling time. This is the amount of time that the analyzer presents the Composite signal before taking the measurement. You should choose a value twice the published attack specification.
3. Press F6 to choose the amount of noise reduction used for the measurements. See Section 2.4.2.2.
4. Press F7 to select the type of battery pill used. If you don't want to test the battery current drain of the aid, you can ignore this selection.

4.4.2 Running the test sequence

1. Level the sound chamber if necessary. See Section 3.2 for details.
2. Set up the aid for testing. See Section 4.2.1.
3. Close the sound chamber.
4. Press START/STOP when you are ready to begin the test.
5. Wait for several tests to be run. For most aids, the analyzer will pause after performing several measurements in order for you to turn down the gain of the aid.
6. If the analyzer pauses, open the sound chamber and adjust the gain control of the aid until the MEASURED gain matches the TARGET gain to within 1 dB when the sound chamber is closed.
7. Press START/STOP to complete the test sequence.

4.4.3 Viewing the results

See Figure 4.4.3 for an an example of ANSI 92 results.

1. NSPL90: RMS of Composite signal response curve taken at 90 dB SPL
2. FULL-ON NOISE GAIN: RMS of response curve taken with the Composite signal at 60 dB SPL minus RMS of the input signal
3. TARGET REF GAIN: Calculated reference test gain
4. ACTUAL REF GAIN: Measured reference test gain
5. CRV 5-9: Response curves at varying amplitudes
6. I/O: Input/output measurement using Composite signal

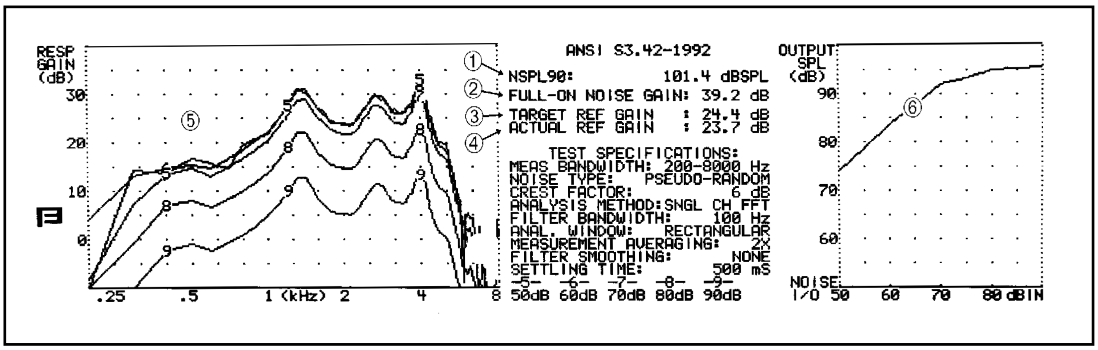


Figure 4.4.3. —ANSI 92 results

4.5 IEC

The IEC (International Electrotechnical Commission) test sequence allows you to test hearing aids according to the IEC 118-7 standard, the performance part of the IEC hearing aid standard, as amended in 1994.

4.5.1 Setting up the aid for testing

When possible, follow the procedure recommended by the hearing aid manufacturer when setting up the aid to perform an IEC test sequence. Otherwise, use the following guidelines:

- Set the controls of the aid to give the greatest possible output and gain. For AGC aids, this is usually accomplished by setting the aid for the minimum compression
- Set the aid for the widest frequency response range.
- Make sure the gain control of the aid is full-on.

Follow the instructions from Section 3.3 to set up the aid in the test box for testing.

4.5.2 Setting up the analyzer for testing

To enter the IEC screen:

1. From the Main Coupler Screen, look at the FP40's display above the F4 function key. If it says "IEC" skip to step 6.
2. Press F1 – Menu.
3. Use the AMPLITUDE and FREQUENCY knobs to select MAIN F4 under FUNCTION KEY DEFIN.
4. Press START/STOP to choose IEC. This will let you use the F4 function key to enter the IEC screen from the Main Coupler Screen.
5. Press F1 to return to the Main Coupler Screen.
6. Press F4 to enter the IEC screen.

To change IEC settings:

1. Press F2 to choose the source level for full-on gain measurements and whether or not you would like to take an I/O measurement. type of aid you are testing. The selections are AGC 50, LINEAR 50, LINEAR 60.
   - Choose 60 for most linear aids.
   - Choose 50 for high-gain linear aids.
   - Choose I/O 60 for AGC aids with the AGC circuit disabled
   - Choose I/O 50 for most AGC aids

   Note: If you are testing a digital aid, you should usually select I/O 50 for this setting. However, ask the hearing aid manufacturer for guidance.

2. Press F3 to set the reference test frequency. If possible, use the frequency recommended by the manufacturer. Otherwise, use 2500 Hz for high frequency emphasis aids and 1600 Hz for all other aids.
3. Press F5 to select the harmonic distortion test frequency.
4. Press F6 to select the noise reduction used to take the measurements.
5. Press F7 to select the battery type.
6. Press F8 to select whether or not you want to perform an equivalent input noise (EQIN also known as EIN) measurement.

   Note: The equivalent input noise measurement is difficult without a very quiet environment, especially with low gain aids.

7. Decide whether you want to test with or without the reference microphone. See Section 3.4.9 for more information.

4.5.3 Running the test sequence

1. Level the sound chamber if necessary. See Section 3.2 for details.
2. Set up the aid for testing. See Section 4.5.1.
3. Close the sound chamber.
4. Press START/STOP when you are ready to begin the test.
5. Wait for several tests to be run. The analyzer will pause after performing several measurements in order for you to turn down the gain of the aid.
6. Open the sound chamber and adjust the gain control of the aid until the MEASURED gain matches the TARGET gain to within 1 dB when the sound chamber is closed.

   Note: If you prefer, you can set the target reference gain to match the manufacturer's specifications as the IEC 118-7 standards instructs instead of using the FP40's calculated target value. However, we have never found any difficulties with using the FP40's calculated target reference gain.

7. Press START/STOP to complete the test sequence.
8. If you have chosen to measure an I/O curve, press the DATA/GRAPH button to display the measurement.

4.5.4 Viewing the results

See Figure 4.5.4 for an example of IEC results.

1. Response curve at 60 dB SPL
2. OSPL90: Measurement at the reference test gain of 90 dB SPL
3. MAX: Maximum frequency response measured and the frequency at which it occurred
4. REFERENCE TEST GAIN CALCULATED
5. REFERENCE TEST GAIN MEASURED
6. TOTAL HARMONIC DISTORTION
7. EQIV INPUT NOISE: Equivalent input noise
8. BATTERY: Battery current drain
9. OSPL90 Curve: Response curve taken at 90 dB SPL
10. FOG 50: Full-on gain response curve taken at 50 (or 60) dB SPL
11. I/O curve: Input/output measurement taken at the reference test frequency

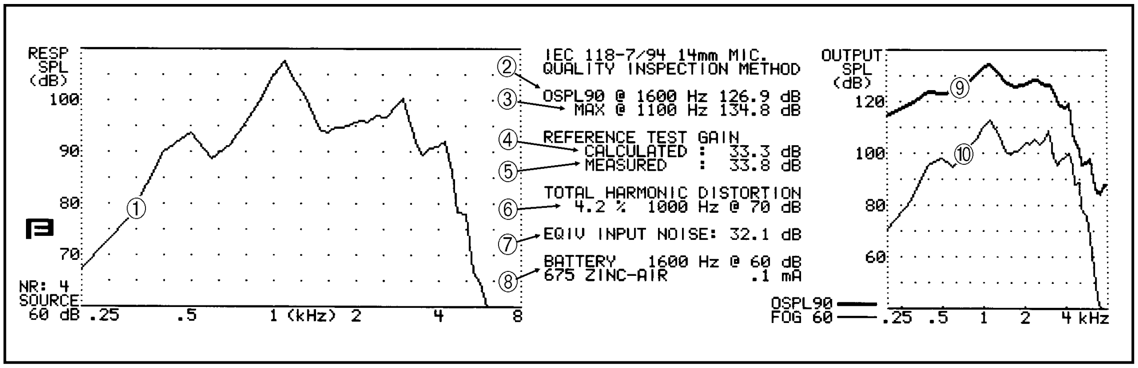


Figure 4.5.4—IEC results

4.6 Profiler

The Profiler is an automated test sequence designed to tell you all the important information about the hearing aid in a very short period of time. It was originally modeled after the ANSI 92 test sequence, but it was expanded the test to also include the most useful measurements from ANSI 87/96. This gives you a complete picture of the hearing aid, allowing you to quickly determine whether the aid is in need of replacement or repair, or whether it has been programmed correctly.

The Profiler is run at the normal user settings for almost all the measurements, eliminating the time and effort required to put the aid in "test" mode.

4.6.1 Setting up for the test

To enter the Profiler screen:

1. From the Main Coupler Screen, look at the FP40's display above the F4 function key. If it says "PROF" skip to step 6.
2. Press F1 – Menu.
3. Use the AMPLITUDE and FREQUENCY knobs to select MAIN F4 under FUNCTION KEY DEFIN.
4. Press START/STOP to choose PROF. This will let you use the F4 function key to enter the Profiler screen from the Main Coupler Screen.
5. Press F1 to return to the Main Coupler Screen.
6. Press F4 to enter the Profiler screen.

To change the Profiler's settings:

1. Press F2 to choose the type of source signal used for the speech curves. You have a choice of Composite (COMP), Digital Speech ICRA (DSPI), and Digital Speech ANSI (DSPA).

2. If you have chosen DSPA or DSPI in step 1, select the length of time each speech curve will be presented with F3.
3. Select the type of equivalent input noise measurement taken with F5. The HFA/SPA/IEC selections use a three frequency average to obtain the EIN. RMS uses a root-mean-square average to take the measurement.
4. Choose the amount of noise reduction used in the soft speech curve with F6.
5. Choose the battery type with F7.

4.6.2 Running the test sequence

1. Level the sound chamber if necessary. See Section 3.2 for details.
2. Set the aid to normal user settings. If the aid has a volume control, it should be set to the setting most used by the client.
3. Attach the aid to the appropriate coupler and place it in the sound chamber.
4. Close the door of the sound chamber.
5. Press START/STOP to begin the measurement.
6. After taking most of the measurements, the analyzer will pause. If the aid has a volume control, use it to turn the aid to full-on gain and press START/STOP to complete the test. Otherwise, press the DATA/GRAPH button to end the test.

4.6.3 Viewing the results

See Figure 4.6.3 for an example of a Profiler test sequence.

1. OSPL90: Pure-tone sweep at 90 dB SPL
2. Total harmonic distortion measurements
3. MAX OUT: Maximum output from the OSPL90 measurement
4. NOISE RED: Noise reduction used for soft measurement curve
5. CRV GAIN: RMS of the medium speech curve or overall average gain of the aid
6. EQ INP NOISE: Equivalent input noise and the type of measurement used to take it
7. BATTERY: Battery current drain
8. S, M, and L: Soft, medium, and loud speech curves taken at 50, 65, and 80 db SPL respectively
9. R: Full-on gain response curve taken at 65 dB SPL

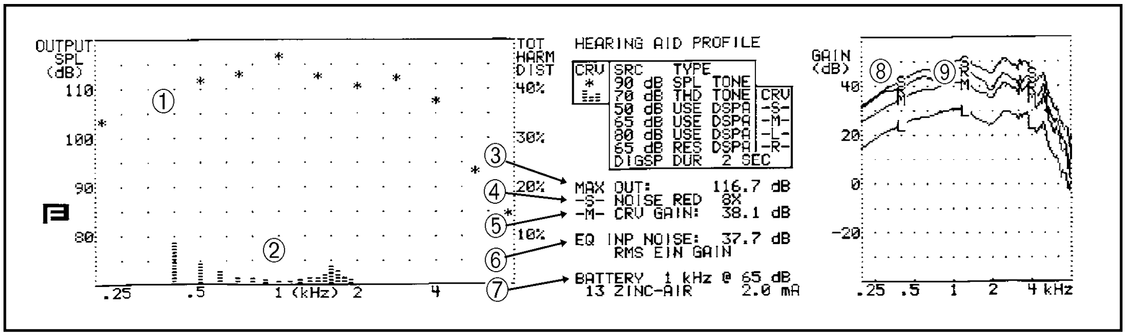


Figure 4.6.3—Profiler results

4.7 ACIC

The ACIC test sequence is the ANSI 87 test sequence with CIC correction factors. Follow the instructions in Section 4.3 to run the ACIC test sequence. Make sure to use a CIC coupler.

The ACIC test sequence is for informational puproses only. It cannot be used for comparison to manufacturer's specifications, which assume a 2-cc coupler.

Chapter 5: Real-Ear Measurements

The Probe Option of the FONIX FP40 allows you to test hearing aids in the client's ear, also known as real-ear measurements. There are three real-ear measurement screens: Insertion Gain, SPL, and Audibility Index. Each display presents different format from which to evaluate your hearing aid fitting. There is also a Target 2-cc coupler screen that lets you take coupler measurements and compare them to appropriate targets. The available test stimuli include pure-tone sweeps, the Composite signal, the Digital Speech signals, and live speech (in spectrum analysis mode).

To take real-ear measurements, the FP40's build-in sound chamber converts easily to a sound field speaker. The larger microphone of the M200 dual microphone set, used as the measurement microphone in coupler measurements, turns into a reference microphone for real-ear measurements. The smaller microphone of the dual microphone set, used as a reference microphone when taking coupler measurements, turns into the measurement microphone when taking real-ear measurements.

5.1 Preparation for Real-Ear Measurements

There are two steps to set up for a real-ear measurement. In the first step, you set the analyzer up for testing. In the second step, you set the client up for testing with the analyzer. Once this is done, you're ready to take the real-ear measurements.

5.1.1 Setting up the analyzer for testing

To set the analyzer up for testing, you need to prepare the microphones and set up the sound field speaker.

5.1.1.1 To set up the microphones and monitor headset

If not already in place, slide the Velcro mounting sleeves onto the reference and probe microphones. See Figure 5.1.1.1.

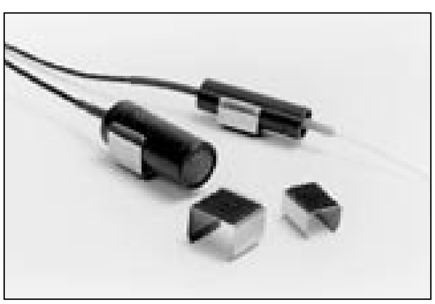


Figure 5.1.1.1—Attaching the mounting sleeves

Plug in the monitor headset if you want to be able to "listen in" on the sound received in the client's ear. The monitor jack, marked "headphones" is found on the back of the FP40. The volume on the headphones is controlled with the knob next to the jack.

5.1.1.2 To set up the internal sound field speaker

Remove the test box from the FP40 compartment:

- Lift the compartment lid on the right side of the FP40 and remove the foam coupler holder. The test box is secured in the compartment with an interlocking stop in the back, a spring catch in front, and velcro on the bottom. See Figure 5.1.1.2A.

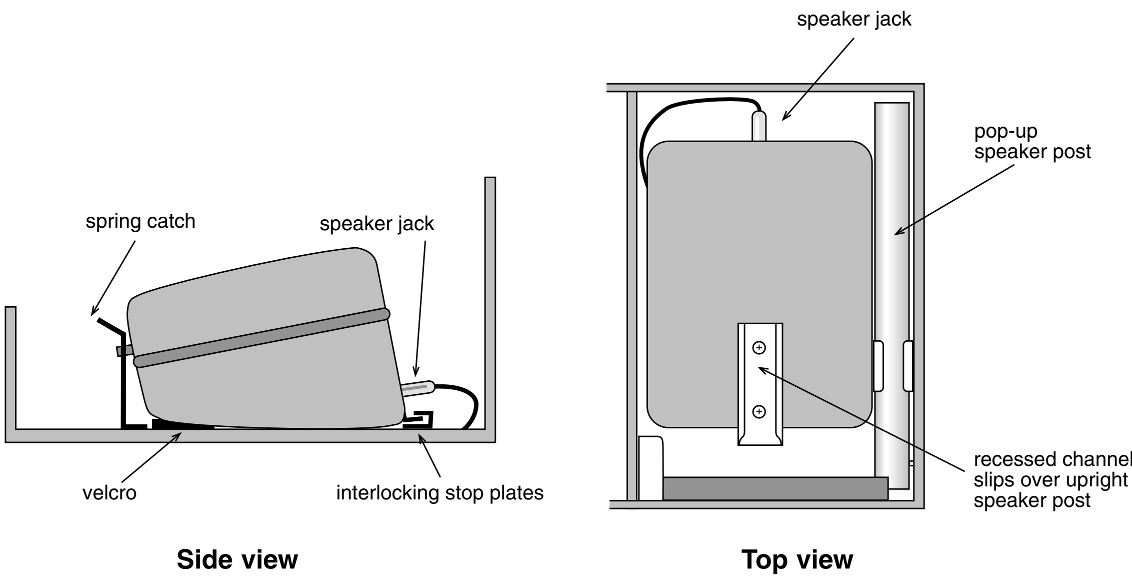


Figure 5.1.1.2A—Sound chamber/sound field speaker

- Release the front spring catch of the sound chamber by pulling it forward.
- Lift the test box up and forward to remove it from the compartment. There will be a little resistance from the velcro on the bottom.

Install the test box/speaker on the metal post

- Locate the metal post on the right side of the compartment.
- Pull the far end of the post up and forward until it locks in the vertical position.
- Open the test box and mount the speaker on the pole. The recessed metal channel on the outside of the box slides over the upright pole. See Figure 5.1.1.2B. The speaker is now ready for real ear testing.

