SpotMic

Microphone Array Processor

"Technology to Make Listening Easier"

SPOTMIC

MICROPHONE ARRAY PROCESSOR

User's Manual
Version 1.1

Revised
November 27, 2002

Digital Audio Corporation
A DRI Company
5121 Holly Ridge Drive
Raleigh, NC 27612

Phone: 1 877 5-DACAUD (532 2283)
Fax: 1 877 5-DACFAX (532 2329)

www.dacaudio.com

TABLE OF CONTENTS

LIST OF FIGURES

FOREWORD

The SpotMic Microphone Array Processor is a system that allows digital beamforming from fixed microphone installations.

SpotMic:

- Offers high gain, electronically steerable beams.
- Supports custom microphone arrays; handles up to 16 channels
- Steers three separate beams from one set of microphones
- Features unique Stereo Mode for natural listening experience
- Offers both hardware and Windows®-based software controls
- Provides a radar-style sound field display in the software controls
- Allows steering in three dimensions with the software controls
- Works with DAC Multi-Channel Audio Processor (MCAP)

1. SYSTEM BASICS

1.1 System Configuration

The basic configuration of the SpotMic system is illustrated in Figure 1-1:

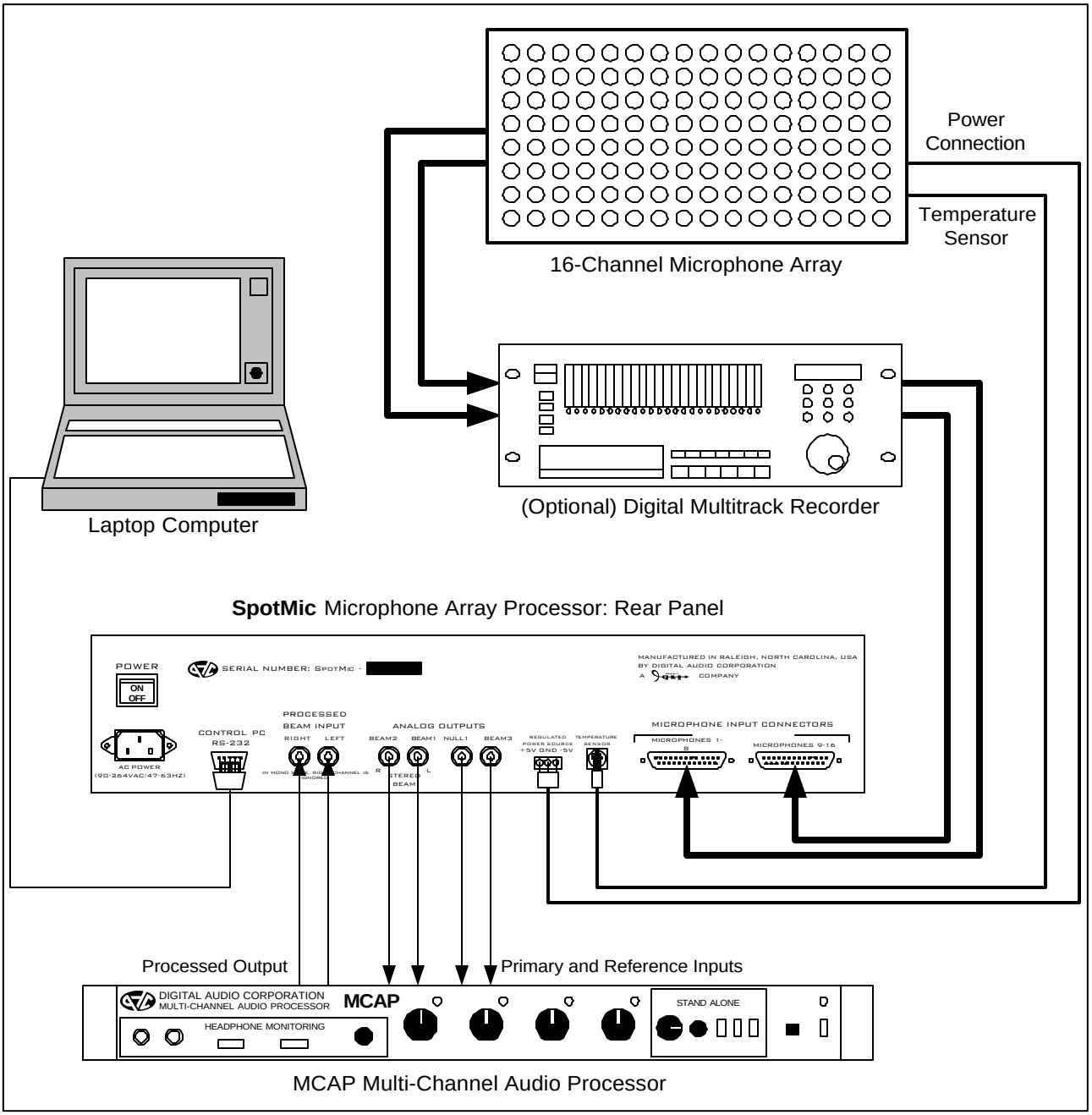

Figure 1-1: SpotMic System Configuration

The SpotMic Microphone Array processor provides precise beamforming for three beams using custom microphone arrays. The SpotMic is designed to work with up to 16 microphones and provides for control via either the front panel or the Microsoft Windows®-based Control Software

Beamforming is a process by which a fixed array can be used to form tight "beams" in which only the audio emanating from a specific direction is heard. This allows specific audio sources to be pinpointed in very noisy environments where there are many interfering noise sources.

The easy-to-use Microsoft Windows-based Control Software allows intuitive control of the entire beam-forming process, including selecting which beam is output to the headphones, microphone configuration, beam steering, and beam gain. Beam bargraphs show the output levels of each beam. Polar and Waterfall displays show a 140 degree sampling of the current audio levels, from all directions.

