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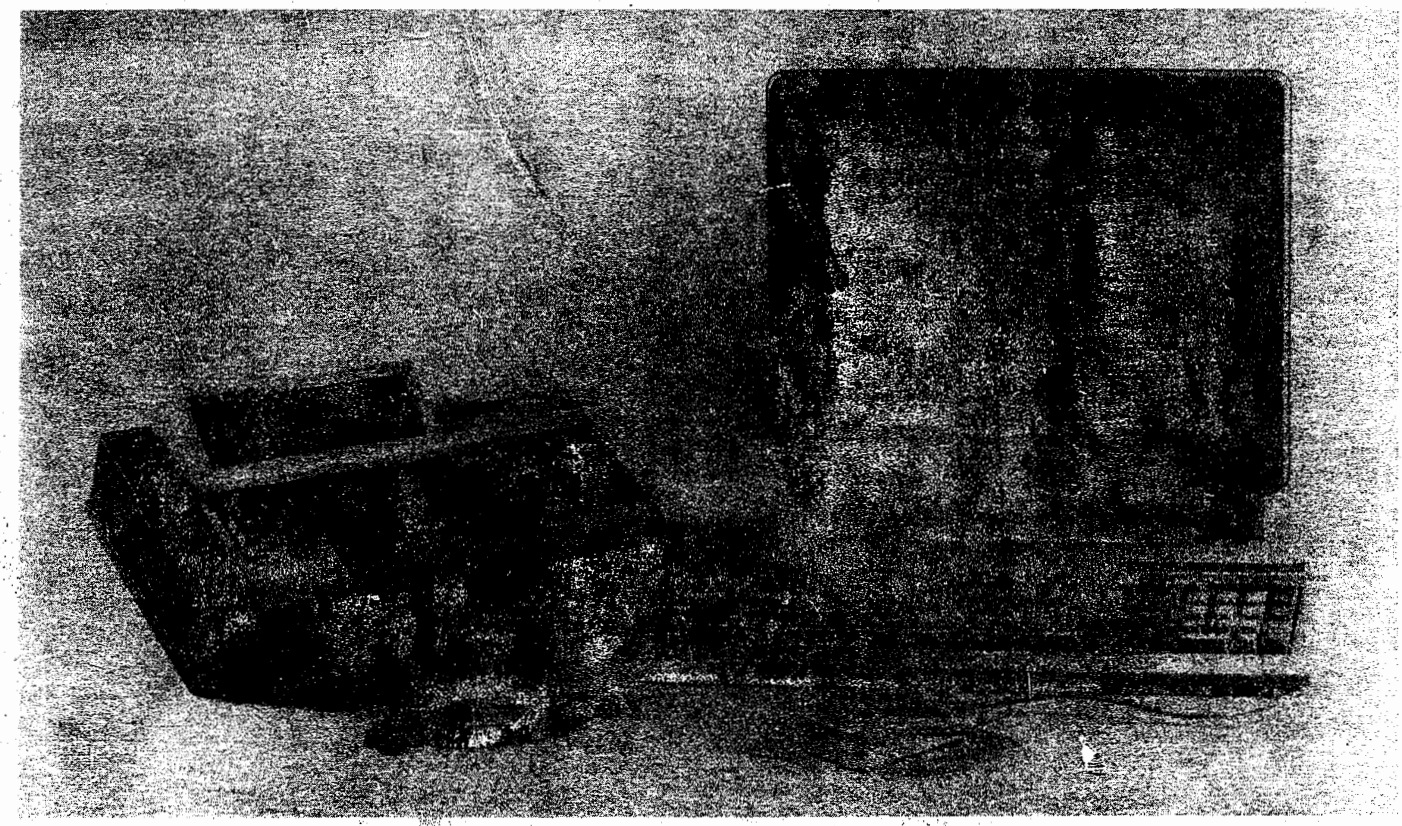
Owner's and Operator's Manual for the PC-40 Audio Spectrum Analyzer



PC-40 Manual Table of Contents

Introduction

Congratulations! With your purchase of the Ivie PC-40, you not only have one of the most powerful, versatile, and accurate audio spectrum analyzers available, but in addition you have an analysis system that is capable of expanding as your needs expand.

This manual is intended to familiarize you with the basic operations of the PC-40 Analyzer, and to whet your appetite concerning some of its possibilities. It is in no way intended to be the total description of all the possibilities of the PC-40. Since its on-board computer is easily programmed using BASIC, the possibilities for using the PC-40, and tailoring it to your specific application needs are almost limitless.

The PC-40 on-board computer is a 64K, CPM 2.2 machine. It has a parallel port and two serial ports (RS 232, and high speed serial, both capable of up to 38.5k BAUD). This manual is not intended to familiarize you with the operation of the computer, but is intended to teach the operation of the PC-40 Analyzer. A complete manual on the computer itself is enclosed for your reference.

With reasonable care, the PC-40 will provide a long period of useful service. Great pains have been taken to assure performance, quality, and reliability. We suggest that this manual be read thoroughly, and that it always be available as a reference. The "Theory of Operation" section which follows is of particular importance in understanding how the PC-40 operates, and why it operates as it does.

Theory of Operation

The PC-40 hardware is actually comprised of two sections, the precise analyzer electronics, and the computer section. These hardware sections may even be physically separated - the computer actually snaps away from the analyzer. Since the analyzer is under the control of the computer, and will, in fact, not work without the computer, it is easiest to think of the analyzer functions as software functions. Each time a command is given the the PC-40, either by use of the function buttons or through the use of the QWERTY keyboard, that command is software executed.

Since the analyzer functions are software based, it gives us some interesting

flexibility. We can make multiple measurements within a given function, or compare and process data from different measurements, or even create our own desired functions, using BASIC. The possibilities are extensive.

Such a broad menu of functions can also create some difficulties. For instance, there are only 5 function buttons available on the PC-40. We were able to double that number using the "shift" button in conjunction with the function buttons. Still, 10 functions is far fewer than are already resident in the PC-40. A difficult question is, "Which functions should we assign to the ten function buttons?" The answer, as it turns out, follows a rather natural delineation.

Some functions we naturally want to be able to perform or change while the analyzer is in operation. These would include changing the reference level, or the filter decay time, or writing into or reading from memory. A single function button is most convenient for initiating these kinds of functions. Other functions don't need to be performed or changed in "real time," such as assigning output data to a particular interface port. These latter types of functions can be addressed from the QWERTY keyboard without inconvenience. As you operate the PC-40, you will find that those functions you use most often, and execute in "real time" are the functions that will be addressed by the function buttons directly.

Getting to Know the PC-40

Installing Cartridge Accessories (The H409A Cartridge Printer etc.)

For complete instructions on installing cartridge accessories, refer to Appendix I of this manual which shows PC-40 disassembly and cartridge loading.

The PC-40 Microphone and Preamp

The PC-40 comes standard with a 1/2 inch air condenser microphone (your choice of a free field or a random response microphone), and the IE-2P Precision Preamplifier. 1/4 inch, 1/8 inch, and 1 inch air condenser microphones are available on a special order basis.

Providing such a quality front-end with your PC-40 is not an inexpensive proposition. You will discover that if you lose your microphone and preamp, it

will cost more than a thousand dollars to replace them. However, we feel strongly that an analyzer and sound level meter can not be more accurate or reliable than the microphone that comes with it. If you look at other analyzers on the market today, you will find that many come without microphones, and many others come with relatively inexpensive commercial microphones. Providing laboratory quality microphones and preamplifiers with analyzers is almost unique to Ivie.

The PC-40 is a Type I sound level meter, and has the accuracy of Class III filters in the analyzer section (in SLM Types, low numbers are best; in filter Classes, high numbers are best). As long as you use the microphone and preamp that came with your analyzer, its accuracy and performance to specifications is assured. You may easily use other microphones with your PC-40 as long as you remember that all readings are then relative, and are not absolute. You must further remember that the spectral information shown on the analyzer will be colored by the response of the microphone you are using.

Other air condenser microphones which conform to international dimension and thread specifications can be used with your PC-40 by simply removing the microphone cartridge from the end of the IE-2P and replacing it with the air condenser cartridge you wish to use. Many air condenser microphones, including those made by B & K, ACO Pacific, and Rion are compatible with the IE-2P. If a one inch, quarter inch, or eighth inch microphone is to be used, adaptors will be needed to adapt to the half inch barrel of the IE-2P. Some one inch microphones require a polarization voltage of 28 volts instead of the 200 volts which is most common. In this case, the polarization voltage of the IE-2P will need to be switched. Some may require the use of the 20dB pad available in the IE-2P, and, of course, changing the microphone will always require recalibration of the system. (For information on changing polarization voltage, the 20dB pad, and recalibration, refer to the IE-2P manual and the section in this manual entitled "System Calibration for OSHA Measurements," under the heading of "Sound Level Testing."

When using another microphone, it is important to know the frequency response of the microphone in order to interpret the display information of the PC-40. The typical frequency response of the standard microphones for the PC-40 (the 1133 Free Field and the 1134 Random Response or Pressure Response) are shown on the following page:

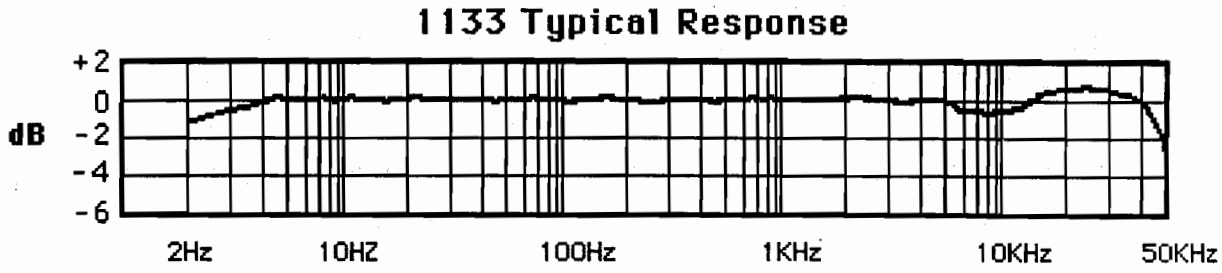


Figure I

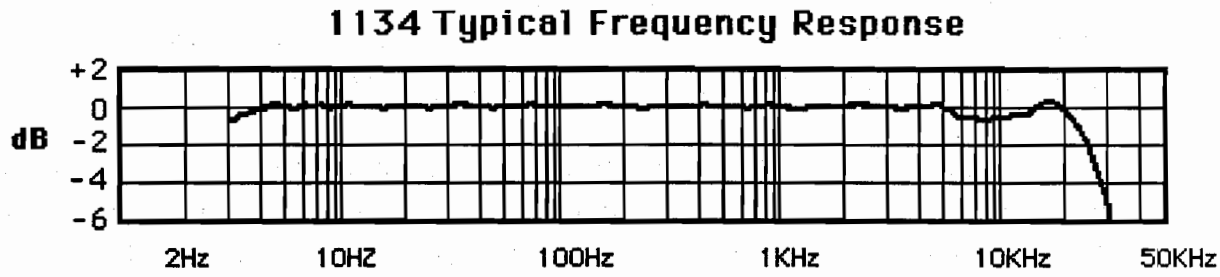


Figure II

As can be seen, these microphones have been chosen for their excellent response characteristics, and their ability to provide maximum accuracy to the measurement capability of the PC-40. Should you have questions about microphones, or their application in analyzer measurements, please don't hesitate to contact us at the factory.

Inputs and Outputs -The PC-40 Microphone Input Plug and the PC-40 I/O Panel

The Microphone Input Plug

The microphone input plug on the PC-40 is a six pin XLR-type connector. Following is an illustration of the pinout of this connector:

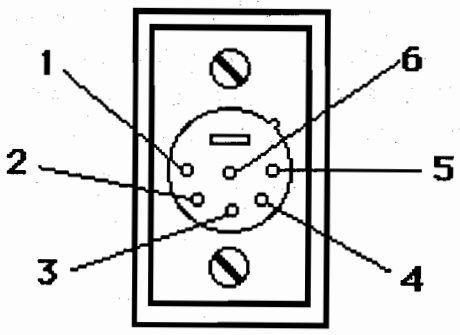


Figure III

Pin 1: Input pin. The input impedance is 100 kΩ. The maximum direct DC input before damage is 100VDC. The maximum direct AC input is 300VAC from 20Hz to 4kHz. For frequencies above 4kHz, derate maximum AC input by 6dB/octave (e.g. 150VAC @ 8kHz, 75VAC @ 16kHz, 6VAC @ 20kHz)

Pin 2: Gain Trim pin. Varying the pin voltage between 8VDC and 0VDC varies the gain of the PC-40 over a 15dB range. This pin is not to be used for AGC purposes, but only as a long term gain adjustment for calibration requirements.

Pin 3: No connection.

Pin 4: Power (V_{CC}) for microphone preamplifier. It provides 10mA (maximum current) at 12VDC.

Pin 5: Calibration pin. Pin 5 is normally tied to pin 4, which sets the PC-40 calibration for dBμV.* IF pin 5 is not tied to pin 4, calibration is set for dB.1μV.†

Pin 6: Ground.

*0dBμV = 1.0μV † 0dB.1μV = 0.1μV

Microphone Extension Cords

It is helpful to know the microphone input pinout, especially if you plan to make your own extension cord. Extension cords are available from Ivie in lengths from 25 ft. to 200 ft. in 25 ft. increments, but should you choose to make you own cord, that can be easily done using a minimum of three conductor shielded cable, and one male and one female 6 pin XLR-type connector. Pin 1 must be

brought through, as well as pins 2, and 4. The shield should be tied to pin 6. Pins 4 & 5 should be tied together at the female XLR which plugs into the PC-40. If you tie them together at the male XLR connector at the other end of your extension cable, no conductors will be tied to them, so they will not be tied together at the PC-40. A highly supple (and therefore, usually expensive) cable is recommended.

The PC-40 I/O Panel

The PC-40 I/O Panel is located at the top of the PC-40 and looks like this:

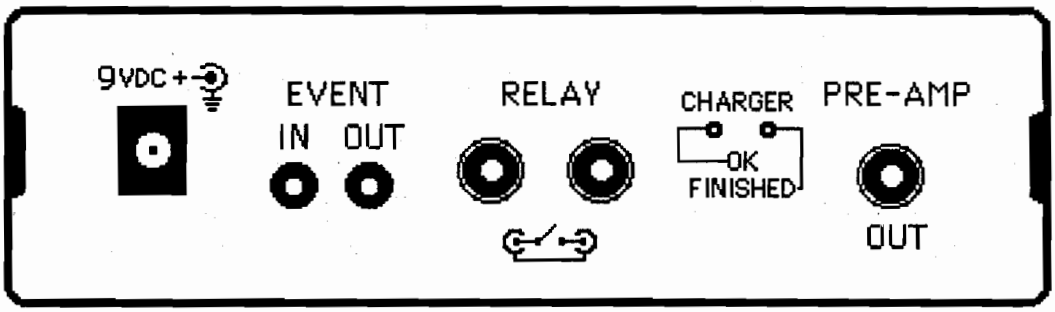


Figure IV

The first item that should be noted is the battery charger input. As can be seen, it is a 9 volt DC input with the center pin positive. Do not plug the PC-40 charger (CH 40) into a disk drive or into the computer section of the PC-40. These inputs are center pin negative, and you will destroy your disk drive, or damage your computer! The battery charger input of the computer has been covered to prevent accidental insertion of the CH 40 Charger. In the unlikely event that the cover should come off, it should be reattached. If it is lost, another is available upon request from Ivie at no cost.

Battery and Line Operation

When fully charged, the PC-40 will operate for at least five hours continuously. In some applications, is will last longer since the analyzer section is "slept" while the computer section processes data. The computer alone will operate for 12 to 14 hours between charges.

Charging the PC-40 completely takes about 5 hours if the unit is off, or about 7

hours if the unit is on. It can be operated continuously while charging with no problem. It will toggle into trickle charge when the batteries reach a full charge. When in the "fast charge" mode, the red LED in the Patch Panel labeled "OK" will be illuminated. (See illustration below.)

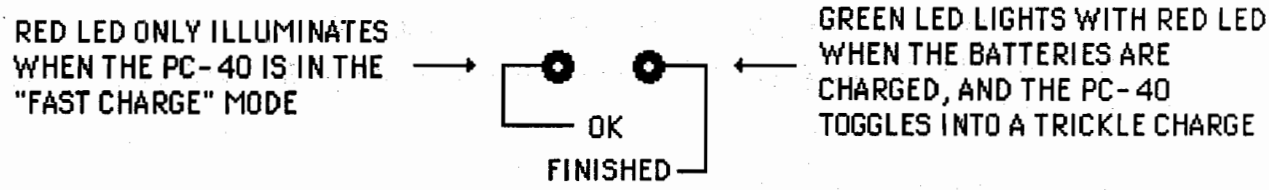


Figure V

After toggling into trickle charge, the red "OK" LED, and the green "Finished" LED will illumninate.

In emergency situations, the PC-40 can be powered from an external 9 Volt DC battery. The battery can be fed into the PC-40 charger input plug. Make sure to observe proper polarity - center pin positive. Length of operation will depend on size of external battery, and application of the PC-40. The current draw of the PC-40 will not exceed one amp, so the time of operation on any external battery can be easily estimated.

The Preamp Output

Figure VI

The preamp output of the PC-40, located at the far, right side of the I\O Panel, is a straight analog output. It provides from 30dB of attenuation to 80dB of gain, relative to the input, in 10dB increments - a total range of 110dB. The gain of the preamp is controlled by the RANGE buttons of the PC-40 which are used to raise or lower the Reference Level of the analyzer.

The output impedance of the preamp is 600 ohms. 600 ohm headphones can be directly driven from the preamp output. The preamp input can be switched

between the PC-40 microphone and the probe, so it can be used as either an audio or an electrical preamp.

The weighting of the preamp output also follows the weighting of the PC-40 SPL meter. If, for example, the SPL meter is set for "A" weighting, the preamp output will be "A" weighted, regardless of whether making audio or electrical measurements. The preamp, then, could be used all by itself as a weighted preamp.

The Audio Relay

Figure VII

The Audio Relay of the PC-40 is a dry contact switch, so it doesn't care which port is the input or which one is the output. The Audio Relay can be accessed via the PC-40 keyboard, or through BASIC or Machine Language programming, and is used in specialized functions of the PC-40, such as RT_{60}. When performing an RT_{60} measurement, the signal source would be fed into the Audio Relay and out to the "house" sound system.

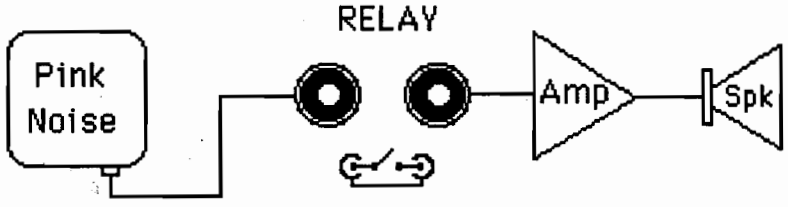


Figure VIII

When performing the RT_{60} measurement, the function of the Audio Relay would be to shut off the audio signal in the room to begin the test. The Audio Relay can be used in any test setup where a programmable audio relay is necessary.

To access the audio relay via the PC-40 keyboard, hold down the **CTRL** key

and press **A** for "Audio." This toggles the relay between open and closed. When the relay is closed, the INS LED on the PC-40 keyboard will illuminate to indicate relay closure.

The Event In/Out

Figure IX

The purpose of the PC-40 Event In/Out is to allow the analyzer to be controlled (ie. turned on or off) by an external event, or to allow an external event to be controlled by the analyzer. The "Event IN" port is used when we want to control the analyzer by some external event. The "Event OUT" port is used when we want the analyzer to control some external event. Below is an illustration detailing the electronics and voltage requirements for using the Event trigger.

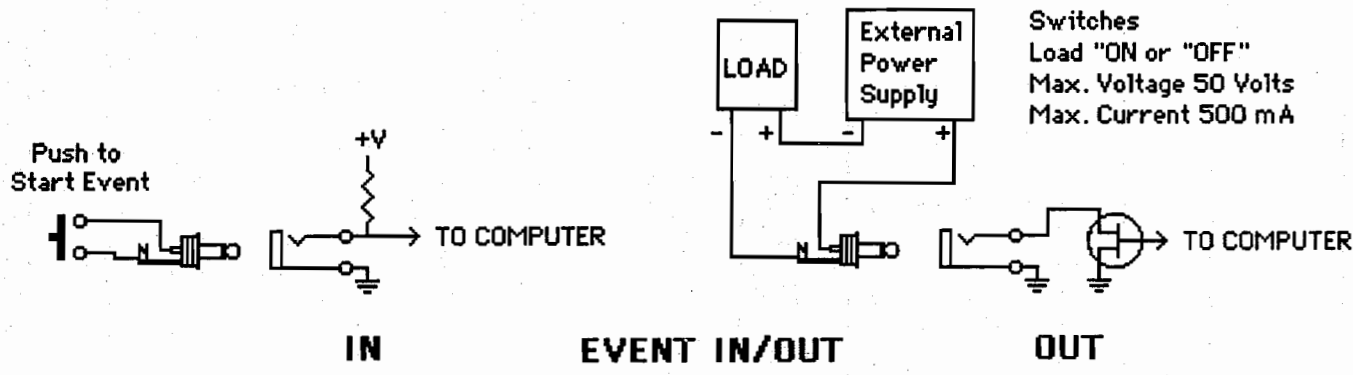


Figure X

The Event trigger is accessible only through BASIC or Machine Language programming, and is not utilized by the resident PC-40 software.

The PC-40 Display Screen

On the following page is an illustration of the PC-40 display screen. The screen is quite self explanatory, but a few items should be noted.

