Appendix 2 – Schematics & parts lists

This appendix provides the technical schematics and parts lists of current Crab Tracker prototypes. This appendix is intended as an aid to anyone fabricating Crab Tracker prototypes, but it could also be useful for those interested in designing their own ultrasonic telemetry system. Each schematic sheet corresponds to a single, discrete aspect of the project design (e.g. there is one and only one schematic for the emitter PCB). Included with the schematics are parts lists that will enable the reader to purchase the components necessary to construct their own Crab Tracker prototypes as well as pictures of the physical prototypes to enable the interested reader to visualize the finished product.

Every effort was made to label schematics clearly and in parallel with the descriptions in the main text of Chapter 2. However, because of the technical nature of this material, specialized electrical engineering symbols and abbreviations are used throughout this appendix. It is important to note that these schematics show the logical connections between components, therefore many actual physical connections are not displayed. The interested reader can seek further enlightenment in any basic electrical engineering text. Coffee won't hurt either.

These documents were constructed with Altium Designer software. Full, editable PCB projects needed to make hardware modifications and gerber files needed to fabricate the current Crab Tracker prototypes can be found at www.OSF.com.

Figure S1. *Emitter schematic (see Page 18).*

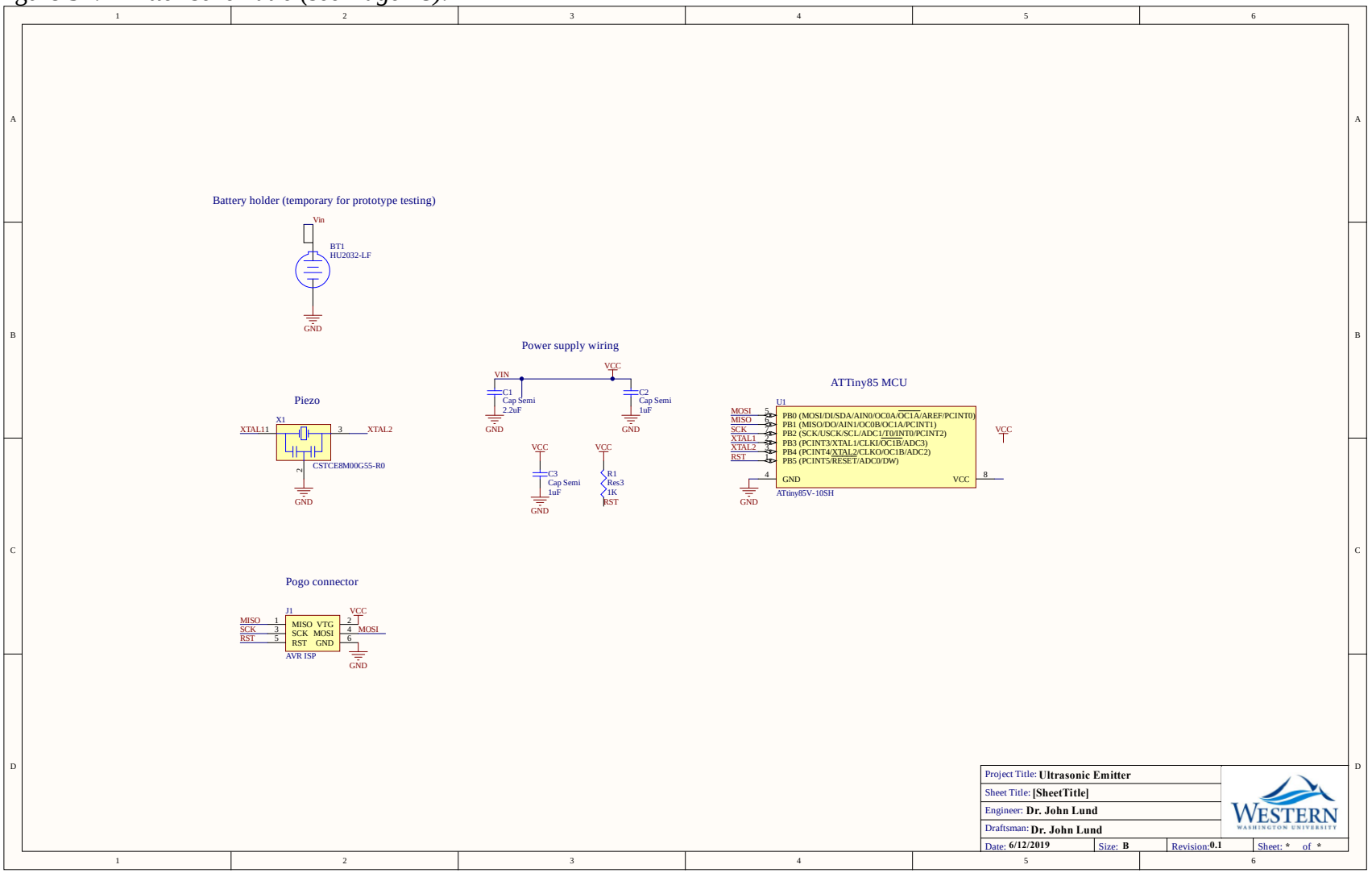

Table S1. *Components needed to populate the emitter PCB.*

Figure S2. *Side (left) and back (right) views of the hydrophone. The metal cylinder is the waterproofed diaphragm piezo not shown in the schematic.*

