UMA16
MICROPHONE ARRAY DEVELOPMENT BOARD

User Manual
**Revision history**

<table>
<thead>
<tr>
<th>Revision</th>
<th>Description</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>V1.0</td>
<td>First version</td>
<td>18 Jan 2018</td>
</tr>
</tbody>
</table>
CONTENTS

Important Information ......................................................................................................................................... 4
System Requirements ........................................................................................................................................ 4
Warranty Terms ............................................................................................................................................... 4
FCC Class B Statement ...................................................................................................................................... 4
CE Mark Statement .......................................................................................................................................... 5
A note on this manual ...................................................................................................................................... 5
1 Product Overview .......................................................................................................................................... 6
2 Board Layout and Connectivity ...................................................................................................................... 7
  2.1 Board layout ......................................................................................................................................... 7
  2.2 DC power ............................................................................................................................................. 8
  2.3 USB connectivity .................................................................................................................................. 8
  2.4 Microphone Knowles SPH1668LM4H-1 ................................................................................................. 8
3 USB Audio ................................................................................................................................................... 10
  3.1 Mac OS X ............................................................................................................................................ 10
  3.2 Windows ............................................................................................................................................ 11
    3.2.1 USB Driver installation ................................................................................................................ 11
    3.2.2 Status ......................................................................................................................................... 11
    3.2.3 Buffer settings ............................................................................................................................ 12
    3.2.4 Volume ....................................................................................................................................... 12
    3.2.5 Info ............................................................................................................................................. 13
  3.3 Compliant USB audio software ........................................................................................................... 13
4 Custom Microphone Board Development .................................................................................................... 14
  4.1 PDM expansion header pinouts .......................................................................................................... 14
  4.2 PDM overview .................................................................................................................................... 15
5 Additional information ................................................................................................................................ 16
  5.1 Specifications ..................................................................................................................................... 16
  5.2 MCU firmware update ........................................................................................................................ 17
    5.2.1 Windows .................................................................................................................................... 17
  5.3 Obtaining support ................................................................................................................................ 19
IMPORTANT INFORMATION

Please read the following information before use. In case of any questions, please contact miniDSP via the support portal at support.minidsp.com.

SYSTEM REQUIREMENTS

To configure the miniDSP audio processor, you will require a Windows PC or Apple Mac OS X computer with the following minimum specification:

**Windows**
- PC with 1GHz or higher processor clock speed. Intel® Pentium®/Celeron® family, or AMD K6®/AMD Athlon®/AMD Duron® family, or compatible processor recommended.
- 512 megabytes (MB) of RAM or higher
- Keyboard and mouse or compatible pointing device
- USB 2.0 port
- Microsoft® Windows® Vista® SP1/ XP pro SP2/Win7/Win8.1/Win10
- Microsoft® .NET framework v3.5 or later
- Adobe AIR environment (latest version)
- Adobe Flash player (latest version)

**Mac OS X**
- Intel-based Mac with 1 GHz or higher processor clock speed
- 512 megabytes (MB) of RAM or higher
- Keyboard and mouse or compatible pointing device
- USB 2.0 port
- Mac OS X 10.8 or higher
- Adobe AIR environment (latest version)
- Adobe Flash player (latest version)

WARRANTY TERMS

miniDSP Ltd warrants this product to be free from defects in materials and workmanship for a period of one year from the invoice date. Our warranty does not cover failure of the product due to incorrect connection or installation, improper or undocumented use, unauthorized servicing, modification or alteration of the unit in any way, or any usage outside of that recommended in this manual. If in doubt, contact miniDSP prior to use.

FCC CLASS B STATEMENT

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions:
- This device may not cause harmful interference.
• This device must accept any interference received, including interference that may cause undesired operation.

Warning: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

• Reorient or relocate the receiving antenna.
• Increase the separation between the equipment and receiver.
• Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
• Consult the dealer or an experienced radio/TV technician for help.

Notice: Shielded interface cable must be used in order to comply with emission limits.

Notice: Changes or modification not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

CE Mark Statement

The UMA-16 has passed the test performed according to European Standard EN 55022 Class B.

A Note on this Manual

This User Manual is designed for reading in both print and on the computer. If printing the manual, please print double-sided. The embedded page size is 8 ½” x 11”. Printing on A4 paper will result in a slightly reduced size.
1 PRODUCT OVERVIEW

Thank you for choosing the UMA-16 audio processor board. The UMA-16 is a cost effective sixteen channels microphone array with plug&play USB audio connectivity. With its embedded SHARC + XMOS controller board, the UMA16 is the perfect fit for researchers looking to develop their own beam forming algorithms.

