
AD2 Functionality Expansion Board

User Manual and Build Guide

Version 1.0

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1.1 Physical Dimensions

Board dimensions

50 mm

100 mm

Assembled dimensions

108 mm

66 mm

Figure 1: Physical dimensions

2. Build Guide

2.1 Bill Of Materials

ITEM	MANUFACTURER PART NUMBER	QUANTITY
PCB		1
Header 2x15 Right Angle	PPPC152LJBN-RC	1
Header 2x4 Right Angle	PPPC042LJBN-RC	1
Header 1x6 Right Angle	PPPC061LGBN-RC	2
Header 2x6	PPTC062LFBN-RC	1
Header 2x4	PPTC042LFBN-RC	1
Male-Male Pin Header 2x40 (Short)	TSW-140-07-T-D	1
Male-Male Pin Header 1x40 (Short)	TSW-140-07-T-S	1
Male-Male Pin Header 1x30 (Long)	TSW-130-17-T-S	1
Qwiic Connector	SM04B-SRSS-TB(LF)(SN)	1
Grove Connector	A118	1
BNC Connector	5413969-2	2
Barrel Jack	PJ-036AH-SMT-TR	1
Hall Effect Sensor	TMCS1108A4UQDR	1
Current Sense Amplifier	INA190A1IDCKR	1
Analog Digital Converter	ADS1015IRUGR	2
Capacitor (0.1 μ F)	CL10B104KB8NNWC	1
Capacitor (150 pF)	CL10C151JB8NFNC	1
Resistor (10 k Ω)	RNCP0603FTD10K0	3
Resistor (100 Ω)	CRT0603-FY-1000ELF	1
Connector Jumper	QPC02SXGN-RC	6
DC Power Supply	L6R48-240	1
Power Board	B08NV3JCBC	1

2.2 Tools and Consumables

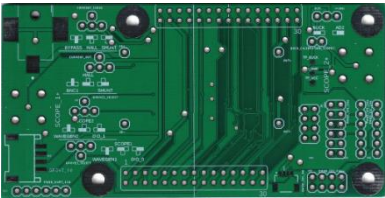



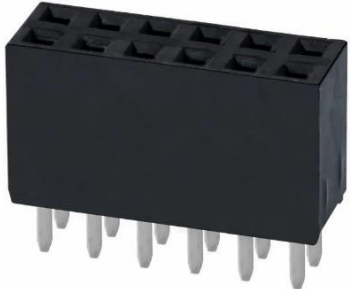







2.2.1 Required for Assembly

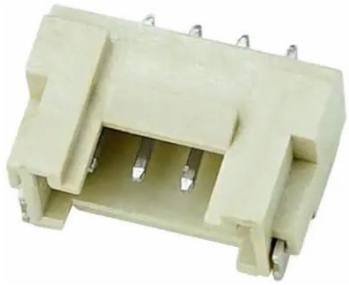


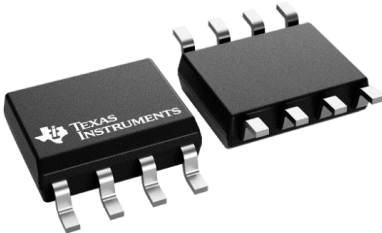
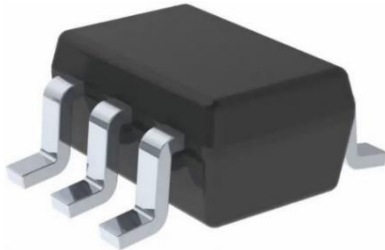
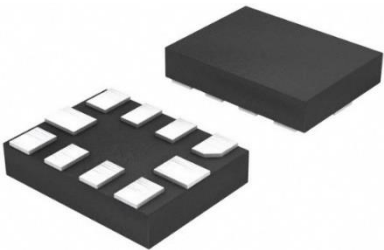

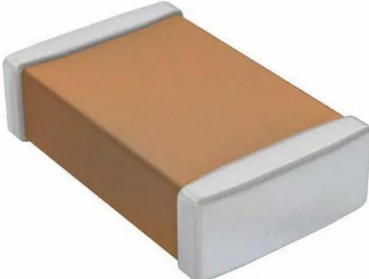

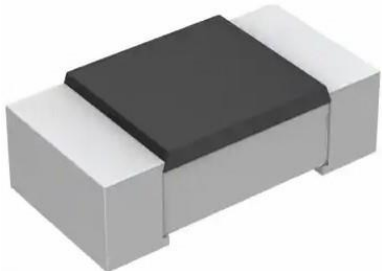
- Soldering Iron
- Solder Wire
- Flux
- Flush Cutter/Pliers with Cutting Implement

