Platypus AudioToy
Technical Manual

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8x8 Matrix Audio Mixer hardware
for the
Teensy Audio Library

An 8x8 sound card based on the CS42448 and CS CS5343

Two input modules for balanced or unbalanced mic/line or inst/line operation

An output module capable of driving balanced or unbalanced loads at +8dbM

An I2C to GPIO expander board that also drives WS2812B LEDs.

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Description

The Platypus AudioToy is a modular 8x8 sound card intended to be fully software compatible and generally hardware compatible with Paul Stoffregen's revised CS42448 8x8 audio board (see https://hackaday.io/project/2984/logs) and software compatible with the CS42448 and TDM objects in the Audio Library. A single register write is required to enable balanced inputs on the CS42448 (which has the potential to improve SNR by 6dB).

While additional +/- supplies specifically for audio circuits are supported, all the boards in the set operate off a single 5V supply, either via USB or a power adapter. All control functions (other than a single pin to drive WS2812B level indicator LEDs) are I2C controlled, to preserve GPIO pins for other purposes.

Two fully-interchangeable input boards are offered, both accepting either balanced or unbalanced inputs and gain-controlled via I2C:

- A two channel mic/line preamp. Input is via an XLR-TRS combo jack that auto-switches to 'straight through' operation for line-level inputs. Notification of TRS insertion is available as a GPIO signal.
- A two channel inst/line preamp. A GPIO pin (to the IS2 to GPIO board) controls a 20dB pad, extending the gain range of the module.

An output board that provides four buffered differential outputs capable of driving 600 ohm lines at +8dBm

A small utility board provides I2C to GPIO conversion to translate the I2C bus voltage (3.3V to 5V), preserve Teensy GPIO pins for other purposes and provide a level shifter to drive a WS2812B LED string for level indicators.

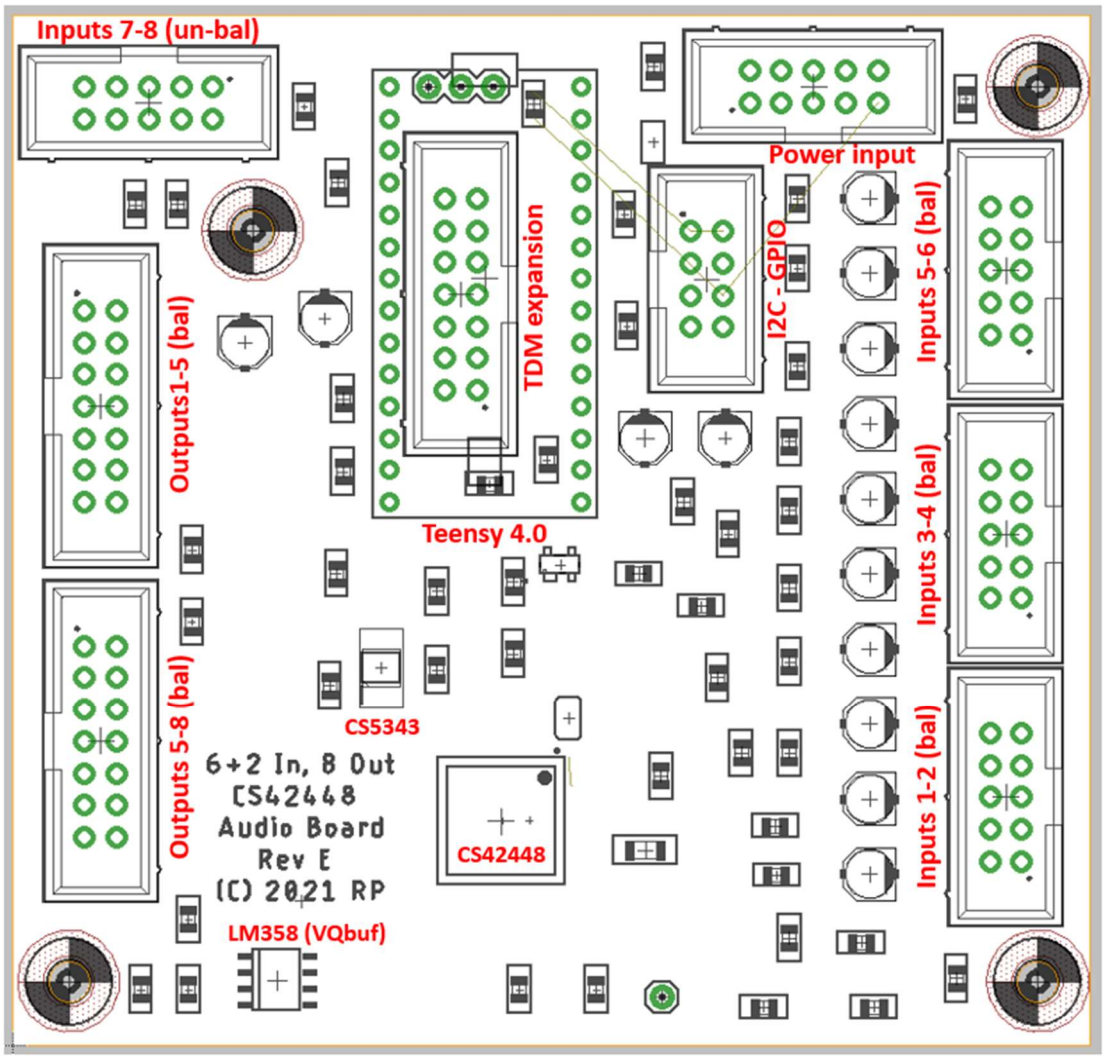
The modules were designed as part of a larger project to develop a compact, remote controlled, 8x8 monitor matrix mixer for live performance. The mixer is WiFi enabled with a comprehensive browser interface plus a standalone touch screen controller based on an ESP32.