The UMA-16 system architecture is powered by two core elements:

- A microphone array PCB with 16 x SPH1668LM4H MEMS Knowles with PDM outputs. A center hole fits an optional USB camera perfect in applications such as acoustic cameras. The microphone array is a simple 2 layer design that can easily be customized to your needs by following our schematics included in this user manual.

- Stacked on top of the mic array is the nanoSharc kit. At the helm of the UMA-16 operation is a 400MHz SHARC ADSP21489 processor combined with XMOS XCORE multicore CPU. This substantial processing power allows for a high quality PDM to PCM conversion and presents all 16 channels of raw audio to the ASIO USB audio driver.

Please note that the following sections will highlight basic operation of the UMA-16. Beamforming algorithm development or any 3rd party support for software (e.g. Matlab) is considered outside the scope of this manual and our support structure.
2 BOARD LAYOUT AND CONNECTIVITY

2.1 BOARD LAYOUT

The below diagram shows the layout of the UMA-16 board. Sixteen MEMS microphone are laid out in a Uniform Rectangular Array (URA) distribution. Microphone offset was set to 42mm. CAD drawings are available on demand.
2.2 DC POWER

The supplied 12 VDC power supply includes a set of interchangeable power pins (for USA, UK, Europe and Australia). Fit the correct pins for your country. Connect the DC plug to the 12 VDC power socket.

2.3 USB CONNECTIVITY

Connect mini USB port (mini type B) to a computer to configure the board. The USB port also provides asynchronous USB Audio (Class 2) streaming at all standard sample rates from 14.7/11.025/12/16/22.05/44.1/48kHz. See section 3 for more details on USB audio connectivity.

2.4 MICROPHONE KNOWLES SPH1668LM4H-1

The UMA16 is fitted with 16 x Knowles MEMS microphones. Please refer to the complete datasheet for more details.

Features:

- Low Distortion of 1.6% at 120dBSPL
- High SNR of 65.5dB
- Flat Frequency Response
- RF Shielded
- Zero-Height MicTM
- Supports Dual Multiplexed Channels
- Standard SMD Reflow
- Omnidirectional
Acoustic performance under the Performance Mode (default)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply Current</td>
<td>I&lt;sub&gt;DD&lt;/sub&gt;</td>
<td>94 dB SPL @ 1 kHz</td>
<td>-</td>
<td>626</td>
<td>700</td>
<td>μA</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>S</td>
<td>65.5 dB(SPL) @ 1 kHz</td>
<td>-30</td>
<td>-29</td>
<td>-28</td>
<td>dBFS</td>
</tr>
<tr>
<td>Signal to Noise Ratio</td>
<td>SNR</td>
<td>94 dB SPL @ 1 kHz, A-weighted, f&lt;sub&gt;CLOCK&lt;/sub&gt;=3.072 MHz</td>
<td>-</td>
<td>6.5</td>
<td>-</td>
<td>dB(A)</td>
</tr>
<tr>
<td>Total Harmonic Distortion</td>
<td>THD</td>
<td>94 dB SPL @ 1 kHz</td>
<td>-</td>
<td>0.1</td>
<td>-</td>
<td>%</td>
</tr>
<tr>
<td>Total Harmonic Distortion</td>
<td>THD</td>
<td>120 dB SPL @ 1 kHz</td>
<td>-</td>
<td>1.6</td>
<td>-</td>
<td>%</td>
</tr>
<tr>
<td>Acoustic Overload Point</td>
<td>AOP</td>
<td>10% THD @ 1 kHz</td>
<td>-</td>
<td>122</td>
<td>-</td>
<td>dB SPL</td>
</tr>
<tr>
<td>Power Supply Rejection Ratio</td>
<td>PSRR</td>
<td>200 mVpp sinewave @ 1 kHz</td>
<td>-</td>
<td>64</td>
<td>-</td>
<td>dBV/FS</td>
</tr>
<tr>
<td>Power Supply Rejection</td>
<td>PSR+N</td>
<td>100 mVpp 1/8 duty cycle rectangular waveform @ 217 Hz, A-weighted</td>
<td>-</td>
<td>-91</td>
<td>-</td>
<td>dBFS(A)</td>
</tr>
</tbody>
</table>

**Typical Free Field Response**

Normalized to 1 kHz
CLK=2.4MHz VDD=1.8V

![Graph showing typical free field response](image)
3 USB Audio

The miniDSP UMA-16 streams PCM audio at sample rates of 14.7k/11.025k/12k/16k/22.05k/44.1k/48k over its USB Audio Class 2 (UAC2) compliant interface. Here are more details on setup and configuration.