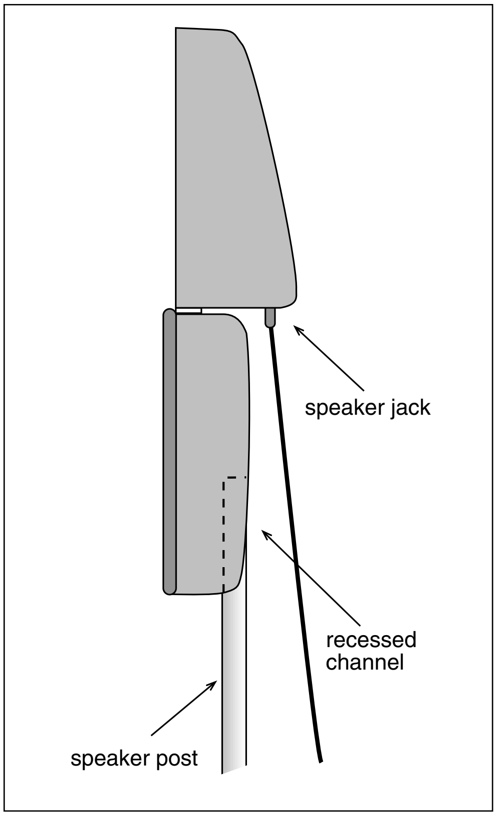


Figure 5.1.1.2B—Upright sound field speaker

Note: Do not close the chamber while it is on the post. In a closed position it may accidentally fall off.

You may find it most convenient to position the FP40 at one edge of a table. If the client is seated at the side of the table, the speaker can be rotated so that the correct angle for testing is very easily achieved. See Figure 5.1.2.1.

Replace the test box/speaker when test is complete

- Remove the test box/speaker from the post and close it.
- The upright post is locked in place with a spring catch. Pull the catch outward to release the post and return it to the horizontal position.
- Make sure all cables in the compartment are put away so they will not interfere with replacing the test box.
- Set the test box back in the compartment, interlocking the back stop plates. As you do this, guide the speaker wire so it stays to the side of the test box, not underneath it. Press down on the front of the test box to snap the front catch in place.

5.1.1.3 To set up an external sound field speaker

If you have a permanent location for your analyzer, you may find it more convenient to use an external sound field speaker for your real-ear measurements. This external sound field speaker can be mounted on either a floor stand or a swing arm. See Figure 5.1.1.3 for an example of the swing arm setup.

When performing real-ear measurements, plug in this sound field speaker to the jack on the back of the FP40 labeled “External Speaker.”

Figure 5.1.1.3—External speaker setup

5.1.2 Setting up the client for testing

To set up the client for testing, you need to position the client in relation to the sound field speaker, place the earhook and the reference microphone appropriately, insert the probe tube, and level the sound field speaker.

5.1.2.1 To position the sound field speaker

The sound field speaker should be about 12 inches (30 cm) from the surface of the client’s head (near the temple) and pointing toward the ear to be tested. We recommend 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 5.1.2.

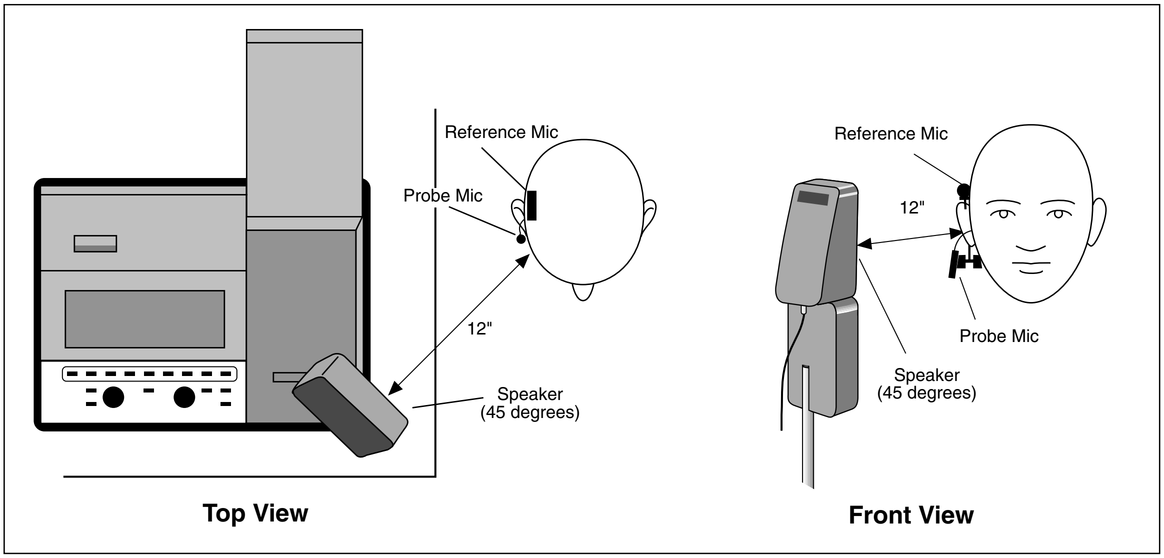


Figure 5.1.2.1—Positioning of the sound field speaker for real-ear measurements

5.1.2.2 To place the earhook and reference microphone

1. Place the wedge-style earhook on the client's ear. Alternately, place an earhook (without a wedge) on the client's ear, and place the Velcro headband around the client's head.
2. Attach the reference microphone, facing forward, on the wedge of the earhook, directly above the ear to be tested. The reference microphone should be as close to the head as possible. See Figure 5.1.2.2.
3. Adjust the round Velcro pad on the wedge style earhook by turning it, so that the inside pad fits firmly against the client's neck.

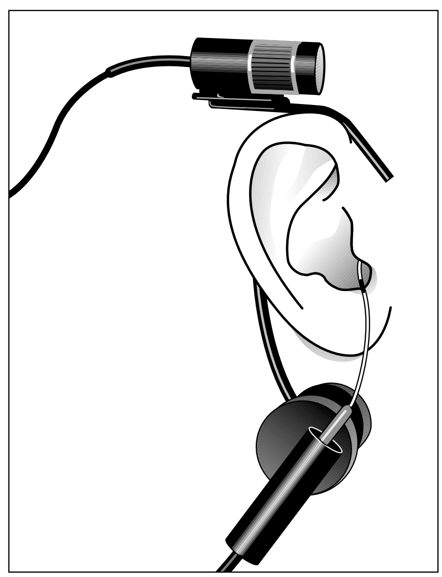


Figure 5.1.2.2—Placing the reference microphone

5.1.2.3 To insert 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 (1/5 inch) 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 5.1.2.3A.
4. Attach the probe tube to the body of the probe microphone.
5. Attach the probe microphone to the round Velco 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. See Figure 5.1.2.2

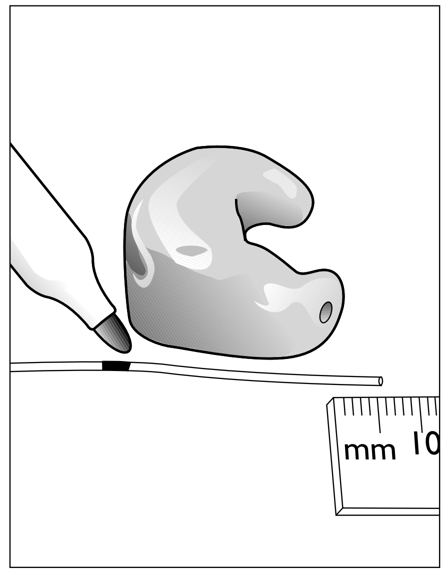


Figure 5.1.2.3A—Marking the probe tube

Method 2

This method is easiest if you have the Composite Option. It uses the fact that there is a dip in gain caused by a standing wave created by the 6 kHz frequency reflecting off the eardrum.

1. Press F5 to enter Probe Mode.
2. Press F7 to select the Composite signal. You may have to press the button repeatedly.
3. Press START/STOP to start a measurement.
4. Insert the probe tube carefully, looking at the composite measurement. At some point, there will be a large dip at 6 kHz caused by the standing wave inside the ear. Keep inserting the probe tube until that dip goes away. See Figure 5.1.2.3B.

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.

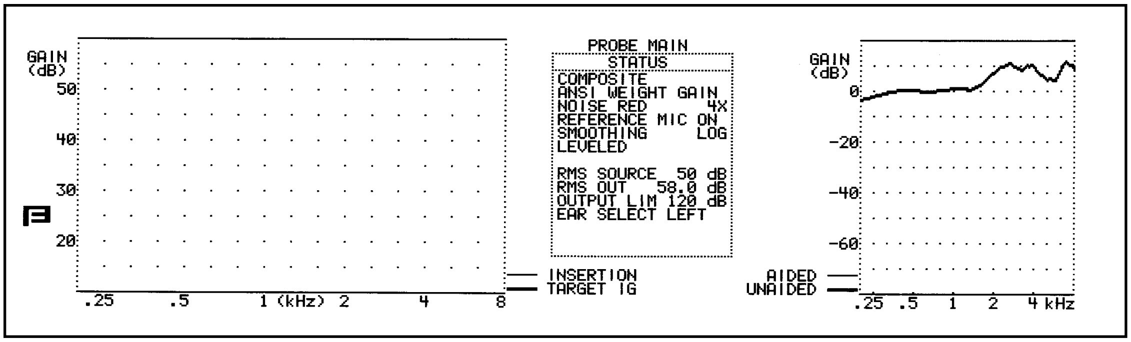


Figure 5.1.2.3B – Unaided response with correct insertion of the probe tube

5.1.2.4 To level the sound field

Leveling is a process that takes into consideration all the inconsistencies in the sound field. In order to get accurate measurements, it is critical that the sound field is leveled for every patient and every ear. The leveling process only uses the reference microphone placed above the client's ear. It does not use the probe microphone, so it doesn't matter whether you insert the probe tube before or after you level the sound field speaker.

If you have the Composite Option, leveling is done with a flat-weighted composite signal and takes just a few seconds. If you don't have the Composite Option, leveling is done with a pure-tone sweep, taking slightly longer than composite leveling.

1. Position the client in front of the sound field speaker as described in Section 5.1.2.1.
2. Position the earhook and reference microphone as described in Section 5.1.2.2.
3. Enter the real-ear measurement screen by pressing F5 from the Coupler Screen.
4. Press LEVEL and START/STOP. This will attempt to level the sound field speaker.

If leveling is achieved, the word LEVELED will appear in the Status box. See Figure 5.1.2.4. If leveling is not achieved, the word UNLEVELED will appear in the Status box. There is an intermediate stage where neither LEVELED or UNLEVELED appears. Pushing the LEVEL and START button again will often produce the desired leveling.

The client must be in the same position for leveling and real-ear testing.

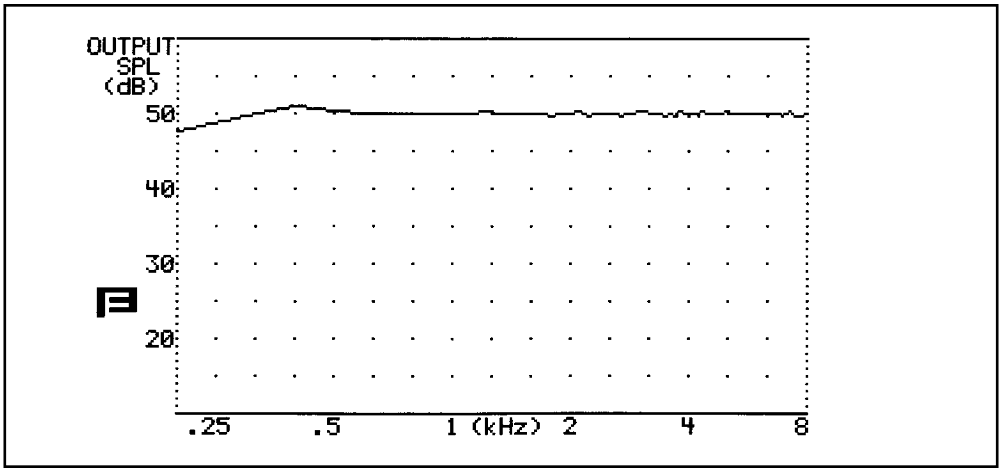


Figure 5.1.2.4—Leveling the sound field speaker

5.2 The Target Screen

The Target screen is used to enter the patient's threshold and uncomfortable levels, select a fitting rule, and create a target. You can modify most real-ear targets in this screen to fit the specific needs of your client. (DSL targets cannot be modified.)

5.2.1 Viewing the target screen

See Figure 5.2.1 for an example of the target screen. If the target screen is entered while the real-ear screen is in SPL display mode (see Section 5.4), you will not see the insertion gain graph on the left side of the display.

WARNING:

Choose OUTPUT LIMITING carefully (see procedure below). You do not want to damage your client's hearing or cause them discomfort during testing. To ensure safety and comfort, the FP40 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 "PROBE OUTPUT LIMIT EXCEEDED" appear on the screen, and the program automatically stops.

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, we recommend extreme caution when using pure tones for "in-situ" SSPL measurements.

Whenever the output limiting function has stopped the test signal, you must either turn down the hearing aid, lower the source SPL, or change the output limit.

To view or change the OUTPUT LIMITING setting:

1. Push F1 [SETUP MENU].
2. Use the AMPLITUDE & FREQUENCY knobs to move the cursor to PROBE PARAMETERS — OUTPUT LIMITING
3. Use the [START/STOP] button to choose the desired limit.
4. Return to PROBE by pushing F1 [EXIT MENU].

SANITATION NOTICE

DO NOT REUSE PROBE TUBES.

Use a new probe tube for each ear to prevent the possible spread of infection. Sterilization of probe tubes is not possible, and germicidal solutions can leave a residue inside the tubing which can result in errors. Do not cut off any portion of the tube.

DO NOT REUSE INSERT EARPHONE EARTIPS

Insert earphone eartips are used primarily for performing RECD and audiometric measurements. Sterilization of these eartips is not possible. When performing these measurements, make sure to use a new ear tip for each patient.

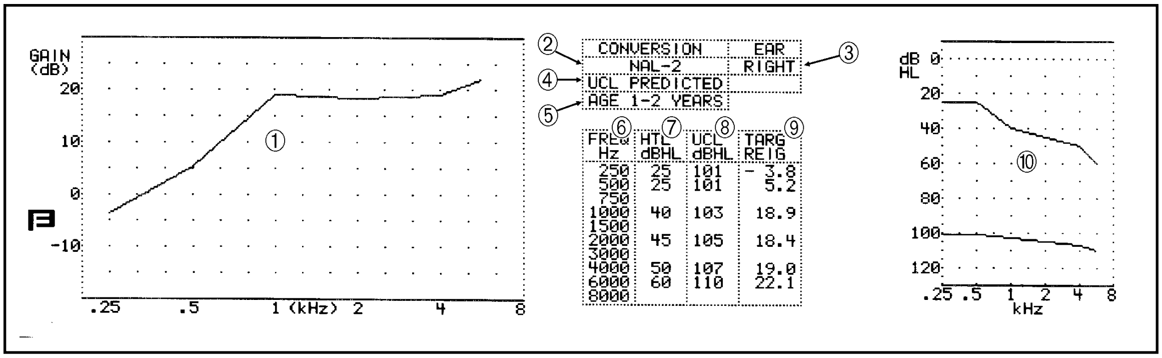


Figure 5.2.1—The Target screen

1. Insertion gain target graphical display.
2. Fitting rule used in generation of the target.
3. Chosen ear.
4. UCL status: predicted or measured.
5. Age of client.
6. Frequency column.
7. HTL data for corresponding frequencies.
8. UCL data for corresponding frequencies. UCLs can be predicted or measured.
9. Insertion gain target data. (DSL LIN and DSL WDRC targets not displayed in this column)
10. HL graphical display for HTL and UCL data.

Note: If DSL WDRC is the chosen fitting rule, the compression threshold will also be displayed, next to the UCL status at the top of the screen.

5.2.2 Creating a target

1. Press F5 to enter the real-ear measurement screen from the Main screen.
2. Press F2, if necessary, to highlight SPL (SPL-o-gram), IG (Insertion Gain), or AI (Audibility Index) as the real-ear measurement type. Note: You must select SPL here to create DSL targets.
3. Press F4 to enter the target screen.
4. Press F1, if necessary, to select the desired ear.
5. Look at the label above F2. HTL should be highlighted. If not, push F2 to highlight HTL.

6. Use the FREQUENCY and AMPLITUDE knobs to input the hearing threshold levels for the selected ear. The numerical values will appear in the HTL dB HL column in the table just to the right of the large graph. As you enter the HTL values, the smaller graph on the right side of the screen will be updated.
7. Press F2 to highlight UCL if you would like to enter measured UCL values using the FREQUENCY and AMPLITUDE knobs. If you would like the analyzer to predict these values from the client's threshold values, skip this step.
8. Press F3 to select the desired fitting rule.
9. Press F6 to select the client's age if the client is a child. If the client in an adult, you can skip this step.
10. Press F5 to generate the target. Predicted UCL values are also generated if you have not entered any measured values.

Notes:

- If you are only going to perform insertion gain measurements, there is no need to input the UCL or age values. They are not used in the insertion gain measurement method.
- If you selected IG in Step 2 of the above instructions, an insertion gain graph will appear on the left side of the target screen. When you generate the target, as described in Step 10, the insertion gain target will be displayed on that graph.
- If you have selected the DSL WDRC fitting rule, you can use F2 to select CT and the AMPLITUDE knob to modify the compression threshold status. The compression threshold is displayed at the top middle part of the screen, next to the UCL status.
- The fitting rule NAL-2 is often referred to as NAL-R in other hearing aid analysis systems.
- It is sometimes useful to clear threshold values. To do this, use F2 to select HTL. Next, press F8 to clear the threshold values. You can also use this method for clearing UCL values and targets.
- It is possible to print the target screen with or without a label. Use F9 to toggle whether or not you want any printouts to include a label.

5.2.3 Setting the default target

If you consistently use the same fitting rule, you may set it as your analyzer's default. To do this, select the desired fitting rule with F3 in the Target screen. Next, press START/STOP. You will see a WAIT message appear on the screen momentarily. When this message disappears, the selected fitting rule is stored as the default.

5.2.4 Creating your own target

Advanced users may want to be able to input their own targets, without applying any particular fitting rule. To do this:

1. Use F3 to select DIRECT.
2. Press F5. This will clear any existing targets and put you in a target editing mode.
3. Use the AMPLITUDE and FREQUENCY knobs to generate your own insertion gain target. (You cannot input target values in terms of dB SPL.)

