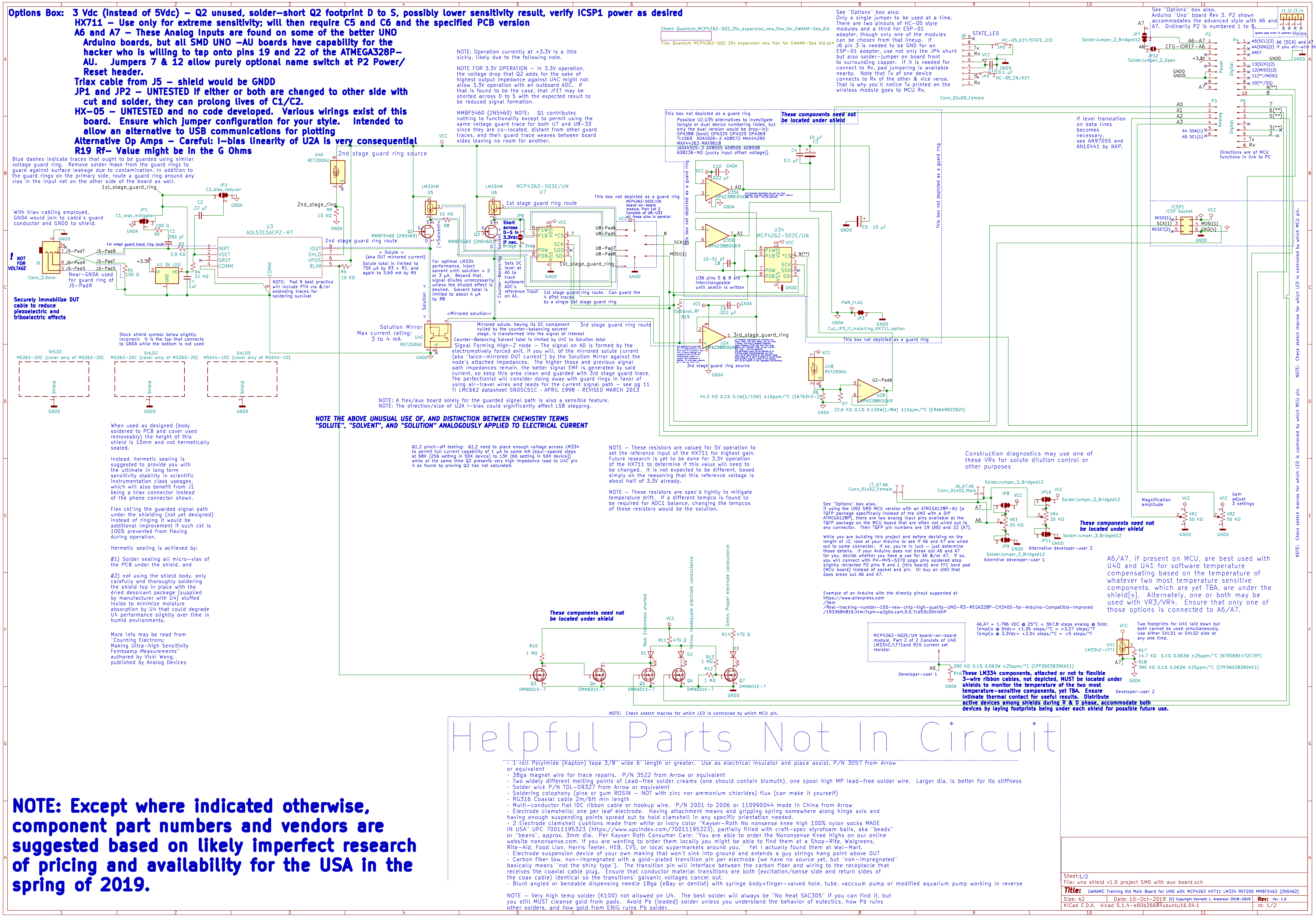