The SpotMic Master Control program is written to be run on any Microsoft Windows 95/98/NT/2000/XP IBM PC-compatible computer. For best performance the following *minimum* system is recommended:

- Intel Pentium CPU processor (at least 200 MHz)
- 32 Megabytes of RAM
- 2.1 GB hard disk drive
- CD-ROM Drive
- 800×600 color SVGA display with 0.28 or better dot pitch
- Two-button mouse
- At least one spare RS232 serial port

Performance of the Control Software will improve with higher speed CPUs.

1.2 External Processor Capability

The SpotMic unit is a high-performance, self-contained microphone array processor that contains five Analog Devices SHARC™ DSP Processors. The SpotMic processor provides:

- Three listening beams
  - All three beams can be configured in mono mode for steering along azimuth
  - Beams 1 and 2 can be configured in stereo mode to aid in audio source location
  - Beam 1 can be configured with software to operate in 3-D mode

- Independent steering and gain adjustment for each beam (Automatic Gain Control is selectable for each beam)

- Coarse and fine beam adjustment allow 0.1 degree steering resolution

- Corresponding complements (nulls) for each beam allowing external audio processors to use reference cancellation to further enhance the beams

- Built-in regulated power supply for external microphone array amplifiers

- Temperature sensor connector for air temperature adjustments for beam steering

- TASCAM® style microphone connectors that are compatible with multi-track digital recorders.

Digital conversion is performed by eight stereo sigma-delta 24-bit converters (16 inputs for the microphones). Digital-to-analog conversion is performed by three stereo delta-sigma 24-bit converters (Beam 1, Null 1, Beam 2, Beam 3, and stereo headphone output).

The sample rate is 16 kHz. A digital Automatic Gain Control (AGC) is provided for each beam.

1.3 External Processor Front Panel

The front panel controls provide for command of the three beams and are arranged into four main groups. The front panel of the SpotMic external processor appears in Figure 1-2.

The CONTROL SELECT rotary switch chooses which beam is output to the headphones. The choices are as follows:

Selection	Description
Processed Beam 1	Selects the Processed Beam Inputs. These inputs are used in conjunction with an external audio processor, such as the MCAP, where the Beam 1 and Null 1 outputs would be fed into the MCAP, processed, and fed back into the Processed Beam Inputs. This feature allows the operator to use one set of headphones to listen to either the unprocessed SpotMic Beams or the processed audio. When selected, the LED under the Beam 1 Level Bargraph illuminates, unless the device is in Stereo Mode where both the Beam 1 and Beam 2 illuminate.
OMNI	The omnidirectional (or "all") microphone.
NULL 1	Everything except Beam 1. When selected, the Beam 1 Level Bargraph selection LED illuminates.
BEAM 1	Beam 1. When selected, the Beam 1 Level Bargraph selection LED illuminates, unless in Stereo Mode where both the Beam 1 and Beam 2 LEDs illuminate. In Stereo Mode, this selection outputs the Stereo Beam.
BEAM 2	Beam 2. When selected, the Beam 2 Level Bargraph selection LED illuminates, unless in Stereo Mode where both the Beam 2 and Beam 1 LED's illuminate. In Stereo Mode, this selection outputs the Stereo Beam.
NULL 2	Everything except Beam 2. When selected, the Beam 2 Level Bargraph selection LED illuminates.
BEAM 3	Beam 3. When selected, the Beam 3 Level Bargraph selection LED illuminates.
NULL 3	Everything except Beam 3. When selected, the Beam 3 Level Bargraph selection LED illuminates.

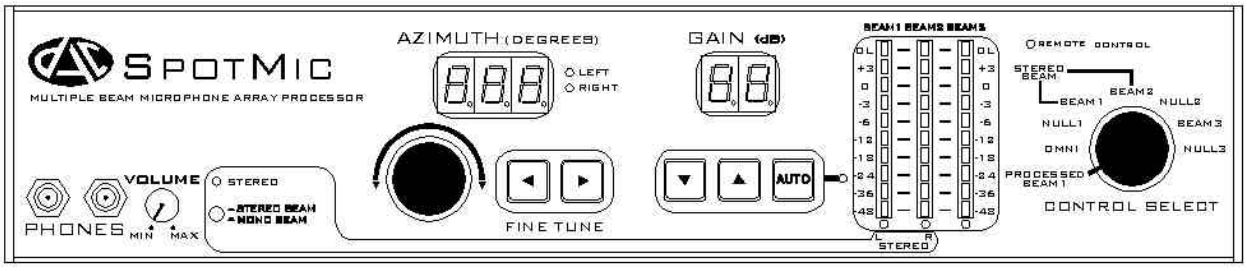

Figure 1-2: SpotMic Front Panel

The Beam Level Bargraphs show the levels of each of the beams after the gain or AGC is applied. The GAIN controls adjust the gain of the beam highlighted by the selection LED located under each Beam Level bargraph. Depressing the AUTO button enables or disables the automatic gain control for the selected beam; when the adjacent LED is illuminated, the AGC is enabled. The gain in dB for the selected beam is indicated by the GAIN display.

The AZIMUTH controls adjust the angle of the beam highlighted by the Beam selection LED. The AZIMUTH display shows the selected beam's angle in degrees. The LEFT and RIGHT LEDs indicate the direction of the angle. Use the rotary knob beneath the AZIMUTH display for coarse adjustments to the beam angle (changes of 1 degree). Use the FINE TUNE buttons for 0.1 degree changes to the beam angle.

The STEREO BEAM button, when depressed, puts the SpotMic into the Stereo Mode. This mode links Beams 1 and 2 together to give a more natural listening experience. The Stereo Mode is useful for finding the location of audio sources. When in Stereo Mode, either the BEAM 1 or BEAM 2 positions on the CONTROL SELECT switch selects the STEREO BEAM.

The VOLUME knob controls the signal level applied to the two PHONES connectors. This knob does not affect the levels applied to the ANALOG OUTPUTS on the back of the SpotMic processor.

1.4 External Processor Rear Panel

The rear panel of the SpotMic external processor appears in Figure 1-3.

