

SeeStar II Arduino Controller Shield
Hardware Interface Document, v0.2

Monterey Bay Aquarium Research Institute

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Overview

SeeStar II is an autonomous and modular imaging system (Fig 1). It is programmed prior to deployment and can be left unattended for months at a time. It is an open source project and is distributed under a Creative Commons Attribution-ShareAlike 4.0 License. SeeStar II consists of three individual modules: the camera, battery, and LED. The camera module contains the Arduino Controller Shield which is responsible for triggering the camera and activating the lights.



Figure 1: Picture of the SeeStar II Imaging System

System Level Description

The Controller Shield acts as the main interface between the Arduino Pro-Mini CPU board and the rest of the electronics in the imaging system. It resides in the camera module and controls the timing of the camera and LED light module. It is programmed via the FTDI port on the Pro-Mini CPU and it contains a Real Time Clock (RTC) for accurate timing.

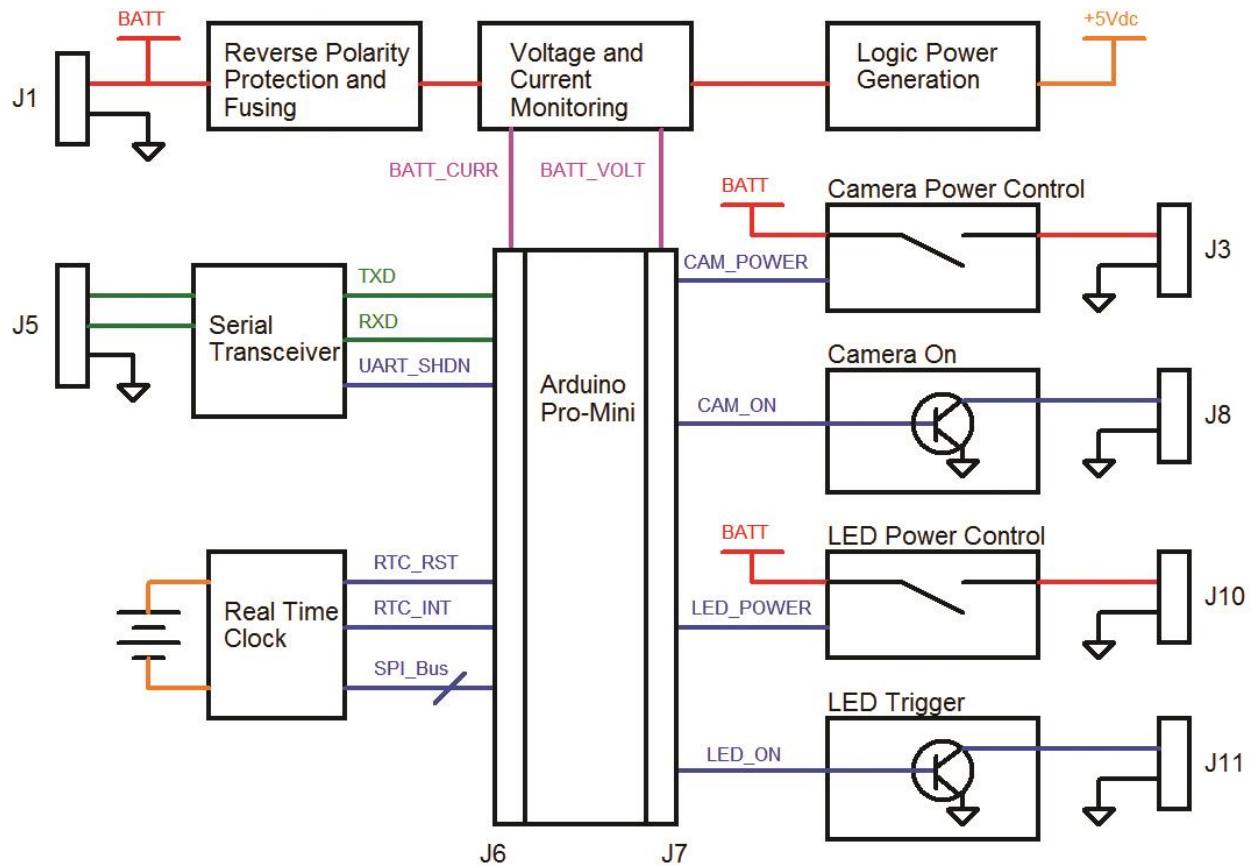


Figure 2: Block Diagram of SeeStar II Arduino Controller Shield

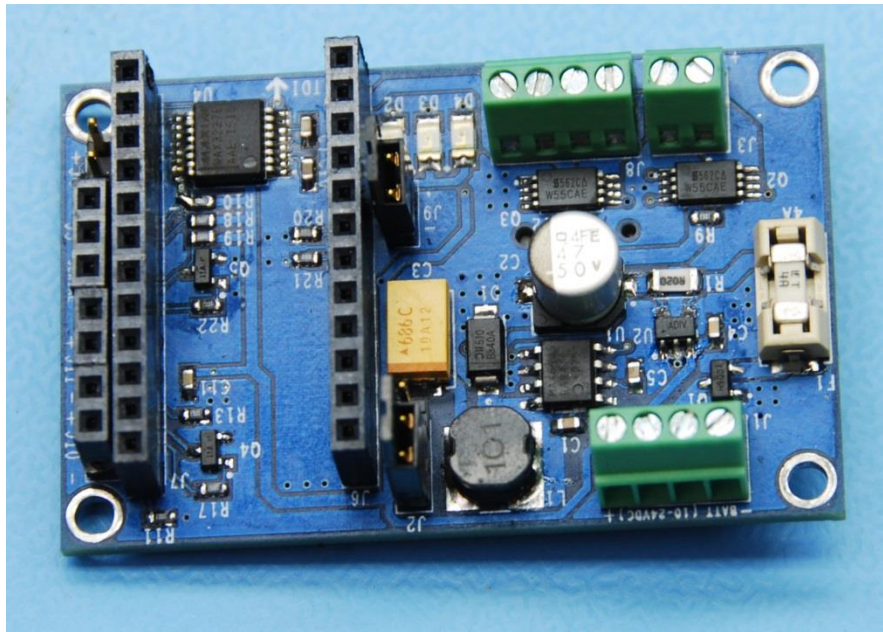


Figure 3: Top view of controller pcb

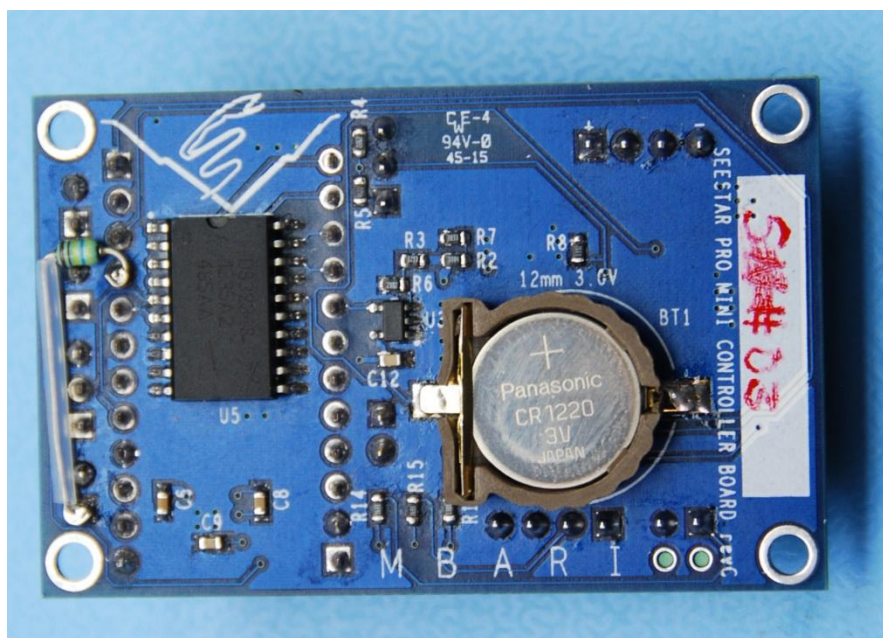


Figure 4: Rear view of controller pcb

Basic Operation

This section is meant to assist the user with simple bench top testing. For details on installing it in the camera module refer to the Camera Technical Manual.

