shimmer™

DISCOVERY IN MOTION

Shimmer PROTO3 Series

User Guide

Revision 1.4

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1. Introduction

This document is an accompaniment to the *Shimmer PROTO3 Series* of prototyping boards, whose aim is to help users to get started with the *Shimmer PROTO3 Series* products.

The *Shimmer PROTO3 Series* consists of three expansion boards for the *Shimmer3* platform, which can be used to interface the *Shimmer3* with an analogue output sensor, a digital output sensor, a serial UART or a parallel bus interface. There are three boards in the *Shimmer PROTO3 Series*:

- *PROTO3 Mini Expansion Board:* Connects to the *Shimmer3* via the internal expansion connectors; fits within the standard *Shimmer3* enclosure.
- *PROTO3 Deluxe Expansion Board:* Connects to the *Shimmer3* via the internal expansion connectors; requires an extended *Shimmer3* enclosure.
- *PROTO3 External[1] Expansion Board:* Connects to the *Shimmer3* via the external expansion; positioned outside the Shimmer enclosure.

The *PROTO3* series of boards enables users to incorporate additional functionality to the Shimmer, providing an outlet to develop their specific application to meet their own user requirements. The *PROTO3* boards allow easy prototyping of 3rd party sensors or custom sensing solutions with Shimmer.

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[1] The *PROTO3 External Expansion Board* is coming soon. In the meantime, the main functionality of the *PROTO3 External Expansion Board* can be achieved using the *Shimmer Expansion Board*. Information regarding use of the *Shimmer Expansion Board* with *Shimmer3* can be found in the *Expansion Board User Guide*.

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2. General Information

2.1. Pre-Requisites

- A *Shimmer3*[2] module programmed with appropriate firmware. For example, *LogAndStream* (v0.6.0 or greater) can be used to stream data over Bluetooth and/or log to the SD card while *SDLog (v0.12.0 or greater)* can be used to log data to the SD card; both are available for download from www.shimmersensing.com.
- A *PROTO3 Expansion Board.*

2.2. *PROTO3* Series Features

- Easy access to *Shimmer3* microcontroller signals using wire holes or solder pads.
- *Shimmer PROTO3 Mini* board fits inside standard *Shimmer3* enclosure.
- *Shimmer PROTO3 Deluxe* board includes 3.5mm jack connectors.
- Connect an auxiliary power supply.
- EEPROM for board identification and user storage.

2.3. Basic Overview

EEPROM

The EEPROM device on the *Shimmer PROTO3 Series* expansion boards has 2048 bytes of memory. Shimmer uses 16 bytes to store a board identifier that defines the hardware design and revision and is useful for debugging purposes. The other 2032 bytes can be used as the user sees fit, to store calibration parameters or other data. *LogAndStream* firmware from Shimmer includes commands to read and write the data on the EEPROM.

PROTO3 Deluxe

The *PROTO3 Deluxe Expansion Board* provides through-hole connections as well as two 3.5mm jacks, for interfacing with external devices, such as analog or digital sensors, from which the user may wish to measure data via the *Shimmer3*. For more details regarding the connections, refer to Section 3.1 of this document.

PROTO3 Mini

The *PROTO3 Mini Expansion Board* provides through-hole connections for interfacing with external devices, such as analog or digital sensors, from which the user may wish to measure data via the *Shimmer3*. For more details regarding the connections, refer to Section 3.1 of this document.

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[2] Please note that the *Shimmer PROTO3 Series* of prototyping boards is not compatible with *Shimmer2* and *Shimmer2r* devices. Users of *Shimmer2/Shimmer2r* should use the *Shimmer Expansion Board* for prototyping purposes, for which a user guide and product information can be found at www.shimmersensing.com.