5.2.5 Modifying an existing target

All non-DSL targets can be modified. To modify an existing target:

1. Generate the target as described in Section 5.2.2.
2. Press F2 until TAR is highlighted.
3. Use the AMPLITUDE and FREQUENCY knobs to make any desired modifications. The target will be labeled with a note denoting that it has been modified. See Figure 5.2.5.

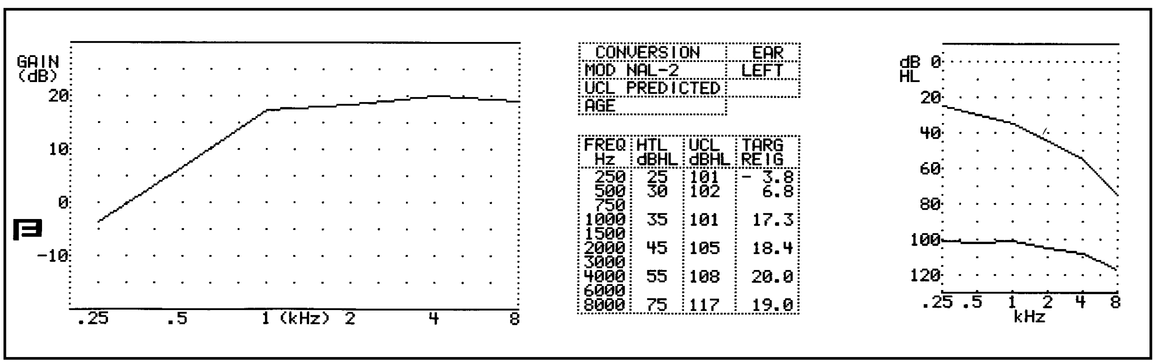


Figure 5.2.5—Modifying an existing target

5.3 Insertion Gain Measurements

The insertion gain test shows you how much gain the hearing aid is providing above the ear's natural resonance. When performing an insertion gain measurement, you enter your client's thresholds to create a target, take the unaided response, take the aided response, and compare the insertion gain response to the insertion gain target, adjusting the hearing aid accordingly.

5.3.1 Viewing the Insertion Gain screen

Here is an picture of the Insertion Gain screen.

1. Insertion gain graph
2. Source type for current curve
3. Noise reduction status for current curve
4. Reference microphone status
5. Smoothing status
6. Leveling status
7. RMS source level used to take measurement
8. RMS of the current curve. Not available with pure-tone source types.
9. Output limit status
10. Selected ear
11. Fitting rule used to create insertion gain target
12. Graph containing unaided and aided gain responses

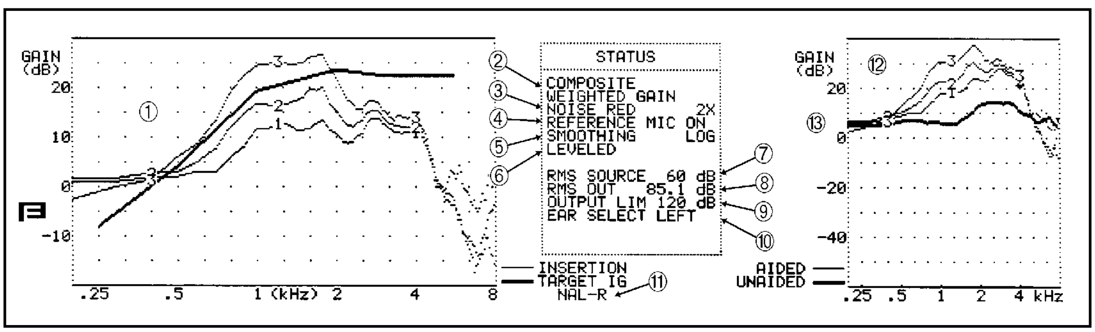


Figure 5.3.1—Insertion Gain display

5.3.2 Taking an unaided response

The unaided response is the first step in the insertion gain measurement procedure.

1. Enter the Probe Mode by either pressing F5 from the Main screen or F4 from the Target screen.
2. Look at the label above F2. IG and UNAIDED should be selected. If not, press F2
3. Position the client in front of the sound field speaker, insert the probe microphone, and perform the leveling procedure. This is described in Section 5.1.2.

4. Select the desired source with F7. Use either NORM (for a pure-tone sweep), or COMP (for a composite signal).
5. Use the AMPLITUDE knob to select the desired amplitude. Unaided measurements are usually made with 65 or 70 dB SPL.
6. Press START/STOP to start the measurement. If you are using a composite source, press START/STOP again when the measurement stabilizes to stop the measurement. See Figure 5.3.2.

The analyzer will automatically set itself up for an aided measurement. To perform another unaided measurement, press F2 to select UNAIDED again.

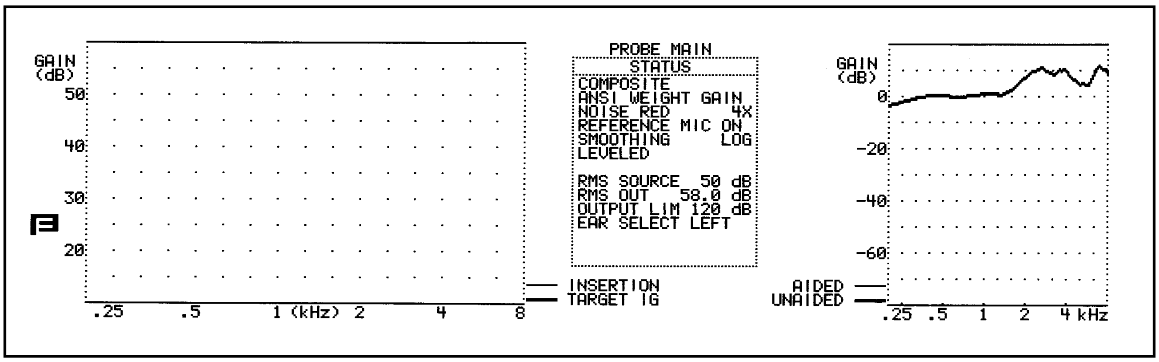


Figure 5.3.2—The unaided response

Note: Every time you leave the insertion gain screen to go to the menu or the target screen, unaided will automatically be selected when you return to the insertion gain screen.

5.3.3 Taking an aided response

The aided response is the second step in the insertion gain procedure.

1. Insert the aid into the ear, making sure the probe tube remains in position.
2. Look at the label above F3. AIDED 1 should be highlighted, assuming you followed the instructions from Section 5.3.2.
3. Select the source type with F7. See Section 2.4 for an explanation of source types.
4. Set the source level by using the AMPLITUDE knob.
5. Press START/STOP to start the measurement. The aided response will appear on the small graph on the right, and the insertion gain response will appear on the larger graph on the left. If a composite, Digital Speech, or fast pure-tone sweep is being used as the source type, press START/STOP to stop the measurement once it has stabilitized.

6. Press F3 to select Aided 2, and repeat steps 3-5 to perform another measurement. A third aided response may be run in a similar fashion.

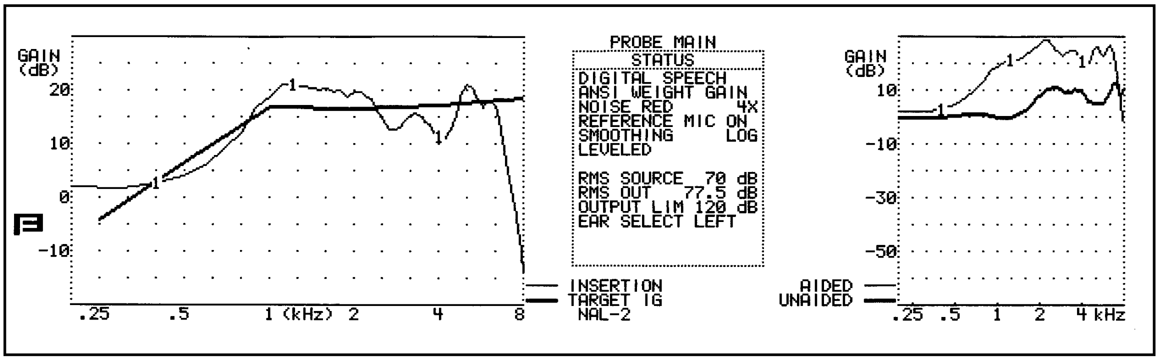


Figure 5.3.3—The aided response

Other functions

- Turn on/off the display of the selected aided curve by pressing F6.
- Clear all measurement curves by pressing F8.
- Set the OUTPUT LIMIT under PROBE SETTINGS in the Menu screen. This sets how loud a signal the probe microphone will level without automatically shutting down the sound field speaker to protect the client. Enter the Menu screen by pressing F1. Use the AMPLITUDE and FREQUENCY knobs to select the setting, and use the START/STOP button to toggle the desired selection.
- Use the F9 button to toggle whether or not you want a label included with a real-ear measurement printout.

5.3.4 Viewing insertion gain

Insertion gain is the difference between the unaided response and the aided response. In other words, it is the amount of amplification provided by the hearing aid, not including the natural amplification of the unaided ear.

If you have created a target, as described in Section 5.1, it will be displayed as a thick solid line in the large graph on the left side of the real-ear insertion gain screen. Any measured insertion gain responses will be displayed as thinner lines on the same graph. You can display up to three different insertion gain measurements at the same time. See Figure 5.3.1 for a view of the insertion gain display.

5.3.5 Testing Open Fit Hearing Aids

Open fit hearing aids have been known to interfere with the reference microphone measurement outside the ear. To determine if a particular hearing aid is interfering with the reference microphone, perform the following measurement in the insertion gain screen. The feedback cancellation and other features normally used by the patient should be enabled on the hearing aid.

1. Measure the aided response as described in Section 5.3.3.
   - The sound field speaker should be LEVELED.
   - The reference microphone setting should be ON. The reference microphone status is displayed in Status box.
   - [F3] should be set to AIDED 1.
   - The source amplitude should be set to 65 dB SPL. Use the Amplitude knob to adjust the source if necessary.
   - [F7] should be set to DIGSP ANSI or COMPOSITE.
2. Press [START/STOP] to start the measurement. Press [START/STOP] again when the measurement has stabilized.
3. Use [F3] to select AIDED 2
4. Press [F1] to open the menu. Use the Amplitude and Frequency knobs to select REFERENCE MIC under PROBE SETTINGS. Press [START/STOP] to change the setting to OFF. Press [F1] to return to the Insertion Gain screen..
5. Measure the aided response as described in Section 5.3.3.
   - The source amplitude should be set to 65 dB SPL. Use the Amplitude knob to adjust the source if necessary.
   - [F7] should be set to the source type used in Step 1.
6. Press [START/STOP] to start the measurement. Press [START/STOP] again when the measurement has stabilized.
7. Look at the difference between AIDED 1 and AIDED 2.

If there is no more than 2 dB of difference between AIDED 1 and AIDED 2 at any frequency, you can perform real-ear measurements using that particular model of open ear hearing aid without adjusting the hearing aid analyzer. If the two measurements are different by 3 dB or greater at any frequency, it is recommended to disable the reference microphone when performing REMs using this type of device. To disable the reference microphone, follow the instructions found in Step 4 above.

When performing a real-ear measurement while the reference microphone is disabled, it is particularly important to make sure the patient doesn't move after the sound field speaker has been leveled because the reference microphone will not be able to compensate for any changes in the patient's position.

5.4 SPL Measurements (including real-ear DSL)

The real-ear SPL screen permits the user to view all the major components of the hearing loss and the hearing aid fitting on one SPL screen with real ear measurements. The hearing thresholds and uncomfortable loudness levels, which are generally measured in HL, are converted to SPL. Target insertion gains are also converted to dB SPL. Provision is made to show three aided responses, in SPL, at three different source amplitude levels. Having all this information in a common format provides a convenient way to view the hearing loss and the amplification solution provided without the confusion of different frames of reference.

5.4.1 Understanding the SPL approach

The idea behind the real-ear SPL screen is to run three aided response measurements on each hearing aid. (Unaided measurements are not necessary in the SPL approach.) These measurement curves are to make sure:

- soft sounds are audible (AIDED 1)
- moderate sounds are comfortable and meet the target (AIDED 2)
- loud sounds do not exceed the user's uncomfortable loudness level (AIDED 3)

The factory default amplitudes used in this program are generally 50, 65 and 90 dB. (Sometimes this differs, depending on the default fitting rule and the configuration of the analyzer.) The user may choose other amplitude levels while conducting the tests. To change the level of the SPL target, modify the amplitude and source type of AIDED 2.

As with other SPL measurements, the reference microphone is turned off during this test. Sound field leveling is still necessary but extra care should be taken by the client not to move around once leveling has been achieved.

Some notes on the SPL display:

- When a pure tone or warble signal sweep is chosen for the SPL test type, it is always speech weighted (unless the amplitude is 85 dB or above). The target is also speech weighted. The measurements and the target will therefore look different from the insertion gain targets that have been commonly used. The speech weighting makes the shape of the pure tone and warble curves conform to that of the composite signal.
- The same target formulas that are used with the Insertion Gain program; NAL-2, Berger, POGO, 1/2 Gain, 1/3 Gain, and 2/3 Gain are available for the SPL approach. **All targets are converted to real-ear SPL by including the AIDED 2 source and the average unaided ear canal into the calculation.** Whenever you change the source amplitude of AIDED 2, the target will change. The target is intended to be at the user's Most Comfortable Level.
- The reference microphone is automatically disabled in the SPL screen. Therefore, no particular adjustment needs to be made to the FP40 analyzer to test open fit hearing aids.

5.4.2 Understanding the specifics of DSL

The Desired Sensation Level (DSL) method is a hearing aid selection and fitting approach with the goal of making amplified speech audible. The desired sensation levels for amplified speech are determined at each frequency for all degrees of sensorineural hearing loss. The DSL method is not an insertion gain formula approach (i.e. NAL, POGO), but it does use probe microphone instrumentation as well as 2-cc coupler measurements in the test box. DSL was originally developed for use with children and later expanded to include adults.

In order to perform a DSL real-ear fitting, follow the general SPL instructions found in Section 5.4.4. Make sure to select DSL WDRC or DSL LIN when generating the target. In order to perform DSL coupler measurements, including real-ear to coupler difference (RECD) measurements, follow the instructions found in Section 5.6.

When DSL is the selected fitting method, the FP40 makes several accommodations in the real-ear and target screens. These accommodations happen automatically, so you don't really have to worry about them, but it's useful to know what's going on.

When DSL is selected:

- The Composite signal is weighted using the adult or child long-term average speech spectrum (LTASS) instead of the normal ANSI weighting. Keep this in mind if comparing real-ear DSL measurements to measurements made with a different type of target.
- The Digital Speech signal is weighted using the adult or child LTASS instead of ANSI or ICRA speech weighting. The Digital Speech source selection is denoted as DIGSP LTASS to reflect its speech weighting.
- A "speech banana" appears on the real-ear SPL screen along with the target, HTL, and UCL data. This speech banana disappears when a measurement is taken, in order to cut down on the number of lines on the screen at the same time.
- There is a CT (compression threshold) selection in the target screen with DSL WDRC is the selected fitting rule. This does not apply for DSL LIN.
- There are no corresponding insertion gain targets since DSL is not meant to be viewed in terms of insertion gain.
- There is no way to edit a real-ear DSL target.

Figure 5.4.2 shows an example of the real-ear SPL screen with a DSL target.

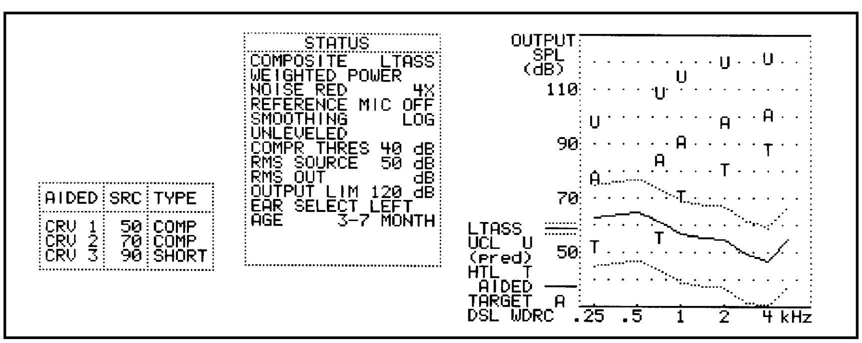


Figure 5.4.2—Real-ear SPL screen using a DSL WDRC target

5.4.3 Viewing the SPL screen

See Figure 5.4.3 for a picture of the SPL testing screen.

1. Curve box containing the source type and amplitude of each of the three measurement curves.
2. Source type for current curve
3. Noise reduction status for current curve
4. Reference microphone status
5. Smoothing status
6. Leveling status
7. RMS source level used to take measurement
8. RMS of the current curve. Not available with pure-tone source types.
9. Output limit status
10. Selected ear
11. Selected age of client
12. SPL graph for aided measurements, HTL, UCL, and AIDED 2 target
13. UCL values shown in dB SPL
14. Target for AIDED 2 shown in dB SPL
15. HTL values shown in dB SPL
16. Selected fitting rule

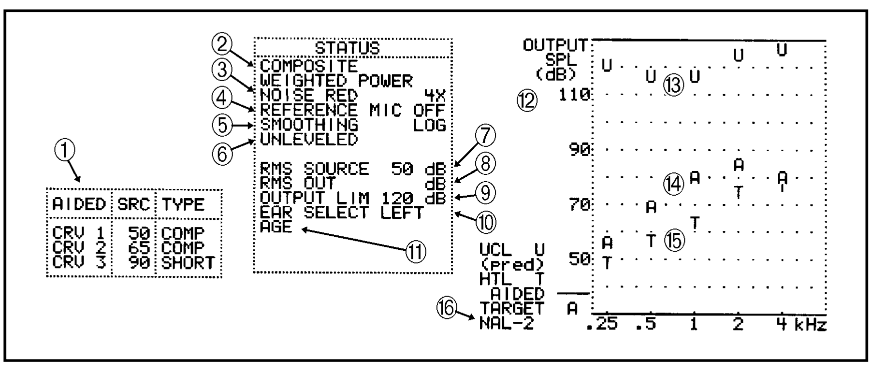


Figure 5.4.3—SPL Testing screen

5.4.4 Taking the SPL measurements

1. Create the real-ear target, if desired, by following the instructions found in Section 5.2. Make sure to choose SPL in step 2 of that section.