Initial Board Power Up and Testing

Before any newly populated boards are powered up and used, a series of tests should be performed in order to ensure proper operation. This section is meant as a quick series of tests, for more details on individual circuits, refer to the Functional Descriptions section.

1. Selection of 3.3V or 5V Arduino

Install a 2-pin shunt jumper on J2.

Pins 1-2 for 5V Arduinos

Pins 2-3 for 3.3V Arduinos

2. Fuse Verification

F1 should have a 4 Amp slo-blo fuse installed

3. LED Functionality

During testing it is useful to use the LEDs for quick visual feedback. Install a 2-pin shunt jumper on J9 to enable the LEDs.

4. Real Time Clock Functionality

Install the required watch battery in BT1 on the rear side of the pcb.

5. Logic Power Verification

Set an external DC power supply up for 12Vdc with a 3 amp current limit. Hook the output of the DC power supply up to J1 on the Controller Shield. Turn on the DC power supply and with a voltmeter, measure Vdd. This can be done at many locations; the positive end of C3 is convenient. Vdd should match the chosen value from step one.

Functional Descriptions

Arduino Pro-Mini Interface

The Arduino Pro-Mini plugs into the top of the Controller Shield; silk-screening on the shield indicates the position of the FTDI connector for proper orientation. The connectors on the shield were numbered to match those of the Pro-Mini (JP6 connects to J6 and JP7 connects to J7). The usage of the Pro-Mini signals is displayed in Tables 1 and 2. Technical details of the signals are described in the board level signal section.

JP7 Pin #	Arduino Name	Shield Name	Arduino Signal Type
12	TXO	TXD	TTL Level Serial
11	RXI	RXD	TTL Level Serial
10	RESET	N/A	
9	GND	GND	Ground
8	D2	RTC_INT	Digital Input
7	D3	N/A	
6	D4	LED_ON	Digital Output
5	D5	RTC_RESET	Digital Output
4	D6	UART_SHDN	Digital Output
3	D7	LED_POWER	Digital Output
2	D8	CAM_ON	Digital Output
1	D9	CAM_POWER	Digital Output

Table 1: Arduino Pro-Mini JP7 Signals

JP6 Pin #	Arduino Name	Shield Name	Arduino Signal Type
1	RAW	BATT	Input Power
2	GND	GND	Ground
3	RESET	N/A	
4	VCC	N/A	
5	A3	N/A	
6	A2	N/A	
7	A1	BATT_CURR	Analog Input
8	A0	BATT_VOLT	Analog Input
9	SCK	SCK	SPI
10	MISO	MISO	SPI
11	MOSI	MOSI	SPI
12	D10	RTC_SS	Digital Output

Table 2: Arduino Pro-Mini JP6 Signals

Battery Monitoring and Input Protection

Battery voltage is applied to the Controller Shield at J1; J1 has four pins due to the positive and negative power lines being doubled up in the inter-module cable to reduce resistive losses. Q1 offers reverse polarity protection and F1 is a replaceable fuse. The maximum current draw should never exceed 3 amps, but the traces and fuse are rated for 4 amps.