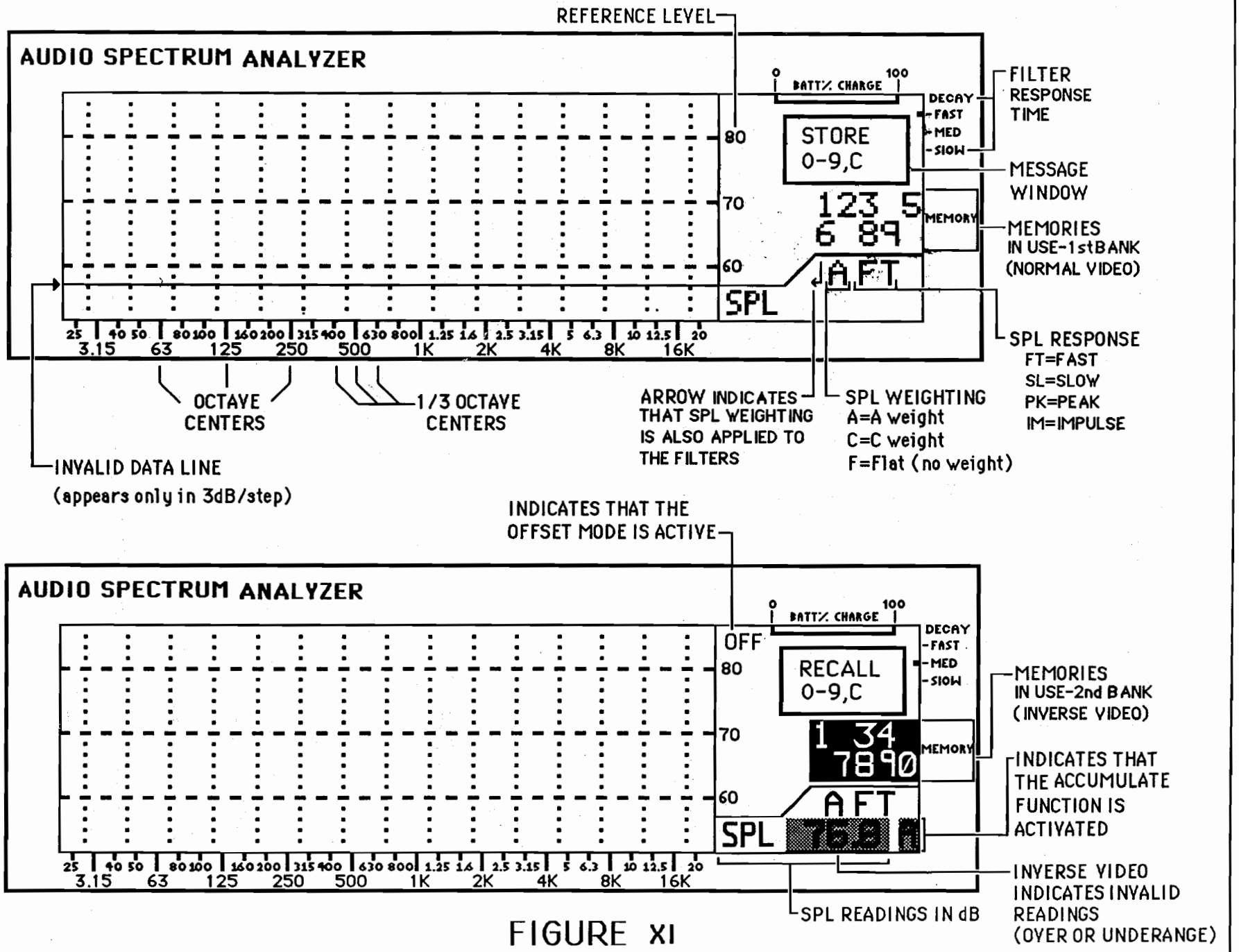

REFERENCE LEVEL
AUDIO SPECTRUM ANALYZER
0
BATT% CHARGE
100
DECAY
FAST
MED
SLOW
FILTER RESPONSE TIME
STORE
0-9,C
MESSAGE WINDOW
80
70
60
123 5
6 89
MEMORY
MEMORIES IN USE-1stBANK (NORMAL VIDEO)
A FT
SPL
SPL RESPONSE
FT=FAST
SL=SLOW
PK=PEAK
IM=IMPULSE
25 40 50 80 100 160 200 315 400 630 800 1.25 1.6 2.5 3.15 5 6.3 10 12.5 20
3.15 63 125 250 500 1K 2K 4K 8K 16K
OCTAVE CENTERS
1/3 OCTAVE CENTERS
ARROW INDICATES THAT SPL WEIGHTING IS ALSO APPLIED TO THE FILTERS
SPL WEIGHTING
A=A weight
C=C weight
F=Flat (no weight)
INVALID DATA LINE
(appears only in 3dB/step)
INDICATES THAT THE OFFSET MODE IS ACTIVE
AUDIO SPECTRUM ANALYZER
0
BATT% CHARGE
100
OFF
DECAY
FAST
MED
SLOW
RECALL
0-9,C
80
70
60
1 34
7890
MEMORY
MEMORIES IN USE-2nd BANK (INVERSE VIDEO)
A FT
SPL
INDICATES THAT THE ACCUMULATE FUNCTION IS ACTIVATED
25 40 50 80 100 160 200 315 400 630 800 1.25 1.6 2.5 3.15 5 6.3 10 12.5 20
3.15 63 125 250 500 1K 2K 4K 8K 16K
INVERSE VIDEO INDICATES INVALID READINGS (OVER OR UNDERANGE)
SPL READINGS IN dB

FIGURE XI

The screen itself may be tilted to approximately 30° to facilitate viewing. To tilt the screen, press the release button on top of the PC-40, and pull the top of the screen toward you.

The memory section and other screen display sections of the PC-40 are identified in the preceding illustration. It should be noted that the memories are divided into two banks of ten each. The first ten are displayed in standard video (black letters on white background), and the second ten are displayed in inverse video (white letters on black background).

****Important Note****

Near the bottom of the display screen, a line appears all the way across the screen when in the 3dB per step mode only. (See the illustration.) This is called the "Invalid Data Line." Because of the number of pixels in a column on the display screen, it works out best to show an "on screen" dynamic range exceeding 60dB - this allows us to work in even numbers of pixels, not having to cut any in halves or thirds, which would be impossible to display. While this works out fine in terms of the pixels in the display, the greater than 60dB of dynamic range actually exceeds the true dynamic range of the filters - that is, we begin to run into the actual noise of the filters themselves when we look that many dB down.

The Invalid Data Line represents the limits of the safe area of the display. Any data below that line may be actual sound, or could be filter noise. Therefore, information below the invalid data line should not be regarded as accurate. The Reference Level should be adjusted so that all data rises above the Invalid Data Line to prevent errors in readings. Information below the Invalid Data Line will not be stored in memory. For further information on this matter, consult the section of this manual entitled, "The PC-40 Memory Functions."

Several references will be made to Figure XI in the next pages of this manual as we explore further the functions of the PC-40.

Individual Filter Display - Graphic & Numeric

You have already had a chance to look at the illustration of the PC-40 display on page 12, and have probably even turned on your PC-40 to see the real-time display for yourself. You are most likely already familiar with the kind of bar graph display presented by the PC-40. Overall SPL is shown numerically, and

the amplitude of each of the octave or 1/3 octave channels is shown graphically. You can't tell it by looking at the graphic display, but the PC-40 actually maintains a resolution of .1dB on individual filter amplitudes. Your eye can't detect that kind of resolution, but, as you will learn later in this manual, it is possible to obtain tabular (numerical) printouts which indicate individual filter amplitudes to a tenth of a dB.

It is also possible to view numerically the amplitude of any given channel in real-time. This is a very useful function, and access to it is easy.

The illustration below is a normal real-time display showing overall SPL numerically, and individual filter amplitude graphically:

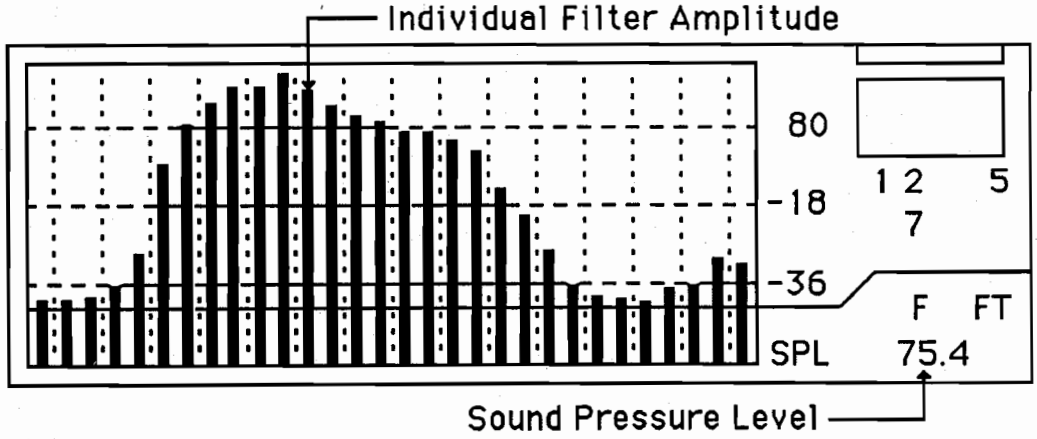


Figure XII

Notice that the Message Window is blank during real-time operation. If you have trouble finding the Message Window, refer back to Figure XI on page 12. The PC-40 can numerically display the amplitude of any filter you choose in the Message Window. To activate this feature, simply press the letter **F** for "Filters." If we pressed the letter **F** while viewing the above display, we would get a display that looked something like the illustration shown on the following page. Compare the Message Window on the two illustrations.

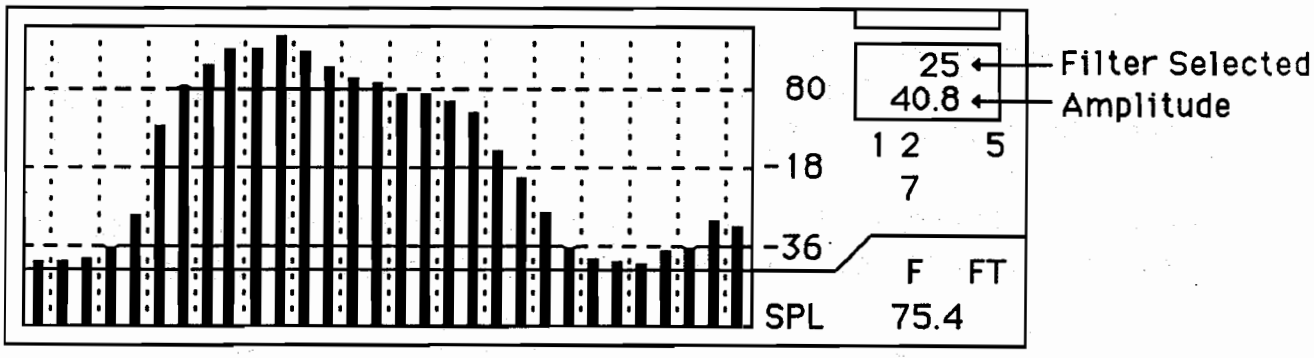


Figure XIII

The first number in the Message Window indicates the frequency of the filter that has been selected. In Figure XIII, it is the 25 Hz filter. The number below indicates the amplitude of the 25 Hz channel - in this case, 40.8 dB. The resolution is .1dB. This is a real-time function just as the graphic display is, so this number will be constantly updating as the amplitude in the channel changes.

In the above example, we looked at the 25 Hz channel, but we could look at any channel we want to. To select a different channel for viewing, use the left and right **Cursor** keys. These are the keys with arrows on them located on the right hand side of the keyboard. The left one will move lower in frequency, and the right one will move higher in frequency. There are up and down **Cursor** keys as well as left and right ones. The up and down **Cursor** keys, and the left and right ones are used in many PC-40 functions.

To get out of this display mode, simply press the letter **F** again and it will return the PC-40 to a standard, real-time display.

Now that you have a little taste of some of the PC-40's exciting capability, let's move on and examine the functions accessed by the function buttons.

The PC-40 Function Buttons and the Accumulate Function

In the highly unlikely event that you haven't already had your PC-40 on, you may turn it on now. The OFF/ON switch is located on the right side of the unit below the keyboard, (See Figure XIV below).

The Function Buttons of the PC-40 are located directly below the display screen of the PC-40, (See Figure XIV below). The rest of the keys are fairly standard.

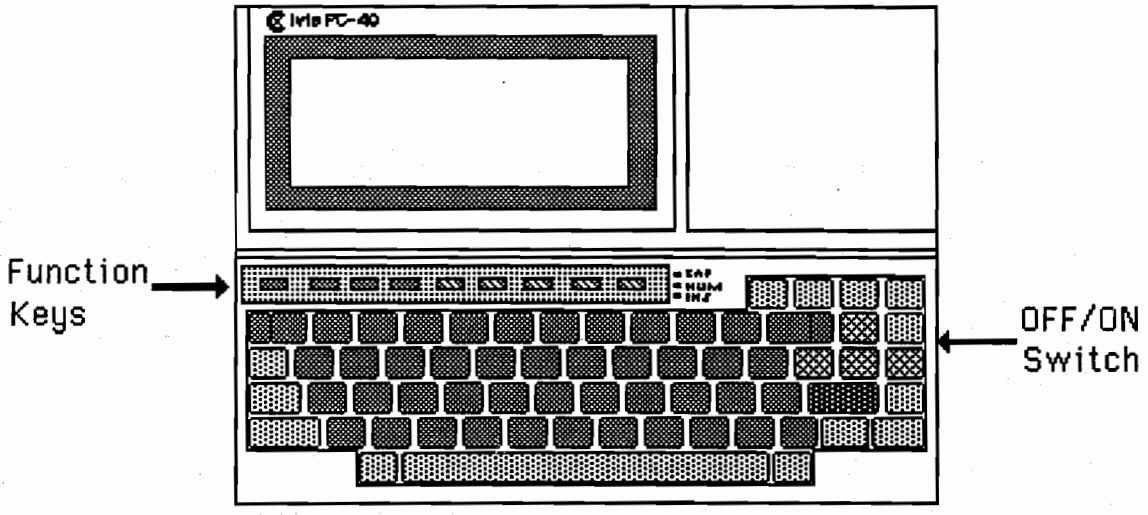


Figure XIV

Before we discuss the function keys, let's talk about the **Accumulate Function** which is activiated by pressing the letter **A**. This could save some frustration later. When the letter **A** is pushed, the PC-40 display screen and the SPL readout go into a peak hold mode - that is, the highest level recorded at each filter is displayed and "frozen" on screen until something higher displaces it. The same is true of the SPL display. If you don't know you are in this mode, the PC-40 screen appears to have "frozen up," and yelling and thumping the PC-40 only makes the display rise a little further, with no other apparent effect.

Actually, **Accumulate** is a very useful function, especially if you want to determine a peak envelope of some program material, or walk an auditorium listening to pink noise and accumulating the peaks. We call this function the "Accumulate" function, and you can always tell you are in this mode by the inverse video "A" that appears next to the SPL readout at the bottom-right of the PC-40 display screen (see Figure XI). To get out of the "Accumulate" function, just press the letter **A** again. Now let's discuss the function keys.

The purpose of the function keys is to simplify operation of the PC-40 without having to make commands from the keyboard. The five right-most keys (labeled **PF1** through **PF5**) will be used most often since they control the basic analyzer functions. These keys have more than one function which can be addressed by using the **Shift** key in conjunction with the function key, or in some cases the **Ctrl** key with the function key.

PF1 and PF2
(The Range Function & Selecting SPL Detectors and Weightings)

Let's examine each key and its functions beginning with **PF1** and **PF2**. These keys have this annotation above them:

The PC-40 screen display has a reference level (See Figure XI) which is adjustable from 30 to 140dB, when using the microphone as the input, or from 50 to 180dB µvolts when using the probe as the input. In either case, the reference level steps in 10dB increments. As the keyboard graphics indicate, pushing **PF1** (the "down" arrow) lowers the reference level by 10dB, and pushing **PF2** (the "up" arrow) increases the reference level by 10dB. This is called the "RANGE" function because raising or lowering the reference level of the PC-40 changes its reading range.

PF1 and **PF2** also perform additional functions which are related to the SPL meter section of the PC-40. Since the PC-40 is a Type I SPL Meter, it must, by definition, be able to perform a number of different measurements. **PF1** allows you to select either "A" weighted (dBA) measurements, "C" weighted measurements, or "Flat" (unweighted) measurements. (For more information on these types of measurements, refer to the manual section on SPL Measurements). To choose "A," "C," or "Flat" measurements, first push and hold the **Shift** key and then, while holding the **Shift** key, push **PF1**. Holding down the **Shift** key while pressing **PF1** will cause the PC-40 to toggle through "A," "C," and "F" weightings. An A,C, or F will appear at the bottom right of the PC-40's screen display to indicate what SPL weighting has been selected (See Figure XI).

The PC-40 also contains all the SPL detector responses necessary to qualify it

for Type I measurements. These include Fast, Slow, Peak and Impulse. These detectors can be selected by pressing and holding **Shift** while pressing **PF2.** The PC-40 will step through "FT," "SL," "PK," and "IM" in the same manner as described for changing SPL weighting. Also, visual indication of the selected detector is given in the lower right corner of the PC-40 display screen (See Figure XI). (For further information on detector responses, refer to the manual section on SPL Measurements.)

PF3
(The dB per Division, and Filter Decay Functions)

Like **PF1** and **PF2**, **PF3** performs a dual function. Pushing just **PF3** will allow you to select 1, 2, or 3dB per division on the PC40 display screen. A screen resolution of 1dB per step (.25 dB per pixel) provides a 16dB display range. 2dB per step (.5 dB per pixel) gives a 32dB display range, and 3dB per step (1dB per pixel) yields a 64dB dynamic display range.

The **Shift/PF3** function is labeled "DECAY." Pressing **Shift/PF3** will allow you to select a filter decay time of "Fast," "Medium" or "Slow." At the top, right hand side, next to the display screen, you will find the words "fast," "medium," and "slow" represented (See Figure XI). The PC-40 will display a small, darkened square beside the filter decay time selected. "Fast" is intended for monitoring signals or program material and will respond to relatively short spikes of information. "Slow," on the other hand, is intended for pink noise use only. Its averaging time is sufficiently long to hold pink noise flutter of the low frequency filters to an acceptable minimum (about plus or minus 1dB).

PF4 and PF5
(Memory Functions and the Display and Relative Functions)

PF4 and **PF5** access the 20 memories of the PC-40. To store a screen of information in one of the memories, simply press **PF4.** The screen will freeze with current data, and await your selection of one of the 20 memories for storage. The Message Window of the PC-40 (See Figure XI) will indicate that you have entered the storage mode. If you wish to store the data in memory #1, for example, press **PF4** (**STORE**) and then press the number **1** on the QWERTY keyboard. If there is already something in memory #1, it will be replaced by what you have just entered. Data stays in a given memory until it is replaced by something else, or until you clear that memory.

After you have pressed **STORE**, **1**, the PC-40 screen will appear to do a carriage return, and a date and time code along with a cursor will appear at the bottom of the screen. You may now type in from the keyboard up to one full line (40 characters) of annotation to document the screen you are storing. This note will be stored with the screen data and will be printed out in full if you choose to print the information in memory. In addition to storing the screen and your note, the PC-40 also enters the date and time that the data was stored (Of course, for the proper date and time to be stored, the PC-40 will have to have been properly set. It leaves the factory initialized for the Mountain Time Zone, but may have to be corrected for your area. (Information on setting the time/date code in the PC-40 can be found later in this section of the manual under the heading, "The Other 4 Function Buttons," and the subheading "Utilities." The specific "Utilities" function relating to this is called "Time.") Again, if you print the memory, the screen, the note, and the date and time it was stored will be printed. As you can see, the possibilities for complete documentation are provided. Figure XV below demonstrates the things we have discussed.

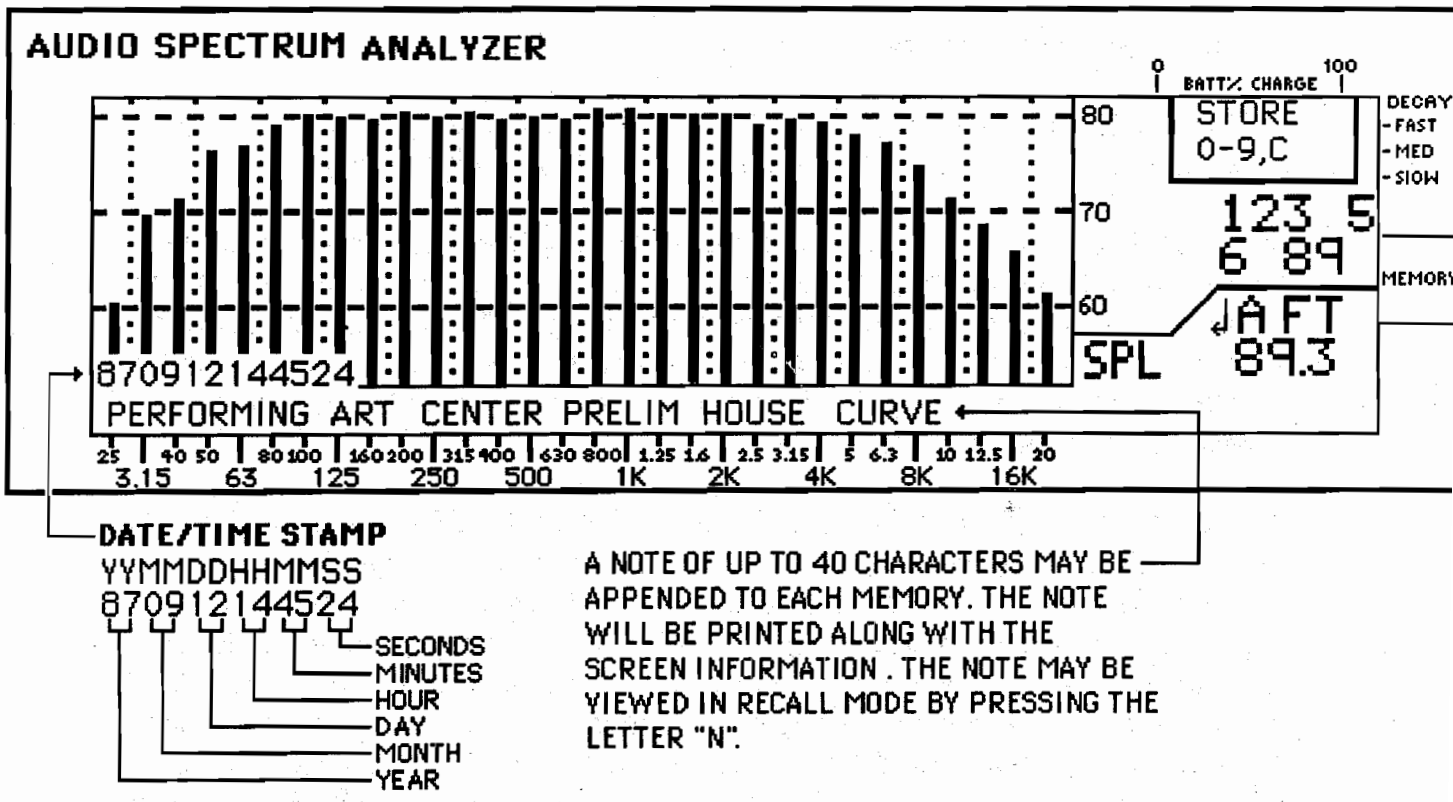


Figure XV

Whenever a memory is occupied by data, that memory number will appear in the memory section located on the right hand, center of the PC-40 display screen (See Figure XI, and Figure XV above). The first ten memories are indicated by standard video (black lettering on a white background) and the second ten memories are indicated by inverse video (white lettering on a black background).

