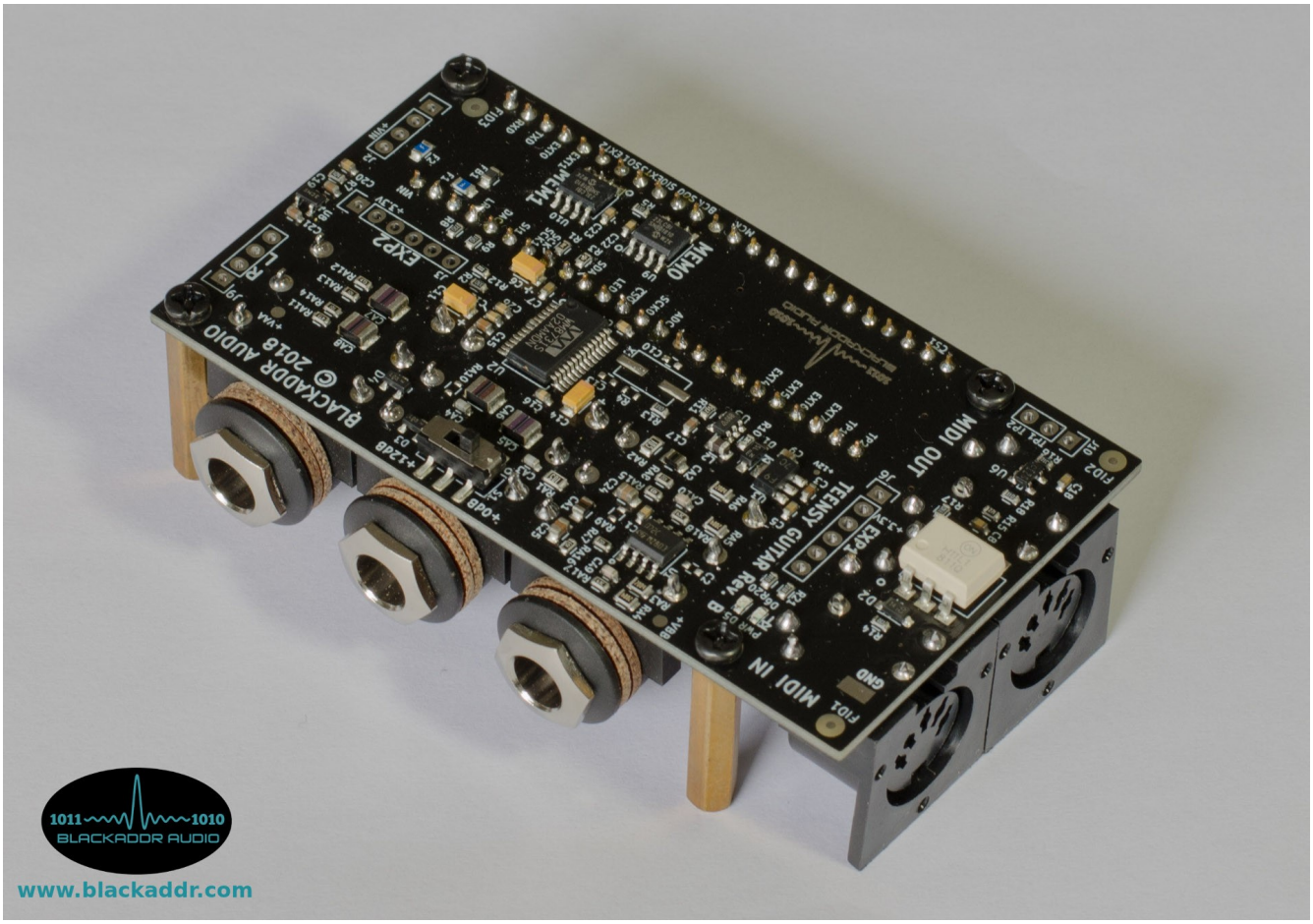
Blackaddr Audio

www.blackaddr.com

Teensy Guitar Audio Series

TGA Pro
(PCB Rev B)
User Guide v1.6



Revision History

V0.9 - 9/17/2017 – Initial Release

v1.0 – 11/01/2017 – Added hints on avoiding ground loop noise

v1.1 – 2018/02/04 – Add complete technical details

v1.2 – 2018/05/30 – Added PCB mechanical Drill guide

v1.3 – Updated to REVB hardware. See v1.2 for Rev2/A

v1.4 – Added instructions on standoff alignment

v1.5 – Added Teensy 4.0 information, memory configuration is now 4/8 Mbit

v1.6 – Added Teensy 4.1 information

TGA Pro Overview

The TGA Pro from Blackaddr Audio is a combined Audio and MIDI shield. This stereo-sound prototyping board is specifically designed for learning about and designing your own digital effects. It can also be easily integrating into a custom project using the schematic and mechanical information provided in this manual.

Teensy-3.X and Teensy 4.X are a series of Arduino-software compatible microcontroller boards by PJRC (www.pjrc.com) that offer significantly improved processing power (up to 600 Mhz) that are ideal for real-time audio applications.

What sets the TGA Pro apart form other boards is it is specifically designed for connecting a wide range of audio sources. On-board high-impedance preamps with adjustable gain permit direct connection of a wide range of sources including guitars, guitar pedals, or line-level sources using the full size 1/4” jacks you are used to. Guitars in particular have a wide range of signal levels ranging from tens of millivolts for passive vintage pickups up to potentially 9V with active pickups!

A wide range of adjustable gain or attenuation is required in order to accommodate any instrument.

Choosing a Teensy

The TGA Pro platform makes choosing a Teensy easy. The Dual Socket add-on option allows use of Teensy 3.x or Teensy 4.x series boards. For the Teensy 4.X support, only the 28-pins on a Teensy 4.0 are used. The expansion pins on the Teensy 4.1 are unused and completely free for the user.

Key Features

- Compatible with Teensy 3.2, 3.5, 3.6 or 4.0, 4.1
- Isolated, clean analog power supplies for analog/digital converters and preamp are generated on-board from the Teensy supplied USB power.
- Overall +24dB to -34.5dB of user-controllable input gain/attenuation.
- 2-channel input, 2-channel output configuration allows you to process signals from other stereo sources such as keyboards, stereo guitar pedals (such as reverb, chorus, etc.) or create your own mono-to-stereo effects.
- Optional 4-Mbit / 8-Mbit SPI RAM for external data storage (ideal for longer delays and audio buffers!)
- Optional Expansion Control Board provides physical pots and switches.
- GPIOs available on user-installable expansion headers allow connecting pots, switches, and LEDs.
- Standard 5-pin MIDI input and output connections for use with Arduino MIDI library.

- Analog dry output jack passively splits out the output of the analog preamp.
- 1 user-controllable on-board LED.
- Overload protection circuit for CODEC analog input.

ADDITIONAL RAM: Please note the external RAM chips provide extra storage via the Teensy SPI peripherals. They can be used for external storage of data, for example large audio buffers for longer delays. They do not increase program memory which stores the executable code you write. The first memory (MEM0) works with all Teensy 3.X/4.0 models. The second memory chip (MEM1) is to provide an extra external memory for Teensy 3.5/3.6 devices.