The current draw and voltage level of the battery module is monitored by the Controller Shield. U2 is a current sense amplifier which amplifies a low level voltage developed across sense resistor R1. The built-in gain of the MAX4372F is 50. The output of U2 (signal BATT_CURR) is a 0-3V analog signal that is calculated by:

$$\begin{aligned}\text{BATT_CURR (volts)} &= \text{IBatt (amps)} \times \text{Gain} \times \text{Rsense (ohms)} \\ &= \text{IBatt (amps)} \times 50 \times 0.02 \text{ (ohms)} \\ &= \text{IBatt (amps)} \times 1 \text{ (ohms)}\end{aligned}$$

or conversely

$$\text{IBatt (curr)} = \text{BATT_CURR (volts)} / 1 \text{ (ohms)}$$

For example, measuring 1.2V at BATT_CURR corresponds to a battery current of 1.2 amps:

$$\begin{aligned}\text{Battery current} &= 1.2\text{V} / 1 \text{ ohm} \\ \text{Battery current} &= 1.2 \text{ Amps}\end{aligned}$$

The battery voltage level is scaled via resistors R3 and R6. With a maximum expected battery voltage of 16Vdc, the scaling ratio is set to 0.188. The output of op amp U3 is BATT_VOLT. It is calculated by:

$$\text{BATT_VOLT (volts)} = (R6/(R3+R6)) \times \text{BATT (volts)} = 0.188 \times \text{BATT (volts)}$$

or conversely

$$\text{BATT (volts)} = 5.319 \times \text{BATT_VOLT (volts)}$$

For example, measuring 2.35V at BATT_VOLT corresponds to a battery bus voltage of 12.5Vdc

Logic Power Generation

The Controller Shield has been designed to work with either the 3.3V or 5V version of the Arduino Pro-Mini. This is accomplished by using an adjustable DC switching regulator with two possible feedback resistors to set the output voltage. A 3-pin jumper, J2, allows the user to configure the controller shield. Jumpering pins 1-2 is used for 5V operation, while jumpering 2-3 is for 3.3V. U1 is a switching regulator (MAX5035D) which provides 1 amp at approximately 85% efficiency.

**** Do not power up the Controller Shield without installing a jumper on J2. Doing so will result in damaging U1 ****

GoPro Hero Power and On/Off Control

The Controller Shield is responsible for supplying battery voltage and a control signal to the GoPro Hero camera. In order to save battery capacity, power is completely removed from GoPro between images. The factory GoPro battery is removed and a Battery Eliminator is used in its place. The Battery Eliminator accepts 9-16Vdc and generates the required voltage for the GoPro.

The active high CAM_POWER signal turns on an N-Channel MOSFET (Q2A) which then turns on a P-Channel MOSFET (Q2B) which passes battery voltage to the Battery Eliminator via J3. This applies power to the GoPro but does not turn it on (electrically equivalent to simply putting a battery in the camera).

The active high CAM_ON signal forward biases an NPN transistor (Q4). The collector of Q4 is connected to pin #12 of the exposed Hero bus on the rear of the camera. Pulling pin 12 low is equivalent to depressing the on/off button. CAM_ON needs to be held high for approximately 1000msec to turn the GoPro on.

LED Power and Trigger

The Controller Shield is responsible for supplying battery voltage and a trigger signal to the LED module.

The active high LED_POWER signal turns on an N-Channel MOSFET (Q3A) which then turns on a P-Channel MOSFET (Q3B) which passes battery voltage to the LED module via J8. This applies power to the LED but does not turn it on.

The active high LED_ON signal forward biases an NPN transistor (Q5). The collector of Q5 is connected to the on/off button on the LED. Pulling this line low turns on the LED and changes the operating mode of the LED. It is a momentary low signal and needs to be held low for approximately 500msec.

Real Time Clock Control

The Controller Shield is equipped with a 2ppm accuracy real time clock (U5). The DS3234 maintains seconds, minutes, hours, day, date, month, and year information. It also has 2 user programmable alarms via the INT pin. The DS3234 communicates via the SPI bus. See the Programming Guide and the DS3234 datasheet for further details.

Serial Interface

The Controller Shield has an optional serial port (via J5) for accessing the Arduino Sketch or for writing a user interface. The TTL level serial signals are shared with the FTDI port and cannot be used simultaneously. Jumper J4 disables the serial transceiver to ensure proper FTDI operation.