To clear a memory, store something over the top of it, or press **STORE**, then **C**. The word "Clear" will appear in the Message Window. Next press the number of the memory you wish to clear. That memory will be cleared, and the PC-40 will return to real-time operation.

To recall a memory, simply press **PF5** (**RECALL**) and then the number of the memory you want to recall. Only those memories with data stored in them may be recalled. Notice that when recalling a memory, the "Note" does not automatically appear. To get the note to appear on screen, press the keyboard letter **N**, and the note will appear at the bottom of the screen. Pressing **RETURN** will then get you back into real-time.

Some important points to remember are:

1: The "Note" in a memory may be viewed and/or changed at any time by pressing the letter **N** (for "Note") while viewing the desired memory.

2: A recalled memory is recalled completely, and that data in the memory is subject to software manipulation. For example, if we recall a memory, we can change the Reference Level, or the dB per step, and the display will accurately reflect the changes we have made. However, when we return a recalled memory back into memory, it will return in the same format it had before we recalled and manipulated it.

3: As was mentioned earlier, the 20 memories of the PC-40 are divided into two banks of 10 each. The first 10 are indicated on the display screen by standard video, and the second 10 are indicated by inverse video. You can toggle back and forth between the two banks of memories by hitting the letter **M** for "memory" while in either the "Store" or the "Recall" mode. For example, if you want to store a memory in one of the second ten memories (inverse video), and you have pressed the **STORE** button and the first ten memories (standard video) are being displayed in the memory box, press **M**, on the keyboard. This will cause the second ten memories to be displayed. Pressing **M** again, will cause the first ten memories to be displayed once more.

This same thing is true when selecting **RECALL**. Pressing **M** will cause the PC-40 to toggle between displaying the first ten and the second ten memories. Memories can be quickly recalled and displayed one after another by simply pressing their numbers when in the Recall Mode.

4: It is first necessary to press either **STORE** or **RECALL** **before** pressing **M** to get the PC-40 to toggle between displaying the two banks of memories.

*****Important Feature---Displaying More Than One Memory*****

More than one memory may be displayed at a time by the PC-40. To display two memories at once, press **RECALL**, then the letter **C**. The keyboard **C** stands for "Composite." Now let's look at Figure XVI below and the Message Window:

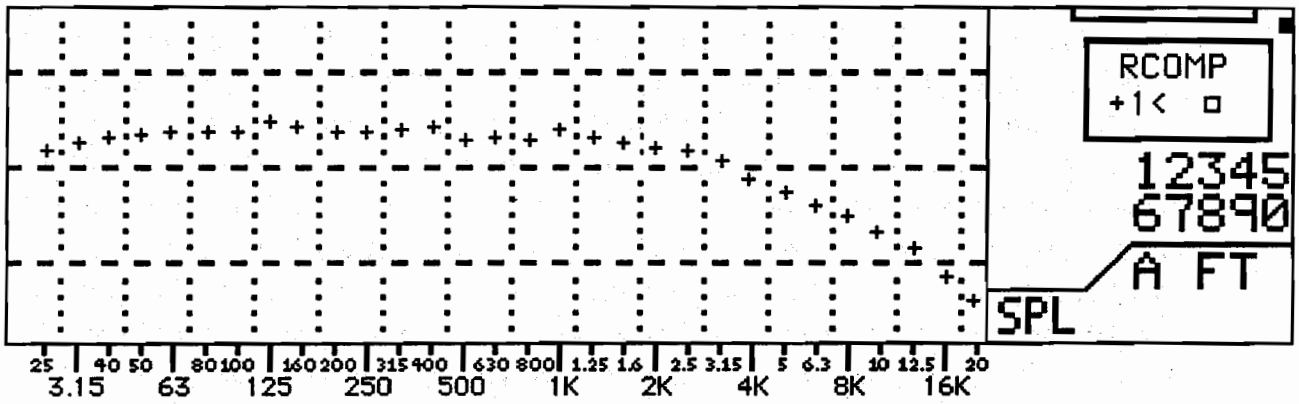


Figure XVI

Notice that the Message Window says RCOMP for "Recall Composite." Below that notation in the Message Window a cursor arrow (<) and a plus (+) and a box (□) are located. In this illustration, the cursor arrow is pointing toward the plus sign, and the number "1" has been printed. This means that the operator has pressed the following keys: **RECALL, C, 1**; for recall composite, display memory #1. Memory #1 has been displayed as plus signs because the cursor arrow is pointing at the plus sign. If we now wanted to display memory #2 as boxes to discriminate it from memory #1, we would point the cursor arrow toward the box sign by pressing the PC-40 keyboard arrow which points right to select boxes, and then press **2** to display memory 2. The number "2" would appear in the message window next to the box symbol, and memory #2 would

be displayed.

Note: If we had made an error in selecting memory #2, and really wanted to display memory #3, we could just push **3** and memory #2 would be replaced by memory #3 on the display screen.

More that two memories can be displayed also, but in this mode, all memories are displayed as dashes. This mode is usually used to display a frequency response window, since one memory display cannot easily be distinguished from another. To display more than two memories in this mode, push **RECALL, C**. Next hit **Ctrl**, and while holding the Control button down, press the numbers of all the memories you want to display. Each one will be displayed as dashes ---. More information on displaying multiple memories and subtracting one memory from another is contained in the section of this manual entitled "PC-40 Memory Functions."

PF4 also has a shift function called "DISPLAY." The PC-40 provides four possible screen displays. These include octave, 1/3 octave, octave weighted, and 1/3 octave weighted. Whether the PC-40 is in the octave mode (10 bars on the display screen) or 1/3 octave (thirty bars on the display screen) is immediately obvious from looking at the display. However, either octave or 1/3 octave displays may be weighted. The weighting follows the "A," "C" or "F" weighting of the SPL meter. As previously discussed, an A, C, or F appear in the SPL section of the PC-40 display screen. If an arrow appears next to the A, the C, or the F, the screen is weighted correspondingly (However, F or "Flat" weighted is the same as unweighted). A quick look at Figure XI on page 12 will easily help locate the position of the arrow.

Shift/PF4 (DISPLAY), then allows you to toggle between selecting octave, 1/3 octave, weighted octave, and weighted 1/3 octave. To select the type of weighting, **Shift/PF1** is used.

PF5 has a **Shift** function which is called "RELATIVE." This is an especially nice function to use when doing seat-to-seat variation in SPL readings in an auditorium. To activate this function, press **Shift/PF5**. When this is done, the PC-40 locks into memory the SPL reading that was occurring the moment the "RELATIVE" function was activated. From that point forward, until "RELATIVE" is deactivated by pressing **Shift/PF5** again, the message window will display the word "REL" and the SPL either above or below the SPL that was locked into

memory. The SPL display will continue to display standard SPL, as shown below:

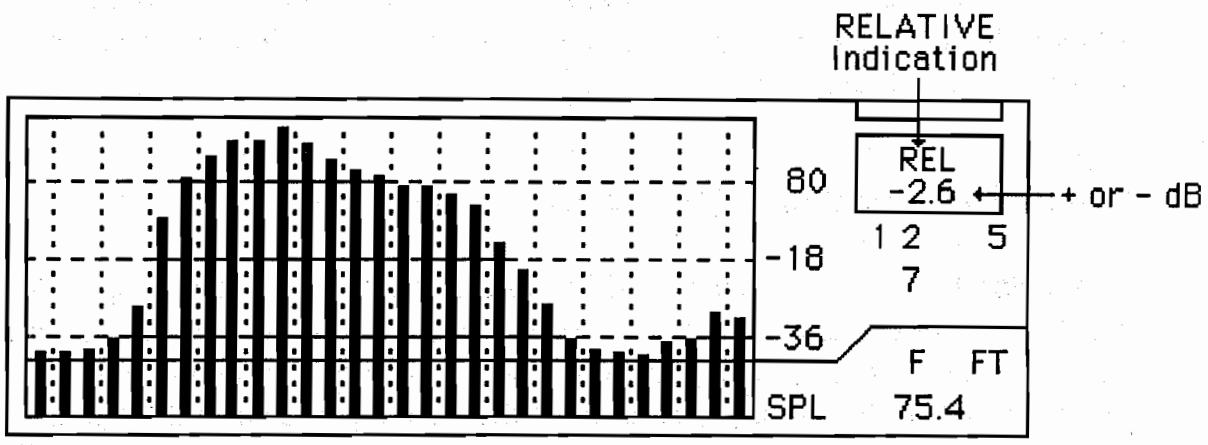


Figure XVII

The RELATIVE function also works when viewing the amplitude of a single channel (see pages 13 through 15 in this manual). When in RELATIVE, you can press the letter **F** (or when viewing individual filter amplitude, you may press **Shift/PF5** for RELATIVE) and the Message Window will display the channel frequency and relative amplitude, instead of relative SPL, as shown in the illustration below:

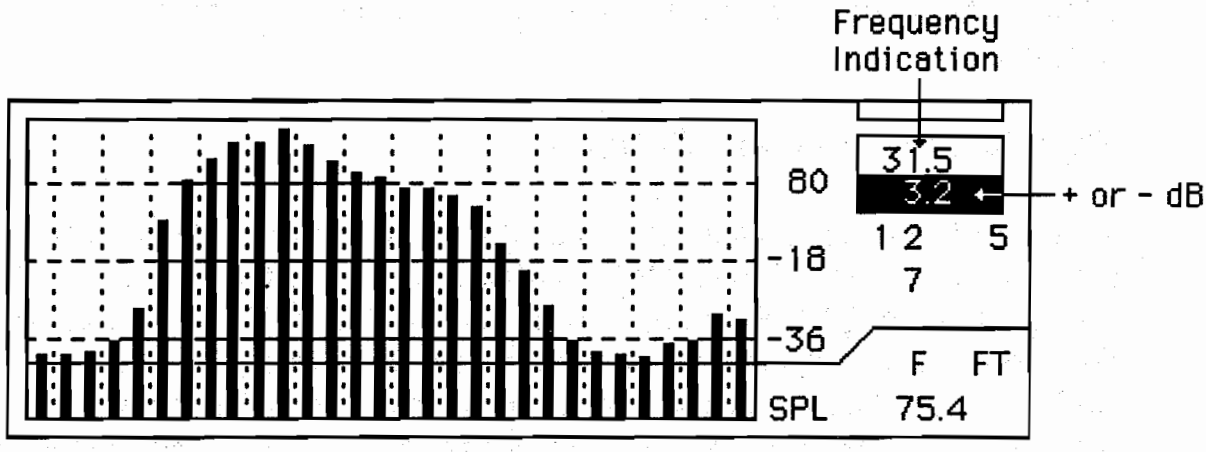


Figure XVIII

Notice that plus or minus dB is now shown in inverse video so that you know you are looking at a single channel, and not broadband SPL.

In our auditorium example, if we didn't want the seat to seat SPL variation at

4kHz to be greater than plus or minus 3dB, we could feed pink noise into the system at some fixed level, select the 4kHz channel for amplitude viewing, then activate the RELATIVE function and walk the auditorium while monitoring the PC-40 Message Window to make sure the relative reading at 4kHz was not swinging more than plus or minus 3dB.

*****Important Function - The "Screen Dump" Print*****

In addition to the above functions, **PF5** also performs a "screen dump" printing function. After we have selected our printer or port option (for more information on selecting a printer, or port option, see the section of this manual entitled "Printing Options"), we simply hold down the **Ctrl** key and hit **PF5** for a "screen dump" printout. When we do this, whatever is currently displayed on the PC-40 screen will be printed. If we recall a memory and print it, the note we have attached will be printed also, as well as the date/time code indicating when the data was put into memory. These memories are nonvolatile and can be saved as long as needed.

*****Important Note***** If you try to activate the "Screen Dump" routine and no printer is connected to the PC-40, or the printer port assignment is incorrect, the computer will "lock up." If this happens, press **Ctrl** and **QUIT** simultaneously to stop the print function, and then check printer connections and port assignments.

The Other 4 Function Buttons

There are four more function buttons on the PC-40. In order, from left to right, they are labeled **QUIT**, **UTILITIES**, **AVERAGE**, and **HELP**. The last three are also labeled ESC (Escape), PAUSE, and SYSTEM. These last labels do not apply to the analyzer operation, but do apply to the computer when using BASIC or the CPM operating system (Refer to page 2-22 of the HX-40 operating manual). ESC, PAUSE, and SYSTEM will not be covered in this manual, but are covered in the computer operation manual.

HELP

We are going to discuss the **HELP** button first, because it applies to all the functions we have previously described, as well as those to follow. The **HELP**

button accesses a context sensitive help screen. Here is the way it works: The PC-40 always knows what function it is performing, and what it is doing within that function. In most instances, when you want to know where you are within a function, or what options are available from there, the "Help" function can do just that - help you. Pressing **HELP** will cause information to appear on the display screen to help you understand where you are and where you may go from there. The best way to describe it is a built-in mini-reference manual. The **HELP** button is your friend and you will want to use it often. As with most other functions, you push **HELP** to get in and you push **HELP** again to get out of the function. In the event you fail to press **HELP** again to get out of this function, the "help" screen will go away on its own after 45 seconds.

QUIT

The red **QUIT** button has a simple function. In most analyzer modes, pressing **QUIT** will drop the analyzer software out of working memory and return you to the menu in the CP/M operating system. From this menu, you may choose what function you desire to perform (BASIC, or back to the PC-40 ROM). There are a few functions, such as "Store" and "Recall," that will not allow you to "Quit" until they have been completed.

UTILITIES

"UTILITIES" allows us to address a number of important and useful functions. (We will introduce them here, but not go into them in detail. The section of this manual entitled "Utilities Functions" goes into great depth, and should be read carefully.) To get into this function, press the **UTILITIES** key. (To get out, press the **UTILITIES** key again. The PC-40 is designed this way on all major functions. To get out of any function, push the same button that got you in.) After you press **UTILITIES**, a menu will appear on the PC-40 display screen. There are ten items on this menu which can be accessed by pressing **PF1** through **PF5**, or **Shift/PF1** through **Shift/PF5**. In essence, the function keys are reassigned to perform utility functions, when in the "Utilities" mode.

Let's quickly examine these items one at a time. The first menu item is "Save." (Unless you have the RT_{60} software, in which case it will be listed first.) To access "Save," press **PF1**. This function allow you to save data to a microcassette, a disk drive, etc., and allows you to select the data you wish to save. To get out, press **PF1** again (unless the menu requests another key to

perform an exit command. This is generally true for getting out of all the "UTILITIES" menus, that is, push the same key to get out that got you in, unless the menu states otherwise.).

The second menu item is called "Time," and allows you to initialize with date and time information. Push **Shift/PF2** to get into this function. The menu here is quite self-explanatory.

The third menu item, "Load," and allows you to load data into the PC-40 from some selected external source, such as a disk.

The next menu item is called "Printr," for Printer, and allows you to select the printer port you wish to use for printing. If the optional cartridge printer (the H409A) for the PC-40 is used, three size printing formats are available, and this utility function allows you to select which size format you desire.

"Offset" is the next utility function and in this mode you may enter a desired curve into the PC-40. After a curve has been entered, and the "Offset" function is active, the displayed information on the PC-40 screen will be relative to the entered offset curve. For example, if we enter a desired house curve as our offset, and then equalize a sound system such that we have a flat display on the PC-40, we will have equalized to our offset curve. (In this case our desired house curve.) Whenever the "Offset" function is activated, the word "Off" will appear to the left of the Message Window on the PC-40 display screen (See Figure XI).

The next utility function is called "Rate," but before we talk about it, we are going to discuss the function before it called "Record," so it will make better sense. The PC-40 has the ability to store successive screens of information into buffer memory. It can store them at a rate of from 1 screen per second up to 100 screens per second (100 is displayed as "00"in the "Rate" menu.) If you want to record into buffer, and you want to select a different record rate, the "Rate" function allows you to do this using the cursor keys (arrow keys) on the PC-40. The "Rate" menu explains how to do it.

*****Important Note - - - "Rate" Affects "Real Time" Data *****

Setting the "Rate" will also affect the real time display of the PC-40. If, for example, you set the sample rate to 1 screen per second and then return to "real time," you will see the filter display of the PC-40 update once each second.

The SPL display upgrades once for every 10 filter display updates, so you would see it display only once each 10 seconds. Being able to slow down the display is a real advantage for some applications. In real time, the PC-40 is capable of displaying up to about 18 or 20 samples per second. If you set the "Rate slower than this, it will slow the display down. If you set the "Rate" higher than this, the PC-40 will still display only as fast as it can - about 18 to 20 samples per second. The SPL meter in the PC-40 can handle a rate of up to 75 samples per second before it tops out. If you set a "Rate" less than 75 samples per second, the SPL meter will be slowed accordingly. For "Rates" above 75 screens per second, the SPL meter simply does what it can - about 75. (If you are using the SPL meter to capture short duration phenomenon, the sample rate should be set for 30 or higher so that no data will be colored because the display is slowed.)

You may ask why we allow the setting of a sample rate that exceeds the analyzer's ability to display the information, and that is a good question. The answer is that while we may not be able to view the samples in real time, we can still write them into memory at these high rates, and then recall them to view. Let's explore that a little further. The illustration below shows the "Rate" menu.

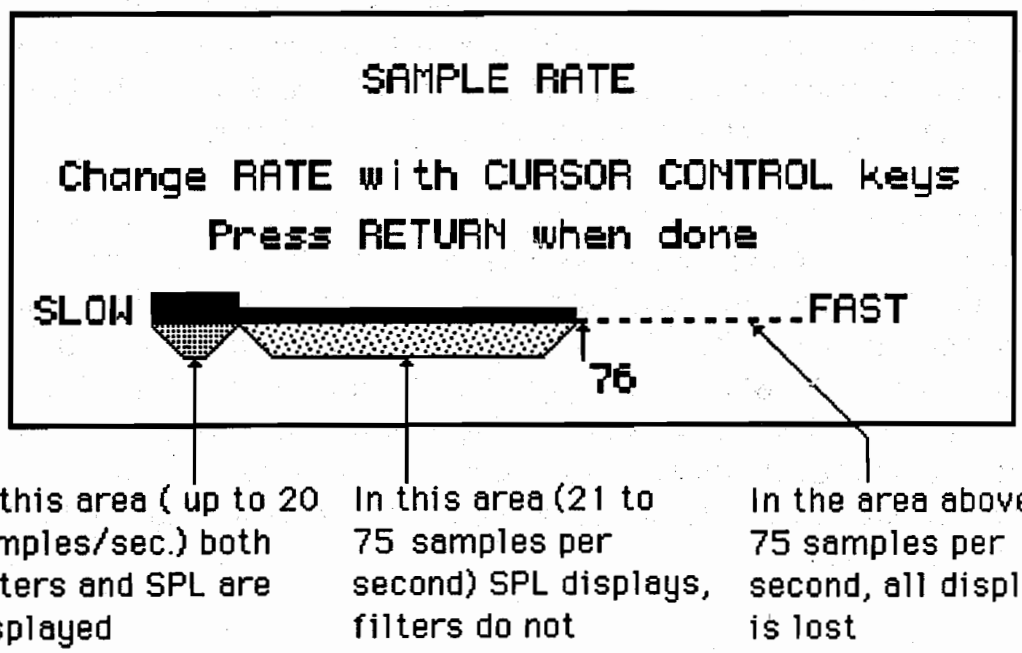


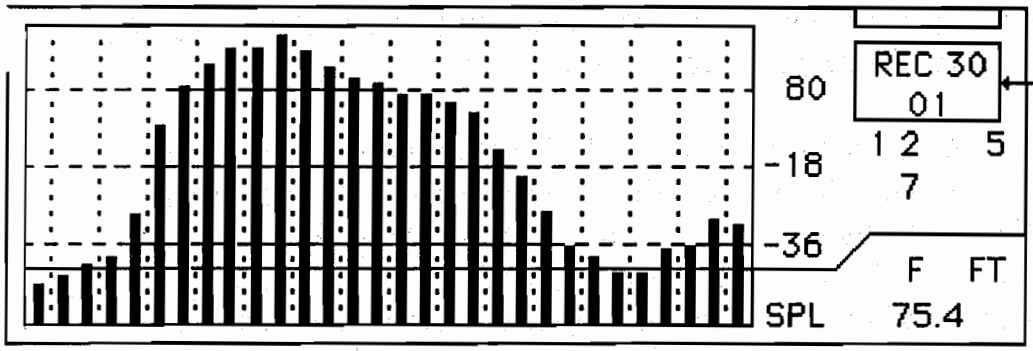
Figure XIX

The bar in the above menu represents the number of samples per second you select. You change the "Rate" by using the left and right cursor arrows on the PC-40 keyboard. The small arrow below the bar with the number by it always tells you how many samples per second have selected. In the example on the preceding page, we have selected 76 samples per second.

The bar is divided into three sections which represent the display capability of the PC-40. If we are in the "Record" function, and have selected a speed of 20 or less samples per second to be written into buffer memory, all the sample screens will be displayed as they are recorded. If we select a speed above 20 screens per second, but less than 75, the filter screen will not display the samples as they are taken (the screen goes blank while recording), but the SPL meter will continue to display samples as they are taken. If we exceed 75 samples per second, both the screen and the SPL display will go blank as samples are written into memory because neither display is fast enough to keep up with the sample recording rate. Those screens are in memory, however, and we can recall and display them.