2.2.2 Recommended for SMD Components

- Hot Air Rework Station/Reflow Oven
- Solder Paste
- Tweezers

2.3 Part List

PCB (1) 	2x15 Right Angle Header (1) 	2x4 Right Angle Header (1) 
1x6 Right Angle Header (2) 	2x6 Header (1) 	2x4 Header (1) 
2x15 Pin Header (1) 	1x3 Pin Header (5) 	1x2 Pin Header (1) 
1x1 Pin Header (4) 	1x1 Long Pin Header (4) 	Qwiic Connector (1) 

Grove Connector (1) 	BNC (2) 	Barrel Jack (1) 
Hall Effect Sensor (1) 	Current Sense Amplifier (1) 	ADC (2) 
0.1μF Capacitor (1) 	150 pF Capacitor (1) 	10k Ohms Resistor (1) 
100 Ohm Resistor (1) 		

2.4 Part Installation

It is recommended to install parts in the following order. Refer to Figure 2 for placement of SMD components in step 1 and Figure 3 for placement of all other components.

1. Install the SMD components.
 - a. 2x ADC
 - b. Current Sense Amplifier
 - c. Hall Effect Sensor
 - d. Resistors/Capacitors
2. Install the BNCs. Since these have a large thermal mass, if available, use a reflow oven or infrared preheater to preheat the PCB to assist in soldering these components.
3. Solder down jumper selectors and power board posts.
4. Slide power board onto posts and solder them together.
5. Solder down remaining parts around the board.
 - a. Barrel Jack
 - b. Qwiic Connectors
 - c. Grove Connectors
 - d. Pmod Connectors
 - e. AD2 Connector/Passthrough

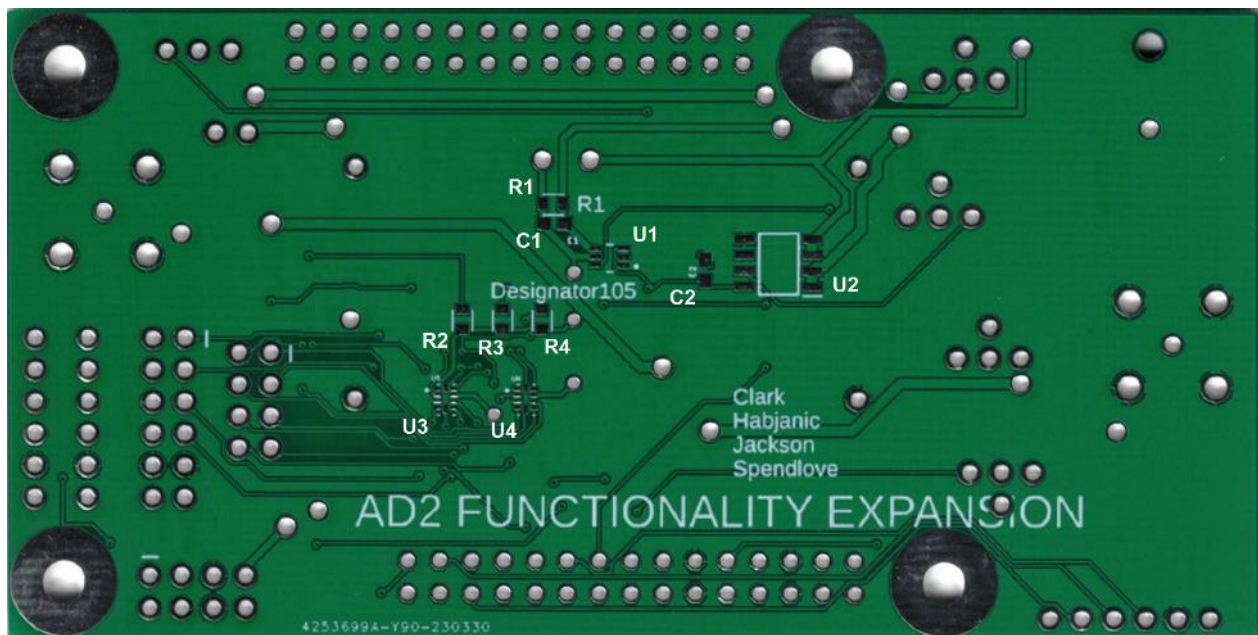


Figure 2: SMD Locations on underside of PCB

LOCATION	PART	LOCATION	PART
C1	150 pF Capacitor	U1	Current Sense Amplifier
C2	100 pF Capacitor	U2	Hall Effect Sensor
R1	100 Ohm Resistor	U3	ADC
R2	10k Ohm Resistor	U4	ADC
R3	10k Ohm Resistor		
R4	10k Ohm Resistor		

