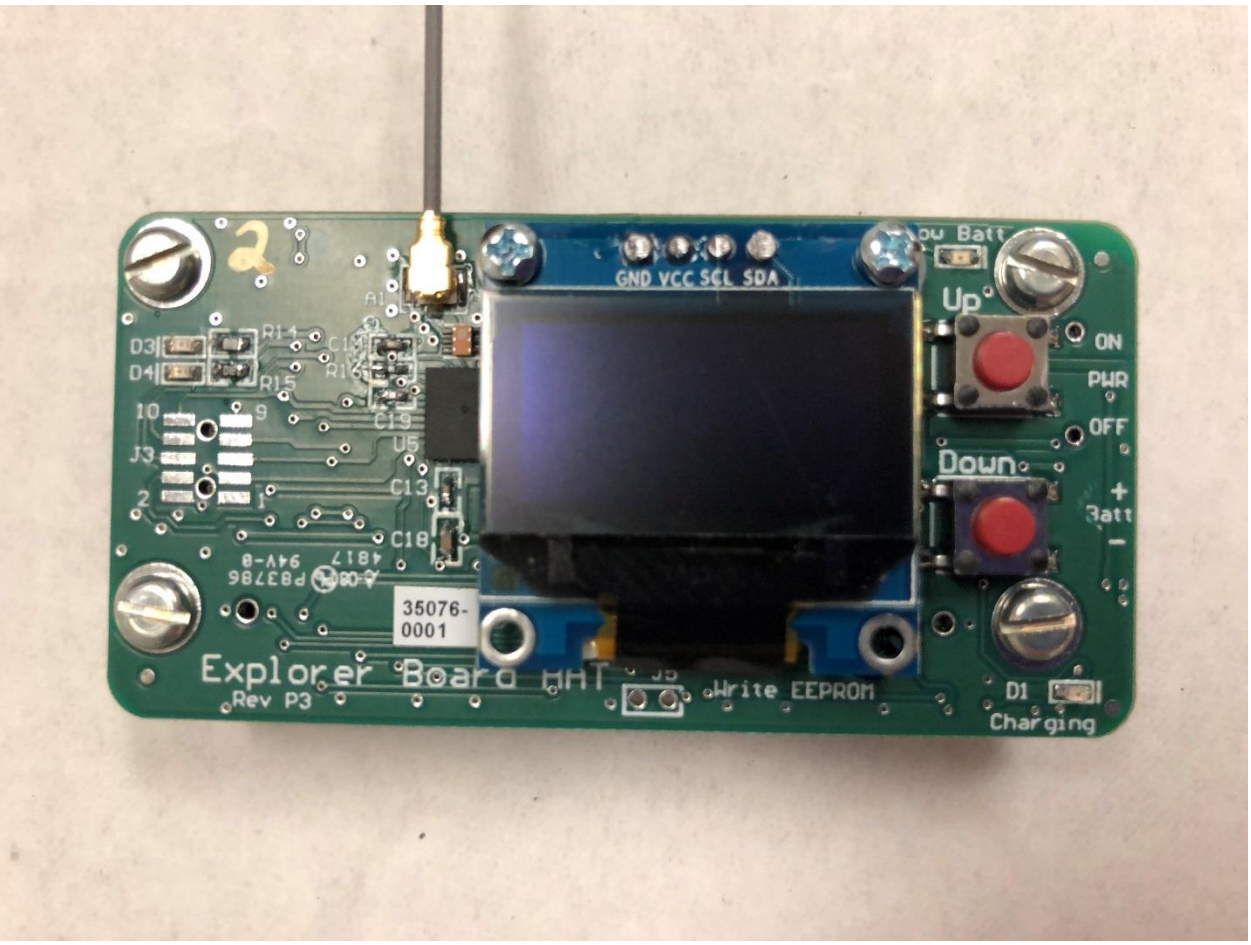
Explorer Board HAT Specification

Patrick Kelly
Jack Kelly
May 11, 2018

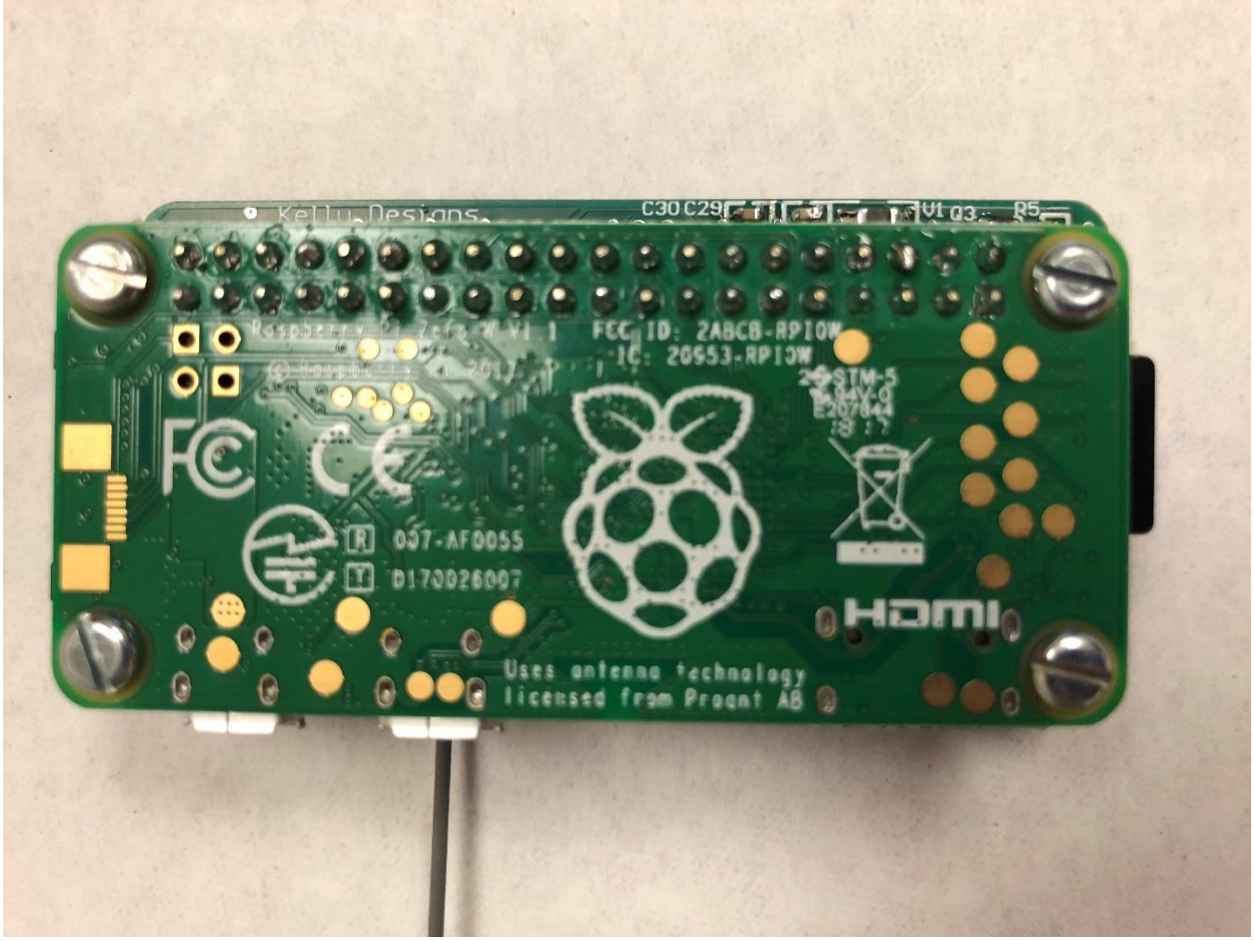
Change History

Rev	Date	Comments
0.1	Jan 23, 2018	Initial Draft
1.0	May 11, 2018	Release Version