2. Set up the client, insert the probe tube, and level the sound field speaker as described in Section 5.1.
3. Insert the client's hearing aid into the ear, making sure not to dislodge the probe tube.
4. Select the desired source type with F7. See Section 2.4 for a discussion of source types.
5. Select the desired amplitude for the first aided measurement by using the AMPLITUDE knob. We recommend a soft speech level such as 50 dB SPL.
6. Press START/STOP to start the measurement. If you are using a composite, fast pure-tone, or Digital Speech signal, you will have to press START/STOP again to stop the measurement when it stabilizes. This "soft speech" measurement curve should exceed the patient's threshold levels, enabling the patient to hear soft speech.
7. Press F3 to select AIDED 2.
8. Select the source level with the AMPLITUDE knob. We recommend using 60-70 dB SPL for a medium speech level measurement. Normally, this measurement will be taken with the same source type used in the first aided measurement curve.
9. Press START/STOP to start the measurement. If you are using a composite, fast pure-tone, or Digital Speech signal, you will have to press START/STOP again to stop the measurement when it stabilizes. This "medium speech" measurement curve should meet the target, enabling the patient to hear normal speech.
10. Press F3 to select AIDED 3.
11. Use F7 to select the source type. Since AIDED 3 is usually done at 90 dB SPL, we recommend the SHORT pure-tone sweep. This will ensure that the pure-tone signal is fully 90 dB SPL at each frequency (not speech weighted), and that the client will be subjected to the loud noise for only a short period of time.
12. Use the AMPLITUDE knob to select the desired amplitude. We recommend using 90 dB SPL as a loud test signal.
13. Press START/STOP to take the measurement. If you are using a short pure-tone signal as recommended, the sweep will only be performed once; you will not need to press START/STOP again unless you want to repeat the measurement.

You now have a good picture of the hearing aid fitting and how the hearing aid responds to signals at soft speech, medium speech, and loud levels. See Figure 5.4.4.

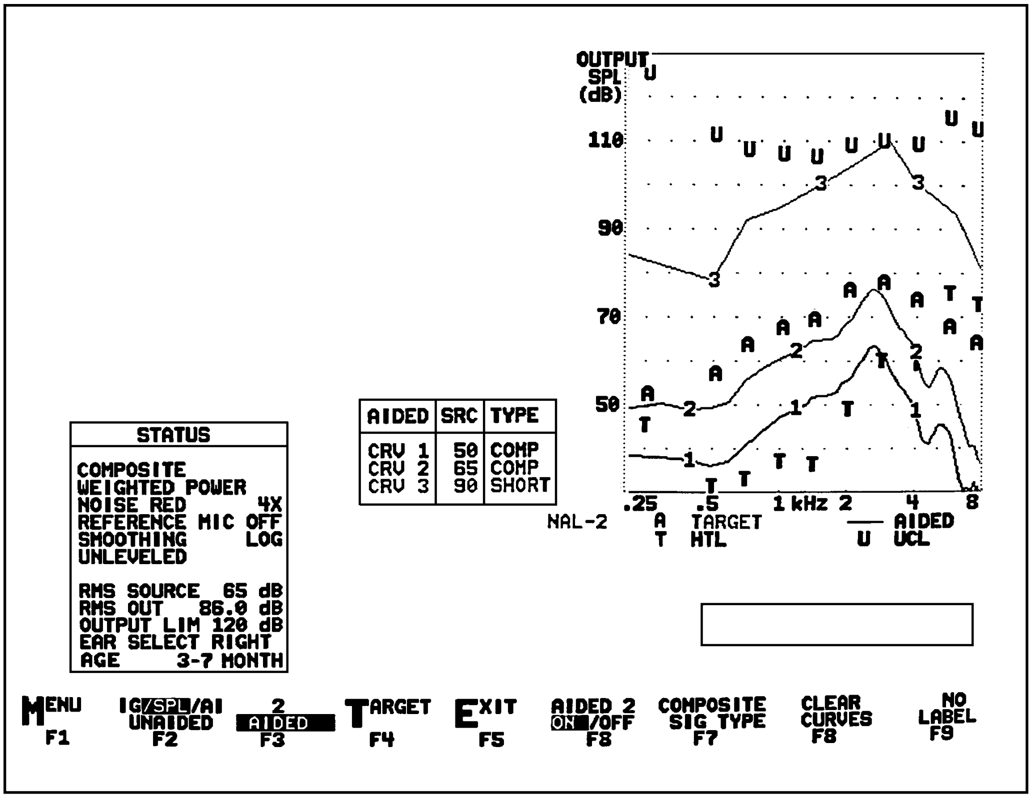


Figure 5.4.4—SPL screen displayed on an external monitor

5.5 Audibility Index (AI)

The Audibility Index screen displays the audiogram, target, and aided response in dB HL on one display. Technically speaking, these aided responses should be called “aided audiograms” because they incorporate the insertion gain obtained by making unaided and aided measurements. This insertion gain is then added to the unaided audiogram to obtain the curves shown on the HL display.

The Audibility Index shows you what percentage of speech sounds are audible to the client with the aided audiograms you have obtained. This Audibility Index is based on the Hearing Level at eight frequencies, weighed according to their importance. This index was primarily based on the publication by Mueller and Killion, “An Easy Method For Calculating the Articulation Index.” The Hearing Journal, September 1990. The name Audibility Index came from “A is for Audibility” by Killion, Mueller, Pavlovic, and Humes, The Hearing Journal, April 1993.

5.5.1 Viewing the AI display

See Figure 5.5.1 for a picture of the Audibility Index display.

1. dB HL graph for unaided and aided audiogram responses
2. Aided audiogram responses (from insertion gain measurements)
3. Insertion gain target displayed in dB HL
4. Table containing expected percentage of audibility of speech
5. Selected fitting rule
6. Source type for current curve
7. Noise reduction status for current curve

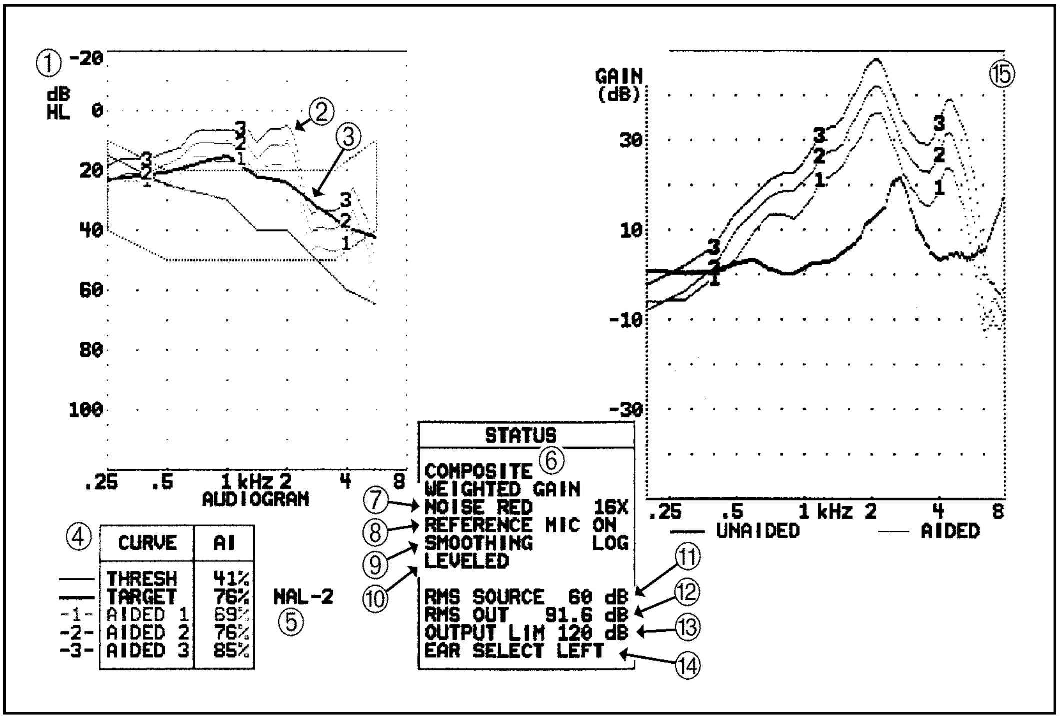


Figure 5.5.1—External video display of the Audibility Index

8. Reference microphone status
9. Smoothing status
10. Leveling status
11. RMS source level used to take measurement
12. RMS of the current curve. Not available with pure-tone source types.

13. Output limit status
14. Selected ear
15. Graph containing unaided and aided gain response

5.5.2 Performing AI measurements

Performing AI measurements is just like performing normal insertion gain measurements. Follow the instructions in Section 5.3.2 and 5.3.3. Instead of choosing IG in step 2 of Section 5.3.2, use F2 to choose the AI display. Alternately, perform the insertion gain measurements as normal in the Insertion Gain display, and then press F2 to switch to the AI display. All measurements will be automatically converted from insertion gain to dB HL.

5.6 DSL Coupler Measurements

Since the DSL fitting method is often used on small children who are hard to fit using conventional real-ear testing methods, often coupler measurements are performed to match corresponding coupler targets.

If possible, it is recommended to perform a real-ear to coupler difference (RECD) measurement on the child in order to generate an accurate coupler target. When it is not possible to perform a measured RECD, an average RECD corresponding to the child's age can be used.

5.6.1 Performing the RECD measurement

RECD is the real-ear-to-coupler difference: the difference between the acoustical resonance of a 2-cc coupler and the acoustical resonance of a person's unaided ear canal. It is calculated by subtracting the frequency response of an insert earphone inside a 2-cc coupler from the frequency response of the same insert earphone placed inside the client's ear.

Why would you want to take the RECD? Well, DSL was developed for fitting hearing aids on children, and, as anyone who has fitted an aid on a child knows, it is sometimes hard to make the infant or child sit still long enough to perform good real-ear measurements on them. So, if you can just make them sit still long enough to get a real-ear unaided response, you can get the RECD and use it to convert real-ear targets to coupler targets. Then, you can test the aid all you want in the coupler and send the child to stay with his parents in the waiting room while you program and test the hearing aid in the sound chamber. If you have a really uncooperative patient, you can even just rely on the average RECD for the child's age group and forgo any real-ear measurement entirely. Of course, when the child gets old enough to sit still long enough to get a good real-ear measurement, real-ear measurements are the way to go.

5.6.1.1 To perform the coupler measurement

The coupler measurement part of the RECD is saved into the analyzer's permanent memory until another measurement is stored on top of it. This saves a lot of time because it means you only have to perform the real-ear part of the RECD for each client instead of performing both the coupler and the real-ear measurements.

Note: Steps 1-7 are optional but good to do in order to get the most accurate RECD.

1. Press F1 from the Main Coupler screen (not the Target 2-cc screen) to enter the setup menu.
2. Press F4 — CAL MIC(S).
3. Attach the calibration clip to the larger coupler microphone so that the metal tube hangs off the very tip of the microphone. See Figure 5.6.1.1A.

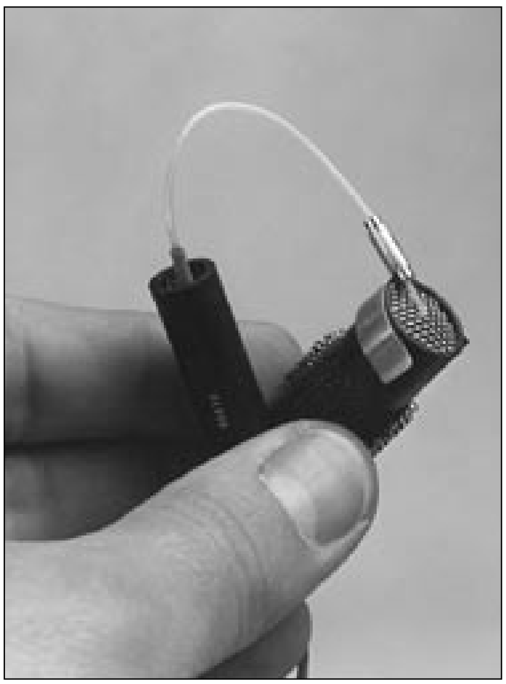


Figure 5.6.1.1A—Attaching the two microphones together

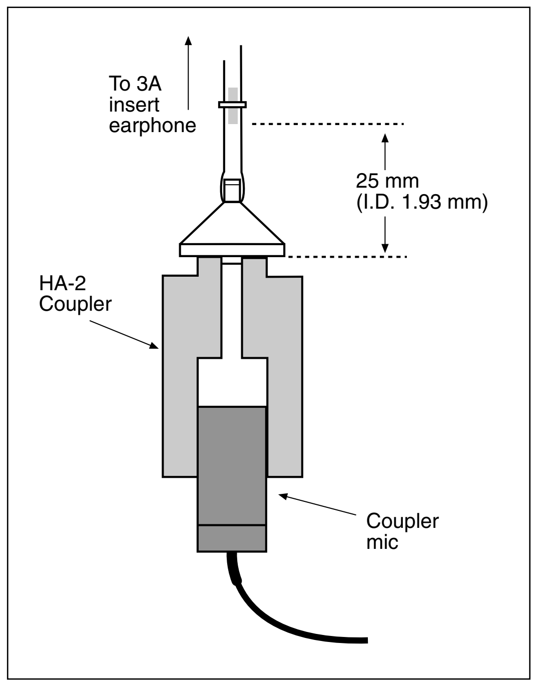


Figure 5.6.1.1B—Coupling the coupler microphone to the insert earphone.

4. Thread probe tube connected to the probe microphone through tube so that the probe tube sticks out over the grill of the coupler microphone.
5. Put assembly in sound chamber and close chamber door.
6. Press F6 – COMPEN PROBE. This will measure and store the differences between the two microphones.
7. Press F1 – EXIT.

8. Plug a 50-ohm insert earphone into the external speaker jack on the back of the FP40. An adapter may be needed if you are taking the insert earphone from an audiometer.
9. Insert the larger coupler microphone into HA-2 coupler.
10. Attach insert earphone plastic tip to the tubing of the HA-2 coupler. See Figure 5.6.1.1B.
11. Press F5 to enter PROBE mode.
12. Press F1 to enter MENU.
13. Press F4 to enter CAL MIC(S).
14. Press F7 to select HA2 ER3A.
15. Press [START/STOP] to begin measurement. A WAIT message will appear on your screen. When this message disappears, the coupler measurement has been taken and stored into permanent memory.
16. Press F1 to exit the menu.

5.6.1.2 To perform the real-ear measurement

1. Plug a 50 ohm insert earphone into the external speaker jack on the back of the FP40. If you are using an insert earphone from an audiometer, you may need to use an adapter.
2. Press F4 to enter Target screen from the Probe screen.
3. Press F7 to enter Target 2-cc screen.
4. Press F3 to enter RECD mode.
5. Press F3 to toggle MEASURED RECD.
6. Insert the probe microphone into the client's ear.
7. Insert the custom earmold or foam eartip coupled to the insert earphone into client's ear. See Figure 5.6.1.2A.
8. Press [START/STOP] to perform measurement.
9. Both the curve and the numerical data will appear on the screen. See Figure 5.6.1.2B.
10. Unplug the insert earphone from the analyzer when done.
11. Press F1 to return to the Target 2-cc screen.

If you have previously performed the RECD and want to enter the data into the RECD screen without taking the measurement again, use the FREQUENCY and AMPLITUDE knobs.