We have talked about getting into the "Record" function, but that needs further discussion. Getting into and out of the "Record" function is different than the other functions of the PC-40. When you want to get into the "Record" function, first press the **UTILITIES** key. Next, select the "Rate" function by pressing **Shift/PF4**, and, using the cursor keys, select the number of screens per second you want to dump into memory. The menu will request you to hit **Return** to get out of the "Rate" function and back into the "Utilities" menu.

When viewing the "Utilities" menu, you may activate the "Record" function by pressing **PF4** (If you have already been in the "Record " function and there is data in the buffer, the screen will prompt you indicating that data will be lost if you continue. You can choose to continue and overwrite the data, or choose not to continue). When you activate the "Record" function, the PC-40 will revert back to a real time display screen. The Message Window will indicate that you are in the "Record" function, and the number of screens per second you have selected will be printed in the Message Window as well. Note the illustration on the next page:



The PC-40 is in the Record Mode, set for 30 samples/sec. The 01 indicates sample #1, which will be taken when the "A" key is pressed.

Figure XX

The system is now armed and ready to begin recording. Recording is started and stopped by pressing the **A** key (the same as for starting and stopping the AVERAGE function). When you press the **A** key, recording will begin and will continue until you hit theA key again, or until internal memory is filled (up to 472 screens, which is expandable to 8150 screens by adding extra memory as a factory option). The bottom number in the Message Window indicates the number of samples taken, or identifies a particular sample screen by number. Also, in the playback mode, the sample number will identify time displacement. In our illustration above, for example, we are set for 30 screens per second. If we were looking at the samples we had taken under this setup, sample #60 would be displaced in time exactly two seconds after we began our sample process. This leads to some interesting possibilities for time domain measurements.

To get out of the "Record" function, you must press **UTILITIES** to bring up the "Utilities" menu, then press **PF4** (the "Record" function) to toggle out. Following this procedure will allow you to toggle in and out of the "Record" function. When you exit the "Record" function, the PC-40 will prompt you and give you an opportunity to add a note the record buffer file. Adding a note to the file is optional, but it is helpful when you are trying to identify the data at some later time. To add a note, type the information you choose and press **Return**. If you do not wish to add notation, simply press **Return.**

The "Playbk" (Playback) function allows you to play back the screens of information you have stored in the "Record" function. When in "Playbk," the cursor keys of the PC-40 will allow you to step forward or backward through the screens of data, either one at a time by tapping the cursor keys, or a rapid scroll by hold a cursor key down. You may also step through the samples in multiples of 10 by holding down the **Shift** key while pressing the arrow keys. If you try to

enter the "Playbk" mode when nothing has been recorded into buffer memory, the menu prompt will let you know you have made an error.

The final "Utilities" function is called "Mic/Prb" (Microphone/Probe). This function simply allows you to select the microphone for acoustical measurements, or the probe as the input source to the analyzer for making electrical measurements. If the probe is used, AC volts can be measured, or dBm or dB volts. When making dBm or dB volts measurements, the resolution is .1dB.

AVERAGE

"AVERAGE" is the last function we will discuss, and it is a somewhat specialized, but very useful function. Basically, it allows you to average a number of screens of information together and display that average, enter it into a memory, or print it. Screens of information can be added to the accumulator for averaging one at a time, or in groups. This is how it works. To enter the "Averaging" mode, press **AVERAGE.** The PC-40 Message Window will indicate that the "Averaging" function has been activated, and the letters "R," "S," and "M" will appear in the window as well. (If you press **HELP** at this point, the menu will provide the same explanation we are about to undertake.) Pressing **R** will reset the accumulators to zero and will ready the PC-40 to begin a new measurement. If you wish to take screen "snapshots" one at a time, push **S** for "Single Samples." You may now take a "snapshot" by pressing the **A** (for "Average) key which will freeze a screen of information. You can then choose to enter this "snapshot" into the accumulators for averaging, or not enter it if you don't like it for some reason. To enter it into the accumulators, hit **Return** and it will be entered. If you don't want to enter the screen for averaging, hit any other key. This will erase the screen, and return the PC-40 to a real time display. When you are ready to take another "snapshot," press the **A** key again. This will freeze the screen as before. If you enter this screen into the accumulator, the number 01 will appear in the Message Window to let you know you have one screen entered. You can continue to enter single screens in this manner to average as many as you wish (up to 9999 samples). You may view the average of the screens you have taken at any time by pushing **V** for "View." Push **V** again to get back to the "Averaging" mode.

If you want to take continuous samples at a rate of about 8 to 10 screens per second , enter the "Average" function by pressing **AVERAGE** and then **M** for

"multiple." (If you are already in the "Average" mode taking single frames of information, you will still need to push **AVERAGE** and then **M** to change to the multiple frames mode of the "Average" function. Furthermore, if frames of information are in the accumulators, they will still be there until you press **R** to reset the system and clear the accumulators.) If you want your new data to be averaged with data already in the accumulators, it will not be necessary to clear them before you begin new measurements. The new data will be automatically averaged with the existing data in the accumulators.

The sample rate of 8 to 10 screens per second is a maximum; fewer samples per second may be selected by using the "Rate" function, but if you select a higher sample rate than 8 to 10, the "Average" function will still take only 8 to 10 samples per second.

In the multiple frame mode of the "Average" function, sample taking starts and stops with the press of the **A** key. In this mode, when samples are not being taken, the display of the PC-40 is a real time display. When samples are being taken, what is being displayed is the average which is constantly being updated as new screens are added. Again, the display is not real time, but is a displayed average of data taken. This means, for example, that if you fed pink noise into the PC-40, and began to take samples in the multiple screen mode of the "Averaging" function, the display would move around quite a bit as you began because of the random nature of pink noise. However, with continuous samples being taken and averaged, the screen would settle down in time to where it didn't move at all since pink noise, averaged over a sufficiently long time, is very flat.

Of course, if you want to view accumulated average without having to take more samples at the same time, you can stop taking samples (which returns the PC-40 display to a real time display) and press **V** to view your average. As you can see, "Average" provides some very interesting possibilities. In doing STC, or NIC measurements, for example, average readings are required. In entirely different applications, such as equalization, using both a microphone multiplexer and the PC-40 averaging capability would give you results that are both time and spacially averaged.

We have now completed a cursory examination of many of the PC-40 functions. We can now move on to a more in depth look at the PC-40 Utility Functions.

Using the PC-40

The Utilities Functions in Depth

The purpose of this section of the PC-40 manual is to explore more of the power and capabilities of the functions found in the Utilities Menu. Some of the functions such as "Rate," or "Time" need no further explanation. However, some of the functions, "Offset," for example, deserve substantial discussion. In this section of the manual, we will cover only those items in the Utilities Menu which deserve further treatment.

Save and Load

The first Utilities Menu item, "Save," which allows you to save data to some external storage device - such as a disk, operates very much like the storage function on any other computer. You may choose what items or blocks of information you wish to save - a single memory, a block of 20 memories, or an entire block of information from the record buffer. Data in the record buffer is stored in the form of complete screens of information, and is accumulated into buffer by use of the "Record" function. When selecting a single memory for saving, the first 10 memories are selected by using keyboard keys 0-9 (0 being memory 10), and memories 11 through 20 are selected by using the shift key in conjunction with keys 0-9 (Shift 0 being memory 20). All data is stored as data files. These files may be saved to various storage devices called drives. The computer utilities CP/M operating system and all files occur under CP/M.

After selecting the information you desire to save, you must select a location to have it saved. It may be saved to Ram disk (Drive A), or floppy disk (recognized by the system software as drive D, E, F, or G), or to a microcassette cartridge (recognized by the system software as drive H). Complete instructions for saving to the optional cassette drive are in the Epson manual which you should have received with your PC-40. In the event you purchase an optional external disk drive, a complete manual from Ivie will be shipped with it, including a utilities disk. Between the Epson manual and the Ivie manual, you should have all the information needed to both read and write to external disks.

After selecting the material to be saved, and the drive to be used, you must name your file. The file name is specified by a field of up to 8 alphanumeric characters. The appropriate file name extension will be appended to the file by

the computer. Only letters and numbers, not spaces, should be used for file names. File name extensions used by the computer are: MEM for a single memory, MBK for a block of 20 memories, and REC for the record buffer. The PC-40 will prompt you through all of the above operations. Once you enter the file name to be saved, pressing the **Return** key will initiate the saving process. The exception to this occurs when you give you file a name that has already been used. When this happens, the PC-40 will prompt to ask whether you want to overwrite the file you have already saved. Pressing **Y** for "Yes" begins the overwrite process, and pressing **N** for "No" aborts the saving process.

Once you have saved some data, the PC-40 will return to the beginning "Save" prompt - it assumes you will want to save something else while in the "Save" mode. If you want to save something else, follow the same steps as above, but if you are through, hit the **UTILITIES** key to exit the "Save" mode.

The "Load" function works very much like the "Save" function. After selecting the "Load" function from the Utilities menu, the PC-40 will prompt you, and you must choose the drive from which you desire to load data. You must next choose where you want the data loaded - into the record buffer, or into one or more of the PC-40 twenty memory locations, for example. Again, the PC-40 will prompt and require an answer. As in the "Save" function, selection of single memories 11 through 20 are accomplished by using the shift key in conjunction with the number keys.

Printer and Printing

Selecting "Printer" from the Utilities Menu allows us to select a printer port, or the optional cartridge printer. The cartridge printer prints in three size formats, and we therefore must select the size to be printed.

Cables are available for external printers. External printers print the same size as the optional cartridge printer in the Large Printout format, but print faster.

If you select a port to which a printer is not attached, and then give the PC-40 a print command, it will go off into Never-Never Land looking for the nonexistent printer. To bring it out of this "lock up," you will have to hold down the **Ctrl** key and hit the red **Quit** button. You may even have to take a pointed object (pen or pencil) and press the recessed reset button on the right side of the computer. This action may or may not cost you the screen you wanted to print, so treat your

PC-40 with kindly printing commands, and it will respond with affection.

If you want to abort printing that is in progress, holding down the **Ctrl** key and hitting the red **Quit** button will accomplish this.

Offset

Offset is a very powerful and flexible function. It may appear to be confusing at first glance, but it is really very easy to use. Conceptually, we can look at "Offset" as an internal memory location to which real-time data is compared and then displayed. Earlier in the manual, we used the example of a preferred house curve being stored in the "Offset" memory. We would equalize the PC-40 display "flat" - visually easy to do - and once done would have equalized to our preferred house curve. The Offset mode works in 1,2,or 3dB per step resolution.

To perform an "Offset" function, we need three things: First a way to get into and out of the "Offset" mode, second a way to create the curves or data that we want to put into the "Offset" memory location, and last a way to get that data into the "Offset" memory.

Let's take them one at a time. Firstly, you don't need to use the Utilities Menu at all to put the PC-40 into the Offset mode, or to get it out. All you need is the **O** key on the keyboard. Hitting **O** (for "Offset") will toggle the PC-40 into or out of the Offset mode. It is easy to tell if you are in the Offset mode, because the letters OFF will appear on the Offset mode. Notice the illustration below:

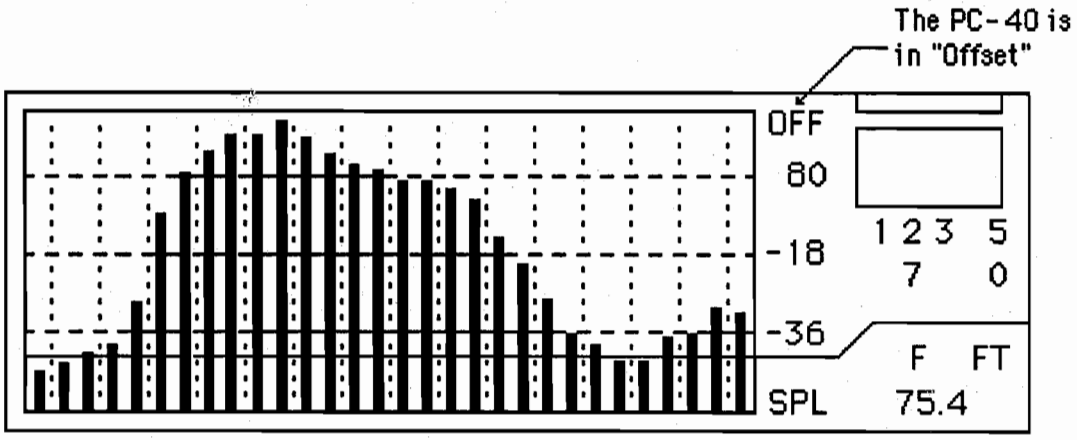


Figure XXI

When the PC-40 is in the Offset mode, it is comparing real-time data to the data in its Offset memory and displaying the difference, between the Offset memory and real-time - that's why it is called the Offset mode. However, there may or may not be any data in the Offset memory. If there is not a curve there to make a comparison to, switching the PC-40 into Offset will not change the display at all. Next, then, let's explore how to create the data your want to put into the Offset memory, and how to get it into the Offset memory.

To create a curve for Offset use, and to get that curve into the Offset memory, we select the function "Offset" from the Utilities Menu. When we have done this, we should get a display that looks like Figure XXII below. If it does not look like this, hold down the **Ctrl** button and press **R**. This will reset the display.

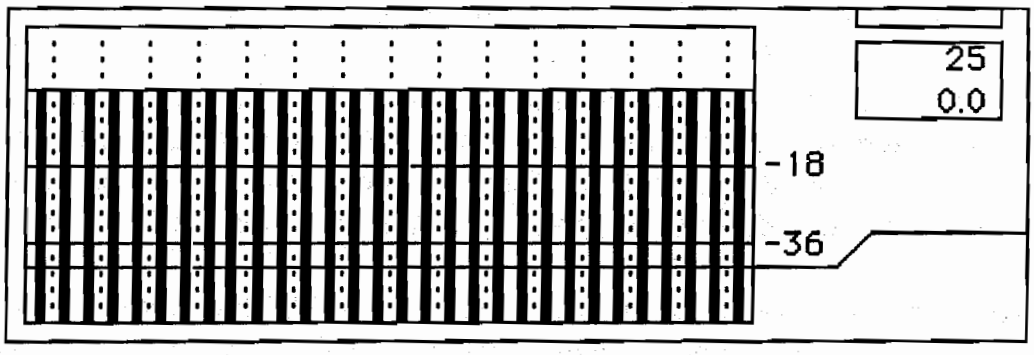


Figure XXII

This curve can be manipulated using the cursor keys of the PC-40. The left and right arrows select a frequency band, and the up and down arrows change amplitude. In our illustration above, the Message Window tells us that we have selected the 25Hz channel, and that the amplitude at this channel is at 0.0dB relative to the reference line - in other words, it is right on the reference line. If we press the down cursor arrow, the 25Hz channel will drop in 1dB increments, and the Message Window will tell us how far below the reference we have dropped (We could go above the reference, too, by using the up cursor arrow). If we want finer resolution, holding down the **Shift** button while using the cursor will move us in .1dB increments.

After we have adjusted the 25Hz channel to our satisfaction, we use the right cursor arrow to move to the next channel, and then we adjust it - and so on, and continuing through all the channels until we have the curve we desire. The

Message window will always tell us what channel we are working on, and how many dB above or below the reference we are.

Let's suppose that we have followed the above procedure, and have created the curve below:

Figure XXIII

We have now created a curve that we may wish to place in the Offset memory, and/or we may wish to store it in one of the 20 memories of the PC-40 for later use, or we may want to entirely discard it because we've decided we don't like it. We can easily do any of these things. Here is how we do it.

To store the curve for future use, simply hit the **STORE** button and store it the way you would any other memory - complete with annotation if you desire. The Reference Level of this stored curve will be the Reference Level the PC-40 showed before you entered the Offset mode. After completing the annotation, hit **Return** to exit the "Store" mode. The curve has now been stored into memory, but not into the Offset memory.

To place the curve into the Offset memory, hit **Return.** When in the Utilities function "Offset," hitting **Return** will place the curve on screen into the Offset memory. If there is already another curve in Offset memory, it will be overwritten.

If you want to both store the curve in memory, and place it into Offset memory, first store it into one of the 20 memories as outlined above. After it is stored, it will still be on screen, and you may then hit the **Return** button to place it into Offset memory as well.

If you want to discard the curve you have created, simply hit the **Utilities**

button. This will place you back into the Utilities menu and your curve will be gone. If you would rather stay in the Offset function and create a new curve, follow this procedure: Instead of hitting the **Utilities** button to exit the program, hold down the **Ctrl** button and hit **R** for "Reset." This will discard your old curve, and initialize your screen as shown in Figure XXII. This is especially useful if you want to create several curves and put them into the PC-40 memories for later use. You simply create a curve, store it in a memory, hit **Ctrl/R** to reset, and create your next curve to be stored.

One thing that should be noted here is that in addition to discarding the curve you may be working on, hitting **Ctrl/R** also clears the Offset memory. If you have had a curve in the Offset memory, and have gone back into the Offset function to create additional curves, and have hit **Ctrl/R** in the process, you no longer have a curve in the Offset memory. You will have to put in back in again, if you desire to use it.

The last thing we need to examine is how to get a curve from one of the PC-40's twenty memories into the Offset memory. It is very simple. First enter the Offset function via the Utilities menu. The "flat" curve shown in Figure XXII will appear. Next, hit **RECALL**, followed by the number of the memory you wish to recall. The memory will appear on screen. Hit **RECALL** again to get out of the Recall mode. The memory curve will still be on screen. You may now hit **Return** to put the curve into Offset memory.

Important Feature

The Offset function can be used to closely examine any curve you may have in memory, not just curves you have created. For example, if we want to take a very close look at a response curve that we have earlier placed in one of the PC-40 memories, we can select the Offset function from the Utilities menu and recall our memory as described above. We hit **RECALL** again to get us out of the Recall mode, and our memory still stays on screen as though we were going to put it into the Offset memory. Instead of putting it into Offset memory, we can use the left and right cursor arrows to scroll through the channels. The Message Window will print the channel selected, and the amplitude in that channel to a resolution of .1dB.

As can be seen, the Offset function presents some very interesting possibilities.

Mic/Probe

The Mic/Probe Utility is a fairly self-explanatory function, but a few items should be noted. It is important, or example, to have the probe selected for making electrical measurements, and the microphone selected for making acoustic measurements. If you try to make acoustic measurements and have selected dBm, dbV, or AC V from the menu, the PC-40 will be looking at the electrical input for signal (the BNC connector on the PC-40), not the microphone input. What you will see displayed in this situation will be cross-talk between the two inputs, and it will look like nothing you are trying to measure. The closest thing it will resemble is white noise. If you are getting strange readings that don't seem to make sense, it's a good idea to check the Mic/Probe Utility to make sure you have the proper input selected.

The second thing you need to be aware of is that the reference level settings are different when using the microphone as opposed to using the probe. The mic reference level ranges from 30dB to 140dB in 10dB increments. This 110dB range represents from 30dB of attenuation to 80dB of gain.

For electrical measurements, the reference level ranges from 50dB to 180dB. The same preamp is used - a range of 30dB of attenuation to 80dB of gain, but a probe pad of either 20dB or 40dB is automatically inserted. The 20dB pad is inserted on the low end; hence we can get down to 50dB instead of 30dB as in acoustic measurements. At the high end, the 40dB pad is inserted so we can get up to 180dB, instead of just 140dB. On previous Ivie instruments, the 20/40dB pad was on the probe itself, and one had to mentally correct measurements. The PC-40 has the pad internally so the reading you see is the reading you have.

The reason for the pad in the first place is to more closely match the measurement capability to the range of signals which are normally measured.

The probe itself has a 1MΩ input impedance and is rated for up to 600VDC (includes peak AC).

Sound Level Testing

Introduction

The decibel (dB) scale has been adopted internationally for use with sound level meter testing. The scale begins at a reference of 0 dB in sound pressure level (0 dB SPL) which corresponds to the smallest sound that can be heard by a healthy human ear, and is equal to $2\mu N/m^2$, or perhaps more commonly, $20\mu Pa$. Following is a chart which shows some various sound pressure levels (SPL's) relative to typical environmental sounds:

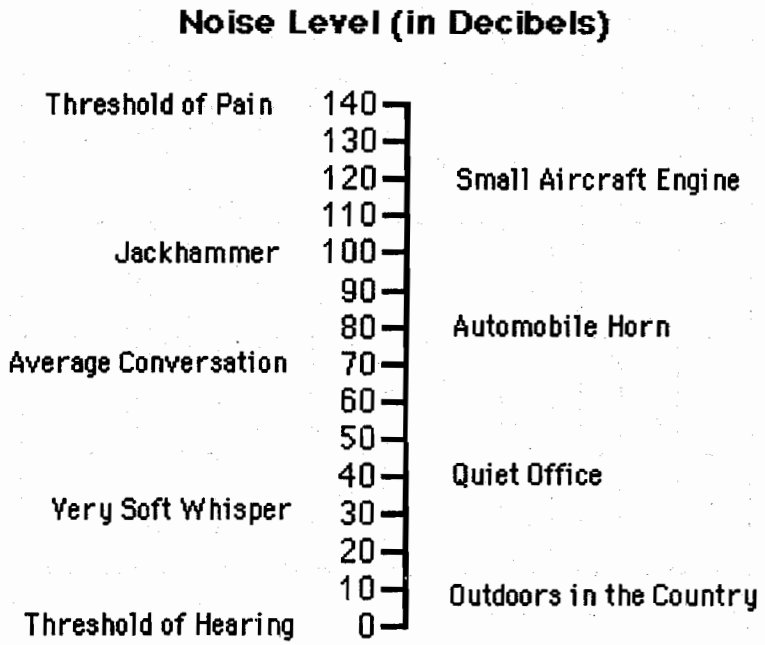


Figure XXIV

When studying sound level measurements, it is of major importance to understand the response characteristics of the human ear. Our ears do not respond equally to all the frequencies of the audio spectrum - in other words, they are not "flat" in their response. To further complicate matters, the response characteristics of human ears change with different SPL's. At relatively quiet

SPL's, our ears attenuate high frequency sounds to some degree, and drastically attenuate low frequency sounds. As SPL's increase, our ears get more efficient at low frequencies and their response to sound becomes more "flat," although they never achieve a totally "flat" response. Following is a set of curves which approximate the hearing response of human ears. The "A" curve shows how ears hear, or perceive sound at low SPL's, while the "C" curve shows how we hear at relatively high SPL's.