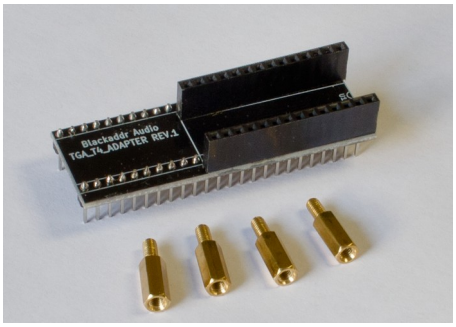
Accessories

Additional RAM

Up to two additional 4-Mbit SRAMs can be added at time of purchase. These memories provide temporary storage of data in order to leave more of the built-in RAM available for running larger programs. This memory is fast enough for moving audio data in realtime, something not always possible with Flash-based memory. The additional memory can be used to store any type of data, but common examples include:

- Audio Delay. 4-Mbit provides 5.92 seconds of mono delay capability. Audio delays can quickly consume the on-chip program RAM, it's best to implement them with external memory.
- Audio Buffers. Projects recording audio to or reading from Flash memory find fast audio buffers are needed in order to ensure no lost samples.
- Wavetables. Non-linear effects such as tube distortion often use pre-computed wavetables. These can be stored on Teensy MicroSD flash (T3.5/T3.5/T4.1) then loaded into external SRAM, saving both built-in Flash and RAM for storing and running your program.
- Graphics Data. If adding a display to your project, graphic sprites can be stored in SRAM for faster retrieval versus Flash memory to have a more responsive user interface.

Dual Socket Adapter



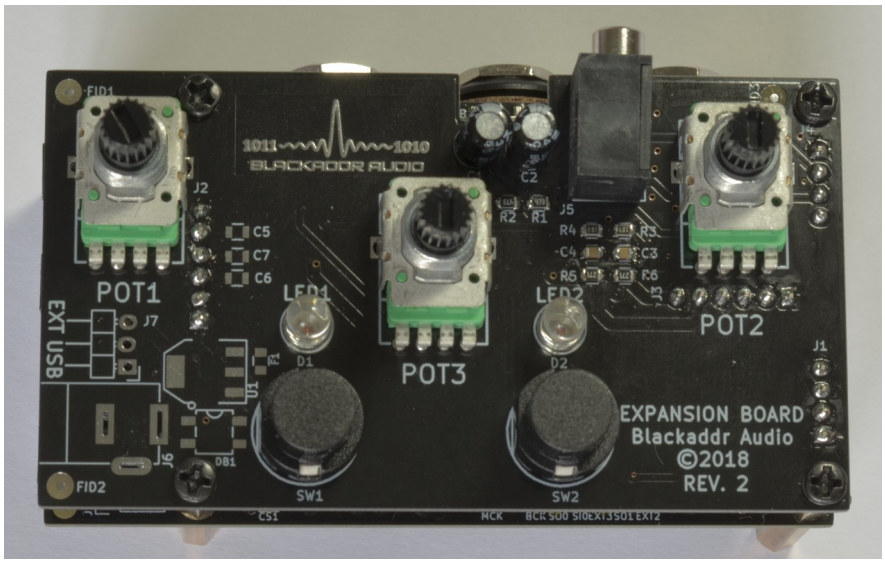
The dual socket adapter is an add-on option that allows either a Teensy 3.X or Teensy 4.X to be used with the same TGA Pro. With this ordering option, the 48-pin Teensy 3.X socket is installed on the main board, and an adapter board is also provided with a 28-pin Teensy 4.0 socket. This permits either a 3.X to be plugged into the mainboard, or a Teensy 4.0 or 4.1 via the adapter. Please note that this results in increased height compared to the standard Teensy 4.X-only option where the adapter PCB is soldered directly to the main board.

Expansion Control Board

An Expansion Control Board is available to supplement your TGA Pro. This add-on provides physical controls and is the recommended way to learn how to master adding buttons/switches and knobs to your project.

By using pre-built hardware, and examining the provided free demo code to go with it, you'll spend less time debugging things like switch bounce and potentiometer calibration. The Expansion Control Board schematic is included at the end of this manual, so you can use it as reference for your own designs!

NOTE: the Expansion Control Board uses pins that are not available on Teensy 3.2. It does support Teensy 3.5 / 3.6 / 4.0 / 4.1.



The Blackaddr Audio Expansion Control Board contains the following:

- 2 soft-touch momentary push-button switches.
- 3 potentiometers
- 2 LEDs
- Headphone circuit and jack. (Amp volume is controlled digitally through the CODEC).

By combining the Expansion Control Board with the TGA Pro, you have everything you need to get audio in and out of the Teensy, as well as physical controls without any need for soldering.

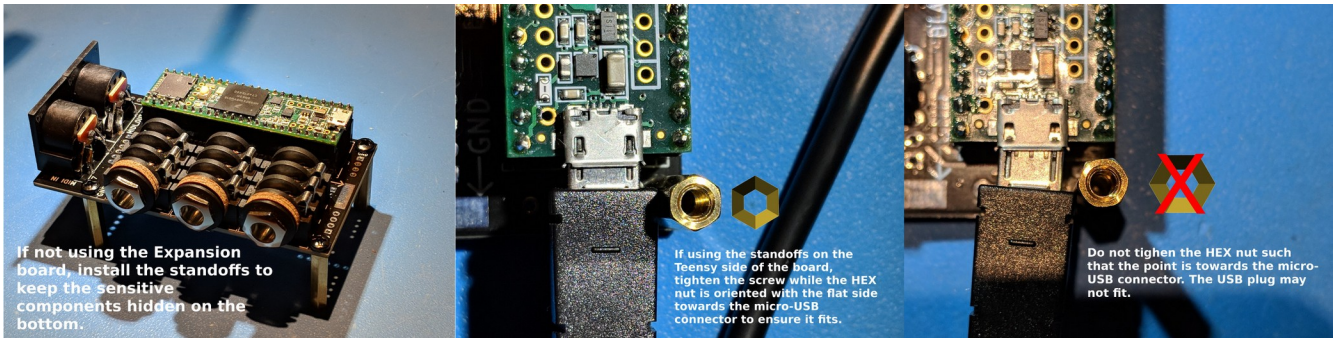
Expansion Control Board Pin Table

The following table lists the which logical pins on the Teensy 3.5/3.6 connect to the expansion board.

Control	Symbolic name in BALibrary	Logical Pin number on Teensy 3.5/3.6	Logical Pin number on Teensy 4.X
POT1	BA_EXPAND_POT1_PIN	A16	A0
POT2	BA_EXPAND_POT2_PIN	A17	A1
POT3	BA_EXPAND_POT3_PIN	A18	A2
SW1	BA_EXPAND_SW1_PIN	2	3
SW2	BA_EXPAND_SW2_PIN	3	4
LED1	BA_EXPAND_LED1_PIN	4	5
LED2	BA_EXPAND_LED2_PIN	6	6

Installing Standoffs

If using the Expansion Control Board, you will need to install the long HEX standoffs on the same side of the board as the Teensy and connectors. To ensure fit, avoid wide plugs and align the flat side of the HEX standoff towards the plug. See the figure below for guidance (centre image below).