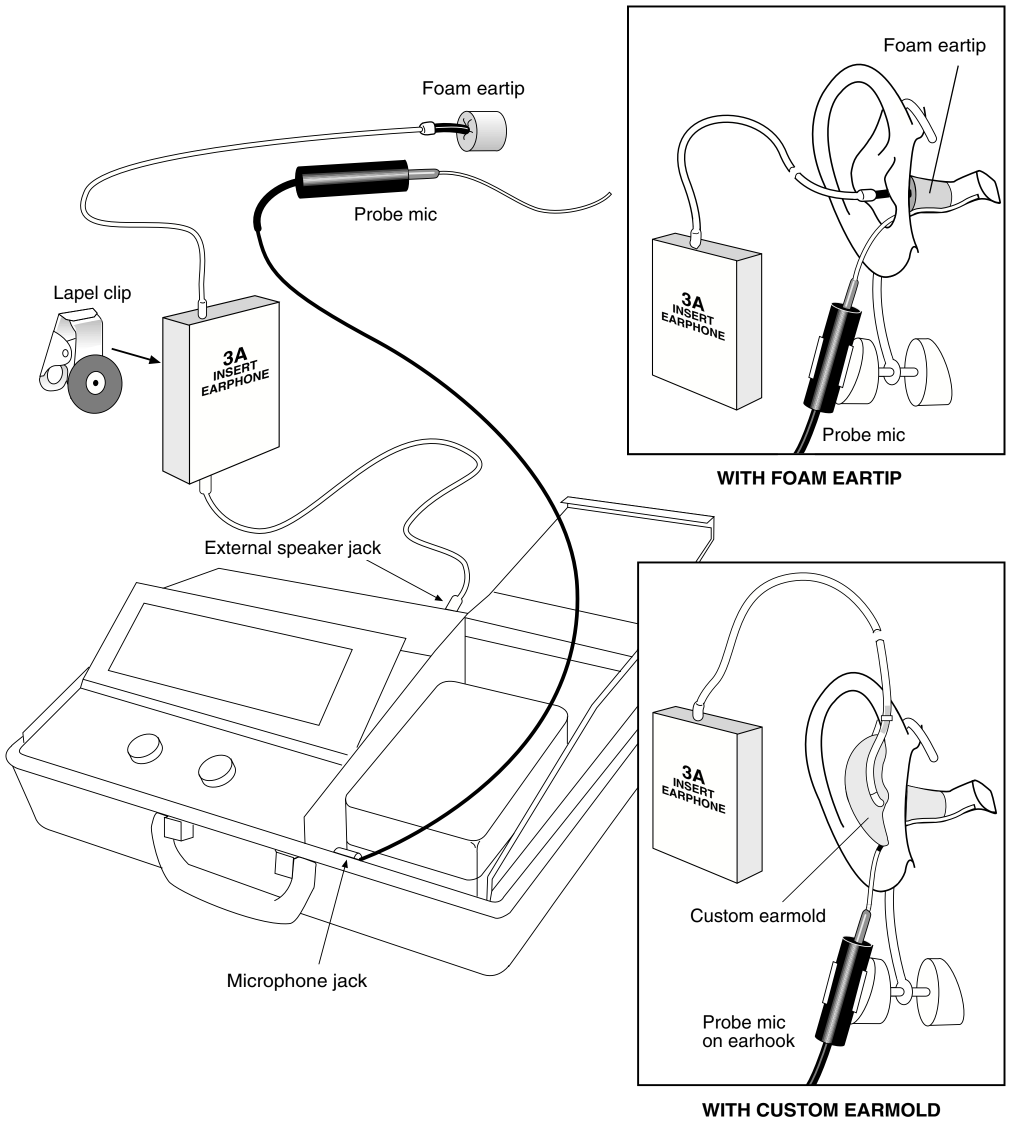


Figure 5.6.1.2A—Setup for real-ear part of the RECD

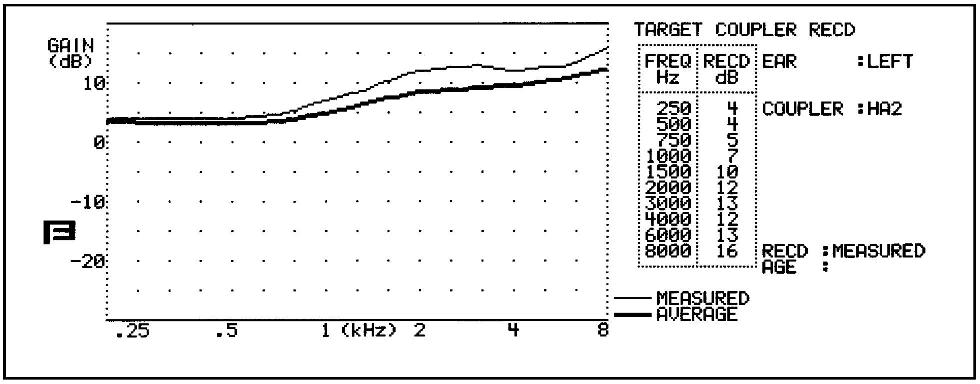


Figure 5.6.1.2B—Measured RECD

5.6.2 Performing coupler measurements to a DSL target

1. Enter your client's thresholds and generate a target as described in Section 5.2. Make sure to input your client's age before generating the target.
2. Enter the Target 2-cc screen by pressing F7.
3. Decide whether you want to use the average RECD data to create the 2-cc target or the client's measured RECD. To measure the client's RECD, follow the instructions found in Section 5.6.1. Make sure to unplug the insert earphone from the analyzer when done.
4. Check and make sure that the RESER is set to zero. This is at the bottom of the table in the middle of the screen.
5. Press F6 to select desired amplitude of test signal.
6. The source type is shown on the screen. The source used is always the last source type you used in the normal Probe screen.
7. Press F4 to choose the aid type.
8. Notice the comparison ratios (CR) displayed in the chart to the right of the target graph. (DSL WDRC only) DSL authorities recommend fitting the aid at the average of the calculated ratios. If there are large differences between the recommended ratios below 1500 Hz as compared to those above 1500 Hz, a dual-channel aid would be preferable.
9. Press [START/STOP] to start measurement. If the signal type is composite or Digital Speech, press [START/STOP] again when satisfied with measurement.
10. Press F6 to adjust the amplitude of the source if you are performing a DSL WDRC fitting. Notice that the target changes as the source level changes. Perform the coupler measurements at several different amplitudes to make sure that the AGC circuits of the hearing aid are compressing properly with the measurement meeting the target at different amplitudes. See Figure 5.6.2A.

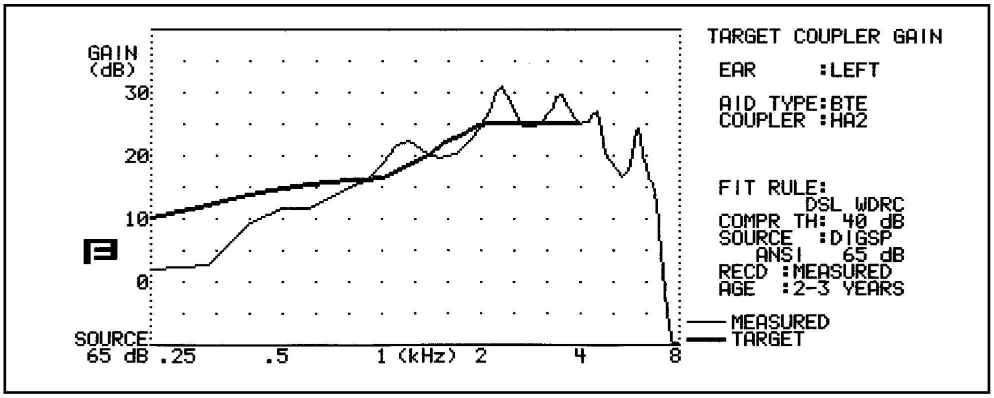


Figure 5.6.2A—Coupler gain measurement with a DSL target

11. Press F5 to enter SSPL MODE. You should see a series of star symbols on the screen. These symbols stand for the highest comfortable levels predicted for this patient. Again, make sure the RESER is set to zero.
12. Press [START/STOP] to take a pure-tone 90 dB measurement. If the resulting measurement is higher than the target symbols, those sounds will be uncomfortable for the patient. Try to adjust the aid so the measurement only reaches at or below those symbols. See Figure 5.6.2B.

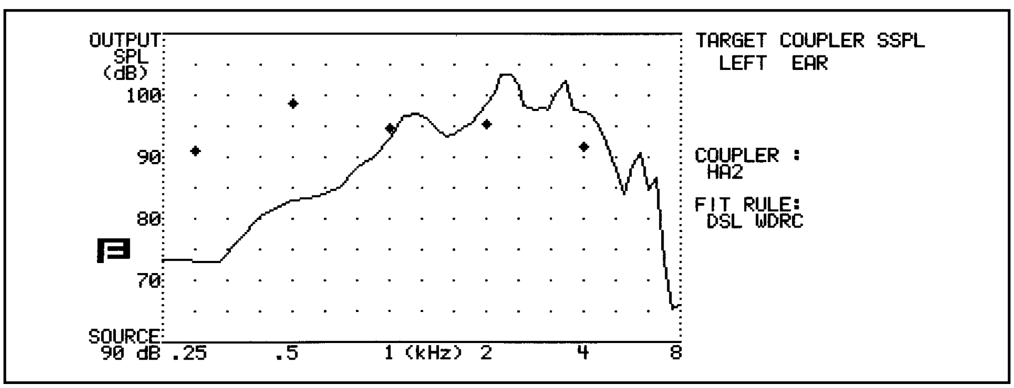


Figure 5.6.2B—SSPL measurement with DSL predicted upper limits of comfort

5.7 Coupler prescription (non DSL)

The object of the Target 2-cc screen is to prescribe a hearing aid using audiogram information, a fitting formula, the choice of styles of hearing aids, age, and RECD information. All of these factors are used to calculate the 2-cc target coupler that can be sent to a manufacturer or that can be used to set the full-on gain of a hearing aid in the sound chamber. UCL data entered or generated in the Target screen is used to generate a corresponding SSPL90 prescription.

If the FP40 has the OES Option, it is also possible to make a prescription that uses the modified Zwislocki (MZ) couplers.

5.7.1 Viewing the Target 2-cc screen

Figure 5.7.1 contains a picture of the Target 2-cc screen.

1. Gain graph containing the 2-cc target including the calculated target and modified target if available.
2. Selected ear.
3. Selected aid type.
4. Selected coupler.
5. Status of unaided response used to make the 2-cc conversion.
6. Fitting rule.
7. Signal source type.
8. Signal source amplitude.
9. Status of RECD.
10. Age of client.
11. Instructions for performing 2-cc target measurements.

Note: Once a measurement is made, the modification box will disappear from the screen.

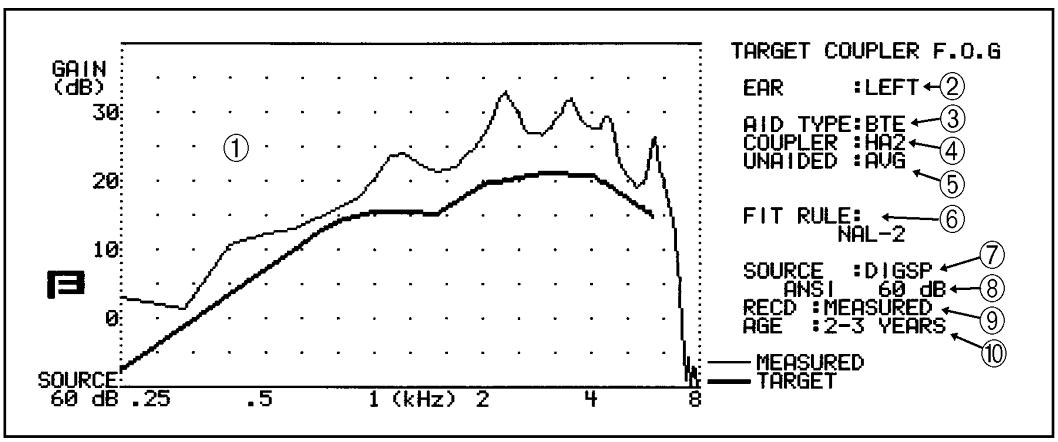


Figure 5.7.1—Target 2-cc screen

5.7.2 Taking the FOG measurement

1. Follow the instructions found in Section 5.2 to generate a real-ear target.
2. Press F7 to enter the Target 2-cc screen.
3. Use F2 to select whether or not you want to use the KEMAR average unaided response to generate the 2-cc target, or the client's measured unaided response. To measure the client's unaided response, follow the instructions found in Section 5.3.2.
4. Decide whether you want to use the average RECD data to create the 2-cc targets or the client's measured RECD. To measure the client's RECD, follow the instructions found in Section 5.6.1.
5. Use F4 to select the aid type.
6. Adjust reserve gain by turning the FREQUENCY knob clockwise until cursor reaches the bottom of the Target Coupler box in the middle of the display. Use the AMPLITUDE knob to change the amount of reserve gain.
7. Use the FREQUENCY and AMPLITUDE knobs to modify the 2-cc target, if desired. See Section 5.7.6 for some suggested vent corrections.
8. Use F6 to select the source level.
9. Place the hearing aid in the chamber and measure the response by pushing START. The analyzer will use the source type last used in the Probe screen.

Other functions & Notes

- Press F8 to clear any modifications made to the target with the AMPLITUDE and FREQUENCY knobs.
- Press F9 to select how the screen is printed before any measurements are taken. FULL print shows both the unmodified target curve, the modified target curve (if applicable), and the modification table. PARTIAL only prints the modified target curve.
- Several choices disappear after you push START to make the measurement. Should you for any reason wish to return to the previous screen, push F1 — FOG MODE

5.7.3 Viewing the SSPL 90 screen

Figure 5.7.3 contains a picture of the SSPL 90 screen.

1. SPL graph containing UCL values converted to dB SPL.
2. Column of frequencies.
3. Column where you can enter modifications to the SPL values.
4. Numerical UCL dB SPL data.
5. Selected coupler.
6. Selected fitting rule.

7. Age of client.
8. Instructions for performing the SSPL 90 measurement.

Note: Once a measurement has been taken, the modification table will disappear from the display.

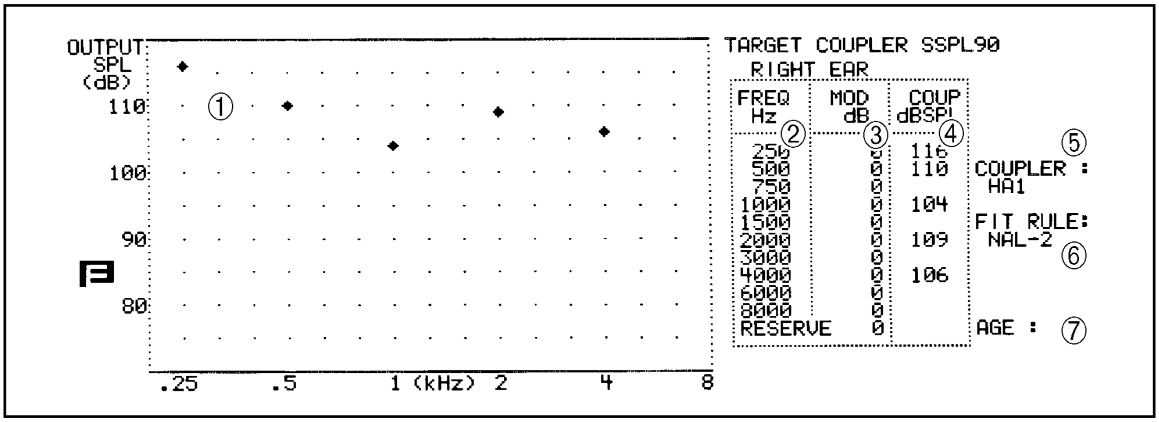


Figure 5.7.3—The SSPL 90 screen

5.7.4 Taking the SSPL 90 measurement

This measurement is always made with a pure-tone sweep in order to make sure the fitting is comfortable for the client even when presented with 90 dB SPL of sound at any frequency.

1. Press F5 to enter the SSPL 90 screen. See Figure 5.7.3 for a picture of this screen. The stars on the graph correspond to the client's UCL values converted to dB SPL using David Pascoe's predictions*.
2. Make any desired modifications to the displayed UCL values using the FREQUENCY and AMPLITUDE knobs.
3. Adjust the reserve gain, if desired, using the knobs.
4. Put the aid in the sound chamber and prepare it for a sound chamber measurement.
5. Press START/STOP to start the 90 dB pure-tone sweep.

5.7.5 Checking an aid against a prescription

This procedure allows the operator to reenter data from the client's initial prescription FOG curve, so that the actual "custom" hearing aid ordered can be compared and adjusted to the original FOG Curve when it is received and before the client is scheduled for a real ear fitting. It is assumed that you have followed the instructions found in Section 5.7.2 and 5.7.4 to generate the client's initial prescription FOG and SSPL 90 curves, ordered the custom hearing aid, and saved this data in the client's file.

When the ordered hearing aid is received, follow these steps to set up the comparison test procedure.

1. Follow the instructions from Section 5.2 to generate a target using the same fitting rule that you used in the previous prescription.
2. Press F7 to enter the COUPLER Mode. If you used an average RECD and an average REUR to generate the 2-cc target, skip to step 6.
3. Press F3 to enter the RECD screen and enter in the client's measured RECD. F1 will return you to the Target 2-cc screen. If you didn't perform an RECD measurement on the client, skip this step.
4. Press DATA to display the numeric curve data.
5. Use the FREQUENCY and AMPLITUDE knobs to modify the 2-cc target until it matches the target generated during your client's last visit.
6. Press F6 to select the source level. You should usually use 50 dB or 60 dB since these are the amplitudes the manufacturer would have used when testing the hearing aid.
7. Place the newly ordered hearing aid in the test box and set it to full-on gain.
8. Press START/STOP to take the coupler measurement.
9. Adjust and modify the hearing aid to match as closely as possible the 2-cc target.
10. Contact the client for a real ear fitting.

Note: This test procedure can be used to compare a stock, programmable, or a client's old hearing aid against the prescribed 2-cc target.

*Pascoe, David P: Clinical measurements of the auditory dynamic range and their relation to formulas for hearing aid gain. Hearing Aid Fitting, Theoretical and Practical Views. Ed. Janne Hartvig Jensen. 13th Danavox Symposium 1988

5.7.6 Accounting for venting effects

You can make 2-cc targets more accurate by modifying the target to account for venting effects.

Target Coupler FOG Vent Corrections

Frequency (Hz)	250	500	750	1k	1.5k
Tight Seal	—	—	—	—	—
Slit Leak	2	2	1	—	—
1 mm	1*	2*	1	—	—
2mm	7*	1*	—	—	—
Long Open	17*	10*	4*	1*	—
Short Open	26*	21*	14*	10*	5*

Note: Use starred values only if prescribed insertion gain is greater than 0 dB at that frequency. Otherwise, use no correction. Blanks indicate use no correction. A slit leak is assumed for all vent conditions except "Tight Seal."

5.7.7 Understanding the technical details

For those of you who are interested in how we came about the correction factors used in the Target 2-cc screen, here is the technical information.

Average unaided

The "average" ear data is from KEMAR, large, right ear, measured with the reference microphone one centimeter above the apex of the pinna, with the probe tube microphone opening approximately 17 mm into the ear canal, with the loudspeaker at ear level, 12 inches from the head surface at an azimuth angle of 45 degrees.

Average RECD

The occluded ear SPL was measured using an Etymotic Research ER-3A insert earphone, with the foam tip inserted 12 mm into the same KEMAR ear as above, with the probe microphone 5 mm beyond the sound opening. The 2-cc coupler SPL was measured with the ER-3A attached to the opening of an HA-1 coupler, using the same probe-microphone arrangement as in the occluded ear.

Aid-type

Same KEMAR ear and configurations of the reference microphone and loudspeaker as for the average unaided ear correction. No correction for BTE, because the reference microphone is precisely at the location of the hearing aid microphone. ITE and Canal corrections are each the average of three measurements with three probe-microphone locations at the surface of simulated hearing aid faceplates.

5.8 Miscellaneous

This section describes a few real-ear features accessible from the Setup Menu.

5.8.1 Single frequency response

In some cases, it's useful to be able to evaluate the real-ear response to a tone presented at a particular frequency. The single tone measurement in the Probe screens is always warbled.

