CR Board Design and Manufacturing

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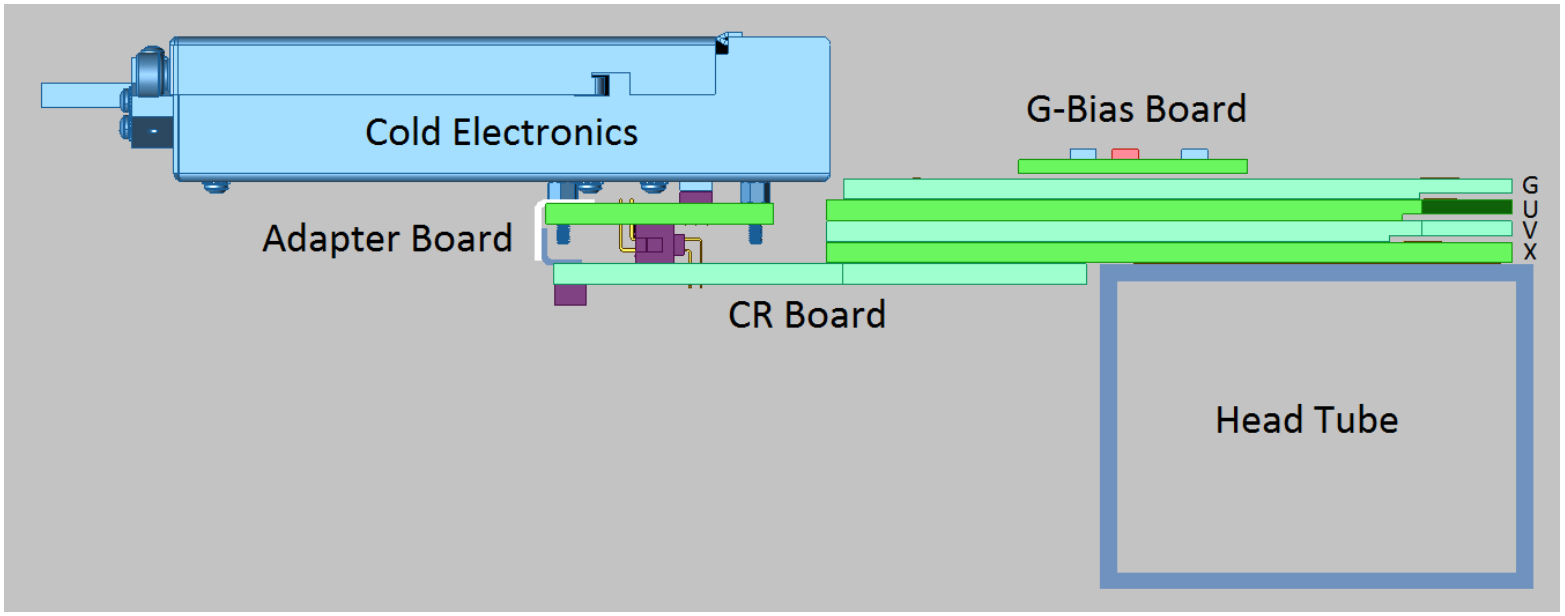
UW Physical Sciences Lab