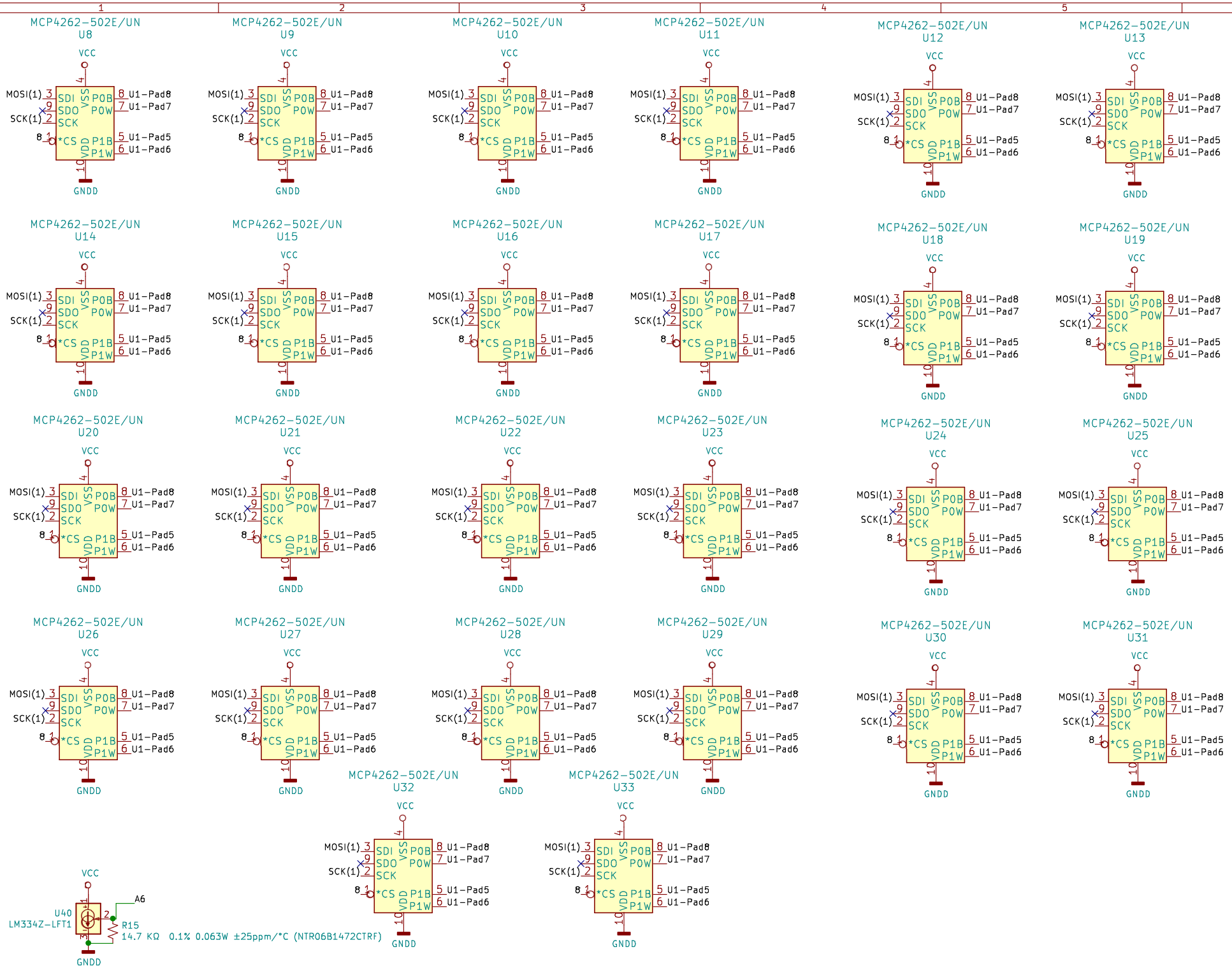