Board Jumper Options

DC Power LEDs

There are three board level LEDs which indicate the state of various power levels. Table three is a listing of the LEDs and levels monitored. Jumper J9 can be installed to enable all three LEDs simultaneously.

LED	Color	Function
D2	Blue	Camera Power
D3	Red	LED Power
D4	Green	Logic Power

Table 3: Board Level LEDs and Functions

Serial Communication Source

The TTL level serial signals are shared by the FTDI connector and the external serial transceiver U4. (MAX3227E). Attempting to use the FTDI port while the serial transceiver is active will result in miscommunication. The serial transceiver may be disabled via the UART_SHDN signal, or easier still is to place a jumper on J4. The serial transceiver will be disabled as long as jumper J4 is installed.

Board Level Signal Descriptions

All analog and digital signals originate or terminate with the Arduino Pro-Mini. Their detailed descriptions and locations are described in this section.

Analog Input Signals

BATT_CURR [A1; JP6-7]

This is a 0-3V analog voltage signal which corresponds to the current draw from the battery module. The conversion factor is $Y(\text{amps}) = 1.0 \times \text{BATT_CURR}(\text{volts})$.

BATT_VOLT [A0; JP6-8]

This is a 0-3V analog voltage signal which corresponds to the output voltage of the battery module. The conversion factor is $Y(\text{volts}) = 5.32 \times \text{BATT_VOLT}(\text{volts})$.

SPI Bus Signals

SCK [SCK; JP6-9]

The clock input for the SPI bus.

MISO [MISO; JP6-10]

The SPI data output of the DS3234.

MOSI [MOSI; JP6-11]

The SPI data input to the DS3234.

Digital Input Signals

RTC_INT [D2; JP6-8]

This is the active low alarm output of the DS3234 real time clock.

Digital Output Signals

RTC_SS [D10; JP6-12]

This is the active low chip select signal for the SPI bus controlling the DS3234 real time clock.

LED_ON [D4; JP7-6]

This is an active high signal which is used to turn on the LED light. This is a momentary signal and needs to stay high approximately 500msec in order for the LED to turn on.

RTC_RESET [D5; JP7-5]

This is active low reset line. It is continuously monitored as a pushbutton input for generating a reset.

UART_SHDN [D6; JP7-4]

This is an active low signal which disables the serial transceiver (U4).

LED_POWER [D7; JP7-3]

This is an active high signal which applies battery voltage to the LED module. This is a continuous signal and must remain high while the LED is in operation.

CAM_ON [D8; JP7-2]

This is an active high signal which is used to turn on the GoPro Hero camera. CAM_POWER must already have been asserted for CAM_ON to work. This is a momentary signal and needs to remain high for approximately 1000msec for the GoPro to turn on.

CAM_POWER [D9; JP7-1]

This is an active high signal which applies battery voltage to the GoPro Battery Eliminator. This is a continuous signal and must remain high while the GoPro is in operation.

Serial Signals

TXD [TXO; JP7-12]

This is a TTL level transmit signal coming from the Arduino.

RXD [RXI; JP7-11]

This is a TTL level receive signal going to the Arduino.

Appendices

Input Voltage	9-15Vdc
<i>Current</i>	
Max	3 amps
Nominal	~50 ma

Appendix 1: Electrical Specifications

Length	2 ³ / ₁₆ in
Width	1 ³ / ₈ in
Height	⁹ / ₁₆ in
<i>Operating Temperature</i>	
Min	0° C
Max	70° C
Operating Depth	1500m