Modules

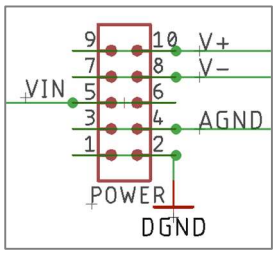
Main Codec board

The main codec board employs a CS42448 6 x8 codec with a satellite CS5343 two input ADC. This chip has marginally better specifications than the PCM1808 used in Paul's design. It features fully balanced inputs and outputs wired to headers that also provide power for preamps.

The CS5343 has single-ended inputs and a slightly different full scale input (0.57 * VA) to the CS44248 (0.56*VA).



Power header



VIN is connected to the same named pin on the Teensy 4.0 socket. It is a general purpose 5V supply. A

local audio 5V supply (VA) is decoupled by a ferrite bead from the digital supply. While VA is provided to the input and output boards as well as supplying the Cs42448, it should not be

used for currents > 5mA, as currents greater than this will cause a significant voltage drop across the single ferrite bead inductor (R ~0.5 ohms) used to decouple VA from VIN.

All audio modules in this set use V+ to power their audio circuitry. (See below for digital powering arrangements via the I2C_PAD header).

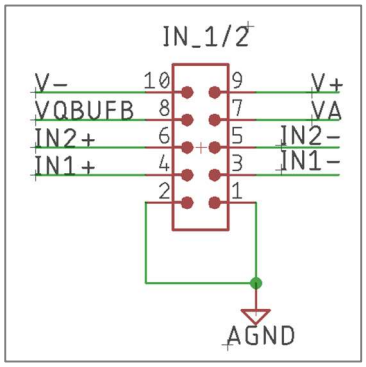
V+ and V- are routed to the input and output board connectors. For these boards, it is sufficient to provide 5V to V+ (V- is not used). Connect a small (e.g. 10uH) inductor between the VIN and V+ (pins 5/6 & 9/10) on the POWER header. With a full complement of modules, the total current is about 100mA. (Kemet SBC2-100-212 pictured).

Analog and digital grounds are separated (joined under the CS42448) wherever possible to reduce audio noise. Where possible, Vin should be returned via DGND, V+ and V- returned via AGND.

Audio input headers

Two channels of balanced input audio are carried on each header (inputs 7-8 are unbalanced, only using the INx+ pins).

Audio inputs are DC isolated by 10uF capacitors and 150 ohm series resistances to improve the robustness to overvoltage inputs.



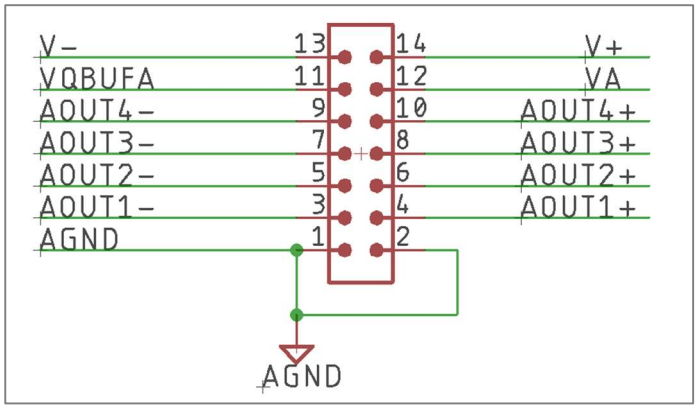
V+ and V- are audio supply voltages provided by the power input header.

VA is a decoupled 5V supply derived from VIN and should not be used for significant current drains (> 5mA per connector).

