External Expansion Board
User Guide
Revision 1.6
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1. Introduction

This document is an accompaniment to the Shimmer External Expansion Board (formerly known as the Shimmer AnEx Board). Its purpose is to be used in conjunction with the Shimmer External Expansion Board Tutorial Video to aid the user in getting started with the External Expansion Board.

The External Expansion Board Board enables an Analog Output Sensor, a Digital Output Sensor, a Serial UART or a Parallel Bus Interface to connect to Shimmer. The External Expansion Board is connected to a Shimmer device via the external connector and is positioned outside the Shimmer enclosure.

The External Expansion Board enables users to incorporate additional functionality to the Shimmer providing an outlet to develop their specific application to their own user requirements. It allows easy prototyping of 3rd part sensors or custom sensing solutions with Shimmer.
2. General Information

2.1. Pre-Requisites

- A Shimmer 2, Shimmer 2r or Shimmer3\(^1\) device programmed with appropriate firmware. For example, LogAndStream (BtStream for Shimmer2/2r) firmware can be used to stream data over Bluetooth and/or log data to the SD card or SDLog firmware can be used to log data to the SD card; both are available for download from [www.shimmersensing.com](http://www.shimmersensing.com) and the latest version should always be used.
- An External Expansion Board.

2.2. External Expansion Board Features

- Easy access to Shimmer microcontroller signals using wire hole or solder pads.
- +/-5VDC charge pump regulator with software-controlled enable pin\(^2\).
- Software assignable User Control button.
- Connect an auxiliary power supply.

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\(^1\) Please refer to the later sections of this document for more details on using the Expansion Board with Shimmer3.

\(^2\) The 5V regulator is not compatible with Shimmer3.
## 2.3. Wire Connections

<table>
<thead>
<tr>
<th>PCB Label</th>
<th>Connector Pin#</th>
<th>hardware.h Pin Label</th>
<th>Shimmer2/2r Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLK</td>
<td>4</td>
<td>UCLK0</td>
<td>SPI0 CLK, or GPIO (wired to MicroSD)</td>
</tr>
<tr>
<td>SI</td>
<td>6</td>
<td>SIMOO</td>
<td>SPI0 SIMO or GPIO (wired to MicroSD)</td>
</tr>
<tr>
<td>#RST</td>
<td>8</td>
<td>N/A</td>
<td>BSL programming, Power control and Board Reset. Same as Shimmer reset button.</td>
</tr>
<tr>
<td>RX</td>
<td>2</td>
<td>URXD0</td>
<td>UART0 RXD or GPIO. A level shifter is required to interface with an RS-232 cable</td>
</tr>
<tr>
<td>CTS</td>
<td>16</td>
<td>SER0_CTS</td>
<td>SPI0 UART CTS or interruptible GPIO</td>
</tr>
<tr>
<td>+3</td>
<td>17</td>
<td>PV</td>
<td>3.0V regulated voltage. Do not exceed 50mA when using this connection.</td>
</tr>
<tr>
<td>+5</td>
<td>N/A</td>
<td>N/A</td>
<td>5.0V regulated voltage. Do not exceed 12mA when using this connection</td>
</tr>
<tr>
<td>-5</td>
<td>N/A</td>
<td>N/A</td>
<td>-5.0V regulated voltage. Do not exceed 12mA when using this connection</td>
</tr>
<tr>
<td>TX</td>
<td>3</td>
<td>UTXD0</td>
<td>UART0 TXD or GPIO. A level shifter is required to interface with an RS-232 cable</td>
</tr>
<tr>
<td>SO</td>
<td>5</td>
<td>SOMIO</td>
<td>SPI0 SOMI, or GPIO (wired to MicroSD)</td>
</tr>
<tr>
<td>A7</td>
<td>13</td>
<td>ADC_7</td>
<td>Analog ADC input 7, DAC output or GPIO. Also used for MicroSD Flash Dat1</td>
</tr>
<tr>
<td>G</td>
<td>GND</td>
<td></td>
<td>Ground Connection</td>
</tr>
<tr>
<td>A0</td>
<td>12</td>
<td>ADC_0</td>
<td>Analog ADC input 0 or GPIO. Also used for MicroSD Flash Dat2</td>
</tr>
</tbody>
</table>