3. Hardware Considerations

3.1. Board Layout and Connections

PROTO3 Mini

The board layout for the *PROTO3 Mini Expansion Board* is illustrated in Figure 3-1, whilst connections for the wire holes on the board and their corresponding functions are listed in Table 3-1. For details on the connections for J6 and J7, which connect the board to the *Shimmer3* mainboard, please refer to the *Shimmer3 User Manual*, which can be downloaded from the Shimmer website.
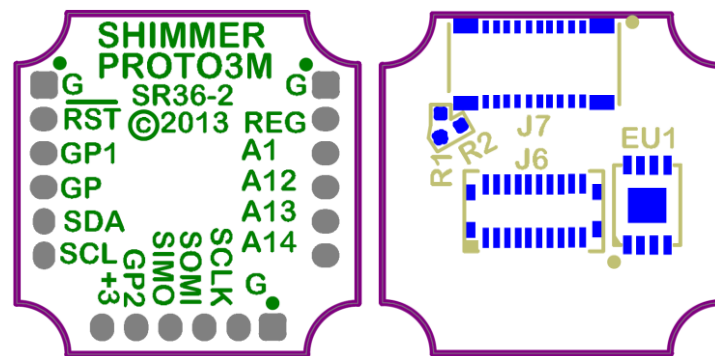

Figure 3-1 Board Layout for PROTO3 Mini Expansion Board: top view (left) and bottom view (right)

PCB Label	Connector Pin #	Shimmer3 Label	Function / Notes	Utilization detail
G	J1.1, J2.1, J3.1	GND	Ground Connection	Shared
+3	J2.6	PV	+3.0V regulated voltage	Shared
RST	J3.2	EXP_RESET_N	Digital output signal, typically used as a power-on-reset (POR) signal	Dedicated
GP	J3.4	GPIO_INTERNAL	General purpose I/O pins	Dedicated
GP1	J3.3	GPIO_INTERNAL1	General purpose I/O pins	Dedicated
GP2	J2.5	GPIO_INTERNAL2	General purpose I/O pins	Dedicated
SDA	J3.5	SB_SDA	USART B0	Shared
SCL	J3.6	SB_SCL	USART B0	Shared
SIMO	J2.4	SA_SIMO_TXD	USART A0	Shared[3]
SOMI	J2.3	SA_SOMI_RXD	USART A0	Shared[3]
SCLK	J2.2	SA_CLK	USART A0 SPI Clock	Dedicated
A1	J1.3	ADC1	Analog-to-digital converter channel	Dedicated
A12	J1.3	ADC12	Analog-to-digital converter channel	Dedicated
A13	J1.5	ADC13	Analog-to-digital converter channel	Dedicated
A14	J1.6	ADC14	Analog-to-digital converter channel	Dedicated
REG	J1.2	PV_REG	Voltage regulator input voltage	Shared

Table 3-1 Shimmer PROTO3 Mini Expansion Board connections

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[3] Shared with Dock; reserved use case.

PROTO3 Deluxe

The board layout for the *PROTO3 Deluxe Expansion Board* is illustrated in Figure 3-2, whilst connections for the wire holes on the board and their corresponding functions are listed in Table 3-2. Once again, for details on the connections for J6 and J7, which connect the board to the *Shimmer3 mainboard*, please refer to the *Shimmer3 User Manual*, which can be downloaded from the [Shimmer website](#).
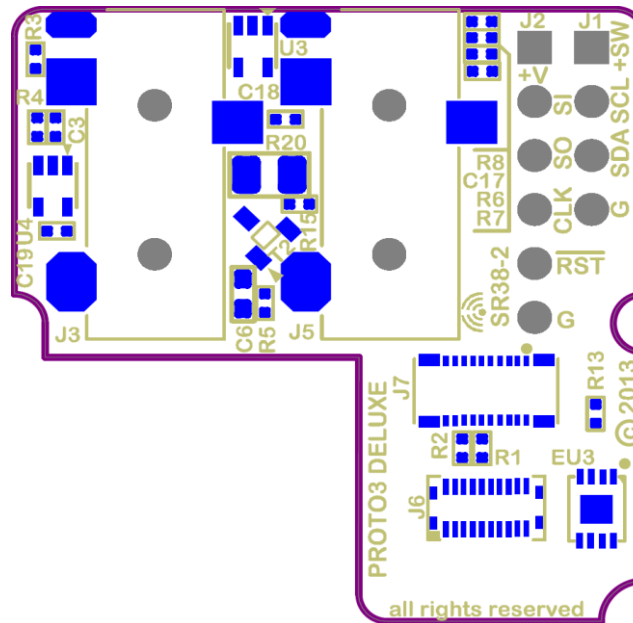