Options Box: 3 Vdc (instead of 5Vdc) – Q2 unused, solder–short Q2 footprint D to S, possibly lower sensitivity result, verify ICSP1 power as desired
HX711 – Use only for extreme sensitivity; will then require C5 and C6 and the specified PCB version
A6 and A7 – These Analog Inputs are found on some of the better UNO Arduino boards, but all SMD UNO –AU boards have capability for the hacker who is willing to tap onto pins 19 and 22 of the ATMEGA328P–AU. Jumpers 7 & 12 allow purely optional name switch at P2 Power/Reset header.
Triax cable from J5 – shield would be GNDD
JP1 and JP2 – UNTESTED If either or both are changed to other side with cut and solder, they can prolong lives of C1/C2.
HX–05 – UNTESTED and no code developed. Various wirings exist of this board. Ensure which jumper configuration for your style. Intended to allow an alternative to USB communications for plotting
Alternative Op Amps – Careful: I–bias linearity of U2A is very consequential
R19 Rf– Value might be in the G Ohms
Blue dashes indicate traces that ought to be guarded using similar voltage guard ring. Remove solder mask from the guard rings to guard against surface leakage due to contamination. In addition to the guard rings on the primary side, route a guard ring around any vias in the input net on the other side of the board as well.
With triax cabling employed, GNDA would join to cable's guard conductor and GNDD to shield.
NOT FOR VOLTAGE
Securely immobilize DUT cable to reduce piezoelectric and triboelectric effects
NOTE: Operation currently at +3.3V is a little sickly, likely due to the following note.
NOTE FOR 3.3V OPERATION – In 3.3V operation, the voltage drop that Q2 adds for the sake of highest output impedance against U4C might not allow 3.3V operation with an outboard ADC. If that is found to be the case, that JFET may be shorted across D to S with the expected result to be reduced signal formation.
MMBF5460 (2N5460) NOTE: Q1 contributes nothing to functionality except to permit using the same voltage guard trace for both U7 and U8–33 since they are co–located, distant from other guard traces, and their guard trace weaves between board sides leaving no room for another.
Sheet: Quantum_MCP4262–502_25x_expansion_new_flex_for_GWAAM–Sea_Aid
File: Quantum MCP4262–502 25x expansion new flex for GWAAM–Sea Aid.sch
This box not depicted as a guard ring
Possible U2,U35 alternatives to investigate (single or dual device numbering listed, but only the dual version would be drop–in): OPA388 (best) OPA320 OPA325 OPA369 TLV369 ADA4500–2 AD8572 MAX44290 MAX44263 MAX9618 [ADA4505–2 AD8505 AD8506 AD8508 AD8236–NO (yucky input offset voltage)]
These components need not be located under shield
See "Options" box also. Only a single jumper to be used at a time. There are two pinouts of HC–05 style modules and a third for ESP–01 adapter, though only one of the modules can be chosen from that lineup. If J6 pin 3 is needed to be GND for an ESP–01 adapter, use not only the JP4 shunt but also solder–jumper on board front to surrounding copper. If it is needed for connect to Rx, pad jumpering is available nearby. Note that Tx of one device connects to Rx of the other & vice versa. That is why you'll notice Tx printed on the wireless module goes to MCU Rx.
See "Options" box also. Arduino "Uno" board Rev 3, P2 shown accommodates the advanced style with A6 and A7. Ordinarily P2 is numbered 1 to 8.
If level translation on data lines becomes necessary, see AN97055 and AN10441 by NXP.
Directions are of MCU functions in link to PC
Signal Forming High–Z node – The signal on A0 is formed by the electromotively forced exit, if you will, of the mirrored solute current (aka "twice–mirrored DUT current") by the Solution Mirror against the node's attached impedances. The higher those and previous signal path impedances remain, the better signal EMF is generated by said current, so keep this area clean and guarded with 3rd stage guard trace. The perfectionist will consider doing away with guard rings in favor of using air–travel wires and leads for the current signal path – see pg 11 TI LMC662 datasheet SNOSC51C - APRIL 1998 - REVISED MARCH 2013
NOTE: A flex/aux board solely for the guarded signal path is also a sensible feature.
NOTE: The direction/size of U2A I–bias could significantly affect LSB stepping.