If you are not using the Expansion Control Board, it's best to mount the standoffs such that the sensitive electronic components are hidden on the bottom. (Left image above). This makes handling the board easier, and permits any size micro-USB plug.

Technical Specifications

Input Channels (unbalanced) : 2

Output Channels (unbalanced) : 2

Input Impedance: 1 Mohm

Maximum INPUT signal level: 9 Vpp

Maximum OUTPUT signal level: 1 Vrms

Maximum CODEC input level: 1 Vrms

Overall Input Gain: +24 dB to 34.5 dB via 2-stage preamp

1st Stage Preamp Gain: switchable 0dB / +12dB via mechanical onboard switch

2nd Stage Preamp Gain: software controllable CODEC provides +12dB to -34.5dB gain

Input Signal Levels

Most audio signals fall in to one of four general groups in order of descending (smaller) signal voltage level. Understanding them will help ensure the preamp gain is set correctly for your application.

- Speaker / Headphone Level
- Line Level
- Instrument Level
- Microphone Level

The preamp circuit on the TGA Pro is powered by +9V, just like a guitar pedal, thus it can safely take a voltage up to +9V peak-to-peak without damage. Note however that as signals near the maximum voltage, this will cause the preamp to distort.

The goal with setting preamp gain is to either raise or lower the voltage to around 1 Vrms using the preamp stages. This gives the ideal signal level for the CODEC to obtain the best signal-to-noise ratio and sound fidelity.

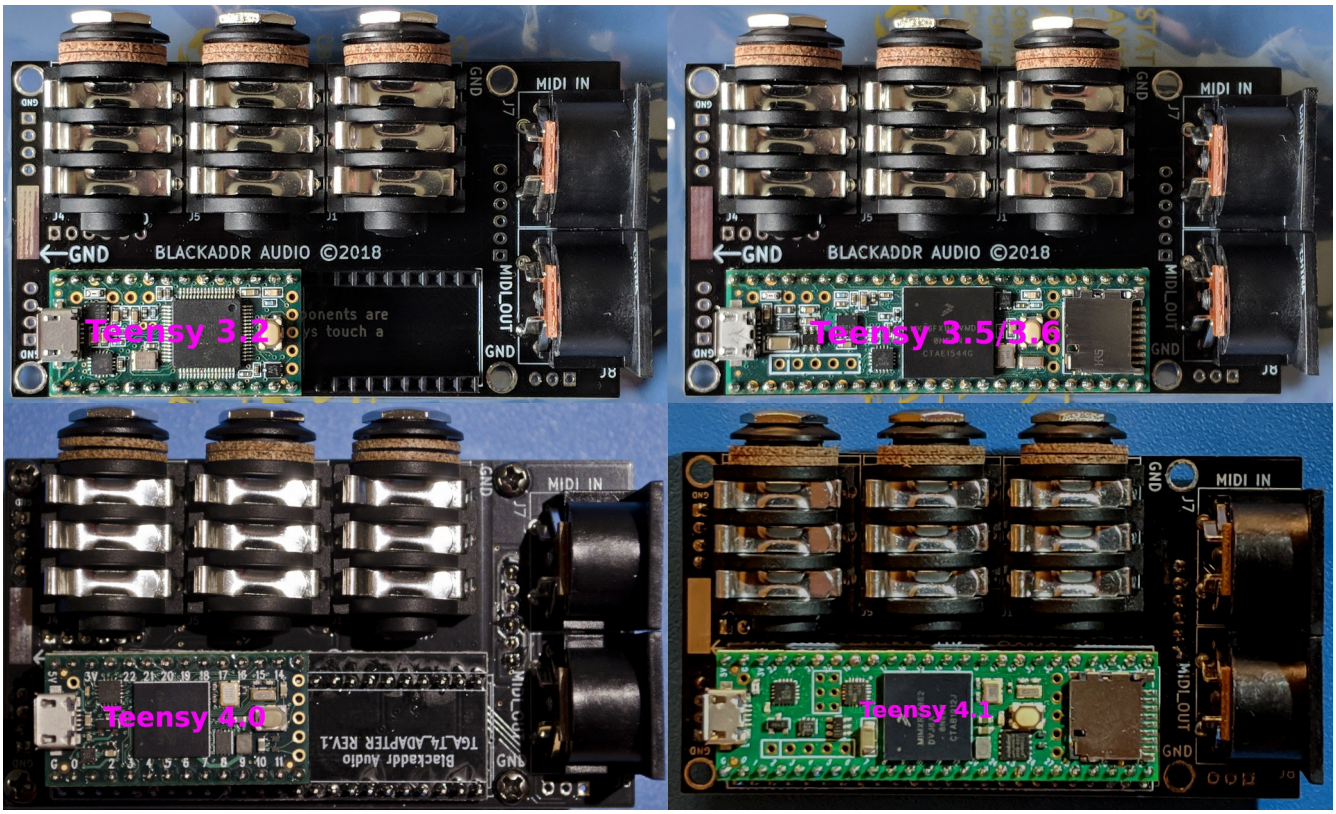
Speaker / Headphone Level – generally these types of outputs are meant to drive actual speakers. However, headphone level from things like smart phones and music players are low enough to connect to the TGA Pro inputs as long as the volume on the source isn't set too high. Start at zero and bring it up. Too high of a signal from a headphone jack can potentially damage the TGA Pro inputs.

Line Level – these signals are usually around 1 V RMS, ideal for the CODEC. Set the TGA Pro switch for 0dB of gain. It usually isn't necessary to adjust the software controlled gain in this scenario much, if at all. These can always be safely plugged into the INPUT jack on the TGA Pro.

Instrument Level – these signals are usually assumed to be from guitar pickups. Passive pickups can be as low as 20 mV. Humbuckers are much 'hotter' and are often 100 mV to 400 mV. Active pickups are as high as several volts. Guitar pedals can also be several volts. The two-stage preamp design of the TGA Pro is intended to give you either the gain, or attenuation, you need for your instrument.

Microphone Level – these signals are often very weak, requiring +20 dB to as high as +60 dB of gain for dynamic mics. For best results when using a microphone, use a proper microphone preamp before connecting to the TGA Pro INPUT.