Figure 3-2 Board Layout for PROTO3 Deluxe Expansion Board

PCB Label	Connector Pin #	Shimmer3 Label	Function / Notes	Utilization detail
G	J1.4, J2.6	GND	Ground Connection	Shared
+V	J1.1	PV_I2C	I2C Peripheral power (use with I2C peripherals)	Shared
+SW	J2.1	PV	+3.0V regulated voltage.	Shared
RST	J2.5	EXP_RESET_N	Digital output signal, typically used as a power-on-reset (POR) signal	Dedicated
SDA	J1.3	SB_SDA	USART B0; install R2 (digital mode).	Shared
SCL	J1.2	SB_SCL	USART B0; install R1 (digital mode).	Shared
SI	J2.2	SA_SIMO_TXD	USART A0.	Shared[4]
SO	J2.3	SA_SOMI_RXD	USART A0.	Shared[4]
CLK	J2.4	SA_CLK	USART A0 SPI Clock	Dedicated
J3	-	-	3.5 mm jack connector	See Table 3-3
J5	-	-	3.5 mm jack connector	See Table 3-4

Table 3-2 Shimmer PROTO3 Deluxe Expansion Board connections.

The 3.5 mm 4-position jack connectors, J3 and J5, have four connections each, as labelled in Figure 3-3. Their connections are listed in Table 3-3 and Table 3-4.

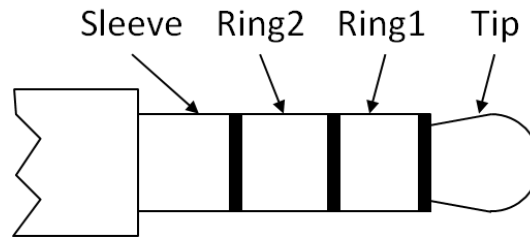[4] Shared with Dock; reserved use case.

Figure 3-3 3.5mm 4-position jack connector labels

Connector Pin #	Shimmer3 Label	Function / Notes	Utilization detail
Sleeve (J3.1)	GND	Ground Connection	Shared
Tip (J3.2)	ADC13	Analog-to-digital converter output channels (analog mode).	Dedicated
	SB_SCL	USART B0; install R1 (digital mode).	Shared
Ring1 (J3.3)	ADC12	Analog-to-digital converter output channels (analog mode).	Dedicated
	SB_SDA	USART B0; install R2 (digital mode).	Shared
Ring2 (J3.4)	PV_REG	Voltage regulator input voltage; install R5.	Shared
	PV_SW	3V if EXP_RESET_N is high.	Dedicated

Table 3-3 Shimmer PROTO3 Deluxe Expansion Board connections for J3.

Connector Pin #	Shimmer3 Label	Function / Notes	Utilization detail
Sleeve (J5.1)	GND	Ground Connection	Shared
Tip (J5.2)	ADC1	Analog-to-digital converter output channels (analog mode).	Dedicated
	PWM0	Install PWM components.	Dedicated via GP
Ring1 (J5.3)	ADC14	Analog-to-digital converter output channels (analog mode).	Dedicated
Ring2 (J5.4)	PV_REGSW	Voltage regulator input voltage; install R6.	Dedicated via GP1
	PV_SW	3V if EXP_RESET_N is high.	Dedicated

Table 3-4 Shimmer PROTO3 Deluxe Expansion Board connections for J5.

3.2. Hardware configuration options

PROTO3 Mini

All boards ship with R1 installed, providing a connection to PV_REG at J1.2.

If it is desirable to use PV_I2C at J1.2, remove R1 and install a zero-Ohm resistor for R2 (see Figure 3-1, bottom view).

PROTO3 Deluxe

Two of the inputs of the J3 3.5mm jack can be analog or digital, depending on the board configuration. See Section 3.1 for details of the connections for J3 and other board connectors.

All boards ship with analog configuration by default; this configuration can be recognised by checking that R1 and R2 are not populated (see Figure 3-2, between J6 and J7).

To switch to digital configuration, a zero-Ohm resistor should be installed for each of R1 and R2.

There is also a PWM option for the *PROTO3 Deluxe Expansion Board*. Users who require PWM functionality should contact Shimmer prior to purchase to discuss the specific requirements for their application, as factors such as end-user load and control signal filtering will determine the values of certain hardware components.

