

# **Pi 2 Design**

**PI2AES-LITE  
Digital Pro Audio Hat  
Hardware Reference Manual  
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# I WARRANTY

The enclosed product ("the Product"), a part of the P2 2 Design Shield/Hat series, is warranted by Pi 2 Design for a period of one year for reasonable development, testing and use, all as further described and defined below. This warranty runs solely to the individual or entity purchasing the Product and is not transferable or assignable in any respect. This warranty is valid only for so long as the product is used intact as shipped from Pi 2 Design. Any attempt or effort to alter the Product, including but not limited to any attempt to solder, de-solder, unplug, replace, add or affix any part or component of or onto the Product, other than components specifically intended for the user to plug and unplug into appropriate sockets and/or Connectors to facilitate user programming, development and deployment, all as specifically described and authorized in this Product Hardware Reference Manual, shall void this warranty in all respects. Coverage under this warranty requires that the Product be used and stored at all times in conditions with proper electrostatic protection necessary and appropriate for a complex electronic device. These conditions include proper temperature, humidity, radiation, atmosphere and voltage (standard commercial environment, 0C to +70C, <60%RH). Any Product that has been modified without the express, prior written consent of Pi 2 Design is not covered by this warranty. The use or connection of any test or bus Connector, adapter or component with any device other than a Pi 2 Design Connector or adapter shall void this warranty and the warranty of all other components, parts and modules connected to the rest of the system. Pi 2 Design shall not be responsible for any damage to the Product as a result of a customer's use or application of circuitry not developed or approved by Pi 2 Design for use on or in connection with the Product.

This warranty does not cover defects caused by electrical or temperature fluctuations or from stress resulting from or caused by abuse, misuse or misapplication of the Product. Any evidence of tampering with the serial number on the Product shall immediately void this warranty. This Product is not intended to be used on or embedded in or otherwise used in connection with any life-sustaining or life-saving product and this warranty is not applicable nor is Pi 2 Design liable in any respect if the Product is so used. Notwithstanding anything to the contrary herein, Pi 2 Design expressly disclaims any implied warranty of merchantability or implied warranty of fitness for a particular purpose in connection with the manufacture or use of the Product.

## 2 OPERATING SPECIFICATIONS

### 2.1 PI2AES-LITE OPERATING SPECIFICATIONS

The PI2AES-LITE conforms to the following specifications:

Specification	Value
Dimensions	65mm x 56.5mm – Hat Compliant
Weight	~8oz
Storage Temperature	-20C to +85C
Operating Temperature	0C to +70C
Humidity	0% to 95% RH, Non-Condensing
Input Voltage (VIN)	+5V +/- 5% from the Raspberry PI
Power Consumption	250mw Typical, 1W Maximum

Table 1 – PI2AES-LITE Operating Specifications

## 3 OVERVIEW

### 3.1 INTRODUCTION

The PI2AES-LITE , designed and manufactured by PI 2 Design, is a professional I/O Shield designed to bring Professional Studio Grade Audio to the Raspberry Pi® family of Single Board Computers. This low-cost Shield converts the Raspberry Pi® I2S Interface to High Definition Digital Audio Coax, SPDIF Coax and Toslink Optical.

The major features of the PI2AES-LITE are as follows:

- **FORM FACTOR** – Raspberry Pi® HAT Size w/40-Pin mating connector.
- **AES TRANSMITTER** – The industry standard WM8804 converts the PI I2S stream to AES3/SPDIF 24-Bit Data up to 192Khz.
- **AES COAX OUTPUT** – A 1:1 Isolation Transformer provides 75-ohm Impedance Controlled Transmission of the Digital Audio Data via AES Standard BNC.
- **SPDIF OUTPUT** – A 1:1 Isolation Transformer provides Bit Perfect Transmission of the Digital Audio Data via RCA Jack.
- **TOSLINK OPTICAL OUTPUT** – Isolated Optical Transmitter Supports Consumer Level DAC's.
- **HIGH RESOLUTION CLOCKS** – A pair of Ultra-Low Noise NDK NZ2520SD oscillators allow the WM8804 to operate in non-PLL mode for the lowest possible noise.
- **ULTRA-LOW NOISE LDO's** – Dual, Ultra-Low Noise LT34042 LDO's (0.9uV noise and 80dB PSRR) are used to supply the WM8804 AES Transmitter and the High-Resolution NDK Clocks for extremely low Jitter.
- **EXTERNAL 5V** –A 2.5MM DC Jack allows the board to operate from an external 5V Linear PSU while powering the PI from its own supply.