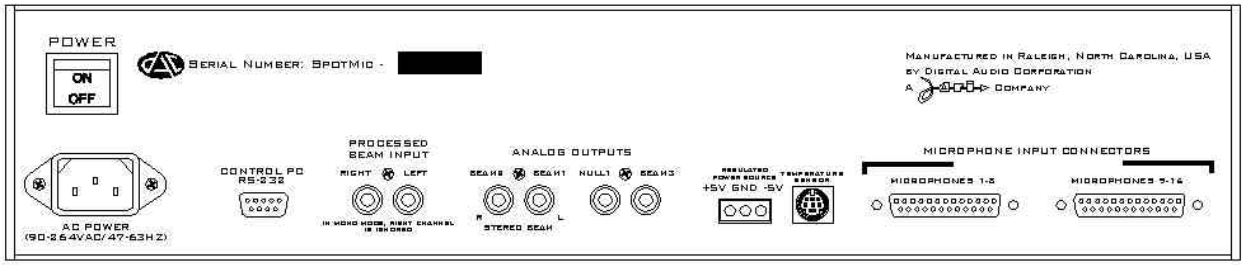

Figure 1-3: SpotMic Rear Panel

The MICROPHONE INPUT CONNECTORS are for connecting the two 25-pin TASCAM™ style cables. MICROPHONES 1-8 use the leftmost connector (when facing the rear panel) while MICROPHONES 9-16 use the rightmost connector. Figure 1-4 shows the pinouts for

the cable. The impedance of the inputs is 25 k?. Each microphone input is configured for a “line level” signal (maximum voltage of 1 V_{RMS}).

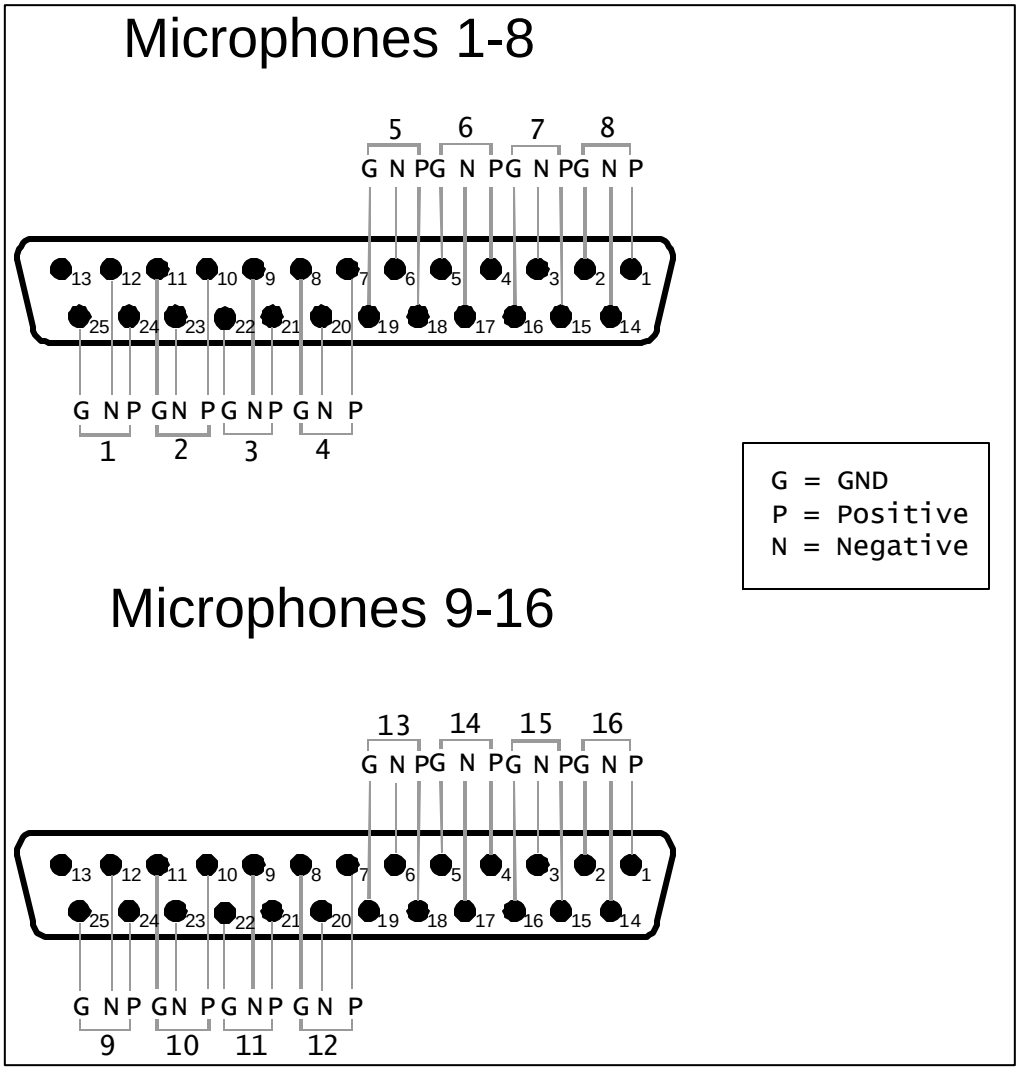

Figure 1-4: TASCAM® Style 8 Channel Connector

The TEMPERATURE SENSOR is currently not supported in this version of the SpotMic. The REGULATED POWER SUPPLY is for powering the external microphone array (provided separately). It provides ±5V at 3A.

The ANALOG OUTPUTS provide line level (1 V_{RMS} max) output of BEAM 1, BEAM 2, BEAM 3, and NULL 1. The STEREO BEAM is output through BEAM 1 (Left channel) and BEAM 2 (Right channel).

The PROCESSED BEAM INPUT inputs are used to monitor the audio output from the external processor (such as an MCAP). In MONO mode, the right channel is ignored.

The RS232 connection to a PC is made via the CONTROL PC RS-232 port. The AC POWER cord (provided by DAC) is connected to the three prong jack on the rear panel and the POWER switch is used to power the unit ON and OFF.

2. SOFTWARE INSTALLATION INSTRUCTIONS

2.1 Cautions to User

To install the SpotMic software, the user must have a good working knowledge of IBM PC-compatible computers and the Microsoft Windows® operating environment. Particularly, the user must know which RS232 COM Ports are COM 1, COM 2, COM 3, etc. Normally, COM 1 is the available Port; hence, COM 1 is the default setting for the software. If COM 1 is not available in the user's PC, it will be necessary to reconfigure the SpotMic software COM Port after completing the software installation procedure in Section 2.2.