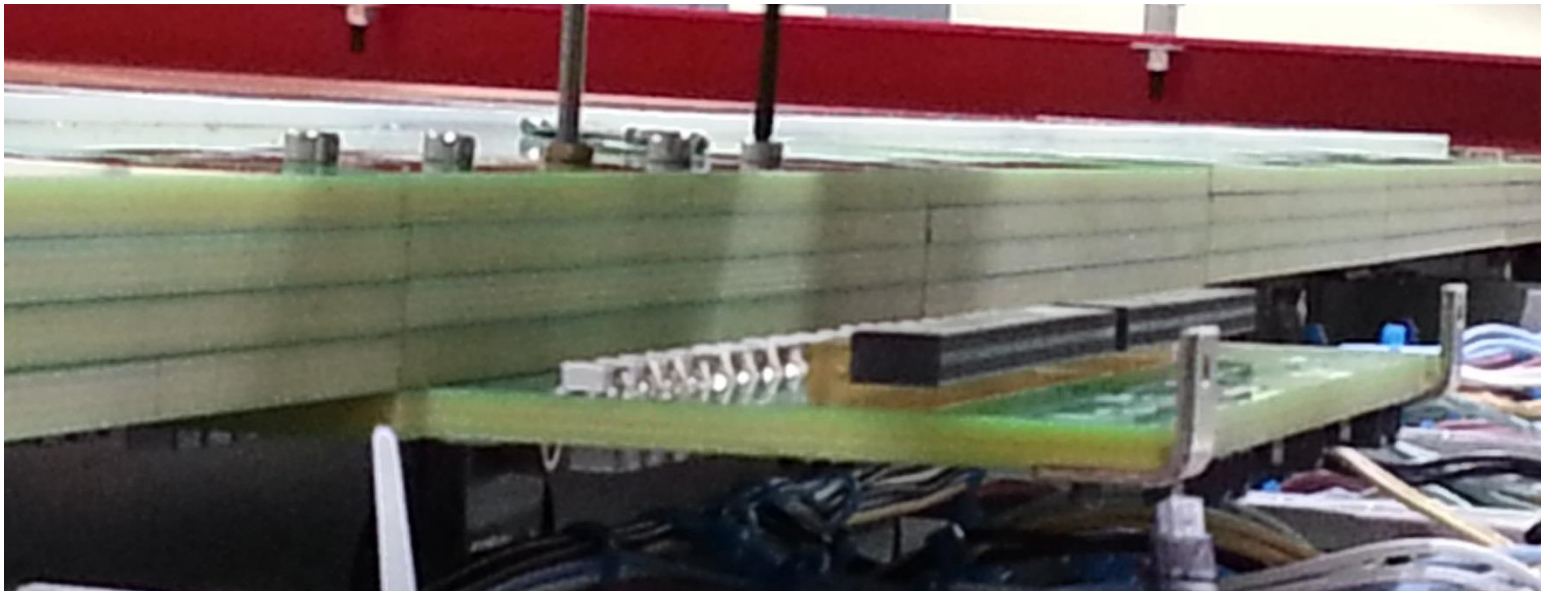
DUNE Electronics Review

2019 November 18

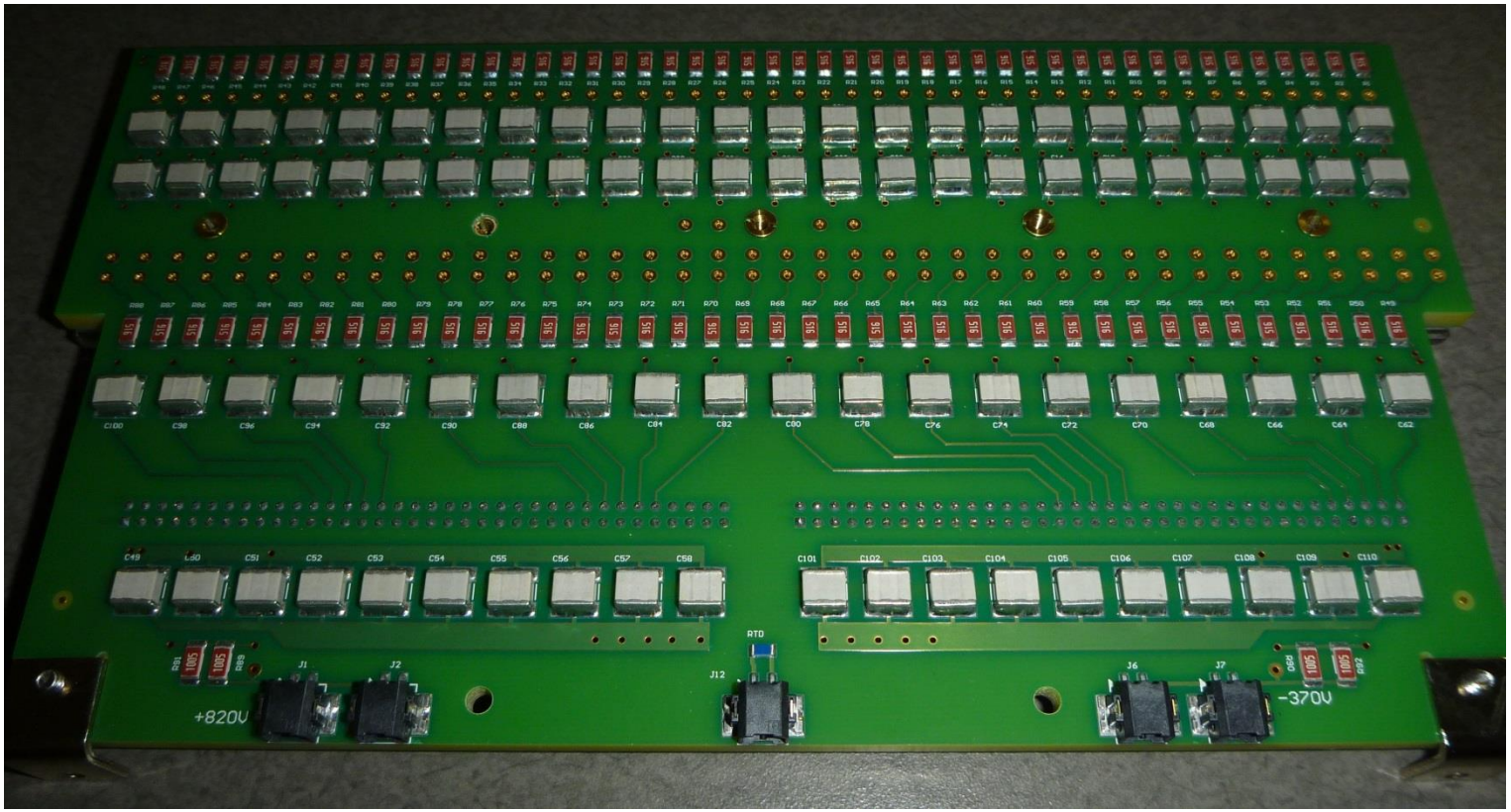
CR Boards Provide Bias to X and U Wires and Route Signal to CE



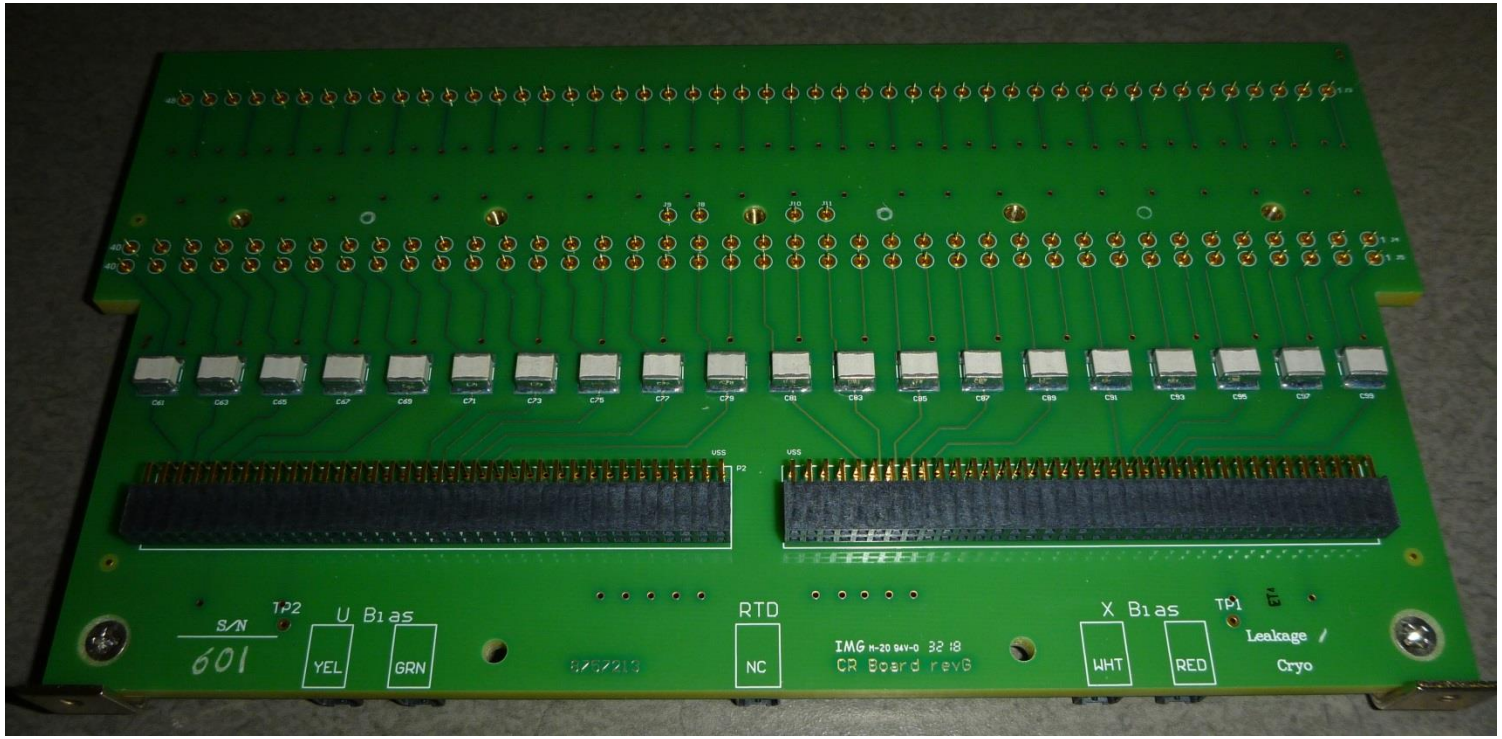
CR boards plug into X-layer head boards. Five screws are gradually tightened to mate pins with receptacles.