To do this:

1. Enter the Probe mode by pressing F5 from the coupler screen.
2. Set up the client for testing as described in Section 5.1. Make sure to level the sound field speaker.
3. Press F1 to enter the Setup Menu.
4. Use the AMPLITUDE and FREQUENCY knobs to select SOURCE in the upper left corner of the screen. If you don't have the Composite Option, you will not have this selection, so skip to step 6.
5. Press START/STOP to select TONE.
6. Use the AMPLITUDE and FREQUENCY knobs to select F7 DEFINITION in the PROBE SETTINGS.
7. Press START/STOP to toggle SINGLE TONE.
8. Press F1 to return to the Probe mode.
9. Press F7 to highlight SNGL TONE.
10. Press START/STOP to start the measurement.
11. Use the AMPLITUDE and FREQUENCY knobs to make any desired adjustments to the tone. The MIC SPL or MIC GAIN will be displayed in the lower right corner of the screen.

5.8.2 Smoothing

Smoothing is a way of averaging measurement results to limit testing artifacts caused by environmental noise. The advantage of smoothing is that you will get a nicer looking curve that contains fewer "spikes" that could be the result of the testing environment and not the aid itself. The disadvantage of smoothing is that it potentially gets rid of useful testing information.

To turn smoothing on/off:

1. Press F1 from a real-ear measurement screen.
2. Use the AMPLITUDE and FREQUENCY knobs to select SMOOTHING under PROBE settings.
3. Press START/STOP to toggle between ON and LOG.
4. Press F1 to return to the real-ear measurement screen.

5.8.3 Reset Level

The reset level is the sound pressure level that the analyzer automatically returns to when the RESET button is pressed. By default, it is set to 70 dB SPL. This is set in the Setup Menu under PROBE SETTINGS.

5.8.4 Data Display

It is often useful to look at the numerical data from real-ear measurements. The DATA/GRAPH button is used for this purpose.

To select which curve is converted to numerical data:

1. Press F1 to enter the Setup Menu from any of the real-ear measurement screens.
2. Select DATA DISPLAY under PROBE settings using the AMPLITUDE and FREQUENCY knobs.
3. Use the START/STOP button to select the curve you want to convert to its numerical data. The selections available are dependent upon the TEST TYPE.
4. Press F1 to return to the real-ear measurement screen.

5.9 Body, CROS, and BI-CROS aids

When using the FP40 probe with a Body aid, CROS, or BI-CROS aid, we suggest the following setups and procedures. But you certainly may experiment with different methods.

5.9.1 Testing body aids

The setup below is recommended for Body aids. Follow normal Insertion Gain measurement procedures.

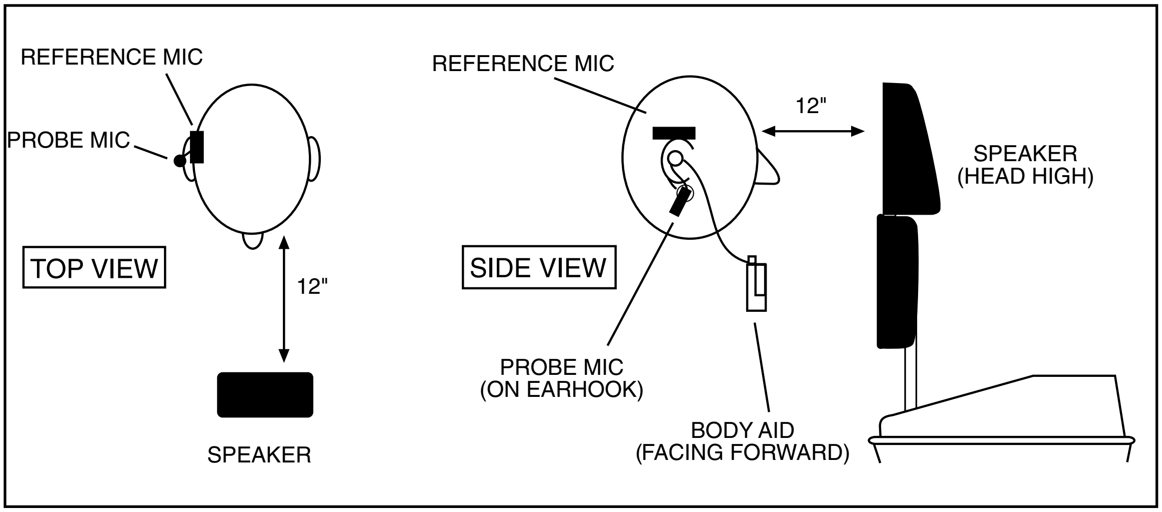


Figure 5.9.1—Real-ear setup for testing body aids

5.9.2 Testing CROS and BICROS aids

Four Goals:

5.9.2.1 Measure the head baffle effect
5.9.2.2 Measure how well the aid overcomes the head baffle effect
5.9.2.3 Measure the overall insertion gain
5.9.2.4 Measure the insertion loss to the "good" ear

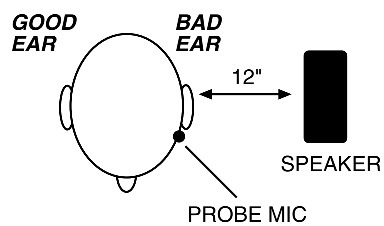
Each of these measurements uses the insertion gain measurement technique, taking advantage of the fact that insertion gain is a difference curve between two measured curves (usually the unaided and aided response). The CROS and BICROS measurement techniques assign the label of "unaided" to one measurement and "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 5.3.2 or measurements labeled "aided" (even if they aren't aided), follow the instructions in Section 5.3.3.

5.9.2.1 Head-Baffle Effect

CROS or BI-CROS

A. **Unaided**—Real Ear response on "bad ear" side



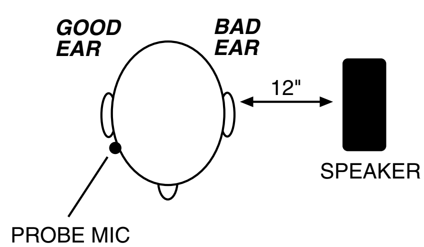
Set up the FP40 analyzer as follows.

- System UNLEVELED
- Reference microphone OFF
- Unaided CUSTOM
- Probe microphone over the bad ear, tube jutting just slightly forward of pinna
- Loudspeaker at 90º, 12 inches from bad ear

B. **Aided**—Real Ear response on "good" ear side

Same setup as A 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 calls for the FP40 to be UNLEVELED with the reference microphone OFF, the rest of the measurements in this section call for the FP40 to be LEVELED with the reference microphone ON.

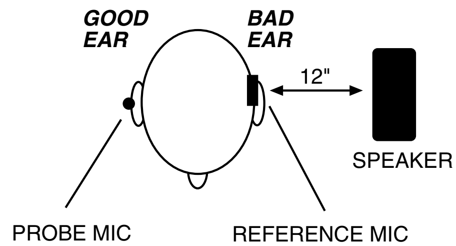
5.9.2.2 How Well the Aid Overcomes the Head-Baffle Effect

CROS

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

Set up the FP40 analyzer 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 90º, 12 inches from bad ear



B. **Aided**—Measurement of “good” ear canal (baffle overcome by aid)

Same setup as A, except:

- Aid in place in good ear and set to normal user gain.

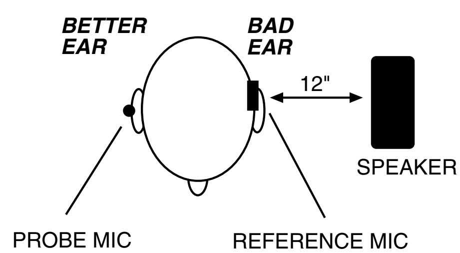
The difference curve, labeled “Insertion Gain” on the screen, shows the benefit the aid gives for sound arriving from the “bad” side.

BI-CROS

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

Set up the FP40 analyzer 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, <u>on</u>, set at use gain
- Transmitter on bad side turned <u>off</u>
- Loudspeaker at 90º, 12 inches from bad ear



B. **Aided**—Measurement of “better” ear canal (baffle overcome by aid)

Same setup as A, except

- Transmitter on bad side turned on

The difference curve, labeled “Insertion Gain” on the screen, shows the benefit of adding the second microphone for sound arriving from the “bad” side.

5.9.2.3 Overall Insertion Gain

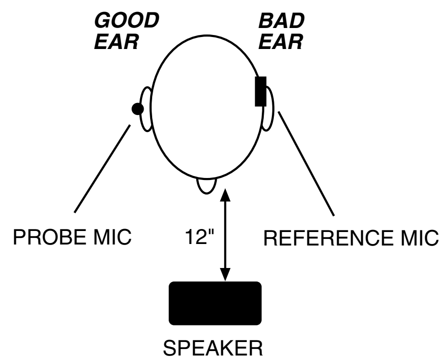
Note: Since it has not been shown for CROS and BI-CROS instruments that a 45° position of the loudspeaker improves the reliability of insertion gain measurements, we recommend a 45° position of the loudspeaker only for monaural instruments, and a 0° position for CROS and BI-CROS instruments.

CROS

A. **Unaided**—Measurement of “good” ear

Set up the FP40 analyzer 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



B. **Aided**—Measurement of “good” ear

Same setup as A, except:

- Aid in place in good ear and set to user gain.

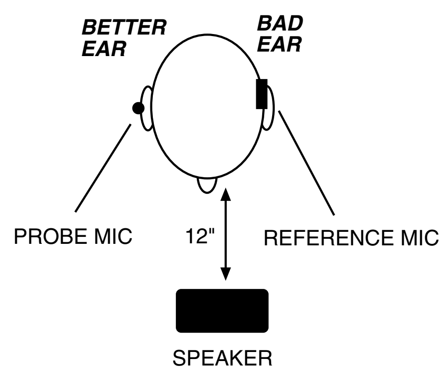
The difference curve, labeled “Insertion Gain” on the screen, shows the overall benefit of inserting the hearing aid.

BI-CROS

A. **Unaided**—Measurement of “better” ear

Set up the FP40 analyzer 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



B. Aided—Measurement of “better” ear

Same setup as A, 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.

5.9.2.4 Insertion Loss to the “Good” Ear (CROS)

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

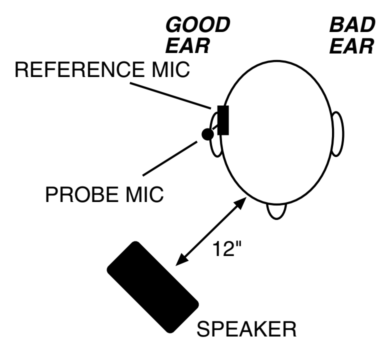
Note: Since this is a monaural measurement, a 45° position of the loudspeaker is recommended.

Two Measurements

A. **Unaided**—Unoccluded Ear canal Response of “good” ear

Set up the FP40 analyzer 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



B. **Aided**—Occluded Response of “good” ear.

Same setup as A, except

- Earmold in place in good ear
- Hearing aid is turned off

The difference curve, labeled “Insertion Gain” on the screen, shows insertion loss, if any, caused by inserting the earmold into the good ear.

5.10 FM Systems

For users who test FM Systems, a comprehensive guidebook is available free of charge. Contact the factory and request the publication Testing FM Systems with FONIX FP40 Analyzers

5.11 Testing Directional Aids

Perhaps the most convenient way to test directionality is with a real-ear measurement. You can use the Insertion Gain screen on the FP40 analyzer to show you the forward and reverse responses as well as a curve showing the directional advantage. All you need is a swivel chair to turn the client around during testing, or an external speaker on a swing arm to move the speaker around the client.

Since we're going to use the Insertion Gain screen for this measurement in order to show the difference between the forward and reverse responses, we're going to treat the reverse measurement as the "unaided" measurement and the forward measurement as the "aided" measurement.

5.11.1 Reverse Measurement

1. Set up the analyzer as you would for any real-ear measurement. Use a 0° azimuth positioning when you level the sound field speaker. See Section 5.1 for details.
2. Insert the probe tube and the hearing aid.
3. Turn OFF the reference microphone. To do this, press F1 from any real-ear measurement screen and change the REFERENCE MIC setting to OFF under Probe Settings. Use the AMPLITUDE and FREQUENCY knobs and the START/STOP button to make this selection. Press F1 again to return to the real-ear measurements screen.
4. Look above F2 on any real-ear measurement screen. IG should be highlighted. If it is not, select IG with F2.
5. Select the source type with F7. If available, choose one of the Digital Speech signals or the Composite signal. Otherwise, select the pure-tone FAST signal.
6. Make sure UNAIDED is highlighted above F2. If it is not, you may need to press F2 to highlight it.
7. Select the source signal using the AMPLITUDE knob. The source should be above the noise floor of the room, but as quiet as you can make it and still get accurate real-ear measurement. The reason for this is that you don't want the aid to go into compression while you are trying to test the directionality characteristics. If possible, use a source of 50 dB SPL; noisy test environments may force you to use a louder level.
8. Turn the patient around so the speaker is pointed towards the "null" spot of the hearing aid. For some aids, this is 180°. For other aids, it might be a different angle. Alternately, if you are using an external speaker on a swing arm, you can swing the speaker around to the back of the patient. Maintain the distance from the patient and the speaker that you used for leveling. See Figure 5.11.1.

9. Press START/STOP to start the measurement. While the measurement is running, you may want to adjust the angle of the speaker (or the position of the client) to make sure the sound source is hitting the null position of the aid. You are looking for the response with the least amount of amplification.
10. Press START/STOP to stop the measurement once it has stabilized. The "unaided" response is now the reverse measurement of the directional aid.

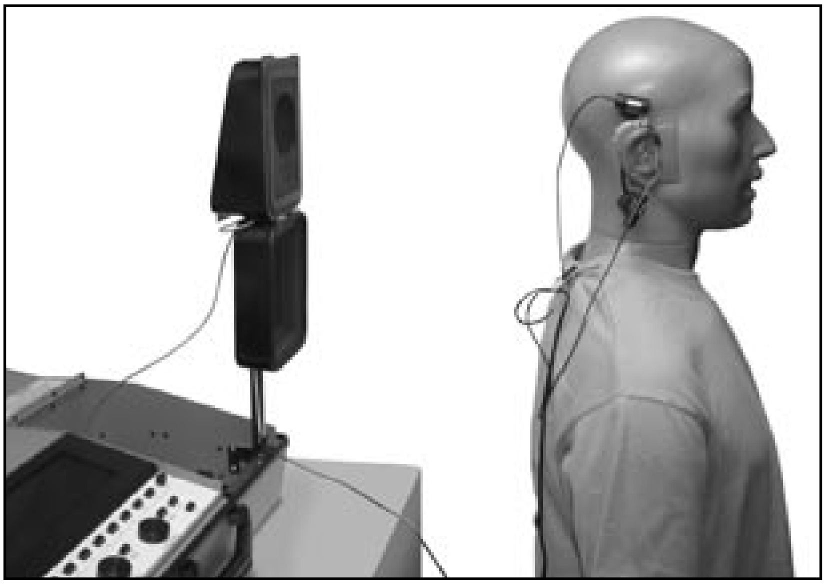


Figure 5.11.1—Reverse measurement positioning for directional test

5.11.2 Forward Measurement

1. Move the patient and/or speaker so that the speaker is positioned at a 0° azimuth.
2. Look above F3 and make sure that AIDED 1 is highlighted. If it is not, press F3 to selected it.
3. Press START/STOP to start the measurement. The source type and level should be the same as used for the reverse measurement.
4. Press START/STOP again once the measurement has stabilized. The "aided 1" measurement is now the forward measurement of the directional aid.
5. Look at the insertion gain graph on the left side of the screen. This shows the directional benefit of the hearing aid – the reverse measurement subtracted from the forward measurement.

6.1 Spectrum Mode

This mode is only available on FP40 instruments that have the Real-Time/Composite Signal.

The FONIX FP40 can be used as a sound spectrum analyzer in either the coupler (test box) or real-ear test modes. When the Spectrum Mode is selected, external sounds can be measured through the microphones, or through a direct electrical connection, and displayed in an amplitude-vs-frequency format.

6.2 Entering the Spectrum Mode

The FP40 must be in the "COMPOSITE MODE."

1. Turn the AMPLITUDE control knob to the left (counter-clock wise) until the "RMS Source" is "OFF."
2. The "Status" information box should read "Spectrum Mode."

6.3 Using the Spectrum Mode

You should find the following three suggested applications clinically helpful, interesting and fun.

APPLICATION 1: MEASURING THE "OCCLUSION EFFECT" OF A HEARING AID.

This simple procedure will help you measure the occlusion effect of the hearing aid wearer's own voice. The spectrum analysis mode will help you judge the sometimes uncomfortable feeling caused by the occlusion effect of a hearing aid. You will be able to measure the effect and the improvements made after venting adjustments have been made.

Suggested procedure:

1. Press F5 from the Main Coupler screen to enter the Probe Mode.
2. Use F2 to select SPL.
3. Use F7 to select a source type of COMPOSITE.
4. Use the AMPLITUDE knob to turn the source all the way OFF. This puts the analyzer in Spectrum Analysis Mode.
5. Place the probe tube as close as possible to the eardrum. Marking the probe tube depth at 25-30 mm should accomplish this in an average adult ear canal. Position the client 12" from speaker at a 45 degree angle.

6. Use F3 to select AIDED 1.
7. Place the hearing aid in the ear. The aid should be turned off.
8. Push the START/STOP button. Instruct the client to sustain the vowel sound “ee.”
9. While the “ee” is still sounding, and once the curve on the screen has stabilized, press START/STOP. Note the total RMS Output in the ear canal as indicated in the status box.
10. If the SPL seems high, you might modify the vent size. Use F3 to select AIDED 2 and repeat steps 6 and 7. If your changes have been successful, you should see a lessening of total RMS Output. AIDED 2 should be less than AIDED 1.

Note: You could also measure the effects with the hearing aid turned on.

