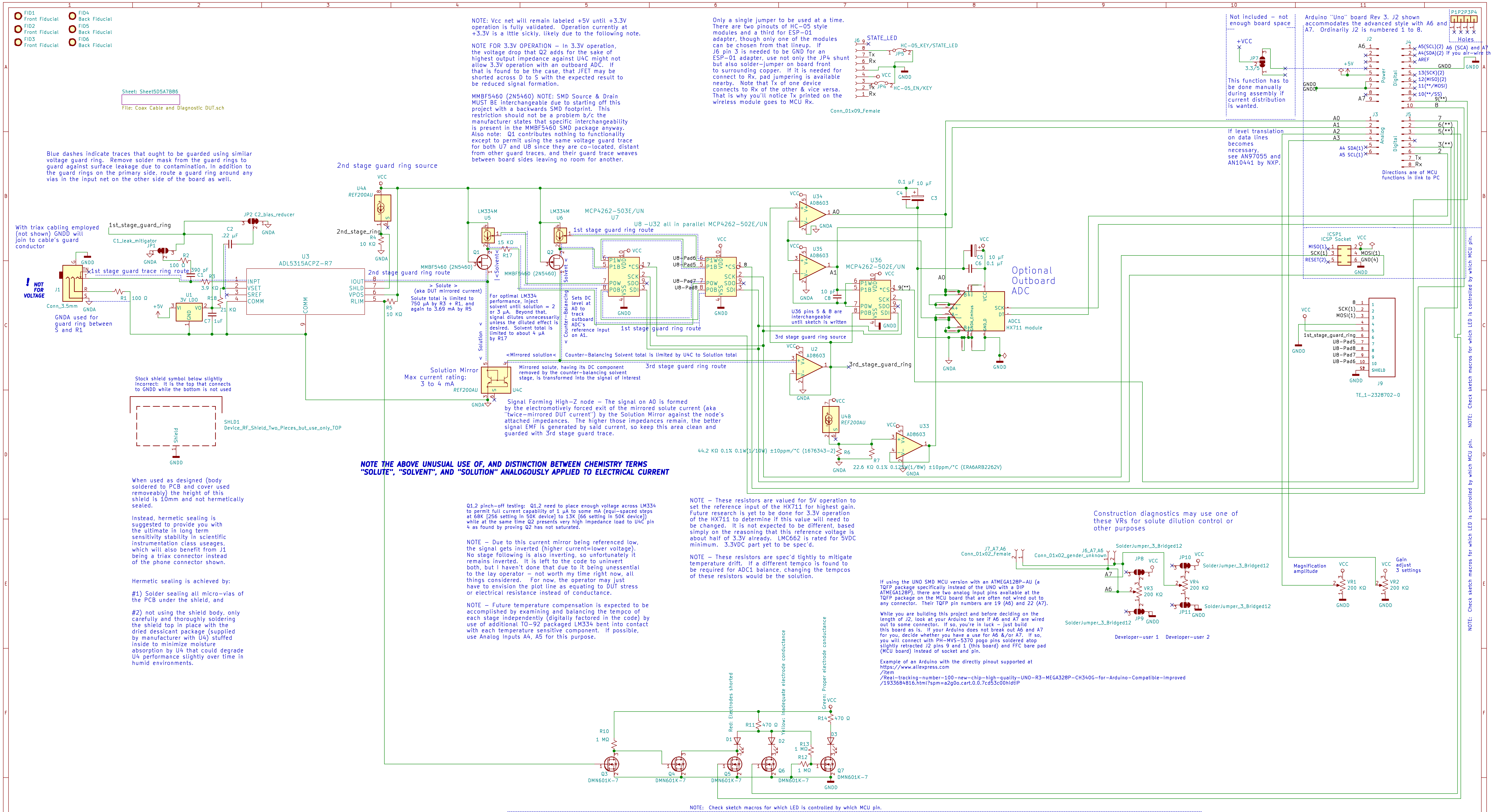


FID1 Front Fiducial
FID2 Front Fiducial
FID3 Front Fiducial
FID4 Back Fiducial
FID5 Back Fiducial
FID6 Back Fiducial
Sheet: Sheet5D5A7B86
File: Coax Cable and Diagnostic DUT.sch
Blue dashes indicate traces that ought to be guarded using similar voltage guard ring. Remove solder mask from the guard rings 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 (not shown) GNDD will join to cable's guard conductor
NOT FOR VOLTAGE
GNDA used for guard ring between 5 and R1
2nd stage guard ring source
1st stage guard trace ring route
2nd stage guard ring route
1st stage guard ring route
3rd stage guard ring source
3rd stage guard ring route
NOTE: Vcc net will remain labeled +5V until +3.3V operation is fully validated. 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: SMD Source & Drain MUST BE interchangeable due to starting off this project with a backwards SMD footprint. This restriction should not be a problem b/c the manufacturer states that specific interchangeability is present in the MMBF5460 SMD package anyway. Also note: Q1 contributes nothing to functionality except to permit using the same voltage guard trace for both U7 and U8 since they are co-located, distant from other guard traces, and their guard trace weaves between board sides leaving no room for another.
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.
Not included – not enough board space.
This function has to be done manually during assembly if current distribution is wanted.
Arduino "Uno" board Rev 3. J2 shown accommodates the advanced style with A6 and A7. Ordinarily J2 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
Optional Outboard ADC
> Solute > (aka DUT mirrored current)
Solute total is limited to 750 µA by R3 + R1, and again to 3.69 mA by R5
For optimal LM334 performance, inject solvent until solution = 2 or 3 µA. Beyond that, signal dilutes unnecessarily unless the diluted effect is desired. Solvent total is limited to about 4 µA by R17
Sets DC level at A0 to track outboard ADC's reference input on A1.
Counter-Balancing Solvent total is limited by U4C to Solution total
<Mirrored solution<
Mirrored solute, having its DC component removed by the counter-balancing solvent stage, is transformed into the signal of interest
Solution Mirror
Max current rating: 3 to 4 mA
Signal Forming High-Z node – The signal on A0 is formed by the electromotively forced exit of the mirrored solute current (aka "twice-mirrored DUT current") by the Solution Mirror against the node's attached impedances. The higher those impedances remain, the better signal EMF is generated by said current, so keep this area clean and guarded with 3rd stage guard trace.