Hydrophone and preamp

Figure S3. *Hydrophone schematic (see Figure 2-5).*

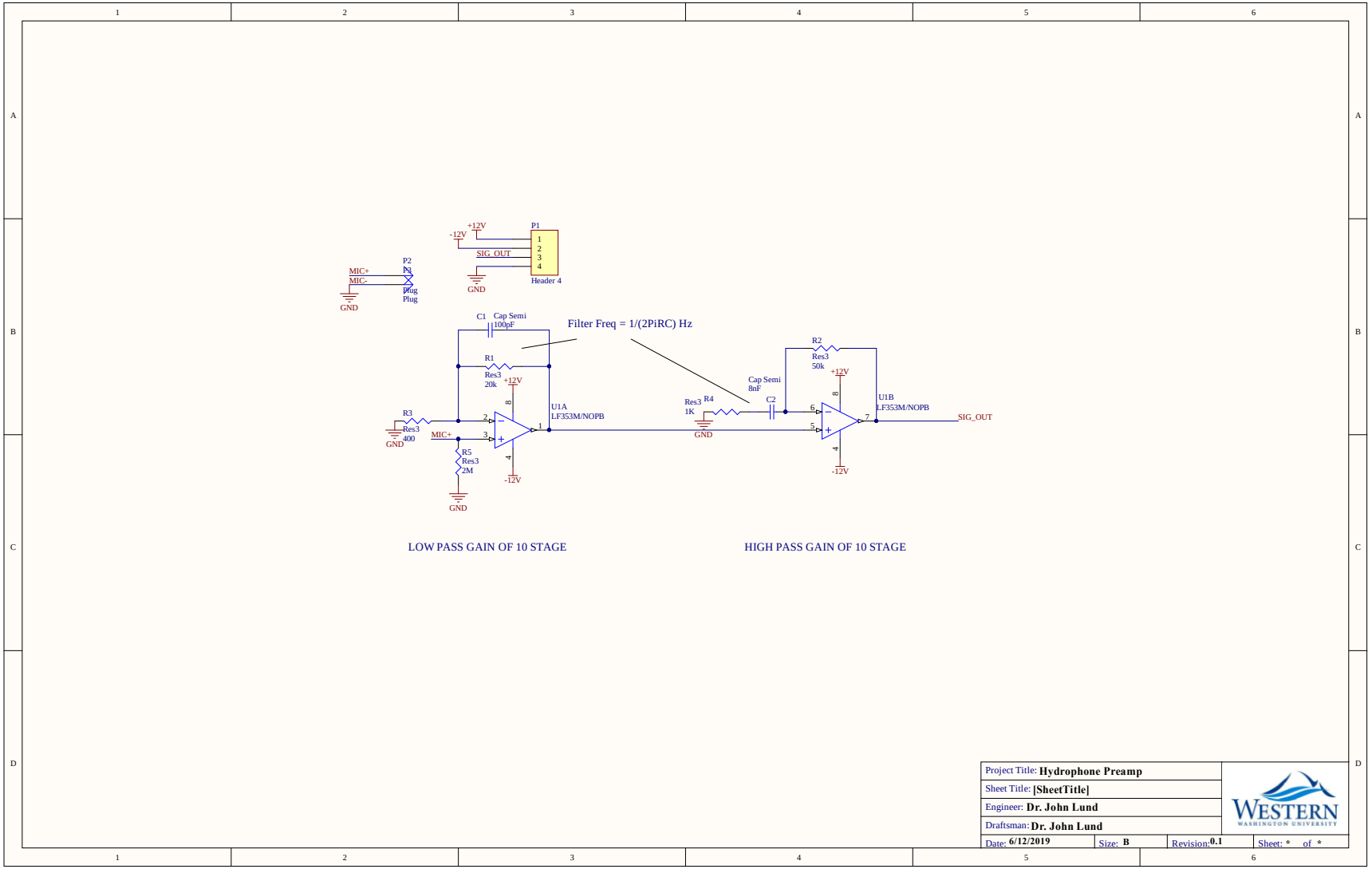

Table S2. *Components needed to populate the hydrophone receiver PCB.*

Designator	Description	Footprint	Value or Part #	Per hydrophone
C1	SMD Cap	1608/0603	100 pF	1
C2	SMD Cap	1608/0603	8 nF	1
R1	SMD Res	1608/0603	20 kΩ	1
R2	SMD Res	1608/0603	50 kΩ	1
R3	SMD Res	1608/0603	400 Ω	1
R4	SMD Res	1608/0603	1 kΩ	1
R5	SMD Res	1608/0603	2 MΩ	1
U1	Opamp	SOIC-8	OPA2171-Q1	1
Not shown in schematic	Diaphragm piezo		SMATR10H40X80	1

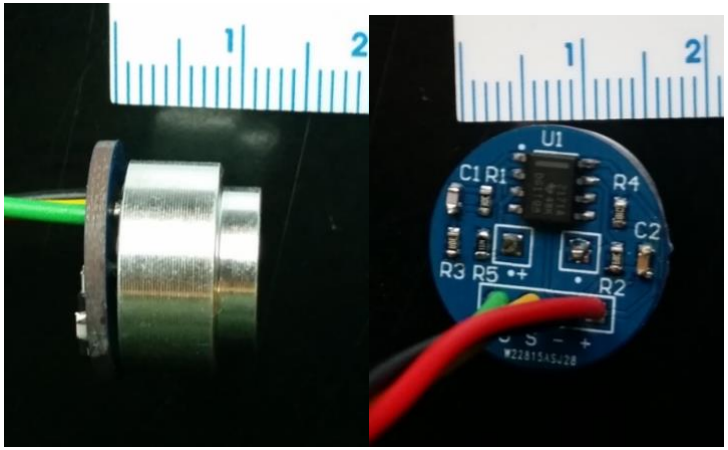

Figure S4. *Side (left) and back (right) views of the hydrophone. The metal cylinder is the waterproofed diaphragm piezo not shown in the schematic.*