Compatibility

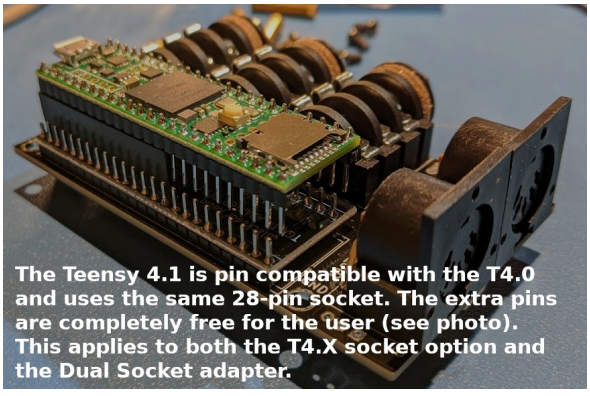


The TGA Pro is designed to work with the following boards from PJRC (www.pjrc.com)

- Teensy 3.2 (does not have pins to support MEM1 or Expansion Control Board)
- Teensy 3.5 / 3.6
- Teensy 4.0 (requires either T4.X socket or dual-socket option at ordering time)
- Teensy 4.1 (Uses the 28-pin T4.X socket, additional pins are not used)

Please note that when installing the microprocessor, the USB connector is always on the opposite side of the MIDI jacks. When installing any Teensy, ensure the pins on the left (USB side) are installed in the far left of the socket. There are more pins in the socket then there are on Teensy 3.2 to support the longer boards.

The 48-pin Teensy 4.1 uses the same 28-pin socket as the Teensy 4.0, but the additional pins are unconnected and available to the user. See photo to the right showing the free T4.X socket option. The same applies to the premium Dual Socket Adapter option.



The Teensy 4.1 is pin compatible with the T4.0 and uses the same 28-pin socket. The extra pins are completely free for the user (see photo). This applies to both the T4.X socket option and the Dual Socket adapter.

Operating Instructions

WARNING:

The TGA Pro contains electro-static-discharge (ESD) sensitive components, as does the Teensy when installed. Avoid directly touching the electronic components on the board whenever possible. Always install and touch one of the metal standoffs while handling the board.

TIPS FOR OPTIMAL AUDIO QUALITY

The TGA Pro is carefully designed to prevent digital signals from the Teensy and TGA Pro digital circuits from coupling into the sensitive analog circuits and appearing as noise or interference in your audio.

However, it is not always easy to prevent ground noise ***from other equipment*** from getting into the audio analog ground. This usually happens through ground loops caused by the common ground in household wiring.

The following tips can be used to reduce interference in audio equipment using unbalanced signals such as guitar pedals, amps and the TGA Pro.

- Plug all audio gear into the same outlet/power bar as the computer providing the USB connection to your Teensy. Using different wall outlets for the computer and your audio gear can create large ground loops in the household wiring.
- When programming/debugging your Teensy programs, connect the Teensy to the PC or laptop host. Once programmed, powering the Teensy with a micro-USB cellphone charger can greatly reduce ground noise caused by computers with particularly noisy USB connections.
- If using a laptop with your Teensy, disconnect the laptop battery charger and run the laptop on it’s own battery. This may also reduce ground loops within the household wiring.

Some computers have extremely noisy USB interfaces. If powering the Teensy with a micro-USB charger makes most the noise go away, you may want to try a different computer or laptop. Once with higher quality USB ports may provide significantly lower noise.

Converting the Teensy USB for external power can also be used to prevent noise. See the PJRC website for information on how to do this.

Software

The BALibrary is used to control and configure the TGA Pro can be downloaded from:

https://github.com/Blackaddr/BALibrary

Installing the Teensy PCB onto the TGA Pro

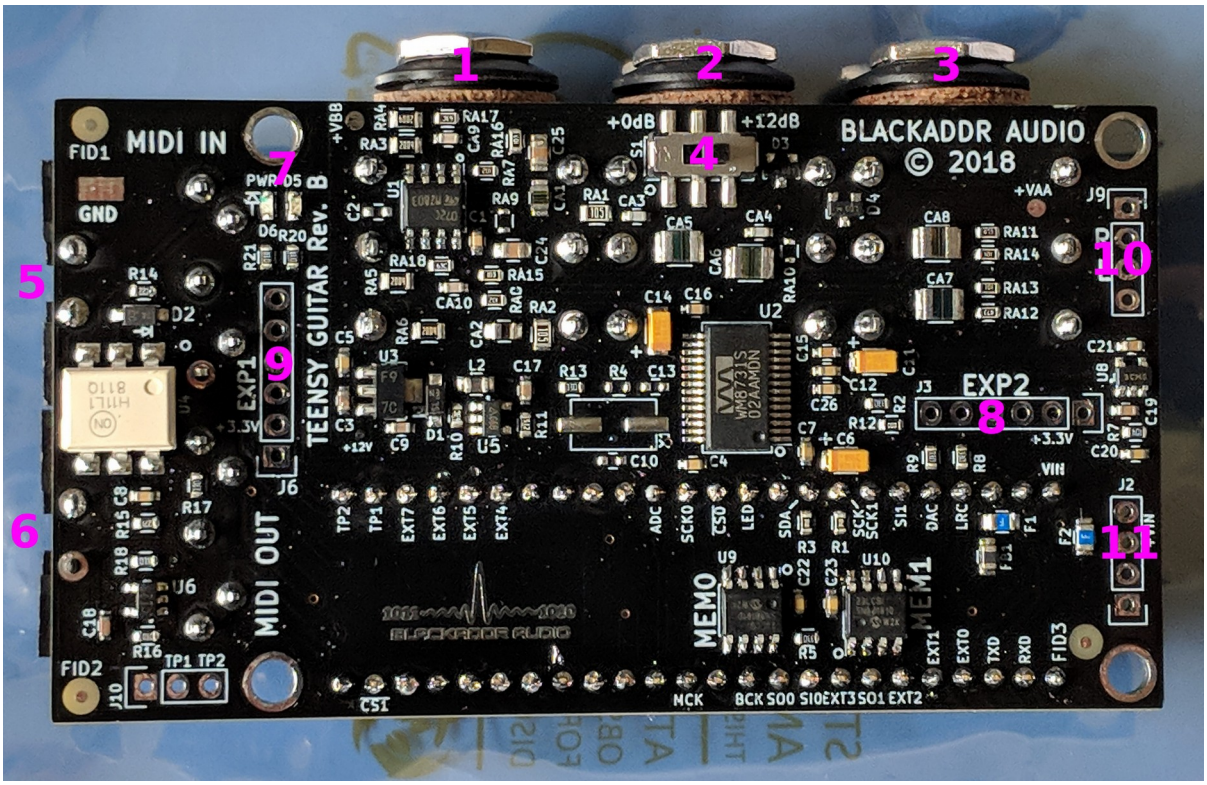
Get to know your TGA Pro before installing a Teensy board.

Install your Teensy microcontroller board into the socket. The Teensy board must have square shaped, 0.1” male pins to insert correctly. It is very important to make sure the Teensy PCB is aligned correctly. **Failure to align the pins correctly (accidentally shifted to the right or the left) can cause permanent damage to both the Teensy PCB and the TGA Pro**. The Teensy should be installed by aligning the rightmost pins on the Teensy board with the right most socket pins when the USB connector is on the side shown below.

TGA Pro Legend

Get to know your TGA Pro!

1. Audio Input
2. Dry Output
3. Audio Output
4. Preamp Gain Switch
5. MIDI Input
6. MIDI Output
7. LEDs
8. J3 GPIO Header
9. J6 GPIO Header
10. J9 Headphone Header
11. J2 Power Header



1. Audio Input

Stereo TRS, unbalanced input. Plug your guitar in to this jack. Also will work with line-level sources. When no plug is inserted, both channel inputs are grounded automatically.