### 3.2 BLOCK DIAGRAM

Refer to the following figure for a block diagram of the PI2AES-LITE Shield.

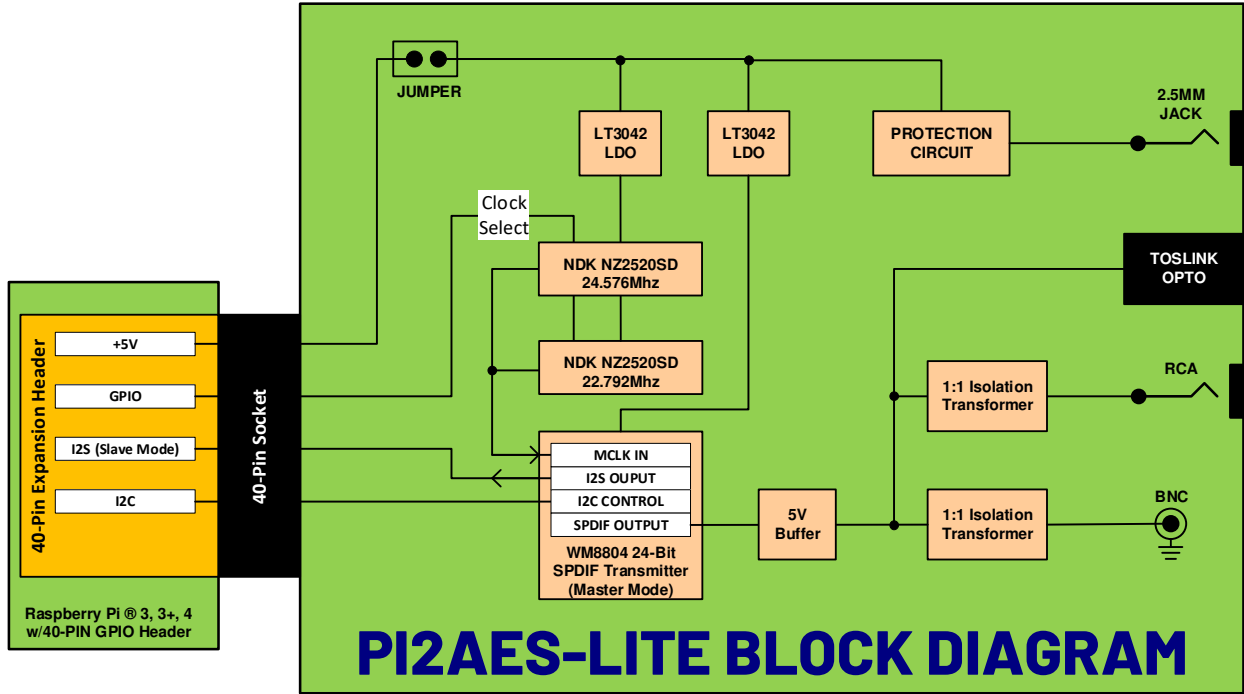


Figure 1 – PI2AES-LITE Block Diagram

## 4 ON-BOARD DEVICES

### 4.1 OVERVIEW

The PI2AES-LITE interfaces to the RPi via the 40-Pin GPIO Connector. This section describes in detail the devices located on the PI2AES-LITE .

#### 4.1 PI2AES-LITE I2C BUS DEVICES

The following table describes the CPU I2C Bus usage of the PI2AES-LITE . Most of these addresses are set by the startup script supplied by Pi2Design. Refer to the respective device documentation for more detail.

I2C Bus	7-Bit I2C Address	Description
I2C	0x3B	WM8804 SPDIF Transmitter

Table 2 – PI2AES-LITE I2C Bus Devices

#### 4.1 WM8804 SPDIF TRANSMITTER

At the core of the PI2AES-LITE is the Cirrus Logic WM8804 AES Digital Audio Transmitter. This device interfaces to the Raspberry Pi via I2S and I2C. The signals used to interface with the WM8804 are shown in the following table.

