

# Imp™ User Manual

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## Overview

The Imp is a 128-channel impedance tester intended for testing electrode impedances on the bench, *in vitro*, or *in vivo*. The low voltage and low current of the test signal are suitable for *in vitro* and *in vivo* operations and limits any electrochemical reactions that normally occur with larger voltages and currents.

## Imp features

- 128 channels
- Large working range: 100  $\Omega$  to 100 M $\Omega$
- 1.4 Hz to 10 kHz test frequencies
- Low test voltage and current suitable for *in vitro* and *in vivo* testing
- Fast measurement time for 128 channels
- Standard connector spacing and pinout – works with existing adapters
- Software available for Windows and macOS

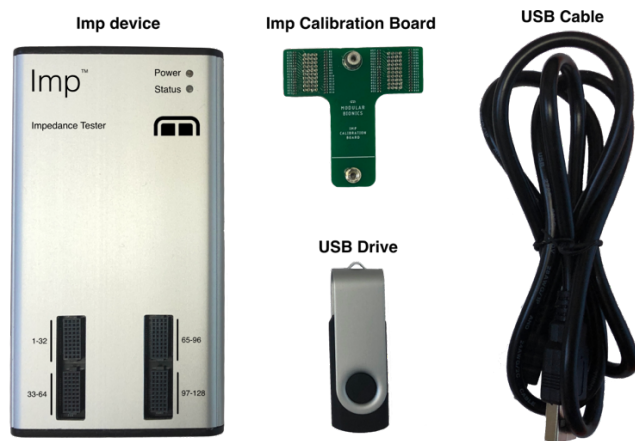
## In the Box

**Imp device**

**USB cable**

**Imp Calibration Board**

**USB drive** containing Imp App and user manual



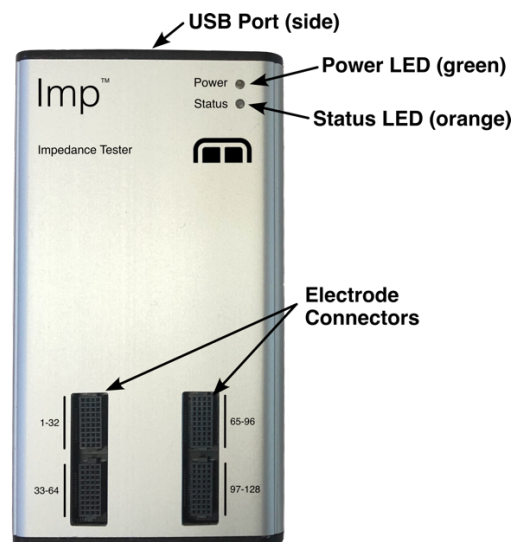
## Device overview

**Power LED (green):** Solid during normal operation. Briefly flashes when connecting to the PC and the Imp App.

**Status LED (orange):** Solid during measurements and when the device is busy. LED will turn off briefly when switching channels or test frequencies.

**Electrode Connectors:** Connects to electrodes and adapters. See Appendix for connector pinout and mechanical details.

**USB Port:** USB interface to the PC



## Quick Start

### Quick Start - Setup

1. Install the Imp App located on the provided USB drive.
2. Plug Imp into your computer with the provided USB cable.
3. Imp drivers should install automatically.
4. Start the Imp App. The power LED (green) remains solid during normal operation and might flash several times when connected to a PC or while the app identifies the device.
5. The Impedance Tab in the Imp App can be used to measure impedances.
6. A digital user manual is provided on the USB drive.
7. The Imp may be disconnected at any time.

### Quick Start – Imp App Overview

1. The Impedance Tab is used for measuring impedances.
2. The Map Tab is used to define and edit custom maps.
3. The Utilities Tab is used for calibration and firmware updates.
4. Test measurements can be made with the Calibration board. Expected values are listed in the manual.

