FONIX®

FP35

MAINTENANCE MANUAL

Rev. 23

FRYE ELECTRONICS, INC.
P.O. Box 23391 • Tigard, OR 97281-3391 • USA
(503) 620-2722 • (800) 547-8209
Fax: (503) 639-0128
www.frye.com • e-mail: sales@frye.com

 Rev. December 21, 2012

Table of Contents

Chapter 1: Intro & Specifications

Introduction

Welcome to the FONIX FP35 Analyzer! The FONIX FP35 provides quick, accurate information about how well a hearing aid works. It uses a graphical display or numerical table to show how much amplification the aid provides, which frequencies it amplifies, and how much distortion is creates.

The FP35 uses a backlit LCD with an adjustable contrast for its main display, and it has a thermal printer built in so that you can print hard copies of gathered data no matter where you are. The FP35 also has an external monitor option that allows the simultaneous display of the built-in LCD and an external monitor. Most computer monitors will work with this feature, although the FP35 display is only in two colors. There is also a parallel port on the back of all FP35 analyzers, allowing the use of an external printer.

Indications for use

The FONIX FP35 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, 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 FP35.

1.1 Acoustical Outputs

Frequencies:	200-8000 Hz in 100 Hz intervals (user interface) 200-8000 Hz in 1 Hz intervals (RS232)
Frequency Accuracy	1%.
Amplitudes:	40-100 dB in 5 dB intervals coupler, 40-90 dB in 5 dB intervals real-ear (user interface) 40-100 dB in 0.01 dB intervals coupler, 40-90 dB in 0.01 dB real-ear (RS232)
Accuracy:	Coupler: ±2.5 dB from 300 to 5000 Hz, all others ±3.5 dB (after leveling) Real-ear: ±3 dB, 200-8000 Hz (after leveling)

Distortion (at 70 dB SPL): Puretone: < 0.5%, 400-2500 Hz

1.2 Telecoil Outputs

Field Strength: TMFS, 1, 1.78, 3.16, 5.62, 10, 17.8, 31.6, 56.2, 100 mA/m (user interface)

0-180 mA/m in 0.01 mA/m specified intervals (RS232)

Accuracy: ± 2 dB

1.3 Battery Current

Readout Range: 0.00-25.00 mA

Accuracy: ± 5%

Resolution: 0.01 mA

Resistance Tolerance: ± 5% ± 0.5 ohm

1.4 Digital Readout of Sound Pressure Level

Frequency Range: 200-8000 Hz

Amplitude Range: 0-150 dB SPL

Resolution 0.1 dB

Accuracy: Coupler measurements: ±2.0 dB

Probe measurements: ±2.0 dB

Reference measurements: ±2.0 dB

Equivalent Input Noise: < 50 dB RMS

1.5 Measurement Inputs

Probe Microphone: Crosstalk from reference microphone: < -80 dB
Crosstalk from coupler microphone: < -80 dB

Reference Microphone: Crosstalk from probe microphone: < -80 dB
Crosstalk from coupler microphone: < -80 dB

1.6 Harmonic Distortion Analyzer

Type	2nd, 3rd, and 2nd + 3rd = Total
Resolution	0.1 percent

1.7 Available Tests

Automated test sequences:	ANSI S3.22-1996, ANSI S3.22-2003, IEC 60118-7:1994, JIS:2000, ISI
Additional Coupler Tests:	Coupler Multicurve, Coupler Target, Coupler Ear Sim
Real-ear Test Screens:	Audiogram Entry, Insertion Gain, Real-ear Unaided & Aided, Real-ear SPL

1.8 Input Power

Voltage	100 – 240 VAC
Frequency	47 – 63 Hz
Current	1.35A
Power dissipation	27 watts typical with full operation. 23 watts when unit is in Standby.
Earth Leakage current	< 500 uA
Patient Leakage current	< 100 uA

1.9 Physical Dimensions

Size:	16 x 11 x 4.9 inches
Weight:	12 lbs (5.45 Kg) with softcase and all accessories except manual
Touch Screen:	Resistive

1.10 Printer, Internal

Type:	Thermal
Paper width:	80 mm (+0, –1 mm)

1.11 Printer, External

Interface:	Parallel
Language:	HP PCL3

1.12 Internal Sound Chamber Dimensions

Test area:	2.65” W x 5.25”L x 1.1” H
Speaker:	2.5" cone

1.13 Environmental Conditions

Operating Conditions:	15 – 35° C (59 – 95° F), 5-85% humidity (non-condensing)
Shipping Conditions:	-20 – 60° C (-4 – 140° F), 5-85% humidity (non-condensing)

1.14 Guarantee

The FONIX FP35 Portable Hearing Aid Analyzer and its accessories are guaraanteed 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.

Chapter 2: Specification Test Procedure

2.1 Source Frequency Accuracy

Instrument Required: Frequency counter accurate to 0.1 percent and capable of measuring 1000Hz.

Setup: Enter the Coupler Multicurve screen of the FP35 analyzer and present a static pure-tone signal with a 100 dB SPL input level at 1000 Hz. Connect the frequency counter to the internal speaker jack.

Measurement: The frequency counter should read 1000 Hz within the tolerance of the counter plus the specified tolerance of the FP35. See Section 1.1.

2.2 Source Harmonic Distortion

Instrument required: Audio Spectrum Analyzer with instrumentation quality microphone and preamplifier.

Setup: Enter the Coupler Multicurve screen of the FP35 analyzer and present a static pure-tone signal with a 70 dB input level. Put the spectrum analyzer microphone in the sound chamber and close the lid. Make sure the room is quiet.

Measurements: At 400, 1000, and 2500 Hz, measure the amplitude of the fundamental, second, and third harmonics. Make sure that the second and third harmonics combined are at least 46 dB (0.5%) below the fundamental. See Section 1.1.

2.3 Source Amplitude Accuracy after Leveling

Instrument Required: Precision sound level meter with 1/2" condenser microphone, response set to flat frequency response (C weighted).

Setup: Enter the Coupler Multicurve screen on the FP35 analyzer and present a static pure-tone signal with a 90 dB SPL input level. Turn off pure-tone noise reduction. Place the coupler microphone at the reference point in the sound chamber. Close the chamber lid. Level the analyzer. Replace the coupler microphone with sound level meter microphone at the reference point in the sound chamber. Close the chamber lid.

Measurements: Starting at 200 Hz, measure the RMS levels at the reference point with the sound level meter for each puretone frequency. It should read 90 dB SPL within the tolerance of the sound level meter plus the tolerance of the FP35 analyzer at each frequency. See Section 1.1.

2.4 Attenuator Accuracy

Instrument required: Precision AC voltmeter that is accurate at 1KHz.

Setup: Enter the Coupler Multicurve screen and present a static pure-tone signal at 1000 Hz. Turn off pure-tone noise reduction. Patch the electrical drive signal from the internal speaker output jack back into the microphone input jack and also into the input of the precision AC voltmeter. The hardware calibration fixture can be used for this test.

Measurements: Set the amplitude of the pure-tone source so that approximately 140 dB SPL is measured by the FP35. Measure the voltage on the voltmeter and note the input amplitude used by the FP35. Reduce the output level in 10 dB increments and note that the voltage changes by 10 dB within the tolerance of the voltmeter plus the tolerance of the FP35 source attenuator. Also note that the input level on the FP35 changes by about the same amount as the voltmeter. See Section 1.1.

Caution: Make sure that an adaquate signal to noise ratio is maintained. This can be important in making good measurements, especially at low signal levels.

An attenuator in the DIN connector of the patch cord may be needed to reach the lower levels on the digitizer. This can be made by using a series resistor and 1000 ohm shunt resistor from the signal lead to ground.

2.5 Accuracy of Coupler Measurement

Instrument Required: Precision sound level meter with 1/2" condenser microphone, response set to flat frequency response (C weighted).

Setup: Enter the Coupler Multicurve screen on the FP35 and present a static pure-tone signal at 90 dB SPL. Turn off pure-tone noise reduction. Place the sound level meter's microphone at the reference point in the FP35 sound chamber. Place the FP35 coupler microphone so that its grill is facing the sound level meter microphone's grill and is 1/8" away from it. Leave the chamber lid open and make sure the room is very quiet.

Measurements: Starting at 200 Hz, measure the RMS levels at the reference point with both systems for each puretone frequency. They should agree within the tolerance of the sound level meter plus the tolerance of the FP35 analyzer. See Section 2.3.

2.6 System Equivalent Input Noise

Coupler Channel

Setup: Insert the coupler microphone into an HA-1 coupler. Plug the access hole in the coupler with Fun-Tak. Put this assembly into the sound chamber and close the lid. Make sure the room is very quiet during the measurements. Enter the Coupler Multicurve screen on the FP35 analyzer. Pure-tone noise reduction and the reference microphone should be off. Put the analyzer in pure-tone static mode and set the source to OFF.

Measurements: Make sure the MIC SPL readout almost always shows less than the equivalent input specification from Section 1.2.

Probe Channel (Composite and Real-ear Options required)

Setup: Plug the end of a probe tube connected to the probe microphone with Fun-Tak. Put this assembly into the sound chamber and close the lid. Make sure the room is very quiet during the measurements. Enter one of the real-ear measurement screens. Turn off composite noise reduction and the reference microphone. Set the source type to Composite and set the input level to OFF. Start the composite spectrum analysis measurement.

Measurements: Make sure the RMS OUT readout shows less than the equivalent input specification from Section 1.3.

2.7 Crosstalk

Equipment Required: The Real-ear and Composite options on the FP35 analyzer. A Horn driver speaker with the horn removed and a 1/2" coupler attached to the speaker opening with Fun-Tak. A sinewave generator and a power amplifier to drive the speaker. This setup needs to be able to drive a microphone between 130 dB-140 dB SPL at 200, 1000, and 8000 Hz.

Testing the required equipment: You need to check the drive level of this setup and the isolation between the horn driver and the sealed microphone in the FP35 sound chamber.

1. Put the coupler microphone into the horn driver. Enter the Coupler Multicurve screen and set the source type to Composite and the source amplitude to OFF. Turn off the composite noise reduction and the reference microphone.
2. Present a 200 Hz signal with an ampltiude between 130-140 dB SPL with the sinewave generator. Note the volume setting used to get this level.
3. Place the coupler microphone into a plugged HA-1 coupler and the assembly into FP35 sound chamber. Close the lid of the chamber.
4. Put a 1/2" dummy microphone in the horn driver.
5. Set composite noise reduction to 16X.
6. Start the composite spectrum analysis measurement and observe the measurement at 200 Hz. This measurement should be at least 100 dB SPL less than the SPL measured in the horn driver.
7. Repeat steps 2-6 for 1000 Hz and 8000 Hz. If necessary to achieve the isolation, locate the horn driver further away or on a different surface than the FP35 analyzer. Alternately, set the horn driver and the FP35 analyzer on a soft foam pad in order to achieve this isolation.

Coupler to Probe Channel:

Setup: Plug the end of the probe tube attached to the probe microphone with Fun-Tak (Blue Stik). Put the probe microphone into the sound chamber and close the lid. Make sure the room is very quiet during the measurements. Place the coupler microphone into the horn driver assembly. In the Coupler Multicurve screen, set the noise reduction to 16X and the reference microphone to ON. Set the source type to Composite and set the amplitude of the source to OFF.

Measurements: Set the sinewave generator to produce a tone at 200 Hz with the volume control position as noted in step 2 of the equipment test above. Start the spectrum analysis measurement with the FP35 analyzer. The output at 200 Hz is the crosstalk measurement. Make sure this meets the crosstalk specification given in Section 1.4. Repeat this test for 1000 Hz and 8000 Hz.

Probe to Coupler Channel:

Setup: Insert the coupler microphone into the HA-1 coupler. Plug the access hole in the coupler with Fun-Tak. Put this assembly into the sound chamber and close the lid. Make sure the room is very quiet during the measurements. Place the probe tube connected to the probe microphone into the horn driver assembly using the probe microphone adapter. Enter the Real-ear Unaided and Aided screen on the FP35 analyzer. Set the composite noise reduction to 16X, turn off the reference microphone, and set the output limit to 140 dB SPL. Set the source type to Composite and set the source amplitude to OFF.

Measurements: Set the sinewave generator to produce a tone at 200 Hz with the volume control position as noted in step 2 of the equipment test above. Start the spectrum analysis measurement with the FP35 analyzer. The output at 200 Hz is the crosstalk measurement. Make sure this meets the crosstalk specification given in Section 1.4. Repeat this test for 1000 Hz and 8000 Hz.

Chapter 3: Calibration

3.1 Introduction

There are several different calibration procedures available on the FP35: Hardware calibration, system calibration, and microphone calibration. The hardware calibration is performed at the factory using a "hardware calibration fixture." This type of calibration only needs to be done at the factory when the analyzer is manufactured or after a major repair or upgrade. This type of calibration does not need to be done in the field.

The FP35 analyzer is temperature sensitive. The system calibration helps account for measurement variations that occur because of the measurement environment. This calibration can be performed by a qualified technician in the field.