3. Getting Started

3.1 Setup Decision Tree

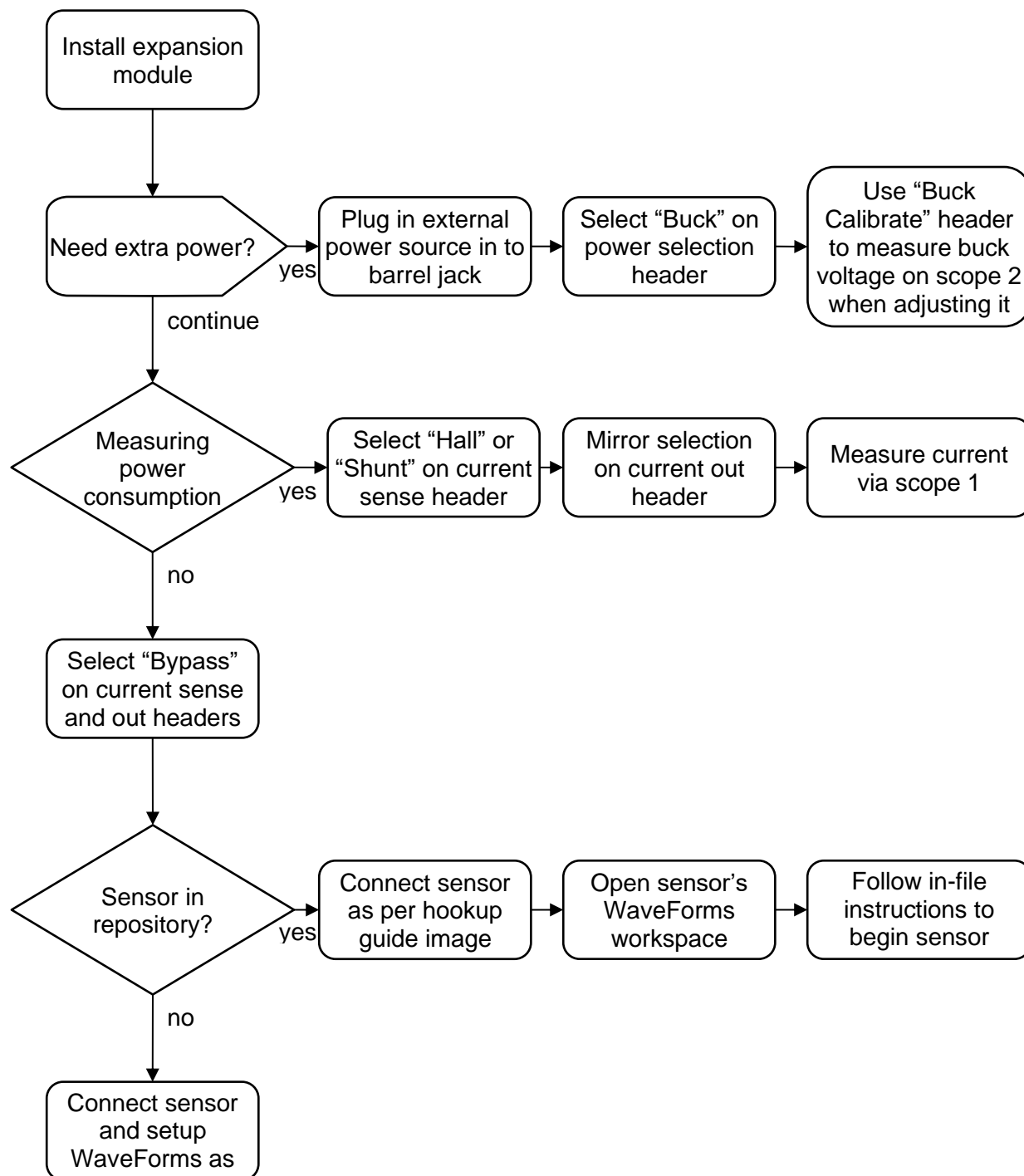


Figure 4: Setup decision tree

3.2 Cautions & Warnings

1. Always check the voltage source before plugging in a sensor. The buck converter is more than powerful enough to blow out a connected device if the voltage is too high.
2. When calibrating the buck converter's voltage output by jumping the 2-pin header, the 3-pin supply select header should not have a jumper. It is recommended to equip the expansion board with one jumper to share among those two headers to avoid damaging devices connected to the board.
3. The 2-pin header used to measure the buck converter's output voltage connects the buck to scope 2, which has a static direct connection to scope 2's BNC connector. This means that when it is jumped to calibrate the buck converter, the BNC connector receives a direct connection to the buck's output, and current is permitted to flow into anything hooked up to it and potentially cause damage.

3.3 Configuration Detail

1. The voltage source can be selected via the 3-pin header. The options are the AD2's source V+ and the buck converter and can be selected as per the diagram printed on the expansion board.
2. When using the buck converter, remove the jumper from the 3-pin source selection header and place it on the 2-pin buck measurement header. The AD2's scope 2 can then be used to measure the output voltage of the buck so that the desired level can be set. When done, the jumper can be returned to the 3-pin header.
3. When measuring current, the desired method can be selected with the 4-pin current sense/out headers. The options are shunt resistor and hall effect and can be selected as per the diagrams printed on the expansion board. The jumpers on the two current sense/out headers should always be in the same position to produce the desired result.
4. The Grove standard has a specification for both digital as well as analog applications. To allow the Grove connector on the expansion board to comply with this specification, two 4-pin headers allow the function of the Grove's data pins to be selected. The options are digital (DIO), analog in (scope), and analog out (wavegen) and can be selected as per the diagrams printed on the expansion board.
5. The files for using a sensor can be found in the repository. There is an image that shows how to connect the sensor to the expansion board and a WaveForms workspace that can be used as-is to begin using the sensor.

4. Using the Board

4.1 Overview

The diagram below describes the top-level functions of the expansion board. An explanation of the select headers can be found in section 4.3 for the “Current Sense” headers and 4.4 for the “Grove Select” headers.