Input impedance: ~ 1M

Voltage Max: 9V peak-to-peak

2. Dry Output - Instrument

Stereo TRS, unbalanced output. This is the output of the analog preamp before going to the CODEC, but after the first-stage anti-aliasing filter. The preamp is is powered by +9V, just like a guitar pedal, and is capable of achieving approximately 6 Vpp. *This output is safe to drive guitar pedals and guitar amps, but should only be connected to line-level inputs if a line-level device is connected to the Audio Input jack.*

Output impedance: ~ 1K

Voltage Range: ~6V peak-to-peak maximum

3. Audio Output

Stereo TRS, unbalanced output. This is the analog output of the stereo codec's digital-to-analog coverter (DAC). It is suitable to drive line-level, guitar pedal, or guitar amp inputs.

Output impedance: ~ 100Ohm

Voltage Range: 1.0V RMS

4. Preamp Gain Switch

This switch selects the gain of the high-impedance preamp. Preamp gain is either 0dB (unity) or +12dB gain.

5. MIDI Input

This jack is a MIDI compliant 5-pin jack. The on-board MIDI phy converts MIDI signals to the correctly levels to be received by the Teensy UART. The Teensy software library has built in MIDI support though this port. See the BALibrary demos for more details.

6. MIDI Output

This jack is operated at 3.3V, and is designed to be compliant with MIDI outputs using the voltage level. It is safe to connect to any MIDI input, regardless of whether that circuit operates at 3.3V (modern) or 5V (vintage). The MIDI output phy is driven by the Teensy UART. The Teensy software library has built in MIDI support through this port. See the BALibrary demos for more details.

7. LEDs

Two LEDs are installed on the TGA Pro. One is BLUE, and will illuminate whenever 3.3V power is received from the Teensy board. The other is GREEN, and is user controllable by software running the Teensy. See the TGA Pro schematic, and BALibrary for more details.

8. J3 GPIO Header

Contains 4-user controllable pins from the Teensy. See the TGA Pro Schematic for details. This pins operate at 3.3V. This is the best header to use for connecting switches and encoders. It connects to pins available on all Teensy 3.X variants.

9. J6 GPIO Header.

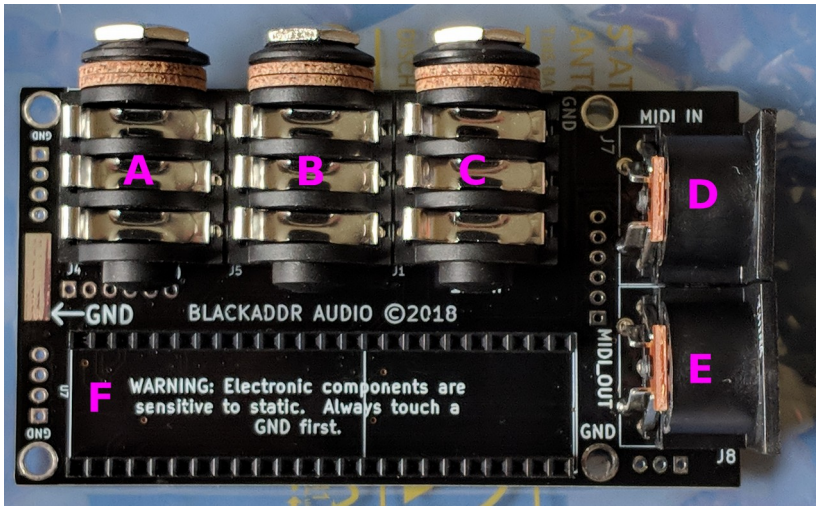
Contains 4-user controllable pins from the Teensy. See the TGA Pro Schematic for details. This pins operate at 3.3V. This pins connect to analog capable pins on the Teensy 3.5/3.6. They can be with analog pots.

10. J9 Headphone Header

Contains analog power, ground and stereo headphone signals for the codec. Requires external capacitors and resistors and a headphone jackee the TGA Pro and Expansion Control board schematics for details.

11. J2 Power Header

Contains the +VIN and ground. +VIN is connected to the VIN pin on the Teensy. Normally power is supplied by the Teensy where +VIN=5V from the USB cable. If USB is not connected, you can also supply +5V yourself to this pin in order to power the TGA Pro and and Teensy from an external supply.



A. Audio Input

B. Dry Output

C. Audio Output

D. MIDI Input

E. MIDI Output

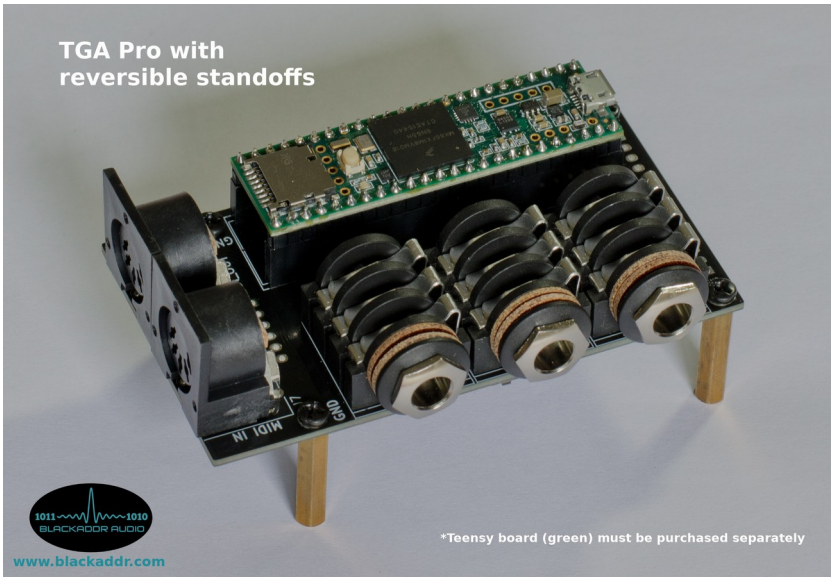
F. Teensy Socket

F. TEENSY SOCKET

Install your Teensy microcontroller board in this socket. The board must have square shaped, 0.1” male pins to insert correctly. It is very important to make sure the Teensy PCB is aligned correctly. Failure to align the pins correctly (accidentally shifted to the right or the left) can cause permanent damge to both the Teensy PCB and the TGA Pro. Use the images in the Compatibility section as guidelines.

Using your TGA Pro

If you are not using the Expansion Board, it is recommended to install the standoffs such that the ESD sensitive components are hidden underneath. This makes handling easier when inserting and removing plugs.



*** In order to have full control over the TGA Pro, install the BALibrary by downloading it from the Github link and installing it into your Arudino IDE as an ‘additional Library’ by importing the ZIP file.

https://www.arduino.cc/en/Guide/Libraries

https://github.com/Blackaddr/BALibrary/archive/master.zip

1. Insert the Teensy PCB as shown previously in this User Guide.

2. Plug a USB cable into the Teensy PCB.

3. Plug the other end of the USB into your computer.

4. Launch the Arduino IDE and program. If you installed the BA Guitar Library you can access the provided examples from with the IDE. Additional Libraries will be found at the very bottom of the list.