VQBUF is a buffered CS42448 VQ voltage for inputs 1-6 (0.5 * VA).
Inputs 7-8 have a different, unbuffered VQ voltage from the CS5343 (0.44 * VA).
Given the capacitor isolated mainboard inputs, this voltage is only provided as an easy-access, mid-supply reference.

Audio output headers

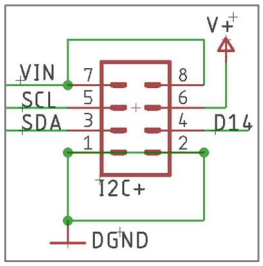
Four channels of balanced output audio are carried on each header. The output voltage is biased to VQ (VQBUFA).



Voltages are as for the Input headers.

Auxiliary headers

I2C_PAD

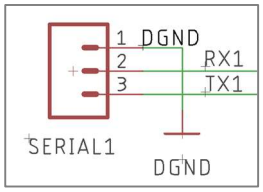


3.3V (V+) and 5V (VIN) are provided.

SDA and SCL have on-board 2.2k pullups to the 3.3V rail.
Pin 4 is connected to GPIO D14 (the standard GPIO for the WS2812B library).

Serial

A serial connection, directly connected to Teensy pins D0 and D1 is provided. It operates at Teensy 4.0 digital levels.



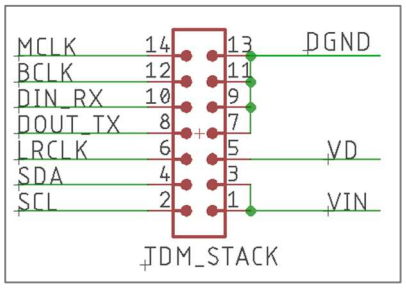
TDM stacking (experimental)

An additional header to accommodate Paul Stoffregen's planned TDM stacking capability is provided. Positional alignment is as close as is possible by visual alignment with the image in Paul's Hackaday post (https://hackaday.io/project/2984/logs).

VD is 3.3V. VIN is 5V.

It has not been tested and the pins may not be correct.

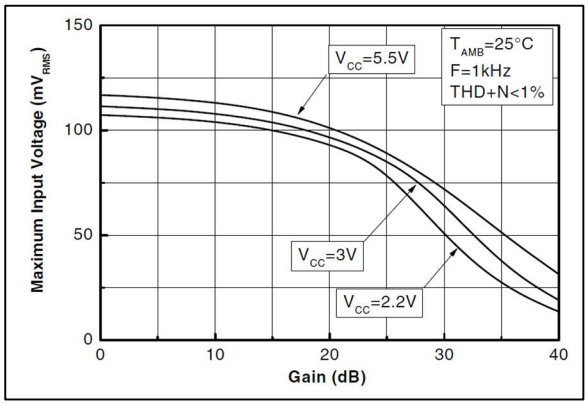
It is understood that additional hardware and code will be required for boards to be successfully stacked.



Two Channel Mic/Line Input Board

This board employs TS472 preamp chips that have their gain controlled by a MCP47CB22 12-bit, two channel I2C DAC. The MCP47CB22 1.227V output range (x1) is most suitable for this purpose, allowing approximately 500 steps (0.0-0.15V) of gain between 0 and +40dB. A voltage divider could have been used to provide more granular control, however a rail-to-rail buffer amplifier buffer would need to be added as V_{GS} is a low impedance input (68 ohms).

The TS472 is only suitable for microphones or other low-level signals due to its limited maximum input voltage (110mV RMS). Despite gains of > 1 (< 0dB) being available (V_{GS} = 0.15 – 0.35V), the maximum input voltage limitation makes these gains practically useless.