The Microsoft Windows operating environment must be in place prior to installing the SpotMic. All video drivers, device drivers, etc. must be installed and operating properly.

2.2 Installation Procedure

1. Carefully remove the SpotMic external processor from the shipping container. Confirm that the AC power cord, RS232 cable, and software CD are included. Also confirm that any optional accessories are included.

2. Connect the AC power cord to the SpotMic rear panel AC POWER connector. Keep the POWER switch OFF for now.

3. With the SpotMic POWER switch OFF, plug the AC power cord into an AC outlet.

4. Connect the supplied RS232 cable between the CONTROL PC RS232 connector on the SpotMic rear panel and the desired computer COM Port (You may need to purchase an adapter if the COM port has 25 pins).

6. Now that they are connected together, switch ON the SpotMic.

7. Once Windows has booted up (Windows 95/98/NT/2000/XP), insert the SpotMic Control Software CD into the CD drive in your PC. The installation program should automatically run. If not, use the **Run** command in the Windows **Start** menu to start the installation program (in the **Run** window type "X:\setup.exe" where "X" is the drive letter of the CD drive.)

   If the machine on which you wish to install the SpotMic Control Software does not have a CD drive, please contact Digital Audio Corporation for installation software diskettes.

9. The SpotMic Setup Utility will now install the SpotMic Control Software on your PC's hard disk. Please follow any instructions displayed by the Setup Utility.

Once the Setup Utility has completed installing the software, the icon in Figure 2-1 should appear on your screen:

Figure 2-1: SpotMic Control Software Icon

Double click on this icon now to run the program. A screen similar to Figure 2-2 should appear:

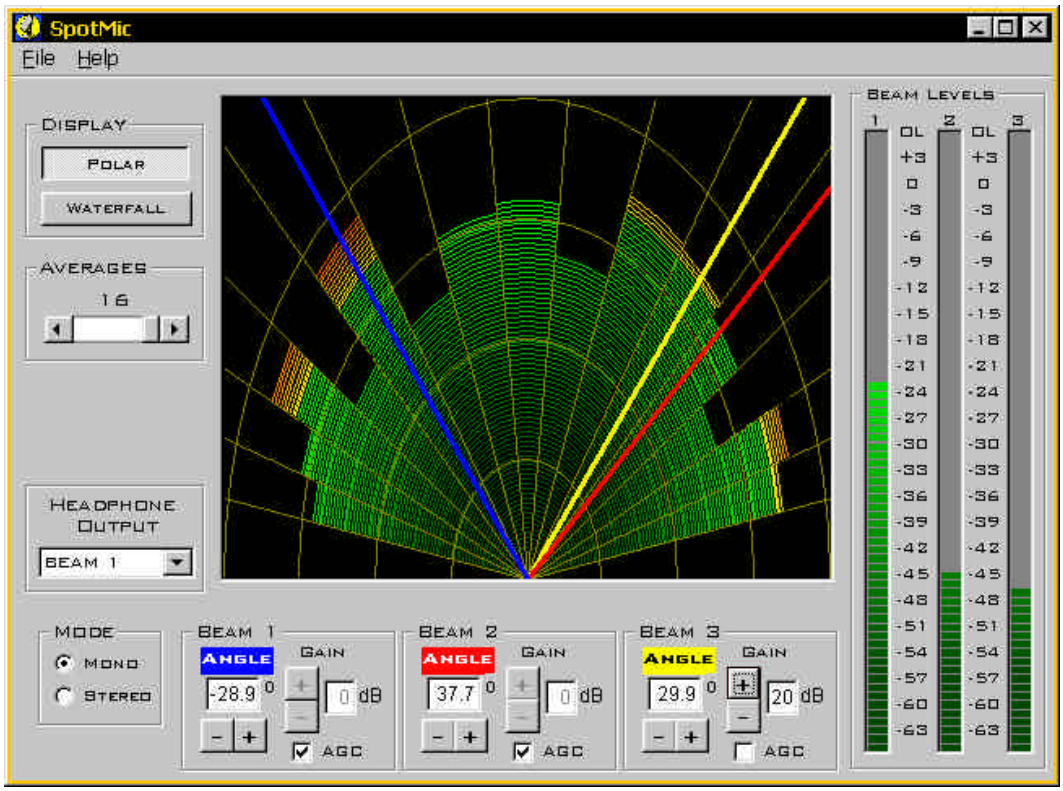

Figure 2-2: SpotMic Main Control Window

If an error message is displayed (Figure 2-3), it is possible that the software is not configured for the correct COM Port (software defaults to COM 1). If you know to which COM Port the SpotMic external processor is connected, use the **File → COM Port** menu option to select it.

Figure 2-3: Communications Error Message

The SpotMic system should now be installed and ready to run.

3. GETTING STARTED

Operation of the SpotMic system is a highly intuitive system that most operators can quickly learn while using. The Fast Start procedure in Section 3.1 should allow first time users to quickly begin controlling the individual beams. For more detailed information on the SpotMic front panel controls, see Section 1.3. For detailed descriptions of the SpotMic Control Software, see Section 4.

The following sections will show you how to configure the SpotMic to work with your custom microphone array and control each of the three beams.

3.1 Fast Start

Fast start the external SpotMic processor and the SpotMic Control Software as follows:

1. Connect the array cables to the SpotMic processor (cable construction is discussed in Section 1.4).

2. Connect the RS232 cable to the external SpotMic processor and to the Control PC.

3. Connect your stereo headphones to either of the two PHONES jacks on the SpotMic external processor front panel as shown in Figure 1-2. Turn the phones VOLUME control to MIN.

4. Power ON the SpotMic (as well as the Control PC). On power-up, the SpotMic is controllable via the front panel.

5. On the Control PC run the SpotMic Control Software by clicking on the SpotMic icon (Figure 2-1) under the Start Menu (Start Menu → Programs → SpotMic → SpotMic Control Software).