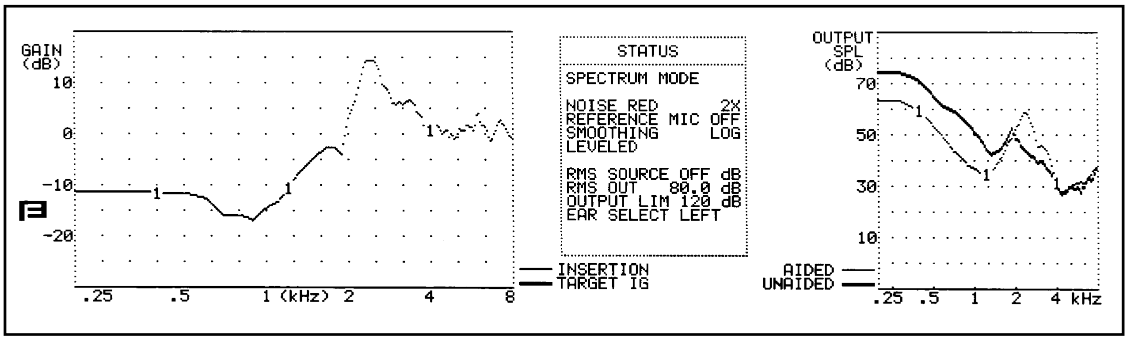


Figure 10.3

APPLICATION 2: INSERTION GAIN MEASUREMENTS USING AN EXTERNAL SOUND SOURCE.

For this procedure the choice of sound source is yours. You may want to use a tape or CD player through a loudspeaker. Any sustained sound source will work. Whether you use a cocktail noise tape or one of the new environment CDs, you should find your test results interesting, especially when testing nonlinear signal processing hearing aids.

Suggested Procedure:

1. Prepare your sound source.
2. Press F5 from the Main Coupler screen to enter the Probe Mode.
3. Use F2 to select IG.
4. Use F7 to select a source type of COMPOSITE.
5. Use the AMPLITUDE knob to turn the source all the way OFF. This puts the analyzer in Spectrum Analysis Mode.

6 Perform a typical UNAIDED and AIDED real-ear test, except use “your external sound source” instead of the composite signal.

Application 3: Real Ear Aided Response (REAR) in SPL Using an External Sound Source.

This application is similar to the Insertion Gain test described in Application 2. But instead of measuring real-ear gain you will measure the SPL generated in the ear canal and compare it to the patient's HTL and UCL values. This is sometimes known as a "Visible Speech."

Suggested Procedure:

1. Prepare the sound source.
2. Press F5 from the Main Coupler screen to enter the Probe Mode.
3. Press F4 to enter the Target screen.
4. Follow the instructions from Section 5.2.2 to input the patient's thresholds. You can also input the patient's measured UCL values or predict them by pressing F5. Pressing F5 will also generate a real-ear target.
5. Press F4 to return to the Probe Mode.
6. Press F2 to select SPL. You should see a graph with the patient's thresholds, uncomfortable levels, and real-ear target all in dB SPL.
7. Press F7 to select a source type of COMPOSITE.
8. Use the AMPLITUDE knob to turn the source signal all the way OFF. This will put the analyzer in Spectrum Analysis Mode.
9. Place the probe tube as close as possible to the eardrum. Marking the probe tube depth at 25-30 mm should accomplish this is an average adult ear canal. Position client 12" from speaker at a 45 degree angle.
10. Place the aid in the ear. Turn it on to "use gain."
11. Press F3 to select AIDED 1.
12. Turn on the external sound source.
13. Press START/STOP to begin spectrum analysis. Then press START/STOP again to freeze the measurement.
14. Turn off the external sound source. You can repeat this for AIDED 2 and AIDED 3. Note: The real-ear target depends on the source level of AIDED 2. If you turn the source of AIDED 2 all the way off to put the analyzer in Spectrum Analysis Mode, you will no longer be able to see a real-ear target.

Telecoil testing is available on serial number 940000 and above, manufactured in September, 1994 and later. Testing with the Telewand is available with software version 3.60 and above.

7.1 Setup with the Telecoil Board

1. Set up the hearing aid in the usual way, by connecting it to the correct coupler and insert the test microphone. You may use either a normal hearing aid battery or a battery substitution pill to power the aid.
2. Place the telecoil board close to the FP40 as shown in Figure 7.1A.

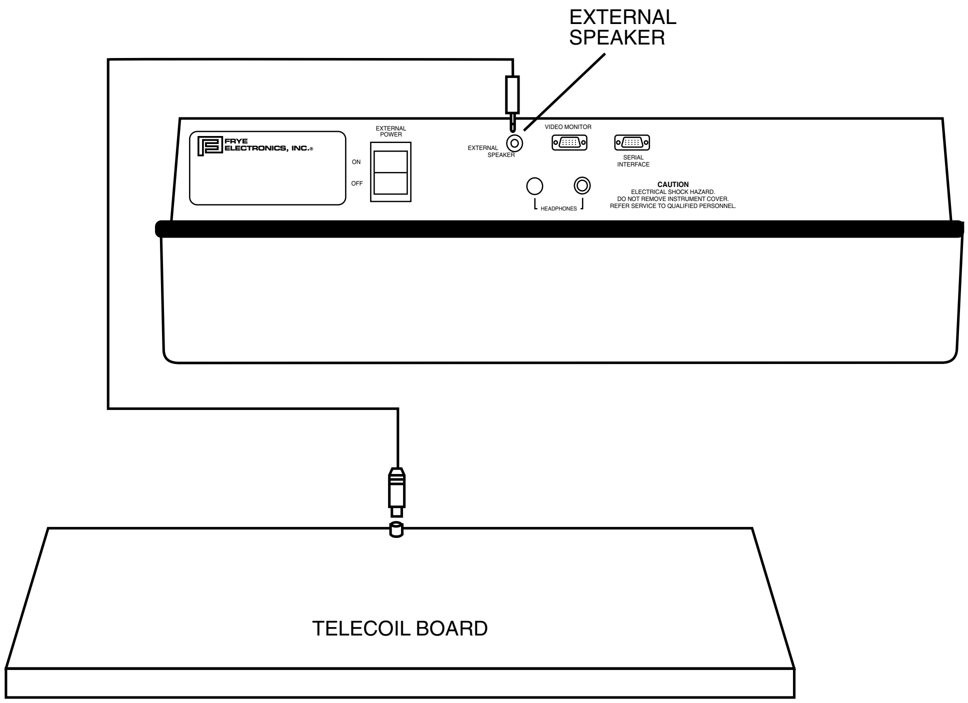


Figure 7.1A Telecoil setup

3. Connect the telecoil to the back of the FP40 at the jack marked external speaker.
4. Press F1 – MENU from the Main Coupler screen in order to enter the Setup Menu.
5. Use the AMPLITUDE and FREQUENCY knobs to select MAIN F2 under FUNCTION KEY DEFIN.
6. Press START/STOP repeatedly to select TELECOIL.

7. Press F1 to return to the Main Coupler screen.
8. Press F2 to turn ON the telecoil feature.
9. Orient the hearing aid on the telecoil board for the maximum output. (If you're using the Composite signal, you will have to press START/STOP to start the test signal.) Figure 7.1B shows various positions that could be tried. Notice that the hearing aid must be at the center of the board.

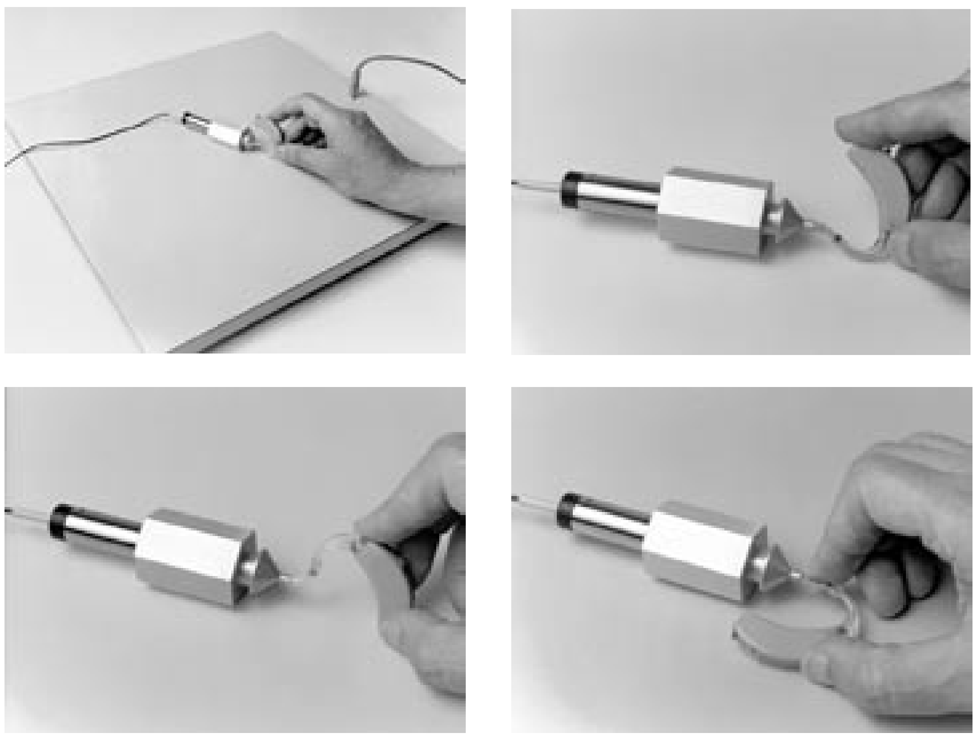


Figure 7.1B Orienting hearing aid for maximum output

7.2 Setup with the Telewand

1. Set up the hearing aid in the usual way, by connecting it to the correct coupler and insert the test microphone. You may use either a normal hearing aid battery or a battery substitution pill to power the aid.
2. Plug the Telewand into the external speaker jack on the back of the FP40 hearing aid analyzer.
3. Press F1 – MENU from the Main Coupler screen in order to enter the Setup Menu.

4. Use the AMPLITUDE and FREQUENCY knobs to select MAIN F2 under FUNCTION KEY DEFIN.
5. Press START/STOP repeatedly to select TELECOIL.
6. Press F1 to return to the Main Coupler screen.
7. Press F2 to turn ON the telecoil feature.
8. Hold the Telewand next to the hearing aid as if you were holding a telephone next to the aid in the patient's ear. That is, if the aid is a BTE, hold the Telewand parallel to the aid's body. See Figure 7.2. If the aid is an ITE, hold the Telewand against the aid's faceplate.

Figure 7.2 –Using the Telewand

7.3 Environmental Magnetic Fields

Telecoil testing can be difficult in the presence of magnetic fields. If you normally use an external monitor with your FP40 analyzer, turn it off for this test and use the LCD only. Check for the presence of unwanted magnetic fields by using a wide range linear hearing aid on the "T" setting and with the volume control full on. Attach the aid to a coupler without the test microphone. Listen through the coupler. In some locations there will be such a loud raspy hum that you will know immediately that it is unusable for this location. Power lines and florescent lights can cause problems. More subtle problems can be detected as you conduct the test.

7.4 Testing

1. Use the amplitude knob to increase the level of the magnetic field. If you are using the Composite signal, the amplitude will be displayed in the Status box. If you are using a pure-tone signal, the amplitude is displayed in the lower right corner of the screen. When changing the field strength from 00 mA/M to 10 mA/M, the amplitude of the response should increase by 10 dB if you are in an environment where it is possible to make valid telecoil measurements. You are then above the background magnetic signal.
2. Use a signal strength of 10 mA/M to perform the telecoil test to the ANSI 87 standard. Use a signal strength of 32 mA/M to perform the telecoil test to the ANSI 96 standard. The measured output will increase by 5 dB as you move from 10 to 18 to 32 to 56 mA/M, provided the orientation of the hearing aid remains constant. These results are normal. Results that vary from this norm may be due to environmental magnetic fields.
3. Press START/STOP to start a pure-tone sweep or the Composite signal measurement.

Notes

Use Noise Reduction when necessary to reduce the effects of stray magnetic fields.

Notice the position of the hearing aid that provides the highest amplitude. It may be useful to explain to your client that his or her head may have to be in an unusual position to take full advantage of the telecoil, or that it may be possible to turn the telephone receiver to increase the amplitude of the signal.

Some users have both a telecoil and a separate sound chamber. For these users we supply a Y cord so that both the sound chamber and the telecoil may be hooked up at the same time.

SINE SIGNAL

Frequencies	1/12 octave frequencies from 200 to 8000 Hz, closest 100 Hz,
Normal Sweep	within 1 %: 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0, 1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9, 2.0, 2.1, 2.2, 2.4, 2.5, 2.6, 2.8, 3.0, 3.1, 3.3, 3.5, 3.7, 4.0, 4.2, 4.5, 4.7, 5.0, 5.3, 5.6, 6.0, 6.3, 6.7, 7.1, 7.5, 8.0 kHz.
Frequencies Fast Sweep	0.2, 0.3, 0.4, 0.5, 0.6, 0.8, 1.0, 1.2, 1.6, 2.0, 2.5, 3.1, 4.0, 5.0, 6.3, 8.0 kHz.
Frequencies Short Sweep	1/2 octave frequencies closest to 100 Hz
Warbled Sinewave	Has a 5 %, 33-1/3 Hz warble
Amplitude (RMS)	Coupler mode: 40 dB SPL through 100 dB SPL in 5 dB steps. Probe mode: 40 dB SPL through 90 dB. Accuracy at reference point, after leveling, 2.5 dB for 500 Hz through 3500 Hz; 3.5 dB for all other frequencies.
Harmonic Distortion	(at 70 dB SPL) Less than 0.5% for 500, 800, and 1600 Hz.

COMPOSITE SIGNAL (optional)

Frequencies	From 200 Hz to 8000 Hz in 100 Hz intervals. Accuracy within 1%.
Amplitude	Coupler mode: (RMS) 40 dB SPL through 100 dB SPL in 5 dB steps. Probe mode: 40 dB SPL through 90 dB. Accuracy at reference point, after leveling, 2.5 dB for 0.5 kHz through 3.5 kHz; 3.5 dB for all other frequencies.
Crest Factor	Less than 9 dB.

BATTERY CURRENT MEASUREMENT

Measurement Range	0 mA to 25.0 mA.
Current Limit	0 mA to 55 mA.
Accuracy	3% of full scale +/- 1 digit.
Resolution	0.1 mA.
Simulated Battery Types	5, 10 A/230, 13, 312, and 675 zinc air; 13, 312, and 675 mercury; 13, 312, 76 silver; AA; and 41 mercury.
Battery Voltages Supplied	1.5 V for silver oxide and AA, 1.3 V for mercury and zinc air.

Tolerance +/- 0.01V, no load.

Battery Type Selection Under software control from front panel, but proper size battery pill must be selected.

DIGITAL READOUT OF SPL

Frequency Range 200 Hz through 8000 Hz.

Amplitude Range 0 dB SPL through 149.9 dB SPL, -70 dB through +100 dB gain.

Max Input Signal 150 dB SPL.

Resolution 0.1 dB.

Type True RMS if Source is set to "off ".

Accuracy From 250 Hz to 2500 Hz, 2 dB +/- one digit. All other frequencies, 3 dB +/- one digit.

SYSTEM NOISE

Equivalent Input Noise 50 dB SPL RMS.

Noise Reduction Averages the measured signal in synchronism with the signal generator by the factor chosen. Averaging factors from 2 to 16 available in powers of 2. Random noise will be reduced by an amount equal to the inverse square root of the factor chosen.

HARMONIC DISTORTION ANALYSIS

Type 2nd, 3rd, and 2nd + 3rd = total.

Resolution 0.1 percent.

Reading Percent with respect to total signal. Readings made at frequencies from 400 through 2500 Hz.

POWER REQUIREMENTS

Voltage 90 VAC to 264 VAC.

Frequency 50 Hz to 60 Hz.

Power Dissipation 40 VA at 120 VAC, 60 Hz input, normal operation

SAFETY UL approval; UL 554 approval upon request

BATTERY OPERATION (optional)

Remote Operation Requires optional battery power module. Operation possible for 3 hours continuously on battery power (with new battery at 25 degrees C.).

Auto Shutdown	General shutdown after no operation of controls for 15 minutes (battery operation only).
Battery Charger	Built-in automatic battery charger. Full charge in 10 hours.

DISPLAY SCREEN

Backlit Liquid Crystal Display	Graphical display, 640 pixels wide x 200 pixels high.
Color	Blue background with white lettering or white background with blue lettering.
Illumination	Fluorescent edge lighted.
Display Angle	Module tilts from 12 to 90 degrees with respect to horizontal.

PRINTER

Type	High speed, thermal.
Print Speed	Screen copy in 14-19 seconds.
Paper Used	Black print on white background. Print density adjustable in software (FP40 only).
Paper Width	60 mm.
Access	Through top mounted door.
Other:	Unit also works with HPCL and EPSON or compatible printers through a serial port.

SOUND CHAMBER

Test Area	3” x 3” (7,5 x 7,5 cm) in acoustical foam-treated area. Separate space for excess microphone cord storage.
Loudspeaker	3” cone, mounted in case. Case mounts on a swivel arm for probe operation.

EXTERNAL CONTROLS, INDICATORS AND CONNECTORS

Front Panel Buttons	9 function keys plus Print, Feed, Data/Graph, Level, Reset, Start/Stop, and Operate On/Off (with guard ring).
Rotary Controls	Front: Amplitude, Frequency; Rear: Probe monitor level.
A/C Power Switch	Rocker type, rear mounted.
Jacks	RS232 (9-pin), probe monitor earphone (1/4” stereo), external speaker jack (3mm phone jack), and VGA (15-pin).

PHYSICAL DESCRIPTION

Dimensions	20.125” x 14.750” x 6.5” (50,5 x 36,9 x 16,25 cm) (with lid on case).
Color	Light grey with black trim, white control panel.
Weight	FP40: 25 pounds (11,40 kg) with lid and battery; 22 pounds (10 kg) without battery FP40-D: 16.5 pounds without accessories

SAFETY

Safety Approval	Note that for the UL listing to be valid, all mains connected electrical equipment attached to the FP40/FP40-D must conform to UL 544. Display monitors and computer equipment attached to the FP40/FP40-D must be “medical grade”. If you order the VGA Option without the monitor, we will continue to affix the UL tag on the assumption that you will purchase a hospital grade monitor. However, if we ship you our industrial grade monitor, we will not affix the UL tag.
CE Mark (Back Panel)	This symbol indicates that Frye Electronics conforms to the Medical Device Directive 93/42/EEC. If an external monitor or printer is used, it should also have a CE mark in order for the FP40 to remain compliant.