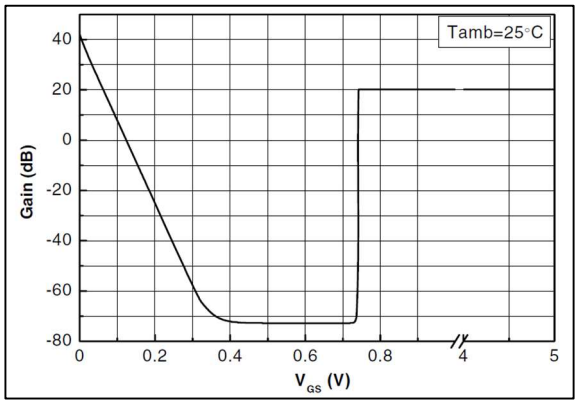


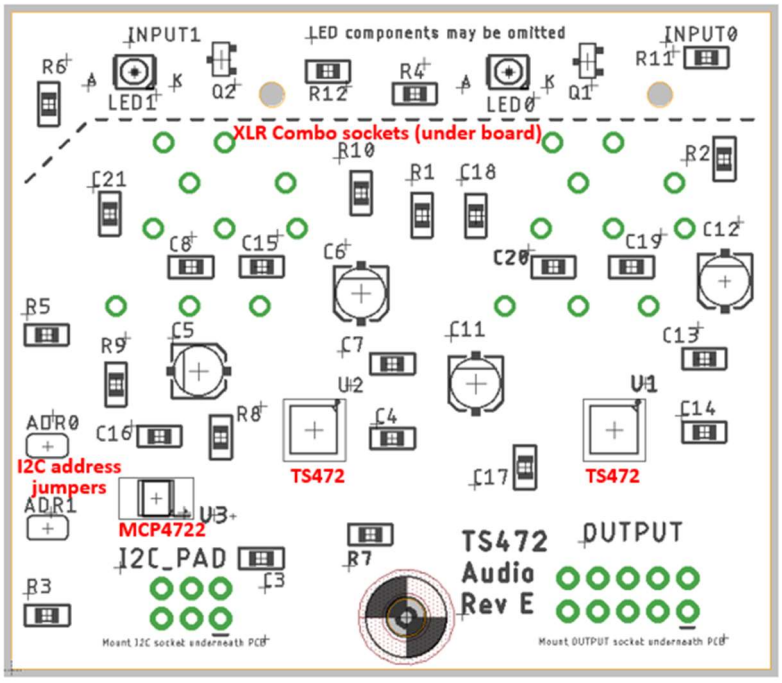
Figure 1. TS472 maximum input voltage vs gain

Figure 2. TS472 gain vs V_{GS}. (st.com)

When a TRS jack is inserted, IC2_PAD:6 (or 8) goes high. (The I2C_PAD header signals are described in the I2C Extender Board section below.)

The standby function of the TS472 is not supported.

Layout



Input and output headers are as defined for the main board.

Only 5V (V+) is used on this board.

A separate 5V logic supply is provided for the MCP4722 via the I2C_PAD connector.

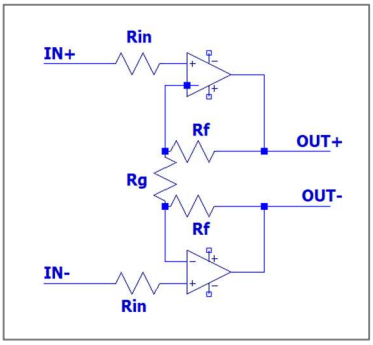
The components above the dotted line on the PCB are optional, driving the two indicator LEDs indicating TRS insertion.

1206 MLCCs may be substituted for the electrolytic capacitors (C5, 6, 11 & 12) with only a notional reduction in performance.

The XLR Combo sockets, as well as the I2C_PAD and OUTPUT headers are mounted *under* the PCB.

Two address jumpers are provided to permit up to four boards to be used on a single I2C bus.