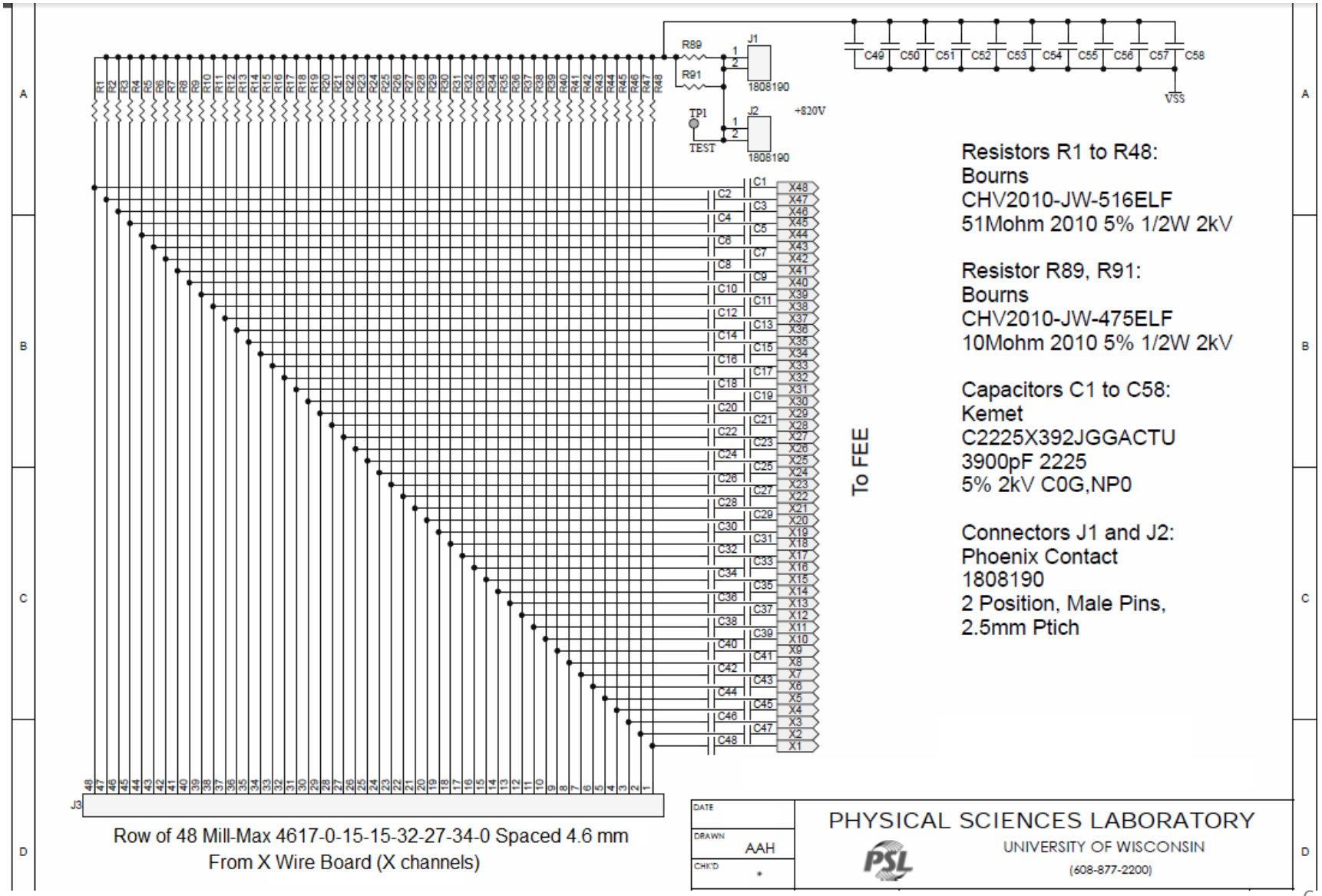
CR Board “Bottom” Side



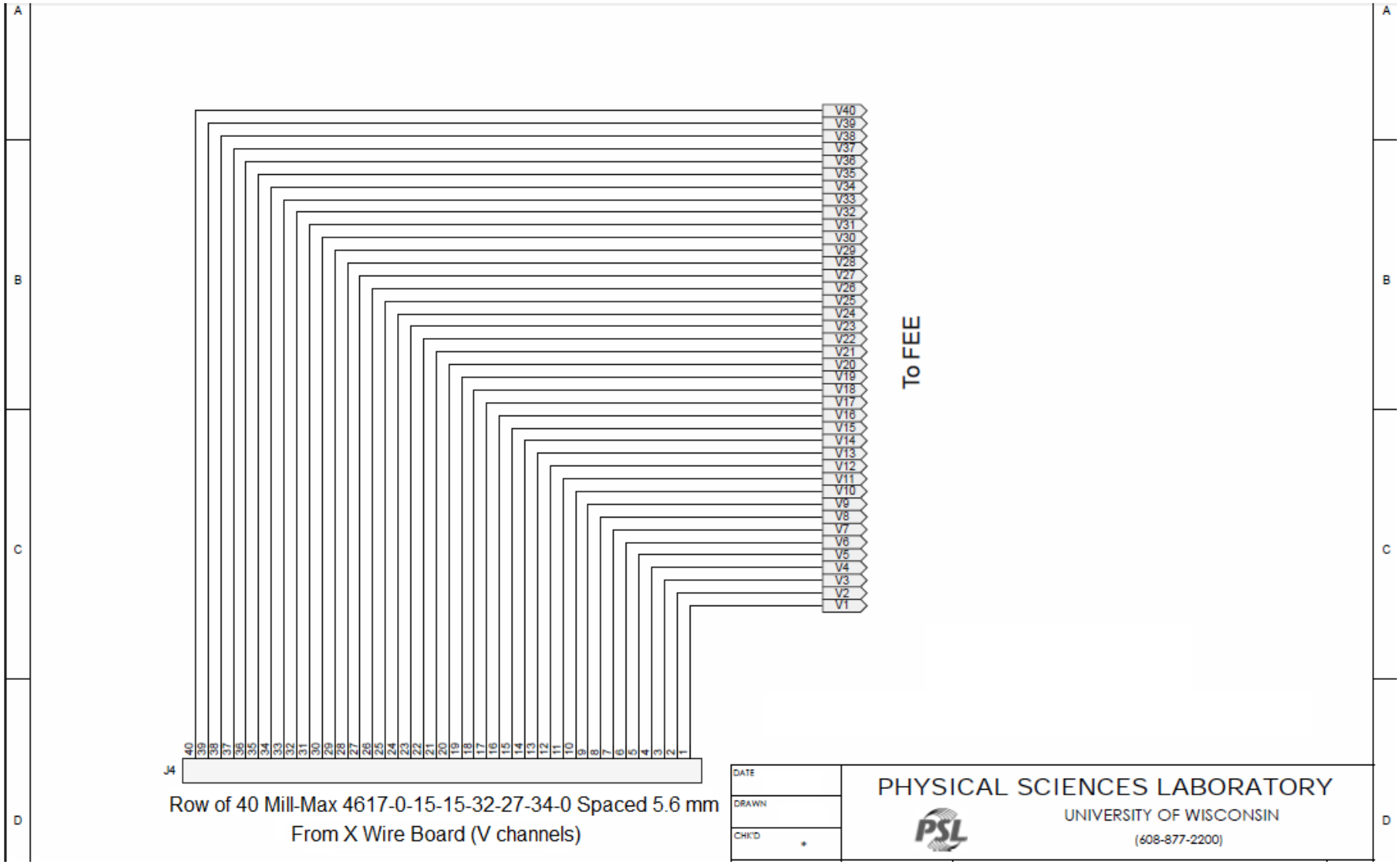
CR Board “Top” Side



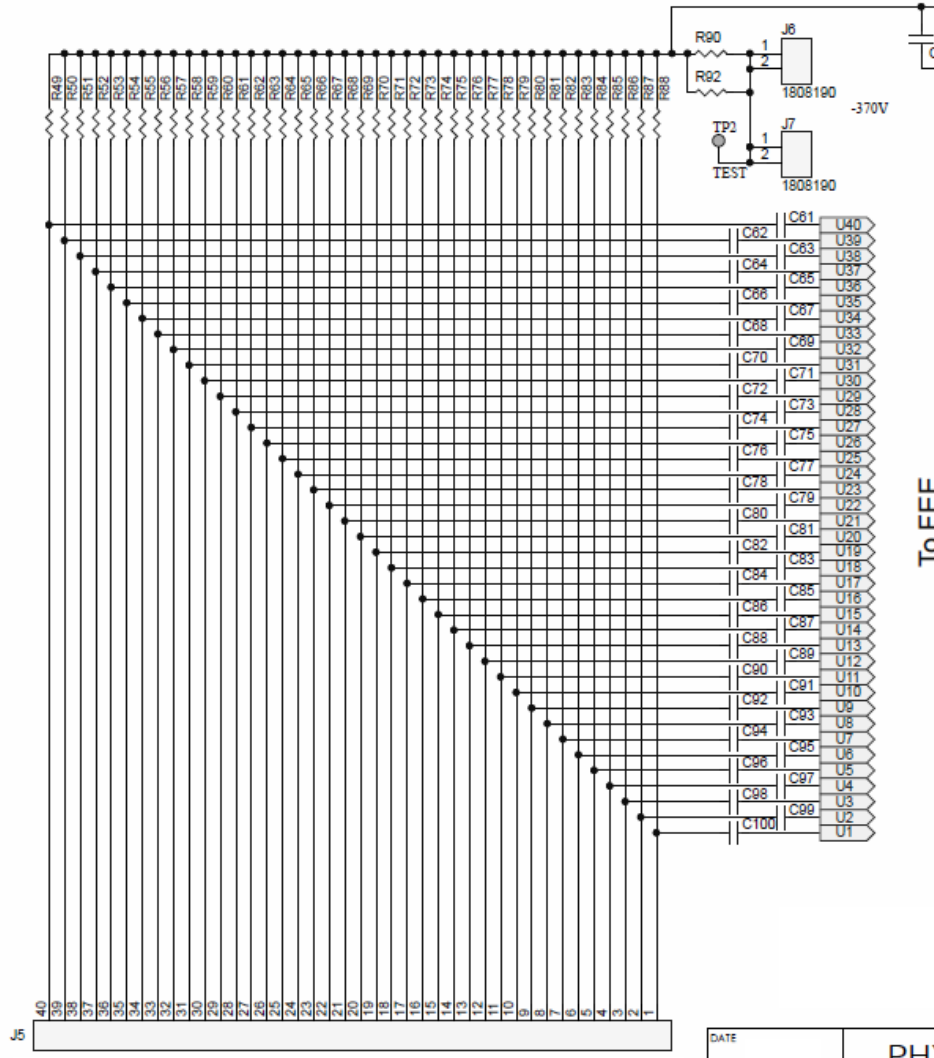
CR Board Schematic p. 1 of 4



CR Board Schematic p. 2 of 4



CR Board Schematic p. 3 of 4



Row of 40 Mill-Max 4617-0-15-15-32-27-34-0 Spaced 5.6 mm
From X Wire Board (U channels)