The microphone calibration adjusts the sensitivity of the microphones. We recommend that a qualified technician perform this calibration once a year with a sound calibrator.

3.2 Hardware Calibration

This type of calibration is generally only performed at the factory after a major repair or upgrade. It requires a "hardware calibration fixture" that is generally not available to customers or distributors.

Make sure the FP35 analyzer has been operating at room temperature for at least twenty minutes. Connect the “hardware calibration fixture” from the earphone jack to the microphone jack (the schematic for this fixture is included at the back of this maintenance manual). **Make sure to always perform a system calibration after doing the hardware calibration.**

From the Opening Screen, press [MENU] to open the Default Settings Menu. Then press [F3] to enter the Calibration Screen.

Press [F2] to enter the Date/Time Screen. Make sure the date and time are set correctly. Press [EXIT] to return to the Calibration Screen.

Press [F5] and [START] to perform the calibration (the calibration function of [F5] is only available when the hardware calibration fixture is connected). The calibration fixture can be disconnected after the FP35 analyzer indicates the calibration is complete and successful.

If any error occurs during calibration, the FP35 analyzer will return a code to indicate what happened. Here are the error code definitions:

1—User abort
2—No calibration cable
3—Measurement error
4—Prescale error
5—Frequency response error
6—Speech filter error
7—Source attenuator error
8—Codec gain error

Contact the factory if you encounter any of these errors.

3.3 System Calibration

This type of calibration should always be performed after the hardware calibration described in Section 3.2. It should also be performed before the microphone check described in Section 3.4 and the microphone calibration described in Section 3.5.

Make sure the FP35 analyzer has been operating at room temperature for at least twenty minutes. From the Opening Screen, press [MENU] and then [F3] to enter the Calibration Screen. Select “Calibrate System” with the up/down keys. Press [START] to perform the calibration. After the calibration is complete, select “Store calibration in EEROM” with the down arrow key, and press [START].

3.4 Microphone Check

Do the following procedure to determine if the coupler and probe microphones are out of calibration.

Calibration instructions are in Section 3.5.

3.4.1 Coupler Microphone

For the coupler microphone, you will need a sound level calibrator such as the Quest QC-10.

1. Press [MENU] from the Opening Screen to enter the Default Settings Menu.
2. Press [NEXT].
3. Use the arrow keys to set the USER LEVEL to ADVANCED.
4. Press [EXIT] to return to the Opening Screen.

5. Press [F3] to enter the Coupler Multicurve Mode from the Opening Screen.
6. Use [F4] to choose NORM.
7. Press [MENU].
8. Set REF MIC to OFF, if necessary, using the arrow keys. (This menu item will not appear on all analyzers.)
9. Press [NEXT] to enter the Advanced Menu. Set STATIC TONE to SINGLE.
10. Press [EXIT] to return to the Coupler Multicurve Screen.
11. Press [▼] repeatedly until the single tone is turned off.
12. Use the microphone adapter supplied with the FP35 to fit the coupler microphone into the calibrator, and turn the calibrator on. See Figure 3.4.1.
13. Observe the output under MIC SPL. If it matches the specified amplitude level of the calibrator within ±1 dB, the coupler microphone is within specifications and does not need to be calibrated. If the coupler microphone is out of calibration, follow the instructions found in Section 3.5.1.
14. Press [EXIT] and follow steps 1-4 again to set the USER LEVEL back to EASY.

Figure 3.4.1: Coupler microphone inserted into sound calibrator.

Note: if you are using a calibrator that uses a signal with a frequency not divisible by 100 Hz, you will need to check the calibration in the microphone calibration screen.

3.4.2 Reference Microphone Check

These instructions only need to be followed if you are using a new style integrated probe microphone set. If you are using an old style (legacy) probe microphone set, skip to the probe microphone calibration check instructions found in Section 3.4.3.

1. Follow Steps 1-4 in Section 3.4.1 above to set the USER LEVEL to ADVANCED.
2. Press [F3] to enter the Coupler Multicurve Mode from the Opening screen.
3. Press [MENU].
4. Press [NEXT] to enter the Advanced Menu, and use the arrow keys to set the STATIC TONE setting to SINGLE.
5. Press [NEXT] to enter the Custom Menu. Use the arrow keys to set the MIC

PORT to EXTERNAL.

6. Press [EXIT] and [MENU] again to refresh the menu selections.
7. Use the arrow keys to set the REF MIC to OFF.
8. Press [EXIT] to return to the Coupler Multicurve Screen.
9. Use [F4] to set the source type to NORM.
10. Use the down arrow key repeatedly until the SOURCE is OFF.
11. Place the rectangular calibrator adapter into the calibrator as shown in Figure 3.4.2. You can either hold the reference microphone to the calibrator manually or use a rubber band.

Figure 3.4.2

12. Turn on the calibrator and observe the MIC SPL. If the reading matches the output specified on the calibrator by ± 1 dB, the reference microphone is within specification and does not need to be calibrated. Otherwise, follow the instructions found in Section 3.5.2 to calibrate the reference microphone.

3.4.3 Probe Microphone Check

1. Follow Steps 1-4 in Section 3.4.1 above to set the USER LEVEL to ADVANCED.
2. Press [F3] to enter the Coupler Multicurve Mode from the Opening Screen.
3. Press [MENU].
4. Press [NEXT] twice to enter the Custom Menu. Use the arrow keys to set the MIC PORT to EXTERNAL. (This setting will not appear on all analyzers.)
5. Press [EXIT] and [MENU] again to refresh the menu selections.
6. Use the arrow keys to set DISPLAY to GAIN, NOISE RED (TONE) to 16X, and

REF MIC to ON.

7. Press [EXIT] to return to the Coupler Multicurve Screen.

8a. If you are using an old style (legacy) probe microphone set, locate the calibration clip and fasten it to the edge of the reference microphone. Insert a fresh probe tube through the tube on the clip until the tip of the probe is at the center of the reference microphone grill as shown in Figure 3.4.3A.

8b. If you are using a new style integrated probe microphone set, fasten the tip of a fresh probe tube to the reference microphone using a dab of putty, as shown in Figure 3.4.3B.

9. Put both microphones in the sound chamber and close the lid.

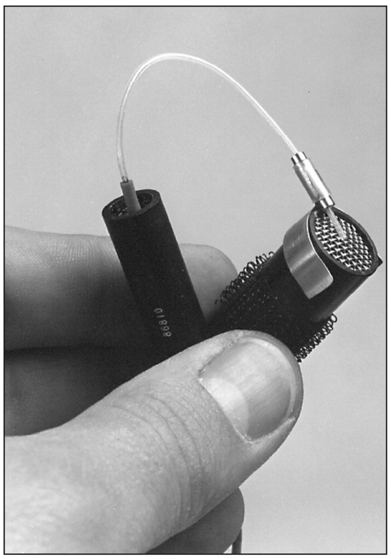


Figure 3.4.3A—Attaching the probe to the reference microphone

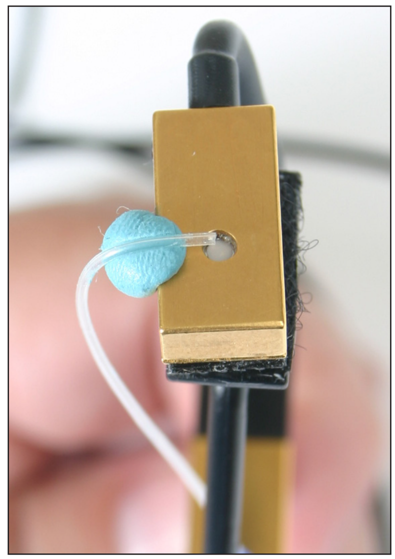


Figure 3.4.3B—Attaching the integrated probe to the reference microphone

10. Set the source level to 90 dB SPL using the up arrow key.

11. Set the source type to COMP (if available) using [F4]. Otherwise, set the source type to NORM.

12. Press [START/STOP]. If you are using the COMP source type, press [START/STOP] again to stop the signal.

13. Look at the response. This curve represents the difference between the probe response and the reference response. The maximum deviation from the zero line should be 5 dB.

14. If you are not sure if the response is ± 5 dB from the zero line, press [MENU], use the arrow keys to set the DATA/GRAPH selection to DATA, and press [EXIT] to return to the Coupler Multicurve screen. This will give you

the numerical data of the frequency response.

15. If the response is within 5 dB of the zero line, the probe microphone is within specifications. Otherwise, the probe microphone needs calibration. See Section 3.5.3.

3.5 Microphone Calibration

The FP35 microphones should be calibrated **after** the system calibration described in Section 3.3, and after the microphones have been checked as described in section 3.4.

There are three possible microphones on the FP35 analyzer:

- Coupler microphone
- Probe microphone
- Reference microphone

There are several variations of these microphones that may be available, depending upon when the analyzer was manufactured and whether or not it includes the Real-ear Option.

FP35 analyzers that do not include the Real-ear Option will only have the coupler microphone. This procedure for calibrating this microphone is described in Section 3.5.1.

FP35 analyzers with the Real-ear Option manufactured during or after November 2008 will have an integrated probe microphone set in addition to the coupler microphone. This consists of a probe microphone integrated into the earhook and a rectangular reference microphone that attaches to the top of the earhook. The procedure for calibrating the integrated probe microphone is described in Section 3.5.3. The procedure for calibrating the rectangular reference microphone is described in Section 3.5.2.

FP35 analyzers with the Real-ear Option manufactured before November 2008 will have a two microphone set consisting of a larger 14 mm coupler microphone and a probe microphone. (The coupler microphone is used as a reference microphone during real-ear measurements.) The procedure for calibrating the coupler microphone is described in Section 3.5.1. The procedure for calibrating the probe microphone is described in Section 3.5.3.

To perform the microphone calibrations, you will need the following equipment, depending on what type of microphones you are calibrating. The adapters come standard with the analyzer. You can purchase additional adapters and a sound calibrator from the factory. (Sound calibrators are special orders and may not be immediately available for purchase.)

- Sound calibrator such as a QC-10 (all calibrations)
- 14 mm-to-1 inch microphone adapter (coupler microphone calibration)
- Rectangular reference microphone adapter (rectangular reference microphone on integrated probe microphone).
- Calibration clip (legacy probe microphone)

Figure 3.5 Microphone calibration equipment.

3.5.1 Calibrating the Coupler Microphone

This procedure describes how to calibrate the coupler microphone. (On FP35 analyzers manufactured before November 2008, the coupler microphone was also used as a reference microphone during real-ear measurements.)

1. Press [MENU] from the Opening Screen to enter the Default Settings Screen.
2. Press [NEXT] to go to the Advanced Default Settings Screen.
3. Use the arrow keys to set the USER LEVEL to ADVANCED.
4. Press [F3] to enter the Calibration Menu.
5. Press [F3] to enter the Microphone Calibration Screen.
6. If you have an FP35 analyzer manufactured after November 2008, select the port the microphone is plugged into. The "internal mic" is the connector located inside the internal sound chamber. The "external mic" is the connector located on the front of the analyzer. This functionality is not available

if the external microphone port is not on the analyzer. Normally the coupler microphone is plugged into the internal port.

7. Use the arrow keys to select "Custom Coupler Mic Cal." This may be the only selection available.
8. Attach the 14 mm-to-1 inch microphone adaptor into the sound calibrator.
9. Insert the coupler microphone into the adapter. See Figure 3.5.1. Turn on the sound calibrator.
10. Press [START/STOP] to start the calibration.
11. Use the up/down arrow keys to adjust the "MEASURED dBSPL" until it matches the output of the calibrator. Pressing the keys briefly will result in 0.1 dB changes. Holding the buttons down will result in 1 dB changes.
12. Once the "MEASURED dBSPL" matches the calibrator, press [EXIT] to return to the Microphone Calibration Screen.
13. Press [F5] to store the calibration.

3.5.2 Calibrating the Rectangular Reference Microphone

This procedure describes how to calibrate the rectangular reference microphone that is part of the new-style integrated probe microphone set. This microphone is not normally available on FP35 analyzers manufactured before November 2008.

1. Press [MENU] from the Opening Screen to enter the Default Settings Screen.
2. Press [NEXT] to go to the Advanced Default Settings Screen.
3. Use the arrow keys to set the USER LEVEL to ADVANCED.
4. Press [F3] to enter the Calibration Menu.
5. Press [F3] to enter the Microphone Calibration Screen.
6. Select the port the microphone is plugged into. The "internal mic" is the connector located inside the internal sound chamber. The "external mic" is the connector located on the front of the analyzer. Normally, the integrated probe microphone is plugged into the external mic port.
7. Attach the rectangular reference microphone adaptor into the sound calibrator.
8. Remove the reference microphone from the integrated ear hook and insert it into the calibration adapter with the opening of the reference microphone pointing into the calibrator. See Figure 3.5.2A. You can use a rubber band to hold the microphone onto the calibrator, if necessary. See Figure 3.5.2B. Turn on the sound calibrator.