Two Channel MCP604 Line/Instrument Input Board

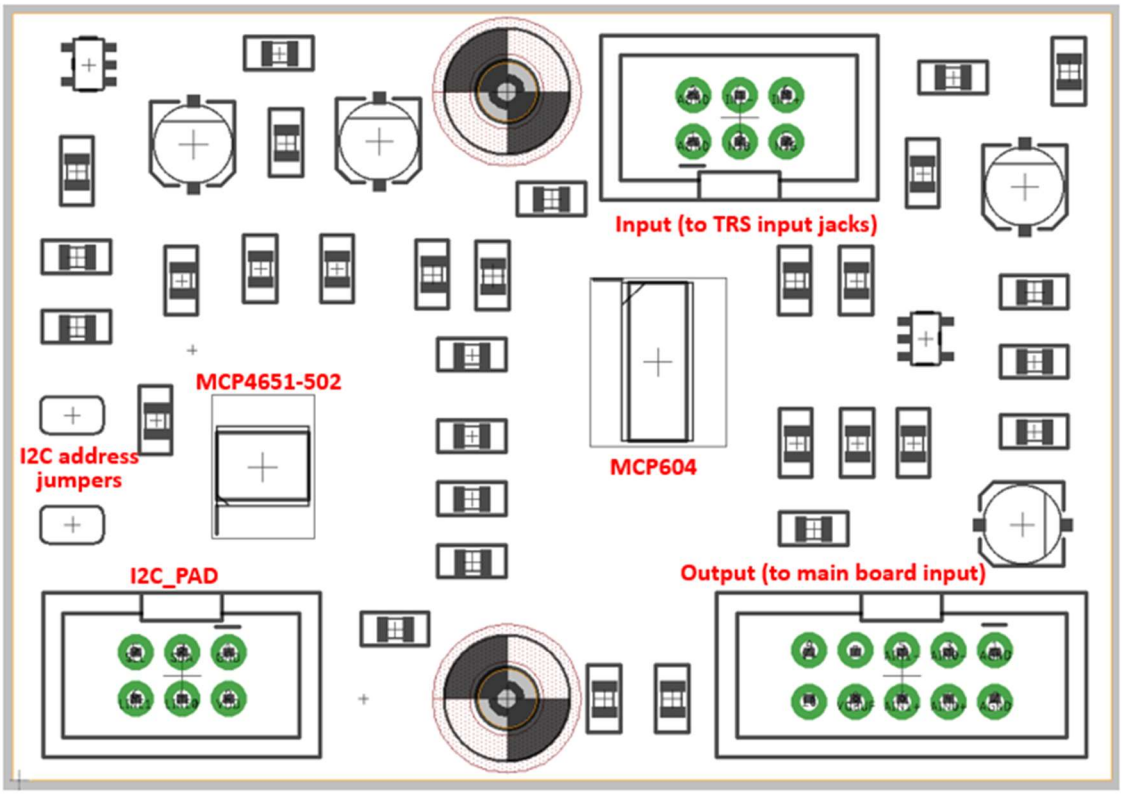


The MCP604 op amps are employed in a gain-controlled balanced instrument amp configuration. The control elements (Rg) are MCP4651 digital pots. Gain is 1+2*Rf/Rg.

With a 5k digital pot, an additional 270 ohm series resistor, and Rf = 10k, the effective gain range is +9 to +29dB (Av = 2.9 to 30). Additional headroom is provided by a 20dB pad, with the overall gain being -11 to +9 dB if the pad inserted.

When IC2_PAD pin 4 (or 6) is set high, the 20dB pad is inserted into the input. This reduces the effective input impedance to 10k Ohms for line inputs. (The I2C_PAD header signals are detailed in the I2C Extender Board section below.)

The input is high impedance without the pad inserted, of the order of 2M Ohms, and thus suitable for electric guitars and other instrument inputs. When the pad is enabled, the impedance drops to 10k Ohms.



The output header is as defined for the main board.

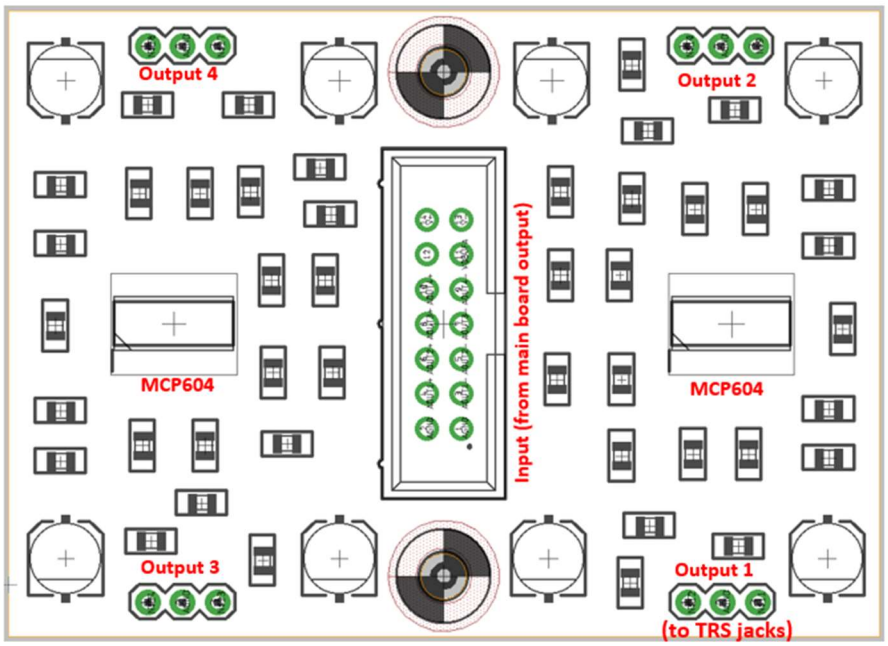
Only 5V (V+) is used on this board. The SN74LVC1G66 analog switches used to connect the input pads are powered from V+ to reduce noise injection.

A separate 5V logic supply is provided for the MCP4561 via the I2C_PAD connector.

Two address jumpers are provided to permit up to four boards to be used on a single I2C bus.

Four Channel Output Board

Unity gain MCP604 op amps drive the output in fully differential mode. 220 ohm current limiting resistors are included on the outputs, allowing the TRS ring connection to be grounded safely if a mono jack is inserted.



The input header is as defined for the main board outputs.

Output headers have GND on the middle pin to allow flexibility in output polarity.

Positive output is Pin3 (right hand in orientation above - where the input connector's pin1 is at the bottom).