6. If the software displays an error telling you that it is unable to connect to the SpotMic, click on the **Communication** menu and then the **COM Port** option. There you can select the Com Port to which the RS232 cable is connected. Once you have selected the correct Com Port click on the **Communication** menu again and select **Connect to SpotMic**; you should now see the Polar Display update as it receives data from the external SpotMic processor. You should also see the front panel AZIMUTH and GAIN displays show only horizontal lines and the REMOTE CONTROL LED illuminate.

7. Now we need to configure the microphone array. Click on the **Microphones** menu and then on **Configure Microphones**. The Microphone Configuration Window will appear (Figure 3-1).

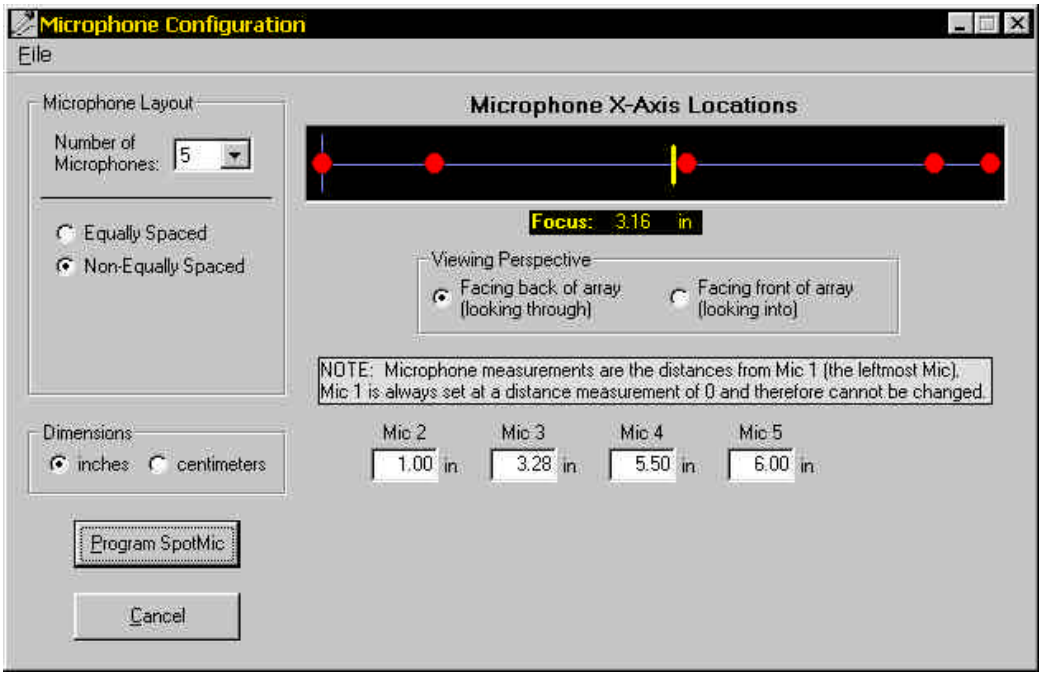

Figure 3-1: Microphone Configuration Window

8. From this window you can enter the measurements (coordinates) of your linear microphone array. Select the **Number of Microphones** in your array from the dropdown box.

9. Next, depending on your microphone configuration, select whether your array is **Equally Spaced** or **Unequally Spaced**. With an **Equally Spaced** configuration you only need enter the **Microphone Spacing** in the text entry boxes. If selecting **Unequally Spaced**, each microphone measurement (coordinate) will need to be entered.

10. Choose the **Viewing Perspective** from which your measurements were taken. When the SpotMic is programmed the software will automatically sort and invert your measurements to correspond to the **Facing back of array** viewing perspective. If your measurements were taken viewing the array from the front, choose **Facing front of array**. Also make sure to choose the correct **Dimensions** that were used when measuring the microphone array placement.

11. Once your have finished your microphone configuration, click the **File** menu and then **Save Mic Configuration**. This will enable you to quickly recall your microphone settings if you choose to use this array configuration again.

12. Now click on **Program SpotMic**. This button will send the microphone configuration settings to the external SpotMic processor where it will be stored in its nonvolatile memory for use. The Microphone Configuration Window will disappear. The **Microphone Configuration** utility only needs to be used each time a new microphone array is used as the external SpotMic processor will store the settings on power-down.

13. You should see the Sweep Display on the Main Window update with new data from the SpotMic. Selecting the **Polar** display will show the sweep data much like a radar screen using arcs to display each sweep angle's magnitude. Selecting the **Waterfall** display will show a "history" of the sweep data over time.

14. To "smooth" the display data use the **Averages** scroll bar. Increasing the number of averages "smoothes out" the displayed data.

15. Now, using the **Headphone Output** dropdown list box select **Beam 1** if it is not already selected. You should then hear the beam audio for Beam 1 through the headphones. To adjust Beam 1's angle you can enter the angle value in it's angle entry textbox (between –70 and +70 degrees), use the "**+**" or "**–**" buttons, or click on the beam line in the display window using your mouse cursor and drag it to the desired angle by holding down the left mouse button. Each beam's audio is displayed in the **Beam Levels** bargraphs on the right side of the Main Window.

16. To adjust the gain applied to each beam use the **Gain** entry text box or the "**+**" and "**–**" buttons. Checking the **AGC** checkbox will activate the Automatic Gain Control for that particular beam.

17. In the **Mode** box select **Stereo**. This will combine Beam 1 and Beam 2 into a **Stereo Beam** allowing you to more easily locate specific sound sources.

18. Once you have familiarized yourself with the SpotMic Control Software close it via the "X" in the top right corner of the Main Window or via the **File** menu. Your settings will remain active on the external SpotMic processor. Upon closing the software you will see on the front panel the REMOTE CONTROL LED turn off and the headphones will output what the CONTROL SELECT knob is set to. Use of the front panel controls is discussed in Section 1.3.