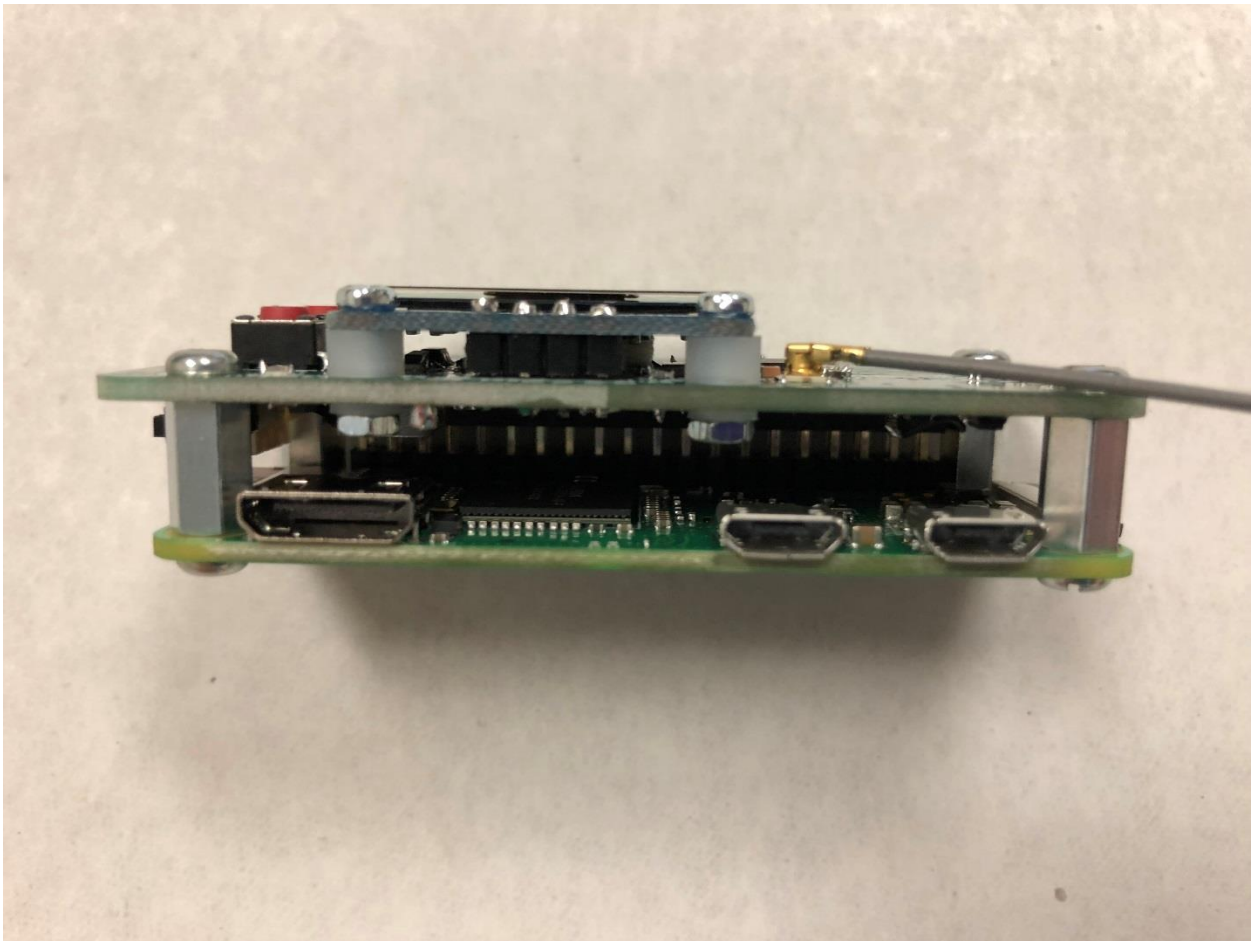
Picture of Raspberry Pi Zero W with Explorer Board HAT
Top View



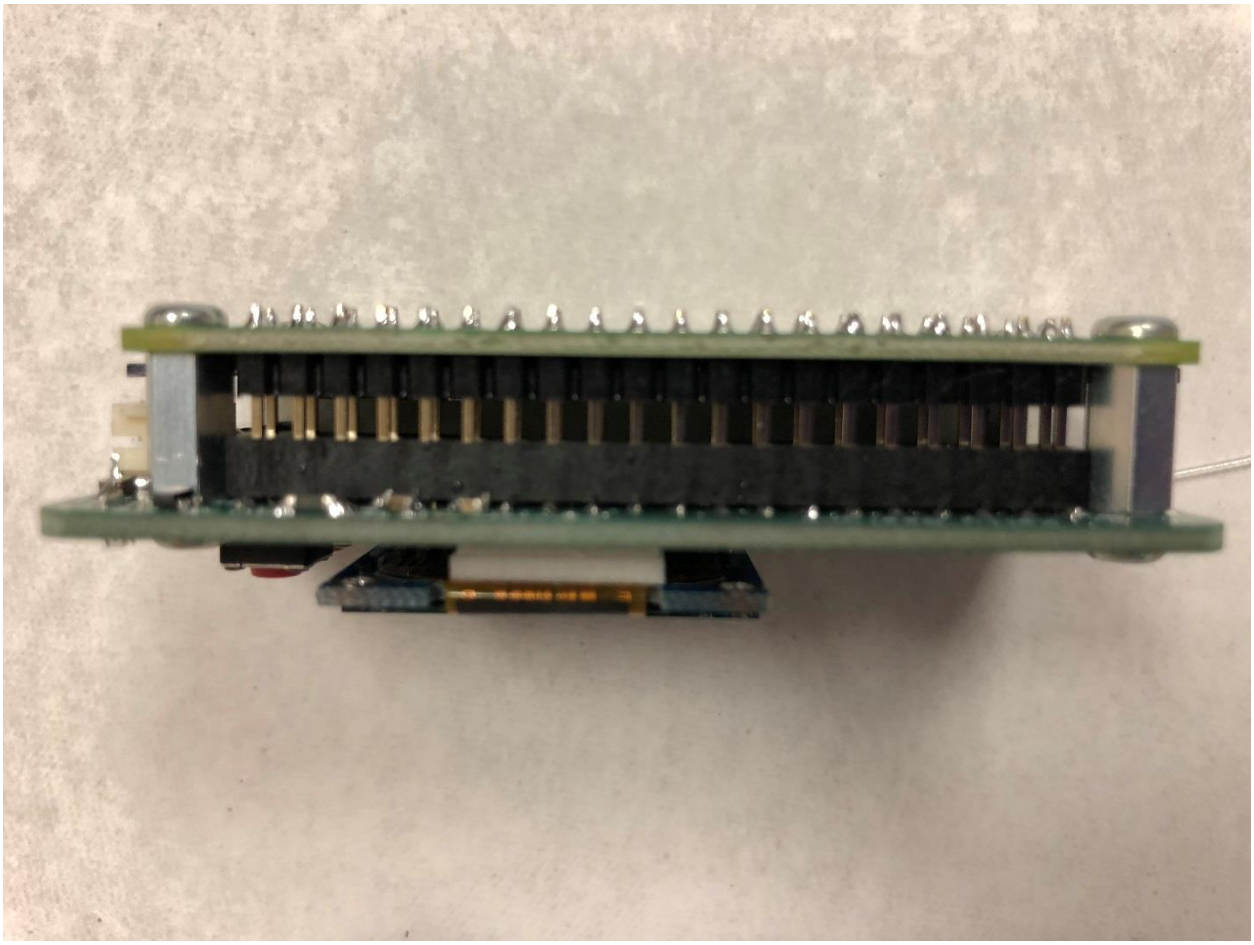
Picture of Raspberry Pi Zero W with Explorer Board HAT
Bottom View



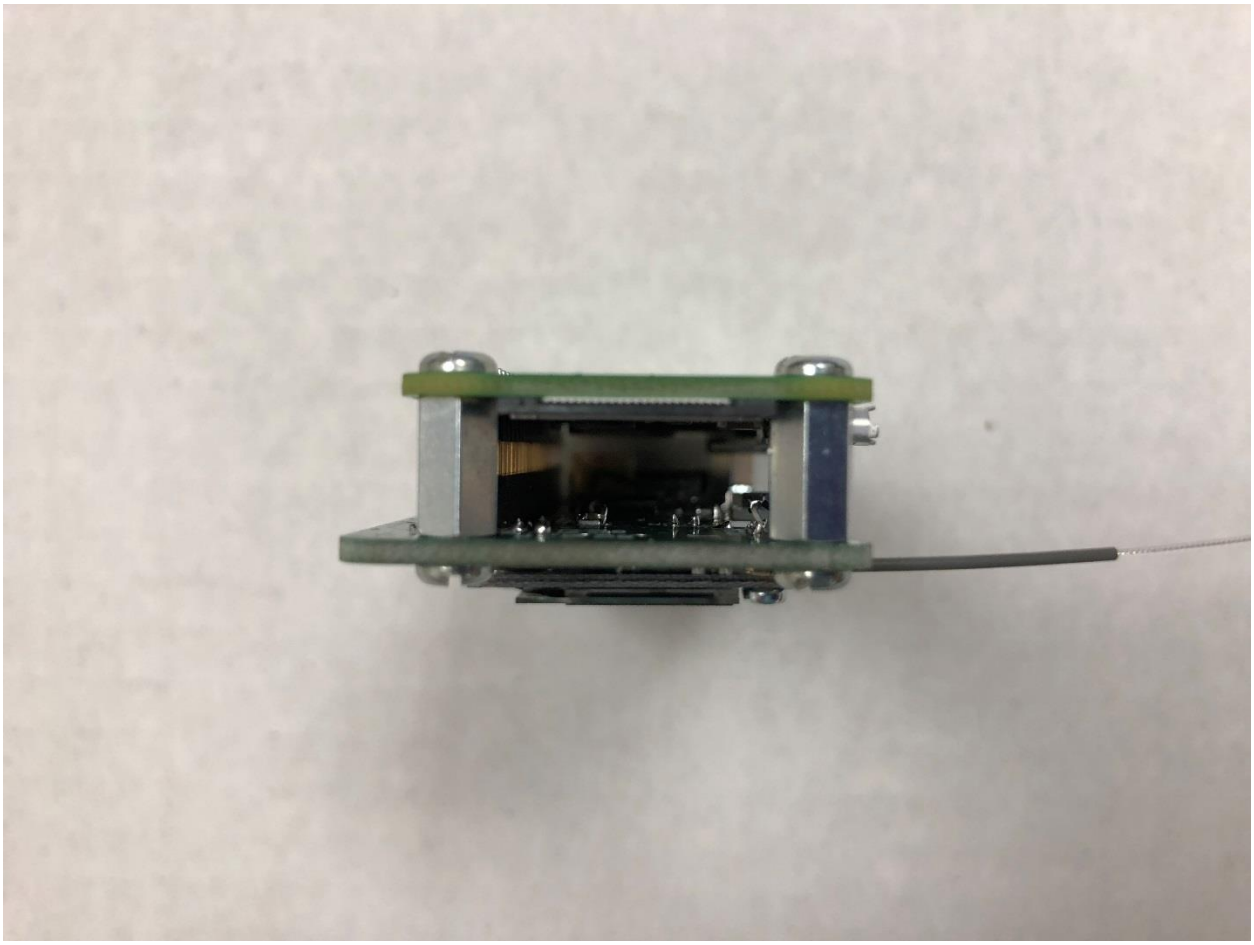
Picture of Raspberry Pi Zero W with Explorer Board HAT
Side Top View