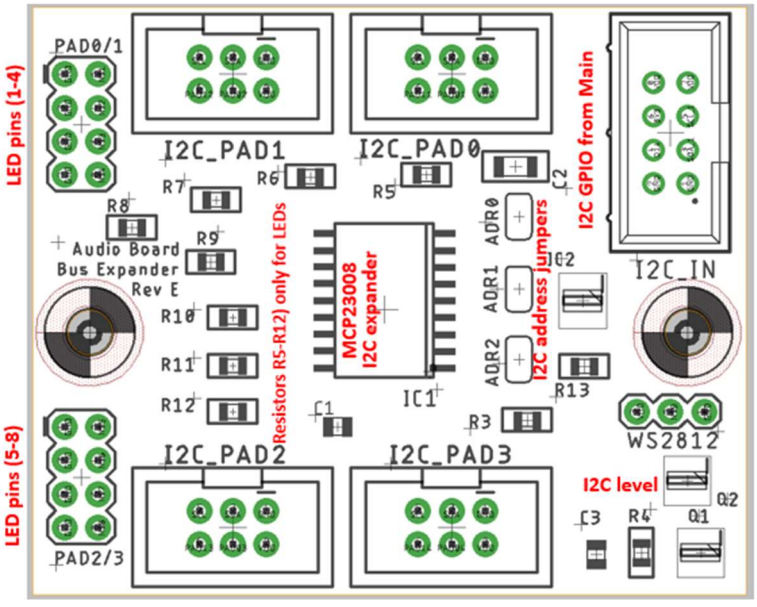
Only 5V (V+) is used on this board.

I2C extender / WS2812 Driver Board

The I2C expander is a MCP23008 which drives outputs high and low, (not open drain).

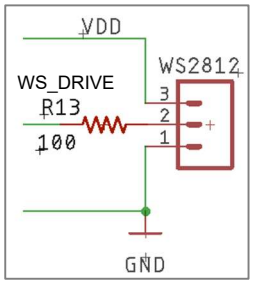
I2C level translation (3.3V to 5V) is delivered by two MOSFETs in the configuration of the modules commonly available from eBay and other sources. (The transistors, marked J1, in the prototype were sourced from one of these modules.)

For the WS2812B LED string, I2C bus translation is delivered by a SN74LV1T34 which can drive 20mA at the speeds required.



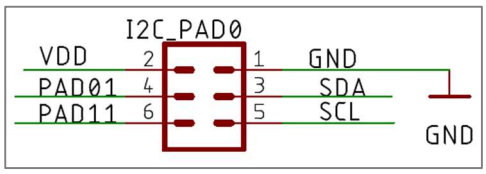
Auxiliary headers

WS2812



GND is to the edge of the board.

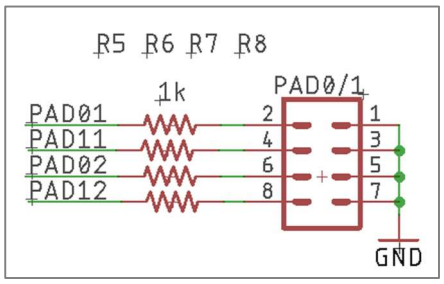
I2C_PAD



SDA and SCL are provided at 5V levels, with optional 2.2k pullup resistors R3 and R4.
The use of MOSFETs to level shift the signals limits usable I2C bus speed to 400kHz.

LED Pins

If it is desired to drive indicator LEDS, optional 1k resistors R5-R12 are provided. These are terminated on a pair of 2x8 headers, with ground to the outside edge of the board.



Specifications

Main board

Footprint	86 x 82mm
Power:	5V DC
Inputs:	4 x 10 pin shrouded headers (each 2 channels of balanced audio + 3 power pins, and buffered VQ reference voltage) Isolating input capacitors 6 balanced, 2 unbalanced inputs
Outputs:	2 x 14 pin shrouded headers (each 4 channels of balanced audio, 3 power pins, and buffered VQ reference voltage) 8 balanced outputs
Power to headers:	*Input & Output:* VA (5V low current. 5mA limit per board) V+ & V- (main audio supplies) *I2C_PAD:* VIN (5V) from USB or plug-pack supply. VD (3.3V) low current, sourced from the Teensy 4.0 onboard regulator