4. Using the *Shimmer PROTO3 Series* (Typical Applications)

4.1. Connecting an Analog Output Sensor

Data from an analog output sensor can be passed to the ADC lines on the Shimmer3 via the *PROTO3 Series* expansion boards.

If the sensor is to be powered via the *PROTO3 Mini Expansion Board* or *PROTO3 Deluxe Expansion Board*, the user should refer to the sensor specification to ensure that +3V is suitable for the power supply connection to the sensor. Connect the 3V and GND connections to the relevant points on the sensor.

The output of the sensor should be connected to either of the A1, A12, A13 or A14 ADC inputs. If the sensor output is outside of the range of the Shimmer ADC (0V - 3V max) an attenuator must be added. It is the user's responsibility to add the required attenuation and/or voltage shifting circuitry.

Connections to the ADC channels can be made directly to the *PROTO3 Mini Expansion Board* through-hole connections or via a 3.5mm 4-position jack to the *PROTO3 Deluxe Expansion Board*.

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.

4.2. Connecting a Digital Sensor using the I2C interface

Following the tables in Section 3.1, connect the sensor to SCL, SDA, GND and the desired power connection.

When using USART B0 bus, the I2C bus is shared with the inertial sensors on the *Shimmer3*. The *Shimmer3* board has 10kΩ pull-up resistors installed. Unless the sensor datasheet specifies otherwise, any pull-ups on the sensor (sometimes present on evaluation boards) should be removed or parts should be replaced with a value calculated based on parallel combination with 10kΩ resistors on Shimmer3 board. Care must be taken to ensure proper bus multiplexing and timing margin.

4.3. Connecting a Digital 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.

The USART A0 SPI interface is dedicated to expansion to allow robust communication with peripherals, even those that are not designed to support multiple slaves.

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.

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4.4. Using the *PROTO3 Deluxe* 3.5mm jack interface

The *PROTO3 Deluxe Expansion Board* includes two 3.5 mm 4-position jacks that can be used to interface external sensors with analog or digital channels on the *Shimmer3*.

In analog configuration (the default configuration for all shipped units), the J3 jack provides an interface with channels A12 and A13, whilst the J5 jack provides an interface with channels A1 and A14 of the ADC; both jacks provide 3V and GND connections.

Example: Optical Pulse Sensing via PROTO3 Deluxe Expansion Board

One possible use of the 3.5mm jack is to interface with an optical pulse sensor, such as the one which can be purchased on the [Shimmer website](#). The *Optical Pulse Sensing Probe* provides a photoplethysmogram (PPG) signal from a finger, ear-lobe (or other capillary tissue location on the body), which, with some processing, can be used to estimate pulse, or heart-rate.

The *Optical Pulse Sensing Probe* that ships from Shimmer has the PPG signal connected to pin 3 of the 3.5mm connector. This should be used with a *PROTO3 Deluxe Expansion Board* in analog configuration (see Section 3.2 for configuration options), such that the PPG signal will be connected to the A13 or A1 channel of the *Shimmer3* ADC, if connected via the J3 or J5 jack, respectively.

The 3V expansion power pin must be enabled for data acquisition from the optical pulse sensor. This can be achieved via any of the Shimmer Instrument Drivers (available for LabVIEW, MATLAB, C# and Android). Please see the documentation for the relevant Instrument Driver for details.

4.5. 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, commonly called "logic level" and used by most IC peripherals such as low-power radio modules or cellular modems.

A level shifter IC or RS-232 level shifter may be used to interface with instrumentation or other computers. Pay careful attention to TXD and RXD orientation.

Some peripherals utilize 3.3V signalling. It is required to place a voltage dropping device such as a diode in series with the output of the peripheral to prevent damage to the Shimmer.

4.6. 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 13-pin bus can be configured but simultaneous operation with the Shimmer's integrated inertial sensors may reduce the number of free signals. Only pins connected to Port0, Port1, or Port2 can generate system interrupts.