## Software Installation

### macOS

1. Open **Imp-macOS.dmg** located on the provided USB drive.
2. Drag the **Imp App** into your Application folder (shortcut provided in .dmg file)
3. Connect the Imp to the computer with provided USB cable.
4. Open the **Imp App**. If a message is displayed about the app being from an unidentified developer, then you will need to approve this app to run in the Privacy & Security settings. Full instructions are found here: <https://support.apple.com/guide/mac-help/open-a-mac-app-from-an-unidentified-developer-mh40616/mac>
5. The **Imp App** will automatically detect the connected Imp.
6. Installation complete.

### Windows

1. Open Imp-Windows.exe located on the provided USB drive.
2. Follow the installation prompts to complete installation.
3. Connect the Imp to the computer with provided USB cable.
4. Open the **Imp App** if it is not already open.
5. The **Imp App** will automatically detect the connected Imp.
6. Installation complete.

## Functions and Operations

The Imp App provides a user-friendly interface for measuring impedances and defining maps. The main functionality is separated into three tabs near the top of the window:

1. The **Impedance Tab** is used for measuring impedances.
2. The **Maps Tab** provides a map editor for creating new maps and editing existing ones.
3. The **Utilities Tab** allows the user to calibrate the Imp and display version information.

## Measuring Impedances – (Impedance Tab)

Impedance measurements are performed with the Impedance Tab. Start by selecting the desired frequencies, impedance range, and map. Pressing the Start Measuring button will start the impedance measurements. Data are saved in as tab-delimited plain text.

The screenshot shows the 'Imp App - Modular Bionics' interface. The 'Impedance' tab is active. The 'Start measuring' button is highlighted. The 'Test Parameters' section includes an 'Impedance Range (ohm)' dropdown set to 'Autorange (Max 280 nA)', a 'Frequencies (1 of 16 selected)' list with '1000 Hz' checked, and 'Channels' controls. The 'Channels' section has 'Show Disabled Channels' and 'Show Unmapped Channels' checked, and 'Enabled' channels for 'Electrode ch 1-32', '33-64', '65-96', and '97-128'. A 'Live signal view' at the bottom shows a purple line. The 'Data table' on the right has columns for 'Electrode Ch', 'Imp Ch', '1000 Hz Mag (Ohm)', and '1000 Hz Phase (deg)'. Annotations point to various UI elements:

- Status message:** Ready
- Start / Abort button:** Start measuring
- Impedance range:** Autorange (Max 280 nA)
- Test frequency list:** 1.4 Hz, 2.7 Hz, 5.5 Hz, 9.6 Hz, 20.6 Hz, 30 Hz, 55 Hz, 100 Hz, 200 Hz, 300 Hz, 600 Hz, 1000 Hz, 2000 Hz
- Show channels control:** Show Disabled Channels, Show Unmapped Channels
- Enabled channels control:** Electrode ch 1-32, 33-64, 65-96, 97-128
- Live signal view:** Test Voltage, Measured Current
- Enable / disable channel checkbox:** Individually enable or disable a channel with checkboxes. To view disabled channels, check the Show Disabled Channels checkbox.
- Map selection:** Active Map: Direct 1-to-1 Map
- Save button:** Save data
- Data table:** A live update of collected data.