Resistors R49 to R88:
Bourns
CHV2010-JW-516ELF
51Mohm 2010 5% 1/2W 2kV

Resistor R90, R92:
Bourns
CHV2010-JW-475ELF
10Mohm 2010 5% 1/2W 2kV

Capacitors C61 to C110:
Kemet
C2225X392JGGACTU
3900pF 2225
5% 2kV C0G,NP0

Connectors J6 and J7:
Phoenix Contact
1808190
2 Position, Male Pins,
2.5mm Ptich

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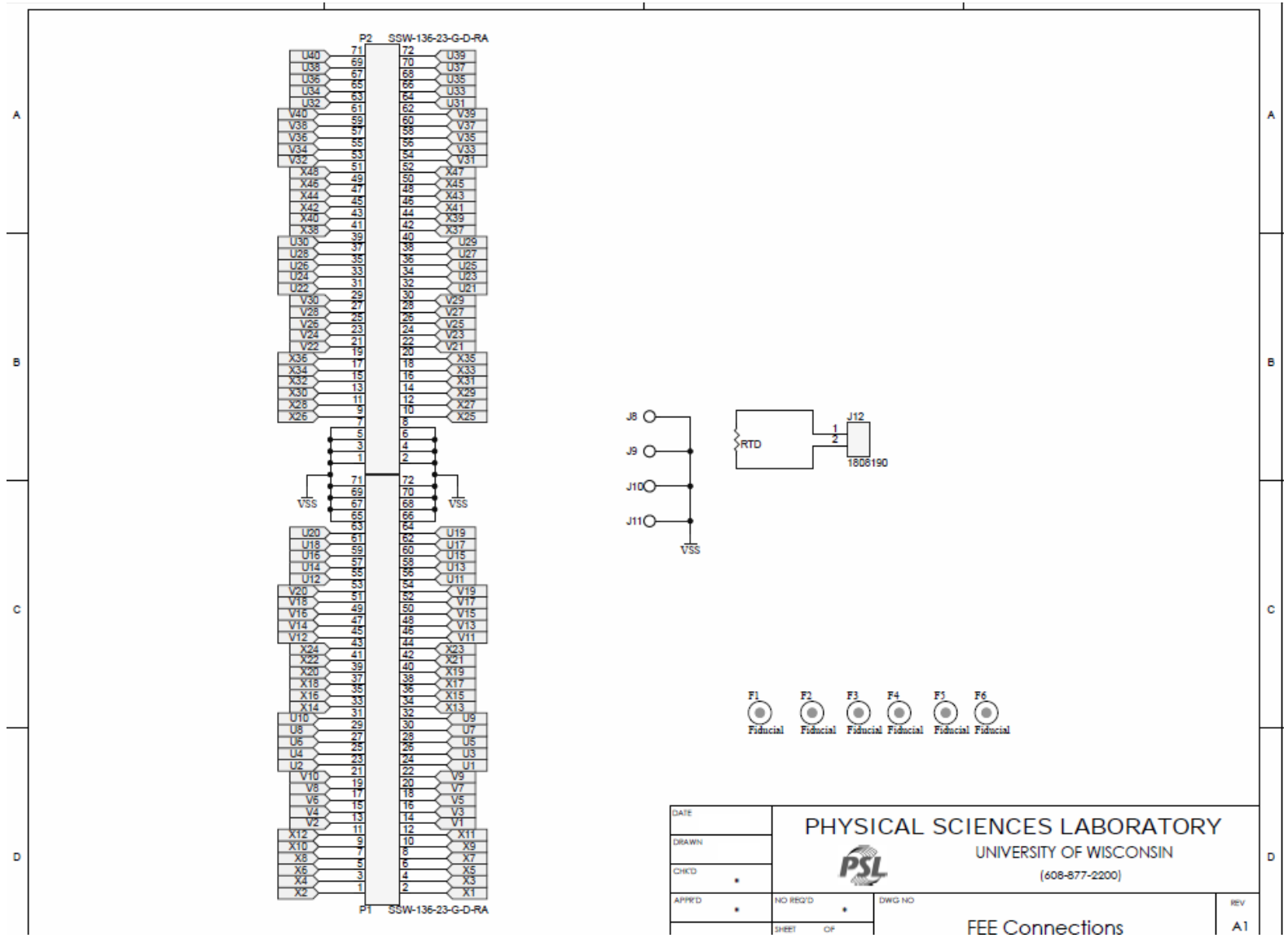
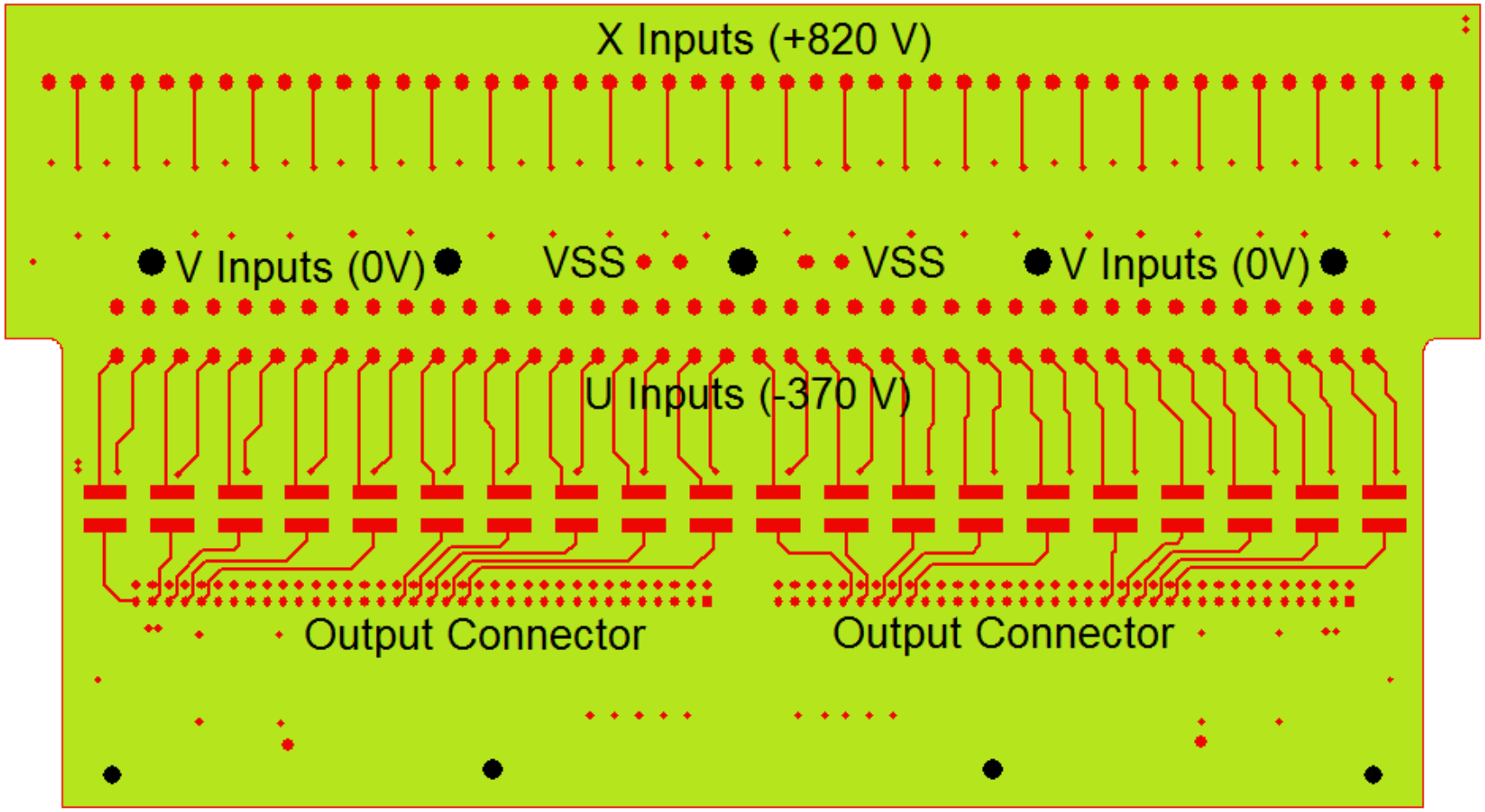
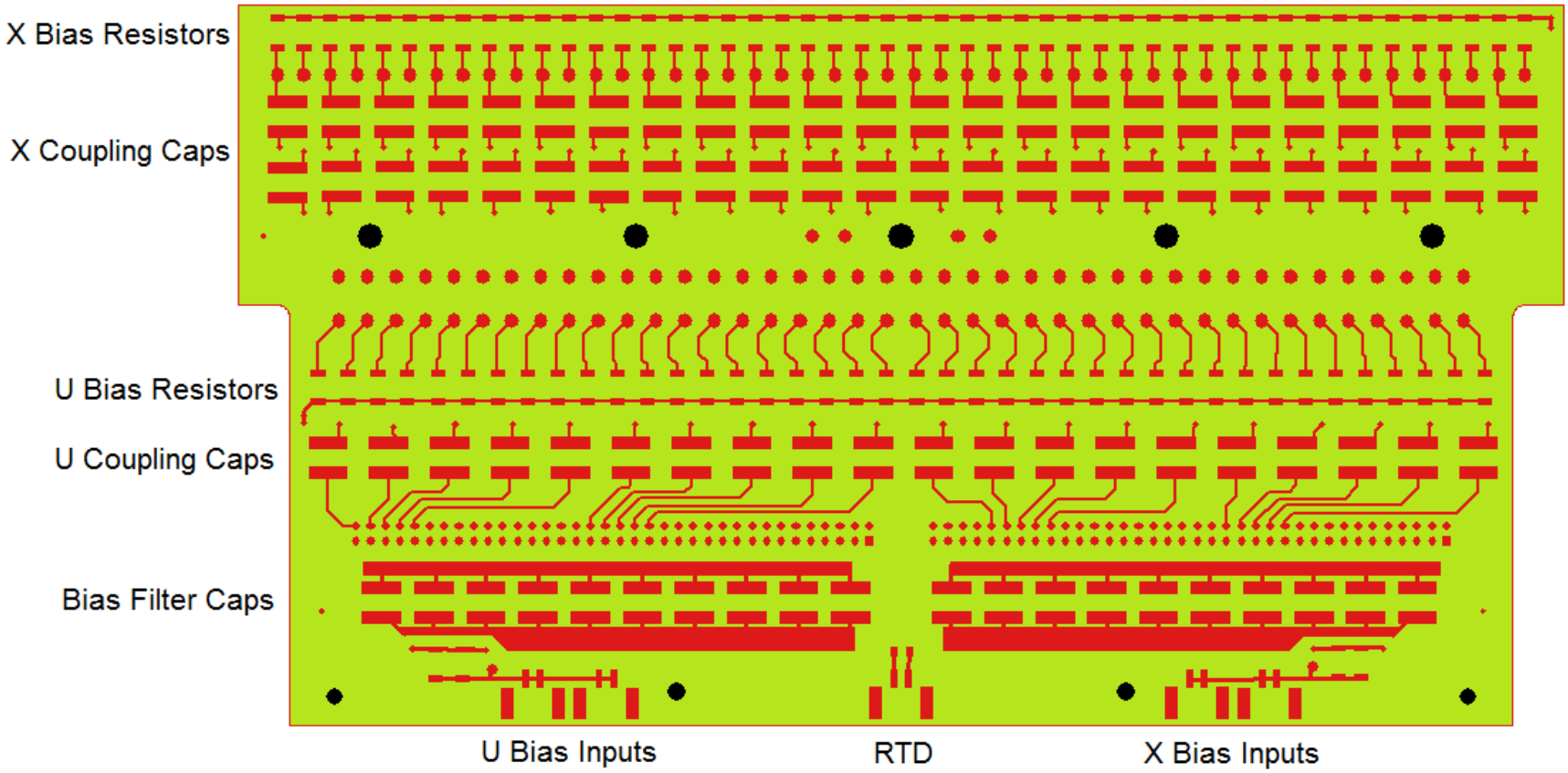
CR Board Schematic p. 4 of 4