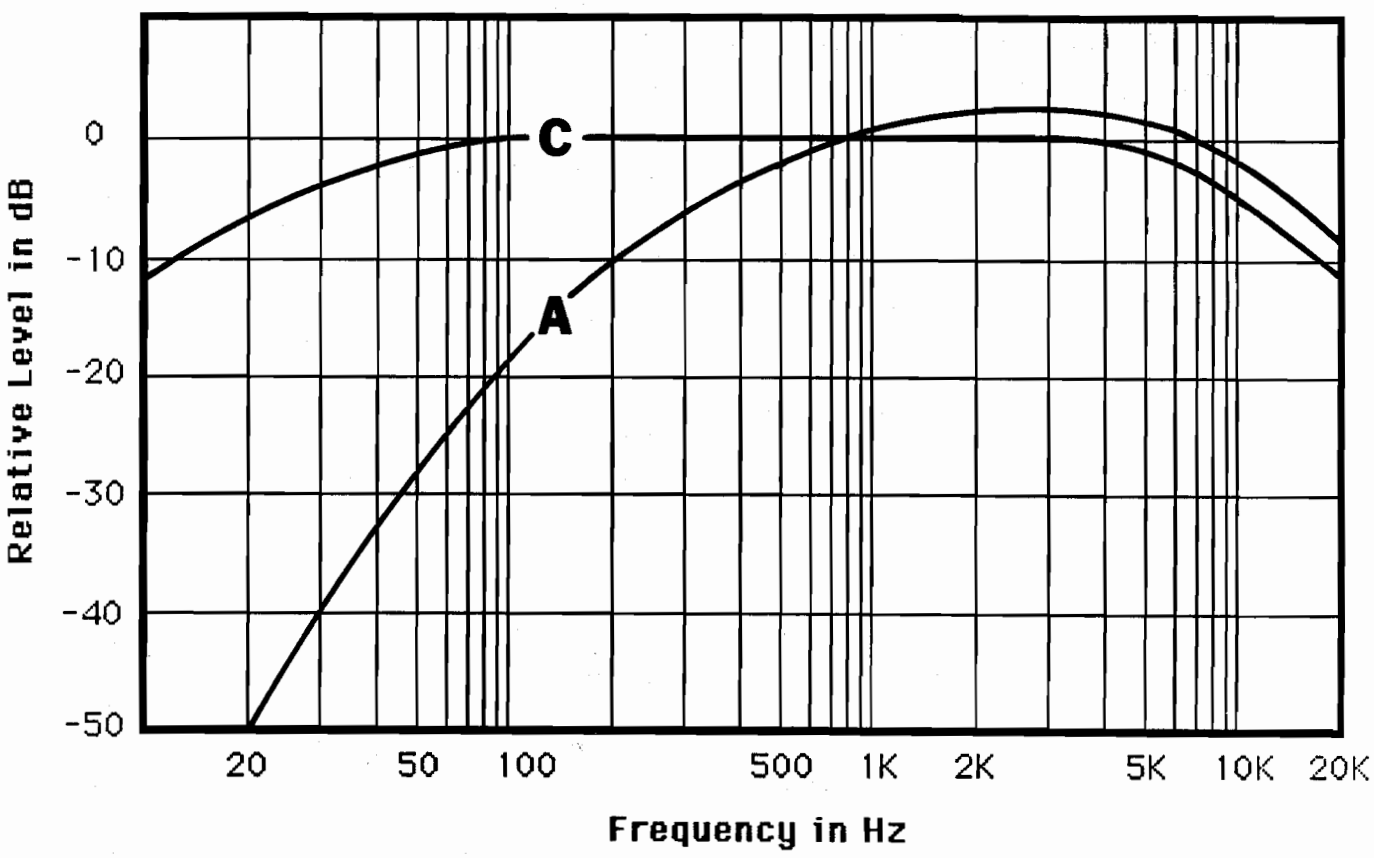


Figure XXV

These curves have been integrated into sound level meters for testing sound levels. "A" weighted (dBA) measurements use the "A" curve above, "C" weighted (dBC) use the "C" curve above, and "Flat" (dB SPL) measurements use no weighting at all.

Noise which causes hearing damage has been found to correlate most closely with the "A" curve. Consequently, OSHA requirements, and many other

government regulations are generally specified in dBA. The Walsh-Healey Public Contracts Act, for example, specifies the following permissible human exposure levels for industrial noise. Notice that all duration levels are specified in dBA.

Permissible Noise Exposures

Hours Duration Per Day	dBA SPL Slow Response
8	90
6	92
4	95
3	97
2	100
1.5	102
1	105
.5	110
.25	115

Figure XXVI

In addition to being concerned about the weighting we use when we make SPL measurements, we need also to be aware of the measurement environment. Sound environments can range from near-field to free-field to diffuse-field. A free-field environment is one that is free of reflections, and is typical of anechoic chambers (sound absorbing rooms) that have acoustically padded walls, floors, and ceilings.

Diffuse (reverberant) fields are often encountered and are purposely created by reverberation chambers that have been designed to cause as much reflection between ceilings, walls, and floors as possible. A diffuse-field is one in which the sound is uniformly distributed throughout the room. Machine noise tests are more often made in reverberant chambers, as they are less costly to build than anechoic chambers.

Typical sound measurements environments, however, are usually some combination of free-fields and diffuse fields, and great care must be taken with

the measurements to help assure that accurate results are obtained. Errors can occur when determining the noise from a single source if tests are made too close (near-field) to the source being measured (See Figure XXVII below). The near-field SPL can change dramatically with small position changes of the sound level meter. To avoid near-field errors, the sound level meter should be located away from the source by at least a distance equal to one wavelength of the lowest frequency radiated from the source, or more than twice the distance of the largest dimension of the source, whichever distance is greater.

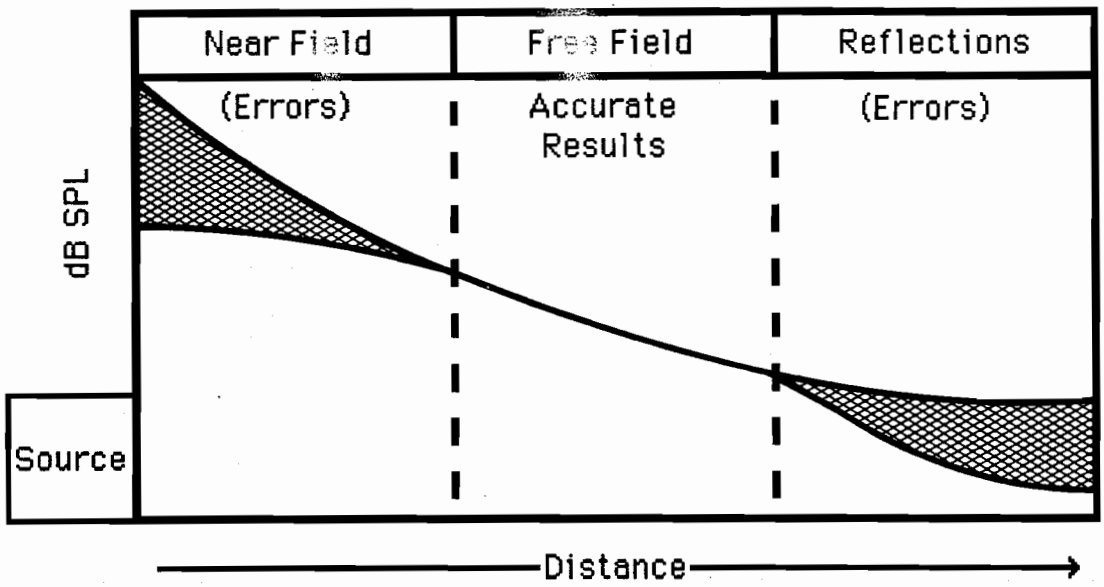
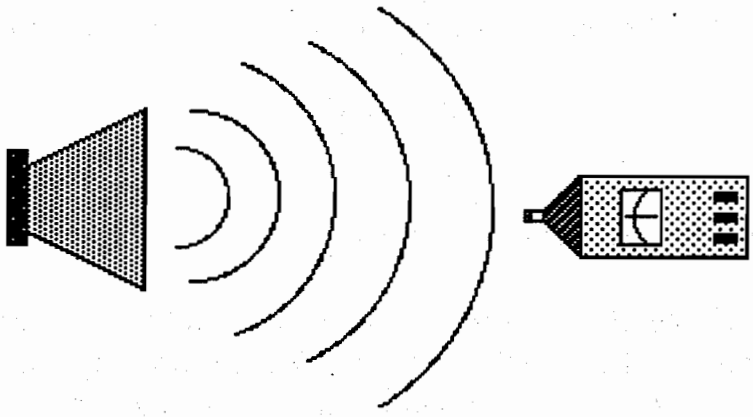


Figure XXVII

As can be seen from the above illustration, errors can occur not only when we are too close to the source, but also when we get too far from the source being measured, room reflections and other room noises may interfere with our readings. The most desirable condition for noise testing would be to perform all tests in a reverberant chamber (diffuse-field) or an anechoic chamber (free-field). Since this is usually not possible, the next best alternative is to find a free-field as close to the object being tested as possible. It is easy to identify a free-field because the inverse square law holds true there. The inverse square law describes the relationship between sound pressure level and distance in a free-field. When the distance from the sound source doubles, the SPL will drop by 6 dB. If the distance is doubled again, the SPL will drop by another 6 dB. If this relationship occurs, the sound waves are traveling unobstructed from the source to you, and by definition, you are standing in a free-field.

Free Field vs. Random Response or Pressure Response Microphones

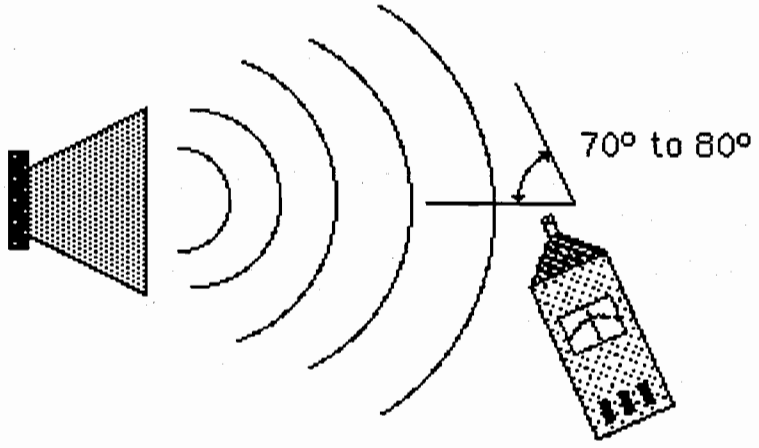
Both free field microphones and random response microphones are used to measure SPL. In Europe and other areas where IEC standards are required, a free field microphone is required. A free field microphone is intended to be used in a free field environment, and should be pointed directly at the sound source as shown below.



Using a Free Field Microphone in a Free Field Environment

Figure XXVIII

In the United States and other areas where ANSI specifications are followed, a random response microphone is normally used on a sound level meter. A random response microphone is intended to be used in a diffuse or reverberant field. However, in free field use, a random response microphone can be used to approximate the response of a free field microphone by positioning the microphone at an angle of 70 to 80 degrees to the sound source, as shown on the following page:



Using a Random Response Microphone in a Free Field Environment

Figure XXIX

Body Effects on Sound Measurements

Something that must be considered when making sound measurements with a hand-held analyzer, is the effect of the operator's body on readings. The operator's body may detract substantially from the accuracy of the measurements. At frequencies near 400 hz, sound reflecting from the body could cause up to 6 dB or error, if measurements are made within three feet of the operator. To minimize this effect, the PC-40 should be positioned as far away from the body as possible. It would also be appropriate to use a microphone extension cable in those instances when it is deemed necessary.

Correcting for Background Noise

Often the need arises to make SPL measurements in the presence of background noise. This can be easily done as long as the SPL of the primary source is <u>at least</u> 3 dB greater than the background noise. Following are the steps for making such a measurement.

1. Measure the total noise. (Background and primary source)

2. Turn off the primary noise source and measure the background noise only. Both tests should be made with the microphone in the same location.

3. Calculate the difference between the two readings measured. If the difference is less than 3 dB, accurate measurements cannot be made. If the difference is greater than 10dB, no correction is necessary. If the difference is between 3 dB and 10 dB, the following chart can be used to make the needed correction.

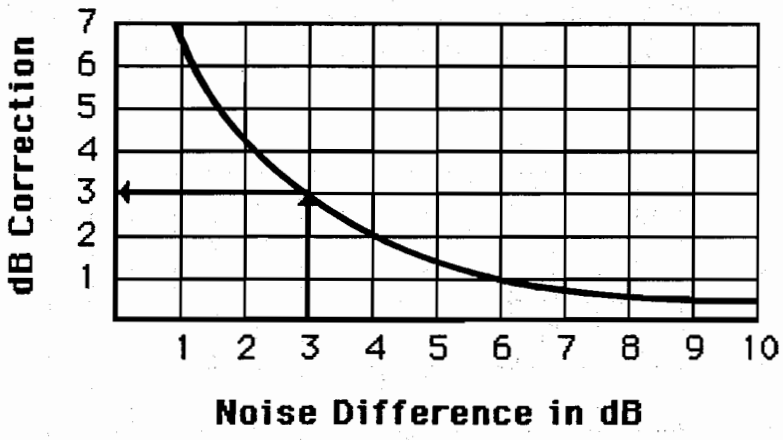


Figure XXX

To use the chart, located the difference of the two measurements on the horizontal axis. From that point, go up to intersect the curve, and then left to the vertical axis. Then subtract the value on the vertical axis from the total noise level first measured.

Example: Total noise = 75 dB. Background noise = 72 dB. Difference = 3 dB. Chart correction = 3 dB. Primary source noise = 75 dB - 3 dB = 72 dB.

There is something very interesting about this example. Notice that the background noise SPL is the same as the source noise SPL, yet when we add those equal noise levels together, the increase is only 3 dB. (72 dB of background noise plus 72 dB of primary source noise equals 75 dB total) 3 dB is only a slight change in the level of "loudness" perceived by the human ear.

This same ratio applies to amplifier power when fed to a speaker. If we double the power (watts) going to a speaker, the change in sound level is only 3 dB, a barely audible change. This gets to be pretty important if we have a huge system using 10,000 watts of power and we decide we want it just a little louder - a mere 3 dB. All we have to do to accomplish this is add another 10,000 watts!

Adding Sound Levels

Since we have just discussed an illustration of adding sound levels together, let's explore the subject further. If two primary sources are measured independently, it is possible to determine what the sound level would be if both sources were operating together. The following chart can be used to determine this, when both tests are made with the PC-40 in the same location.

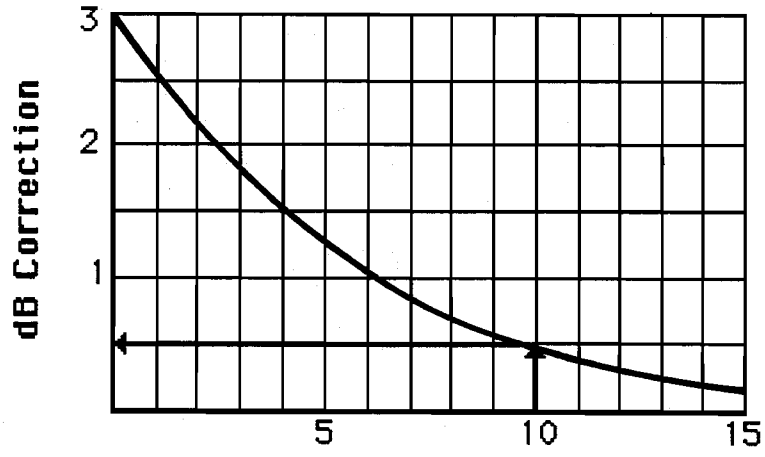


Figure XXXI

To use the chart, first measure the levels of the two sources independently and then find the difference between the two levels. Locate the difference on the bottom of the chart. Go up until the curve is intersected, and then go left to the vertical axis. Then add the correction in dB indicated by the vertical axis to the value of the highest reading made. This number indicates the combined SPL of the two sources.

In the example shown above, Source 1 equals 79 dB, and Source 2 equals 69 dB. The difference is 10 dB. Chart correction is .5 dB, so the total noise is 79.5 dB.

System Calibration for OSHA Measurements

OSHA measurements generally require equipment that meets minimum specification standards - at least an ANSI Type II sound level meter, for example. (The PC-40 is a Type I Sound Level Meter, and therefore exceeds OSHA minimum requirements). In addition to the equipment meeting minimum specification standards, it must also be properly calibrated in order for an acceptable OSHA measurement to be made.

What this normally requires is calibration prior to the measurement, and then a recheck of calibration after the measurement is made. In the case of SPL measurements, a calibration device (either a pistonphone or an acoustic calibrator) must be used. The standard PC-40 microphone is a 1/2 inch, air condenser microphone. It's size and thread specifications are the same as other internationally recognized 1/2 inch microphones. Any quality calibration device will work, if it is used properly. Most calibrators are made to accommodate a 1 inch microphone, and they have an insert to adapt them to 1/2 inch microphones. Use the 1/2 inch adapter and make sure the microphone fits snugly inside the insert.

To calibrate for OSHA measurements, fit the calibrator on to the PC-40 microphone and turn on both the calibrator and the PC-40. Following the directions that come with the calibrator, calibrate the PC-40 to the proper SPL. The PC-40 calibration potentiometer is found in the IE-2P microphone preamplifier. It is recessed inside the IE-2P tube, as shown below, and has to be accessed with a small screw driver.

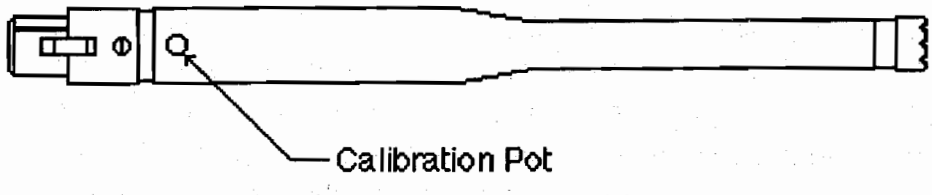


Figure XXXII

Pink Noise Testing with the PC-40

Introduction - Pink Noise Theory

When is pink noise flat? Never!

There are a few fundamentals that should be understood before doing pink noise testing. Pink noise is random noise that appears flat only after being averaged over time by special detectors on a real-time analyzer, or a true rms voltmeter. On an oscilloscope, or a standard voltmeter, pink noise appears to be a mass of random voltage spikes - which is exactly what it is. However, when averaged over time, the noise appears very flat and the output rms voltage is highly stable. When measuring with pink noise and the PC-40, the detectors in the PC-40 should always be in the pink noise averaging mode (slow).

We are often asked, "How flat is your noise generator?" That can be a misleading question, because noise is never flat. As we have said, noise is random in nature, and can be made to "appear" flat only when averaged over a sufficiently long period of time. Noise is a statistical phenomenon, and the averaging time necessary to create a "flat" appearance is mathematically predictable. Far better questions to ask are , "How flat are the filters in your noise generator?" and "What is the averaging time of the detectors in your real-time analyzer?"

To create pink noise, a noise generator first generates white noise. Our white noise generation is accomplished by a statistically accurate, shift register technique. Since white noise is equal energy per frequency, the energy content doubles each time you step up an octave. Such a signal is therefore too "hot" at high frequencies to be used as a sound system test signal. Pink noise, or equal energy per octave, is a much better test signal. To produce pink noise from white noise, we run the white noise through a 3dB per octave roll-off filter. The accuracy, or "flatness" of this filter determines the "flatness" of the pink noise produces. The filters in our noise generators are six pole filters and are very flat, which results in a very flat time-averaged output. The detectors in the PC-40 (the pink noise, or "slow" detectors) are designed to allow a maximum, ±1dB flutter when the analyzer is in the 1dB/step mode. Furthermore, this mild flutter occurs only at the lower frequencies. Since each 1/3 octave bandwidth

contains exactly twice as many discrete frequencies as the adjacent 1/3 bandwidth below it, as we increase in frequency, we increase in statistical stability. This means that as we continue to climb in frequency, we need shorter and shorter averaging times to achieve statistical stability. The PC-40 does, in fact, have shorter averaging times for the detectors at the higher frequency bandwidths. Even with these shorter averaging times, the higher frequency bandwidths are slightly more statistically stable than the lower frequency bandwidths.

You can create statistical instability in your measurement by changing the PC-40 detector response from "slow" to "medium" or even "fast." You will notice increased random movement of the display, especially at the lower frequencies. In the "fast" mode, it is virtually impossible to obtain a reasonable pink noise reading at low frequencies. It can easily be seen that making pink noise "flat" is as much a function of a good spectrum analyzer and its chosen integration time, as it is a function of a good noise generator.

What is Crest Factor?

An important aspect of a noise generator is its crest factor. The output of Ivie noise generators is calibrated in volts rms, and crest factor is the ratio of the peak voltage to the rms voltage. If a noise generator had a crest factor of 2, we could expect instantaneous voltage peaks, or spikes (either positive or negative) to reach an amplitude twice our rms output voltage. In other words, an rms voltage output of 1 volt could see peaks as high as 2 volts.

The purpose of pink noise is to provide a reference signal that approximates program material as closely as possible. If the crest factor is too low, we provide a signal with little dynamic range, which will not give us a very clear picture of how our sound system may perform with program material having normal dynamics. If our crest factor is to high, on the other hand, we will provide a signal with such a broad dynamic range that we could be causing clipping. Experimentation has shown that a crest factor of from 3.5 to 4.0 seems to work best and most closely approximate normal program material dynamics. Ivie noise generators have a crest factor of 3.75.

In conclusion, pink noise approximates actual audio signal better than any other type of signal source. It is also one of the best signal sources available for doing rigorous testing of amplifier durability, and transient signal handling

capabilities. Pink noise is used in conjunction with a real-time analyzer more widely than any other signal source. Some analyzers have pink noise generators built into them. Ivie has chosen to keep its noise generators separate from its analyzers, even though it is more expensive to do so, because experience has shown that the location where we want to inject pink noise into a system is rarely the same location where we want to have our analyzer. Additionally, having the noise generator in the same box with the analyzer generates the temptation to match one to the other, by "tweaking" the analyzer filters to match the pink noise output. Some manufacturers do in fact do this, which makes the analyzer incompatible with another pink noise source. At Ivie, we believe it is better to have both instruments independently flat, and so that is the approach we use. Any Ivie noise generator will work with any Ivie analyzer.