Help & Troubleshooting

Help with the Arduino IDE and Teensy PCB programming can be obtained from the PJRC Forums.

https://forum.pjrc.com/

For questions about the BALibrary, or the TGA Pro board, use the contact below.

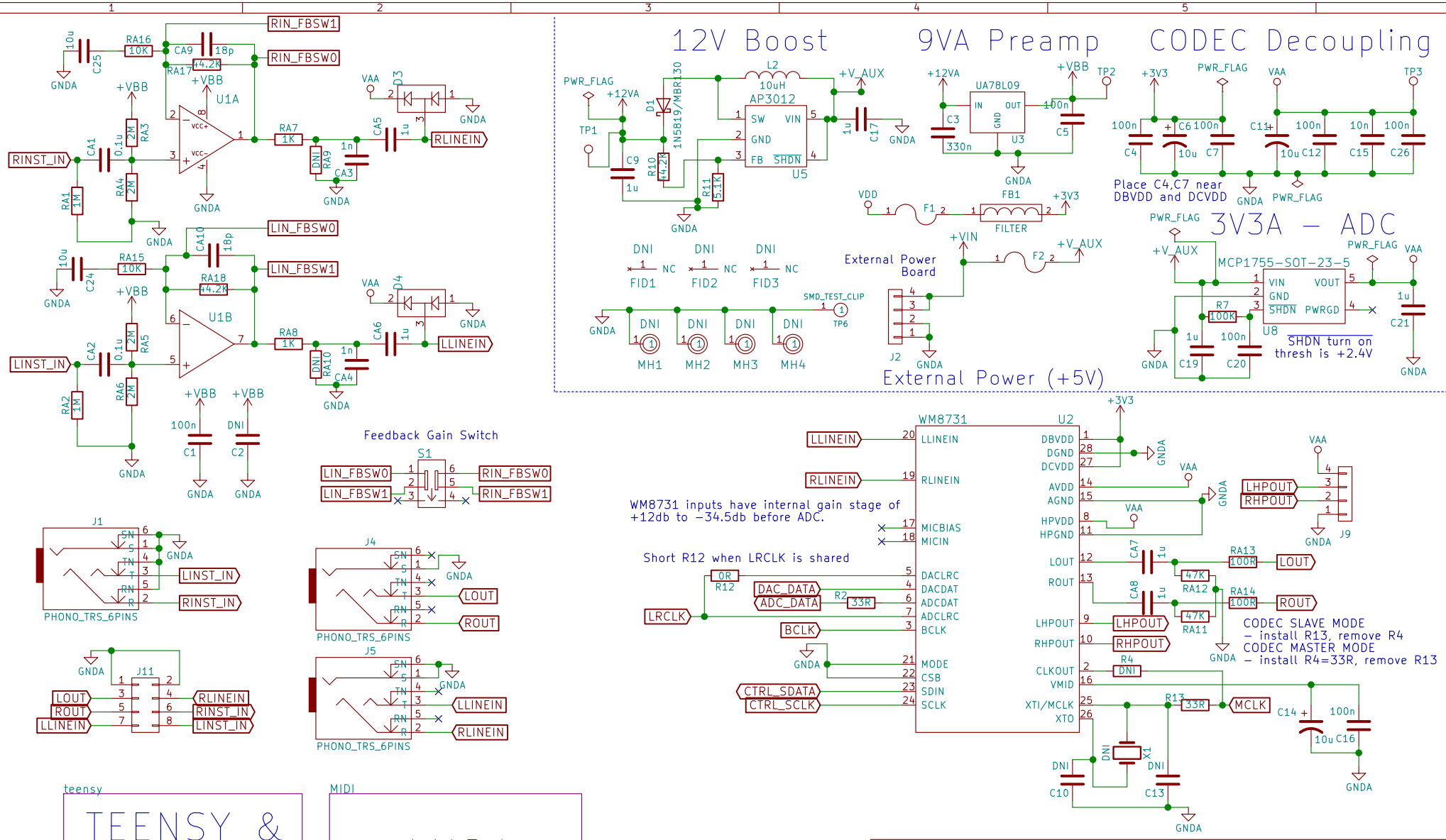
Eratta

None at this time.

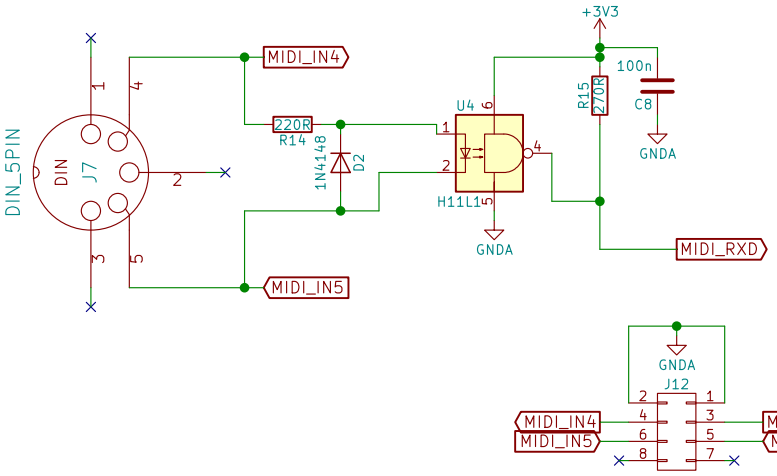
Contact

Blackaddr Audio

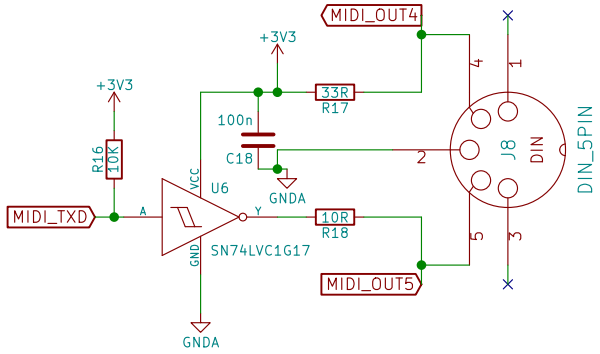
http://blackaddr.com/contact/


12V Boost
9VA Preamp
CODEC Decoupling
3V3A – ADC
External Power (+5V)
TEENSY & MEMORY
MIDI
WM8731 inputs have internal gain stage of +12db to −34.5db before ADC.
Short R12 when LRCLK is shared
Feedback Gain Switch
Place C4,C7 near DBVDD and DCVDD
SHDN turn on thresh is +2.4V
CODEC SLAVE MODE
– install R13, remove R4
CODEC MASTER MODE
– install R4=33R, remove R13
Copyright Blackaddr Audio ©2017
Blackaddr Audio
Sheet: /
File: teensy_audio_revB.sch
Title: Teensy Guitar Audio
Size: A4
Date: 2017-03-15
Rev: A
KiCad E.D.A. kicad 4.0.7
Id: 1/3
teensy.sch
MIDI.sch