### Table 1 Wire Connections for Shimmer2/2r

<table>
<thead>
<tr>
<th>PCB Label</th>
<th>Connector Pin#</th>
<th>MSP430 Pin / Label</th>
<th>Shimmer3 Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>RX</td>
<td>2</td>
<td>P3.5 / SA_SOMI_RXD</td>
<td>USART A0 SOMI or RXD or GPIO. A level shifter is required to interface with an RS-232 cable</td>
</tr>
<tr>
<td>TX</td>
<td>3</td>
<td>P3.4 / SA_SIMO_TXD</td>
<td>USART A0 TXD or SIMO or GPIO. A level shifter is required to interface with an RS-232 cable</td>
</tr>
<tr>
<td>CLK</td>
<td>4</td>
<td>FLASH_SCLK_EXT</td>
<td>USART B1 SPI CLK, or GPIO (wired to MicroSD)</td>
</tr>
<tr>
<td>SO</td>
<td>5</td>
<td>P5.4 / FLASH_SOMI</td>
<td>USART B1 SPI SOMI, or GPIO (wired to MicroSD)</td>
</tr>
<tr>
<td>SI</td>
<td>6</td>
<td>P3.7 / FLASH_SIMO</td>
<td>USART B1 SPI SIMO or GPIO (wired to MicroSD)</td>
</tr>
<tr>
<td>#RST</td>
<td>8</td>
<td>RST / MSP_RESET_N</td>
<td>Microcontroller Reset line - typically used to reset the board</td>
</tr>
<tr>
<td>A0</td>
<td>12</td>
<td>P6.6 / ADC6_FLASHDAT2</td>
<td>Analog ADC input 6 or GPIO</td>
</tr>
</tbody>
</table>
## 2.4. Test Pad Connections

<table>
<thead>
<tr>
<th>PCB PAD Location</th>
<th>Connector Pin# (name)</th>
<th>hardware.h Pin Label</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Center above Shimmer Connector</td>
<td>14 (BSL_TX)</td>
<td>PROG_OUT</td>
<td>Programming pin or interruptible GPIO</td>
</tr>
<tr>
<td>Right of Center below Shimmer Connector</td>
<td>11 (BSL_RX)</td>
<td>PROG_IN</td>
<td>Programming pin. <strong>Do not use this pin for GPIO.</strong></td>
</tr>
<tr>
<td>Left of Center below Shimmer Connector</td>
<td>9 (PV_REG)</td>
<td>N/A</td>
<td>Board pre-regulator voltage after isolation diode. When used as an output, this will be the battery voltage. Typically 2.8-3.7V. <strong>Do not exceed 200mA when using this connection.</strong> A DC power source (bench or battery) can be connected to this connection. To prevent damage to the power source a series diode is recommended when the Shimmer battery is also in use and the power supply is &lt;4.0VDC. <strong>Do not exceed 5.5V or 200mA.</strong></td>
</tr>
</tbody>
</table>

*Table 3 Test Pad Connections for Shimmer2/2r*
2.5. Board Layout

Figure 1: External Expansion Board Top View

Figure 2: External Expansion Board Bottom View
3. Using the External Expansion Board (Typical Applications)

3.1. Connecting an Analog Output Sensor

Using the sensor specification, choose either +3, +5, or +/-5V\(^3\) as the power supply connections to the sensor (in order of preference). The output of the sensor should be tied to either the A0 or A7 ADC inputs\(^4\). If the output is outside of the range of the Shimmer ADC (3V max) an attenuator must be added.

**Note:** For Shimmer2/2r there is an issue with crosstalk on the accelerometer signals when the ADC is provided with an un-buffered moderate to high impedance signal. To avoid such issues signals should be buffered with an appropriate voltage buffer.

If the sensor uses the bipolar power supply, the output must be AC-coupled via a series capacitor to an appropriate DC bias resistor network connected to the ADC input pin.