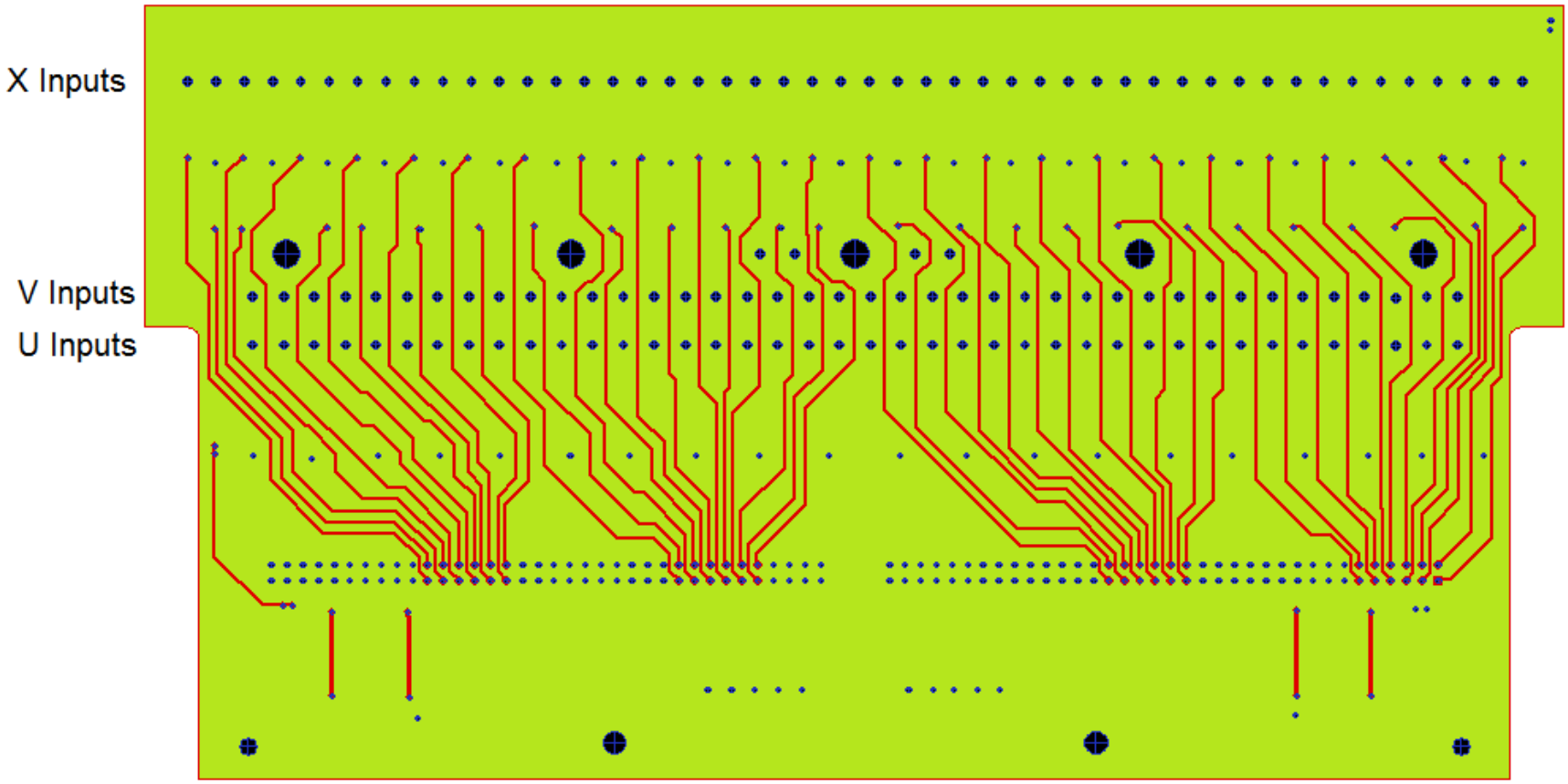
CR Board Top Metal Layer



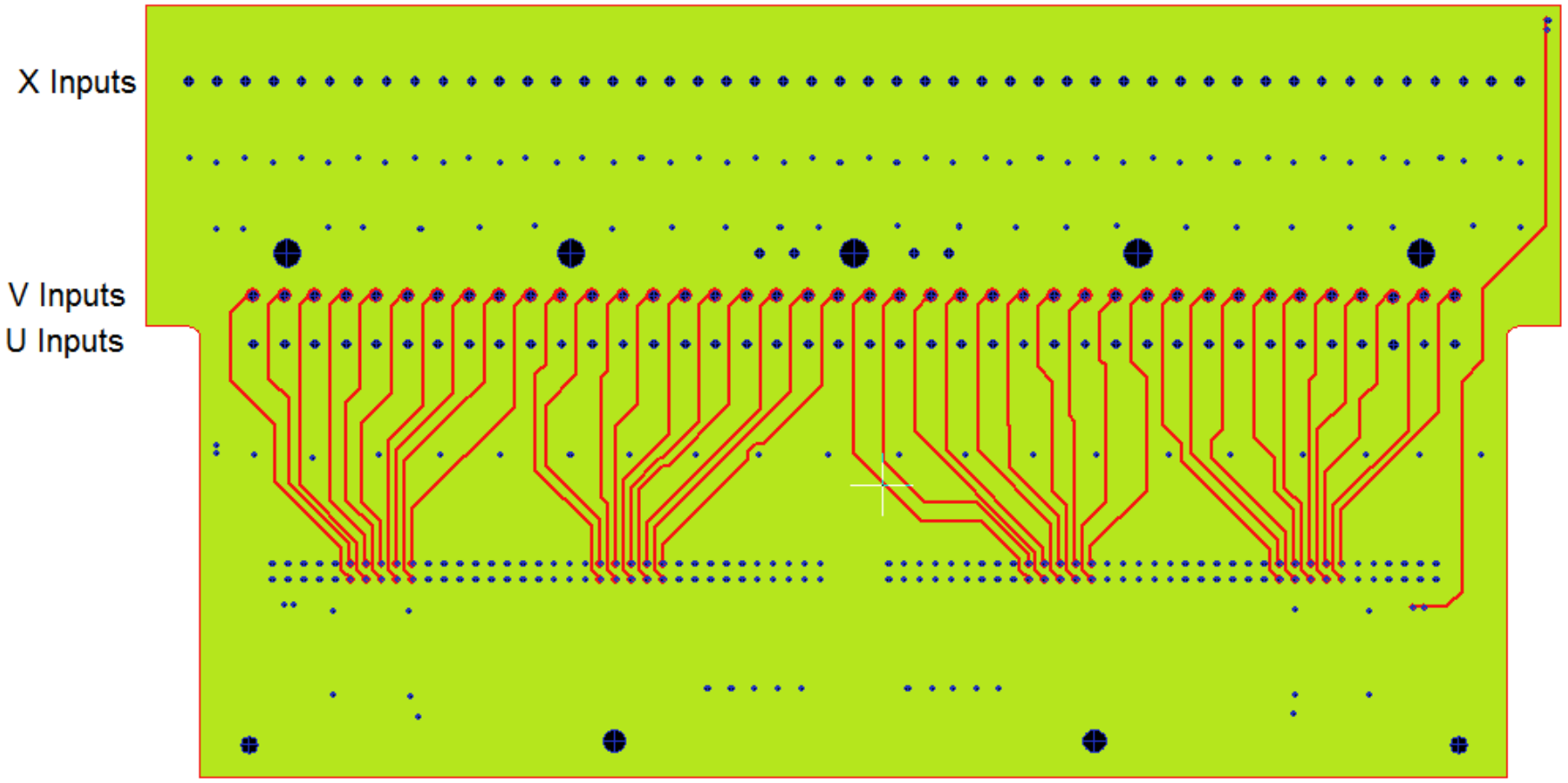
CR Board Bottom Metal Layer



CR Board Signal Layer 1



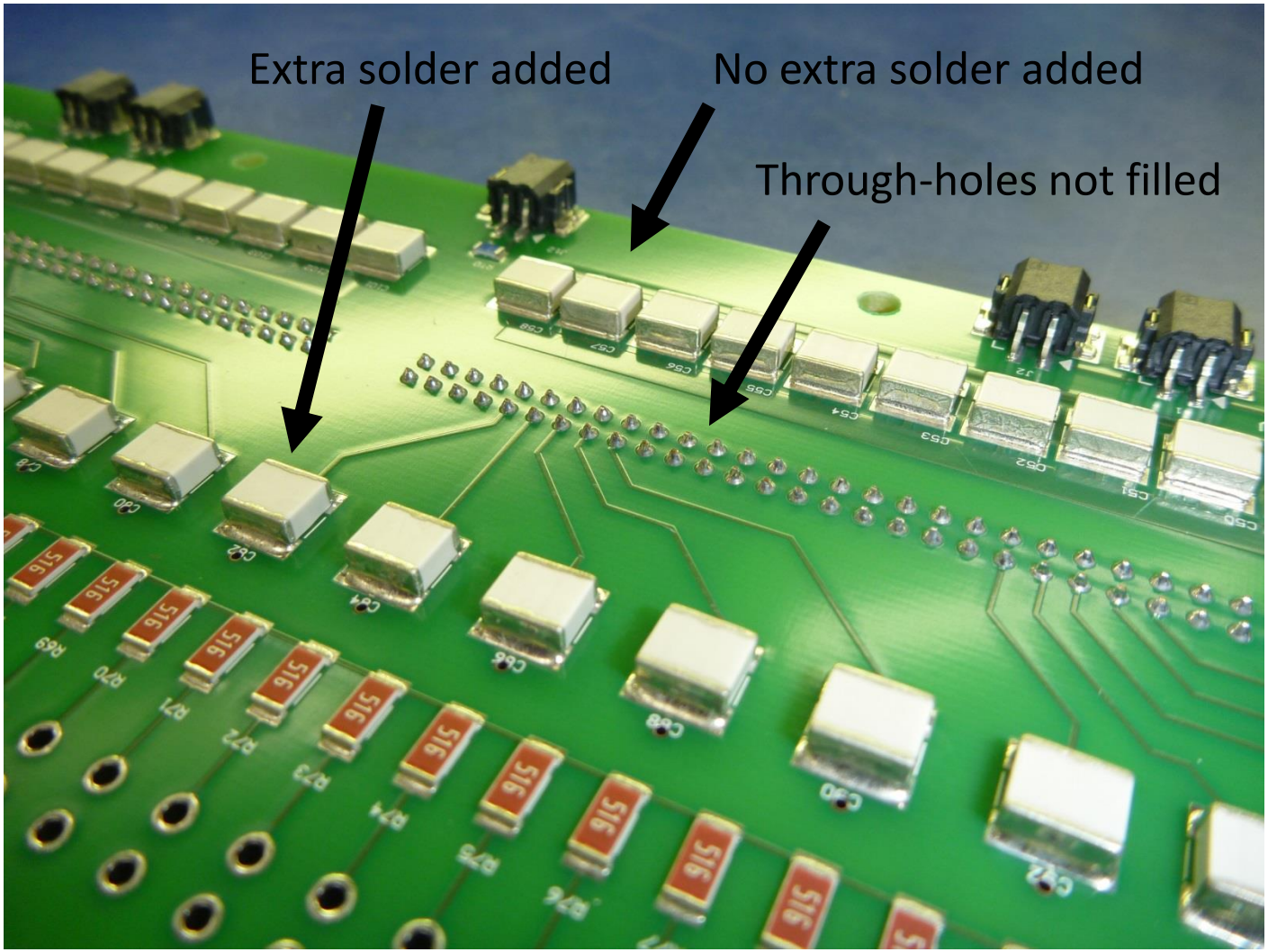
CR Board Signal Layer 2



ProtoDUNE CR Board Mfg. Process

- Reflow bottom side in IR reflow oven
- Add solder paste to caps and reflow again
- Reflow 20 top-side capacitors in IR reflow oven
- Add solder paste to caps and reflow again
- Hand-solder through-hole output connectors
- Wash boards and bake dry