### Impedance range options

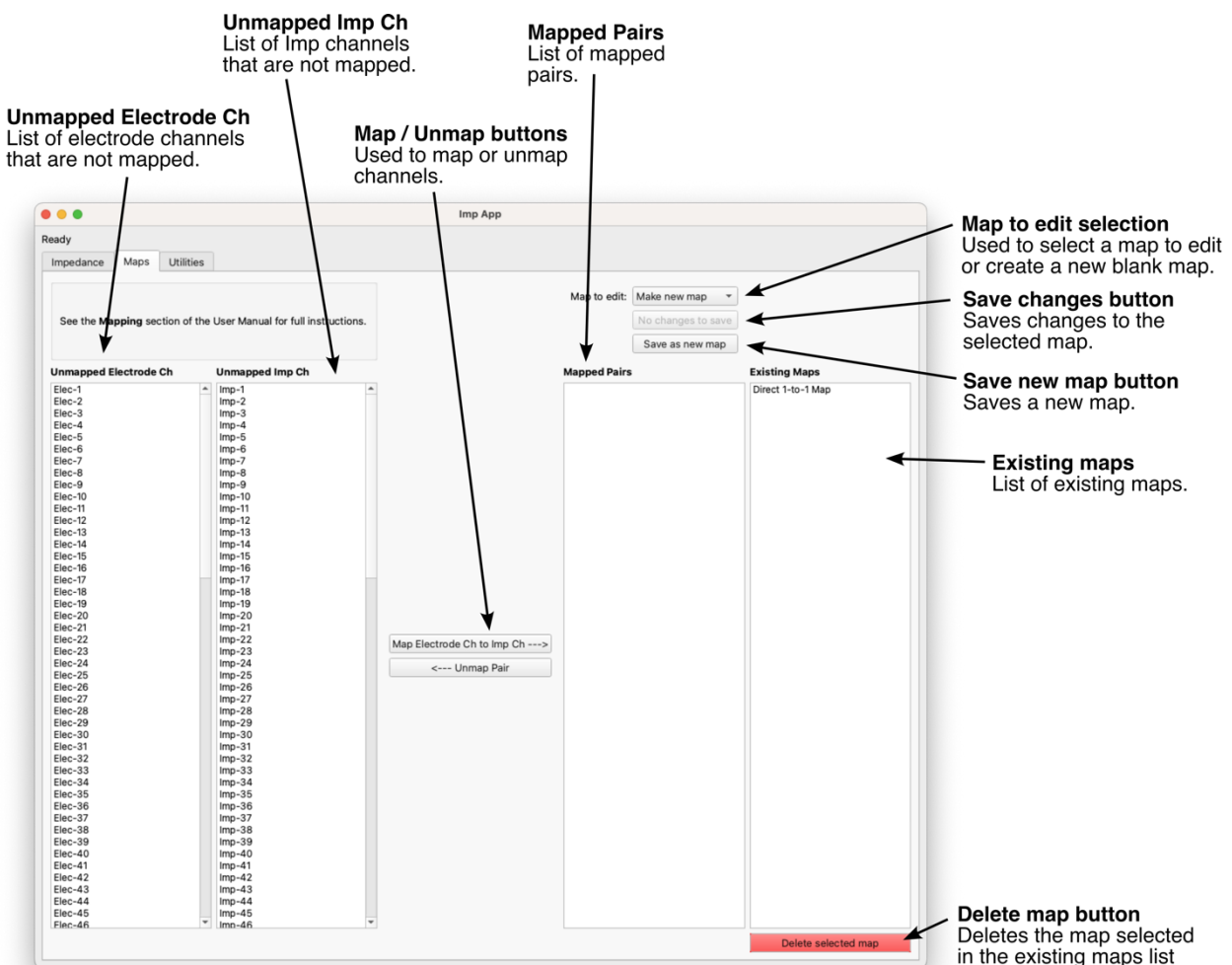
The app offers three impedance ranges:

1. **Autorange** has the largest impedance range but will take longer than other ranges if it requires multiple measurements for a given result.
2. **High** range has the lowest maximum current, useful for experiments that require minimal levels of current.
3. **Low** range can be faster than **Autorange** if all measured impedances are in **Low** range.

## Mapping – (Maps Tab)

Maps provide a convenient method for organizing impedance data. It is common for the electrode (or adapter) channel numbers to not match the connected Imp channel numbers. Maps allow the user to determine which channels are measured and the order they are displayed. See Appendix B for the Imp connector pinout and mechanical specification.

The **Map electrode ch to Imp ch button** maps the channel selected in the **Unmapped Electrode Ch list** to the channel selected in the **Unmapped Imp Ch list**. These mapped channels are removed from the unmapped lists and displayed as a mapped pair in the **Mapped Pairs list**. Similarly, the **Unmap pair button** unmaps the pair selected in the **Mapped Pairs list**. These now unmapped channels are removed from the **Mapped Pairs list** and are displayed in the Unmapped channel lists. To change a mapped pair, it must first be unmapped and then re-mapped with the desired changes.