9. Use the arrow keys to select “Custom Reference Mic Cal.”
10. Press [START/STOP] to start the calibration.
11. Use the up/down arrow keys to adjust the “MEASURED dBSPL” until it matches the output of the calibrator. Pressing the keys briefly will result in 0.1 dB changes. Holding the buttons down will result in 1 dB changes.

Figure 3.5.2A: Rectangular reference microphone inserted into sound calibrator.

Figure 3.5.2B: Using a rubber band to hold the microphone in place on the calibrator.

12. Once the “MEASURED dBSPL” matches the calibrator, press [EXIT] to return to the Microphone Calibration Screen.
13. Press [F5] to store the calibration.

3.5.3 Calibrating the Probe Microphone

These instructions describe how to calibrate the probe microphone. There are two models of probe microphone on the FP35 analyzer: the old style 1 cm diameter microphone and the new style integrated microphone. The calibration procedure is the same.

1. Press [MENU] from the Opening Screen to enter the Default Settings Screen.
2. Press [NEXT] to go to the Advanced Default Settings Screen.
3. Use the arrow keys to set the USER LEVEL to ADVANCED.
4. Press [F3] to enter the Calibration Menu.
5. Press [F3] to enter the Microphone Calibration Screen.
6. If you have an FP35 analyzer manufactured after November 2008, select the port the microphone is plugged into. The “internal mic” is the connector located

inside the internal sound chamber. The "external mic" is the connector located on the front of the analyzer. This functionality is not available if the external microphone port is not on the analyzer. Normally the probe microphone is plugged into the external port when it's available.

7. Use the arrow keys to select "Custom Probe Mic Cal."
8. Attach a new probe tube to the probe microphone.
9. If you have the old style microphone, attach the calibration clip to the reference microphone and thread the probe tube through it so that the end of the probe tip is centered on the grill of the reference microphone. See Figure 3.5.3A.

   If you have the integrated microphone, place the end of the probe tip over the reference microphone and secure with Fun Tak. See Figure 3.5.3B.

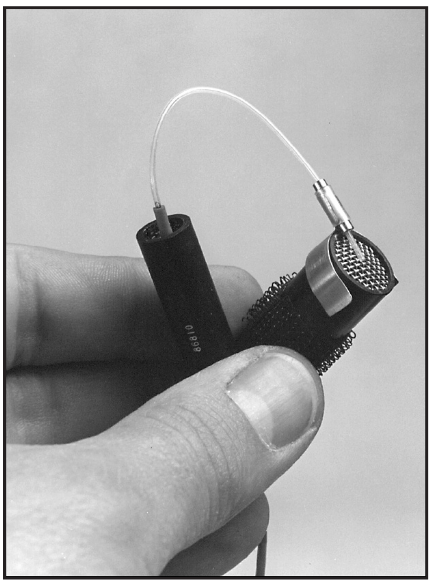


Figure 3.5.3A: Attach probe to the reference microphone using the legacy (old style) probe microphone set.

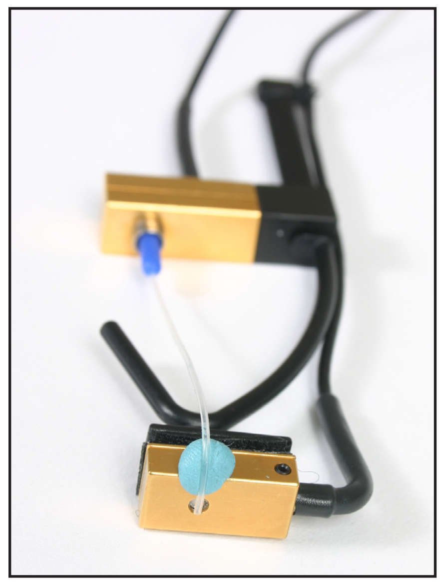


Figure 3.5.3B: Attach probe to the reference microphone using the integrated probe microphone.

10. Place the probe and reference microphones together at the reference point in the sound chamber.
11. Press [START/STOP] to start the calibration.
12. Press [F5] to store the calibration.

3.6 Insert Earphone Calibration

Before you can perform RECD or audiometric measurements, it is necessary to calibrate the insert earphone(s) that you will be using. The calibration for the insert earphones is based on the ANSI S3.6-1996 specifications. There is no need to specifically calibrate individual HL levels because the following calibration procedure provides a sufficiently stable reference.

3.6.1 RECD coupler setup

1. Insert the insert earphone into the "earphone" jack on the back of your analyzer.
2. Plug the other end of the insert earphone into the tubing of the ear level adapter attached to an HA-2 coupler. See Figure 3.6.1A.
3. Insert coupler microphone into the HA-2 coupler. See Figure 3.6.1B.
4. From the Opening Screen, press [MENU] to enter Default Settings Menu.
5. Press [F3] to enter the Calibration Screen.
6. Press [F4] to enter the Earphone Calibration Screen.

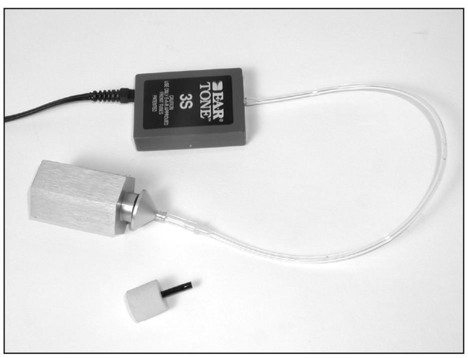


Figure 3.6.1A—Insert earphone connected to ear level adapter and HA-2 coupler.

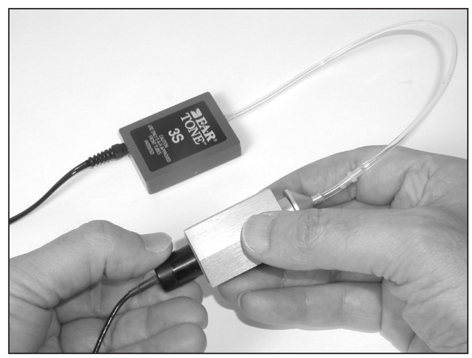


Figure 3.6.1B—Coupler microphone inserted into HA-2 coupler.

3.6.2 RECD coupler measurement

1. Set up your insert earphone for calibration as described above.
2. If you have the external integrate probe microphone plugged into the front of the analyzer, unplug it. (This does not apply to the older style probe microphone set that plugs inside the internal sound chamber.)
3. Select "Cal Left (Single) Ins. Earphone (RECD)" with [▲,▼].
4. Press [START/STOP] twice to perform the calibration.
5. If you are using only one insert earphone for the RECD measurements, skip to step 8. If you are using two insert earphones (one per ear), proceed to the

next step.

6. Set up the right insert earphone as described above.
7. Use [▼] to select "Cal Right Ins. Earphone (RECD)."
8. Press [START/STOP] twice to perform the measurement.
9. Press [F5] to save the insert earphone calibration.
10. Press [EXIT] to exit Earphone Calibration Screen.

3.6.3 Audiometer calibration setup

1. Attach the earphone calibration adapter to the HA-2 coupler
2. Insert the insert earphone into the "earphone" jack on the back of your analyzer.
3. Plug the other end of the insert earphone into the earphone calibration adapter. See Figure 3.6.3A.
4. Insert coupler microphone into the HA-2 coupler. See Figure 3.6.3B.
5. From the Opening Screen, press [MENU] to enter Default Settings Menu.
6. Press [F3] to enter the Calibration Screen.
7. Press [F4] to enter the Earphone Calibration Screen.

Figure 3.6.3A—Insert earphone connected to earphone calibration adapter and coupler

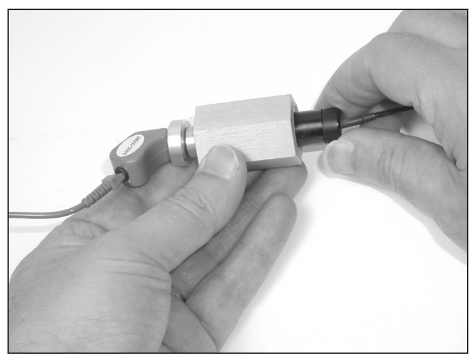


Figure 3.6.3B—Coupler microphone inserted into HA-2 coupler

3.6.4 Calibrating the audiometer

1. Set up the left insert earphone for calibration as described above.
2. Select "Cal Left (Single) Ins. Earphone" using [▲] if necessary.
3. Press [START/STOP] twice to perform the calibration.
4. If you're only using one earphone, skip to step 8. Otherwise, proceed.
5. Set up the right insert earphone for calibration as described above.

6. Use [▼] to select “Cal Right Ins. Earphone.”
7. Press [START/STOP] twice to perform the calibration.
8. Press [F5] to save the insert earphone calibration.
9. Press [EXIT] to exit Earphone Calibration Screen.

3.6.5 Erasing the insert earphone calibration

If you want to set the calibration to be electrically flat to allow you to use the “earphone” jack for other devices, perform the following operation.

1. Press [F1] to erase the calibration.
2. Press [F5] to save this change.

Chapter 4: Circuit Description

4.1 System Overview

The FP35 is a hearing aid analyzer capable of measuring the frequency response and distortion of a hearing aid using coupler or real-ear measurements. Two input channels are available: one for the coupler microphone and, optionally, one for a probe microphone. The FP35 analyzer includes a internal sound chamber that doubles as a sound field speaker, a backlit 320 x 240 LCD, and an internal thermal printer. An external VGA connector is optional.

There are six different circuit boards associated with the FP35 analyzer (not all are included on a single analyzer):

- Main board
- Standard Daughter board (when optional VGA not included)
- VGA Daughter board (optional replacement for Standard Daughter board)
- Backlight Inverter board
- Microphone board (only available with –09 rev to Main board)
- Printer Interface board (only available with Main board rev –11 and above)

The FP35 uses an external switching power supply that is capable of operation anywhere in the world.

The Main Board Includes:

- The CPU including RAM and FLASH ROM.
- Non-Volatile EEROM for storing default settings, calibration, and chamber leveling information.
- Dual Asyncronous Serial Port.
- Digital Thermometer to monitor internal temperature.
- JTAG port for automatic testing and CPLD programming.
- The Membrane Keyboard interface.
- Most of the LCD interface circuitry.
- The circuitry to drive the Internal Thermal Printer.
- The External Printer Parallel Port.
- The Two Channel Source Digital to Analog Signal Generator.
- The Speaker Amplifier.
- The Internal/External Speaker select circuitry.
- The Stereo Earphone Driver.
- Two independent Microphone Prescalers and Analog to Digital converters.

- The External Line Input and selection circuit.
- The Internal Microphone Input and Internal/External selection circuit.
- The Voltage Regulators for the Earphone Amplifier, Signal Generator, and the Digitizer.

The Standard Daughter board includes:

- The interface between the Main Board and a particular LCD.
- The LCD Contrast Control circuit.
- The LCD VEE supply.
- The Backlight Inverter connection.
- The Real Time Clock.

The VGA Daughter board includes all of the parts of the Standard Daughter board plus the VGA display circuit.

The Microphone board includes the jack for the external microphone input.

The Printer Interface board contains the circuits to control the print head and motor. For the Fujitsu FTP628 printer.

4.2 CPU

Refer to (CPU) and (MEMORY) of the FP35 Main Board schematics for the following discussion.

Master Clock:
Y1 supplies the 66.667MHz master clock for the CPU and the CPLD. The 33.333MHz clock(CLKOUT) is generated by the 386EX.

CPU Supervisor:
U11 supplies the power-on reset for the CPU and other circuits.

CPU Chip:
The KU80386EX CPU(U12) includes the following integrated peripherals:

- 386SX type CPU
- Interrupt Control Unit. We're using 5 of its external interrupts. It also has internal interrups going to other internal peripherals.
- Three general purpose timers
- Two Asyncronous Serial Ports
- Two DMA Controllers
- A Syncronous Serial Port
- A Chip Select unit. We're using five of its chip selects.

- General Purpose I/O pins. We're using 13 of them.
- A Watchdog Timer which is connected to the Non Maskable Interrupt pin.
- JTAG port.

CPU Bus:
The following lines on the 386EX comprise the CPU Bus:

- BLE, BHE, and A1 through A25 are the address bus
- D0 through D15 are the data bus.
- RD, WR, UCS, CS0, CS3, CS4, and CS6 are the control Bus.

I2C Port:
A standard I2C two line syncronous communication bus is implemented by general purpose lines P2.1(I2CSCL) and P2.2(I2CSDA) of the 386EX.

Quiet Bus:
The 386EX syncronous serial transmit pins(STXCLK, SSIOTX) and P1.0(SRLATCH) are used to implement the "Quiet Bus". This bus is used to communicate with U20 and U31 (74HC595) to generate the control signals for the Digitizer Prescalers and Analog I/O selections.

ROM:
U16(E28F400C5) is a FLASH ROM device that holds the FP35 program. This part is non-volatile when power is removed, but can be written to by the CPU. The UCS(FLASHSEL) chip select is used to select this part. Q5 and 386EX line P1.5(VPP_CNTRL) are used to control the program power(VPP) for this part. The 386EX line P1.6(WP) is used to control the Write Protect line for this part. JP3 and JP4 are not used at this time.