The last thing we wish to say about pink noise is that it **cannot** be used for gating or pulsing techniques. The random nature of pink noise (which is, in fact, its greatest asset) prevents it from being spectrally complete or repeatable in short bursts. Consistent results cannot be produced.

Room Response Testing

Pink noise is often used in conjunction with a real time analyzer for testing room response and for equalizing sound systems. Preferred equalization curve requirements differ according to the intended use of the sound system and its environment, and there are many opinions as to what those curves should look like. It is not the intent of Ivie to recommend one equalization curve or process over another, but to provide equipment with sufficient flexibility to allow the user to make his own choices.

There are, however, some useful techniques that are quite universal in application. These involve such things as system documentation, electrical testing and trouble-shooting, and measurement of acoustical performance. Some of these techniques are explored in the next section of this manual entitled "Electrical Testing and System Documentation Using Pink Noise." Acoustical testing is touched upon as well, but there is much that is left unexplored. There are many aspects of these techniques about which much has been written and argued - whether to use one microphone, or several; whether to do only time averaging, or do spacial averaging as well - this list goes on and on. The reader is encouraged to study and learn as much about all of these approaches as he can, and to make his own determination as to the techniques he prefers. The PC-40 will accommodate them.

Electrical Testing and System Documentation Using Pink Noise

One of the most useful aspects of the PC-40 Audio Spectrum Analyzer and the IE-20B Pink Noise Generator is their ability to be used in tandem to perform a great variety of of useful electrical measurements. These measurements can not only verify system specifications, but, when properly documented, can also save literally hours in trouble shooting.

The first step in making electrical measurements is calibrating the analyzer to the pink noise generator to establish a reference. The following illustration demonstrates this:

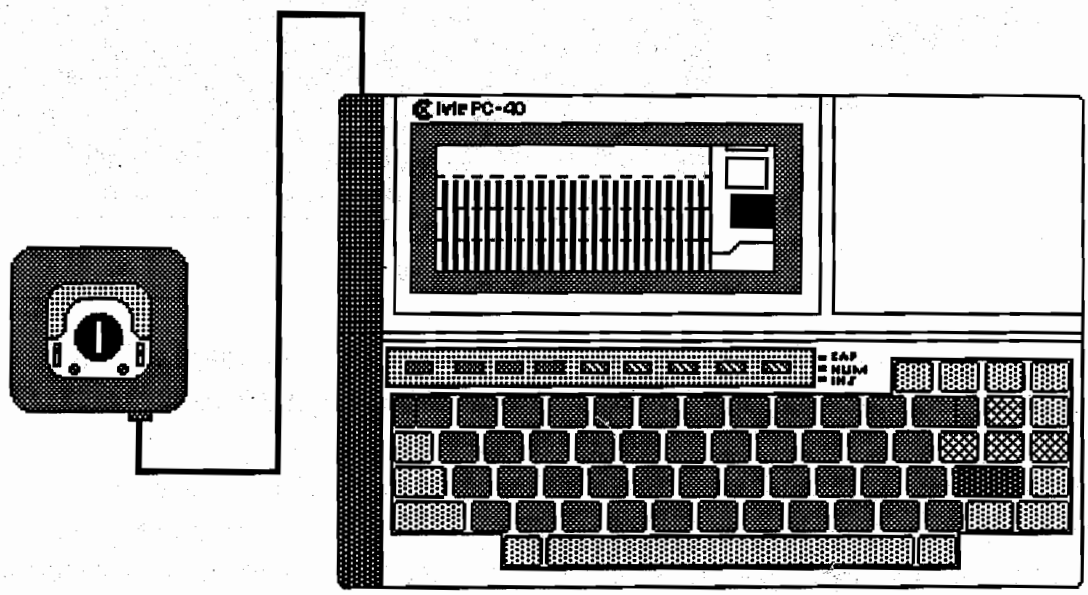


Figure XXXIII

In this example, the pink noise level has been set such that the amplitude of the display reaches a reference line. With the analyzer set to measure dB volts, an exact signal level can be read directly to a resolution of .1dB. We now have a reference spectral content, amplitude within each 1/3 octave band, and the absolute level of the input signal.

If we now insert an audio device into the circuit between the pink noise generator and the analyzer, we can measure all kinds of parameters. Let's take insertion loss as an example. We insert the device to be tested as shown below:

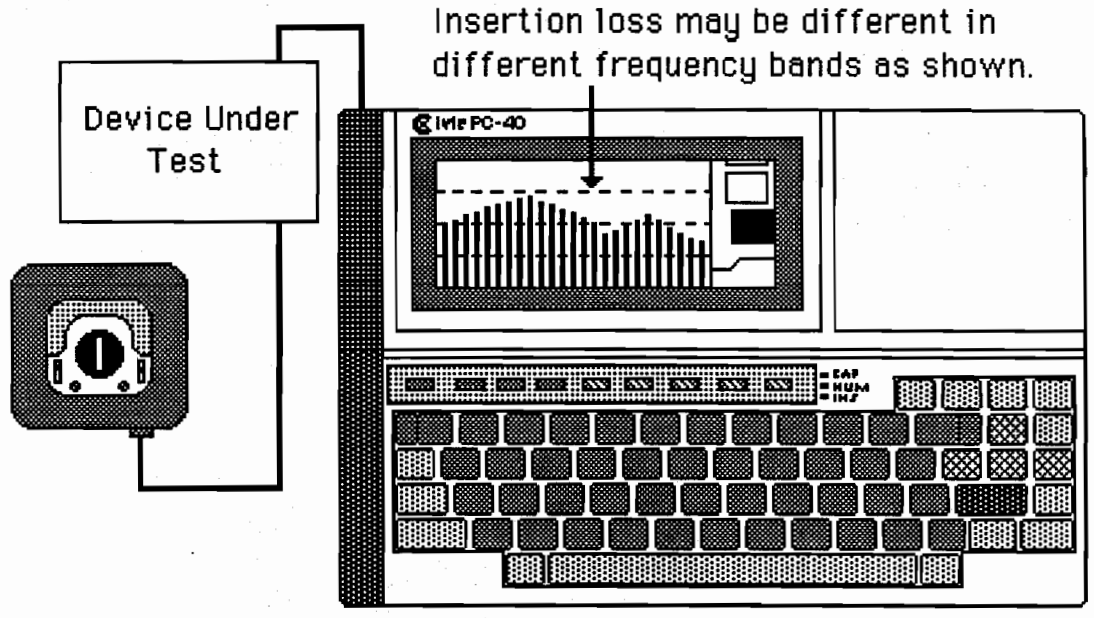


Figure XXXIV

In this measurement we can see the frequency selective nature of insertion loss. We can also measure, in dB, the exact drop in total signal level.

If our device under test were an amplifier, we could measure its 1/3 octave frequency response, and its voltage gain. If the device under test were a crossover, we could measure its gain or loss, see the frequency response of each leg, view the crossover point, and verify the roll-off associated with the band pass filters. We could measure the gain structure and frequency response of a single filter, or a whole bank of filters such as found in an equalizer.

Let's consider another interesting measurement. We can set it up feeding pink noise into the front end of our sound system. Using the PC-40 probe, we can tap into the output of our amplifier (the amplifier should be loaded) and look at the spectral display of information coming from the amplifier. Setup would be as shown on the following page:

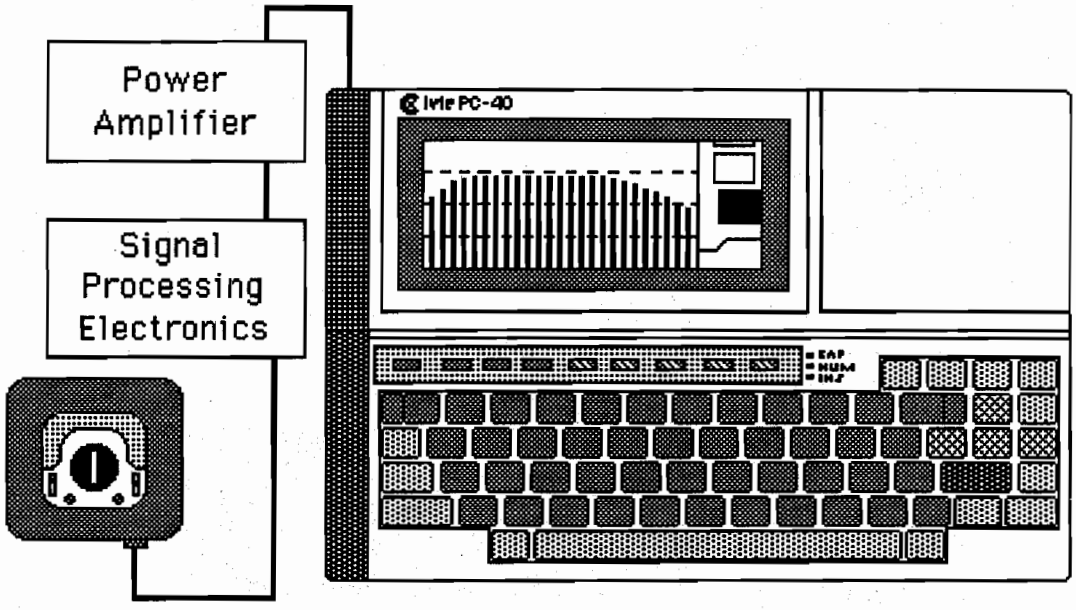


Figure XXXV

Notice that the output from the amplifier has been adjusted with both low and high end rolloff - not unlike we would expect to see. Other than that, the response looks very flat.

Next, for fun, we can look at the acoustic output of the speaker being fed by the amplifier to compare its spectral output with its electrical input. This time, instead of using the PC-40 probe, we plug in the microphone and listen to the speaker without changing our input signal. Any differences in spectral information will reflect the performance of the speaker in its environment. Incidentally, research has shown that the anechoic response of a speaker can quite accurately predict its response in an ordinary room. If we have a plot of the anechoic response, we would expect the response in our room to correlate.

At any rate, our test setup would change as shown on the following page:

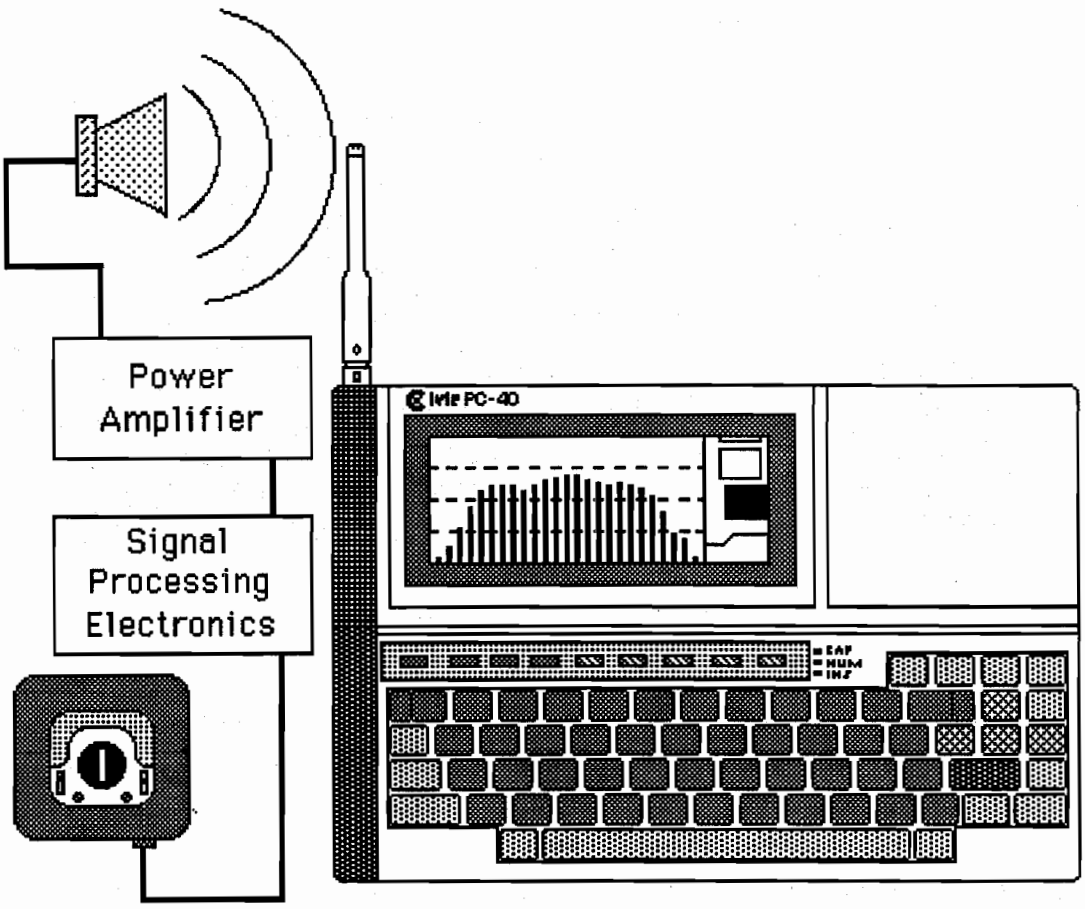


Figure XXXVI

Obviously, we would expect to see some differences in response, as this illustration shows.

The power of this simple measurement process should become somewhat evident. By adding simple variations to the above setups, the parameters we can measure or verify are extensive. Let's consider the value of this approach in trouble shooting.

We are called back to a system which is not properly operating. It's a fairly simple system - a four input automatic mixer with an aux channel for music, a 1/3 octave equalizer, a two-way crossover, two one hundred watt amps for bass, and three fifty watt amps driving the high end.

We bring our set of documentation for this job, and we plug our pink noise

generator into the music channel of the mixer. Our documentation shows the following:

1. The input level at which we should set our pink noise.
2. The settings on the mixer
3. The output level and a plot of the spectral response of the mixer (which is also the input information for the equalizer).
4. The output level of the equalizer and a spectral plot of its output.
5. The output level of each of the legs of the crossover, and a spectral plot of each one showing crossover point and filter skirts.
6. The input level, gain, and output spectral plot for each amplifier.
7. A map of the listening area for the system with several points located. For each point, there is a spectral plot and dB SPL referenced.

It is now a quick and simple matter to step through each component of the system with the analyzer and a probe. Any defective component or change in setting can be quickly detected. Setting changes can be speedily corrected. If everything checks out electrically, measurements at the documented points in the listening area can identify speaker problems. Since we know what the output and spectral content of each amplifier is, we can verify that information at the input of a speaker to make certain we have no wiring problems.

Obviously, we have not covered every sound system parameter, but it can be easily seen that spending a little time in system documentation can save a lot of time in trouble shooting and correcting system problems.

The PC-40 Memory Functions

The 3dB/Step "Invalid Data Line"

As discussed earlier in this manual, (under the section entitled "The PC-40 Display Screen") when displaying data on screen in the 3dB/step mode, the display of the PC-40 actually shows a dynamic range greater than the filter dynamic range. In simple terms, this means that before a signal could drop off the bottom of the display screen, it may run into the noise of the filters themselves. Thus, noise at the bottom of the PC-40 screen in the 3dB/step mode may or may not be valid data.

To help solve this problem, a line appears across the display screen, near the bottom, when in the 3dB/step mode. This line is called the "Invalid Data Line," and is shown in the following illustration:

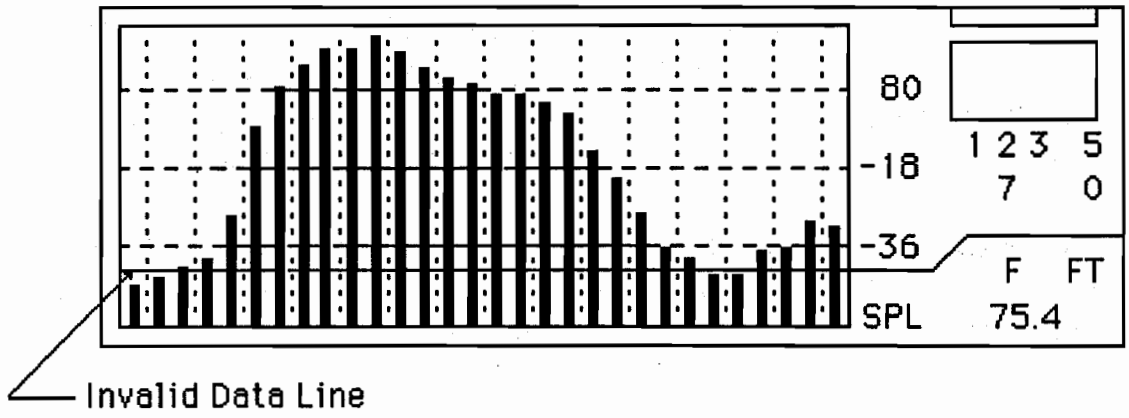


Figure XXXVII

Notice that in the above example, there are two low frequency filters and two high frequency filters that display data below the Invalid Data Line. In practice, we understand that this information may not be valid. An interesting question arises when we consider what might happen if we stored the above display into memory, recalled it, and then began to manipulate the data. If we changed the Reference Level, for example, and moved the data up on the screen, these four low filters would rise above the Invalid Data Line and would appear to be valid data.

The same thing might be asked of another display which had filter noise hanging just below the level of the display screen, so it would not be displayed.

If we stored that display, recalled it, and then began to lower the Reference Level, we could bring this noise up on screen and mistake it for real data.

To solve this potential problem, any data below the Invalid Data Line is not entered into memory during the STORE function. Let's look at the preceding example, for instance. Looking at the display tells us that several memories have been used. However, memory #8 is vacant, so let's store the display in memory #8. If we then RECALL memory #8, the following display would appear:

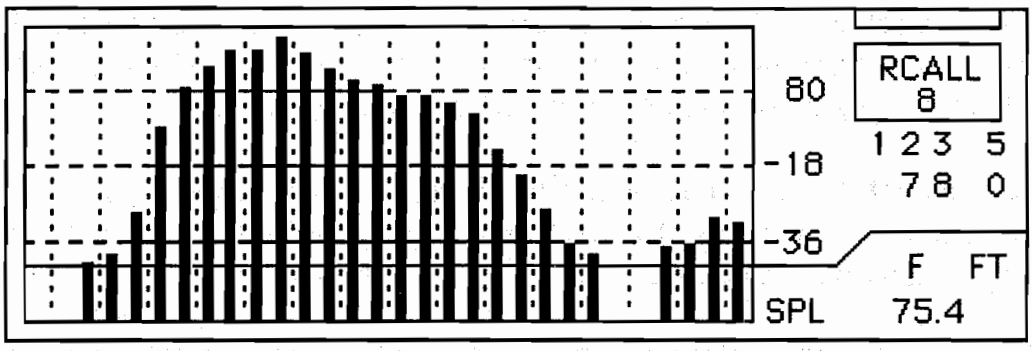


Figure XXXVIII

Notice that the four filters which were below the Invalid Data Line have disappeared. Questionable data has not been saved. Even if we change the Reference Line to raise the data up on the screen, no data will appear under the four filters in question, as shown by the following illlustration:

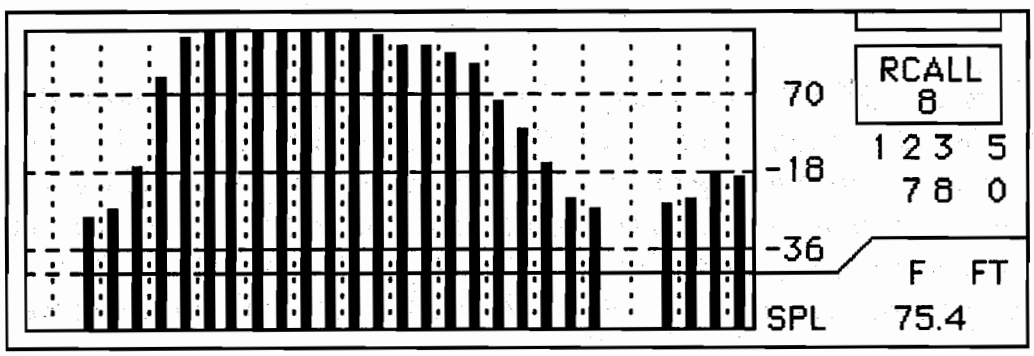


Figure XXXIX

This safeguard protects against the possibiltiy that invalid data could be raised up on the screen, or brought to the screen through manipulation of data in memory. In this manner, measurement integrity is assured. Any data that is display from a memory function will be good data.

Recalling and Displaying More Than One Memory

You have already learned that the PC-40 can recall and display any one of its twenty memories. It also has the ability to recall and display 1 or 2 memories simultaneously, or recall and display more than 2 memories simultaneoulsy. When displaying 2 memories, each is clearly differentiated from the other. When displaying several memories at once, one is not differentiated from the others and the display is intended to show an envelope only.