U36 pins 5 & 8 are interchangeable until sketch is written
U8 – U32 all in parallel MCP4262-502E/UN
44.2 KΩ 0.1% 0.1W(1/10W) ±10ppm/°C (1676343-2)
22.6 KΩ 0.1% 0.125W(1/8W) ±10ppm/°C (ERA6ARB2262V)
Stock shield symbol below slightly incorrect: It is the top that connects to GNDD while the bottom is not used
SHLD1 Device_RF_Shield_Two_Pieces_but_use_only_TOP
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.
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.
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 – Due to this current mirror being referenced low, the signal gets inverted (higher current=lower voltage). No stage following is also inverting, so unfortunately it remains inverted. It is left to the code to uninvert both, but I haven't done that due to it being unessential to the lay operator – not worth my time right now, all things considered. For now, the operator may just have to envision the plot line as equating to DUT stress or electrical resistance instead of conductance.
NOTE – Future temperature compensation is expected to be accomplished by examining and balancing the tempco of each stage independently (digitally factored in the code) by use of additional TO-92 packaged LM334 bent into contact with each temperature sensitive component. If possible, use Analog Inputs A4, A5 for this purpose.
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. LMC662 is rated for 5VDC minimum. 3.3VDC part yet to be spec'd.
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.
Construction diagnostics may use one of these VRs for solute dilution control or other purposes
Magnification amplitude
Gain adjust 3 settings
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 build this board as is. 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 J2 pins 9 and 1 (this board) and FFC bare pad (MCU board) instead of socket and pin.
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.0.0.7cd53c00hidtIP
Developer-user 1
Developer-user 2
Red: Electrodes shorted
Yellow: Inadequate electrode conductance
Green: Proper electrode conductance
NOTE: Check sketch macros for which LED is controlled by which MCU pin.

Helpful Parts Not In Circuit

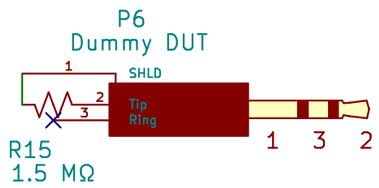
- 1 roll Polyimide (Kapton) tape 3/8" wide 6' length or greater. Use as electrical insulator and place assist. P/N 3057 from Arrow or equivalent
- 38ga magnet wire for trace repairs. P/N 3522 from Arrow or equivalent
- Solder wick P/N TOL-09327 from Arrow or equivalent
- Soldering colophony (pine or 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 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 Nononsense 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.