4.7. Connecting an External Power Battery Pack

The PV_REG pad can be used to connect 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 irreversible damage will occur to the Shimmer

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 4-5.0V

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 2 years.

www.ShimmerSensing.com   info@ShimmerSensing.com

5. Firmware Considerations

5.1. Multifunction pins

The MSP430 processor uses multifunction pins. The functionality of the pin depends on firmware configuration. For more information please refer to the MSP430 programmers guide and reference code. Also, developers can post a question on the shimmer-users mailing list or send an email to support@shimmersensing.com.

6. Appendices

6.1. Opening or assembling the PROTO3 Deluxe enclosure

Whilst the *Shimmer3* enclosures can be opened to allow hardware reconfiguration of the device (e.g. adding an expansion board), it is important to note that the plastic enclosures are not designed for regular opening and closing. In particular, it is recommended that the screws not be removed and reinserted on a regular basis as damage to the plastic by over-use of the screw mechanism will occur.

Please, consider your configurations carefully to minimise the number of hardware reconfigurations you will need to carry out.

The following instructions should be used as a guide for opening and closing the *Shimmer3* expansion enclosure and inserting the *PROTO3 Deluxe Expansion Board*.

For instructions on opening and closing the standard *Shimmer3* enclosure please refer to the *Shimmer User Manual*.

Assembling the enclosure

1. Ensure that you have all of the required plastic parts as shown in Figure 6-1, as well as two long (M2.0 x 8mm) and two short (M1.8 x 6mm) screws.
2. Assemble the orange clip fittings in the bottom of the enclosure (these are both the same so it doesn't matter which one goes to which side), as shown in Figure 6-2.
3. Install the power switch cap, as shown in Figure 6-2.
4. Place the main circuit board, with the battery attached to the underside, into the bottom of the enclosure, see Figure 6-3.
   - The bottom of the enclosure has a plastic divider to hold the battery in place; ensure that the battery is fitted beside this divider.
   - Ensure that the power switch actuator sits in the notch on the power switch cap and that the dock connector sits neatly into its slot.
   - Ensure that the battery wires are fully underneath the circuit board and not obstructing the screw positions.
   - The orange clip fittings are designed to hold the circuit board in place – it should be an exact fit.
5. Loosely place the *PROTO3 Deluxe Expansion Board* (and optionally the SD-Card), with the connectors to the underside, into the left bottom of the enclosure as soon shown in Figure 6-4.
6. Gently press the *PROTO3 Deluxe Expansion Board* in place as shown in Figure 6-5.
   - Take care not to force the connectors, which can easily be damaged by mishandling.
   - If you find that the connection is not made, realign the expansion board connectors with the *Shimmer3* connectors.
7. Carefully attach the top of the case as shown Figure 6-6. When the top is in place, gently push down on the top to close.

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o   Do not force the top closed – if there is an obstruction, remove the top to clear the obstruction before trying again.

8.   Tighten the screws in the underside of the enclosure. Before doing so, please read the notes below!

    o   **Note**: there are two sizes of screws. Make sure to use the long (M2.0 x 8mm) screws at the end closest to the External Expansion Connector and use the short screws (M1.8 x 6mm) at the end closest to of the *PROTO3 Deluxe Expansion Board* .

    o   **Note**: it is very important to hold the boss ends together while running in the screw. Do not let the screws draw the parts together as this could damage the enclosure.

    o   **Note**: do not over-tighten the screws as they may damage the top of the enclosure; when the top of the screw is flush with the plastic, stop tightening.

Figure 6-1 Plastic enclosure parts
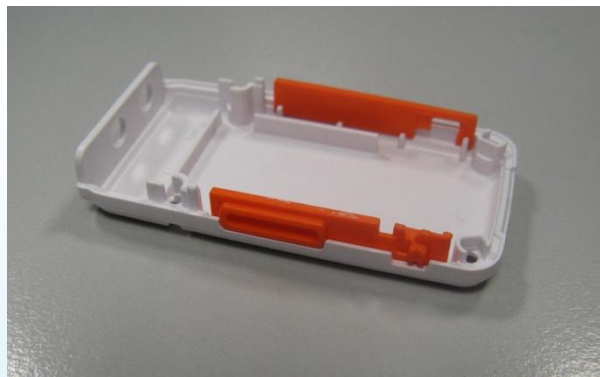
Figure 6-2 Install Power Switch Cap