Inputs

Two channel mic/line module

Footprint:	65 x 56mm
Power:	5V DC (audio)
Control:	6 pin header I2C and GPIO indicating TRS insertion
Audio/power:	10 pin header.
XLR input:	Electronically balanced or unbalanced XLR (no phantom power)
Gain:	0 to +62dB
Input levels:	110mV RMS maximum
Input impedance:	2k ohms
Harmonic distortion:	0.05%
Noise (EIN):	-68dB (balanced input @ 40dB gain, 150 ohm source impedance)
TRS Input:	Inputs 1-6: electronically balanced or unbalanced Inputs 7-8 are unbalanced.
Gain:	0 to +23dB
Input levels:	2V RMS maximum
Input impedance:	35k ohms (inputs 1-6). >1 M ohm for inputs 7-8
Harmonic distortion:	0.005%
Noise (EIN):	-82dB (balanced input @0dB gain, 1k ohm source impedance)

Two channel line/Instrument module

Footprint:	60 x 42mm
Power:	5V DC (audio)
Control:	6 pin header I2C and GPIO indicating TRS insertion
Audio/power:	10 pin header.
Connection:	Electronically balanced or unbalanced TRS
Gain:	9 to +29dB (-11 to +9dB with 20dB pad)
Input levels:	2V RMS maximum 12V RMS with pad
Input impedance:	500k ohms (10k ohms with line pad)
Harmonic distortion:	0.005%
Noise (EIN):	-82dB (balanced input @0dB gain, 1k ohm source impedance))

Outputs

Four channel output module

Footprint:	64 x 46 mm
Power:	5V DC (audio)
Audio/power:	14 pin header.
Connection:	Electronically balanced or unbalanced TRS
Output levels:	2V RMS (+8dbM) maximum into 600 ohms
Output impedance:	200 ohms
Noise (EIN):	-82dB (balanced input @0dB gain, 1k ohm source impedance))

I2C Extender Board

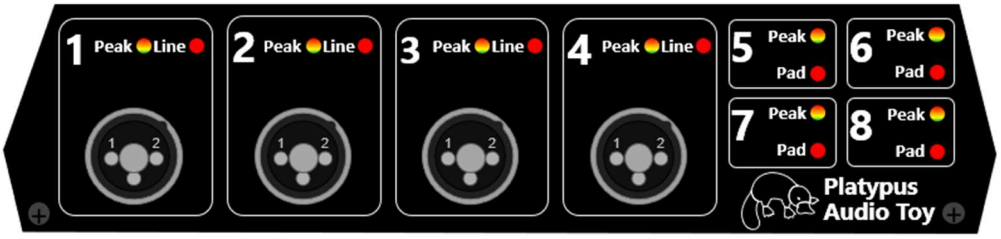
Footprint:	54 x 45 mm
Power:	5V DC (logic)
I2C bus:	3.3V (Teensy side). 5V (audio module side)
LED drive:	3mA (approx. when 1k resistors are installed.)