3.1 Mac OS X

Open the program Audio MIDI Setup (in Applications->Utilities). The UMA-16 will appear as “nanoSHARC micArray 16” in the list on the left hand side. Clicking on it will show the input and output channels. Sample rate can be selected in the dropdown menus:
3.2  WINDOWS

3.2.1  USB Driver installation

1. Connect the UMA-16 to the computer using the supplied USB cable, and power it on with the 12V supply.
2. Navigate to the WinDrivers folder of the software download and double-click on the appropriate installer:
   - miniDSP_UAC2_v2.29.0_ForWinXP_Vista.exe for Windows XP and Vista
   - miniDSP_UAC2_v3.34.0_ForWin7_8_10.exe for Windows 7, 8, and 10

(The version number embedded in the filename may be different.)

We recommend accepting the default installation location. Once the driver installation completes, click the Finish button.

The Windows PC will not be able to communicate properly with the UMA16 if you did not have the it connected by USB and powered on when you installed the driver. If that is the case, you will need to uninstall the driver, connect the UMA16, power it on, and run the installer again.

To configure the UMA-16, open the miniDSP UAC2 Control Panel (from Start Menu -> miniDSP Ltd). It has several panes, described below.

3.2.2  Status

This panel shows the current sample rate of the UMA-16. This setting cannot be changed in the Control panel, but simply reflects the current sample rate of the UMA-16. This setting will be affected by the recording software when the USB audio stream starts.
3.2.3 Buffer settings
The buffer settings are for those looking to optimize buffering and latency settings. Note that changing these settings may result in unstable operation. For example, the lowest latency settings require high amounts of CPU and memory, and may not work on some machines. If you do not require lowest latency, we recommend that you do not depart from the default safe settings.

3.2.4 Volume
This panel contains the volume controls for input channels.

- To reset the master volume control or a pair of channels to 0 dB (no attenuation), click the **0dB** button.
- To mute all channels, click either of the speaker icons.
- To control volume separately for each channel, click on the “Link” icon to turn it off.
3.2.5 Info
This panel shows information about the UMA-16. Important data includes the firmware and driver versions.

![MiniDSP UAC2 Control Panel](image)

3.3 Compliant USB Audio Software
Please note that the UMA16 requires a multichannel recording software with ASIO support. Not all software support such needs. E.g. Audacity freeware only supports WDM and therefore won’t work.

We recommend some Digital Audio Workstation (DAW software) such as Reaper/Cubase/Protools for a reliable experience.

Also note that Matlab running the latest audio toolbox will support ASIO fine. Please consult Matlab tech support for more details. ([https://www.mathworks.com/help/audio/ref/asiosettings.html](https://www.mathworks.com/help/audio/ref/asiosettings.html)) In the coming months, miniDSP will issue some application notes to showcase demo of the UMA16 with Matlab.
4  CUSTOM MICROPHONE BOARD DEVELOPMENT

In an effort to help the community, miniDSP is providing full schematics of the microphone board PCB (nanoSHARC kit not included). Please consult the appendix at the end of this manual. Based on a simple 2 layer design, one can easily route a test PCB to trial various microphone arrangements.

NOTE: Electronic engineering support is unfortunately outside miniDSP’s support structure. If you were to design your own MEMS array and lack the engineering knowledge to do so, we strongly recommend that you to seek 3rd party engineering support. Thanks for your understanding!

4.1  PDM EXPANSION HEADER PINOUTS

Headers J2 and J3 of the nanoSHARC kit are providing the PDM clocks/data to the microphone board as follow.

Note that I2C_SCL and I2C_SDA are intended for miniDSP use only – they are not documented or supported for other use.