19. You have now familiarized yourself with the basic features of the SpotMic Control Software.

4. SPOTMIC SOFTWARE REFERENCE MANUAL

This portion of the user's manual is designed as a reference guide to which the user may refer for more detailed information on the features of the SpotMic Control Software. It is assumed in this section that the user has a good working knowledge of Microsoft Windows and has properly installed the SpotMic hardware and software using the installation instructions in Section 2.2.

4.1 Main Window

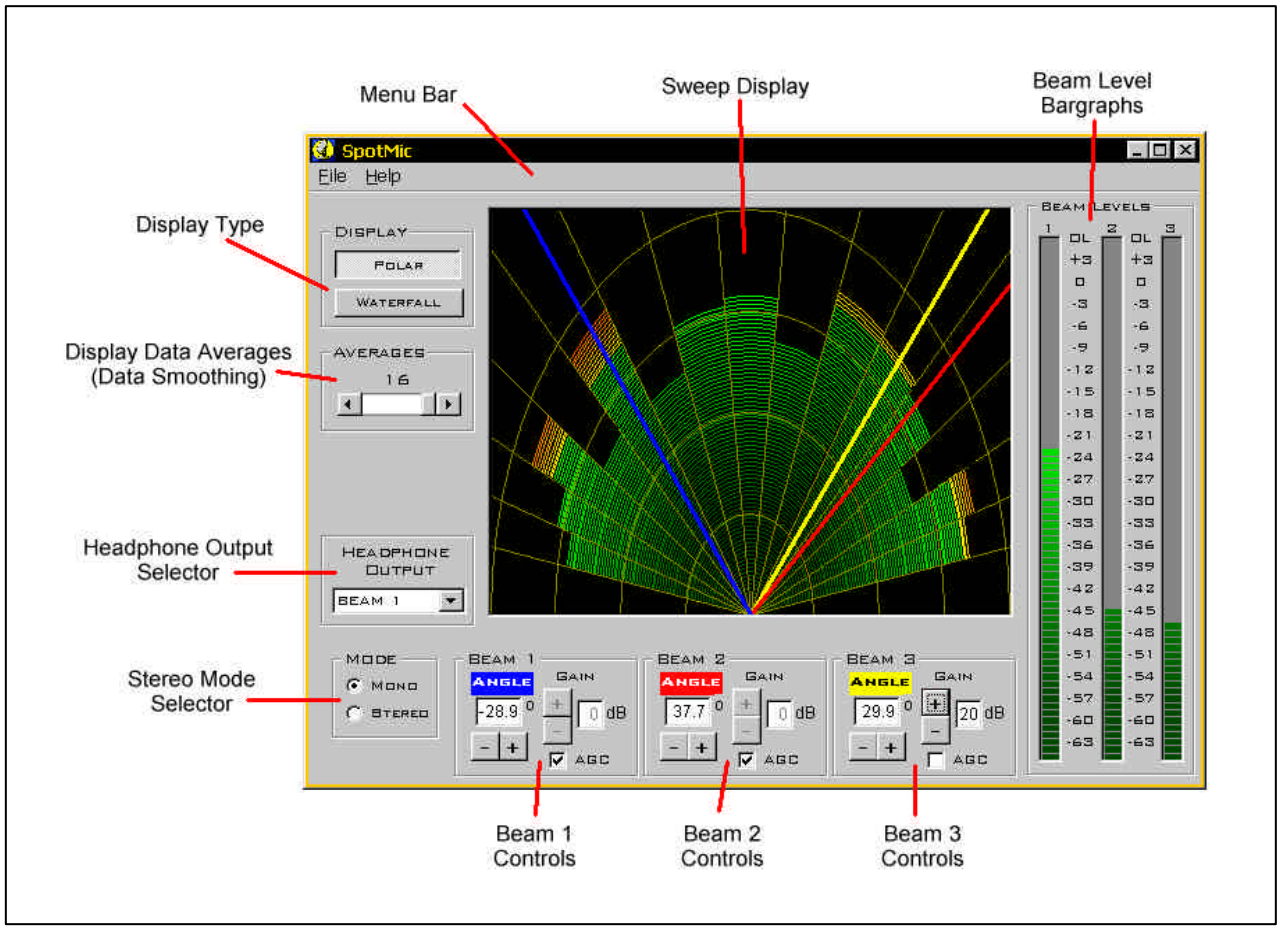

Figure 4-1: SpotMic Control Software Main Window

When the SpotMic Control Software program is run from Microsoft Windows, the Main Window appears. The Main Window features are shown in Figure 4-1.

From this screen, the main external processor capabilities can be accessed. Master Control functions are as follows:

Menu Bar: Used to access the pull-down menu, which allows connecting and disconnecting to the external SpotMic processor, configuring RS232 communication with the external processor, and activating the Microphone Configuration Window for configuring the Microphone array. On the pull-down menu, choose between the following options:

File Menu	
Open	Opens a previously saved settings (".spt") file
Save	Saves the current SpotMic settings in a ".spt" file
Save As	Saves the current SpotMic settings as another name than the currently loaded ".spt" file
Exit	Exits the SpotMic Control Software
Communication Menu	
Connect to SpotMic	Attempts to connect to the external SpotMic processor through the RS232 connection. This connection will disable the front panel controls of the external processor. The front panel REMOTE CONTROL LED will illuminate.
Disconnect from SpotMic	Closes the RS232 connection with the external SpotMic processor, re-enabling control from its front panel. The front panel REMOTE CONTROL LED will turn off.
COM Port	Select the COM Port to which the external SpotMic processor is connected
Microphones Menu	
Configure Microphones	Opens the **Microphone Configuration Window**. See Section 4.2.

The pull-down **Help** menu allows viewing online help and viewing software and firmware version information using the **About SpotMic** option.

Sweep Display: Displays the sweep data as a **Polar** Level Display or as a **Waterfall** Display (Figure 4-2). The radar like **Polar** Level Display shows a snapshot of the current sound field with the sound level of each sweep beam indicated by the number of arcs shown. The **Waterfall** Display shows the history over time of the sound field with the sound level of each sweep beam indicated by its color and intensity.