EEROM:
U10(24C128) is a small EEROM that is also non-volatile when power is removed, and can also be written to by the CPU, but is more convienient to store small amounts of data such as default settings, calibration, and chamber leveling. The CPU communicates to this part through the I2C bus. U32 and U33 are not currently used. They are provided to allow expansion of the ERROM storage should it be needed.

RAM:
U9(ASC4098) is a Static RAM where the FP35 program stores temporary information. The CS6(RAMSEL) chip select is used to select this part.

Digital Thermometer:
U5(DS1820) can be read by the CPU to measure the temperature inside the unit. This is done to improve the internal print consistency. The CPU communicates to this part through a one wire bus implemented on pin P1.3 of the 386EX.

Asyncronous Ports:
RS232 transceiver U13 and connector J11 interface the two asyncronous serial ports inside the 386EX to the rear of the unit. These lines are protected from static and RF by D29 to D36, C214 to C220 and L27 to L33. Pin 9 of J11 provides an external trigger output for external equipment. This line goes high during the time when a measurement is being made. The signal is also available at TP3 on the board. Data sent and received on pins 2 (TXD) and 3 (RXD) of J11 are monitored by D90 (red and green leds) to provide a visual indicator to the user.

CPU pins Foat:
JP2 can be used to force all the pins on the 386EX to float. This is needed if a hardware debugger is to be used.

JTAG Port:
J4 is used to connect an external PC to the JTAG ports on the 386EX and the CPLD. An external interface is used between the PC's parallel port and the FP35's JTAG port. This port can be used to perform automated testing of the FP35, and to program the CPLD.

Special Test RAM:
U29 and U30 are not installed; they are only used on the development systems.

4.3 CPLD

Refer to the FP35 Main Board schematics for the following.

The CPLD U2 is used to interface the following peripherals to the CPU:

- The Membrane Keyboard
- The Internal Printer
- The LCD
- The External Printer Parallel Port
- The External Keyboard (not available on rev –08 and later Main boards)

The CPU Interface to the CPLD is comprised of:

- The Data Bus on D0 to D15.
- The Address Bus on BLE, BHE, A1, and A2.
- The Control Bus on RD and WR.
- The Chip Selects on CPLDSEL and LCDFLY.

Board Identification Circuit:
Starting with the –08 board, the software needs to know which board is installed so that it can be adapted for that board revision. The BID1 and BID2 signals provide the identification.

BID1 = +5V BID2 = +5V : Rev –07 board or below

BID1 = 0V BID2 = +5V : Rev –08 board, Rev –12 board

BID1 = +5V BID2 = 0V : Rev –09 board, Rev –10 board and Rev –11 board

BID1 = 0V BID2 = 0V : <future expansion of ID>

Up until the –07 board, the hardware configuration remained the same. With the –08 revision, the speaker and earphone jacks were changed. With the –09 revision, the external line input and optional external microphone input were added. If the BID1 and BID2 signals are both 0V, then board identification will be determine using a different (yet to be determined) method.

Note: There is a jumper wire on the –10 revision board between JP14 pin 1 and U31 pin 7 to identify it as a rev –11 or rev –12 board.

Membrane Keyboard Interface:
The membrane keyboard is connected to J1. Each button on the keyboard connects one column to one row when it is pressed.

The three column signals are driven out pins 1,2, and 11 of J1. The CPLD drives these as open drain lines. The pull-up resistors R24, R30, R102 on those lines pull the column lines high when they aren't driven low by the CPLD.

The six Row signals are received on pins 3,4,5,6,7,8 of J1. Each of these lines are pulled high by a pull-up resistor R19 to R22 and R26 when they aren't connected to a column by a pushed button. They are buffered by U6(74HC244D), and then sent to the CPLD.

The Two LEDs on the keyboard are connected back to back and then to pins 9 and 10 of J1. They are driven by the 386EX P3.6 and P3.7 through current setting resistors R17 and R18. The green LED is lit when KEY_LED1 is driven high and KEY_LED2 is driven low at the same time. The red LED is lit when the converse is true.

The keyboard circuit is protected from static discharge by 11 zener diodes D18 to D28. C94, C107, C112, C125, C128, C129, C130, C136, C137, C142, C143, L63, L66, L67 and R135 to R140 provide RF protection for the keyboard circuit.

External Printer Parallel Port:
The CPLD directly drives J10 with all eight data lines and handshaking and control lines. The external printer circuit is protected from static discharge by 17 zener diodes, D1 to D17. L9 to L26 and C140 provide RF protection for the external printer circuit. The pull-up resistors R114, R115, R116, R128 and R129 are used to pull the open collector control lines on the printer port to +5D.

Also Refer to the FP35 Main Board Schematics (LCD Printer) and (CPU) for the following discussion.

Internal Printer Interface: (Seiko MTP401 printer)
Timer 0 in the 386EX is used to generate the master clock(T0OUT) for the printer driver. This signal goes into the CPLD at TØOUT.

The eight Print Head drive signals come from the CPLD pins I/O66 to I/O73 (PH1 to PH8). The eight 4.99K resistors set the signals to 0V when the CPLD pins are tri_stated. They then control the octal transistor array U1(LB1256M), and go to Flex Circuit connector J5. The print head circuit is protected from static discharge with 8 zener diodes, D63 to D70. RF protection is provided by L40 to L48 and C139.

The printer motor plugs into J6. The following describes the motor controller:

The motor drive signal(MDRV) comes from CPLD pin I/O75 and controls NMOS-FET Q4(IRLML2803). This signal is duty cycle controlled, and syncronized with the TACH signal from the motor. This is used to get the motor to run at the desired rate.

Q2, R27, and R33 convert the tach signal from them printer motor from a sinewave to a TTL signal. This signal is then sent to CPLD pin MTACH.

The motor brake signal(MBRAKE) comes from CPLD pin MBRAKE is level shifted by Q1(MMBT2222A), R25, R31, and R32 and then controls Q3(MMBT2907A). This is used to short the motor to get it to stop faster when it reaches the home position after the last line is printed. The JP12 jumper is used to disable the MBRAKE circuit during testing.

If both the MBRAKE and the MDRV signals are high at the same time, it can damage Q3 and R28. To prevent this, Q8 is used to disable the MDRV signal when the MBRAKE signal is on.

The Home Switch signal is sent to U12(386EX) pin P3.4. This is how the program knows when the print head is in the home position.

The printer motor circuit is protected from static discharge and voltage spikes by D51 to D54 and R130. RF protection is provided by L49 to L53 and C152.

Fujitsu FTP628 Printer Interface:
The FP35 can support either a (slow) moving head Seiko MTP401 printer, or a (fast) fixed head Fujitsu FTP628 printer.

While the Fujitsu printer can be operated with the older Seiko printer circuit in place (as long as the Seiko printer itself is not attached), normally the Seiko circuits will not be installed on the mainboard.

The CPLD must be programmed for the printer that is being used.
The Fujitsu printer requires at least a rev –11 main board.
The Fujitsu printer also requires newer software (V6.10 or higher) which provides support for the new printer.

When the Fujitsu printer is used, a 40pin connector J16 on the main board is used to attach the printer board. The Fujitsu printer board contains a motor controller and a head control circuit for the printer.

The Fujitsu printing is mapped from the screen as 3x3 printer dots for each screen pixel (three printer lines for each screen column).
Printing is done from top to bottom left to right. The printout is turned 90 degrees from the screen layout to maximize the print size.

LCD Interface:
Explanation of the display process:

1. Timer2 in the 386EX periodically supplies requests to DMA1 in the 386EX.
2. DMA1 then reads from the current location of display memory in the SRAM(U9). This read from display memory also causes the chip select LCDFLY to go active. LCDFLY tells the CPLD to latch the 16 bits of display data on the data bus.
3. The CPLD now clocks out the 16 bits of display data as four nibbles.
4. The CPLD also keeps track of when the end of each display line is reached, and when the end of each display frame is reached. The CPLD provides the data nibble, data clock, line latch, last line, and AC drive signals to the LCD.

The daughter board plugs into J7.

The following signals on J7 come from the CPLD:

> The LCD nibble data(LD0 - LD3), the Nibble Clock(CP),
> the Line Latch pulse(LP), the Last Line signal(FLM), and
> the AC drive signal(M).

The following signals on J7 come from the 386EX:

> The LCD On/Off signal(D_OFF), the Backlight control(BL_CNTRL),
> and the I2C bus(I2CSCL, I2CSDA).

U17(TLE2027CD), R48, R49, R50,R51, and R54 is used to generate an AC signal that the option board will use to generate the appropriate VEE and VO signals for the LCD.

The Contrast Control(R61) connects to a circuit on the option board that generates the appropriate Contrast voltage for the LCD.

4.4 Signal Source

Refer to the FP35 Main Board schematics for the following discussion.

The CODEC U23(AD1845) has the following source related circuits in it:

- Interface to CPU Bus
- Interface to DMA0 controller on 386EX
- Dual Digital to Analog converter
- Smoothing Filter
- Source Attenuator
- External Digital Control line XCTL0

The output from the codec (L_OUT and R_OUT) is filtered by R79,C103 and R80,C104 to remove the clock noise from the signal. JP5 and JP6 are provided to disconnect the codec output from the amplifiers during testing. U25A and U27A are used to buffer the codec output. The amplifier power supplies are filtered from the +-8A analog power with R133, C144, R134, C145, R93, C138, R105, C141. The output of the codec rides on a +2.5V DC offset.

C99 and C92 are used by the codec to internally filter the signals. C100 and C101 are not used. C97 and C126 are used to provide filtering of the reference supply voltage used by the internal codec filters. C98 is used to provide filtering of the reference supply voltage used to provide the +2.5V DC offset that the external inputs and outputs ride on.

The digital supply to the codec uses a filter +5D supply via L3. The analog supply for the codec is provided by a separate voltage regulator (U7) (Power) which provides the +5A power.

Y2, C76 and C80 are intended for use with a different type of codec. They are not currently used.

Speaker Drive:
The Line output from the CODEC is buffered by U25 and U27 and then fed to the speaker driver U26 (OPA548). C91 and C202 are used to decouple the 2.5V DC offset of the codec output to the ground referenced signal required by U26. R73 and R174 provide the ground reference. The gain of the amplifier is set to 16.07 dB (6.36x) for the 12V power supply, and 19dB (8.9x) for the 15V power supply by R90 and R91. C162 helps to prevent the speaker amplifier from oscillating and reduce sensitivity

to RF. R113 and C124 are a snubber circuit used to prevent the speaker amplifier from oscillating due to the inductive load presented by the speaker. R83 sets the peak current limit for the output of U26 (1.2amp for the 12V power supply, and 1.75amp for the 15V power supply). R131, C74 and C123 protects the current limit circuit from noise.

The speaker amplifier can be turned on and off by the DRVSPK signal originating at the quiet signal shift register U20 (74HC595D) (CPU), and then level shifted by Q7. –VP disables the speaker amplifier, -9V or higher enables the amplifier. C178 and C108 are used to slow down the switching and to protect the signal from RF. (–VP is –12V for the 12V power supply. –VP is –15V for the 15V power supply).

The speaker amplifier output is biased by R95 to improve the distortion at low signal levels. This resistor causes the output to go to –VP when U26 is turned off. To prevent that, Q9 is used to disconnect the resistor from –VP and connect it to ground via R158 when then amplifier is turned off. R176 parallel with R95 and C90 are used to slow the transition of the switching to further reduce the switching noise in the speaker output. R127 and C69 filter the –VP supply signal used by R95.

The Speaker Relay (K1) is used to direct the signal to either the internal (J3) or external (J11) speaker jack. The speaker select signal (SP_RELAY) originates at the CODEC XCTL0 line. It is then buffered by Q6 before driving the relay.

The speaker circuit is protected from static discharge at J3 and J12 by D55 and D56. RF protection is provided by C180, C198, L6 and C186, C199, L7. C181 is not currently used.

Starting with the –09 board, the speaker source is selected by U28. The source can come from the buffered L_OUT or R_OUT signals, or directly from the external line input jack J9 (CH1 or CH2 signal). U28 is controlled by the EXT_SW0 and EXT_SW1 signals that come from the U31 quiet signal shift register (CPU). R154 protects U28 from damage should U26 fail or the signal is accidently shorted. U28 is protected from power failure and overvoltages on its inputs by D80 and D81. C163 and C164 provide filtering for the U28 power supplies.

Starting with rev –12 mainboard the speaker analyzer is driven with ±15V power. This provides 2dB more output for the speaker compared to the older 12V power supply.

Earphone Drive:
Both line outputs of the CODEC are fed to the dual power amplifier U24(LM4880). The earphone signals are then routed to J13. The earphone circuit is protected from static discharge by D58 and D59. RF protection is provided by C196, C197, C223,

C224, L4 and L5. R111, C120 and R112, C119 are snubbers to prevent circuit oscillation that can be caused by the inductive speaker load. C79 and C89 decouple the +2.5VDC offset on the outputs of U24 from the speaker. R100 and R101 provide the DC return path to ground for the capacitors when there is no speaker attached. R81, R88 and R89,R92 set the gain of the earphone amplifier to 1x. C96 and C102 help to prevent U24 from oscillating and reduces sensitivity to RF.