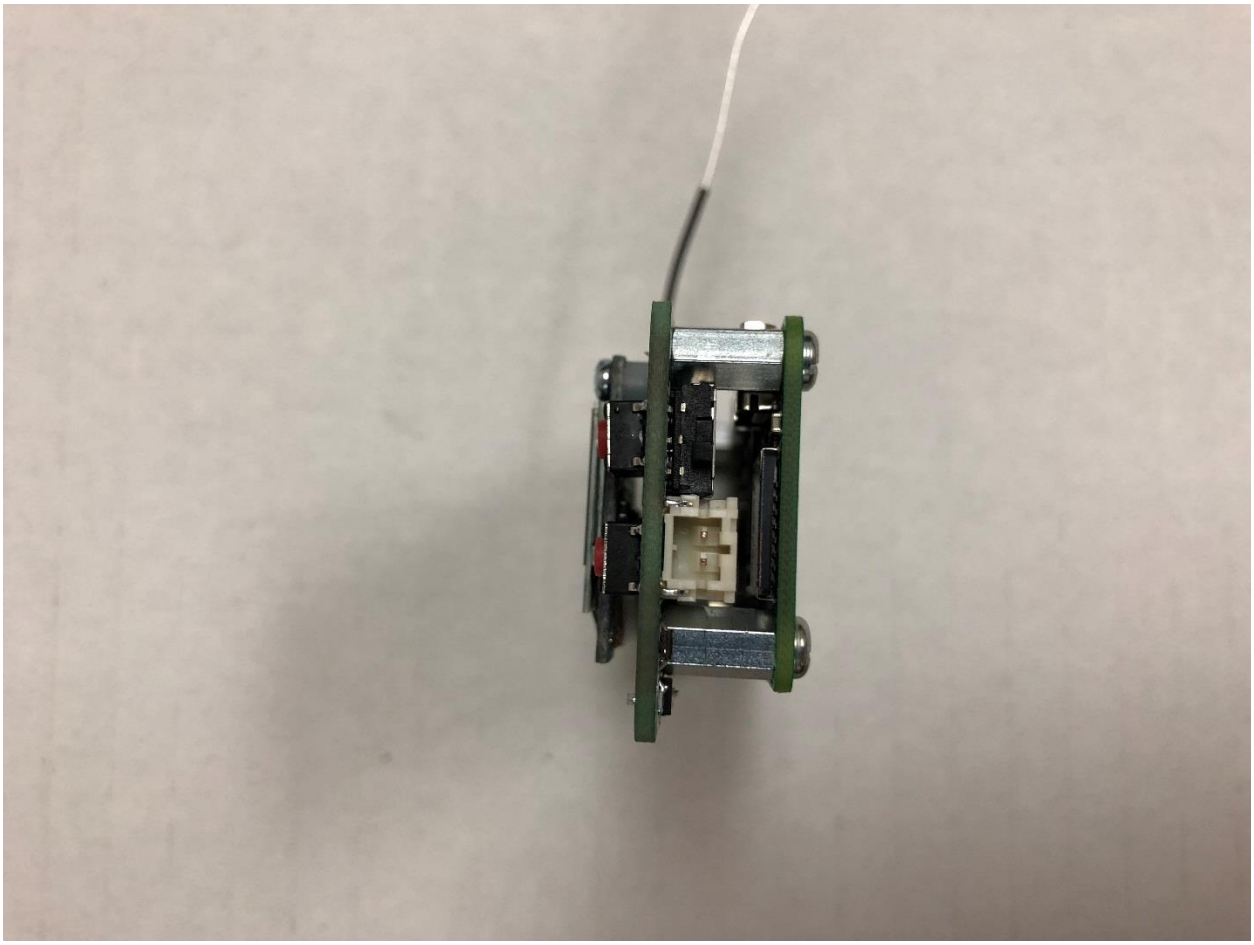
Picture of Raspberry Pi Zero W with Explorer Board HAT
Side Bottom View