Figure S5. *Bandpass Filter (see Figures 2-5, S8).*

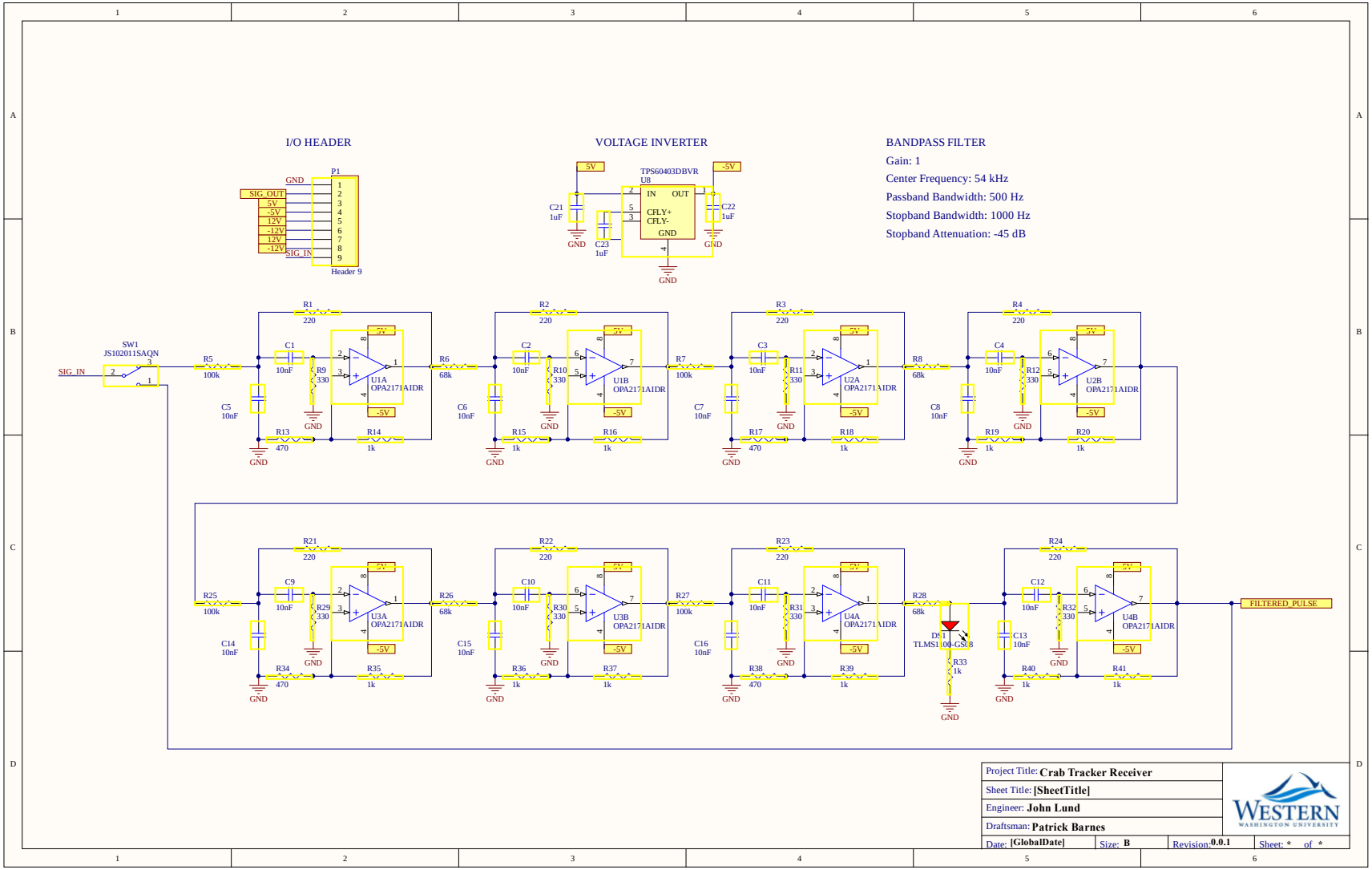

Figure S6. *Variable gain, rectification, digitization (see Figures 2-5, S8).*

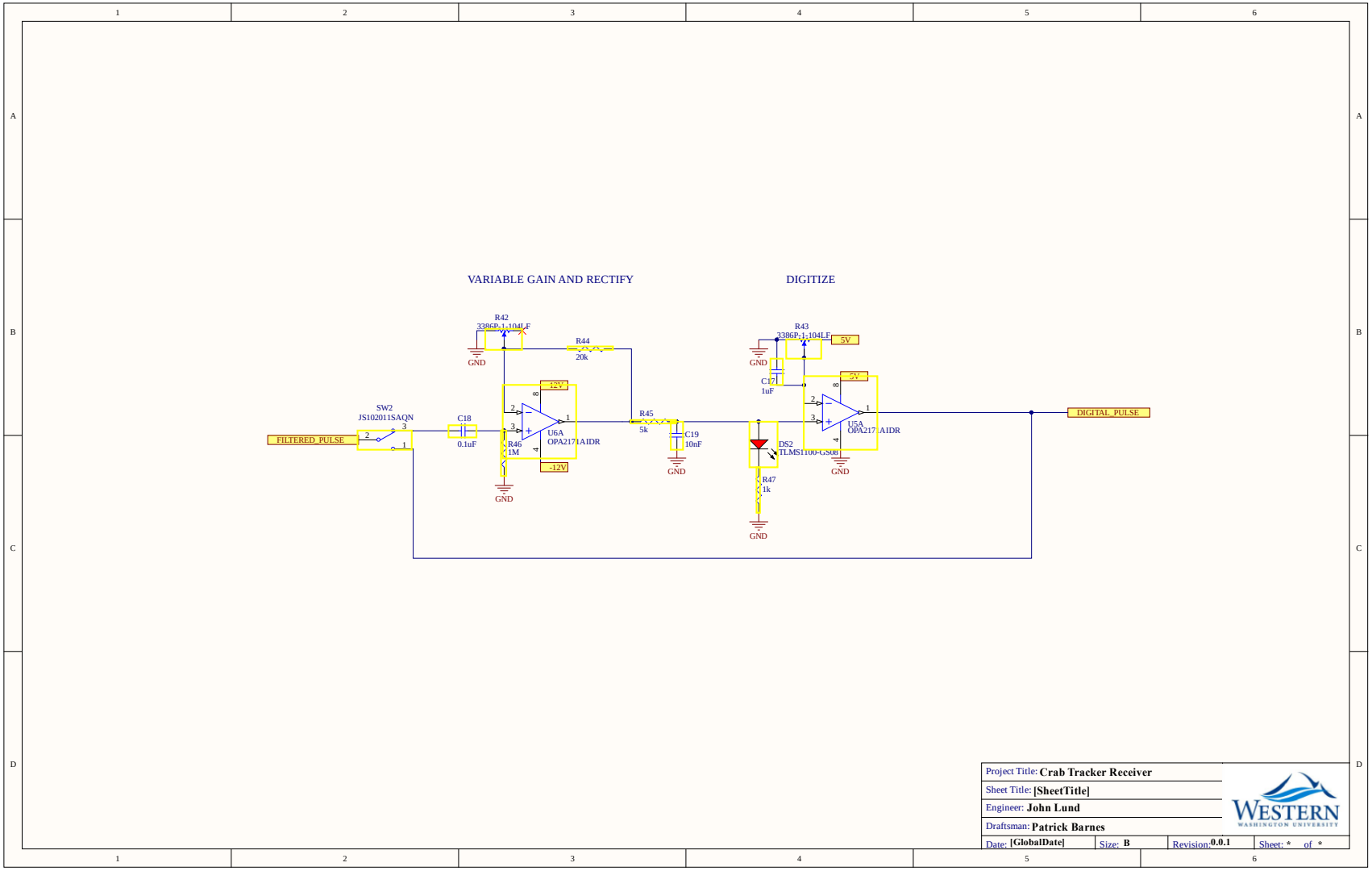

Figure S7. *Schmitt trigger (see Figures 2-5, S8).*

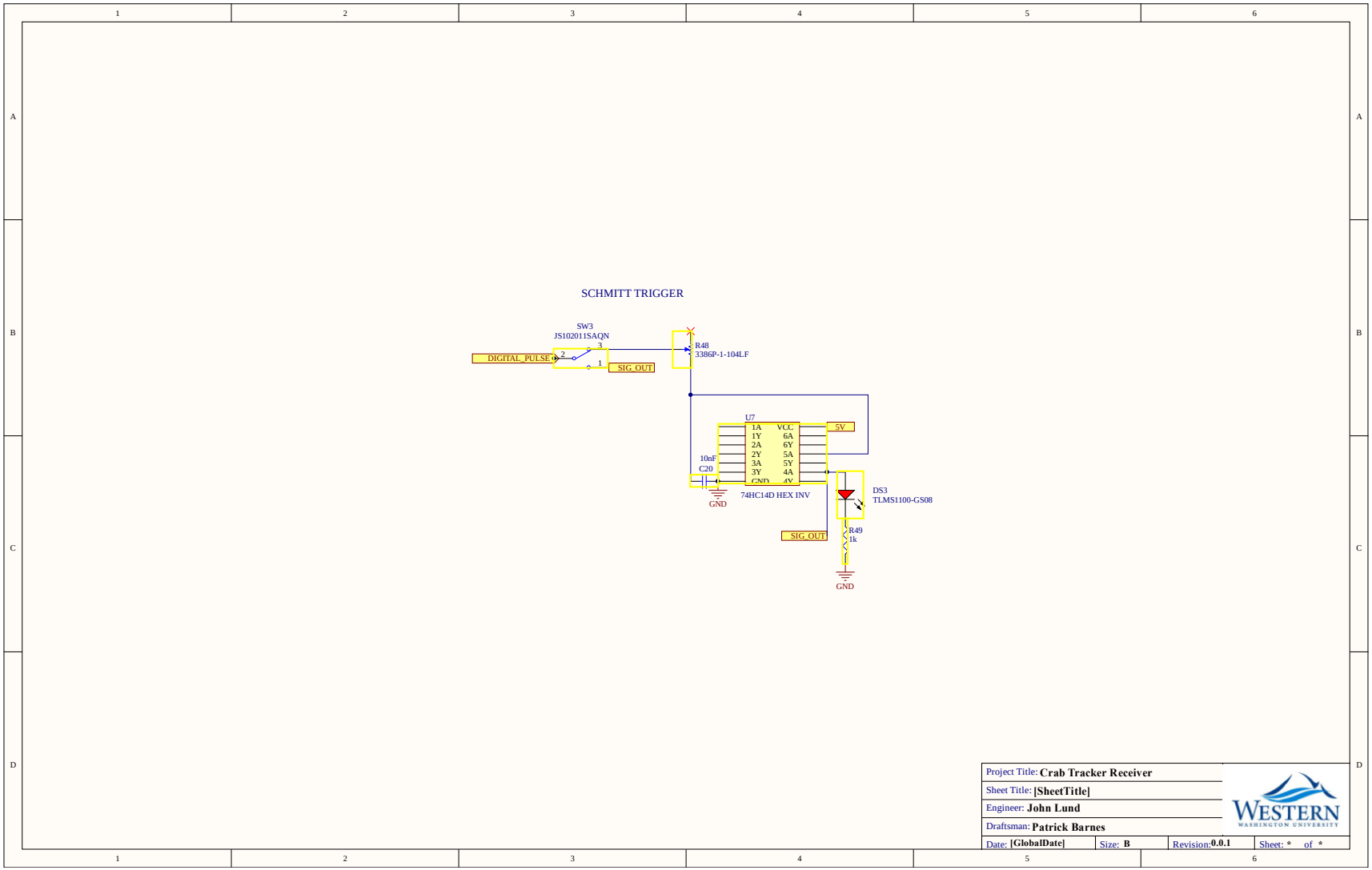

Table S3. *Components needed to populate the PCB containing the bandpass filter, analog-to-digital converter, and Schmitt trigger.*

Designator	Description	Footprint	Value or Part #	Per Hydrophone