Let's examine this in further detail. First, let's look at displaying 2 memories. We begin by hitting the RECALL button just as if we were going to recall a single memory. The display would then look like this:

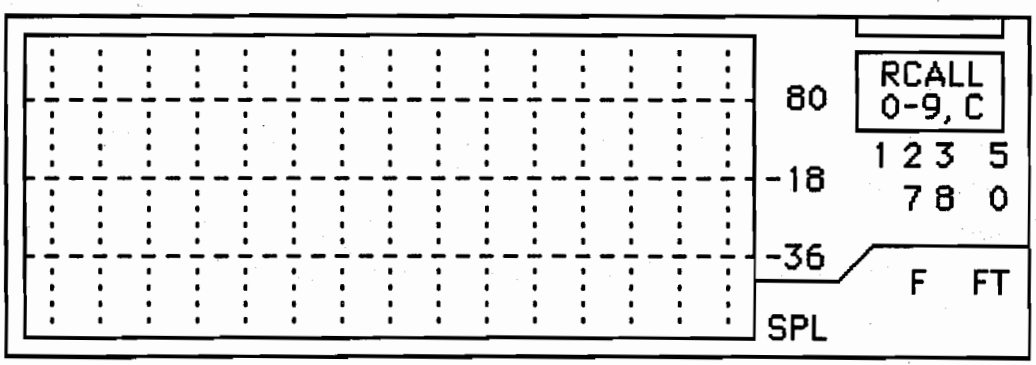


Figure XL

Notice that the PC-40 Message Window reads RCALL, signifing that we are in the Recall Function, and below RCALL, we find 0-9, C. This indicates our function key options when in the Recall Function. Hitting one of the keys from **0** to **9** will allow us to recall a single memory. However, if we want to recall more than one memory, we first hit **C**, which signifies "composite." When we hit **C**, the Message Window of the PC-40 will change as shown on the following page:

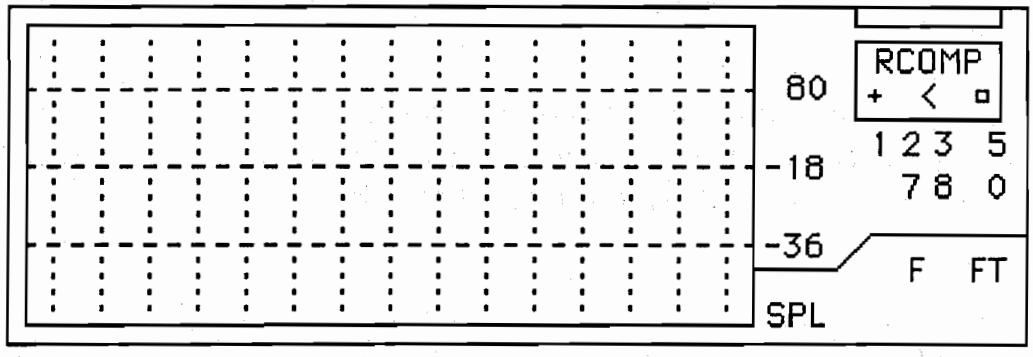


Figure XLI

Notice that the prompt "RCALL" in the message window has been replaced by the prompt "RCOMP," signifing "Recall Composite." Below that, we see a + symbol, and a □ symbol. This means we can display one memory as plus signs, and the other as boxes, to differentiate between the two. The arrow pointing at the symbol tell us which symbol we have selected for display. In the above illustration, we have selected the plus sign. If we wanted boxes instead, we could use the curser arrow on the PC-40 keyboard to select boxes. The left and right keyboard arrows can be used to change the direction of the pointer in the message window.

Let's go through the steps to finish displaying two memories simultaneously. The pointer in the above illustration has selected the plus sign for displaying the first memory. Let's say we want to display memory number 1. Since we are already in the RCOMP mode, the PC-40 is already to display our first memory. We simply need to hit the key **1**. Memory 1 will be displayed as shown below:

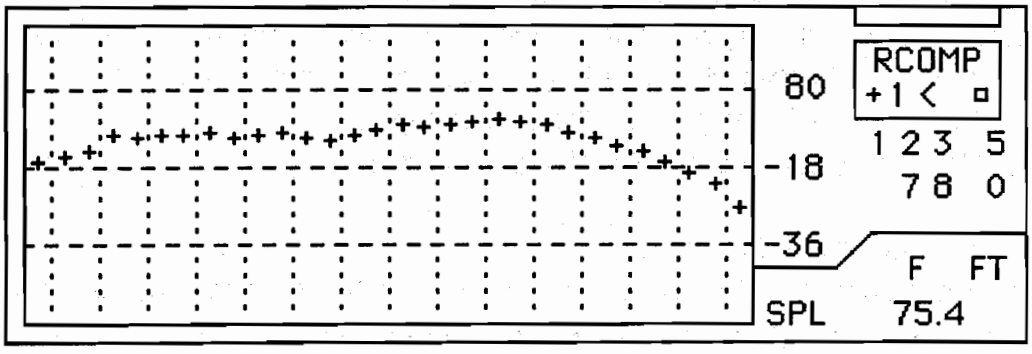


Figure XLII

Notice that the message window indicates we are displaying memory 1 as plus signs.

Now, let's display memory 2 as boxes. We first hit the right cursor arrow on the keyboard to get the pointer in the message window pointing at boxes. They we hit **2** to recall memory 2. Our display will then look like this:

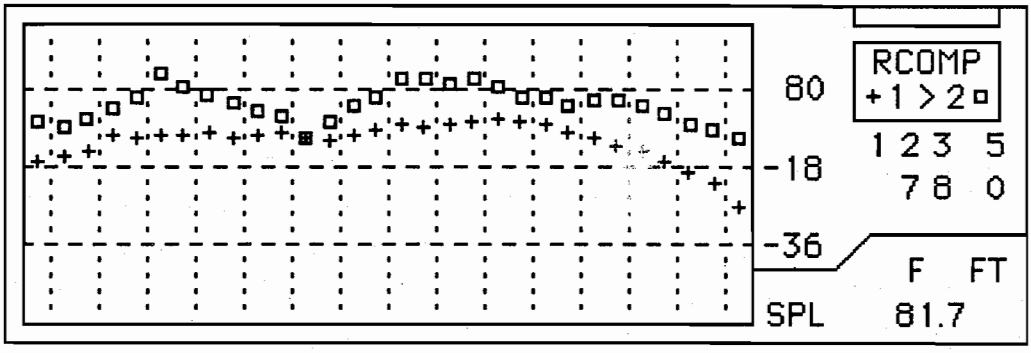


Figure XLIII

Again, the message window tells us we have displayed - in this case, memory 2 as boxes. The first memory displayed on the PC-40 screen is clearly differentiated from the second memory displayed. The SPL information showing comes the last memory displayed, memory 2.

Notice also, in the above example, that both of the curves displayed have the same amplitude at one of the filter frequencies. The plus sign and the box both show up together, making it obvious that the values are equal.

In addition to being able to display two memories simultaneously, three or more can be displayed to form and envelope display. To accomplish this, follow the same keystrokes as discussed for displaying two memories:

1. Press **RECALL** to get into the Recall mode.
2. Press **C** to get into the Recall Composite mode.

Now comes the difference.

3. Hold down the **Ctrl** (Control) key and hit the number key for each memory you wish to display. Each memory will be displayed as dashes ----, so one memory cannot be differientiated from another. This display mode is for the generation of an envelope display only.

Important Note: To get out of the Recall Composite mode, hit **RECALL**. As in most instances with the PC-40, you get out of a function using the same button that was used to get into the function.

Very Important Note: Sometimes you may recall two memories that have different Reference Levels. The first memory you recall will print the Reference Level for that memory. The second memory you recall will be automatically adjusted on the screen to be correct for the Reference Level already indicated by the first memory. For example, you may have stored two memories that were in about the same position on the PC-40 screen, but their Reference Levels were 40dB apart. If you recalled both of these memories together, the second memory may not even show up on screen because it is 40dB different in level from the first memory. You could "find" the second memory by stepping the Reference Level up or down, thus moving the second memory on screen and the first memory off screen.

Subtracting One Memory from Another (The A-B Function)

In many circumstances, such as in STC and NIC measurements, it is advantageous to be able to subtract on memory from another. This can be useful in even more simple applications such as comparing before and after equalization curves. Subtracting the before equalization curve from the after equalization curve will provide a graphic display of exactly what boost or cut had to be effected at each 1/3 octave channel to achieve the desired equalization.

Performing the A-B Function is a simple operation. Follow the same format for displaying two memories simultaneously. You may remember that in the previous example, we had recalled two memories resulting in the display shown on the following page:

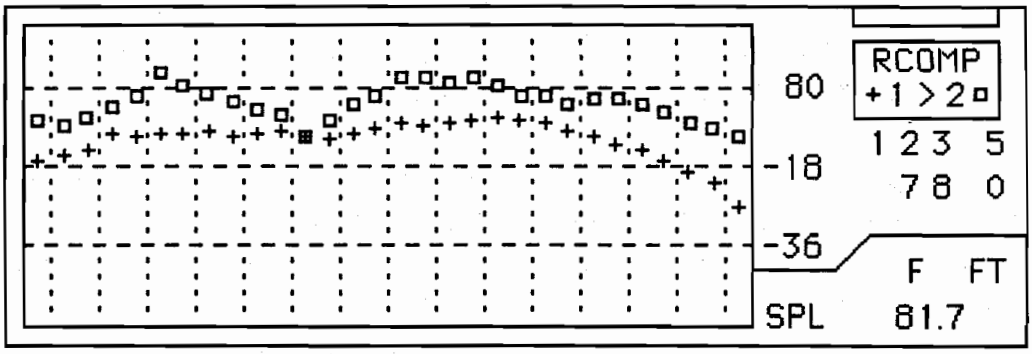


Figure XLIV

Once we reach the point of having two memories displayed, we must choose which memory is "A" and which is "B." Keep in mind that this is an A-B function, so "B" will always be subtracted from "A." We select the "A" memory with the pointer in the message window. The pointer always points at the "A" memory. In our example above, memory 2 is the "A" memory, so memory 1 is the "B" memory. We can toggle the pointer back and forth between the two memories to select our "A" memory by using the left and right cursor arrow keys on the PC-40 keyboard.

Once we have selected our "A" memory, we perform the A-B function by a single keystroke, the **"minus"** key on the PC-40 keyboard. (This key is on the top row of keys, near the right-hand side, and has an "equals" symbol and a "minus" symbol on its face).

If we follow this sequence for our example above, memory 1 will be subtracted from memory 2, and the display on the following page will result:

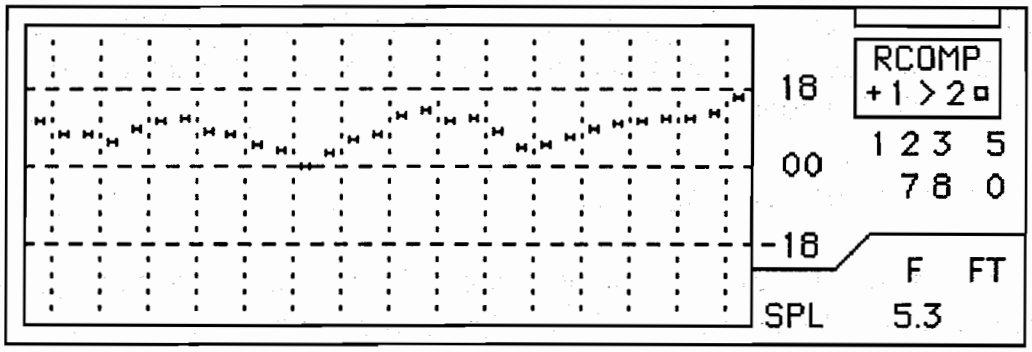


Figure XLV

The display format for the A-B function is slightly different from other display formats for the PC-40. We show a center reference of zero dB, and 18dB above and below that reference is indicated. If our A and B curves were exactly identical, subtracting one from the other would equal zero dB difference at each 1/3 octave channel. This would be displayed as a flat curve, its amplitude reaching zero at every frequency.

Since any curve may be higher in amplitude at one frequency than another curve, but lower in amplitude at another frequency, provision must be made to indicate both positive and negative numbers when subtracting one curve from the other. The A-B display format accomplishes this.

Notice also the the SPL displayed in the A-B format is the difference between the SPL's of the two curves.

Important Note #1: The A-B curve can be stored in a separate memory, if you desire. The process is the same as with any other memory storage, simply hit the STORE button and select one of the 20 memory locations.

Important Note #2: To get out of the A-B mode without storing the A-B curve, use the same keystrokes in reverse order. Hitting the **"minus"** key again will get us from the A-B display back to the two memory display. Hitting **RECALL** again will get us out of the Recall mode back into a real-time display.

A - B Printouts

As you have already learned earlier in this manual, a "screen dump" printout of

the A-B curve can be executed by pressing **PF5** while holding down the **Ctrl** button. A tabular printout of the A-B information is also available. This is executed by pressing **P** (for "print") while holding down the **Ctrl** key. For more information on tabular printouts, refer to the Appendix II of this manual entitled "PC-40 Printing Options."

Averaging Memories Together

You should already be familiar with the PC-40's ability to average many spectral samples together. The PC-40 can also average memories together, if you wish. It is done in the following manner:

Step 1: From real-time operation, select the Average Mode by pressing the **AVERAGE** button. Then press **R** to clear the accumulators. (Make sure there is nothing in them you do not want to dump!) Then exit the Average Mode by pressing the **AVERAGE** button again.

Step 2: Now enter the Recall Mode by pressing the **RECALL** button. Recall any memory you wish to have averaged by selecting its number. Simply recalling the memory will not enter it into the averaging accumulators, so you may step through the memories, if you wish, to confirm the ones you want to average.

Once you have selected a memory you wish to enter into the averaging accumulators, you may enter it by pressing the **AVERAGE** button. Notice the Message Window as you press the **AVERAGE** button. It will tell you that you are in the Recall Mode, and will list the number of the memory you have recalled. As you press the **AVERAGE** button, another number will appear momentarily next to the memory number. This number indicates the number of samples entered into the accumulators. The first time you press the **AVERAGE** button, the number 1 will appear, the second time, the number 2, and so on. You should note that you can enter a memory into the accumulators more than once. If you press the **AVERAGE** button twice while viewing the same memory, it will be entered as a sample twice. If you wish to weight an average by entering a sample several times, you may do so.

Step 3: After you have entered all the memory samples you wish to average together, exit the Recall Mode by pressing the **RECALL** button. You may now view the average of all the samples you have placed into the accumulators by pressing the letter **V** for "View." This display can be printed, graphically, or as a

tabular printout, the same as other displays. It can also be stored as a separate memory. To discontinue viewing the average display, press the **V** key again to return to real-time.

PC-40 BASIC Programming

The PC-40 has built-in BASIC, and therefore has the capability to be programmed for a number of different applications. It is not the intent of Ivie to teach programming, but we have created a number of machine language subroutines, callable in BASIC, which perform various analyzer functions that can be used as building blocks for assembling programs.

Information on these subroutines is available from the factory, and a complete manual concerning them will become available from Ivie at a nominal cost. Should more subroutines become available in the future, they will be available at no cost to those who have already purchased a manual.

Appendix I
PC-40 Mechanical

It may sometimes be necessary to remove the computer from your PC-40. This necessity will occur if you need to change the PC-40 ROM, or require a "hard" reset of the computer, or desire to change one of the cartridge accessories available for the PC-40 (printer, microcassette, modem, DMM, etc.) These accessories are described in the PC-40 brochure.

Removing the computer is a simple matter. There is a Release Tab located on the right side of the PC-40 as shown below. Lifting this tab releases the locking catch to allow the computer to be slid off to the right.

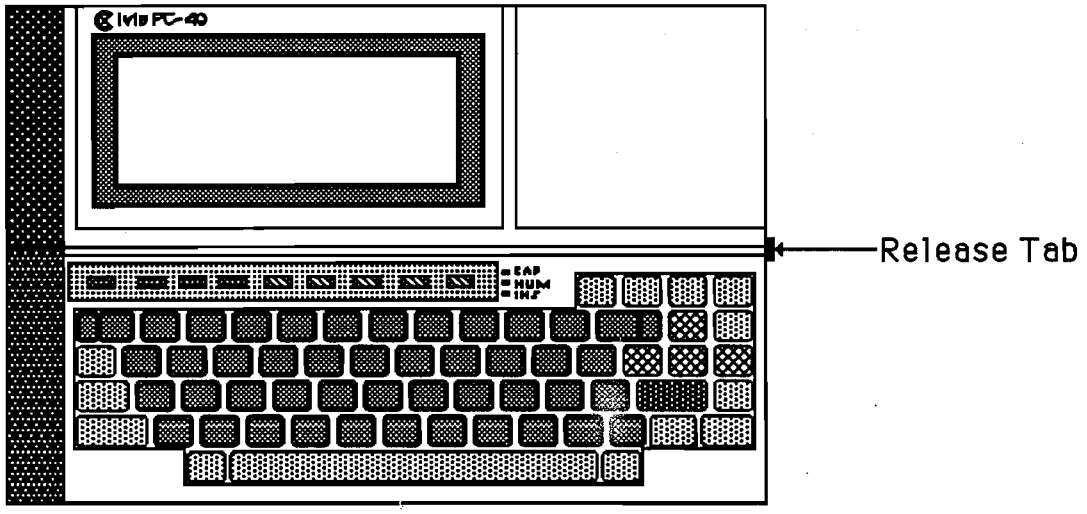


Figure A

To remove the computer, lift the release tab, then get your fingers between the computer and the dark brown PC-40 case, and slide the computer to the right as shown in Figure B. New PC-40's are usually tight and removing the computer the first few times will require firm pressure.

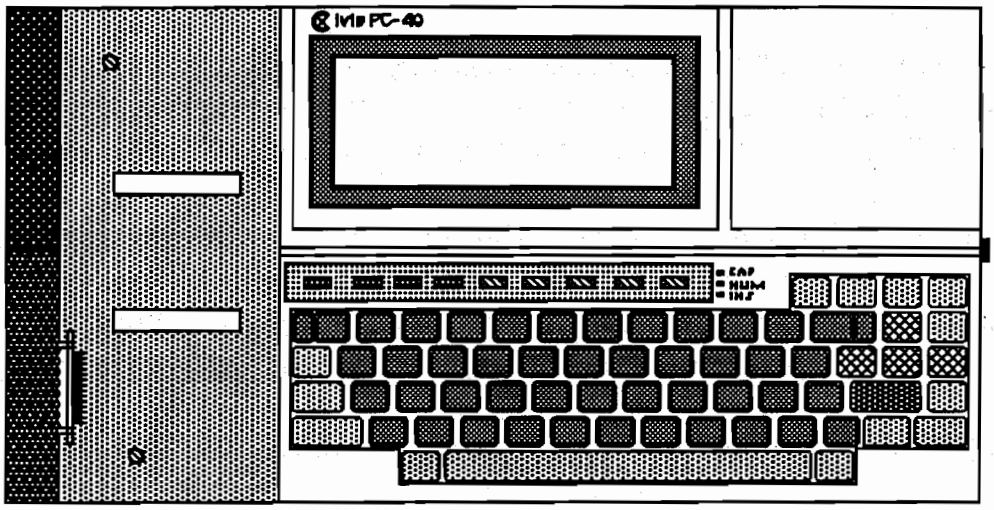


Figure B

Once the computer is off, turn it over to expose the bottom. The slide, and various compartments and switches are shown in Figure C below.

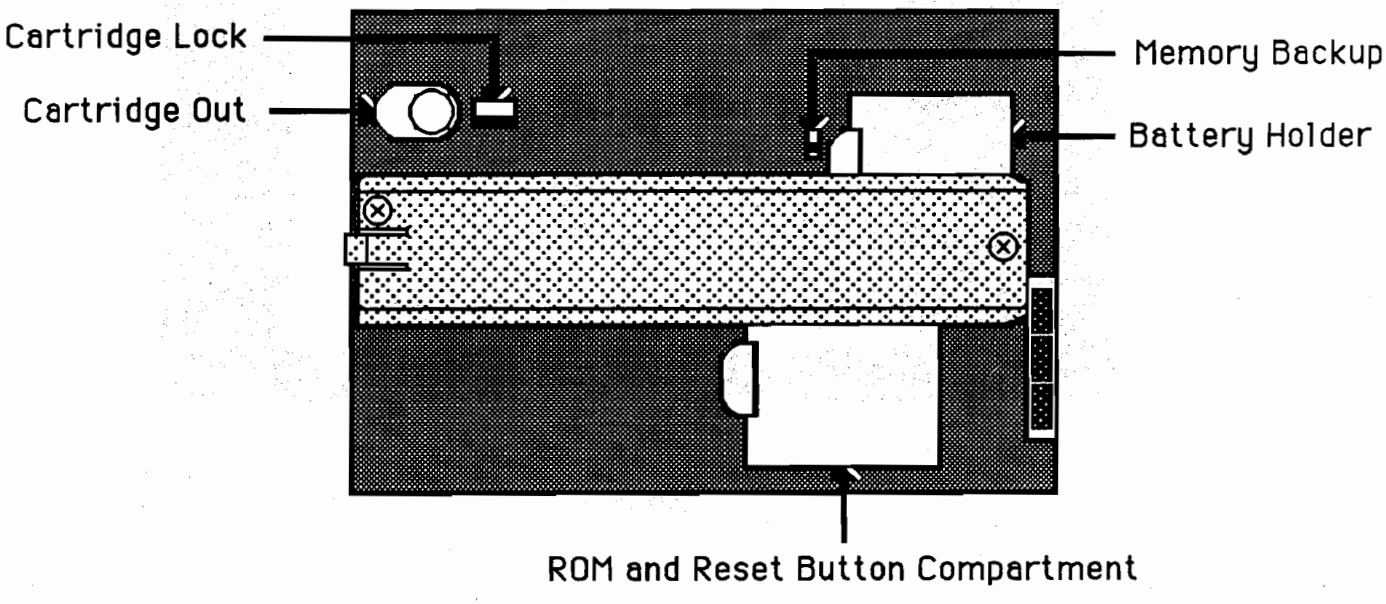


Figure C

The "Cartridge Lock" and "Cartridge Out" facilitate accessory cartridge removal

or changing.

The "Memory Backup" switch should always be in the "on" position for PC-40 operation. The "off" position may be used for other computer functions. For further details, refer to the HX-40 manual which you received with your PC-40.

The "Battery Compartment" is empty. The computer receives its power from the PC-40 mainframe. If you wish to use the computer by itself, you may install batteries, **but, to avoid damage to the computer, they must be removed before reattaching the computer to the PC-40 mainframe.**

A magnified view of the "ROM and Reset Button Compartment" is shown below.