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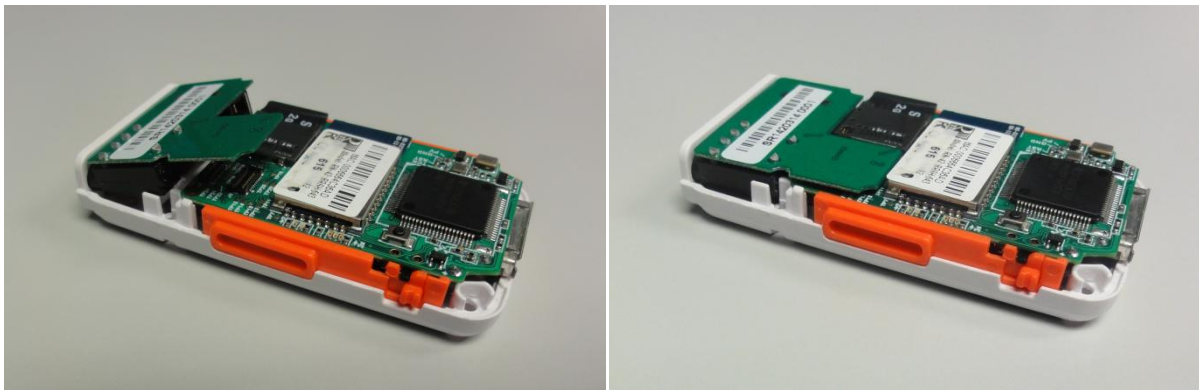*Figure 6-3 Place the main circuit board*

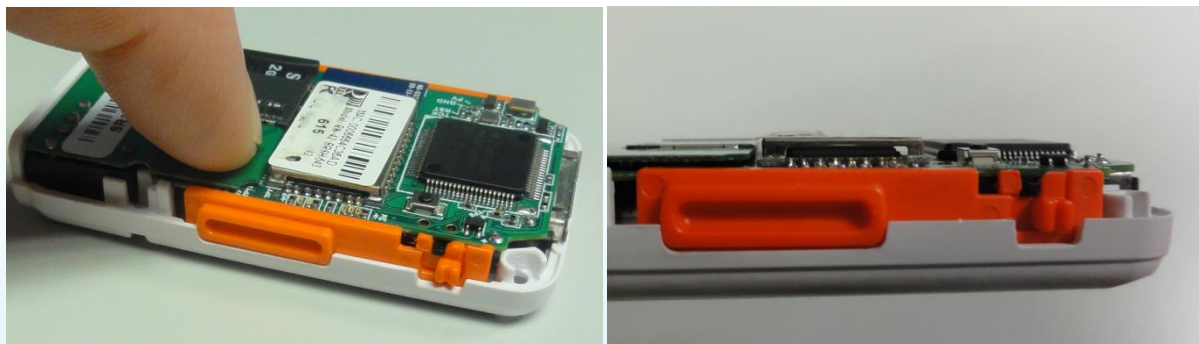*Figure 6-4 Place the PROTO3 Deluxe Expansion Board*

Figure 6-5 Press the PROTO3 Deluxe Expansion Board in place

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Figure 6-6 Closing the enclosure

Opening the enclosure to change the SD card or exchange the expansion board

1. Unscrew the screws using a T6 screwdriver.
2. Turn the unit over so that the orange button is facing up.
3. Carefully remove the top of the case, opening from the end of the External Expansion Connector, see Figure 6-7.
4. You now have access to the SD card slot and the expansion board.
5. If you need to remove the *PROTO3 Deluxe Expansion Board* , hold the main board and the enclosure between your thumb and index finger of your right hand, with your index finger at the bottom of the enclosure and your thumb on the area marked with the red `'I'` in Figure 6-8, while pulling the expansion board away from the main board in the direction indicated by the arrows.
    o   **Note**: Do not use a screwdriver for disconnecting the expansion board from the main board as this could damage the boards.
6. If, for any reason you need to remove the circuit board from the case, lift it upward out of the case. The battery should be attached to the underside of the board – ensure that it comes out of the case with the board so as not to damage the connections.