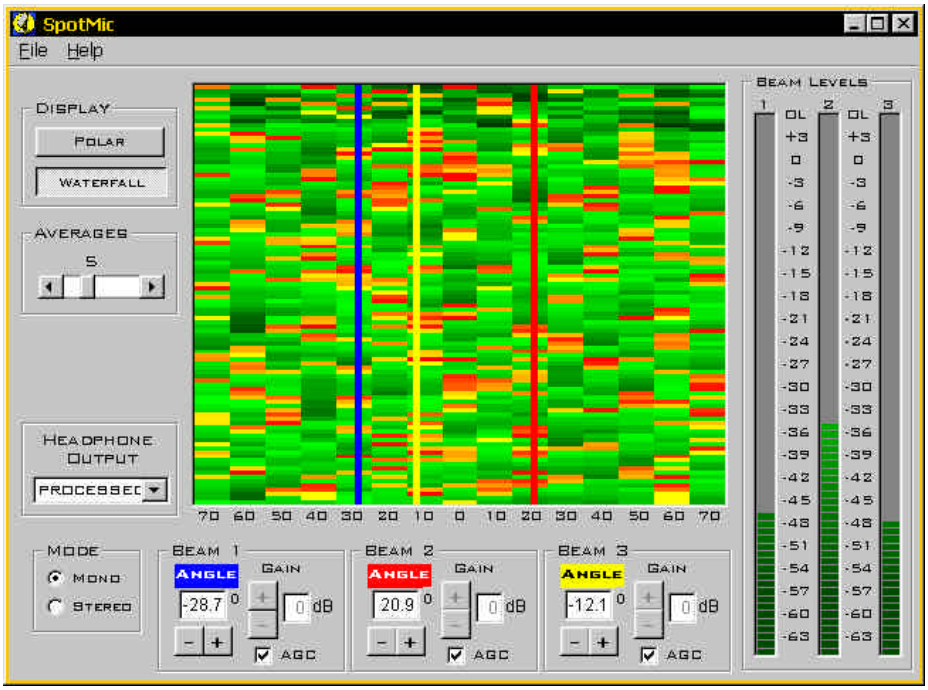

Figure 4-2: Waterfall Display

Beam Level Bargraphs: Shows the current level (in dB) of each of the three beams.

Beam Controls (1, 2, and 3): Allow for the adjustment of the Beam **Angle** (-70 to +70 degrees) and the Beam **Gain** (0 to 30 dB). For Automatic Gain Control, use the **AGC** option.

In 3-D mode, you can also control the Beam **Elevation** (-70 to +70 degrees) and the Beam **Range** (0.5 to 81.91 m) for Beam 1. For a range of infinity or greater than 82 m, use the **Infinite** option.

NOTE: The mouse can also be used to adjust the beam angles (azimuth) in both the Polar and Waterfall displays. First, click (using the left mouse button) on the beam line color corresponding to the desired beam (Beam 1: Blue, Beam 2: Red, Beam 3: Yellow). Next, while holding down the left mouse button, drag the mouse cursor left

or right in the direction desired. Release the mouse button when you have moved the beam to the desired angle.

Mode: Used for selecting **Mono**, **Stereo**, or **3-D** mode. In **Stereo** mode, Beam 2 becomes the "right" channel of the stereo, which is linked to Beam 1 (the "left" channel), and therefore is no longer selectable. In **Mono** mode, each beam is available for control. In **3-D** mode, a single beam (Beam 1) can be steered in three dimensions.

Headphone Output: Enables selection of the headphone output source. The selection choices are similar to those on the front panel of the external SpotMic processor. Selecting Beam 2, for example, will cause the SpotMic to output the audio from Beam 2 through the headphones.

Averages: Controls the number of averages (smoothing) applied the sweep data. The greater the number of averages applied, the greater the smoothing of the sweep data.