NOTE THE ABOVE UNUSUAL USE OF, AND DISTINCTION BETWEEN CHEMISTRY TERMS "SOLUTE", "SOLVENT", AND "SOLUTION" ANALOGOUSLY APPLIED TO ELECTRICAL CURRENT
Q1,2 pinch–off testing: Q1,2 need to place enough voltage across LM334 to permit full current capability of 1 µA to some mA (equi–spaced steps at 68K [256 setting in 50K device] to 13K [66 setting in 50K device]) while at the same time Q2 presents very high impedance load to U4C pin 4 as found by proving Q2 has not saturated.
NOTE – These resistors are valued for 5V operation to set the reference input of the HX711 for highest gain. Future research is yet to be done for 3.3V operation of the HX711 to determine if this value will need to be changed. It is not expected to be different, based simply on the reasoning that this reference voltage is about half of 3.3V already.
NOTE – These resistors are spec'd tightly to mitigate temperature drift. If a different tempco is found to be required for ADC1 balance, changing the tempcos of these resistors would be the solution.
When used as designed (body soldered to PCB and cover used removeably) the height of this shield is 10mm and not hermetically sealed.
Instead, hermetic sealing is suggested to provide you with the ultimate in long term sensitivity stability in scientific instrumentation class useages, which will also benefit from J1 being a triax connector instead of the phone connector shown.
Flex ckt'ing the guarded signal path under the shielding (not yet designed) instead of ringing it would be additional improvement if such ckt is 100% prevented from flexing during operation.
Hermetic sealing is achieved by:
#1) Solder sealing all micro–vias of the PCB under the shield, and
#2) not using the shield body, only carefully and thoroughly soldering the shield top in place with the dried dessicant package (supplied by manufacturer with U4) stuffed inside to minimize moisture absorption by U4 that could degrade U4 performance slightly over time in humid environments.
More info may be read from "Counting Electrons: Making Ultra–high Sensitivity Femtoamp Measurements" authored by Vicki Wong, published by Analog Devices
Construction diagnostics may use one of these VRs for solute dilution control or other purposes
See "Options" box also. If using the UNO SMD MCU version with an ATMEGA128P–AU (a TQFP package specifically instead of the UNO with a DIP ATMEGA128P), there are two analog input pins available at the TQFP package on the MCU board that are often not wired out to any connector. Their TQFP pin numbers are 19 (A6) and 22 (A7).
While you are building this project and before deciding on the length of J2, look at your Arduino to see if A6 and A7 are wired out to some connector. If so, you're in luck – just determine those details. If your Arduino does not break out A6 and A7 for you, decide whether you have a use for A6 &/or A7. If so, you will connect with PH–MVS–5370 pogo pins soldered atop slightly retracted P2 pins 9 and 1 (this board) and FFC bare pad (MCU board) instead of socket and pin. Or buy an UNO that does break out A6 and A7.
Example of an Arduino with the directly pinout supported at https://www.aliexpress.com/item/Real–tracking–number–100–new–chip–high–quality–UNO–R3–MEGA328P–CH340G–for–Arduino–Compatible–Improved/1933684816.html?spm=a2g0o.cart.0.0.7cd53c00hidtlP
A6/A7, if present on MCU, are best used with U40 and U41 for software temperature compensating based on the temperature of whatever two most temperature sensitive components, which are yet TBA, are under the shield[s]. Alternately, one or both may be used with VR3/VR4. Ensure that only one of those options is connected to A6/A7.
MCP4262–502E/UN board–on–board module, Part 2 of 2 Consists of U40 LM334Z/LFT1and R15 current set resistor
A6,A7 = 1.796 VDC @ 25°C = 367.8 steps analog @ 5Vdc
TempCo @ 5Vdc= +1.35 steps/°C = +3.27 steps/°F
TempCo @ 3.3Vdc= +2.04 steps/°C = +5 steps/°F
Two footprints for U41 laid down but both cannot be used simultaneously. Use either SHLD1 or SHLD2 side at any one time.
These LM334 components, attached or not to flexible 3–wire ribbon cables, not depicted, MUST be located under shields to monitor the temperature of the two most temperature–sensitive components, yet TBA. Ensure intimate thermal contact for useful results. Distribute active devices among shields during R & D phase, accommodate both devices by laying footprints being under each shield for possible future use.