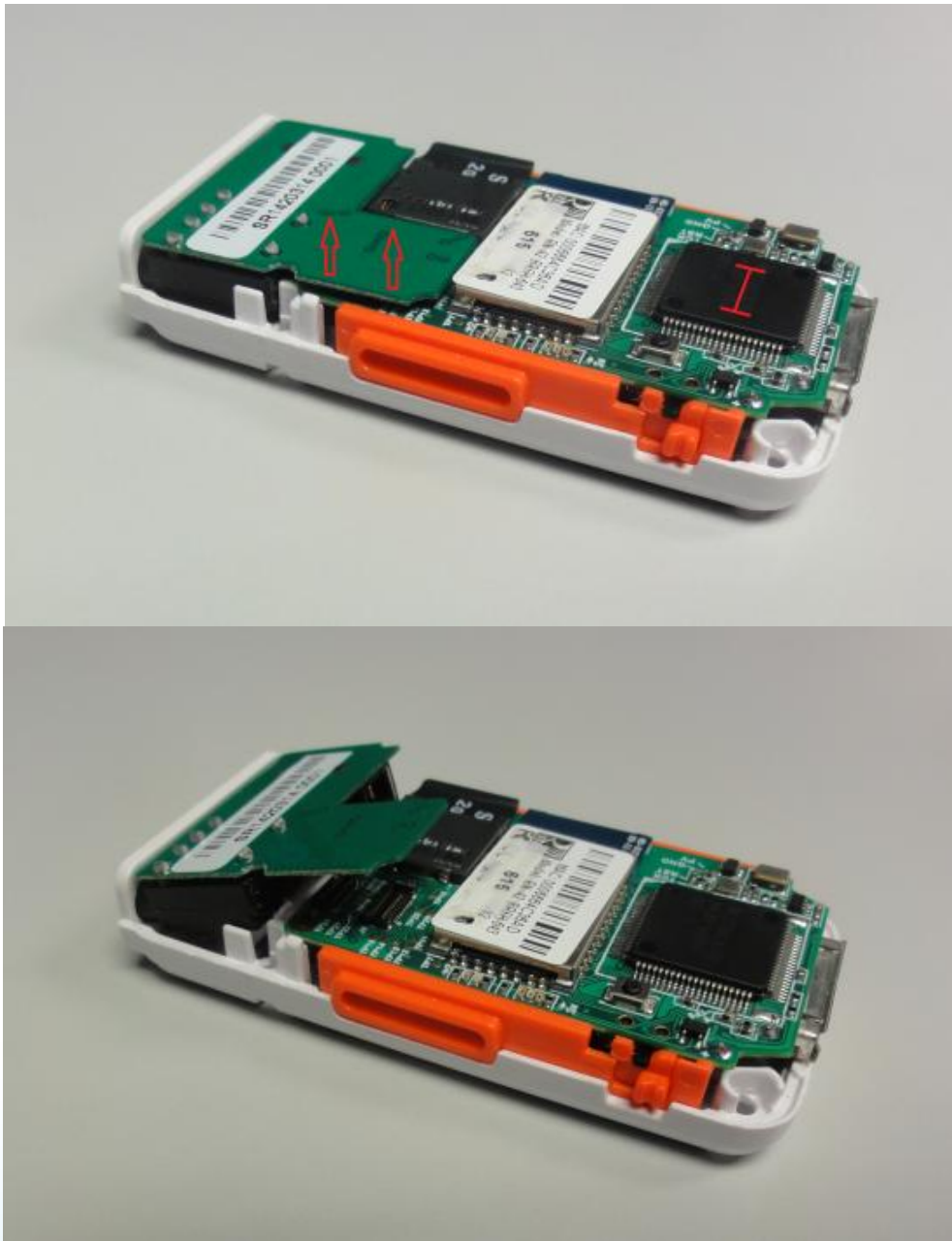*Figure 6-7 Opening the enclosure*

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Figure 6-8 Remove the PROTO3 Deluxe Expansion Board

6.2.   Assembling the PROTO3 Mini Expansion Board

When using the *PROTO3 Mini Expansion Board*, the Shimmer3 enclosure may need to be modified to allow for user-connected components and/or wires. The following instructions should be followed to attach the *PROTO3 Mini Expansion Board* to the *Shimmer3 mainboard*.