WM8804 Signal	RPi Signal	Description
MCLK	-	Unused
BCLK	BCLK	I2S Bit Clock Output to Pi
LRCLK	LRCLK	I2S Word Clock Output to Pi
SDIN	SDOUT	I2S Serial Audio Data Input from Pi
SCL	SCL	I2C Clock from Pi
SDA	SDA	I2C Data to/from Pi
XIN	GPIO5	1 = Select 22.5792Mhz Input Clock for 44.1Khz, 88.2Khz and 176.4Khz Frame Rates
XIN	GPIO6	1 = Select 24.576Mhz Input Clock for 48Khz, 96Khz and 192Khz Frame Rates

TXO	-	AES3/SPDIF encoded digital audio output
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Table 3 – RPi to WM8804 Connections

#### ***4.1.1 WM8804 SPDIF TRANSMITTER NOTES***

1. The WM8804 is controlled using the I2C port. Refer to the WM8804 documentation and Pi 2 Design supplied driver code for more detail.
2. The PI2AES-LITE is designed to operate the WM8804 in Master mode. In this mode the WM8804 receives its master clock from XIN and drives MCLK (unused), BCLK and LRCLK to the Pi. Serial Data in is received from Pi.
3. Pi GPIO's 6 and 13 are used to select the desired clock input. GPIO 6 and 13 are pulled low by default. CAUTION - Do not select more than one clock at a time!

#### ***4.2 DUAL HIGH RESOLUTION NDK CLOCKS***

A pair of NDK NZ2520SD Ultra-Low Noise clocks provide the critical timing signals for the WM8804. They are selected via Raspberry PI GPIO5 (22.5792Mhz) and GPIO6 (24.576Mhz).

#### ***4.3 3.3V TO 5V BUFFER***

A 74HCT125 Quad Buffer is used to drive the WM8804 TXO output to the SPDIF (RCA) and AES (Coax) Transfoerms and to the Toslink Optical Transmitter LED.



# 5 RPI GPIO

## 5.1 OVERVIEW

The PI2AES-LITE uses a number of signals from the RPi GPIO header for control and status purposes. This usage is defined in the following table.

RPI PIN	DIR	AF	PUP/PDN	PI2AES-LITE Name	Description/Notes
1	-	-	-	-	RPi +3.3V - Unused
2	-	-	-	+5V	+5V Power to/from the RPi
3	I/O	Y	PUP	I2C_SDA	I2C Bus Data
4	-	-	-	+5V	+5V Power to/from the RPi
5	OUT	Y	PUP	I2C_SCL	I2C Bus Clock
6	-	-	-	GND	
7	OUT	-	-	GPIO4	Unused
8	-	-	-	GPIO14	Unused
9	-	-	-	GND	Unused
10	-	-	-	GPIO15	Unused
11	-	-	-	GPIO17	Unused
12	IN	Y	-	BCLK	I2S Bit Clock from WM8804
13	-	-	-	GPIO27	Unused
14	-	-	-	GND	
15	-	-	-	GPIO22	Unused
16	-	-	-	GPIO23	Unused
17	-	-	-	RPi +3.3V	Used to Generate Reset to the WM8804
18	-	-	-	GPIO24	Unused
19	-	-	-	GPIO10	Unused
20	-	-	-	GND	
21	-	-	-	GPIO9	Unused

RPi PIN	DIR	AF	PUP/PDN	PI2AES-LITE Name	Description/Notes
22	-	-	-	GPIO25	Unused
23	-	-	-	GPIO11	Unused
24	-	-	-	GPIO8	Unused
25	-	-	-	GND	
26	-	-	-	GPIO1	Unused
27	I/O	Y	-	ID_SDA	Unused
28	OUT	Y	-	ID_SCL	Unused
29	-	-	-	GPIO5	Unused
30	-	-	-	GND	
31	OUT	-	PDN	GPIO6	0 = Select 22.5792Mhz Clock Input to WM8804 1 = Select 24.5760Mhz Clock Input to WM8804
32	-	-	-	GPIO12	Unused
33	OUT	-	-	GPIO13	Unused
34	-	-	-	GND	
35	IN	Y	-	LRCLK	I2S Left/Right Clock from WM8804
36	-	-	-	GPIO16	Unused
37	-	-	-	GPIO26	Unused
38	-	-	-	GPIO20	Unused
39	-	-	-	GND	
40	OUT	Y	-	SDOUT	Pi I2S Serial Audio Data Out

Table 4 – CPU GPIO Pin Assignments

**5.1.1 RPI GPIO NOTES**

1. DIR is from the point of view of the RPi.
2. Y in the Alternate Function (AF) column indicates that the use of this pin requires the pin to be assigned to the function as defined by the RPi specifications.
3. PUP/PDN indicates if the GPIO should have its associated Pullup (PUP) or Pulldown (PDN) resistor enabled.
4. An asterisk “\*” at the beginning of the name indicates a low true signal.