C1, C2, C3, C4, C5, C6, C7, C8, C9, C10, C11, C12, C13, C14, C15, C16, C19, C20	Cap	1608/0603	10 nF	18
C17, C21, C22, C23	Cap	1608/0603	1 uF	4
C18	Cap	1608/0603	0.1 uF	1
R1, R2, R3, R4, R21, R22, R23, R24	Res	1608/0603	220 Ω	8
R5, R7, R25, R27	Res	1608/0603	100 kΩ	4
R6, R8, R26, R28	Res	1608/0603	68 kΩ	4
R9, R10, R11, R12, R29, R30, R31, R32	Res	1608/0603	330 Ω	8
R13, R17, R34, R38	Res	1608/0603	470 Ω	4
R14, R15, R16, R18, R19, R20, R33, R35, R36, R37, R39, R40, R41, R47, R49	Res	1608/0603	1 kΩ	15
R44	Res	1608/0603	20 kΩ	1
R45	Res	1608/0603	5 kΩ	1
R46	Res	1608/0603	1 MΩ	1
R42, R43, R48	Trimpot	BOUR-3386P	100 kΩ	3
DS1, DS2, DS3	LED	1608/0603		3
U1, U2, U3, U4, U5, U6	Opamp	SOIC-8	OPA2171AIDR	6
U7	Schmitt inverter	SOIC-14	74HC14D	1
U8 *	Charge pump	SOT-753	TPS60403DBVR	1
SW1, SW2, SW3 **	Slide switch		JS102011SAQN	3

** This part is a known issue in current prototypes - find a less noisy source of -5V that can provide more current.*

*** Another known issue - use double switches to prevent backflow voltage into bandpass filter. Not necessary for function, consider removing switches entirely.*