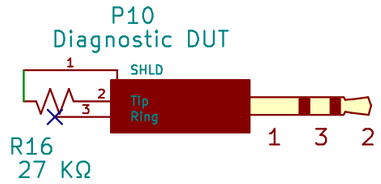
NOTE – Very high temp solder (K100) not allowed on U4. The best solder will always be "No Heat SAC305" if you can find it, but you still MUST cleanse gold from pads. Avoid Pb (leaded) solder unless you understand the behavior of eutectics, how Pb ruins other solders, and how gold from ENIG ruins Pb solder.

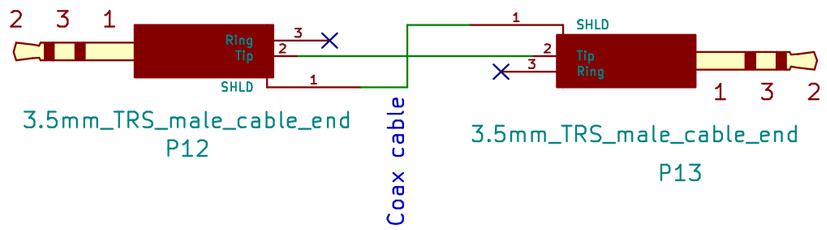
NOTE: Except where indicated otherwise, component part numbers and vendors are suggested based on likely imperfect research of pricing and availability for the USA in the spring of 2019.

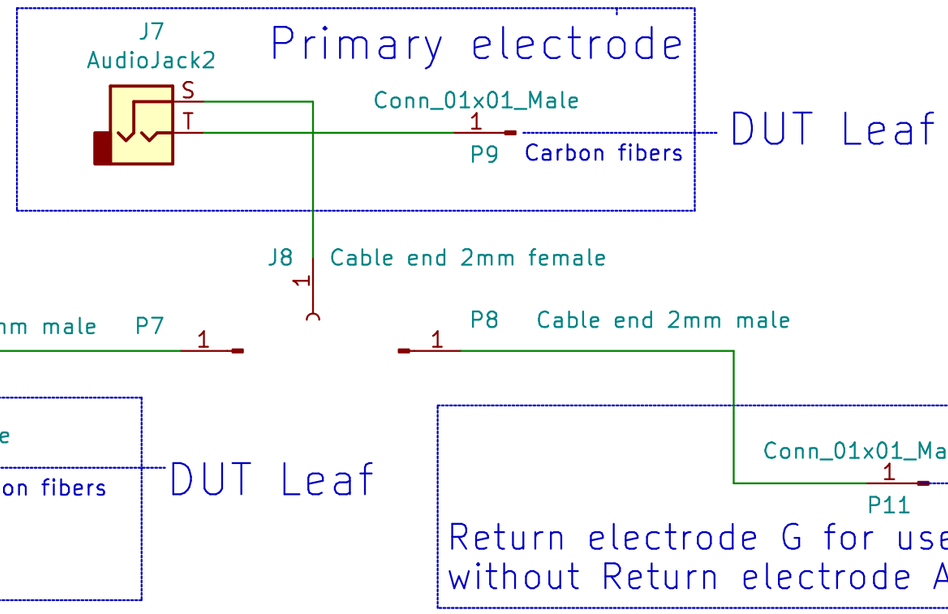
Sheet: 1/2
File: uno shield v1.0 project SMD LM662.sch
Title: GWAAMC Training Aid Main Board for UNO with MCP4262 HX711 LM334 REF200 MMBF5462 (2N5462)
Size: A2 | Date: 10-Oct-2019 (C) Copyright Kenneth L. Anderson 2018-2019 | **Rev:** Ver. 1.0
KiCad E.D.A. kicad 5.1.4-e60b26684ubuntu16.04.1 | Id: 1/2

NOTE: These symbols are required to generate an accurate BOM. To use them in that way, copy them and paste them anywhere into the main page.
They do not have to show within any sheet boundary.
Generate the new BOM and delete the symbol copies from the main page, and main page only, when finished, always leaving the original symbols in this sheet.
If the copies are left in the main page when later updating the PCB, they will interfere with the generation of the PCB Gerber files because these have no residencies on the PCB.









The pins inside the electrodes are to enable gold compatible finish electrical contact in the electrode assemblies for the carbon fiber. One pin belongs in each electrode assembly.

Sheet: /Sheet5D5A7B86/ File: Coax Cable and Diagnostic DUT.sch		
Title:		
Size: A4	Date:	**Rev:**
KiCad E.D.A. kicad 5.1.4-e60b26684ubuntu16.04.1		Id: 2/2