4.2 Microphone Configuration Window

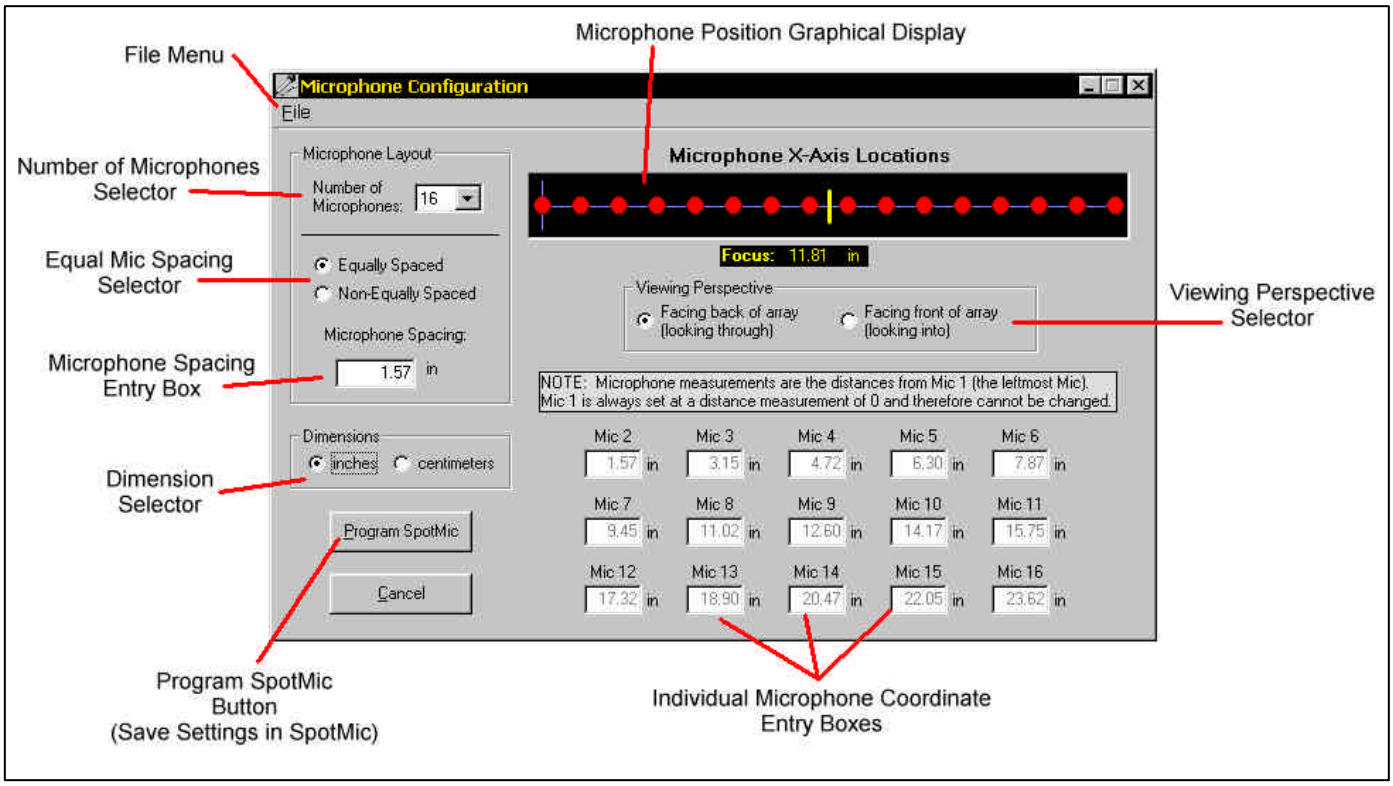

Figure 4-3: 1-D Microphone Configuration Window

After selecting the **Microphones** menu from the Main Window, the Microphone Configuration Window will appear. This window allows you to configure the SpotMic to work with your customized microphone array. The controls are as follows:

Microphone Position: Graphical Display — Gives a graphical representation of the position of the microphones on the linear array. The *focus* is the center point of all the microphones, and the software automatically calculates its position. It is from the *focus* that the beams originate. Yellow lines represent the focus.

Viewing Perspective: Selector — Chooses the direction from which the array is being viewed. If the measurements of the microphone positions (horizontal measurements only) were made while facing the array (the opposite direction in which the microphones are pointed), select the “Facing front of array (looking into)” option. If the measurements of the microphone were made while

looking at the back of the array (the same direction in which the microphones are pointed), select “Facing back of array (looking through)” (this selection is the default).

NOTE: The coordinates of the microphones may be entered in any order. All measurements must be made relative to an imaginary origin.

Microphone Coordinate: Entry Boxes	Provide the ability to enter each microphone’s vertical location measurement (X- and Y-coordinates) in inches or centimeters (depending on the **Dimension Selector** setting). For a one-dimensional (linear) array, set all mics to a Y-position of 0. These coordinates must correspond to the microphone numbers for the wiring connection to the SpotMic hardware.
Program Button:	Updates the microphone settings on the SpotMic. This button must be clicked before the new microphone settings will take effect.
Cancel Button:	Closes the Microphone Configuration Window *without* updating the settings on the SpotMic.
Dimension Selector:	Converts the current microphone measurements to the dimension (unit) of choice: inches or centimeters.
Microphone Spacing: Entry Boxes	Allows the microphone spacing for an equally spaced microphone array configuration to be entered (minimum of 0.1 cm).
Equal Mic Spacing: Selector	Chooses between an **Equally Spaced** microphone array configuration where the **Microphone Spacing** entry boxes are used or an **Unequally Spaced** configuration where the microphone coordinate entry boxes are used.
Number of Microphones: Selector	Selects the number of microphones in the array configuration (between 2 and 16).

Menu: Chooses between the following options:

Configuration Menu	
New	Resets the displayed microphone configuration (does not reprogram the SpotMic)
Open Mic Configuration	Opens a previously saved microphone configuration (".mic") file.
Save Mic Configuration	Saves the displayed microphone configuration in a ".mic" file.
Save Mic Configuration As	Saves the displayed microphone configuration as another name than the currently loaded ".mic" file.
Retrieve Configuration from SpotMic	Reads the current microphone configuration from the SpotMic. This retrieval is done automatically when the Microphone Configuration Window is loaded if the SpotMic is connected.
Exit	Exits the Microphone Configuration Window without updating the Spotmic
Viewing Perspective Menu	
Reverse Array	Changes perspective option while leaving the picture and entered positions intact
Rotate View of Array	Changes the perspective option while reversing the picture and relative positions such that the absolute mic positions are the same

5. SPOTMIC SPECIFICATIONS

Analog Input/Output

Line Inputs (18)	Two rear-panel, single-ended, RCAs. Zin = 10kΩ
	Two 25-pin DSUB connectors. Each connector carries 8 balanced, differential inputs (total of 16) Zin = 25kΩ
Line Outputs (4)	Four rear-panel, single-ended, RCAs. Zout = 51Ω
Headphone Outputs	Dual front panel stereo jacks with volume control **CONTROL SELECT** switch selects which source user is monitoring
Bandwidth	350Hz - 6500Hz bandwidth, fixed.
Analog Conversion	Eight 24-bit sigma-delta stereo A/D converters on microphone inputs.
	Three 24-bit delta-sigma stereo D/A converters for line outputs and headphone.
Dynamic Range	> 90dB

Digital Processing

Beamforming	3 simultaneous beams are formed using whole sample and fractional sample delays.
	0.1° azimuth and elevation adjustment resolution
	±70° sweep area in sound field
	45 dB gain max
	1 cm range resolution; infinite range option
AGC	Independently controlled for each beam. Maximum automatic gain applied = 30 dB
Stereo Mode	Left and right channel separation = 6°
Microprocessor	Five ADSP-21062 SHARC processors running at 40 MHz. All beamforming and FIR filters are performed in these processors.
Computer Interface	RS232 serial interface. 57600 baud rate, 8 data bits, 1 stop bit, no parity. Used to interface to MS Windows software.

Construction

Packaging	2U high (3.31”), 16.48” W, 11.75” D
	Rugged Aluminum Enclosure
Power	90 VAC to 264 VAC, 47 to 63 Hz auto-switching power supply, built-in
Host Computer	Requires MS Windows™ 95/98/NT/2000/XP desktop or laptop system with CD drive, minimum 640×480 screen resolution, 5 MB of free hard drive space, and one spare RS232 (COM) port for connection to SpotMic.

Specifications subject to change without notice.