## 6 PI2AES-LITE POWER

### 6.1 OVERVIEW

The PI2AES-LITE is designed to be powered from either the Raspberry Pi GPIO Pins 1 and 3, or from an external +5V (+/-10%) source. Jumper W2, when installed, allows the PI2AES-LITE to be powered from the Raspberry Pi. When jumper W2 is removed, separate 5V power must be supplied to the PI2AES-LITE and the Raspberry Pi.

Note, the on-board protection circuit ensures proper operation when jumper W2 is removed and power is applied via J1 and from the Pi (P1) simultaneously.

See the below block diagram for a simplified view of the PI2AES-LITE power.

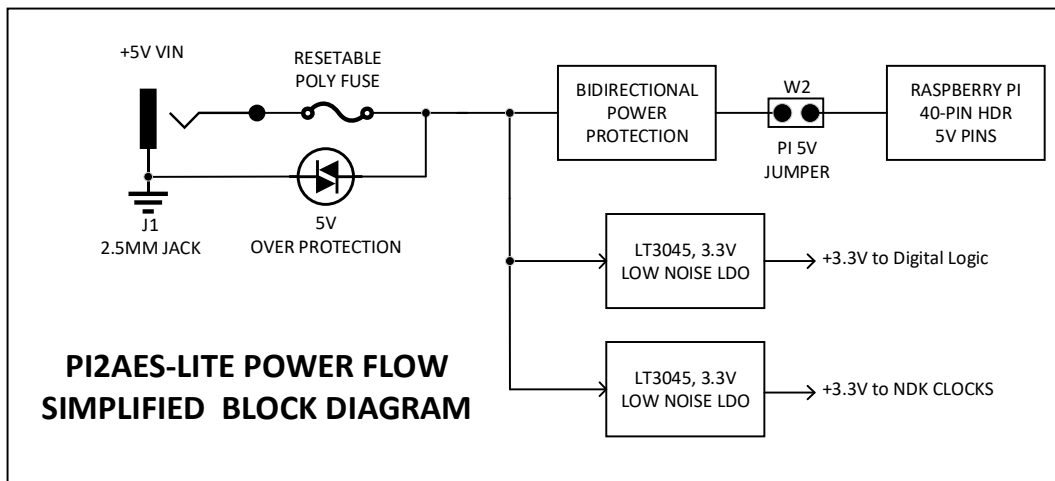


Figure 2 – PI2AES-LITE Power, Simplified Block Diagram

## 7 PI2AES-LITE SOFTWARE

### *7.1 OVERVIEW*

Due to the various resources interfaced on the PI2AES-LITE , both internal and external to the RPi, it is necessary to initialize a large number of CPU registers and external devices before correct operation can begin. These values and their proper sequencing are beyond the scope of this document. For most Raspberry Pi Software, the HifiBerry Digi+ Pro driver can be used.

# 8 CONNECTORS

## 8.1 OVERVIEW

This section provides the type and location of the connectors on the PI2AES-LITE .