MIDI_IN



MIDI_OUT



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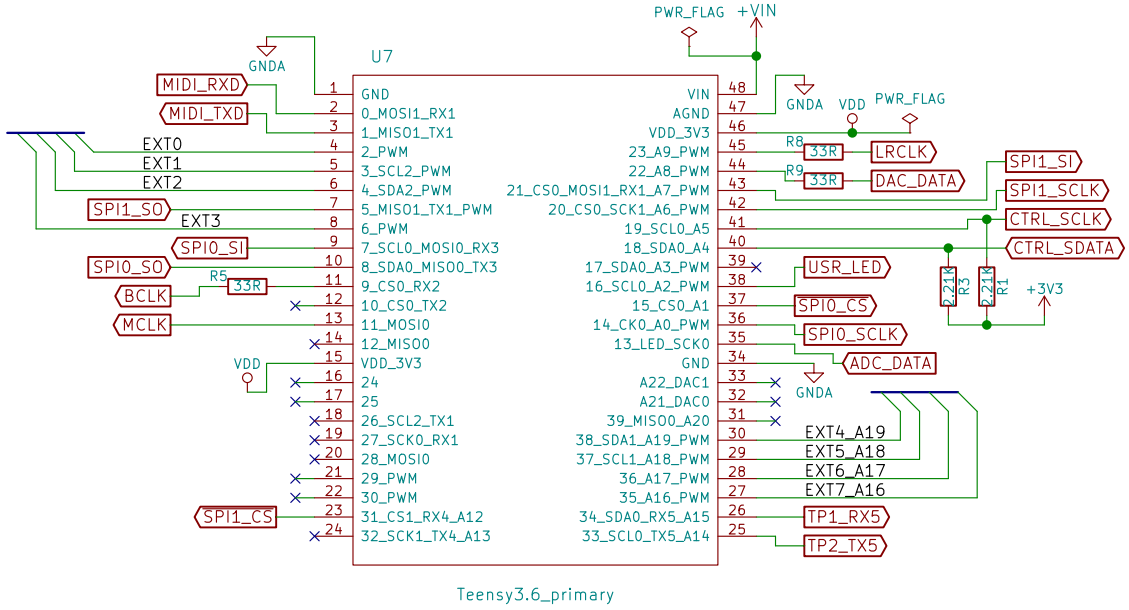
Title: Teensy Guitar Audio

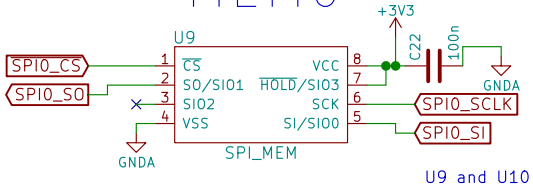
Size: A4	Date: 2017-03-15	**Rev: 1**
KiCad E.D.A. kicad 4.0.7		Id: 2/3

TEENSY 3.6



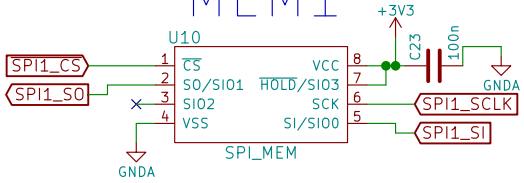
Teensy3.6_primary

MEMO

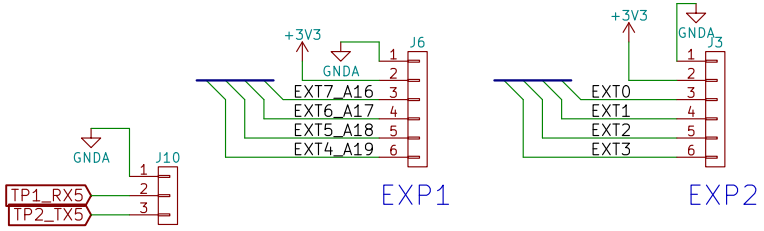


U9 and U10 are only installed if ordered.

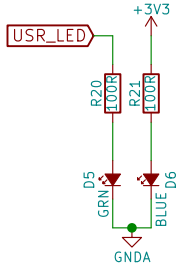
MEM1



EXTERNAL IO / SPI



LEDS



Blackaddr Audio

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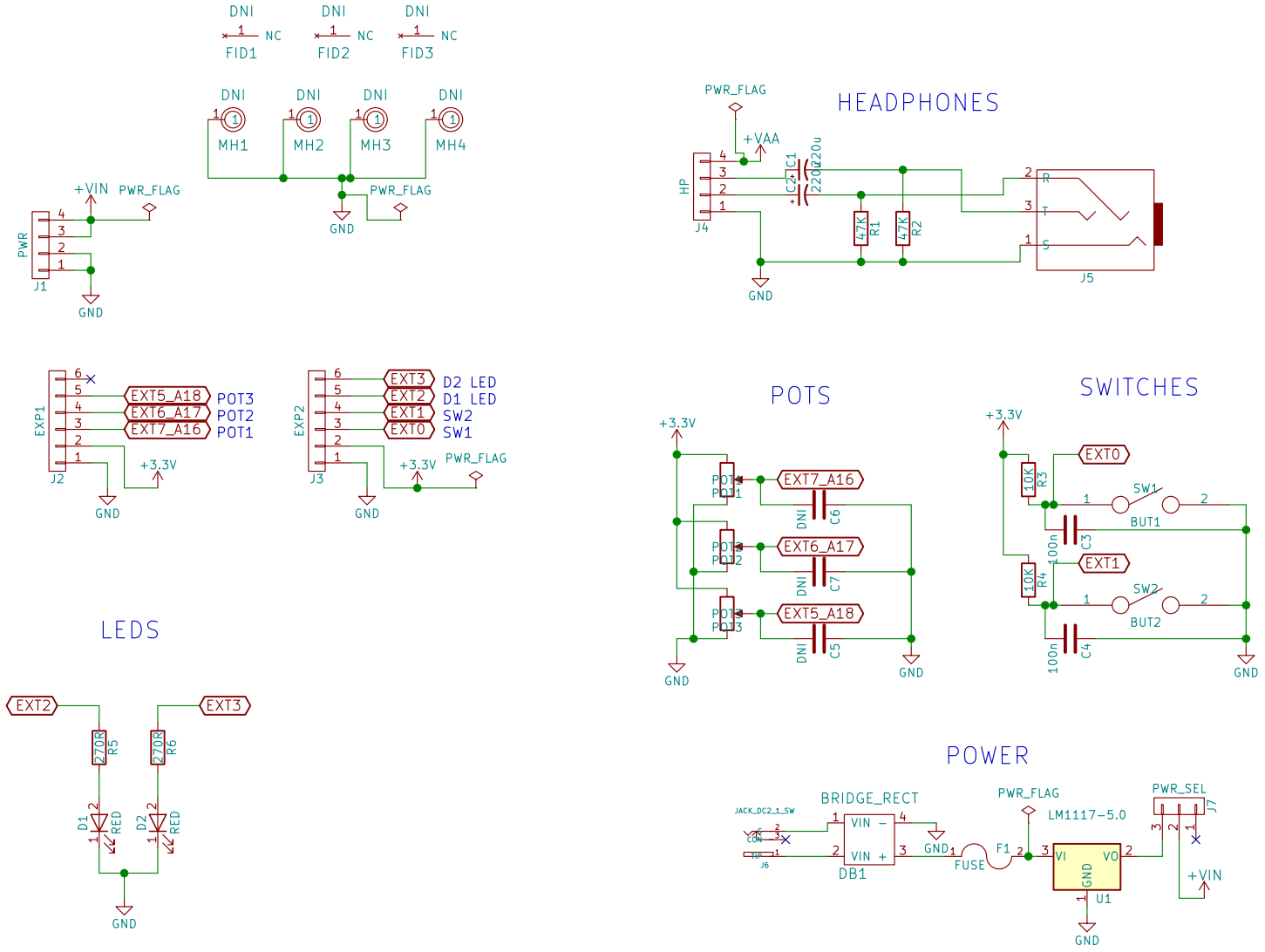