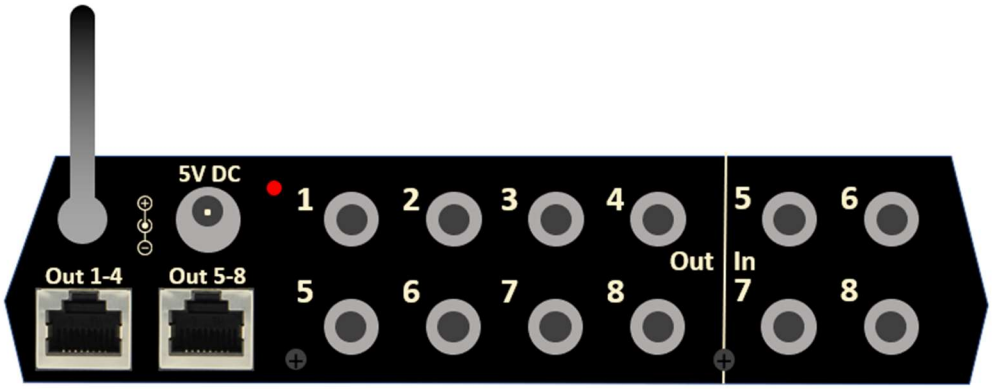
Electrical

Mainboard + 4 input and 2 output boards: 5VDC @ 0.3A

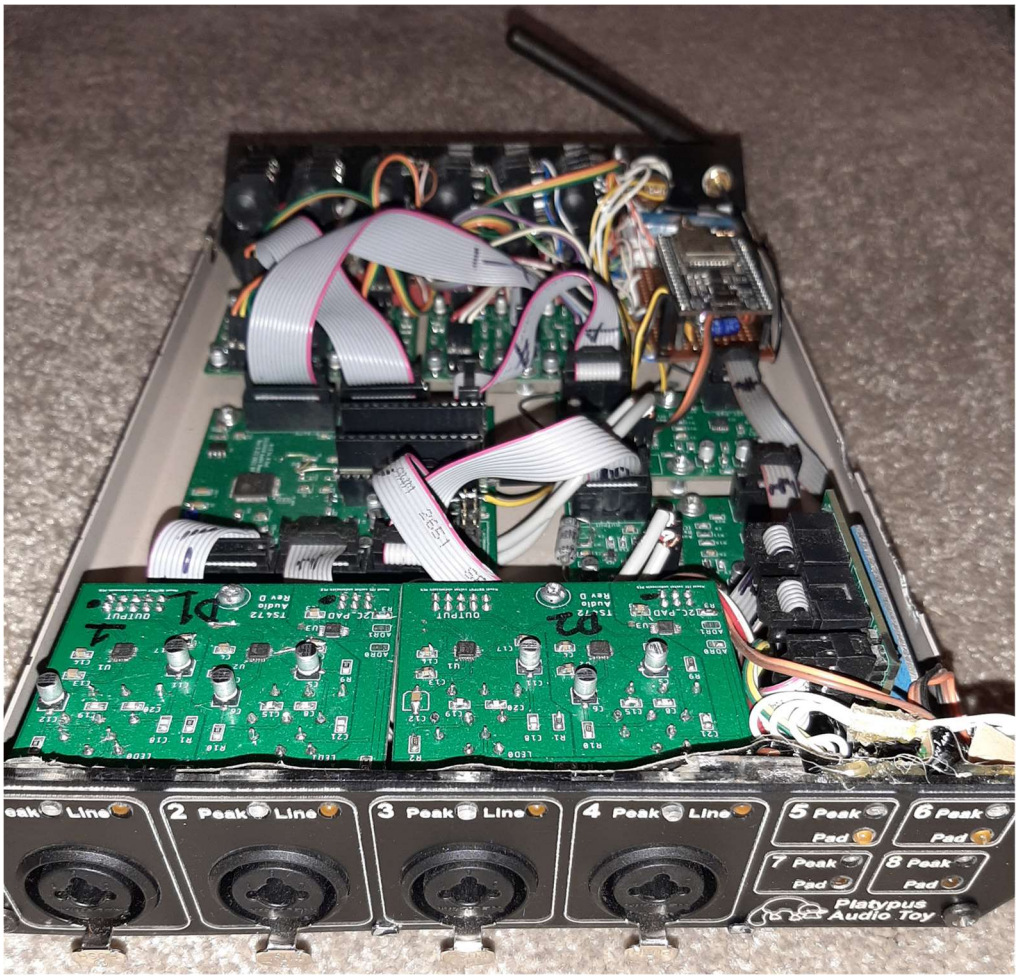
Appendix: AudioToy 8x8 Matrix Mixer Project

The main AudioToy unit

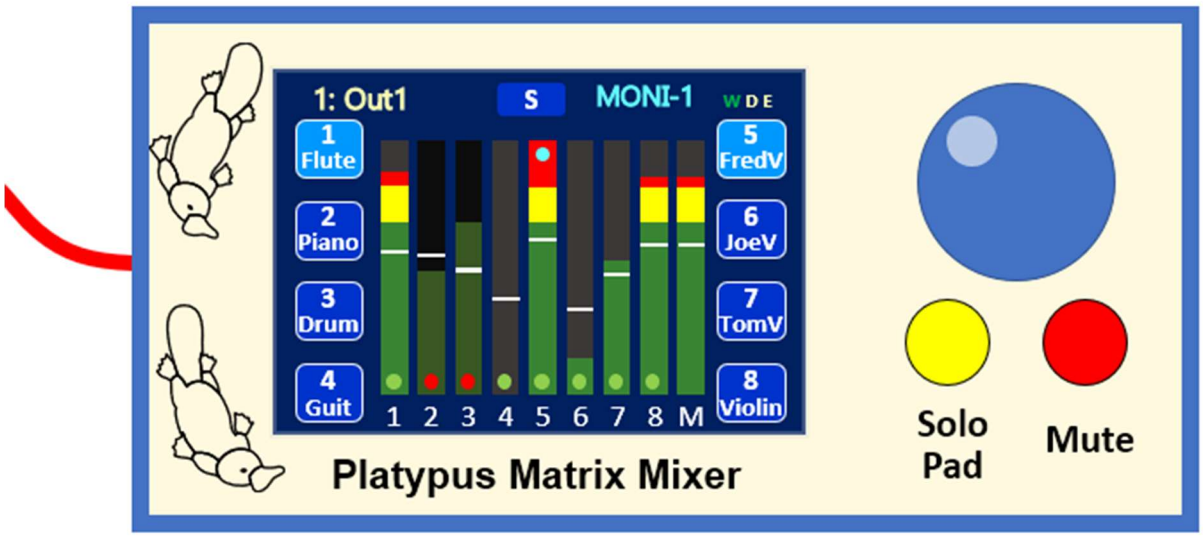




Inside the box



WiFi Remote Control



Browser Interface