Picture of Raspberry Pi Zero W with Explorer Board HAT
End View



Picture of Raspberry Pi Zero W with Explorer Board HAT
Opposite End View

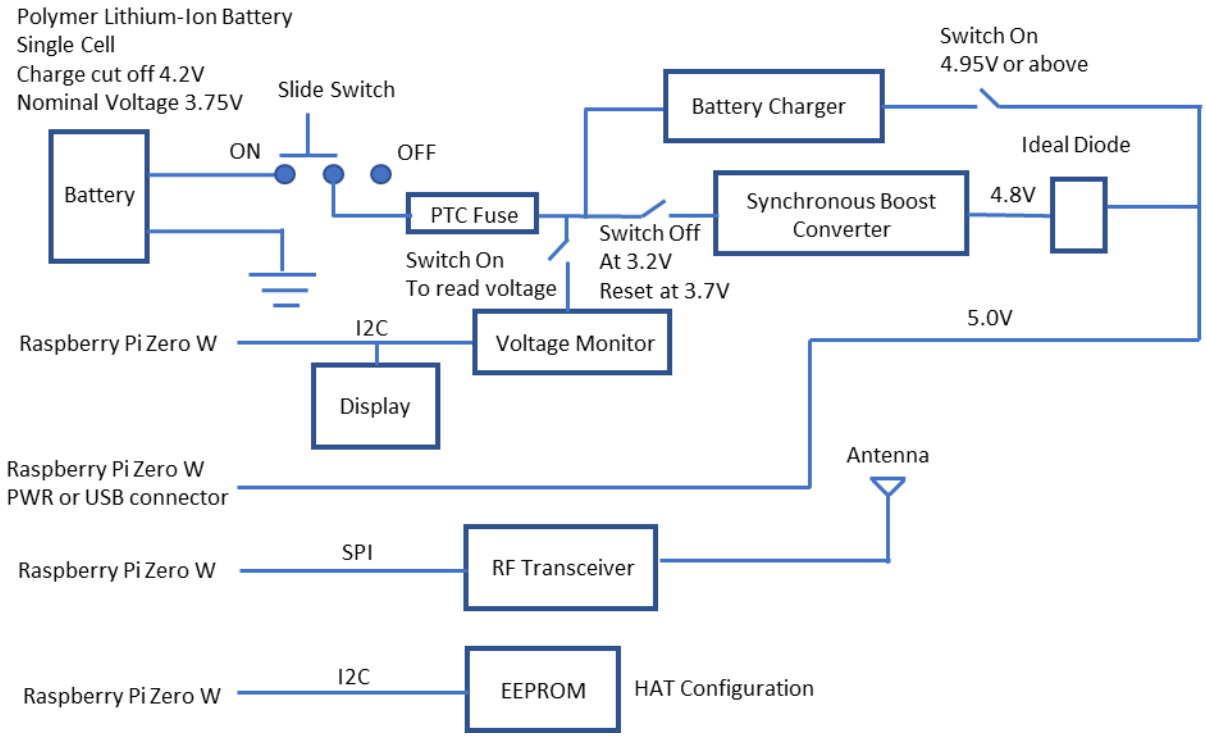


Introduction

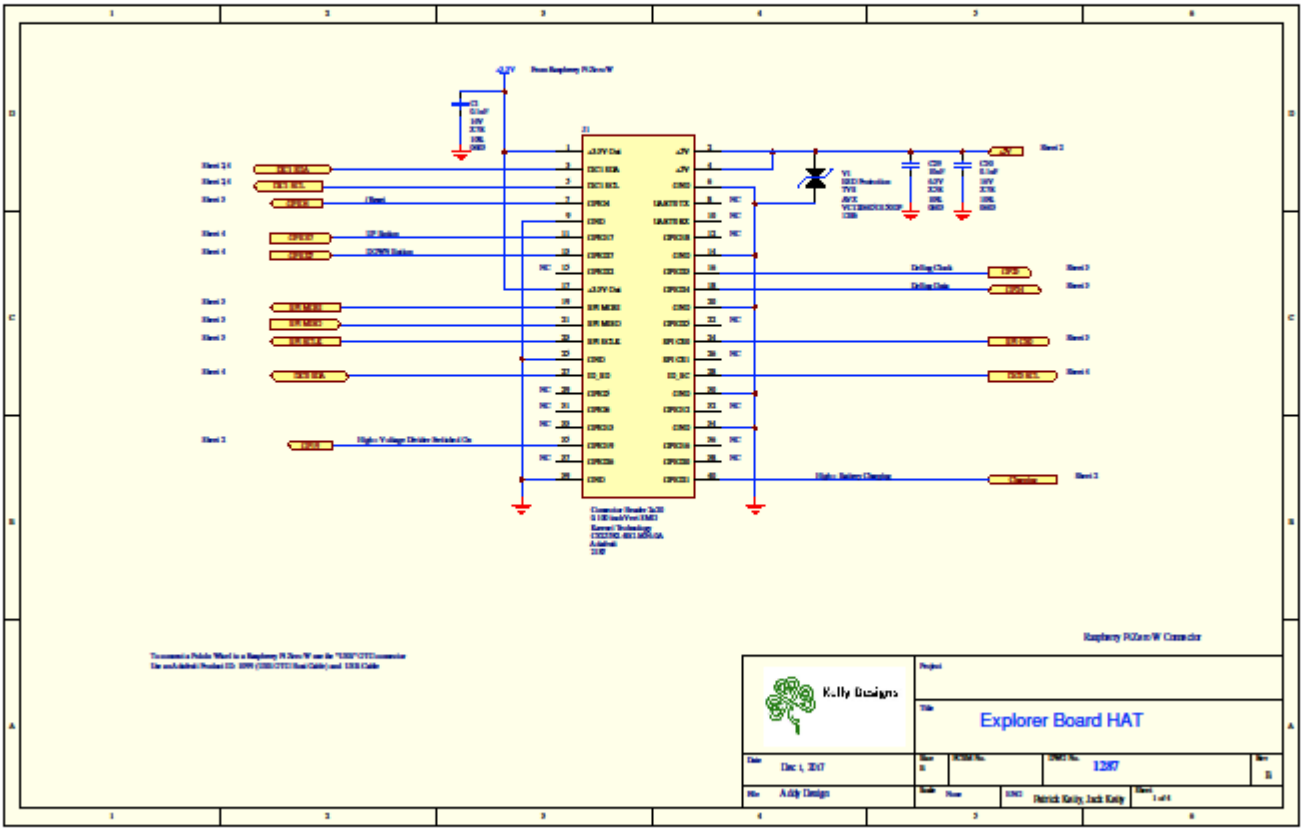
The Explorer Board HAT was designed to be used with a Raspberry Pi Zero W controller board but can be used with any version of a Raspberry Pi.

The Explorer Board HAT is 68mm long x 33.9mm wide and 1.6mm thick.

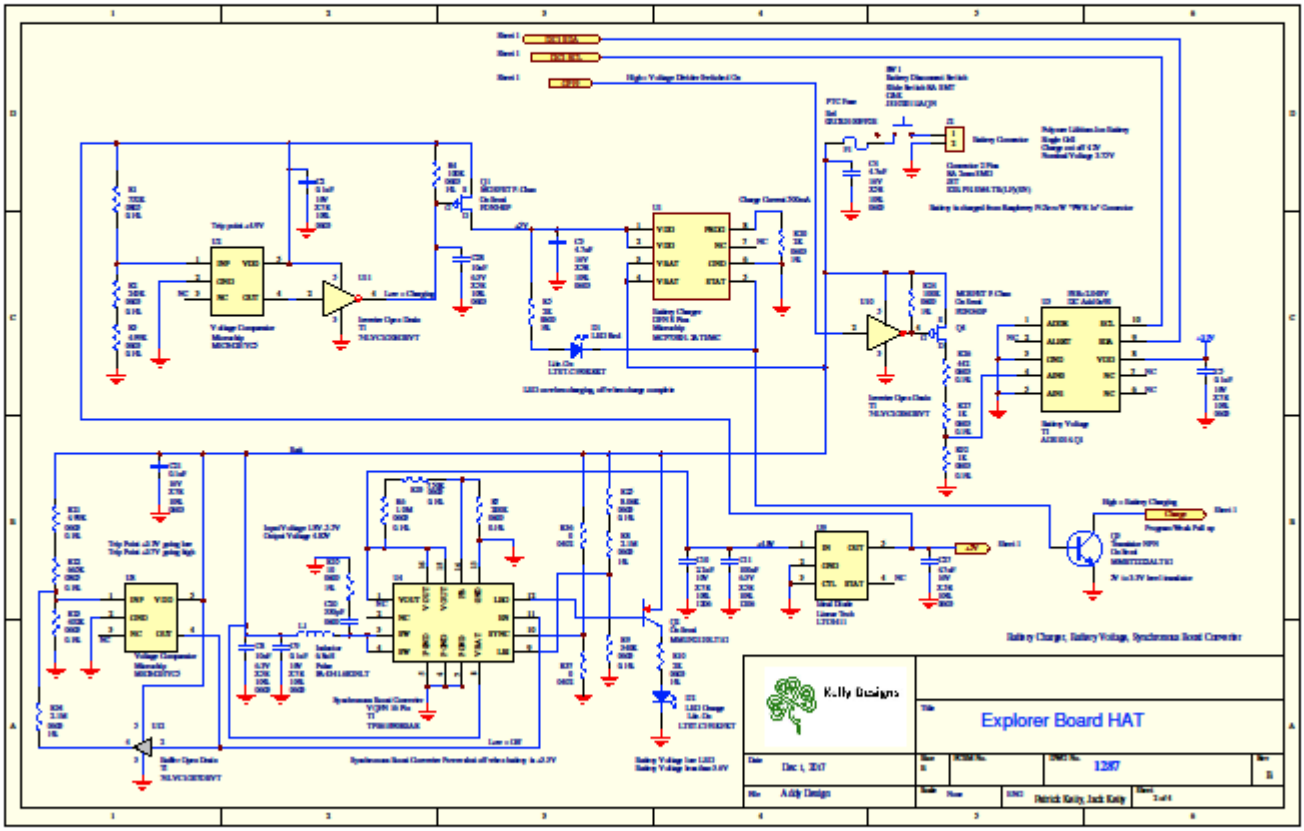
Block Diagram



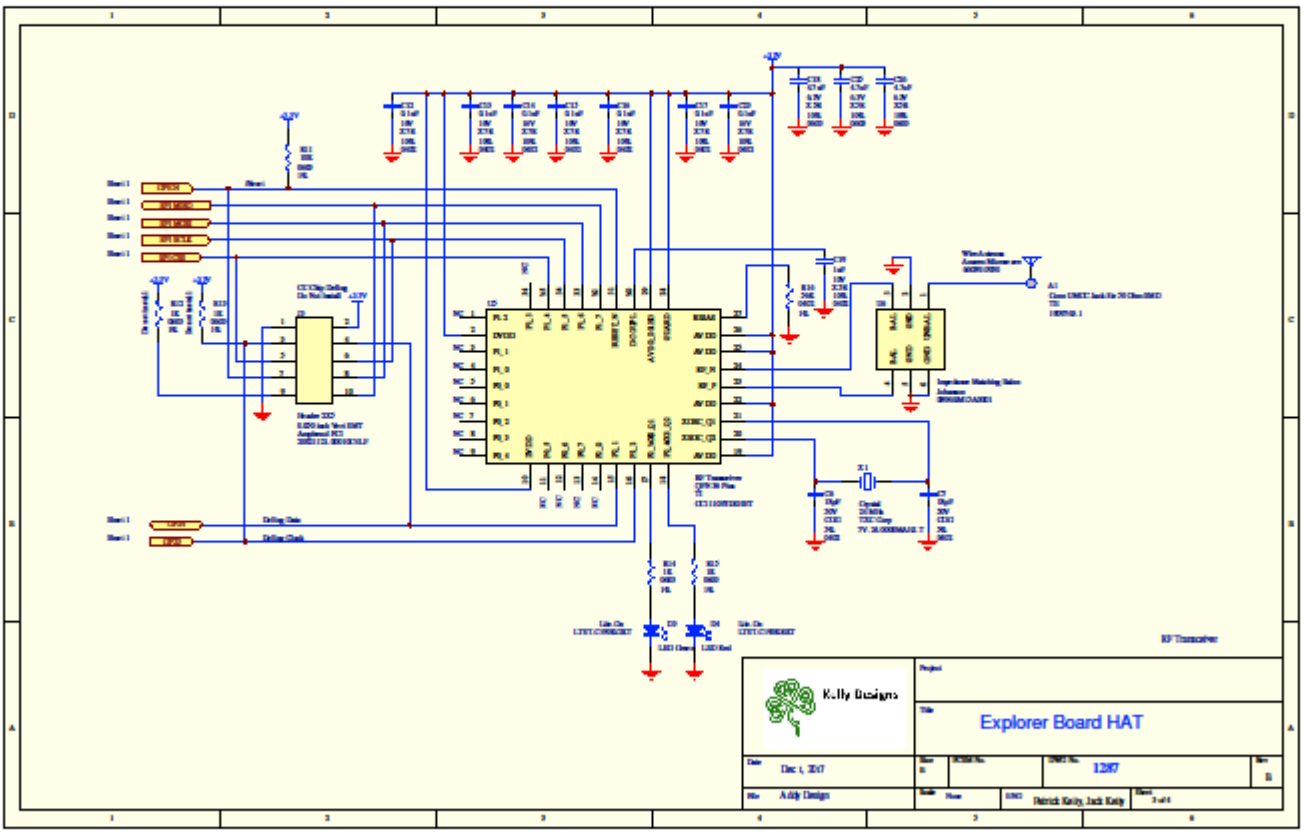
Schematic Drawing (Sheet 1 of 4)