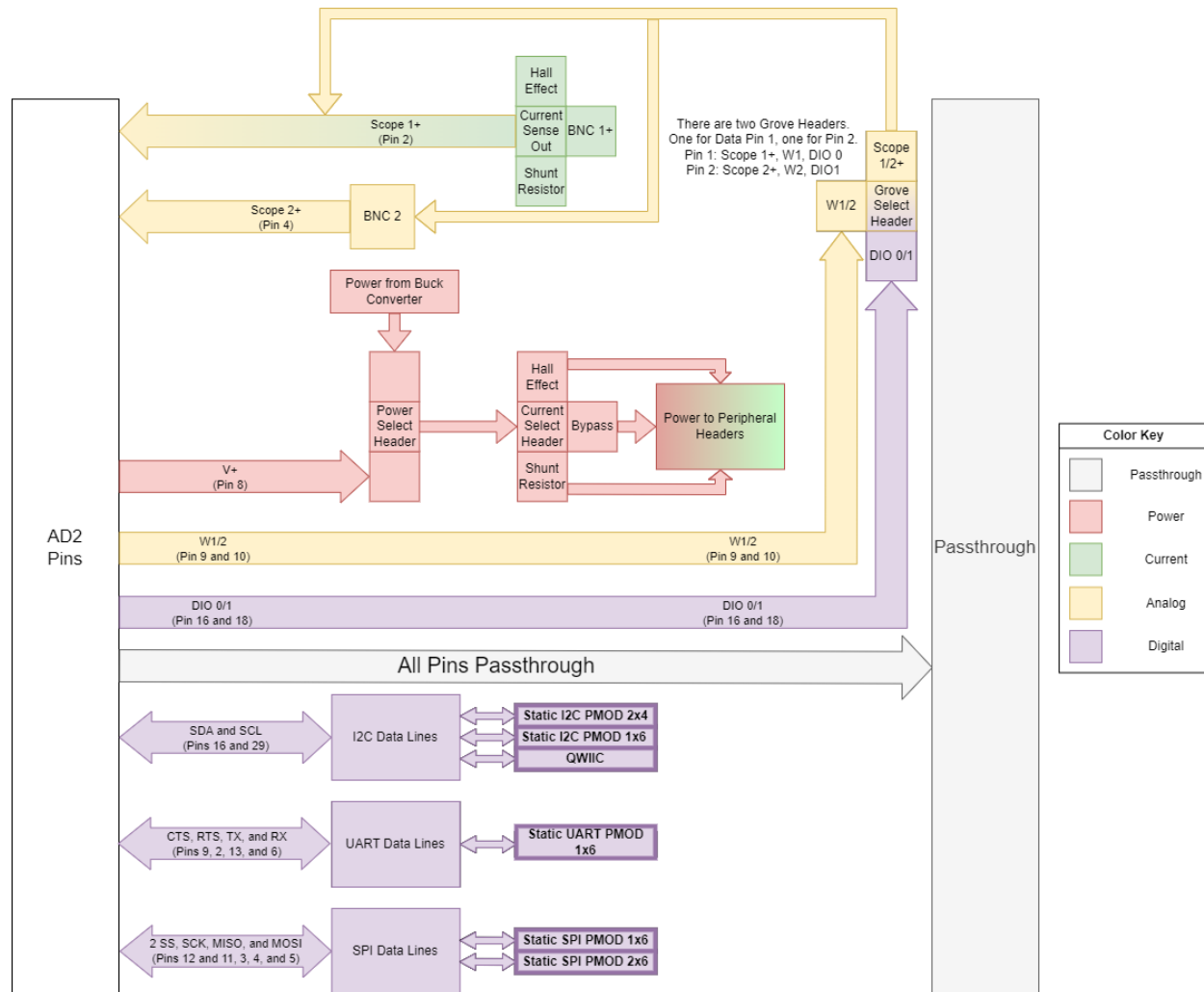


Figure 5: Functional diagram of the expansion board

4.2 Schematic

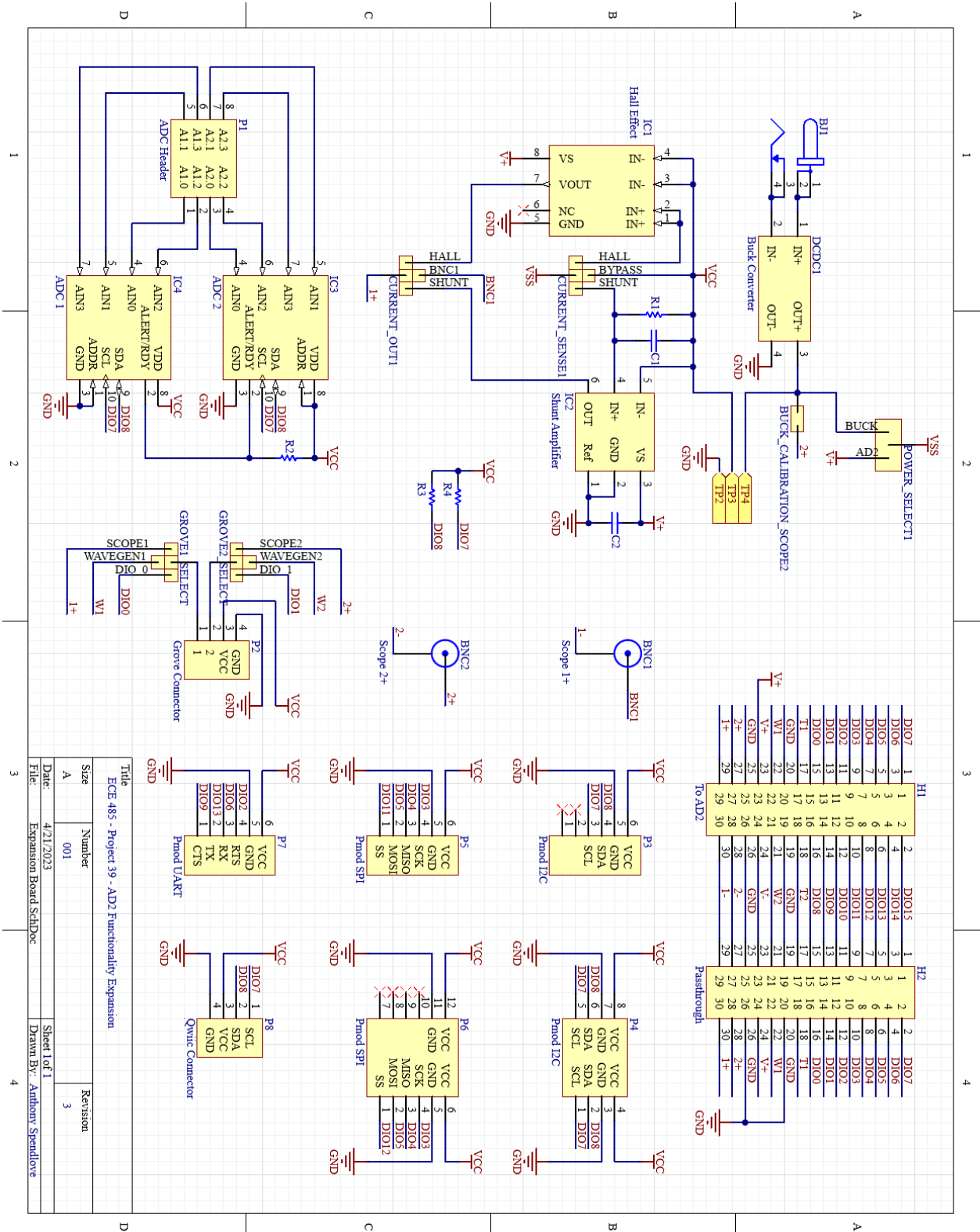


Figure 6: Expansion board schematic

4.3 Passthrough

A 2x15-pin header duplicates the main AD2 connector with a direct connection between each pin and the corresponding pin on the AD2. Note that the AD2 ribbon cable must be plugged in with its key facing the center of the board (upwards in the image below) to match how it would fit in the AD2.

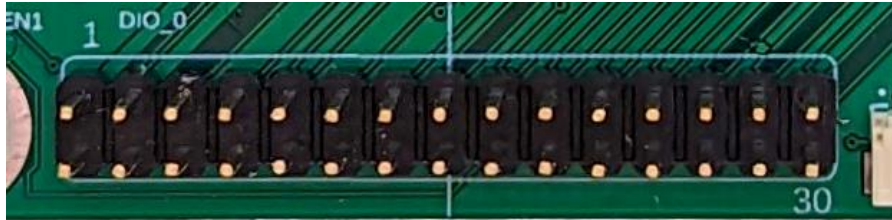


Figure 7: Passthrough connector

Table 4.1: Passthrough header pinout

PIN	AD2	FUNCTION NAME	PIN	AD2	FUNCTION NAME
PIN 1	1+		PIN 2	1-	
PIN 3	2+		PIN 4	2-	
PIN 5	GND		PIN 6	GND	
PIN 7	V+		PIN 8	V-	
PIN 9	W1		PIN 10	W2	
PIN 11	GND		PIN 12	GND	
PIN 13	T1		PIN 14	T2	
PIN 15	DIO 0		PIN 16	DIO 8	SDA
PIN 17	DIO 1		PIN 18	DIO 9	CTS
PIN 19	DIO 2	RTS	PIN 20	DIO 10	SS_3
PIN 21	DIO 3	SCK	PIN 22	DIO 11	SS_2
PIN 23	DIO 4	MISO	PIN 24	DIO 12	SS_1
PIN 25	DIO 5	MOSI	PIN 26	DIO 13	TX
PIN 27	DIO 6	RX	PIN 28	DIO 14	
PIN 29	DIO 7	SCL	PIN 30	DIO 15	

4.4 Power Supply

The external power subsystem gives users the option of providing more power to their peripherals.

The 3-pin jumper header in the top-right of the board allows selection of either the AD2's positive voltage supply or the buck converter as the voltage source for the DUT.

The 2-pin jumper header below the power selection header connects the output of the buck converter to the AD2's scope channel 2+, which allows the output voltage to be measured in WaveForms. The buck converter's potentiometer, seen in the image below, is used to adjust its output voltage to the desired level.