The EAROFF signal is used to turn the earphone amplifier on or off. The earphone amplifier requires that its input be referenced to its internal 2.5VDC offset, while the codec output on R_OUT and L_OUT has its own separate 2.5VDC offset. To reduce popping and clicking when turning the earphone amplifier on and off, C203 and C204 are used to couple the inputs to the earphone amplifier.

U37 and U38 are used to disconnect the Earphone amplifier outputs when the amplifier is not in use. This prevents residual audio signal leakage through the earphone amplifier gain resistors into the earphone output when the amplifier is not in use. It also helps to reduce popping in the earphone output when the instrument is first turned on. R168 and R169 protect the U37 and U38 switches from any excess voltage that might be potentially produced by the U25 and U27 buffers.

The earphone amplifier circuit is designed to allow an improved amplifier (lower noise floor) to be installed at a future date. R172 is removed, and R173 and R174 have 1K ohm resistors installed. U24 (LM4880) is then replaced with LME49721MA audio amplifier IC.

Telecoil Drive:
The Telecoil is driven directly by the earphone or speaker output.

External Line Input:
The External Line Input (J9) allows an external source signal to be used instead of an internally generated signal in the FP35. The signals are buffered by U25B and U27B, then presented to U28 to allow the signal to be directly sent to the FP35 speaker amplifier. The signals are also presented to the codec on the L_AUX1 and R_AUX1 inputs that allows the codec to control the signal amplitude and to be able to send the signals to the earphone circuits.

The external line input is protected from static discharge by D60 and D61. RF protection is provided by C158,C182,C183,C166,C167,L61 and L62. JP9, JP13 and JP16 are not used (left open). R164 and R165 provide a DC resistive load for the input signals in case a capacitively coupled signal source is used. C172 and C173 are used to decouple any DC offset that might be present on the input signal. R166 and R167 are not currently used. C184,C185,C205 and C206 are used to provide additional RF protection. They are located near U25 and U27. R160,R161 and R162,R163 set the gain of the external line input buffers to 1x. The ground reference return of the buffers is separately returned to the J9 jack to minimize ground noise getting into the signals. C156 and C157 are used to prevent U25B and U27B from oscillating and to reduce sensititive to RF. C170 and C171 decouple the outputs of the buffers to reduce pops and clicks that might occur when selecting the signals.

The external line source signal is provided to U28 to be used directly by the speaker, and to the codec AUX1 inputs for use by the codec. The signals are filtered and reduced in amplitude to the codec by 6dB via R150,R151,C160 and R152,R153,C161. This allows the codec to handle a 2V RMS external input instead of 1V RMS. When the external line signal is sent directly to the speaker amplifier, it is limited to 1V RMS maximum. JP8 and JP10 are provided to disconnect the AUX1 inputs on the codec during testing. C168 and C169 decouple the +2.5V DC offset present on the inputs from the signal being presented.

4.5 External Microphone Adapter Board *(see FP35 Mic Board Schematic)*

The external microphone adapter board adds an external microphone connector on the front of the FP35 analyzer. The circuit on this board is the same as the circuit around J2 on the FP35 Main board with the exception that the chassis ground also has RF filtering in order to remove any RF that may have been picked up between the case entry point and the J15 connector on the Main board. The circuit functions the same as the circuit around J2 on the Main board.

4.6 Microphone Prescaler

Refer to the FP35 Main Board Schematics (Input) and (Prescalers) for the following discussion.

All the control signals mentioned here come from shift registers U20 and U31 (CPU).

Microphone Inputs:
Prior to the FP35 -09 board, there was only one microphone connector (J2) on the analyzer. There are two microphone inputs on the FP35 -09 board: J2 (internal) and J15 (external). J15 is connected to a separate microphone adapter board that is attached to the FP35 case.

For the –09 board, the microphone assembly to be used is selected via “T” switches (U34 and U35) on the inputs and the Mic ID switch (U36). The switches are controlled by the MIC_SEL0 control signal. A “T” switch configuration is used because it provides the required isolation needed for the sensitive microphone circuits. D86, D87, D88, D89 are used to protect U34 and U35 from latch-up or damage caused by power supply failure or input overloads. C189, C190, C191, C192 filter the power supply lines for U34 and U35.

The FP35 microphone input can operate with either a high impedence long-tail current source microphone such as the FM35 coupler only, a M300 real ear probe type dual microphone set, or a low impedence direct output instrumentation microphone (M1950 type microphone).

The FP35 provides a 160 uA current source via a current resistor (R85, R87) connected to the -8A power supply. This current load is always presented on the input. While the M1950 type microphone does not need the current load, it is not affected by the load.

Note: prior to the FP35 -09 board, the current load was 88uA (via a 90.9 K resistor). This was less than the current load recommended by the microphone manufacturer so it was updated for the FP35 -09 board to meet the desired specifications.

The coupler (probe reference) microphone is connected to pin 1 of J2 (pin 2 on J15). D41 provides protection from static discharge on the mic port. C209, C147, R191 are used to reduce RF going into and out of the J2 connector on pin 1. the +8A power for the microphone is provided on pin 6. The power is filtered by R77, C83 to prevent noise on the power supply from getting into the microphone. C210, C148, L39 are used for RF reduction on pin 6 of J2. D42 is used to protect pin 6 from static discharge. Pin 3 of J2 is used for the probe microphone input. It is protected from static discharge by D38. C201, C150, R190 are used for RF protection on pin 3 or J2. The +8A power for the probe microphone is provided on pin 7. D39 is used to protect pin 7 from static discharge. C200, C149, L36 are used for RF protection on pin 7 or J2. When using the M1950 microphone or the hardware calibration fixture, an additional -8A power must be provided. This power is available on pin 4 of J2. D40 is used to protect pin 4 from static discharge. C208, C146, L37 are used for RF protection on pin 4 of J2. The -8A power for pin 4 is filtered by R78, C82. The power pins (4,6,7) of J2 can withstand a short duration (one second) short to ground, but long term shorts (two or more seconds) should be avoided or the power filter resistors (R75, R77, R78) may be damaged.

The static discharge, RF protection and power filter circuits for the external microphone are located on the separate external microphone adapter board. Since the external microphone may not be installed in the FP35 (it is an option). The coupler and probe inputs on J15 are protected for RF and static (D78,C212 and D79,C213). This protection is minimal since it is not directly exposed to the outside world. Its primary purpose is to protect U34 and U35 when there is no external microphone board installed.

Frye microphones provide calibration and identification information via a Dallas memory device located in the microphone connector. This signal (MIC_ID) is provided on pin 5 of J2 (pin 9 on J15). D37 is used to protect pin 5 of J2 from static discharge. C207, C211, L34 are used for RF protection of pin 5. There is no direct static or RF protection for the MIC_ID signal on J15 pin 9 as the protection is located on the separate external microphone adapter board. The Mic_ID signal requires two additional design requirements. It must have a series load for impedance matching (reduces ringing on the line), and it must be protected from the user inadvertenly plugging the FP35 power supply into the microphone connector. R94 for J2 and R157 for J15 provide the require resistance (180 ohms). D45 for J2 and D99 for J15 provide the protection from power supply problem (+12V is connected to the Mic_ID pin). R6 and R96 are used to further protect U36 since the 5.6V zener clamps (D45, D99) allow the input signal to exceed the specified input maximum voltage on U36. The resistors also contribute to the series load resistance for the Mic_ID signal. Because U36 is a digital switch, cpu signals can leak into the switch control line (pin 6). The signal leak can then further leak into the microphone switch circuits. To reduce this effect, a 10K resistor is provided in series with the control signal going to pin 6 of U36.

The signal return for the microphones is provided on pin 2, 8 of J2 (pin 3,5 on J15) which are attached to the chassis ground at the connector. The microphone shield is connected to pin 9, 10 of J2 (pin 1, 7, 10 of J15) which is attached to the chasis ground at the connector. The Mic_ID signal normally gets its ground return signal via pin 2 of J2 (pin 3 of J15). Since the Mic ID information is only read when the microphone is not being used, the degradation of the mic return signal when the Mic ID information being read is not a problem.

Coupler Mic (Probe reference) Prescaler:
The coupler input prescaler has three stages. A 24dB gain stage, a 12 dB attenuator stage, and a speech filter stage. Each of the stages can be switched in or out of the circuit by the cpu.

U22A provides 24 dB of gain when the gain is selected with U18C via the A_PRESC signal. The gain is controlled by R65, R63 which are set up to provide 16x gain (24.08 dB). C62 is used to add a rumble filter (50 Hz high pass filter) to the circuit when the 24 dB of gain is enabled. This helps to prevent the output from saturating in the presence of low frequency signals outside the normal measurement range. In addition, the '-' input is referenced at the microphone connector when the 24 dB gain is en-abled. This helps to provide additional noise rejection on the mic circuit by using the common mode rejection of the opamp. When the 24 dB gain is turned off, the return leg of C62 is connected to the output of U22A (pin 1). This effectively turns the circuit into a unity gain amplifier (1x gain). R69, C72 and R67, C60 are used to filter the power supply to U22. This helps to reduce noise and crosstalk in the circuit from the power supply circuits. C187 and C194 are used to reduce RF from getting into U22A. C65 is used to prevent U22 from going into high frequency oscillation. R87 is used to provide the long-tail current source load for the microphone (as described earlier). R76 and C84 provide filtering of the -8A supply used by the long-tail current source. Because C62 is connected to the the opamp output when the 24 dB gain is turned off, the rumble filter aspect is no longer in effect. Also, the common mode rejection is no longer in effect since the signal is no longer connected to the microphone ground return entry point. With the gain turned off though, this is not as important. Implementing the circuit this way makes the circuit vastly simpler and just as effective.

The next stage is the 12 dB attenuator. Because the codec can only accept a 1V RMS input and the input can be as high as 5V RMS, an attenuator is needed to reduce the input signal to a level that the codec can handle. The attenuator can reduce the signal from 4V RMS to 1V RMS. The additional remaining 0.25V RMS may or may not be usable by the codec (it varies from codec to codec). The attenuation is set by R59,R53. This provides an attenuation of 4x (12.06dB). C56 is used to decouple any DC component from U22A. It also proves additional rumble filtering. The attenuation resistor provide the ground path for C56. U18A is used to select the attenuation. U18A is controlled by the A_ATTEN signal which is set by the cpu. U22B is used to buffer the output of the attenuator to provide the low impedence drive required by the speech filter stage.

The third stage of the prescaler is the speech filter. R58, R47, R43, C45, U15B form a 900Hz high pass speech filter. This filter is the inverse of the output speech filter. It is used to restore the composite signal to a flat signal level to be feed to the codec. The 3dB knee point is at 900Hz and rises at 6dB per octave above that. The signal A_FILTR is sent to U18B pin 10 to turn on the speech filter. When the speech filter is off, C45 is disconnected from the circuit. This turns U15B into a unity gain (1x) amplifier instead of being a speech filter. C42 is used to prevent U15B from oscillating and to reduce RF from affecting the opamp. C52 is used to decouple the output of the opamp from the codec input which has a 2.5V DC bias offset. Because the codec is limited to 1V RMS input, but the U15B opamp is capable of output of up to 5V RMS, R98 is used to limit any over voltage swings from damaging the codec.

The U15A section of the opamp is not used (spare). The power supplies of the U15 opamp are filtered by R107, R108, C87, C88 to prevent noise and crosstalk from affecting the circuit. The U18 switch is protected from power failure and input overload (which can cause them to latch up) by D46, D47. C115, C116 provide filtering for the U18 power supplies. R98, D84, D85 are used to clip the signal going into the codec to prevent overvoltage input that can disrupt the codec.

Probe Mic Prescaler:

The probe prescaler works similar to the coupler prescaler except that the probe prescaler has an additional probe equalizer circuit. The probe equalizer compensates for the probe tube on the probe microphone (roughly 6 dB per octave from 100 Hz to 8 KHz).

The 24 dB prescaler portion of the probe prescaler works just like the coupler prescaler. The one exception is the feedback capacitor on U21A which is increased to 56 pf to reduce the sensitivity to high frequencies (creates a 16 KHz low pass filter). The coupling capacitor, C57, between the 24 dB prescaler and the 12 dB attenuator stage is changed to 3.3 nF, and the attenuator resistors are also reduced a bit. This creates a high pass filter with the knee at 8 KHz. This is the first stage of the probe equalization. The attenuator buffer (U21B) is setup to have 32 dB of gain (40x). This in combination with the high pass filter attenuator circuit provides a filter with 0.1 dB gain at 200 Hz rising to 29.1 dB gain at 8 KHz. The feedback capacitor for U21B is set in combination with the gain set feed-back resistor to provide a low pass filter tuned to 16.9 KHz. Again, this helps to prevent high frequencies from being amplified and overloading the filter circuit.