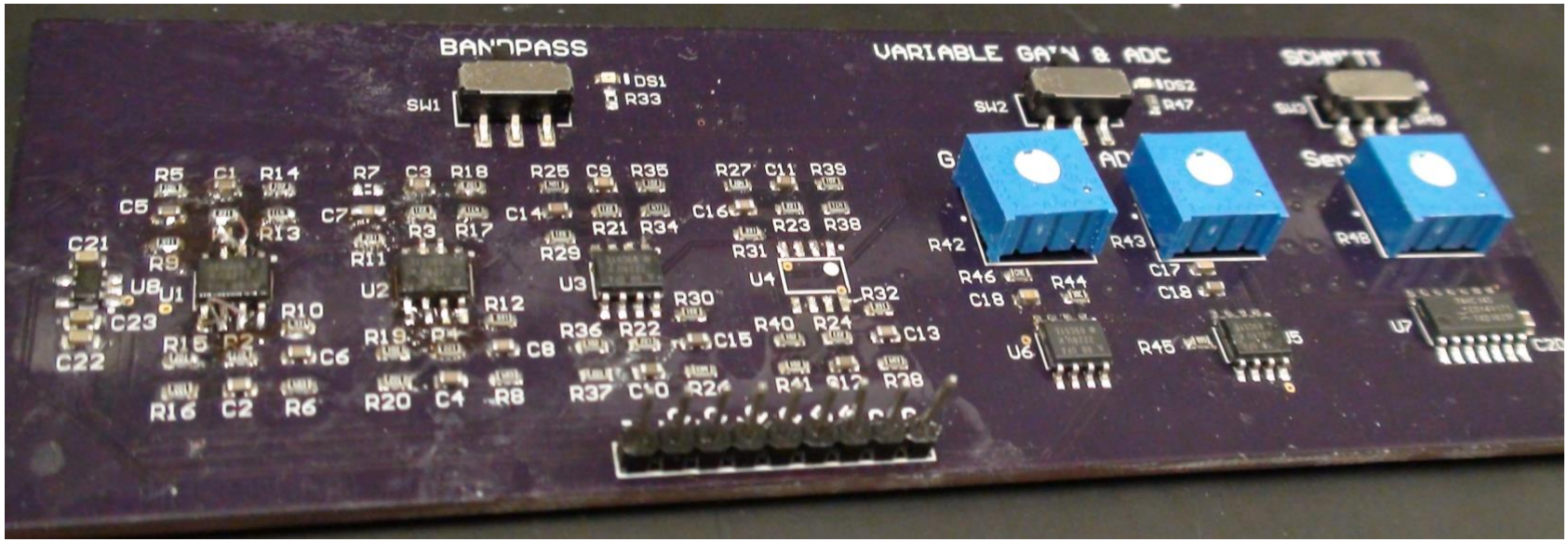

Figure S8. *Current prototype of filter and analog-to-digital converter. There are multiple known issues with this prototype. Issue 1 – the charge pump (component U8) used to generate a -5V rail for bandpass filter opamps does not provide enough current and is too noisy for this application. Issue 2 – the switches allow backflow voltage into the filter, Issue 3 – opamps are wired backwards in the Altium schematic. Solution 1 – find an external, reliable source for - 5V. Solution 2 - use double switches or remove switches entirely. Solution 3 – reverse inputs on opamps in PCB design (switch pin 2 with pin 3 and switch pin 5 with pin 6).*

Figure S9. *Breakout board for GPX2 timing chip (see Page number here). This configuration uses CMOS inputs, SPI communication, and detects rising edges of signals. Refer to the GPX2 datasheet for details on how to modify this breakout to use other configurations.*