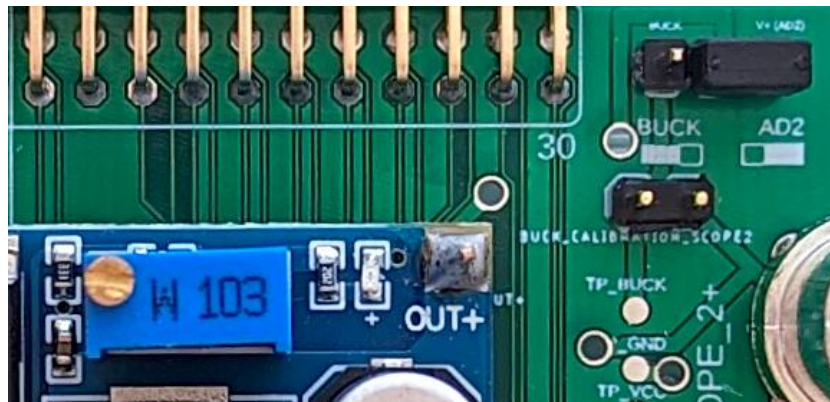


Figure 8: Power management

4.5 Current Measurement

There are two current measurement systems included on the expansion board, namely a hall effect sensor and a shunt resistor. They can be selected via the upper two 4-pin jumper headers. The top header selects which system is placed in the current path, while the bottom header selects which system is measured by the AD2's scope channel 1+. When in "Bypass" mode (shown in the image below), the sensors are not in the current path and the scope channel 1+ connects to its BNC connector.

The jumper headers each have 3 possible configurations and should always match each other:

1. Bypass/BNC1 – to be used when current sensing is not desired
2. Hall – to be used for any current level, but with a low resolution of $800\ \mu\text{A}$
3. Shunt – to be used for currents up to $1.32\ \text{mA}$ with a resolution of $128\ \text{nA}$



Figure 9: Current measurement jumper headers

4.6 Grove Select Header

The Grove connector standard includes specifications for analog and digital operation. To cover all possible configurations, the two data lines of the grove connector can be connected to the AD2's scope channels (for analog in), wavegen channels (for analog out), or DIO pins (for digital I/O) using the lower two 4-pin jumper headers.



Figure 10: Grove connector function select jumper headers

4.7 Connector Pinouts

4.7.1 ADC Header

PIN	ADC #	ADC CHANNEL	PIN	ADC #	ADC CHANNEL
PIN 1	0	0	PIN 2	0	2
PIN 3	0	1	PIN 4	0	3
PIN 5	1	0	PIN 6	1	2
PIN 7	1	1	PIN 8	1	3

4.7.2 Grove Connector

GROVE SELECT HEADER POSITION				
PIN	LEFT	VERTICAL	RIGHT	FUNCTION NAME
PIN 1	1+	W1	DIO 0	GROVE1
PIN 2	2+	W2	DIO 1	GROVE2
PIN 3				VCC
PIN 4				GND

4.7.3 Pmod I2C 1x6

PIN	DIO	FUNCTION NAME
PIN 1		VCC
PIN 2		GND
PIN 3	DIO 8	SDA
PIN 4	DIO 7	SCL
PIN 5		
PIN 6		

4.7.4 Pmod I2C 2x4

PIN	DIO	FUNCTION NAME	PIN	DIO	FUNCTION NAME
PIN 1	DIO 7	SCL	PIN 2	DIO 7	SCL
PIN 3	DIO 8	SDA	PIN 4	DIO 8	SDA
PIN 5		GND	PIN 6		GND
PIN 7		VCC	PIN 8		VCC

4.7.5 Pmod SPI 1x6

PIN	DIO	FUNCTION NAME
PIN 1	DIO 11	SS_2
PIN 2	DIO 5	MOSI
PIN 3	DIO 4	MISO
PIN 4	DIO 3	SCK
PIN 5		GND
PIN 6		VCC

4.7.6 Pmod SPI 2x6

PIN	DIO	FUNCTION NAME	PIN	DIO	FUNCTION NAME
PIN 1	DIO 12	SS_1	PIN 2		
PIN 3	DIO 5	MOSI	PIN 4		
PIN 5	DIO 4	MISO	PIN 6		
PIN 7	DIO 3	SCK	PIN 8		
PIN 9		GND	PIN 10		GND
PIN 11		VCC	PIN 12		VCC

4.7.7 Pmod UART 1x6

PIN	DIO	FUNCTION NAME
PIN 1	DIO 9	CTS
PIN 2	DIO 13	TX
PIN 3	DIO 5	RX
PIN 4	DIO 2	RTS
PIN 5		GND
PIN 6		VCC

4.7.8 Qwiic Connector

PIN	DIO	FUNCTION NAME
PIN 1		GND
PIN 2		VCC
PIN 3	DIO 8	SDA
PIN 4	DIO 7	SCL