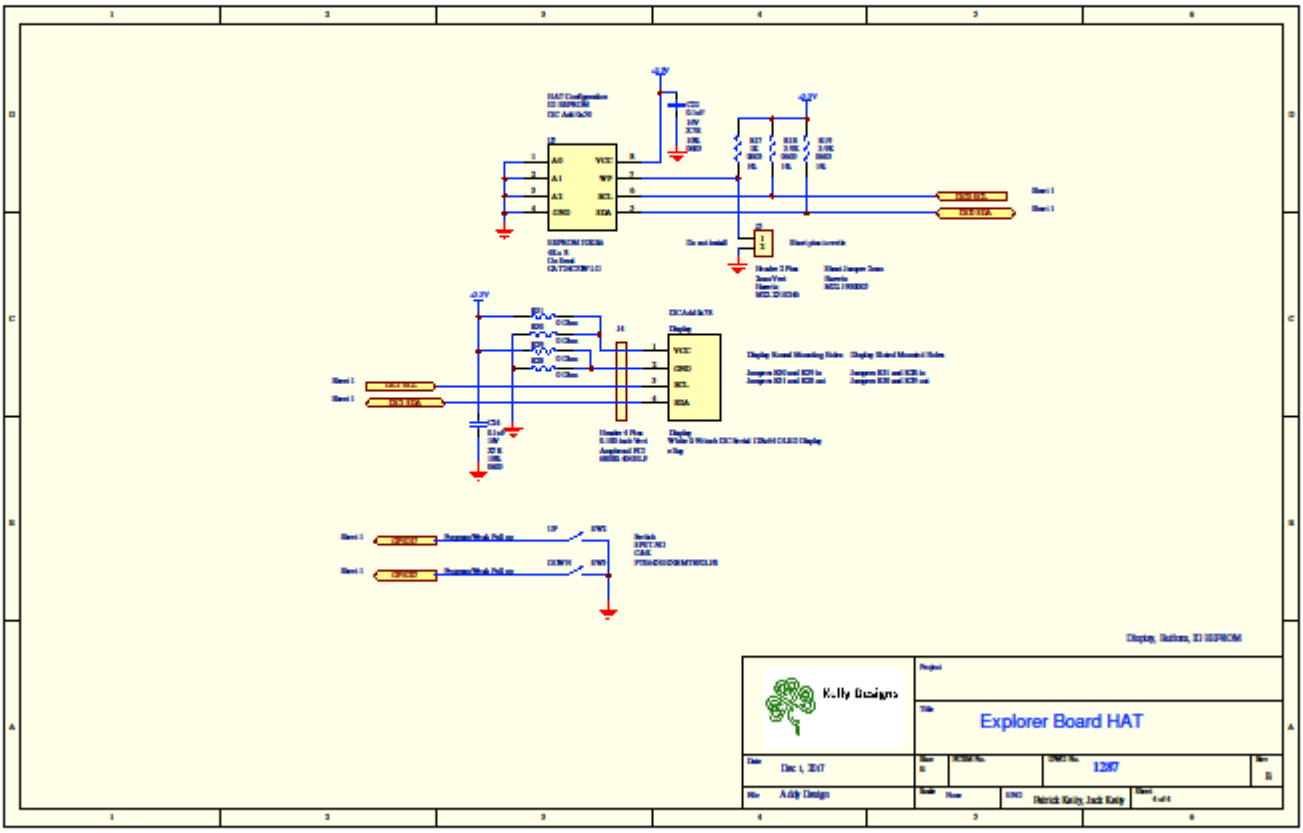
Schematic Drawing (Sheet 2 of 4)



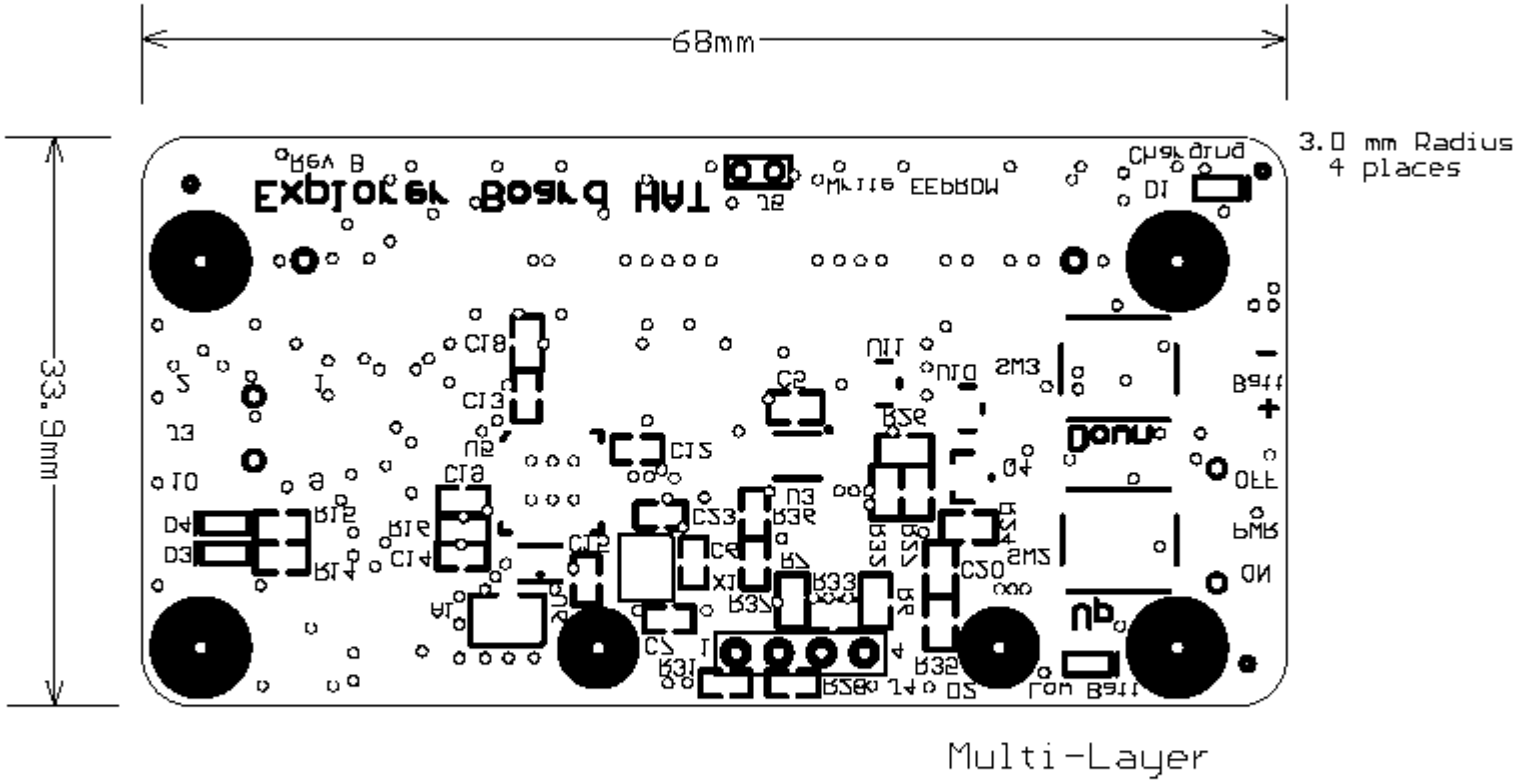
Schematic Drawing (Sheet 3 of 4)