The speech filter section is constructed the same as the speech filter for the coupler mic, except that the feedback capacitor (C37) is slightly larger (creating a 16.5 KHz low pass filter) to again help reduce high frequencies from overloading the filter.

Unlike the coupler prescaler, the probe prescaler has a final two pole low pass filter tuned to 16 KHz (U14A). This reduces frequencies above 16 KHz from getting into the codec.

The power supplies of the U14 opamp are filtered by R109, R110, C113, C114 to prevent noise and crosstalk from affecting the circuit. The U19 switch is protected from power failure and input overload (that can cause them to latch up) by D48, D49. C117, C118 provide filtering for the U19 power supplies.

C51 is used to decouple the output of the U14 opamp from the codec input which has a 2.5V DC bias offset. Because the codec is limited to 1V RMS input, but the U14A opamp is capable of ouput of up to 5V RMS, R99 is used to limit any over voltage swings from damaging the codec.

R99, D91, D92 are used to clip the signal going into the codec to prevent overvoltage input that can disrupt the codec.

4.7 Power Supply

Refer to sheet 8 (POWER) of the FP35 Main Board Schematics for the following discussion.

J8 is the connector to the external Power Supply.

Three LEDs D44 (+5V), D62 (+12V) and D71 (-12V) provide visual monitoring of the three main power voltages provided by the external power supply.

Test points are provided to measure the power supplies.

Digital power test points located near J10: +5D, +12V, -12V, +12VD, -12VD, DGND (TP4)

Analog power test points located near J10: +12PA, -12PA

Analog power test points located near U3,U4,U7: +5A, +8A, -8A

+5VE test point is located near U8. +5P test point is located near J5.(LCD Printer) +5C test point is located near U23(CODEC). AGND (TP5) is located near J2 (mic)(Input).

U3 regulates the -12V from the Power Supply to -8A for the digitizer.

U7 regulates the +12V from the Power Supply to +5A for the CODEC (23) and control selection registers (U20, U31).

U8 regulates the +12V from the Power Supply to +5VE for the earphone amplifier.

U4 regulates the +12V from the Power Supply to +8A for the digitizer.

RF filtering of the power supply voltages on J8 is provided by L54 to L60, L64, L65, C9 and C131 to C134. High frequency power supply noise filtering is provided by C4, C6 and C14.

L1 and L1 connect the Chassis ground and printer grounds to the central ground distribution while reducing the injection of CPU noise on these grounds.

15 Volt Power Supply

The 15 volt power supply is used to increase the sound field power by 2 dB. If a 15 volt power supply is used, the rev –10 mainboard must be modified to accept the higher voltage. Also, J8 is changed to prevent accidently plugging a 15 volt supply into an older 12 volt system.

J8 is changed from a 5 pin DIN to a 6 pin DIN to support the 15 volt power supply. L54 and L64 are removed when using a 15 volt power supply.

U45 and U46 provide the regulation to convert the ±15 Volt power to the circuits that need ±12 Volts. The ±15 Volts is separately feed to the speaker amplifier U26.

R91 and R51 are also changed to increase the gain of the speaker amplifier to 19 dB (8.9x) in order to make use of the extra power available with the ±15V supply.

R83 is also changed to increase the current limit cut-out on the speaker amplifier to 1.75 Amp.

The Board ID resistors are also changed to identify the mainboard as a rev –12 board so that the software can recognize the hardware changes.

4.8 Standard Daughter Board

Refer to the FP35 Mono Daughter Board Schematic for the following discussion.

The daughter board connects to the Main Board through J3.

The LCD is connected to J2 on the Daughter board.

LCD Contrast Control:
The base emitter junction of a transistor is used as the temperature sensor. This transistor is attached to the LCD assembly and plugs into J4 on the daughter board. R5 supplies current to the sensor. The voltage of a forward biased silicon diode junction such as this decreases about 3mV for each 1 degree Centigrade rise in temperature. The sensor affects the voltage at the inverting input of U3. The Contrast control on the Main board is connected to the noninverting input of U3. R10 is used to center the contrast control. R11 sets the range of the contrast control voltage.

VEE Supply:
The AC signal generated on the Main Board is rectified, doubled and filtered by C4, C5, CR1, and CR2. R3 and R4 set the regulating voltage of U1 to -24V which is required by the VEE supply on the LCD.

Backlight Inverter Interface:
The backlight control signal from the Main Board(BLCNTL) is level shifted from TTL levels to 0-12V by Q1 and R2. R1 is used to set the backlight intensity. The backlight inverter is plugged into J1.

Real Time Clock:
Battery BT1 supplies power to real time clock chip U2 when the FP35 is not supplied power from the external supply. Y1 is the 32KHz crystal that is used for timekeeping. The CPU on the Main Board communicates with the clock using the I2C interface.

4.9 VGA Daughter Board

The VGA Daughter board includes all of the parts on the Standard Daughter board plus the VGA Display circuit. The CPLD consists of two free running state machine based scanning engines plus some control features.

There is no reset operation. The state machines are self-synchronizing. The CPLD monitors the LCD data transfer port and captures the data it sees coming across into the on-board memory. The VGA scanner engine transfers the memory image to the VGA display monitor.

Data is stored in memory as a VGA bitmap of 640x480 pixels. It is read out of memory at 75 frames per second (VESA standard rate). This minimizes problems with flicker in countries with 50Hz power and helps to prevent display twinkle effects that can occur with 60Hz based power.

The FP35 VGA Daughter Board is designed as a hardware only upgrade. Although reality is that older instruments require that the motherboard CPLD be updated to work properly with the new VGA Daughter Board. Also, while the VGA Daughter Board will work with older software, the V3.40 software provides the ability to control the color selection on the VGA display.

Since the LCD display is 320x240 and VGA is 640x480, the VGA interface must also expand the LCD image to fit the VGA display. This is done by doubling the width of the LCD pixels being presented on the VGA display and presenting two VGA scan lines for each LCD scan line.

The VGA interface uses LD0, LD1, LD2, LD3, CP, LP and FLM to capture the LCD data. The LCD nibble data (LD0->LD3) consists of four pixels of LCD data. This is captured by the CPLD on the negative transition of CP. The CPLD watches for LP to go high to mark the start of a new scan line. It also watches for FLM to go high which provides the synchronization for the screen data.

FP35 Fast Line Printer Operation

Overview:

The FP35 can support either a (slow) moving head Seiko MTP401 printer, or a (fast) fixed head Fujitsu FTP628 printer.

See the older maintance manual for the Seiko printer operation. While the Fujitsu printer can be operated with the older Seiko printer circuit in place (as long as the Seiko printer itself is not attached), normally the Seiko circuits will not be installed on the mainboard.

The CPLD must be programmed for the Printer that is being used. The Fujitsu printer requires at least a rev-10 mainboard. The Fujitsu printer also requires newer software (V6.10 or higher) which provides support for the new printer. When the Fujitsu printer is used, a 40pin connector on the main board is used to attach the printer board. The Fujitsu printer board contains a motor controller and a head control circuit for the printer.

The Fujitsu printing is mapped from the screen as 3x3 printer dots for each screen pixel (three printer lines for each screen column). Printing is done from top to bottom left to right. The printout is turned 90 degrees from the screen layout to maximize the print size.

Motor Circuit:

The motor driver U1 controls the stepper motor in the printer that is used to advance the paper. The motor steps 12 times for each screen line that is printed (four for each printer dot line).

The motor driver is controlled from the cpu on the mainboard via the CPLD. The CPLD is used as an output latch. The PM1->PM4 and Hold signals are used to control the U1 motor driver IC. R15->R18 are used to keep the motor control lines inactive during power up and in case the connector cable should become detached.

The A3966 (U1) uses PWM to control the motor and to limit the maximum current drive to the motor. The step per motor allows a maximum of 440mA on each of it's two coils. An RC (R23 and C27) circuit controls the frequency (approximately 23KHz) of the PWM circuit.

R24 and R25 (Rs) are used to sense the current through the motor coils. The current limit is determined by the VREF voltage. Equation: Coil on Current = (VREF / (4 * Rs)) - 0.018Amp Where Rs is either R24 or R25 (one for each coil) and VREF is the voltage present on pin 8 (VREF).

The voltage on VREF is controlled by the voltage divider consisting of R22 and R26. This sets a voltage of approximately 0.86Volts for 440mA of coil current. The 2N2222 transistor Q4 is used to reduce the current through the coils when both coils are on to 330mA by adding a 30.1K resistor (R19) in parallel with R22 (10K) to reduce the VREF voltage to approximately 0.65 Volts. R20 and R21 are used to convert the TTL signal (Hold) to the current drive required to turn Q4 on and off.

The motor driver U1 is powered from both +VP and +5D power supplies. The +VP can be either +12 volts or +15 volts depending on the power supply attached to the FP35 mainboard. Since the motor is being driven by a current controlled driver, the supply voltage is not important as long as it is in range of what the IC can handle. C29 and C28 are used to filter the power supply signals going to U1.

The outputs of U1 are sent to the printer stepper motor through the RF suppression circuits (L1->L4 and C16->C19). MTA and MTA/ are used to drive one coil. MTB and MTB/ are used to drive the other coil.

The stepping method used is modified 1-2 stepping. During the odd steps, only one motor phase coil is on. During the even steps, both motor phase coils are on. When only one phase is on, the full 440ma of current is used. When both phases are on, the current to each coil is reduced to 330mA. Reducing the current reduces the motor step noise.

Head Data:

The print head contains a shift register which is used to collect the data being sent to the printer via an SSIO (SPI) interface. Data in (SRDATA) contains the data, The Data clk (SRCLK) signal is used to clock the data into the print head shift register. The data is shifted into the print head shift register while the printer is printing. It does not affect printing because there is a separate data latch which is used to control the print dots. When the Data Latch (Latch) line is strobed, it causes the data that was collected in the shift register to be transferred to the print head latch. The latch signal is sent just prior to beginning the printing of a new line. The 74HCT14 buffer/inverter U8 is used to provide noise immunity to data lines to minimize false data transfers. The RF suppression circuits L5->L6 and C9->C11 are used to reduce RF in and out of the circuit. The zeners Z3->Z5 are used to protect U8 from static damage.

Head Strobes:

Once the data has been latched into the print head latch, printing can begin. This is done by enabling the head strobe lines for the desired head segments that are to be printed.

The head is divided into segments (64 dots each), because if all the dots on a print line were to be printed at the same time, it would require 16 amps of current from the 5 volt supply. That is not available, so the printing must be done in smaller segments. The FP35 can handle up to 128 dots at once (3.6 Amps). Since normally all the dots on a line are not being printed at once, the FP35 looks at the data and adjusts the printing based on the number of dots found in the print segments. The FP35 uses three different print methods depending on the dots it finds in the line to be printed. It can print two segments at once, three segments at once, or 5+4 segments at once (5 segments are printed first then the remaining 4 segments are printed). The selection occurs based on the number of dots found in the segments to be printed. As long as there are fewer than 128 dots on in the segment group, the group can be printed. The advantage of the intelligent print method is a much faster print time while still retaining the desired print density.

The head strobes consist of five strobe lines (STB1->STB5) and two enable lines (AEN1/ and AEN2/). U5 and U6 are used to buffer and control the strobe lines. The printer requires special control of the strobe lines which will be described later. The strobe liens are driven by the CPU via the CPLD. The CPLD is used as a simple output latch. The strobe lines are feed through the RF suppression circuits (L8->L14 and C20->C26) and Zeners Z7->Z13 are used to protect U5 and U6 from static. The pull-down resistors (R30->R36) are used to keep the strobe lines off when not in use. The stobe and enable lines are used to select any of the nine available head segments and/or certain combinations of the segments.

The time that a strobe is enabled must be carefully controlled to prevent damage to the head and to insure a proper heating of the print dot to form the image on the thermal paper. The enable lines of U5 and U6 are used to control the time period that the strobe signals are applied to the print head. The strobe enable lines are themselves controlled by a NAND gate (U7). The gate keeps the strobes disabled when there is no power applied to the head and enables the strobes for a short duration to do the dot "burn".

The two enable lines that go to the head are controlled separately. They are enabled when head power is applied.

The strobe and enable lines are controlled by tri-state buffers because the signals must be pulled to ground when head power is removed to prevent reverse current flow through the strobe lines.

Head Power:

The head power is turned on at the start of printing and turned off when printing is done. Turning off the head prevents damage from possible static discharge triggering a burn, or software or hardware failure causing a burn to occur. It also helps to prevent head damage due to ion migration in humid environments.

The head power is controlled by Q1 and Q3 which are driven by the CPU via the CPLD. R14, R13 and Q3 convert the TTL level signal from the CPLD to the switching signal needed to drive Q1's gate. R12 is used to turn off Q1 when the head power is turned off. C13, C14, C38, C39 and C40 provide power supply decoupling for the head power circuit. C15 and C37 are used to reduce RF, and Z14 is used for static protection.

The logic circuits in the head are supplied by a separate VDD power line. L15 and C3 provide RF suppression on the VDD power supply and C1 and C1 provide power supply noise decoupling.