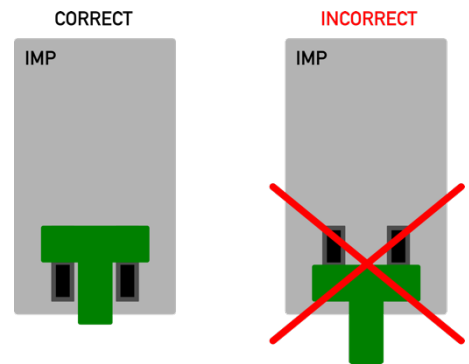
## Calibration – (Utilities Tab)

The Imp comes factory calibrated. Re-calibration on a yearly basis is recommended and can be performed with the provided calibration board. The app will provide a message if no calibration file is found on the device.

## Calibration steps

Do not handle the device during calibration and position it away from any electromagnetic interference.

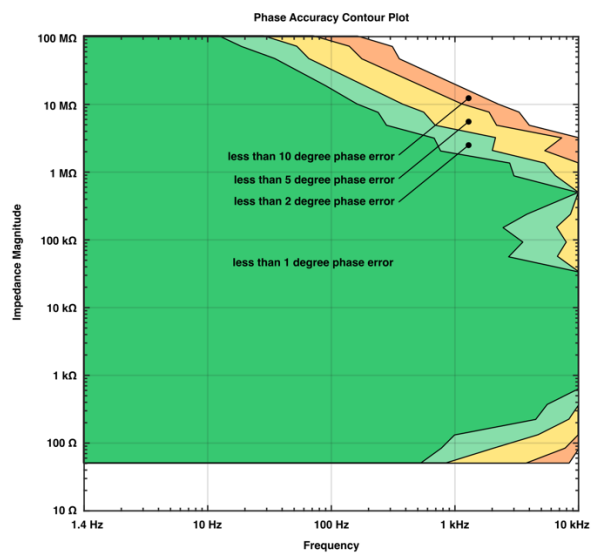
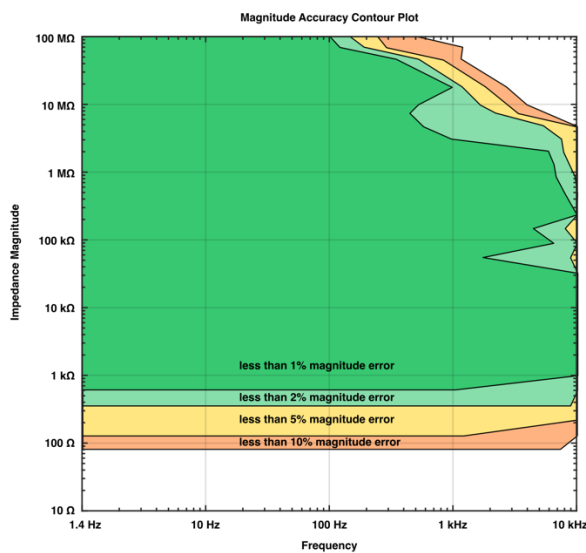
1. Connect the Imp to the computer.
2. Attach the calibration board as shown below.
3. With calibration board attached, let the Imp warm up for at least 30 minutes.
4. Go to the Utilities tab in the app and click on the Calibrate button.
5. Follow the additional dialogs and run calibration.
6. The Status LED will blink during the calibration process. Do not disconnect the Imp during the calibration process.
7. Calibration is complete and the Imp is ready to use when the Status LED remains off and the status in the Imp App changes from “Calibrating” to “Ready”