Figure 6-9, below, shows the *PROTO3 Mini Expansion Board* and *Shimmer3*.

To assemble:

1. Align the connectors J7 and J6 of the *PROTO3 Mini Expansion Board* and the *Shimmer3 mainboard*, as shown in Figure 6-10*.*
2. Gently press the *PROTO3 Mini Expansion Board. * Figure 6-11 shows the end result*.*
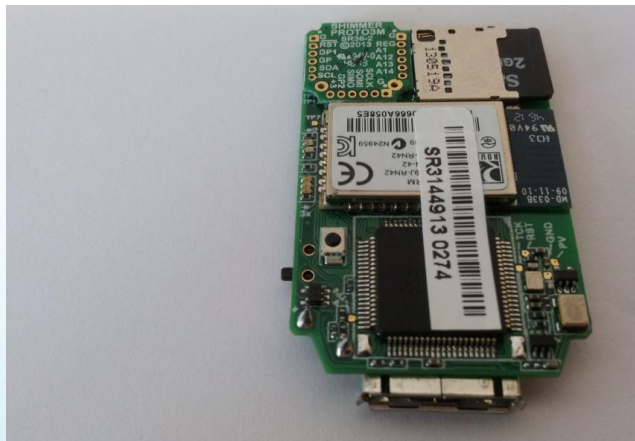

Figure 6-9 PROTO3 Mini and Shimmer3

Figure 6-10 PROTO3 Mini connected to Shimmer3 mainboard
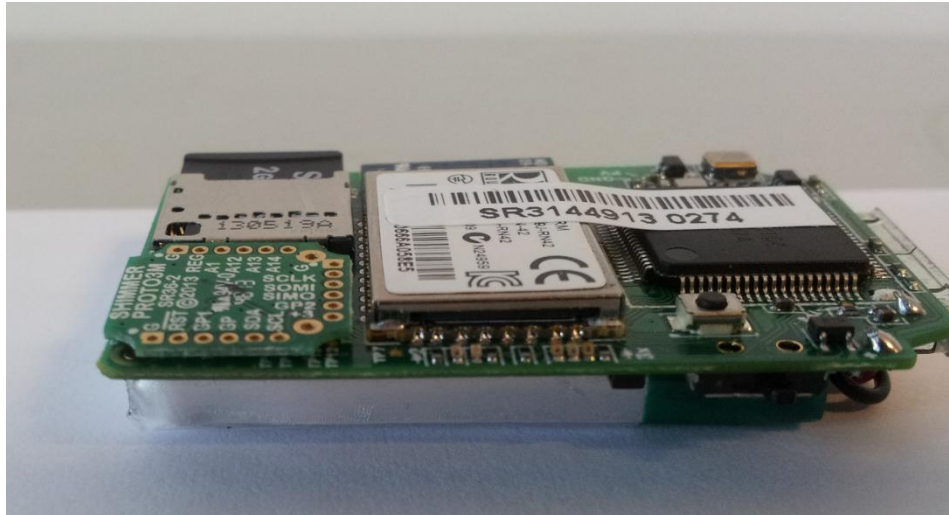
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Figure 6-11 PROTO3 Mini connected to Shimmer3 mainboard

To disassemble:

1. Gently remove the *PROTO3 Mini Expansion Board* from the *Shimmer3 mainboard* by pulling upwards*.* Avoid any shearing forces which will damage the connectors.

7. Troubleshooting

7.1. Secure connection between Shimmer and expansion board

Shimmer recommends an adhesive to secure the connection between the *Shimmer3* mainboard and Expansion Boards. The adhesive that is used by Shimmer during assembly is called Superdots (www.superdots.com). We use the Ultra Tak variety. With Superdots applied, the expansion boards can still be removed and swapped out, if required, as the adhesive does not go solid but has a rubbery consistency, allowing it to be removed. However, customers should remember that frequently removing expansion boards is not recommended and can cause damage to the connectors. Superdots also provides some shock absorbtion.

Shimmer fits the Superdots by stretching them around the edges of the Expansion Board. This ensures that the adhesive doesn't prevent the connectors from making a good connection and there is enough adhesive to secure the boards together but not to interfere with the fit.

Note: Shimmer does not supply Superdots.

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