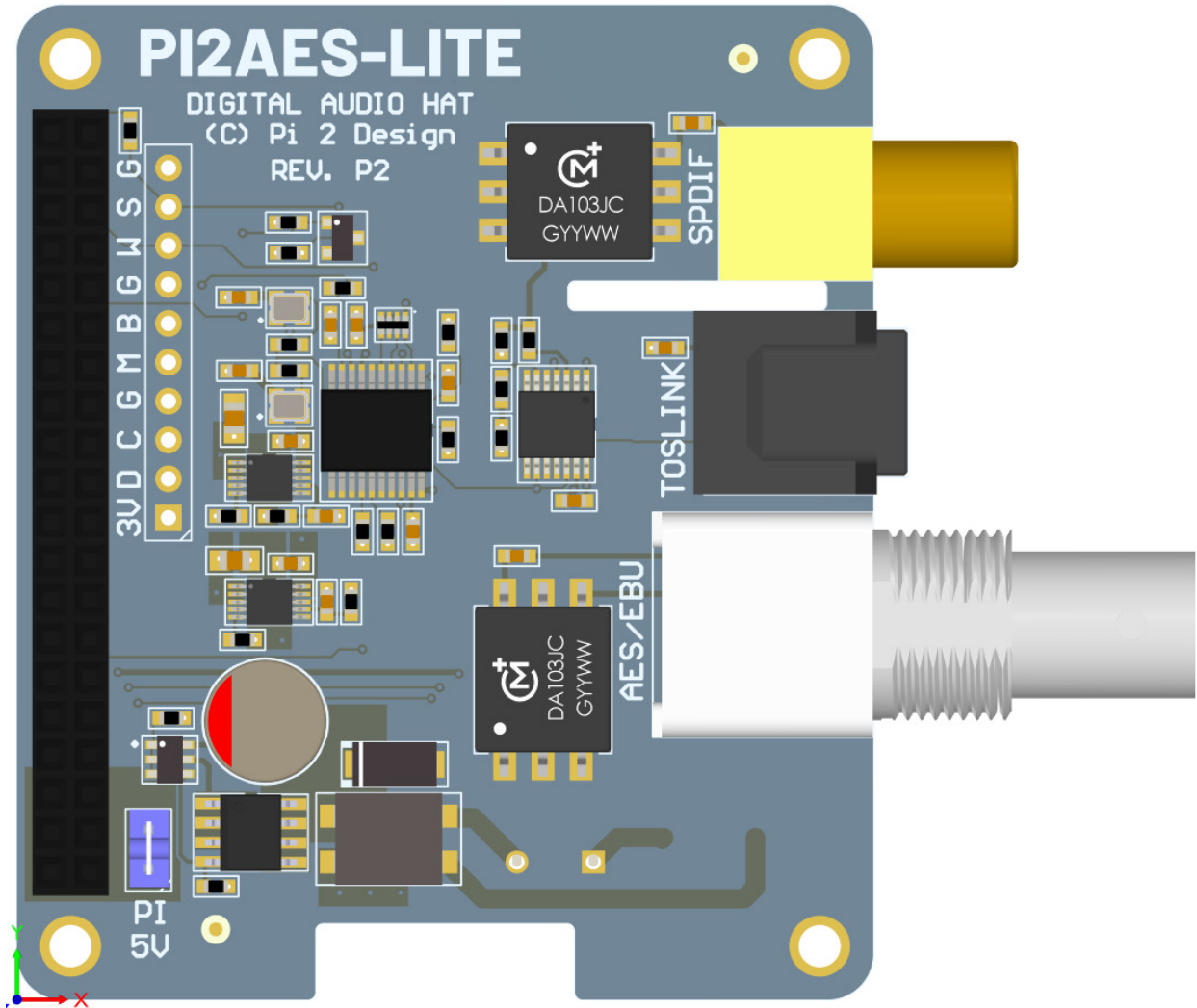


Table 5 – PI2AES-LITE Connector Locations

## 9 DOCUMENT REVISIONS

Date	Revision	Change
09/04/2022	P2.0	Preliminary Release
08/24/2023	P2.1	Updated Section 6 to include note regarding voltage drop
02/04/2024	P2.2	Re-worded Section 6 to define power options

Table 6 – Document Revisions

# IO ERRATA

## *10.1 OVERVIEW*

The External 5V Option has been updated to include the voltage drop issue.

## II CASE ASSEMBLY

### *11.1 OVERVIEW*

This section describes the Acrylic case included with the PI2AES-LITE and how to assemble it for the PI 3 or PI 4.

### *11.2 PART DESCRIPTIONS*

The acrylic case itself consist of 6 panels referred to as Bottom, Right, Left, Rear, Front and Top. Note that the Left and Front are different for the PI 3 and PI 4.

Additionally, there is the following HW:

- M2.5 6mm Male-Female Standoff x 4
- M2.5 18mm Male-Female Standoff x 4
- M2.5 30mm Female-Female Standoff x4
- M2.5 6mm Panhead Phillips Screw x 9 (1 extra in case it runs away!)

The following photo shows these parts as well as the PI2AES-LITE.