Appendix 2: Mechanical Specifications

Ref	Value	Manufacturer	Manufacturer PN	Description
BATT	CR1220	Panasonic	CS1220	Battery Lithium 3V Coin 12.5mm
BT1	S8411-45R	Harwin Inc	S8411-45R	BATTERY HOLDER 12.0MM COIN SMD
C1	0.1uF	TDK Corporation	C1608X7R1H104K	CAP CER 0.1UF 50V 10% X7R 0603
C2	47uF	United Chemi-con	EMVE500ADA470MF80G	CAP ALUM 47UF 20% 50V SMD
C3	68uF	AVX Corporation	TAJD686K016RNJ	CAP TANTALUM 68UF 16V 10% SMD
C4	0.10uF	Kemet	C0603C104K4RAC	CAP, CER, 0.10uF, 16V, 10%, X7R, 0603
C5	0.1uF	TDK Corporation	C1608X7R1H104K	CAP CER 0.1UF 50V 10% X7R 0603
C6	0.22uF	Kemet	C0603C224K3RAC	CAP CER 0.22UF 25V X7R 0603
C7	1.0uF	Kemet	C0603C105K4RAC	CAP CER 1UF 16V X7R 0603
C8	0.22uF	Kemet	C0603C224K3RAC	CAP CER 0.22UF 25V X7R 0603
C9	1.0uF	Kemet	C0603C105K4RAC	CAP CER 1UF 16V X7R 0603
C10	1.0uF	Kemet	C0603C105K4RAC	CAP CER 1UF 16V X7R 0603
C11	0.10uF	Kemet	C0603C104K4RAC	CAP, CER, 0.10uF, 16V, 10%, X7R, 0603
C12	0.10uF	Kemet	C0603C104K4RAC	CAP, CER, 0.10uF, 16V, 10%, X7R, 0603
D1	B340A-13-F	Diodes Inc	B340A-13-F	DIODE SCHOTTKY 3A 40V SMA
D2	LTST-C150TBKT	Lite-On Inc	LTST-C150TBKT	LED 468NM BLUE CLEAR 1206 SMD
D3	LTST-C150KRKT	Lite-On Inc	LTST-C150KRKT	LED SUPER RED CLEAR 1206 SMD
D4	LTST-C150KGKT	Lite-On Inc	LTST-C150KGKT	LED GREEN CLEAR 1206 SMD
F1	0154004.DRT	Littelfuse Inc	0154004.DRT	FUSE SLOW 125VAC, 125VDC 4A SMD
J1	1725672	Phoenix Contact	1725672	CONN TERM BLOCK 2.54MM 4POS
J2	TSW-103-14-T-S	Samtec Inc.	TSW-103-14-T-S	CONN HEADER 3POS .100" SNGL TIN
J3	1725656	Phoenix Contact	1725656	CONN TERM BLOCK 2.54MM 2POS
J4	TSW-102-14-T-S	Samtec Inc.	TSW-102-14-T-S	CONN HEADER 2POS .100" SNGL TIN
J5	SSW-103-01-T-S	Samtec Inc	SSW-103-01-T-S	CONN RCPT .100" 3POS SNGL TIN
J6	SSW-112-01-T-S	Samtec Inc	SSW-112-01-T-S	CONN RCPT .100" 12POS SNGL TIN
J7	SSW-112-01-T-S	Samtec Inc	SSW-112-01-T-S	CONN RCPT .100" 12POS SNGL TIN
J8	1725672	Phoenix Contact	1725672	CONN TERM BLOCK 2.54MM 4POS
J9	TSW-102-14-T-S	Samtec Inc.	TSW-102-14-T-S	CONN HEADER 2POS .100" SNGL TIN
J10	SSW-102-01-T-S	Samtec Inc	SSW-102-01-T-S	CONN RCPT .100" 2POS SNGL TIN
J11	SSW-102-01-T-S	Samtec Inc	SSW-102-01-T-S	CONN RCPT .100" 2POS SNGL TIN
L1	100uH	Bourns Inc.	SRN6045-101M	FIXED IND 100UH 700MA 494 MOHM