Burn Timer:

The 555 timer (U2) controls the amount of time that segment burns are applied to the head. The RC circuit R37 and C33 control the base timing of the 555 timer (approximately 750us). The time period is adjusted depending on head temperature via the CV input (pin 5) of the 555 timer. The CV input is controlled by a thermistor located in the print head which is buffered by U3. The resistors R8 and R9 are used to adjust the thermistor resistance to develop the proper voltage needed to be applied to the CV input of the timer. C30 is used to average out any noise that occurs on the thermistor signal.

The timer is triggered by the CPU through the CPLD and via Q2, R10 and R11 which converts the TTL signal from the CPLD to the trigger signal needed by the timer circuit. R27, R28,C31 and D1 change the trigger signal into a trigger pulse required by the timer circuit. The trigger to the 555 timer is normally in the range of 10uS to 100uS. The circuit (C1/R28) requires at least 100uS to recharge (R27/D1) after the trigger has occurred (controlled by the CPU).

C32 and R38 are used to filter noise from the power supply to minimize the power supply noise effects on the timer.

The actual burn time of a segment is dependant upon both the thermistor control of the timer and retriggering of the timer by the cpu. The basic timer output is controlled by the thermistor and will normally be between 400us and 1.0ms depending on temperature. Normal operating range of the head is between 5C and 65C. The table below shows the approximate relationship between the CV voltage, temperature and burn time.

CV Voltage	Time	Temperature
3.6 Volts	1.0mS	5C
3.0 Volts	0.8mS	25C
2.4 Volts	0.6mS	45C
1.7 Volts	0.4mS	65C

If the head temperature exceeds 65C during a print, the software will slow down the printer operation to give the head a chance to cool down. Once printing is completed, the software will prevent a new print until the head has cooled down below 60C. For normal printouts on the FP35, the head temperature will normally be in the range of 40C to 55C.

With normal thermal paper, a single burn at 750uS will not be enough to provide a desirable print density. The amount of burn time to use is dependant upon the type of paper used, and the desired darkness of the printout. To compensate for the differences in paper and desired darkness, the FP35 provides a print density control (menu selection), The value selected is the number of times that each segment is "burned". If a print density of "7" is selected, then the 555 timer will be triggered 7 times for each segment burn. The more burns that are triggered, the darker the print will be.

The trade-off of darker print is a longer print time since the print is extended by the number of repeated burns. Too many burns will also cause thermal bleeding on the paper. The exact density to use is dependant upon the type of paper (high, medium or low sensitively) and the desired darkness of the print by the user. The default selection of the FP35 for density is 5. This works for high and medium sensitivity paper and provides a reasonable darkness on the printout although the medium sensitivity paper will be grayer than the high sensitivity paper. Low sensitivity paper should use a setting of 7 or 8. For high sensitivity paper, a setting of 10 or 12 will cause excessive thermal bleed, especially if the FP35 is operated in a hot environment.

For a density setting of 7, the average print time for a typical single screen printout at an ambient temperature of 25C will be about 8 to 10 seconds. If more prints are done, this time will decrease as the head temperature rises. The head and stepper motor advance times are synchronized, so the faster the burn, the faster the stepper motor has to go to keep up. Screens that have large areas of dark on them may take longer as the printer has to slow down to reduce power drain due to the dark print areas. An example of this would be the Easter Egg picture screen (Exit/Start/Start). Most of the FP35 screens are light and can be printed at full speed or nearly full speed.

Paper and Platen Sensors:

The Fujitsu printer provides paper out and platen sensors. The printer can be potentially damaged if printing is done without the platen or paper in place. So this condition must be detected and printing prohibited when the platen is removed or there is no paper present.

The platen sensor is a simple switch located at the right side of the printer (opposite the motor). U6-D is used to buffer the signal and provide it to the cpu to read. C8 is used to debounce the switch signal. Since the switch is a normally closed switch, R7 is used to pull the signal to +5V when the platen is removed. L16 and C12 are used for RF suppression and Z2 is used for static protection.

The paper out detector is an optical sensor. It uses an infrared LED to shine light on the paper. If the optical sensor sees the light, it turns on. R1 is used to provide power to the LED. The sensor pulls the signal to +5D when it sees paper, so R2 is used to pull the signal to ground when there is no paper present. C4 is used to prevent RF from affecting the signal and Z1 is used to protect the circuit from static.

Because the optical sensor is a noisy high impedance signal, it must be cleaned up and buffered before it can be used by the cpu for paper out detection. U3 is used as a comparator to clean up and buffer the signal. R3 and R4 provide the detection sense threshold voltage of 1.67 volts. R5 is used to add +-0.1V hysteresis to the circuit. This causes it to set the output low when the paper sensor output goes above 1.77 volts and to go high when the signal falls below 1.57 volts. C5 is used to prevent RF signals from affecting the circuit. C6, C7 and R6 are used to filter power supply noise that might get into the circuit.

Power Supplies:

The power return for the logic circuits on the printer board is shared with the motor and head grounds. However the Digital ground on the main board is supplied separately. To prevent the power surges that can occur on the printer from getting into the mainboard digital logic, L18 is used to decouple the printer logic ground from the mainboard digital logic ground. The +5D printer logic supply is provided from the mainboard +5D Logic supply. The Head +5P power is supplied via a separate power line from the FP35 power connector. This helps to reduce the power surges from affecting the mainboard +5 volt logic power. The stepper motor supply requires at least 8 volts but can be up to 24 volts, so it gets it's power from the +VP supply on the mainboard. The +VP supply can be either +12V or +15V depending on the version of the mainboard and the power supply attached to the FP35.

Software:

Printing occurs by reading the lcd screen memory and sending the data read to the printer. The screen is read left to right, bottom to top. The bottom left screen pixel translates to the top left dot on the printer. The screen data is translated based on the screen palette. This is so that the print will always be black text and graphics on a white background.

Each of the screen pixels is translated to 3x3 dots on the print out.

At the start of printing, zeros are preloaded into the printer registers. This allows the printer to be synchronized to the screen. Actual printing occurs delayed by two screen column reads. For each screen column that is read, 3 print dot lines are printed. During this time the stepper motor will be advanced 12 times. When a screen column is read, the number of printer dots that are on in each print head segment is counted. The segment print method is then selected based on the number of on dots. One two, three, four or five segments may be printed at the same time depending on the number of on dots found in the segments. No more than 128 dots can be on at any time during a head burn time period.

When the screen is read, the data is stored into a buffer. On the next screen column print pass, the buffer is sent to the printer head shift register buffer via the SSIO (SPI) bus. At the same time, the determined segment burn method is transferred to a temporary register that follows the data that was transferred to the print head. Once a line has been fully burned, the data in the print head shift register is transferred to the printer head latch by strobing the Data Latch line. At the same time, the Segment burn method that was previously saved during the SSIO transfer is transferred to the segment print routine. The segment print method is used to determine which code path will be used to print the screen data that was transferred to the printer. The data will remain in the printer latch for 12 steps of the printer stepper motor. The number of burns will be dependant upon the density selected and the segment print method that was determined. The density setting multiplies the number of segment burns by the specified density number.

Assuming a print density setting of one:

Segment print Method #2 = print 2 segments at a time

This is a total of 15 burns per screen line (5 burns in each print line, three print lines total).

Note: there are a total of 9 segments, so the final burn is one segment.

Segment print Method #3 = print 3 segments at a time

This is a total of 9 burns per screen line (3 burns in each print line, three print lines total).

Note: there are a total of 9 segments, so the burn is three equal groups.

Segment print Method #4 = print 4+5 segments at a time

This is a total of 6 segments per screen line (2 burns in each print line, three print lines total).

Note: there are a total of 9 segments, so the first burn is actually 5 segments and the remaining burn is 4 segments.

Note: Segment burn method #1 is not used as we don't need the power savings.

Segment print Method #1 = print 1 segment at a time

This is a total of 27 segments per screen line (9 burns in each print line, three print lines total).

Note: Segment burn method #5 is not used as we don't have the power to do it.

Segment print Method #5 = print 9 segments at a time

This is a total of 3 segments per screen line (1 burn in each print line, three print lines total). This method is not used as we don't have the power available to handle this method. Although it is possible to detect and use this method if fewer than 128 dots total are on in a line, this would be unusual. It would also cause a lot of jitter in the stepper motor and potentially leave gaps in the printout.

The typical segment print method that is discovered is #4 (4+5). Occasionally when there is a vertical line present, or lots of text present, the software may have to back-off to method #3 or method #2. You can usually tell when this happens by a change in the sound coming from the printer.

For density settings higher than one, the print time is increased by the multiple of the density setting number. ie a setting of 5 will take five times longer to print than a setting of 1. The minimum print density setting is three (3), maximum is twelve (12).

Time is also partially determined by the head temperature. Because the stepper motor must be synchronized to the head burning, and the hotter the head gets the shorter the burn time, as the printing progresses, it will get slightly faster. You can usually notice this as a slight increase in print speed during the printing.

The base segment burn time is controlled by the 555 timer. It has a default setting of approximately 700uS at 25C. This time will increase when the printer is cold (900us at 5C) and decrease when the print is warm (300us at 65C). The 555 timer is controlled by a thermistor located in the print head which monitors the head temperature.

If the head temperature rises above 65C, the software will slow the printing down to give the head a chance to cool off. This prevents head damage from excess heat and minimizes thermal bleed from excess head heat.

Thermal paper that is intended to last a long time in storage will normally be low sensitivity paper requiring the use of a higher density setting. High sensitivity paper allows faster printing (and is more commonly available), but has a shorter storage life after being used. Shelf life is also somewhat determined by the density setting. Burning the print longer will make the printout darker and thus increase storage life. Excessive darkness though can cause thermal bleed which will blur the print image. Because of the variabilities, there is no single best density setting, you must select the setting that best suits your particular needs.

Worse case print time is about 40 seconds (long storage paper, density setting of 12, solid black picture, and 5C temperature). Fastest print time is about 5 seconds (high sensitive paper, density setting of 3, head temperature > 40C, minimal data printed - eg: coupler screen with no graph data present). Normal print time for most screens is about 8 to 10 seconds assuming standard paper, density setting at 7, head temperature between 30C and 50C, and printing a typical screen with graph data.

Chapter 5: Service and Repair Guide

Opening the FP35 for service

To expose the component side of the Main board, turn the unit upside down and remove the four screws on the aluminum bottom panel. Be sure to use these screws with the lockwashers when you reattach the bottom panel.

To remove the chassis from the plastic case, first remove all items from the chamber area. Next remove the four panhead screws from the rear panel area, and the four flathead screws from the four corners of the bottom of the plastic case.

To remove the boards from the chassis, set the assembly upside down and with the chamber opening in the top panel on your left. Unplug the membrane keyboard tail from the connector on the Main board. Next remove the two screws from the microphone connector, the two flathead screws from close to the Audio Power Amp, and the one screw with a lockwasher close to the Mecca ground. Now gently lift the board from the left side and unplug the cables from both boards.

Reassemble in the reverse order of the above. Be sure to plug the cables in so that the color dot on each connector plugs into the board with the same color dot and is oriented so that the color dots are adjacent to each other. Serious damage may occur if this is not done correctly.

Don't try to service the external power supply since hazardous voltages are present inside the unit. Just replace the unit if the power supply fails. Lethal voltages may be present even after the power supply is unplugged from the wall. Also remember that the primary side of the circuits are not referenced to ground and so can only be tested with a differential oscilloscope.

Chapter 6: Cleaning

For your safety, disconnect the FP35 power supply from the mains power while cleaning.

Wipe the FP35 case with a slightly moist but not dripping soft cloth. Use plain water or water with mild dishwashing detergent. Wipe away any detergent with a slightly moist cloth, then dry the FP35.

The LCD surface can be easily damaged so wipe lightly and use a soft cloth slightly moistened with water to clean it. Do not allow liquid to enter the LCD opening.

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

The external power supply may be cleaned with a cloth dampened with cleaning alcohol on the outside of the enclosure only.

Warning: Do not immerse the power supply in water or a safety hazard could arise during use.

Never allow fluid to enter:

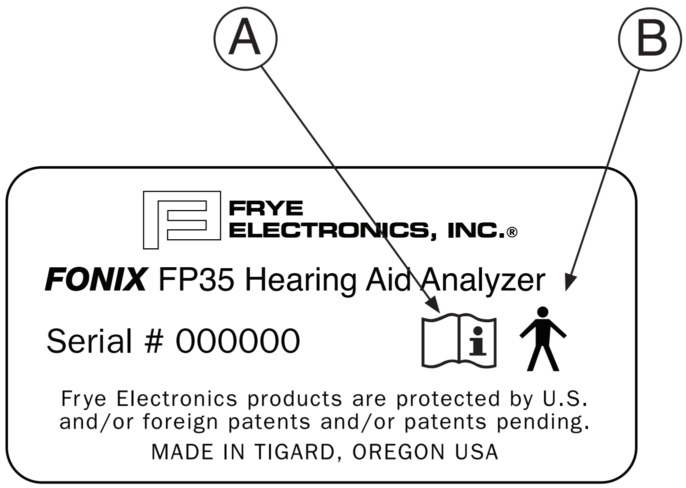
- The Liquid Crystal Display(LCD)
- The electronics module
- The electrical connectors
- The external power supply

Solvents and abrasives will cause permanent damage to the FP35.