Example: A sensor requires +/-5V supply, and has an output of +/-1.25V. A 10µF capacitor is used to couple a signal such that 1.5V = zero-signal by connecting a 100k resistor from A0 (ADC0) to +3 (3.0V) and a 100k resistor from A0 (ADC0) to G (GND).

Any remaining GPIO pins can be used to configure control pins on the sensor. Verify the configuration of any of these pins in the Shimmer application code.

3.2. Connecting a Digital Output Sensor using the SPI interface

Paying attention to the required master-slave relationship in your application (Shimmer is usually master), connect up the SI, SO, and CLK pins. Use another GPIO pin as a Chip Select to complete the digital interface. The UART0 module will need to be configured for SPI mode-- there are examples for Shimmer2/2r in the TinyOS reference code library. For power supply connections choose either +3, +5, or +/-5V as the power supply connections to the sensor (in order of preference).

Remember that the Shimmer's microSD storage is also connected to the SPI bus. An internal expansion board may also use this signal. The application must ensure that the bus is correctly multiplexed using the SPI0 chip-select signals.

Any remaining GPIO pins can be used to configure control pins on the sensor. Verify the configuration of any of these pins in the Shimmer application code.

**Note for Shimmer3 users**

When using the *External Expansion Board* with Shimmer3, the SPI bus is shared with the microSD, making the interface much more complicated than that for the *PROTO3 Deluxe Expansion Board*, which uses the dedicated internal bus. For that reason, Shimmer recommends use of *PROTO3 Deluxe Expansion Board* wherever possible. Furthermore, Shimmer recommends that the *External

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\(^3\) Do not choose +/-5V for Shimmer3.

\(^4\) Note that for Shimmer3, the pin marked A0 on the Expansion Board is tied to the A6 ADC channel.
Expansion Board should only be used in cases where MicroSD will not be used, and noting that this use case will receive limited support from Shimmer.

3.3. Connecting to a Serial UART

Similar to the SPI directions above, the UART0 module must be configured for UART operation. The output signals will be digital at a 3.0V reference. A level shifter IC or RS-232 level shifter may be used to interface with instrumentation or other computers.

3.4. Connecting a Parallel Bus interface

To use a parallel bus interface, most pins will need to be configured as GPIO instead of the default functionality. Up to a 9-pin bus can be configured.

3.5. Connecting an External Power Battery Pack

The PV_REG pad can be used to solder on a battery pack or power supply. This power supply will not charge the Shimmer battery and must be isolated by a Schottky diode when the Shimmer battery is also in use. This Schottky diode should be included in the users circuitry.

Note: Do not exceed 5.5VDC.

Note: Do not exceed 200mA.

When operating without a Shimmer battery, the recommended input voltage range is 3.1-5.0V

When operating with a Shimmer battery, the recommended input voltage range after an isolation diode is 4.5-5.0V

For example, a battery pack consisting of 3 "D" alkaline cells in series is used instead of the stock Shimmer battery. The resulting voltage will be 4.5V at start. The resulting battery pack will have over 18000mAh capacity. A Shimmer application burning 25mA will run for over 2years.
4. Firmware Considerations

4.1. +/-5V DC Regulator

The signal, SER0_RTS from the processor is used as an enable signal on the 5.0V regulator on Shimmer2/2r\(^5\). When driven low (clear) the regulator will be shut down. The power consumption of the regulator in shut down state is 10\(\mu\)A.

4.2. User button

For Shimmer2/2r, the user button is pulled down on the Shimmer board. Pressing the button will result in a high signal that can be used as a polled or interruptible signal on Shimmer applications.

For Shimmer3, the user button on the External Expansion board is tied to P1.5 of the MSP430 (GPIO External).

4.3. Multifunction pins

The MSP430 processor uses multifunction pins. The functionality of the pin depends on firmware configuration. For example the pin A7 (ADC input 7) can be configured an ADC input or GPIO pin. For more information please refer to the MSP430 programmers guide and TinyOS reference code. Also, developers can post a question on the shimmer-users mailing list or support@shimmersensing.com.

\(^5\) Note this is not available on Shimmer3.