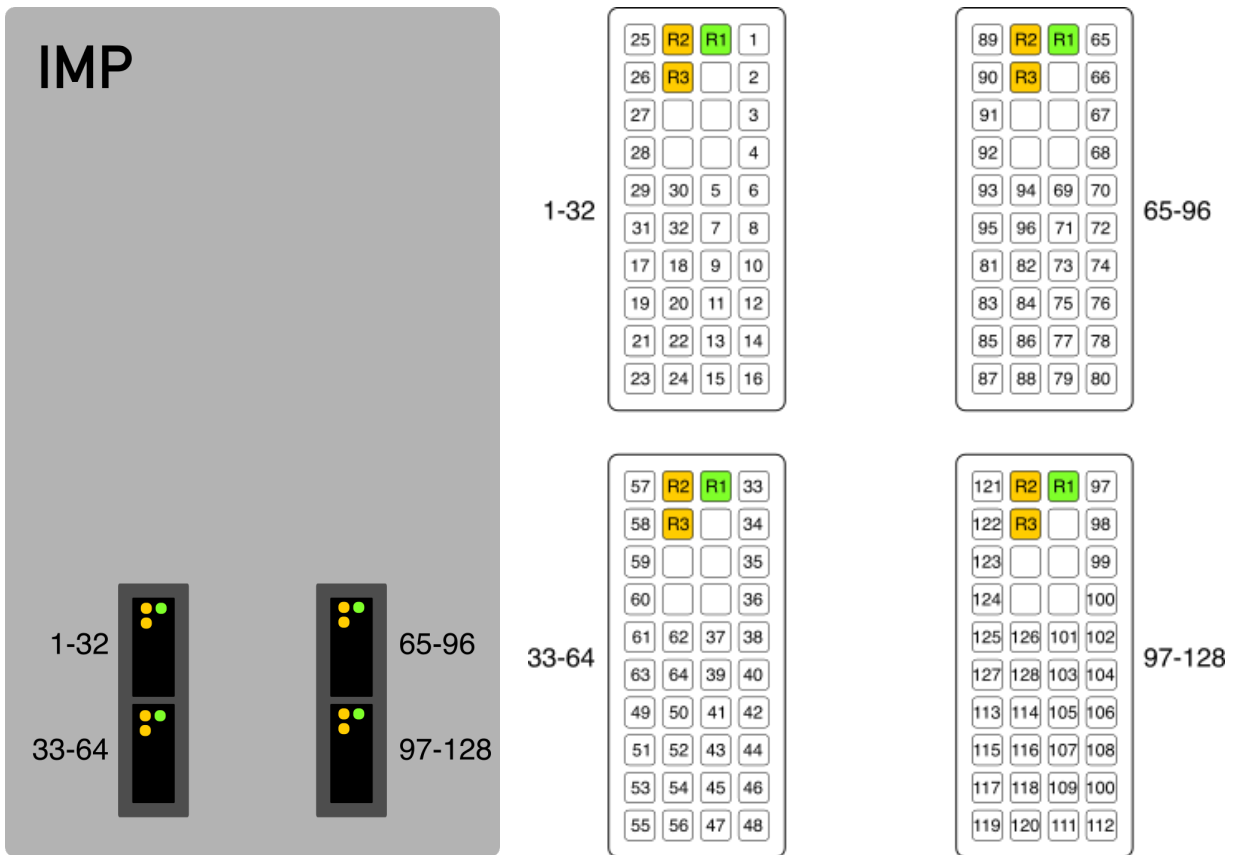
## Appendix A: Specification

- Number of channels: 128
- Impedance measurement range: 100  $\Omega$  to 100 M $\Omega$  (Aurorance)
  - High: 20 k $\Omega$  to 100 M $\Omega$
  - Low: 100  $\Omega$  to 50 k $\Omega$
- Impedance test frequencies: 1.4 Hz to 10 kHz sinusoid
- Display resolution: 1  $\Omega$
- Accuracy: See accuracy plot
- Impedance test signal: 4 mV peak-to-peak sinusoid
- Maximum current: High mode = 2.8 nA RMS Max, Low Mode = 280 nA RMS Max
- Autoranging: Yes
- Imp connectors: 4x Samtec FOLC-110-L1-S-Q
- Imp interface: Compatible with existing 3<sup>rd</sup> party adapters with 1x and 2x FOLC-110-01-S-Q connectors
- Computer interface: USB 2.0
- Calibration: Device-specific calibration data is stored on the device
- Weight: 126 g
- Dimensions: 126 mm x 70 mm x 12 mm
- Software compatibility:
  - Windows 8 or newer
  - macOS 10.5 (Catalina) or newer
- Low test current range (High impedance mode) suitable for *in vitro* and *in vivo* testing
  - < 1 nA RMS for  $|Z| > 1 \text{ M}\Omega$
  - < 2.8 nA RMS for  $|Z| < 1 \text{ M}\Omega$



Accuracy contour plots were based on impedance measurements in Autorange mode of fixed resistors between 51  $\Omega$  and 100 M $\Omega$ . Magnitude and phase accuracy assumed ideal resistor behavior. Magnitude accuracy was evaluated by comparing the Imp impedance magnitude measurements to the compensated impedance magnitude measurements at 1 Hz of a Gamry Reference 600 potentiostat. Phase accuracy was evaluated by comparing the Imp impedance phase measurements to 0 degree phase.