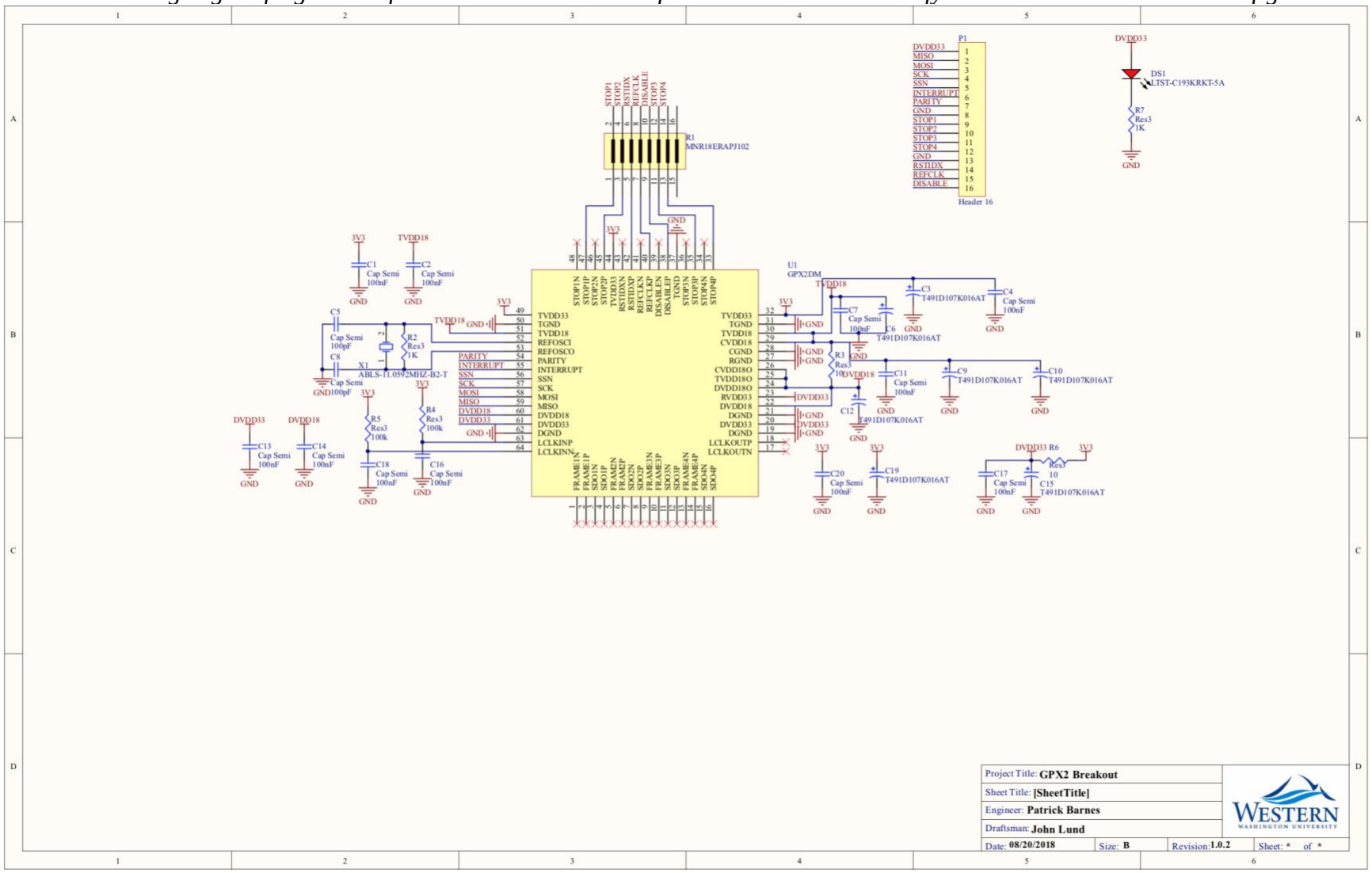

Table S4. *Components needed to populate the GPX2 breakout board.*

Designator	Description	Footprint	Value or Part #	Per Hydrophone
C1, C2, C4, C7, C11, C13, C14, C16, C17, C18, C20	Cap	1608/0603	100 nF	11
C8, C5	Cap	1608/0603	100 pF	2
C3, C6, C9, C10, C12, C15, C19	Cap		T491D107K016AT	7