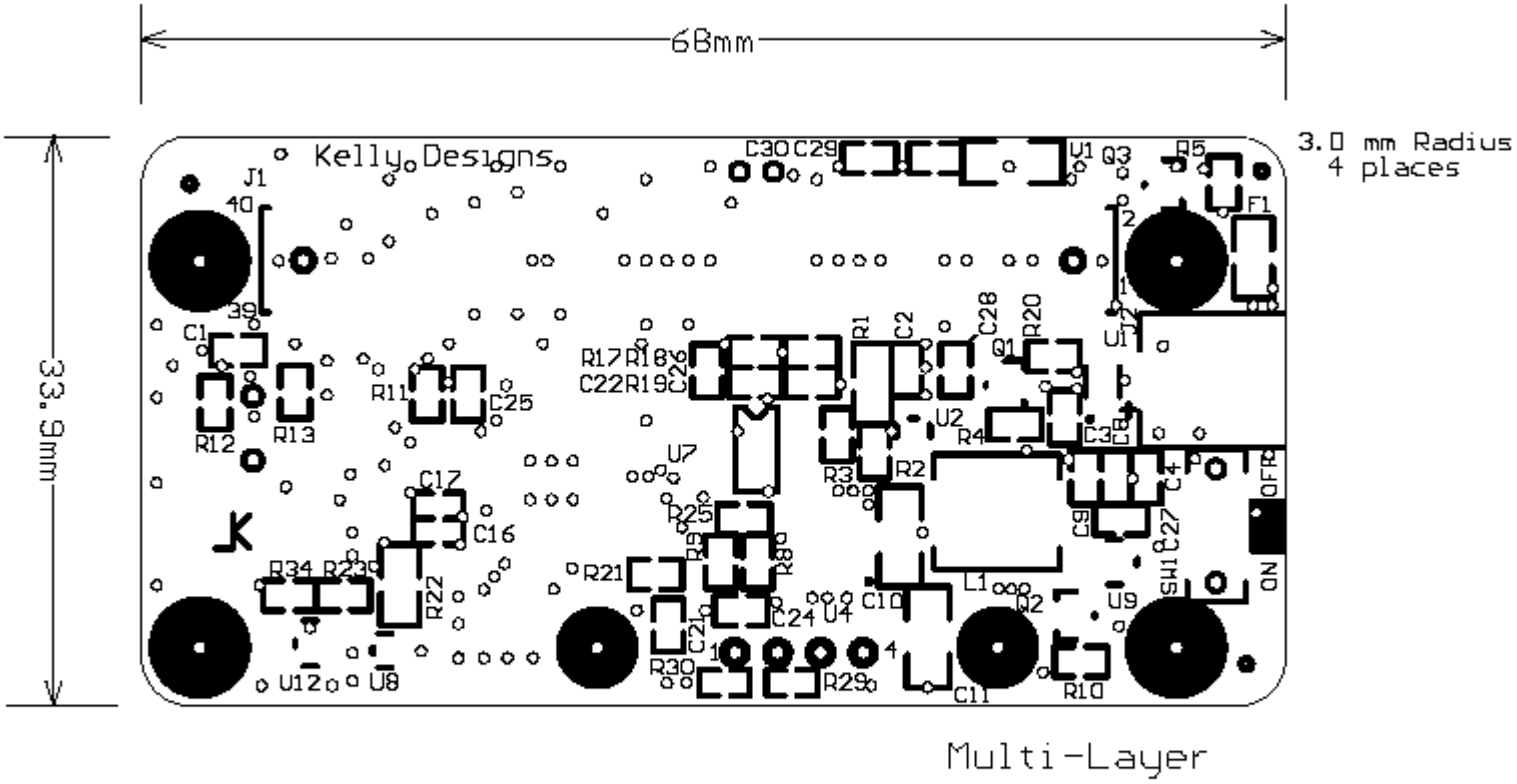
Schematic Drawing (Sheet 4 of 4)



Assembly Drawing (Bottom Side)



Assembly Drawing (Top Side)



Bill of Materials (BOM)
Explorer Board HAT

Kelly Designs

Explorer Board HAT
PN: 1287
Rev B

As of: 1/11/2018
Patrick Kelly, Jack Kelly
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Item	Qty	Location (bottom)	Mfg Part #	Description	Rating	Footprint	Mfg	Mouser	DigiKey	Notes	$ each	Total
1	1	A1	1909763-1	Conn UMCC Jack Str 50 Ohm SMD		SMD	TE	571-1909763-1	A118077CT-ND		0.322	0.322
2	2	C6, C7	GRM1555C1H180JA01D	Cap Cer 18pF 50V COG 5% 0402	COG	0402	Murata	81-GRM1555C1H180JA1D	490-5858-1-ND		0.006	0.012
3	8	C1, C2, C5, C9, C21, C22, C24, C30	CC0603KRX7R7BB104	Cap Cer 0.1uF 16V X7R 10% 0603	X7R	0603	Yageo	603-CC603KRX7R7BB104	311-1088-1-ND		0.005	0.040
4	7	C12, C13, C14, C15, C16, C17, C23	GRM155R71C104KA88J	Cap Cer 0.1uF 16V X7R 10% 0402	X7R	0402	Murata	81-GRM155R71C104KA8J	490-6328-1-ND		0.006	0.042
5	3	C3, C4, C27	CC0603KRX5R7BB475	Cap Cer 4.7uF 16V X5R 10% 0603	X5R	0603	Yageo	603-CC603KRX5R7BB475	311-1785-1-ND		0.072	0.216
6	3	C8, C28, C29	GRT188R61C106KE13D	Cap Cer 10uF 6.3V X5R 10% 0603	X5R	0603	Murata	81-GRT188R61C106KE3D	490-12317-1-ND		0.154	0.462
7	1	C10	CC1206KKX7R6BB225	Cap Cer 2.2uF 10V X7R 10% 1206	X7R	1206	Yageo	603-CC126KKX7R6BB225	311-1953-1-ND		0.037	0.037
7	0	C10	GRM31MR71A225KA01L	Cap Cer 2.2uF 10V X7R 10% 1206	X7R	1206	Murata	81-GRM426XG225K010L	490-1803-1-ND		0.118	0.000
7	0	C10	C1206C225K8RACTU	Cap Cer 2.2uF 10V X7R 10% 1206	X7R	1206	Kemet	80-C1206C225K8R	399-8182-1-ND		0.470	0.000
7	0	C10	LMK316B7225KL-T	Cap Cer 2.2uF 10V X7R 10% 1206	X7R	1206	Taiyo Yuden	963-LMK316B7225KL-T	587-2232-1-ND		0.074	0.000
8	1	C11	GRM31CR60J107KE39L	Cap Cer 100uF 6.3V X5R 10% 1206	X5R	1206	Murata	81-GRM31CR60J107KE9L	490-13982-1-ND		0.290	0.290
8	0	C11	CL31A107MQHNNNE	Cap Cer 100uF 6.3V X5R 20% 1206	X5R	1206	Samsung	NA	1276-1782-1-ND		0.261	0.000
8	0	C11	JMK316BJ107ML-T	Cap Cer 100uF 6.3V X5R 20% 1206	X5R	1206	Taiyo Yuden	963-JMK316BJ107ML-T	587-1963-6-ND		0.472	0.000
9	3	C18, C25, C26	CC0603KRX5R5BB475	Cap Cer 4.7uF 6.3V X5R 10% 0603	X5R	0603	Yageo	603-CC603KRX5R5BB475	311-1521-1-ND		0.025	0.075
10	1	C19	LMK105BJ105KV-F	Cap Cer 1uF 10V X5R 10% 0402	X5R	0402	Taiyo Yuden	963-LMK105BJ105KV-F	587-1454-1-ND		0.023	0.023
11	1	C20	CC0603KRX7R9BB331	Cap Cer 330pF 50V X7R 10% 0603	X7R	0603	Yageo	603-CC603KRX7R9BB331	311-1186-1-ND		0.024	0.024
12	2	D1, D4	LTST-C190KRKT	LED Red Clear 0603		0603	Lite-On	859-LTST-C190KRKT	160-1436-1-ND		0.068	0.136
13	1	D2	LTST-C191KFKT	LED Orange Clear 0603		0603	Lite-On	859-LTST-C191KFKT	160-1445-1-ND		0.068	0.068
14	1	D3	LTST-C190KGKT	LED Green Clear 0603		0603	Lite-On	859-LTST-C190KGKT	160-1435-1-ND		0.068	0.068
15	1	F1	0ZCK0100FF2E	Fuse PTC Resttable 1.0A 6V Chip 0805		0805	Bel Fuse	530-0ZCK0100FF2E	507-1815-1-ND		0.185	0.185
16	1	J1	CS25582-40G-M36-0A	Conn Socket 2x20 0.100 inch SMD		0.100	Kaweei Tech	(Buy from Adafruit #2187)	NA		1.950	1.950
17	1	J2	S2B-PH-SM4-TB(LF)(SN)	Conn Header PH Side 2 Pos 2mm SMD		SMD	JST	NA	455-1749-1-ND		0.419	0.419
18	0	J3	20021121-00010C4LF	Conn Header 10 Pos DL 0.050 in SMD		SMD	Amphenol	649-20211210001OC4LF	609-3695-1-ND		0.606	0.000
19	0	J5	M22-2510246	Header 2 Pos 2mm		2mm	Harwin	855-M22-2510246	952-2280-ND	5,6	0.082	0.000
20	0	J5 Shunt	M22-1900005	Shunt Jumper 2mm		2mm	Harwin	855-M22-1900005	952-1305-ND		0.215	0.000
21	1	L1	PA4341.682NLT	Inductor 6.8uH 4.5A 60 Mohm SMD			Pulse	673-PA4341.682NLT	553-3420-1-ND		0.702	0.702
21	0	L1	PA4341.682NLT	Inductor 6.8uH 4.5A 60 Mohm SMD			Pulse	buy from Arrow			0.663	0.000
22	2	Q1, Q4	FDN340P	MOSFET P-Chan 20V 2A SSOT-3		SSOT-3	On Semi	512-FDN340P	FDN340PCT-ND		0.157	0.314
23	1	Q2	MMUN2133LT1G	Trans Prebias PNP 246mW SOT23-3		SOT23-3	On Semi	863-MMUN2133LT1G	MMUN2133LT1GOSCT-ND		0.039	0.039
24	1	Q3	MMBT2222ALT1G	Trans NPN 40V 0.6A SOT-23		SOT-23	On Semi	863-MMBT2222ALT1G	MMBT2222ALT1GOSCT-ND		0.034	0.034
25	3	R14, R15, R17	RC0603FR-071KL	Res 1.0K Ohm 1% Thick Film 0603	1%	0603	Yageo	603-RC0603FR-071KL	311-1.00KHRCT-ND		0.006	0.018
26	1	R1	RT0805BRD07732KL	Res 732K Ohm 0.1% Thin Film 0805	0.1%	0805	Yageo	603-RT0805BRD07732KL	YAG4938CT-ND		0.114	0.114
27	1	R22	ERA-6AEB6653V	Res 665K Ohm 0.1% Thin Film 0805	0.1%	0805	Panasonic	667-ERA-6AEB6653V	P665KDACT-ND		0.118	0.118
28	1	R7	RT0603BRD07200KL	Res 200K Ohm 0.1% Thin Film 0603	0.1%	0603	Yageo	603-RT0603BRD07200KL	YAG1578CT-ND		0.127	0.127
29	2	R3, R21	RT0603BRD074K99L	Res 4.99K Ohm 0.1% Thin Film 0603	0.1%	0603	Yageo	603-RT0603BRD074K99L	YAG1678CT-ND		0.127	0.254
30	1	R2	ERA-3AEB2433V	Res 243K Ohm 0.1% Thin Film 0603	0.1%	0603	Panasonic	667-ERA-3AEB2433V	P243KDBCT-ND		0.117	0.117
31	1	R23	RN73C1J402KBTD	Res 402K Ohm 0.1% Thin Film 0603	0.1%	0603	TE	279-RN73C1J402KBTDF	A124747CT-ND		0.437	0.437
32	1	R6	CPF0603B1M0E1	Res 1M Ohm 0.1% Thin Film 0603	0.1%	0603	TE	279-CPF0603B1M0E1	A102234CT-ND		0.157	0.157
33	1	R33	CPF0603B750KE1	Res 750K Ohm 0.1% Thin Film 0603	0.1%	0603	TE	279-CPF0603B750KE1	A102315CT-ND		0.199	0.199
34	1	R25	ERA-3AEB8061V	Res 8.06K Ohm 0.1% Thin Film 0603	0.1%	0603	Panasonic	667-ERA-3AEB8061V	P8.06KDBCT-ND		0.117	0.117
35	1	R9	RN73C1J340KBTD	Res 340K Ohm 0.1% Thin Film	0.1%	0603	TE	279-RN73C1J340KBTDF	A124740CT-ND		0.437	0.437
36	0	R12, R13	RC0603FR-071KL	Res 1.0K Ohm 1% Thick Film 0603	1%	0603	Yageo	603-RC0603FR-071KL	311-1.00KHRCT-ND		0.006	0.000
37	3	R5, R10, R20	RC0603FR-072KL	Res 2.0K Ohm 1% Thick Film 0603	1%	0603	Yageo	603-RC0603FR-072KL	311-2.00KHRCT-ND		0.006	0.018
38	2	R4, R24	RC0603FR-07100KL	Res 100K Ohm 1% Thick Film 0603	1%	0603	Yageo	603-RC0603FR-07100KL	311-100KHRCT-ND		0.006	0.012