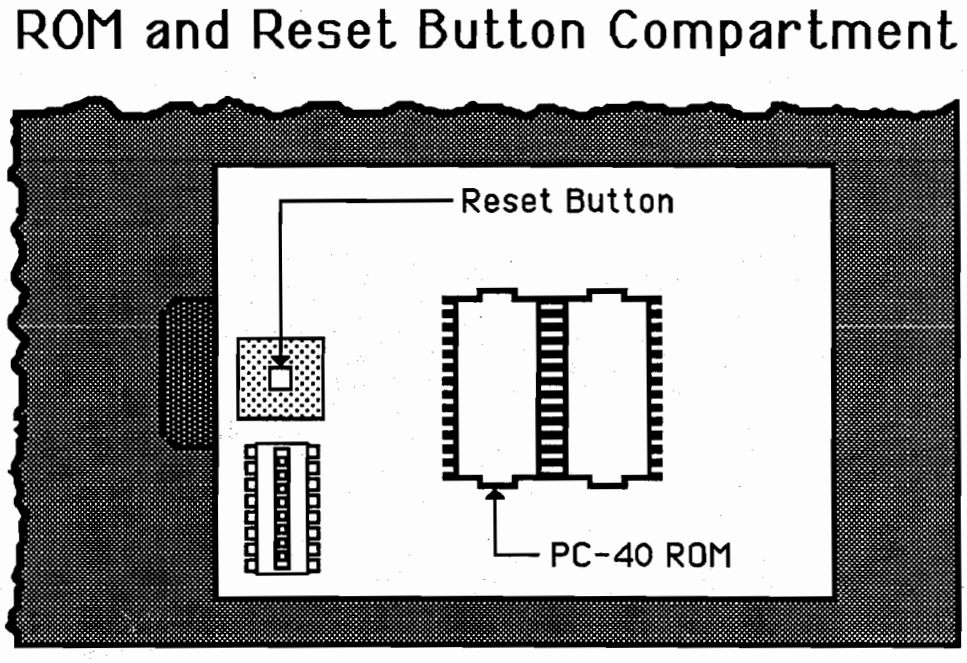


Figure D

Of course, to gain access to either the "Battery Compartment or the "ROM and Reset Button Compartment," the slide will have to be removed. In the "ROM and Reset Button Compartment" you will find the PC-40 ROM, the BASIC ROM, and a "hard" reset button. Use of the "Reset Button" is detailed in Appendix III,

entitled "Troubleshooting Your PC-40." We refer you to that section for additional information.

The PC-40 ROM is easy to identify since it will always have a paper label on it with its identifying version number hand written on the label. The ROM is in a carrier which should be removed with it. Any new ROMs from Ivie will be supplied in a carrier for easy change out.

To change a ROM, carefully remove the old one in its carrier, and observing proper polarity (the ROM carrier is keyed with different shaped tabs on each end to help insure proper polarity), carefully insert the new one. The old one should be placed in proper protective packaging and returned to Ivie, since it can be reprogrammed and used again.

Appendix II
PC-40 Printing Options

This short appendix is intended to familiarize you with the various printouts and printing options of the PC-40. Many other references to printing and printing instructions are found throughout the PC-40 manual. The information here may serve as a reference, and additional background will be provided here which is not found elsewhere in the manual.

Printer Ports

Printing can be assigned to three ports on the PC-40. The ports are the parallel port, the RS232 port (these ports are labeled and are located on the top edge of the PC-40 computer), and the cartridge printer port. The H409A Cartridge Printer is the only cartridge printer that can be used with the PC-40, and must be plugged into the cartridge slot on the PC-40 computer. Instructions for putting cartridges into the PC-40 are contained in Appendix I.

Printer ports are selected through use of the UTILITIES menu, PRINTER section, as described in the PC-40 manual. As noted there, it is very important not to send a printing command to a port where no printer is connected. This locks up the system.

Three printout sizes are available for graphic printouts when using the H409A Cartridge Printer. These are labeled in the PRINTER menu as Cartridge Tiny, Cartridge Small, and Cartridge Large. You may select the size printout that best suits your needs. Obviously, the Cartridge Tiny format prints out much faster than the Cartridge Large format.

It should be noted that there is no special printer driver software resident in the PC-40 for formating printouts sent to the RS232 or the parallel ports. Printouts from these ports will be the same size and configuration as the Cartridge Large printouts coming from the H409A Cartridge Printer. The one exception to this is when using the PC-40 to PC software package which links the PC-40 to an MS DOS computer. Printer driver software is resident within that system and printouts are formatted a little differently, with both a graphic and a tabular printout being provided.

Graphic vs. Tabular Printouts

Graphic and tabular printouts contain exactly the same information, when dumped from a PC-40, but each has its strong and its weak points. Graphic printouts provide a great overall view of what is happening spectrally, but precise amplitudes within each channel are difficult to determine visually. Tabular printouts, on the other hand, give very precise amplitude readings in each channel (to 1/10dB resolution), but do not provide a quick, visual reference to amplitude relationships throughout the spectrum. A tabular printout is especially useful for RT_{60} information when using the RT_{60} software available for the PC-40. Each type of printout has its value, so we give you the option of either or both.

Graphic printouts are executed by pressing **PF5** while holding down the **Ctrl** button, and tabular printouts are executed by pressing **P** while holding down the **Ctrl** button.

Graphic printouts ave available in all PC-40 functions, and tabular printouts are available in most PC-40 functions. Printout availability for each specific PC-40 function is detailed in the manual under the function heading.

Appendix III
Troubleshooting Your PC-40

Navigating Around Your PC-40

The Ivie PC-40 Analyzer is based on the Epson HX-40 Computer. The functions performed by the analyzer are software functions. In other words, one of the programs that can be run on the HX-40 is the PC-40 program. Physically, the bottom half of the PC-40 (that part which is not the HX-40 Computer) consists of the filters, the power supply, and other hardware which comprises the "guts" of the PC-40. This section is analog, and the information generated here is sent to an A/D interface where it can be accessed by the HX-40. When the PC-40 Analyzer program is running on the HX-40, it regularly interrogates the interface to get data it wants, and to tell the hardware what the computer wants it to do.

This procedure is nothing new. It's just standard stuff, but the point we are trying to make is that the PC-40 is not just a dedicated analyzer. It can also function as a computer. While this flexibility is a positive feature, it can also cause some problems. If you inadvertently crash the PC-40 program, or otherwise exit it, you may find yourself in some other function of the HX-40 Computer wondering how to get your PC-40 to be an analyzer again. This part of the manual is designed to help you navigate around your PC-40 and still get back to where you want to be.

One more bit of important introductory information first. The HX-40 computer has the ability to remember where it was when you turned it off, and it will return to that same point when you turn it back on. This is a great feature and is one of the reasons it was chosen for the basis of the PC-40. Most other computer systems, when they are turned on, go through a defined startup or "boot" sequence that always places the system at the same place or prompt. The HX-40 just returns to where it left off. If you are running the analyzer program and turn the PC-40 off, it will come up in the analyzer program again when you turn it back on. However, the negative side to this is also true. If you are somewhere in the computer where you don't want to be, and you turn your PC-40 off, you

will still be where you don't want to be when you turn it back on.

The CP/M Operating System Menu

Figure E below shows the PC-40 screen when you have called up the CP/M Operating System Menu. This is a happy screen. It tells you that you have returned to PC-40 access safely from wherever you were.

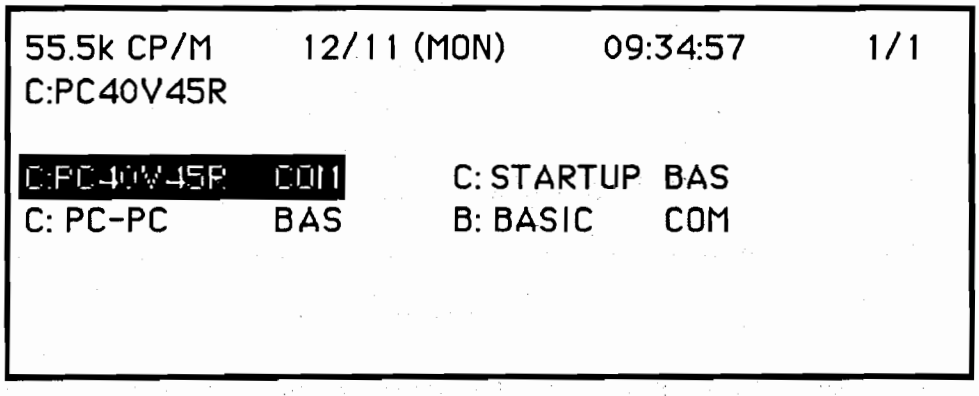


Figure E

This menu shows the programs resident in the PC-40. You may select a program shown in the menu by using the up, down, right, and left cursor arrow keys. The program selected is shown in inverse video. In the screen shown above, the selected program is the PC-40 Analyzer program. Notice that the ROM version number is shown. In our example above, the ROM is version 4.5.

Other programs that can be run are also shown in the menu. Below the PC-40 Analyzer program, the PC-40 to PC program is shown. Of course, if you do not have this optional software program, it will not show up in the menu.

To the right, the BASIC programs are are shown. B:BASIC COM is the Microsoft BASIC program, and C:STARTUP BAS is the BASIC interface program which allows you to interface BASIC programs you have written to the PC-40. Once you have selected the program you wish to run, pressing **RETURN** will run the program. For the purposes of discussion here, we will assume that you wish to run the analyzer program. What we will be discussing next is how to return to this CP/M Menu from wherever you might be in the HX-40. Once you return to this menu, you may select the PC-40 program, and then press **RETURN** to activate the PC-40 Analyzer.

Returning to the CP/M Operating System Menu from BASIC

If your PC-40 screen looks like Figure F below, you are in the BASIC program.

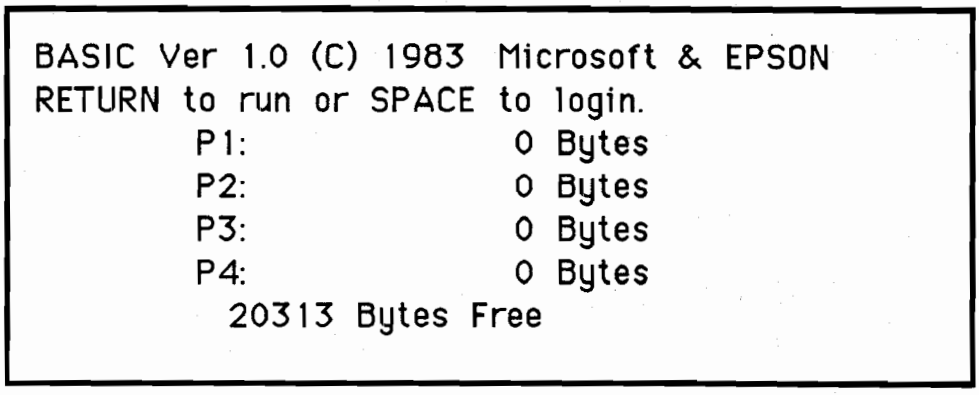


Figure F

This is the BASIC Log In Screen. The only way out of BASIC back to the CP/M Operating System Menu is to log in. This is done by pressing the **SPACE BAR**. When you press the **SPACE BAR** to log in to BASIC, you should get a screen that looks like either Figure G below, or Figure H on the following page:

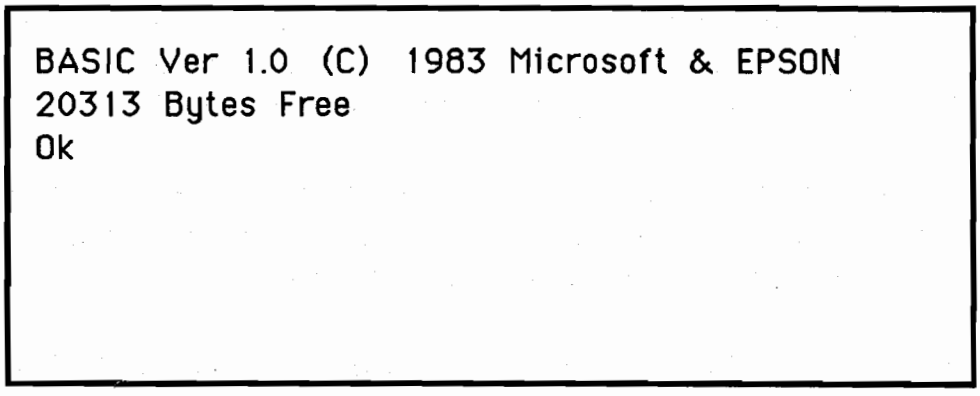


Figure G

This is a BASIC System Screen. (For further information on BASIC programming, consult your HX-40 BASIC Programming Manual which came with your PC-40).

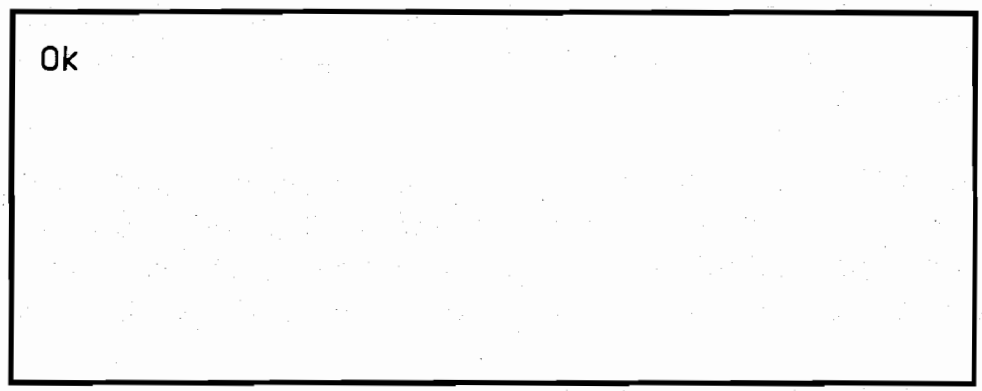


Figure H

This is also a BASIC System Screen, as is Figure G. To return to the CP/M Operating System Menu from here, type the word **"SYSTEM"** and then press the **RETURN** key.

Returning to the CP/M Operating System Menu from CP/M

When you are in the CP/M Operating System, you will get an "A" Prompt screen, if you have selected the "A" drive, or a "C" Prompt screen, if you have selected the "C" drive, etc. An "A" Prompt screen is shown is Figure I below:

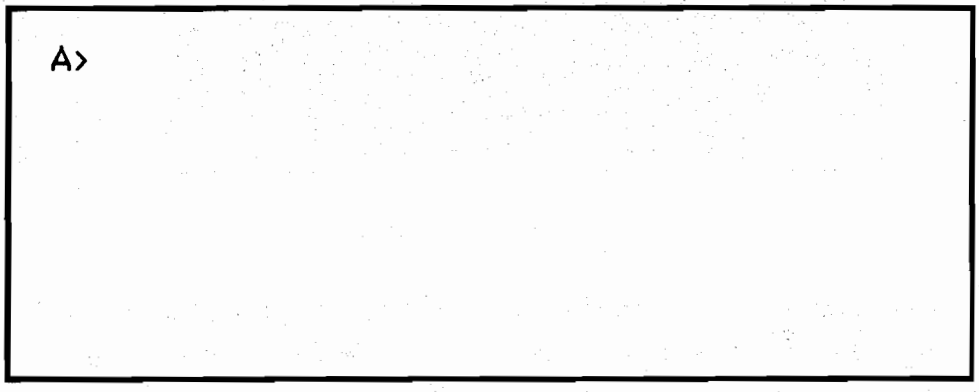


Figure I

From the CP/M Prompt screen, you may enter any CP/M command. These include commands like **"DIR"** to see a directory of files stored on a drive. You may also type the name of a program to execute it and start it running. If you typed **C:PC40V45R**, and then pressed **RETURN**, the PC-40 analyzer program would begin to run (if, of course, your ROM was version 4.5). If you

don't remember the version number of your ROM, and therefore can't type in the name of your PC-40 program, you will want to return to the CP/M Operating System Menu to reactivate the analyzer program. To do this, execute the following steps.

First, make sure that the flashing cursor is located just after the CP/M Prompt. This can be accomplished by using the **HOME/BS** key to backspace over any existing command or space. Then press the red **QUIT** button at the top, left of the keyboard. This will usually return you to the CP/M Operating System Menu.

Under some conditions, the above procedure will not return you to the CP/M Operating System Menu. If this is the case, you may need to re-boot your system by pressing the **RESET** button found near the **ON/OFF** switch, on the right side of the PC-40, as shown in Figure J below:

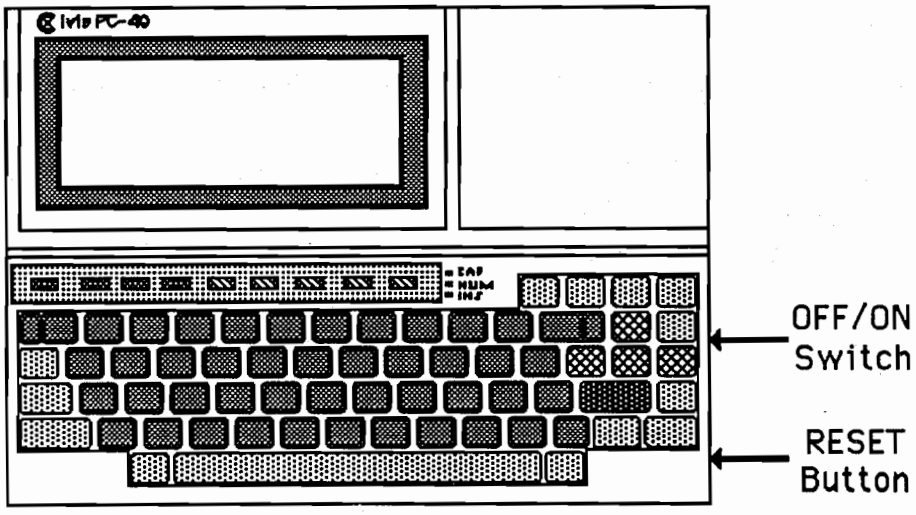


Figure J

You will need to use a pencil or ball point pen to press the **RESET** button. Re-booting you system should restore the CP/M Operating System Menu, unless the menu has somehow been turned off.

If the CP/M Operating System Menu is configured to be off, then re-booting the system will obviously not display the menu. If you are unable to get the menu to display, check its status to make sure it is on. To verify the status of the CP/M Operating System Menu, hold down the **CTRL** key while pressing the **SYSTEM** key (located just above the **4** key). This should bring up the System Display Screen as shown in Figure K on the following page:

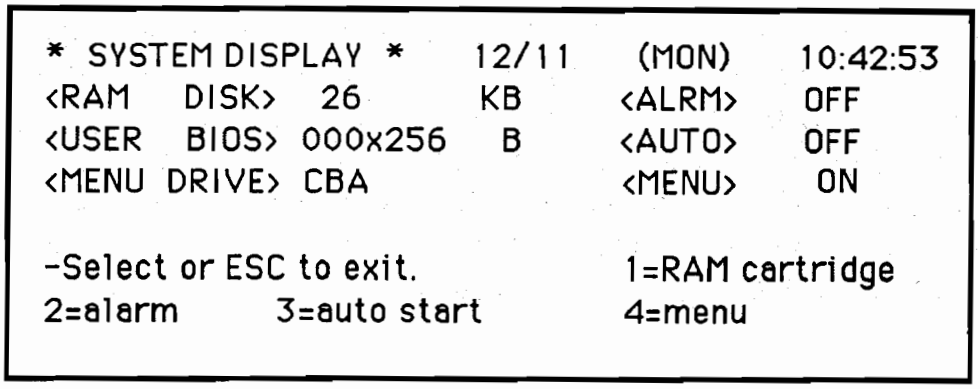


Figure K

In Figure K, we see that the menu (labeled <menu>) is ON. If it were not on, we would, of course, want to turn it on. To do this, press **4** to select the Menu Control screen. The Menu Control screen is shown in Figure L below:

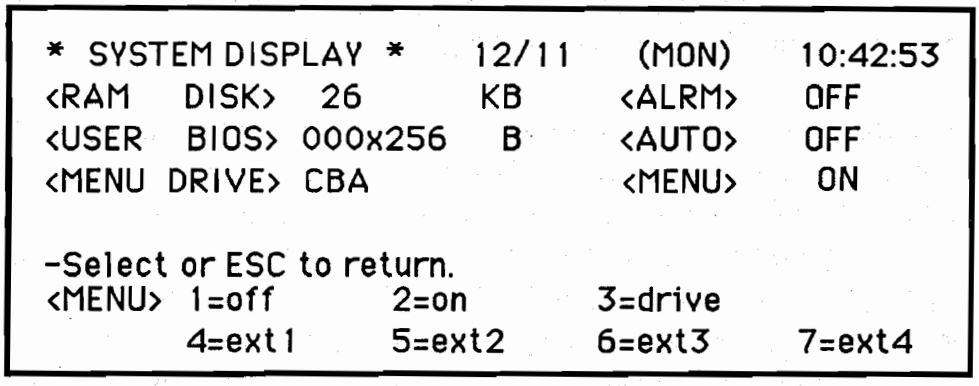


Figure L

Once into the Menu Control screen, the menu can be turned on by pressing the number **2**, as shown above.

One more thing should be mentioned here. Notice the <MENU DRIVE> line in the screen above. The drives associated with the menu are C, B, and A. The PC-40 Analyzer program is located in drive C. If, for some reason, the C drive were not listed, you would not be able to pull up the CP/M Operating System Menu with the PC-40 Analyzer program listed in it. In the highly unlikely event that the C drive is not listed, you may press the number **3**, as shown in Figure L, to select the Drive Control screen. Once in this screen, you may add the drives you wish, but the C drive must be one of them.

Once you have made certain that the menu is on, and have finished any other configurations you wish to make, you may return to the main CP/M Operating System display by pressing **ESC** (located just above the 2 key) once or twice as prompted. Once you have returned to the main CP/M Operating System display, you may pull up the CP/M Operating System menu by following the instruction previously outlined on pages 75 and 76. This will, of course, get you back to PC-40 Analyzer operation once again.

Recovering from Crashes, Lockups, and Other Minor Catastrophes

Sometimes things happen which result in program crashes, lockups, or other unpredictable occurrences. The following section will help you deal with most of these. We will, of course, be operating under the assumptions that nothing is wrong with the hardware, and the software is undamaged. If this is not the case, these procedures will obviously not help.

The first thing to check is battery and AC charger status. Low batteries are not usually the culprits because the system will shut itself down to computer operation only and give an on screen, written indication of low batteries. The converse may be true, however. If you are operating with the charger plugged in and the batteries are quite fully charged, a dirty AC line, or an excess AC voltage may find its way through the charger and the batteries to cause problems. The normal symptom of this is strange looking, or a locked screen, or sometimes failure of the signal amplitude on screen to change as the Reference Level is changed.

Unplugging the charger from the PC-40, and turning the unit off and then on again will normally correct this condition. Then just operate it from the batteries only until they need to be charged.

If that does not solve the problem, or if something else has occurred which is not related to the PC-40 power supply, you will need to try resetting, or re-booting the system. There are several levels of reset available to you, and the reset required is determined by the seriousness of the problem.

We refer you to page 2-62 of the Epson HX-40 manual, for a detailed explanation of the resets available. The section of the Epson manual is

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