Table 1. J3 expansion

<table>
<thead>
<tr>
<th>Usage</th>
<th>Pin Number</th>
<th>Usage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not in use</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Not in use</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Not in use</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>GND</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>PDM[7]</td>
<td>15</td>
<td>16</td>
</tr>
<tr>
<td>PDM CLK2</td>
<td>17</td>
<td>18</td>
</tr>
<tr>
<td>GND</td>
<td>19</td>
<td>20</td>
</tr>
<tr>
<td>3V3</td>
<td>21</td>
<td>22</td>
</tr>
</tbody>
</table>

Table 2. J2 expansion header pinout

<table>
<thead>
<tr>
<th>Usage</th>
<th>Pin Number</th>
<th>Usage</th>
</tr>
</thead>
<tbody>
<tr>
<td>I2S LRCLK</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>GND</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>I2S Out0</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>I2C SCLK</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>GND</td>
<td>9</td>
<td>10</td>
</tr>
<tr>
<td>12V+ IN</td>
<td>11</td>
<td>12</td>
</tr>
</tbody>
</table>

NOTE: I2S out isn’t enabled on current firmware and only documented here for future use.
4.2 PDM OVERVIEW

PDM stands for Pulse Density Modulation. It is an ideally suited digital audio transmission method for MEMS microphone as it brings benefits of digital audio (noise immunity, high quality audio) at very low cost.

**PDM CLK** The PDM clock always runs at 3.072MHz.

**PDM[0..7]** Each data lines carrying a stereo feed of 2 x microphones by using the SELECT PIN.

The timing of data lines is as illustrated in the following diagram:

All lines use a 3.3V logic level. Ensure that connected circuits use a compatible level.
## 5 ADDITIONAL INFORMATION

### 5.1 SPECIFICATIONS

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Digital Signal Processor</td>
<td>32-bit Floating point Analog Devices SHARC ADSP21489 / 400 MHz</td>
</tr>
<tr>
<td>Control</td>
<td>Driverless USB 2.0 control interface for Windows/Mac OS X environments</td>
</tr>
<tr>
<td></td>
<td>A computer is only required for the initial configuration and for USB audio streaming</td>
</tr>
<tr>
<td>USB audio input</td>
<td>XMOS Xcore200 asynchronous USB audio up to 192 kHz, USB Audio Class 2 compliant</td>
</tr>
<tr>
<td></td>
<td>- ASIO drivers for Windows</td>
</tr>
<tr>
<td></td>
<td>- Driverless for Mac OS X</td>
</tr>
<tr>
<td>PDM inputs</td>
<td>Up to 16 x MEMS microphone connections (8 x stereo PDM data lines)</td>
</tr>
<tr>
<td>MEMS microphone on UMA16</td>
<td>16 x SPH1668LM4H</td>
</tr>
<tr>
<td>ADC/DAC Sample rate &amp; Resolution</td>
<td>Resolution: 24 bit</td>
</tr>
<tr>
<td></td>
<td>Sample rate: 14.7k/11.025k/12k/16k/22.05k/44.1k/48k</td>
</tr>
<tr>
<td>USB port</td>
<td>USB port type Mini-B for audio streaming, real time control and firmware upgrade</td>
</tr>
<tr>
<td>Power supply</td>
<td>12 VDC single supply / Header input / 2.5W</td>
</tr>
<tr>
<td>Dimensions (H x W x D) mm</td>
<td>132 x 195 x 30 mm</td>
</tr>
<tr>
<td>Mounting</td>
<td>4 x M3 holders for front panel mounting / CAD drawings available on demand</td>
</tr>
</tbody>
</table>
5.2 MCU FIRMWARE UPDATE

5.2.1 Windows

1. Connect the UMA16 to your computer via USB (if not already connected) and power it on.
2. Start the miniDSP UAC2 DFU Tool.

3. The upgrade program will start:
4. Click on the **Browse** button, navigate to the folder **XMOS_Firmware** in the plugin download folder, and select the firmware file.

5. Click on the **Start** button.

6. You will get a progress bar as upgrade proceeds:

7. Once the firmware upgrade completes, you will see a message that the upgrade completed successfully:

8. Click on **Exit**.
5.3 Obtaining Support

1. Check the forums on miniDSP.com to see if this issue has already been raised and a solution provided.

2. Contact miniDSP via the support portal at minidsp.desk.com with:
   a. The specific product you are having an issue with (in this case, UMA-16 board or accessories).
   b. A clear explanation of the symptoms you are seeing.
   c. A description of troubleshooting steps (see Troubleshooting above) performed and your results.

Please note that miniDSP is only able to provide support for the hardware and functions documented in this manual, and only for problems specifically related to the miniDSP hardware and software functions. Any other items, such as designing or debugging your PDM interface circuitry or layout or interfaces to third-party hardware, are specifically excluded from the scope of miniDSP support.