Bill of Materials (BOM)
Explorer Board HAT

39	2	R8, R34	CRCW06032M10FKEA	Res 2.1M Ohm 1% Thick Film 0603	1%	0603	Vishay Dale	71-CRCW06032M10FKEA	541-2.10MHCT-ND		0.014	0.028
40	1	R35	RC0603FR-0710RL	Res 10 Ohm 1% Thick Film 0603	1%	0603	Yageo	603-RC0603FR-0710RL	311-10.0HRCT-ND		0.006	0.006
41	2	R18, R19	RC0603FR-073K9L	Res 3.9K Ohm 1% Thick Film 0603	1%	0603	Yageo	603-RC0603FR-073K9L	311-3.90KHRCT-ND		0.006	0.012
42	1	R26	RT0603BRD07442RL	Res 442 Ohm 0.1% Thin Film 0603	0.1%	0603	Yageo	603-RT0603BRD07442RL	YAG4558CT-ND		0.069	0.069
43	1	R11	RC0603FR-0710KL	Res 10K Ohm 1% Thick Film 0603	1%	0603	Yageo	603-RC0603FR-0710KL	311-10.0KHRCT-ND		0.003	0.003
44	1	R16	RC0402FR-0756KL	Res 56K Ohm 1% Thick Film 0402	1%	0402	Yageo	603-RC0402FR-0756KL	311-56.0KLRCT-ND		0.005	0.005
45	2	R27, R32	RT0603BRD071KL	Res 1K Ohm 0.1% Thin Film 0603	0.1%	0603	Yageo	603-RT0603BRD071KL	YAG1237CT-ND		0.069	0.138
46	3	R28, R31, R36	RC0402JR-070RL	Res 0 Ohm Jumper Thick Film 0402		0402	Yageo	603-RC0402JR-070RL	311-0.0JRCT-ND		0.003	0.009
47	0	R29, R30, R37	RC0402JR-070RL	Res 0 Ohm Jumper Thick Film 0402		0402	Yageo	603-RC0402JR-070RL	311-0.0JRCT-ND		0.003	0.000
48	1	SW1	JS102011JAQN	Switch Slide SPDT 300mA 6V SMD			C&K	611-JS102011JAQN	CKN10720CT-ND		0.350	0.350
49	2	SW2, SW3	PTS6455K43SMTR92 LFS	Switch Tactile SPST-NO 0.05A 12V SMT			C&K	611-PTS6455K43SMTR92	CKN9084CT-ND		0.176	0.352
50	1	U1	MCP73831-2ATI/MC	IC Controller Li-Ion 4.2V 8DFN		8DFN	Microchip	579-MCP73831T-2ATIMC	MCP73831-2ATI/MC-ND		0.450	0.450
51	2	U2, U8	MIC842HYC5-TR	IC Compartor w/Ref Open Drain		SC-70-5	Microchip	998-MIC842HYC5TR	576-2926-1-ND		0.420	0.840
52	1	U3	ADS1014BQDGSRQ1	IC ADC 12-Bit I2C SMD			TI	595-ADS1014BQDGSRQ1	296-45252-1-ND		2.170	2.170
53	1	U4	TPS61090RSAR	IC Reg Boost Adj 2A Sync 16VQFN		16VQFN	TI	595-TPS61090RSAR	296-15259-1-ND		1.720	1.720
54	1	U5	CC1110F32RHHT	IC RF TxRx MCU ISM<1GHz 36-VFQFN		36-VFQFN	TI	595-CC1110F32RHHR	296-38889-1-ND		4.480	4.480
55	1	U6	0896BM15A0001	RF Balun Filter 863-928 MHz		0805	Johanson	609-0896BM15A0001E	712-1474-1-ND		0.522	0.522
56	1	U7	CAT24C32WI-G	IC EEPROM 32KBit 400KHz 8SOIC		SOIC-8	On Semi	698-CAT24C32WI-G	CAT24C32WI-GOS-ND		0.220	0.220
57	2	U10, U11	SN74LVC1G06DBVR	IC Inverter SGL 1 input SOT23-5		SOT23-5	TI	595-SN74LVC1G06DBVR	296-8483-1-ND		0.134	0.268
58	1	U9	LTC4411ES5#TRMPBF	IC OR Controller TSOT23-5		TSOT23-5	Linear Tech	584-LTC4411ES5TRMPBF	LTC4411ES5#TRMPBFCT-ND		2.328	2.328
59	1	U12	74LVC1G07DBVT	IC Buffer Non-Invert 1 input SOT23-5		SOT23-5	TI	595-SN74LVC1G07DBVT	296-26590-1-ND		0.400	0.400
60	1	V1	VC120605D150DP	TVS 5.6VDC 150A 1206		1206	AVX	581-VC120605D150DP	478-2517-1-ND		0.370	0.370
61	1	X1	7V-24.000MAHJ-T	Crystal 24.0000MHz 18pF SMD		SMD	TXC Corp	717-7V-24.000MAHJ-T	887-2580-1-ND		0.522	0.522
62	1			PCB Bare								0.000
						Sub total:			*$22.85*			
				Assemble Display and Antenna to Explorer Board HAT								
1	1	Display	NA	Display 128X64 I2C OLED 0.96 inch white			eBay	NA	NA	6,2	3.670	3.670
2	0	J4	68000-404HLF	Header 4 Pos 0.100 in Str Tin		0.100	Amphenol	649-68000-404HLF	609-3262-ND	6,2	0.155	0.000
3	2	M1, M2, M3,M4	R30-6700394	Spacer M3 nylon 3mm			Harwin	855-R30-6700394	952-1526-ND		0.127	0.254
4	2	M1, M2, M3,M4	MPMS 002 0008 PH	Screw Machine Pan M2 x 8 Phillips			B&F Fastener	945-SCREWM2.0-8	H739-ND		0.070	0.140
5	2	M1, M2, M3,M4	MHNZ 002 4	Nut Hex 0.157" M2			B&F Fastener	NA	H761-ND		0.049	0.098
6	2	M1, M2, M3,M4	3114	Washer Flat #2 Nylon			Keystone	534-3114	36-3114-ND		0.070	0.140
7	0	M1, M2, M3,M4	222 (Purple)	Threadlocker 222 tube 6 ml			Loctite	(on M2 nut end)	Amazon		8.140	0.000
8	0	A1	66089-0930	Antenna U.FL 915MHz 30MM			Anaren	620-66089-0930	1173-1135-ND		3.560	0.000
8	1	A1	66089-0930	Antenna U.FL 915MHz 30MM			Anaren	RichardsonRFPD			2.180	2.180
9	1	Under Display	Cat 111-24	3M Scotch 111 Heavy Duty 1 inch Mounting Squares			Scotch	Amazon		4	0.100	0.100
						Sub total:			$4.30			