Blackaddr Audio

Sheet: /

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Title: Teensy Audio Expansion

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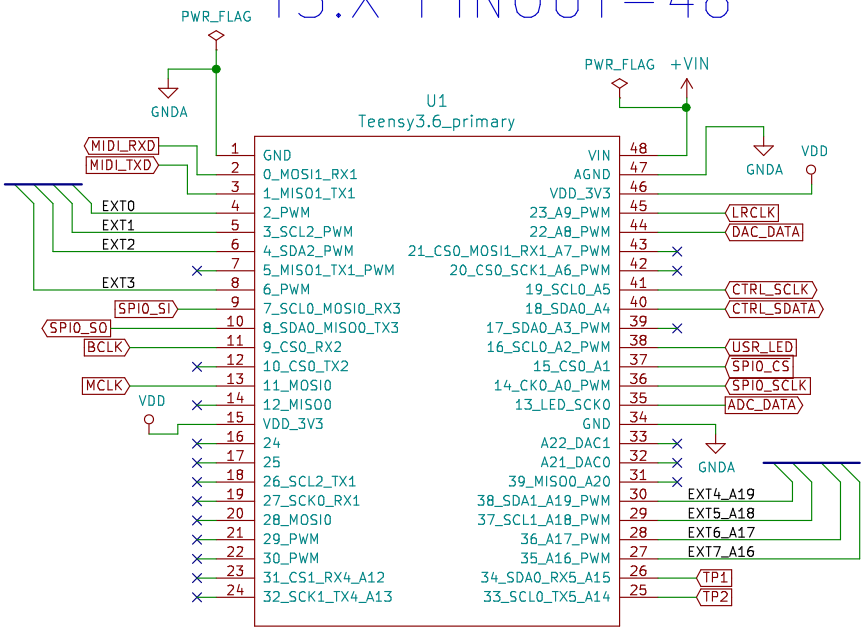
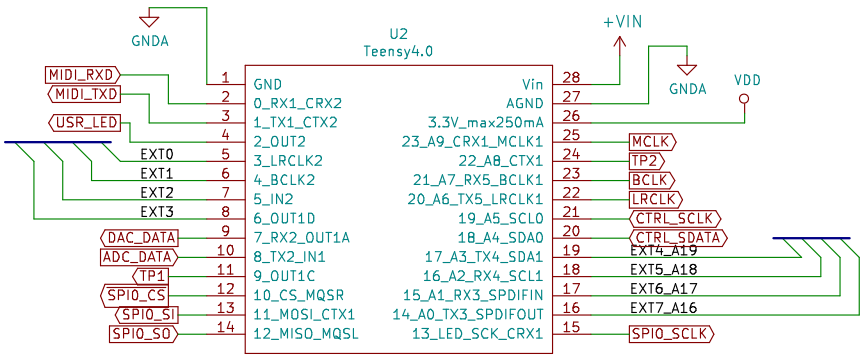
KiCad E.D.A. kicad 4.0.7		Id: 1/1

T3.X PINOUT—48



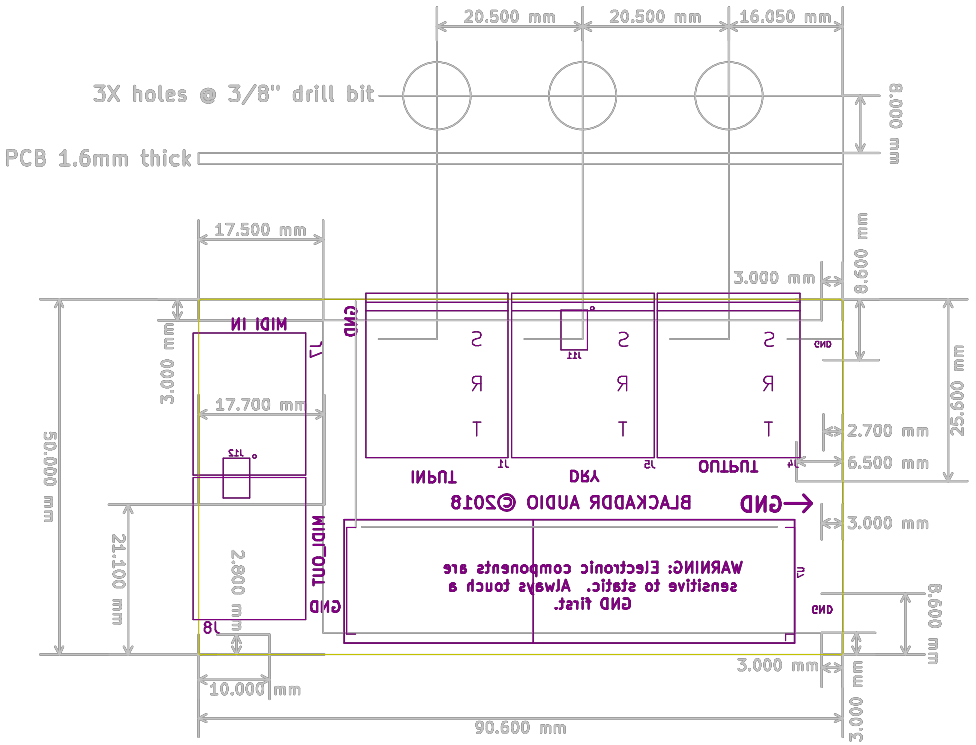
T4.0 PINOUT—28



The adapter PCB maps the Teensy 3.X pinout on the TGA Pro board to the Teensy 4.0 pinout. The second SPI port (SPI1) is not available on Teensy 4.0 pins.

Blackaddr Audio		
Sheet: /		
File: tga_t4_adapter_rev1.sch		
Title: TGA_T4_ADAPTER		
Size: A4	Date: 2019-10-28	**Rev: 1**
KiCad E.D.A. kicad 5.0.2-5.fc29		Id: 1/1

TGA Pro Rev B
Mechanical and Drilling Guide



As viewed from component side of the PCB

Sheet: File: teensy_audio_revB.kicad_pcb		
Title:		
Size: A4	Date:	**Rev:**
KiCad E.D.A. kicad 4.0.7		Id: 1/1