Q1	SI2369DS-T1-GE3	Vishay Siliconix	SI2369DS-T1-GE3	MOSFET P-CH 30V 7.6A TO-236
Q2	SI6562CDQ-T1-GE3	Vishay Siliconix	SI6562CDQ-T1-GE3	MOSFET N/P-CH 20V 6.7A 8-TSSOP
Q3	SI6562CDQ-T1-GE3	Vishay Siliconix	SI6562CDQ-T1-GE3	MOSFET N/P-CH 20V 6.7A 8-TSSOP
Q4	MMBT3904	Fairchild	MMBT3904	TRANSISTOR GP NPN AMP SOT-23
Q5	MMBT3904	Fairchild	MMBT3904	TRANSISTOR GP NPN AMP SOT-23
R1	0.02	Stackpole	CSR1206FK20L0	RES SMD 0.02 OHM 1% 1/2W 1206
R2	1.00M	Vishay	CRCW06031M00FKEA	RES SMD 1M OHM 1% 1/10W 0603
R3	121.0K	Vishay	CRCW0603121KFKEA	RES SMD 121K OHM 1% 1/10W 0603
R4	22.6K	Vishay	CRCW060322K6FKEA	RES SMD 22.6K OHM 1% 1/10W 0603
R5	41.2K	Vishay	CRCW060341K2FKEA	RES SMD 41.2K OHM 1% 1/10W 0603
R6	28K	Vishay	CRCW060328K0FKEA	RES SMD 28.0K OHM 1% 1/10W 0603
R7	383.0K	Vishay	CRCW0603383KFKEA	RES SMD 383K OHM 1% 1/10W 0603
R8	13.3K	Vishay	CRCW060313K3FKEA	RES SMD 13.3K OHM 1% 1/10W 0603
R9	100.0K	Vishay/Dale	CRCW0603100KFKEA	RES 100K OHM 1/10W 1% 0603 SMD
R10	100.0K	Vishay/Dale	CRCW0603100KFKEA	RES 100K OHM 1/10W 1% 0603 SMD
R11	100.0K	Vishay/Dale	CRCW0603100KFKEA	RES 100K OHM 1/10W 1% 0603 SMD
R12	100.0K	Vishay/Dale	CRCW0603100KFKEA	RES 100K OHM 1/10W 1% 0603 SMD
R13	100.0K	Vishay/Dale	CRCW0603100KFKEA	RES 100K OHM 1/10W 1% 0603 SMD
R14	1.69K	Vishay	CRCW06031K69FKEA	RES SMD 1.69K OHM 1% 1/10W 0603
R15	1.69K	Vishay	CRCW06031K69FKEA	RES SMD 1.69K OHM 1% 1/10W 0603
R16	130	Vishay	CRCW0603130RFKEA	RES SMD 130 OHM 1% 1/10W 0603
R17	10.0K	Vishay	CRCW060310K0FKEA	RES SMD 10K OHM 1% 1/10W 0603
R18	100.0K	Vishay/Dale	CRCW0603100KFKEA	RES 100K OHM 1/10W 1% 0603 SMD
R19	100.0K	Vishay/Dale	CRCW0603100KFKEA	RES 100K OHM 1/10W 1% 0603 SMD
R20	0.0	Vishay/Dale	CRCW06030000Z0EA	RES 0.0 OHM 1/10W 0603 SMD
R21	0.0	Vishay/Dale	CRCW06030000Z0EA	RES 0.0 OHM 1/10W 0603 SMD
R22	10.0K	Vishay	CRCW060310K0FKEA	RES SMD 10K OHM 1% 1/10W 0603
U1	MAX5035DASA+	Maxim Integrated	MAX5035DASA+	IC REG BUCK ADJ 1A 8SOIC
U2	MAX4372FEUK+T	Maxim Integrated	MAX4372FEUK+T	IC AMP GAIN +50V/V PREC SOT23-5
U3	AD8603AUJZ	Analog Devices Inc	AD8603AUJZ-REEL7	IC OPAMP GP R-R CMOS TSOT23-5
U4	MAX3227EAAE+	Maxim Integrated	MAX3227EAAE+	IC TXRX RS-232 W/SHTDWN 16-SSOP
U5	DS3234S#	Maxim Integrated	DS3234S#	IC RTC W/TCXO 20-SOIC

Appendix 3: Controller Shield Bill of Materials