DS1	LED	1608/0603		1
R1	Res Array		MNR18ERAPJ102	1
R3, R6	Res	2010/5025	10 Ω	2
R2, R7	Res	1608/0603	1 kΩ	2
R4, R5	Res	1608/0603	100 kΩ	2
U1	Timing chip		GPX2 ADC	1
X1	Crystal oscillator		ABLS-11.0592MHZ-B2-T	1

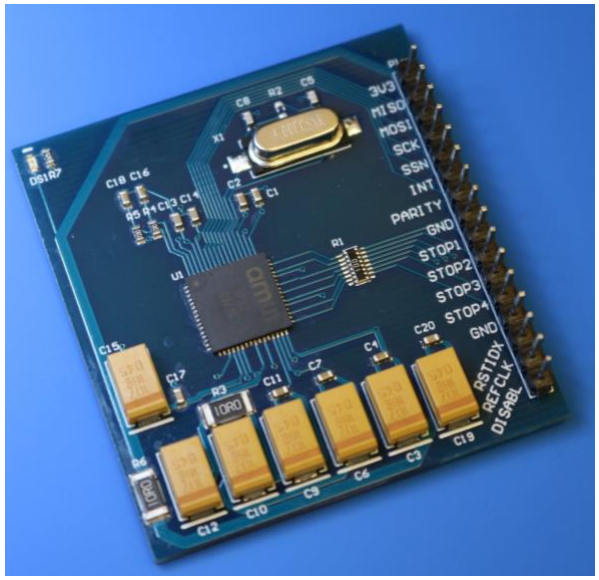

Figure S10. *GPX2 Breakout board.*

Figure S11. *All hardware prototypes* .