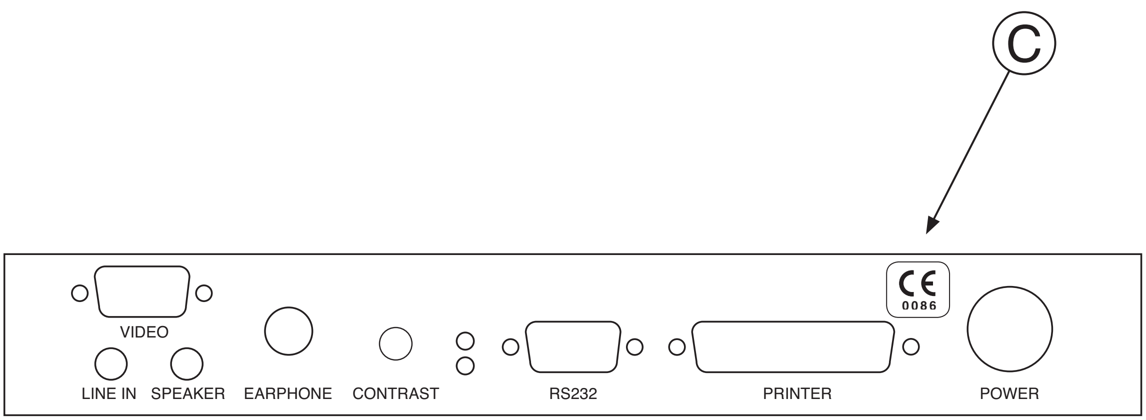
MAINTENANCE

Periodic leakage current testing should be done on the power supply, with the FP35 connected, on a yearly basis when used in a hospital environment where such test equipment is commonly available.

FP35 Safety Markings



FP35 serial number label (on bottom of unit)



FP35 rear panel

Chapter 7: Safety

Warning on AC power cord for medical grade power supply:

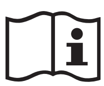
> GROUNDING RELIABILITY CAN ONLY BE ACHIEVED WHEN THE EQUIPMENT IS CONNECTED TO AN EQUIVALENT RECEPTACLE MARKED **HOSPITAL** ONLY OR **HOSPITAL GRADE**.

Safe operation of the FP35 absolutely depends on the integrity of the safety earth connection at your mains outlet. If you have any doubts concerning the adaquacy of your mains outlet, contact a qualified electrician.

For safety reasons, the appliance inlet (the power cord connection to the power supply) should be kept accessible at all times.

Warning: Do not modify this equipment without authorization of the menufacturer.

7.1 Safety Markings

Symbol	**Meaning**
(A) 	Read the accompanying documents
(B) 	Type B applied part. The probe microphone and insert earphone are type B applied parts according to IEC 60601-1
(C) CE 0086	CE signifies compliance with the European union’s Medical Devices Directive.

7.2 Safety Classification for IEC 60601-1

Type of protection against electric shock:	Class 1
Degree of protection against electric shock:	Type B
Protection against harmful ingress of water:	Ordinary
Mode of operation:	Continuous

The FP35 does not require sterilization or disinfection.

The optional probe microphone and insert earphone are applied parts of the FP35 analyzer.

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

Warning: Connect only to the power supply packaged with the FP35. This power supply is a component of the FP35 analyzer. Using other power supplies could lead to electric shock or other safety hazards.

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

Warning: Do not connect the probe microphone to the patient unless it is connected to the FP35 analyzer.

7.3 Connection of peripheral equipment to the FP35

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

All electrical equipment attached to the FP35, such as video monitors, computer equipment, etc. must, at a minimum, meet one of the following conditions:

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

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

Warning: Connecting equipment to the FP35 analyzer that does not meet these guidelines could result in previously unidentified risks to patients, users, or third parties. Please contact Frye Electronics at *support@frye.com* if you have any questions about what equipment can be connected safely to the analyzer.

The FONIX FP35 Test System is equipped with USB and RS232 connections that will allow you to connect to a personal computer and exchange data. You will also need a software program, such as WinCHAP, on your Windows computer that can communicate with the analyzer. It is possible to make your own program using the FRYERS protocol. See www.frye.com for details.

Failure of the hardware connection or software program could result in incorrect transfer of data.

Connecting the FP35 to other equipment could result in previously unidentified risks to patients, operators of third parties. The installer should identify, analyze and control these risks.

Changes to the network could introduce new risks and require additional analysis. These changes could include:

- Changes to the configuration
- Connection of additional items
- Disconnection of items
- Updates to the connected equipment

7.4 Electromagnetic compatibility

The FP35 complies with IEC 60601-1-2.

The FP35 generates and uses radio frequency energy. In some cases the FP35 could cause interference to radio or television reception. You can determine if the FP35 is the source of such interference by turning the unit off and on.

If you are experiencing interference caused by the FP35, you may be able to correct it by one or more of the following measures:

1. Relocate or reorient the receiving antenna.
2. Increase the distance between the FP35 and the receiver.
3. Connect the FP35 to a different outlet than the receiver.

In some cases radio transmitting devices, such as cellular telephones, may cause interference to the FP35. In this case try increasing the distance between the transmitter and the FP35.

Warning: Using the FP35 with the optional M311 microphone with a 6 ft. cable for use with an external sound chamber will compromise its RF immunity and compliance with IEC 60601-1-2.

7.5 Disposal of the FP35 and accessories

The FP35 and its accessories contain lead. At the end of its useful life, please recycle or dispose of the FP35 according to local regulations.

7.6 Disconnection of the FP35 Analyzer

The means of isolating the FP35 Analyzer from the supply mains is to unplug it.

Chapter 8: Electromagnetic Compatibility

Warning: The use of accessories, transducers and cables other than those listed in the tables below may result in increased emissions or decreased immunity of the FP35.

Cables with which the FP35 complies with IEC 60601-1-2		
Cable	**Type**	**Maximum Length (m)**
RS232	9 conductor shielded	2
Speaker	2 conductor	3
Printer	25 conductor shielded IEEE 1284	2

Accessories with which the FP35 complies with IEC 60601-1-2		
Description	**Manufacturer**	**Model/Part Number**
Coupler Microphone	Frye Electronics, Inc.	M367
Coupler/Probe Microphone Set	Frye Electronics, Inc.	M357
Insert Earphone	EAR	3A
LCD VGA monitor		

Warning: The FP35 should not be used adjacent to or stacked with other equipment. If adjacent or stacked use is necessary, the FP35 should be observed for normal operation in the configuration in which it will be used.

Warning: Using the FP35 with the optional M311 microphone with a 6 ft. cable for use with an external sound chamber will compromise its RF immunity and compliance with IEC 60601-1-2.

Guidance and manufacturer's declaration – electromagnetic emissions		
The FP35 is intended for use in the electromagnetic environment specified below. The customer or the user of the FP35 should assure that it is used in such an environment.		
Emissions test	**Compliance**	**Electromagnetic environment - guidance**
RF emissions CISPR 11	Group 1	The FP35 uses RF energy only for its internal function. Therefore, its RF emissions are very low and are not likely to cause any interference in nearby electronic equipment.
RF emissions CISPR 11	Class A	The FP35 is suitable for use in all establishments other than domestic and those directly connected to the public low-voltage power supply network that supplies buildings used for domestic purposes.
Harmonic emissions IEC 61000-3-2	Class A	
Voltage fluctuations/flicker emissions IEC 61000-3-3	Complies	

Guidance and manufacturer's declaration – electromagnetic immunity			
The FP35 is intended for use in the electromagnetic environment specified below. The customer or the user of the FP35 should assure that it is used in such an environment.			
Immunity test	IEC 60601 test level	Compliance level	Electromagnetic environment—guidance
Electrostatic discharge (ESD) IEC 61000-4-2	+/- 6 kV contact +/- 8 kV air	+/- 6 kV contact +/- 8 kV air	Floors should be wood, concrete or ceramic tile. If floors are covered with synthetic material, the relative humidity should be at least 30%.
Electrical fast transient/burst IEC 61000-4-4	+/- 2 kV for power supply lines +/- 1 kV for input/output lines	+/- 2 kV for power supply lines +/- 1kV for input/output lines	Mains power quality should be that of a typical commercial or hospital environment.
Surge IEC 61000-4-5	+/- 1 kV differential mode +/- 2 kV common mode	+/- 1 kV differential mode +/- 2 kV common mode	Mains power quality should be that of a typical commercial or hospital environment.
Voltage dips, short interruptions and voltage variations on power supply input lines IEC 61000-4-11	$<5\%\ U_t$ ($>95\%$ dip in U_t) for 0.5 cycle $40\%\ U_t$ (60% dip in U_t) for 5 cycles $70\%\ U_t$ (30% dip in U_t) for 25 cycles $<5\%\ U_t$ ($>95\%$ dip in U_t) for 5 sec	$<5\%\ U_t$ ($>95\%$ dip in U_t) for 0.5 cycle $40\%\ U_t$ (60% dip in U_t) for 5 cycles $70\%\ U_t$ (30% dip in U_t) for 25 cycles $<5\%\ U_t$ ($>95\%$ dip in U_t) for 5 sec	Mains power quality should be that of a typical commercial or hospital environment. If the user requires continued operation during power mains interruptions, it is recommended that the FP35 be powered from an uninterruptible power supply.
Power frequency (50/60 Hz) Magnetic field IEC 61000-4-8	3 A/m	3 A/m	Power frequency magnetic fields should be at levels characteristic of a typical commercial or hospital environment.
Note Ut is the a.c. mains voltage prior to application of the test level.			

Guidance and manufacturer's declaration – electromagnetic immunity			
The FP35 is intended for use in the electromagnetic environment specified below. The customer or the user of the FP35 should assure that it is used in such an environment.			
Immunity test	**IEC 60601 test level**	**Compliance level**	**Electromagnetic environment —guidance**
Conducted RF IEC 61000-4-6 Radiated RF IEC 61000-4-3	3 Vrms 150 kHz to 80 MHz 3 V/m 80 MHz to 2.5 GHz	3 Vrms 3 V/m	Portable and mobile RF communications equipment should be used no closer to any part of the FP35, including cables, than the recommended separation distance calculated from the equation applicable to the frequency of the transmitter. Recommended separation distance $d = 1.2 \sqrt{P}$ $d = 1.2 \sqrt{P}$ 80 MHz to 800 MHz $d = 2.3\sqrt{P}$ 800 MHz to 2.5 GHz Where P is the maximum output power rating of the transmitter in watts (W) according to the transmitter manufacturer and d is the recommended separation distance in meters (m). Field strengths from fixed RF transmitters as determined by an electromagnetic site survey,[a] should be less than the compliance level in each frequency range.[b] Interference may occur in the vicinity of equipment marked with the following symbol: 

Note 1 At 80 MHz and 800 MHz, the higher frequency range applies.

Note 2 These guidelines may not apply in all situations. Electromagnetic propagation is affected by absorption and reflection from structures, objects and people.

[a] Field strengths from fixed transmitters, such as base stations for radio (cellular/cordless) telephones and land mobile radios, amateur radio, AM and FM broadcast and TV broadcast cannot be predicted theoretically with accuracy. To assess the electromagnetic environment due to fixed RF transmitters, an electromagnetic site survey should be considered. If the measured field strength in the location in which the FP35 is used exceeds the applicable RF compliance level above, the FP35 should be observed to verify normal operation. If abnormal performance is observed, additional measures may be necessary, such as reorienting or relocating the FP35.

[b] Over the frequency range 150 kHz to 80 MHz, field strengths should be less than 3 V/m

Recommended separation distances between portable and mobile RF communications equipment and the FP35			
The FP35 is intended for use in an electromagnetic environment in which radiated RF disturbances are controlled. The customer or the user of the FP35 can help prevent electromagnetic interference by maintaining a minimum distance between portable and mobile RF communications equipment (transmitters) and the FP35 as recommended below, according to the maximum output power of the communications equipment.			
Rated maximum output power of transmitter W	**Separation distance according to frequency of transmitter** (m)		
	150 kHz to 80 MHz $d = 1.2\sqrt{P}$	**80 MHz to 800 MHz** $d = 1.2\sqrt{P}$	**800 MHz to 2.5 GHz** $d = 2.3\sqrt{P}$
0.01	0.12	0.12	0.23
0.1	0.38	0.38	0.73
1	1.2	1.2	2.3
10	3.8	3.8	7.3
100	12	12	23

For transmitters rated at a maximum output power not listed above, the recommended distance *d* in metres (m) can be estimated using the equation applicable to the frequency of the transmitter, where *P* is the maximum output power rating of the transmitter in watts (W) according to the transmitter manufacturer.

NOTE 1 At 80 MHz and 800 MHz, the separation distance for the higher frequency range applies.

NOTE 2 These guidelines may not apply in all situations. Electromagnetic propagation is affected by absorption and reflection from structures, objects and people.