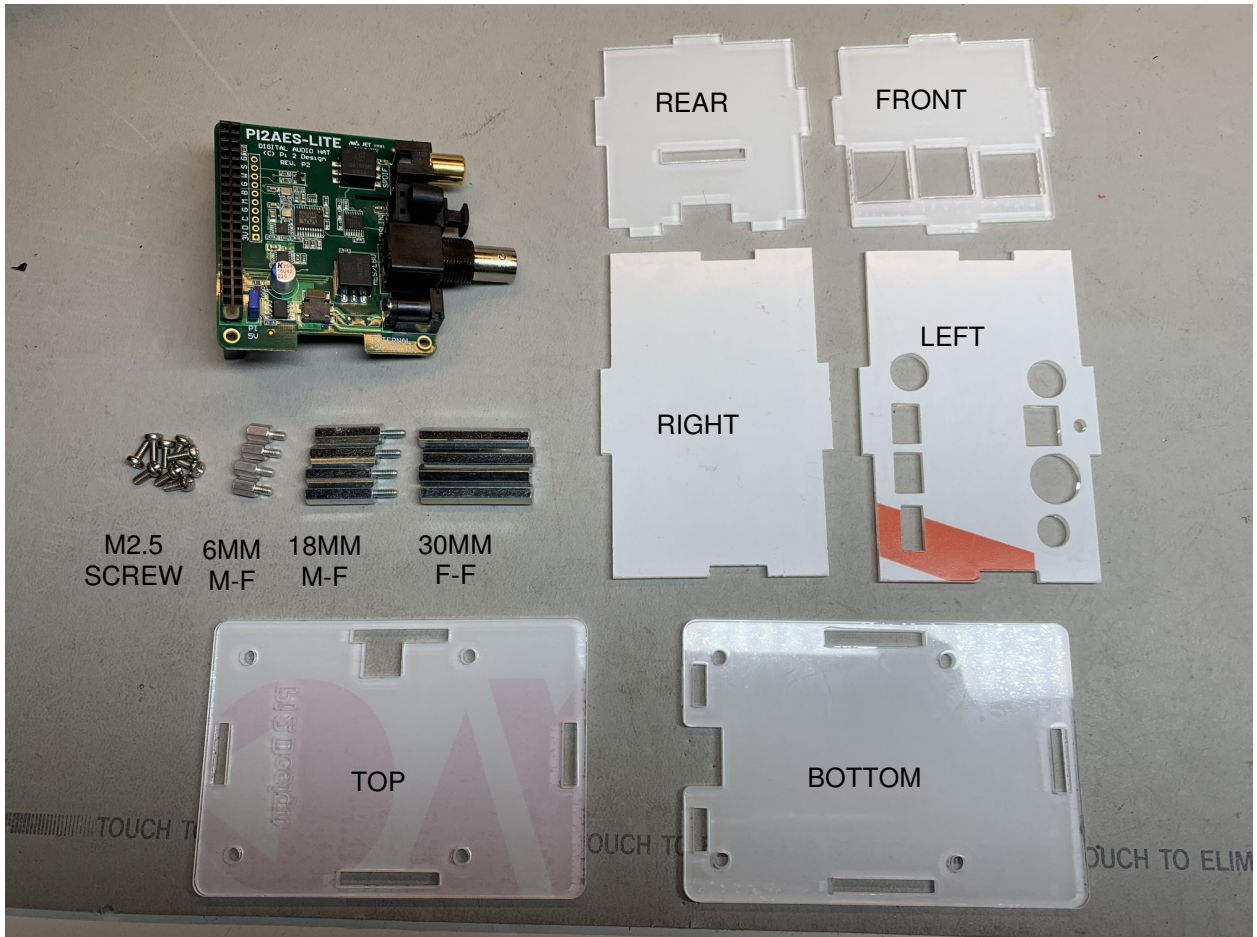
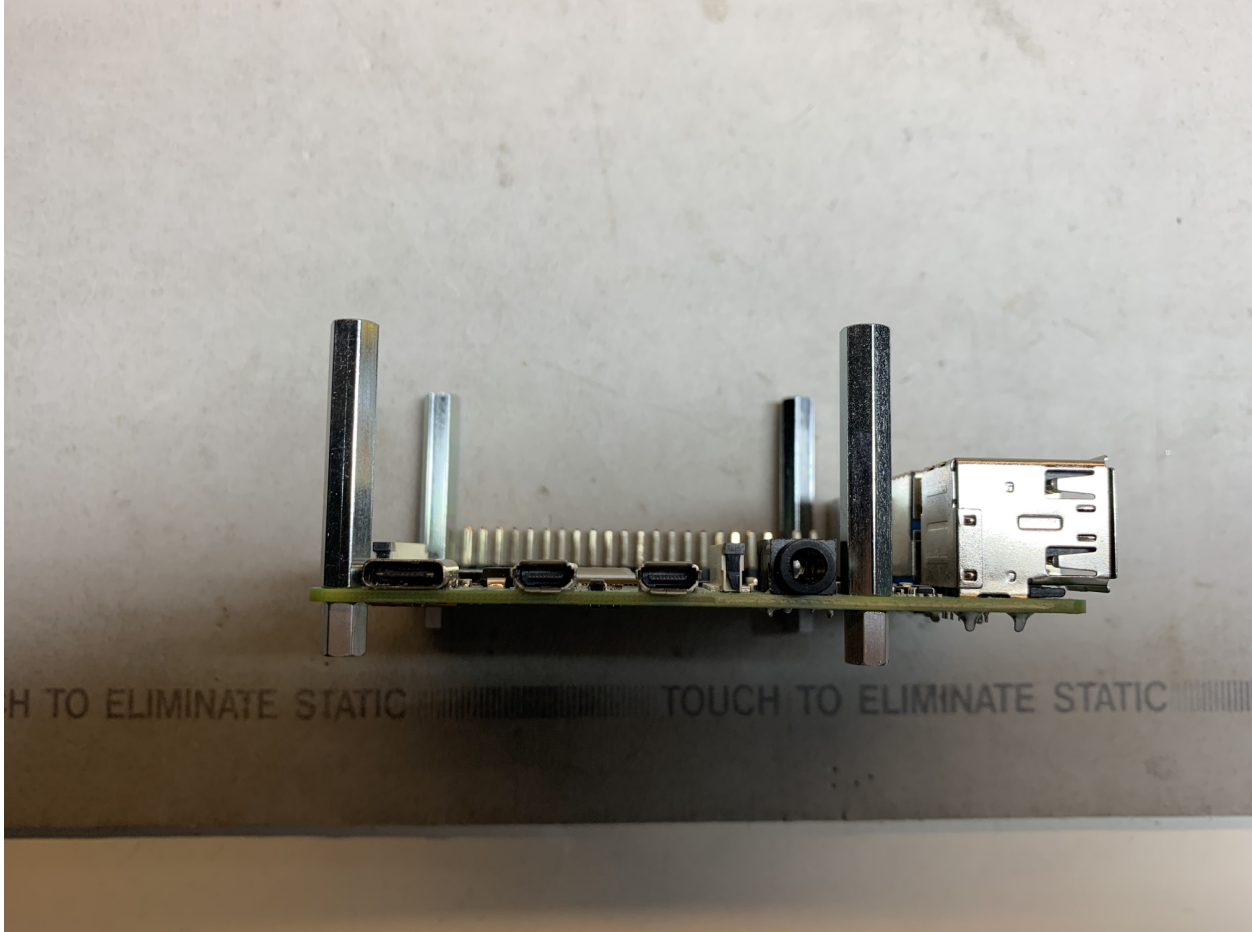


Figure 3 - PI2AES-LITE Acrylic Case Parts

***11.3 ASSEMBLY STEP 1***

Attach the 30mm F-F standoffs to the PI using the 6mm M-F to hold them as shown in the following picture.



#### ***11.4 ASSEMBLY STEP 2***

Attach the bottom panel to the 6mm M-F standoffs as shown in the following picture. Note the orientation of the SD Card cutout.



### 11.5 ASSEMBLY STEP 3

Attach the PI2AES-LITE to the Raspberry Pi as shown in the following picture.





#### ***11.6 ASSEMBLY STEP 4***

Place the various side panels into the respective bottom panel slots as shown in the following pictures. Note that there are two left side panels (with HDMI) and two front side panels (USB), one pair each for the PI3 and PI4. PI4 is shown in the picture.



### *11.7 ASSEMBLY STEP 5*

Capture the side panels using the top panel and screw into place using 4 m2.5x6mm screws. Note the orientation of the cutout for the optical jack.