NOTE: Check sketch macros for which LED is controlled by which MCU pin.
Helpful Parts Not In Circuit
· 1 roll Polyimide (Kapton) tape 3/8" wide 6' length or greater. Use as electrical insulator and place assist. P/N 3057 from Arrow or equivalent
· 38ga magnet wire for trace repairs. P/N 3522 from Arrow or equivalent
· Two widely different melting points of Lead–free solder creams (one should contain bismuth), one spool high MP lead–free solder wire. Larger dia. is better for its stiffness
· Solder wick P/N TOL–09327 from Arrow or equivalent
· Soldering colophony (pine or gum ROSIN – NOT with zinc nor ammonium chlorides) flux (can make it yourself)
· RG316 Coaxial cable 2m/6ft min length
· Multi–conductor flat IDC ribbon cable or hookup wire. P/N 2001 to 2006 or 110990044 made in China from Arrow
· Electrode clamshells; one per leaf electrode. Having attachment means and gripping spring somewhere along hinge axis and having enough suspending points spread out to hold clamshell in any specific orientation needed.
· 2 Electrode clamshell cushions made from white or ivory color "Kayser–Roth No nonsense knee high 100% nylon socks MADE IN USA" UPC 70011195323 (https://www.upcindex.com/70011195323), partially filled with craft–spec styrofoam balls, aka "beads" or "beans", approx. 3mm dia. Per Kayser Roth Consumer Care: "You are able to order the Nonsense Knee Highs on our online website nononsense.com. If you are wanting to order them locally you might be able to find them at a Shop–Rite, Walgreens, Rite–Aid, Food Lion, Harris Teeter, HEB, CVS, or local supermarkets around you." Yet I actually found them at Wal–Mart.
· Electrode suspension device of your own making that won't sink into ground and extends a guy strings hang point above DUT
· Carbon fiber tow, non–impregnated with a gold–plated transition pin per electrode (we have no source yet, but "non–impregnated" basically means "not the shiny type"). The transition pin will interface between the carbon fiber and wiring to the receptacle that receives the coaxial cable plug. Ensure that conductor material transitions are both (excitation/sense side and return sides of the coax cable) identical so the transitions' galvanic voltages cancel out.
· Blunt angled or bendable dispensing needle 18ga (eBay or dentist) with syringe body+finger–valved hole, tube, vaccuum pump or modified aquarium pump working in reverse
NOTE – Very high temp solder (K100) not allowed on U4. The best solder will always be "No Heat SAC305" if you can find it, but you still MUST cleanse gold from pads. Avoid Pb (leaded) solder unless you understand the behavior of eutectics, how Pb ruins other solders, and how gold from ENIG ruins Pb solder.
NOTE: Except where indicated otherwise, component part numbers and vendors are suggested based on likely imperfect research of pricing and availability for the USA in the spring of 2019.
Sheet:1/2
File: uno shield v1.0 project SMD with aux board.sch
Title: GWAAMC Training Aid Main Board for UNO with MCP4262 HX711 LM334 REF200 MMBF5462 (2N5462)
Size: A2
Date: 10–Oct–2019 (C) Copyright Kenneth L. Anderson 2018–2019
Rev: Ver. 1.0
KiCad E.D.A. kicad 5.1.4–e60b26684ubuntu16.04.1
Id: 1/2



1 step MSB is 50000 ohms per device/256 steps per device = 195.3125 ohms = 195 ohms

5000 ohms LSB:
a single LSB device full resistance is 5000 ohms per device

number of LSB devices to parallel together to make their full resistance value equal to 195 ohms is 5000 ohms per device/195 ohms = 25.6 devices

cost = $25 + flex board a little larger size

Alternate design under consideration 1000 ohms LSB:
a single LSB device full resistance is 1000 ohms per device

number of LSB devices to parallel together to make their full resistance value equal to 195 ohms is 1000 ohms per device/195 ohms = 5.13 devices

Equivalent 2 devices/package, so 3 packages @ $6/pkg = $18 for savings of $7 or so and a much smaller flex board but with a different pinout of both the flex connector and the MCU connector from which it will consume one more digital pin.

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File: Quantum MCP4262-502 25x expansion new flex for GWAAM-Sea Aid.sch

Title:

Size: A3	Date:	**Rev:**
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