Calibration

Your new instrument has been calibrated at the factory. However, from time to time, you will wish to check it with an external source, a sound level calibrator. Frye Electronics offers the QUEST QC-10 calibrator, especially adapted to our equipment, but other models can also be used.

While in the SETUP menu, push F4, CAL MIC(s).

Calibrating the Coupler /Reference Microphone

1. Place the 1” to 14 mm adapter in the QC-10 calibrator.
2. Place the coupler/reference (larger) microphone in the adapter. See Figure B-1
3. Turn on the calibrator, noticing the stated output (114 dB).
4. The measured output can be seen on the display. If it is higher or lower than the desired output, you may adjust the calibration by using a small screwdriver at the REF GAIN control inside the sound chamber (Fig. B-2). You must first remove the sound box on FP40 units with serial no. 941655 and higher, and FP40-Ds with serial no. 944402 and higher.

Figure B-1

Figure B-2

Calibrating the Probe Microphone

1. Place the probe calibration adapter in the 1" to 14 mm adapter as show in Figure B-3
2. Put the probe tube in the adapter, pushing it completely through, as shown in Figure B-4

Proceed as in Fig. B-1, except observe the measured output for the probe microphone and adjust the calibration at the control marked PROBE GAIN.

Figure B-3

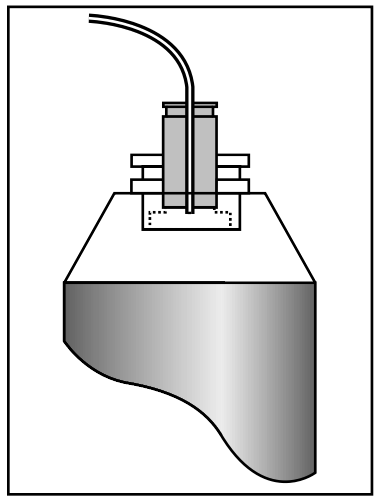


Figure B-4

Compensating Probe Microphone to Reference Microphone.

Since it is not necessary to compensate the probe microphone often, and an unintentional use of this function could cause measurement problems, the compensation function is hidden under CAL MIC(S). To further insure that it is not enabled accidentally, you must go to SETUP from the coupler measurement mode, not the probe mode.

1. Make sure that REFERENCE MIC is ON under PROBE SETTINGS.
2. Exit PROBE by pushing F5.
3. Place Reference Microphone and Probe Microphone together in the sound chamber at the reference point. See Figure 5.6.1.1A.
4. Close the sound chamber lid.
5. Push F1 SETUP MENU.
6. Push F4 CAL MIC(S).

7. PUSH F6 COMPEN (compensate) Probe. When the signal stops, the probe has been compensated and the compensation has been saved.
8. To view the effects of compensation, EXIT MENU, adjust AMPLITUDE to 70 dB and push START.

Note:
You may want to view the uncompensated differences between the two microphones. Follow instructions 1-7 above. Interrupt the compensation process by pushing RESET shortly after you hear the tones. Then follow instruction 8 above to view uncompensated differences.

Note:
If after Step 8 the differences between mics are unacceptable, try the process again, but level the instrument between steps 7 and 8.

The compensation process can adjust for differences of up to 3.5 dB. If the difference between the two microphones is more than 5 dB after calibration, consult factory.

IF YOU PUSH RESET DURING THE COMPENSATION PROCESS TO SEE THE UNCOMPENSATED DIFFERENCES, YOU HAVE REMOVED THE COMPENSATION. IF YOU NOW WANT TO HAVE COMPENSATED MICROPHONES, YOU MUST REDO THE COMPENSATION.

Appendix C: History of Changes

VERSION 1.0 (ORIGINAL RELEASE 3/90)

VERSION 1.2 (5/90)

Added: JIS Standard.

VERSION 1.3 (8/90)

Added: ISI Standard; CRT Option.

VERSION 2.0 (3/91)

Added: Fast Sweep

VERSION 2.1 (2/92)

Added: New Multi-Curve in Real Ear & Coupler. Target 2cc FOG & SSPL90. Easy-to-read Double-Size Characters. Full & Partial Menu Choices. Probe Signal Selection (F7 Definition).

VERSION 2.3 (4/93)

Added: 40 dB Input Source (K-Amp). Spectrum Analysis Mode.

Improved: Video Display Format (everything on one screen). Target 2cc FOG vs Actual FOG Comparison in Test Box. Equivalent Input Noise (EIN) Measurement.

VERSION 2.5 (2/94) (2.6 last version available for old CPU boards)

Added: RS232 Computer Interface. Laser Printer Interface. CHAP & HearWare Interface.

VERSION 3.02 (10/94)

Added: New CPU, VGA Color Option, Telecoil Option, (Earlier FP40/FP40-D can be upgraded.) Interfaces with CHAP and HearCare, a new office management software package.

VERSION 3.1 (1/95)

Added: AI (Audibility Index). New Laser Printout format. External Color Ink Jet Printer Interface.

VERSION 3.2 (4/95)

Added: CIC and ANSI '92

VERSION 3.3 (10/96)

Added Real Ear SPL software for non-linear hearing aids. New sound chamber and probe speaker.

VERSION 3.4 (6/97)

Added: DSL 4.1 Linear and WDRC.

VERSION 3.5 (10/99)

Added: Digital speech testing and expanded DSL

VERSION 3.6 (4/00)

Added: ANSI '96 and Profiler automated test sequences.

Appendix D: Custom RECD Test

There are two methods of getting Custom RECD measurements with the FP40 using the Probe Option. One method uses a linear BTE hearing aid and the other uses an ER-3A Insert Earphone. This appendix describes the BTE method. The insert earphone method is described in Section 5.6.1.

BTE / RECD Method

This simple method doesn't require any additional equipment. A linear BTE hearing aid with a moderate amount of gain is all that is required. The volume control should be taped in position so that it provides about 20 dB of gain. Make sure that you go into the MENU (F1) and change the DATA DISPLAY choice to AIDED (REAR.) Follow the steps as outlined in Part A, B, and C.

Note: The BTE method for measuring the RECD is not consistent with the DSL definition of the RECD.

Part A: The 2cc Coupler Measurement.

1. Attach the BTE hearing aid to an HA-2 coupler.
2. Make sure the FP40 is in the Gain mode, then select a 60 dB input signal (either pure tone/ normal sweep or composite.)
3. Measure the 2-cc gain.
4. Press the DATA/GRAPH button to convert the curve to data.
5. Print and save the results.

Part B: The REAR measurement.

1. Measure and mark the probe tube depth. Adults: 25-30 mm, Children: 10-15 mm.
2. Position and setup the client just like a REAR test at a 45 degree angle and 12" from the speaker. Place the probe tube in the ear, and the reference mic above the ear.
3. Attach a disposable earmold to the BTE hearing aid and place it in the client's ear with the probe tube in position, like an AIDED/REAR test. Note: Make sure the aid is OFF.
4. Level. After leveling is complete, turn the aid ON.
5. Press [F4], Target mode, then press [F1] to select right or left test ear, then EXIT.
6. Press [F2] to select IG test, adjust the AMPLITUDE knob to a 60 dB input signal (either pure tone or composite), then press [F3] and measure the AIDED – 1.
7. Press the DATA/GRAPH button to convert the curve to data.
8. Print and save the results.

Part C: The RECD Calculation.

On a separate sheet of paper, subtract the REAR measurements (Part B) from the 2cc coupler measurements (Part A). The differences at the required test frequencies are the RECD values. These RECD correction factors can be used for DSL and TARGET 2cc (sections 7.7.1, 7.7.3) calculations.

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 CIC coupler with a proper response correction would give better data to a hearing professional than the use of the standard 2cc 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 do not 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.

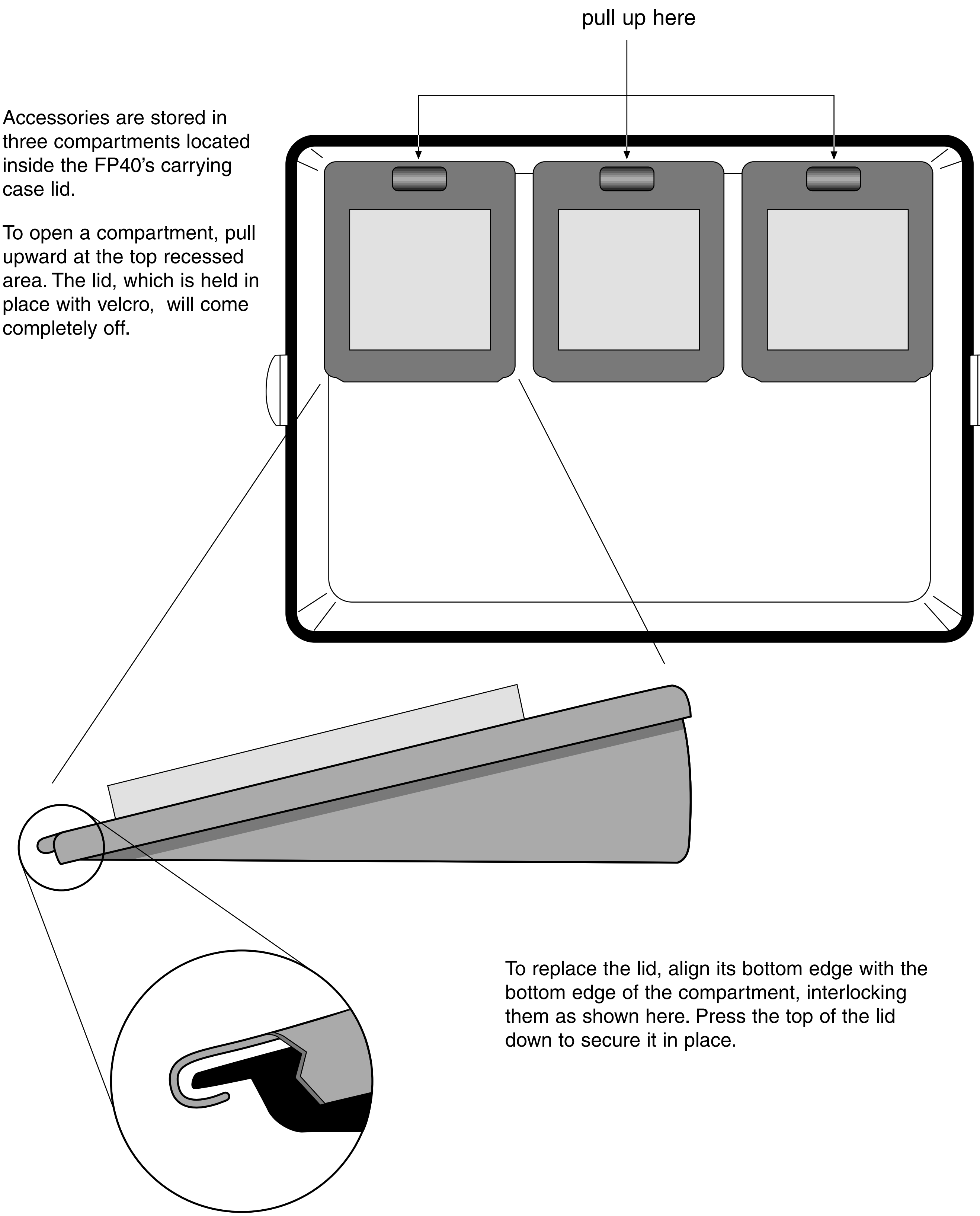
CIC CORRECTION FACTORS

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		

Appendix F: Storage Compartments in the FP40

Accessories are stored in three compartments located inside the FP40's carrying case lid.

To open a compartment, pull upward at the top recessed area. The lid, which is held in place with velcro, will come completely off.



To replace the lid, align its bottom edge with the bottom edge of the compartment, interlocking them as shown here. Press the top of the lid down to secure it in place.

Appendix G: 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:

1. No power

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

2. CRT/VGA/LCD display monitor is not working

a. Check the ON switch. (CRT/VGA monitors only)
b. Make sure the power cable is plugged into working wall outlet.
c. Check the monitor brightness and contrast controls and the LCD contrast knob.
d. Check the Screen Saver—push any front panel button to activate the screen.

TEST CHAMBER PROBLEMS:

1. Test Chamber Microphone does not Level

a. Check your mic calibration.
b. Is the mic properly plugged into the instrument?
c. Are all connections clean and tight?
d. Is the mic cable loose, broken, cut or worn or frayed?
e. Make sure everything is out of the test chamber (except the mic) when trying to Level. (See Operator's Manual)
f. Open the test chamber and listen for the leveling signal.
g. Is there an unusal 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.
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 released.

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's thermal paper. If not, it's plain paper and will not work.

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

1. Add the source level for Aided curve 2.
2. Interpolate from 10 frequency to 80 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:

Target SPL = Target IG + CRV2 source + AVG REUR
(If Aided2 is composite) - 10.7 dB - Speech Weighting.
(If Aided2 is speech tone) + 2.1 dB - Speech Weighting.

- 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 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	12.0
2000	15.0
3000	15.5
4000	13.0
6000	13.0
8000	14.0

This table is only used when the age is not specified in the Target Screen. For age-specific conversion values, contact Frye support at support@frye.com or call the factory.

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		

Notes on the DSL® Programming

The DSL® (Desired Sensation Level) software in the FONIX FP40/FP40-D program is based on the latest copyrighted I/O computer program. The DSL method was originally described by Seewald, Ross & Stelmachowicz in 1987. Its purpose was to provide amplified speech that is consistently audible, comfortable, and undistorted across the broadest relevant frequency range. Recently this method has been elaborated to attempt to provide audibility for as broad a range of inputs as possible. The goal is to make soft sounds audible, bring average speech sounds to the most comfortable level to maximize speech discrimination, and to keep loud sounds from exceeding the comfort level of the hearing aid wearer. These goals are addressed by the WDRC formula.

The original purpose of the DSL method was to fit hearing aids on children. Children present particular obvious problems in testing. Since it is often impossible to get as much reliable data as needed from the child, methods were developed to predict audiometric and acoustic information and to be able to do most of the fitting of the hearing aid in a sound chamber rather than in the real ear. Nevertheless, the DSL programming in the FP40 is found in the Probe section. Verification of the fitting is done whenever possible in the real ear.

The size of the ear canal, a function of the age of the child, affects the frequency response of the aid. Therefore, corrections are built into the FP40 target curves based on age. These are in addition to the corrections for microphone placement that are determined by the type of hearing aid. Frye electronics has long had its own corrections for microphone placement. The DSL corrections are used instead when the DSL formula is chosen so that the results are equivalent to those found in the DSL I/O computer program (If another formula is used, our original calculations are used. If desired, users may apply the DSL age corrections to the target coupler conversions that originated from existing insertion gain fitting formulas).

Sensation Level refers to an amount of sound above threshold. Frequency-specific target values, or Desired Sensation Levels, provide guidance in choosing and setting the hearing aid. Research findings* show that the required sensation levels for maximum speech discrimination vary with thresholds. Adjustments are made to the formula to reduce the upward spread of masking from the lower frequencies. Finally, predictions of uncomfortable levels are made from threshold data. The high level limits in DSL are not the traditional UCLs, but are one standard deviation below. They are designed to be at the upper limit of comfort (when formulas other than DSL are chosen, the SPL display in the FP40's Probe Option reflects the traditional UCL numbers).

Two important considerations in prescribing WDRC hearing aids are the compression threshold and compression ratios. The compression threshold should correspond to the hearing aid being fitted. The DSL creators recommend setting the compression threshold at the lowest possible setting. Compression ratio targets are given for each audiometric frequency. This information can be used in selecting a hearing aid. If all the compression ratios are very similar, a single-

*Erber, NP & Witt, LH (1977) Effect of stimulus intensity on speech perception by deaf children. Journal of Speech and Hearing Research, 42, 271-278 channel instrument can meet those targets. If the compression ratio targets are very different in different frequency regions, a dual-channel or multi-channel instrument may provide a better fitting for the client. When setting the aid, the compression ratio should be set to match the average of the target compression ratios in each frequency band.

Warning: If the prescribed compression ratio is greater than 4:1, a WDRC fitting may not be appropriate for this hearing loss.

In the DSL approach, all measurements are referenced to Sound Pressure Level. HL (Hearing Level) thresholds, no matter how they are obtained, are changed to real-ear SPL. Once the threshold is entered, the next step can be to go to the SPL display in the Probe screen to show the client or parent where the thresholds are in relation to the normal speech spectrum. The LTASS—Long Term Average Speech Spectrum—will be either the adult's or child's, depending on the age selected. The child's LTASS is based on Cornekussem, Gagné & Seewald.* Alternately, the operator can go from the target screen to the target coupler gain screen The hearing aid prescription curve will be displayed there. It is in this screen that a custom RECD (Real Ear to Coupler Difference) measurement can be made, using an insert earphone to add to the validity of the prescription. The hearing aid is now measured in the chamber at a range of amplitudes. The operator can make adjustments and the aid can be re-tested in the chamber.

Finally, when possible, the operator can return to the SPL screen in the Probe Option and validate the fitting in the real ear. The mid-range target will be displayed on that screen.

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*Cornelisse LE, Gagné JP & Seewald RC (1991) Ear level recordings of the long-term average spectrum of speech, Ear & Hearing, 12(1): 47-54

FP40 Battery Simulator Settings

Battery Size	Battery Chemistry	Impedance	Voltage
NONE	0V	1 OHMS	0.0V
10A/230	ZINC-AIR	10	1.3V
312	SILVER	10	1.5V
312	MERCURY	8	1.3V
312	ZINC-AIR	6	1.3V
13	SILVER	8	1.5V
13	MERCURY	8	1.3V
13	ZINC-AIR	6	1.3V
76	SILVER	5	1.5V
675	MERCURY	5	1.3V
675	ZINC-AIR	3.5	1.3V
401	MERCURY	1	1.3V
AA		1	1.5V
LOW BAT 1.0V		10	1.0V
5	ZINC-AIR	10	1.3V

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