Notes:

1	These components should be stocked due to concerns over lead time and/or limited substitutions available.
2	Cut pins flush to this board (0.030 inch or less)
3	Do not wash
4	Stack 2 squares on top of each other, then cut to about 0.5 x 0.33 inch, then place under Display to support it
5	Leave holes open (do not fill with solder)
6	Thru-hole component
7	

Bill of Materials (BOM)
Explorer Board HAT Pi Zero Kit

Kelly Designs

Explorer Board HAT Pi Zero Kit
PN: 1289 Rev B

As of: 1/11/2018
Patrick Kelly, Jack Kelly
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Item	Qty	Location (*bottom*)	Mfg Part #	Description	Rating	Footprint	Mfg	Mouser	DigiKey	Notes	$ each	Total
				Parts for the Raspberry Pi Zero W								
1	1	Pi Zero W	3400	Raspberry Pi Zero W				Buy from Adafruit			10.000	10.000
2	1	PI Zero Micro SD Card	SDSQUNC-016G-GN6MA	Micro SD Card 16GB Class 10			SanDisk	Buy from Amazon	NA		9.950	9.950
3	1	PI Zero GPIO Conn	2822	Header male 2x20 0.100 inch		0.100		Buy from Adafruit	NA	6	0.950	0.950
												0.000
						Sub total:			**$20.90**			

Notes:

1	These components should be stocked due to concerns over lead time and/or limited substitutions available.
2	Cut pins flush to this board (0.030 inch or less)
3	Do not wash
4	
5	Leave holes open (do not fill with solder)
6	Thru-hole component
7	

Bill of Materials (BOM)
Explorer Board HAT Coupling Kit

Kelly Designs

Explorer Board HAT Coupling Kit
PN: 1278 Rev B

As of: 1/11/2018
Patrick Kelly, Jack Kelly
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Item	Qty	Location (*bottom*)	Mfg Part #	Description	Rating	Footprint	Mfg	Mouser	DigiKey	Notes	$ each	Total
				Assemble Explorer HAT to Raspberry PI								
1	4	M1, M2, M3,M4	970090151	Hex Spacer M2.5 threaded Al 9mm			Wurth	NA	732-10537-ND		0.422	1.688
3	8	M1, M2, M3,M4	29300	Screw Machine Pan M2.5 x 4mm			Keystone	534-29300	36-29300-ND		0.237	1.896
5	0	M1, M2, M3,M4	222 (Purple)	Threadlocker 222 tube 6 ml			Loctite	(on screw)	Amazon		8.140	0.000
						Sub total:			**$3.58**			

Notes:

1	These components should be stocked due to concerns over lead time and/or limited substitutions available.
2	Cut pins flush to this board (0.030 inch or less)
3	Do not wash
4	
5	Leave holes open (do not fill with solder)
6	Thru-hole component
7	

Connector J1 Pin Out (standard Raspberry Pi Pinout)

Pin	Description	Pin	Description
1	+3.3V Out	2	+5V
3	I2C1 SDA	4	+5V
5	I2C1 SCL	6	GND
7	GPIO4	8	UART0 TX
9	GND	10	UART0 RX
11	GPIO17	12	GPIO18
13	GPIO27	14	GND
15	GPIO22	16	GPIO23
17	+3.3V Out	18	GPIO18
19	SPI MOSI	20	GND
21	SPI MISO	22	GPIO25
23	SPI SCLK	24	SPI CS0
25	GND	26	SPI CS1
27	ID_SD	28	ID_SC
29	GPIO5	30	GND
31	GPIO6	32	GPIO12
33	GPIO13	34	GND
35	GPIO19	36	GPIO16
37	GPIO26	38	GPIO20
39	GND	40	GPIO21

The following are some of the IC chips are used on the Explorer Board HAT Board.

Ref	Part Number	Vendor	Description
U1	MCP73831-2ATI/MC	Microchip	IC Controller Li-Ion 4.2V 8DFN
U3	ADS1014BQDGSRQ1	TI	IC ADC 12-Bit I2C SMD
U4	TPS61090RSAR	TI	IC Sync Boost Adj 2A Sync 16VQFN
U5	CC1110F32RHHT	Ti	IC RF TxRx MCU ISM<1GHz 36-VFQFN
U7	CAT24C32WI-G	On Semi	IC EEPROM 32KBit 400KHz 8SOIC

Battery

Use a Polymer Lithium-Ion Battery, Single Cell, Charge cut off 4.2V, Nominal Voltage 3.75V. The Explorer Board HAT has for it battery connector a JST 2 pin SMT 2mm right angle S2B-PH-SM4-TB. The mating connector on the battery is: JST PHR-2, terminals JST SPH-002-P0.5S.

Slide Switch

The Slide Switch is used to disconnect the battery from the powering the "Rig". The slide switch has an "ON" and "OFF" position. When the battery is connected, the "Rig" can be powered on or off with the switch.

If the USB cable is connected, the "Rig" will not be powered down with the slide switch. To power down the USB cable must be disconnected and then the slide switch to "OFF".

PTC Fuse

The PTC Fuse will trip when more than 1A is drawn from the battery. This is to protect the battery from a short. After waiting a couple of minutes, the PTC Fuse will reset, and the battery can now power the "Rig".

Synchronous Boost Converter

The Synchronous Boost Converter takes the battery voltage and boosts it to 4.8V. The battery voltage can be between 4.2V to 3.2V. The battery voltage is then boosted to 4.8V.

Battery Charger

The Battery Charger uses a fully integrated Li-Ion, Li-Polymer charge management controller. The constant voltage regulation is fixed at 4.2V. The constant current value is set at 500mA. The battery charger controls a red LED (Charging). The red LED is on when the battery is charging. The red LED goes off when the battery is charged.

The battery charging is started by plugging a USB cable into the Raspberry PI Zero W "PWR" or "USB" connector. To start charging, the voltage on the USB cable must be 4.95V or greater. Sometimes if the USB cable is too long the voltage will not be high enough. Then try using a shorter USB cable. Also, sometimes an Ethernet switch or USB charger will have a lower than 4.95V output. This lower voltage will not charge the battery (Charging LED will not come on).

Ideal Diode

An Ideal Diode is used to separate the output of the Synchronous Boost Converter (4.8V) and the 5.0V when an external USB power is plugged into the Raspberry Pi Zero W PWR or USB connector.

Voltage Monitor

The Voltage Monitor measures the battery voltage. When the voltage monitor measures the battery voltage a resistor divider is turned on. When the voltage monitor is not measuring the battery voltage then the resistor divider is turned off. In this way the battery is not drained with the resistor divider always connected to the battery.

Display

The Display is an OLED white 128 x 64 dot matrix. The display can show 21 characters across and 8 rows down. The Raspberry Pi controls the display with its I2C port 1 bus.

Up and Down Push-Buttons

The Up Push-Button when single clicked moves the display cursor up. The Up button when double clicked will move the cursor back one page.

The Down Push-Button when single clicked moves the display cursor down. The Down button when double clicked will select the item the cursor is on.

900MHZ RF Transceiver

The RF Transceiver transmits and receives information. The Raspberry Pi controls the RF Transceiver using the SPI bus.

Antenna

The antenna is a single wire. This antenna plugs into the A1 connector. This is an U.FL ultra-miniature coaxial connector (UMCC). North America uses the 915 MHz frequency and Europe uses the 868 MHz frequency.

Frequency	Anaren Model
915 MHz	66089-0930
868 MHz	66089-0830

EEPROM

The EEPROM stores the HAT configuration. This EEPROM is used by the system. The user software does not use this device. The device is accessed thru I2C port 0.

Low Battery LED

The Low Battery LED is an orange LED. This LED comes on when the battery voltage is 3.6V. This will still the user notice that there is a short period of more time to run the "Rig".

The "Rig" will automatically shut down when the battery voltage is 3.3V or lower. This is a hardware function and does not depend on the software. This enabled is to protect the battery so the battery can have a maximum number of charge cycles and not cause damage to the battery. The "Rig" will power up again when the voltage is above 3.7V. This hysteresis (3.3V to 3.7V) is designed to protect the "Rig" from powering off then powering back on again. Plugging in the USB cable will turn the "Rig" back on.