## Appendix B: Connector Pinout and Mechanical Specification



**Imp channels** are numbered in the image to the right.

**R1 (green)** outputs the test voltage and must be physically connected to the electrolyte for proper operation. All four of the R1 pins are electrically connected together.

**R2, R3 (orange)** are reserved for future use and should have nothing connected to them to (i.e., these pins must be floating).

**Boxes without numbers** have no function.

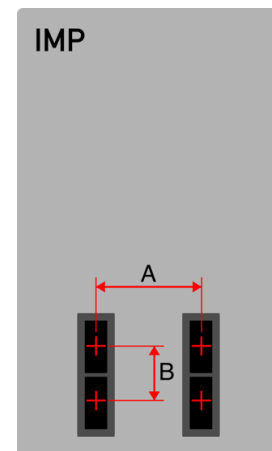
**Connectors on Imp:** Samtec FOLC-110-L1-S-Q

**Mating connectors:** Samtec MOLC-110-01-S-Q

**A** = 28 mm center-to-center

**B** = 17 mm center-to-center

**Note:** Red crosses indicate the center of each connector and are aligned vertically and horizontally.



## Appendix C: Imp Calibration Board Values

Imp Channel	Resistance (1% tolerance)	Capacitance (5% tolerance)
1	0 Ω (Short)	-
2	-	0.1 uF
3	499 Ω	-
4	499 kΩ	-
5	1 kΩ	-
6	2 kΩ	-
7	16.9 kΩ	-
8	499 kΩ	-
9	4.12 kΩ	-
10	8.45 kΩ	-
11	4.99 kΩ	-
12	499 kΩ	-
13	34.8 kΩ	-
14	69.8 kΩ	-
15	143 kΩ	-
16	499 kΩ	-
17	287 kΩ	-
18	1.18 MΩ	-
19	2.43 MΩ	-
20	499 kΩ	-
21	4.87 MΩ	-
22	10 MΩ	-
23	20 MΩ	-
24	499 kΩ	-
25	-	220 pF
26	-	10000 pF
27	-	33 pF
28	499 kΩ	-
29	4.99 kΩ	-
30	499 kΩ	-
31	-	1000 pF
32	Open	

Imp Channel	Resistance (1% tolerance)	Capacitance (5% tolerance)
65	0 Ω (Short)	-
66	-	0.1 uF
67	499 Ω	-
68	499 kΩ	-
69	1 kΩ	-
70	2 kΩ	-
71	16.9 kΩ	-
72	499 kΩ	-
73	4.12 kΩ	-
74	8.45 kΩ	-
75	4.99 kΩ	-
76	499 kΩ	-
77	34.8 kΩ	-
78	69.8 kΩ	-
79	143 kΩ	-
80	499 kΩ	-
81	287 kΩ	-
82	1.18 MΩ	-
83	2.43 MΩ	-
84	499 kΩ	-
85	4.87 MΩ	-
86	10 MΩ	-
87	20 MΩ	-
88	499 kΩ	-
89	-	220 pF
90	-	10000 pF
91	-	33 pF
92	499 kΩ	-
93	4.99 kΩ	-
94	499 kΩ	-
95	-	1000 pF
96	Open	

**Note 1:** The impedance of a capacitor decreases as frequency increases. The phase of an ideal capacitor is -90 degrees.

**Note 2:** The impedance of an ideal resistor does not depend on frequency and has a phase of 0 degrees. The impedance of real resistors has some frequency dependence due to parasitic capacitance and/or inductance, which is more pronounced in larger value resistors and at higher frequencies. These parasitic effects are observable with megaohm resistances and kilohertz frequencies on the calibration board.