- Test all coupling caps for leakage at 1.0 kV
- Press in Mill-Max connector pins
- Test all resistors and capacitors warm, cold, warm

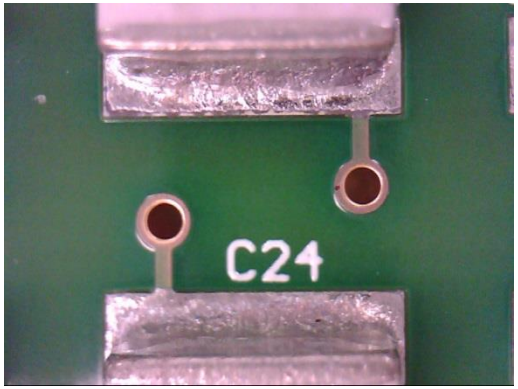
ProtoDUNE Soldering Challenges

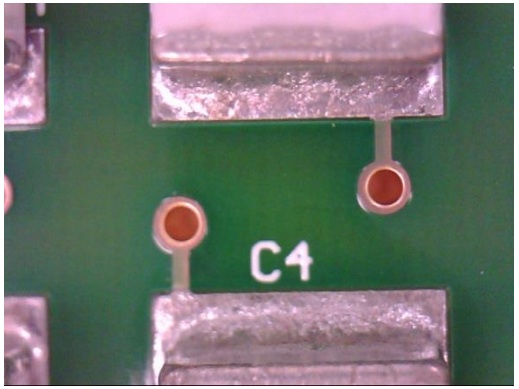


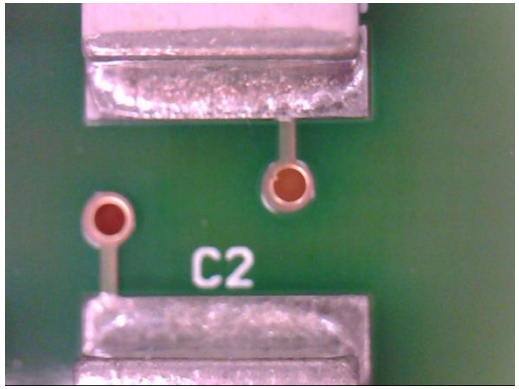
Proposed DUNE CR Board Manufacturing Using Vapor-Phase Reflow

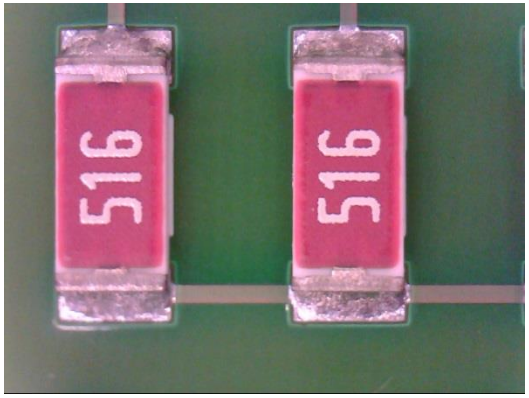
- Reflow 20 top-side capacitors in V-P reflow oven using lead-free solder (230C reflow temperature)
- Reflow bottom side in V-P oven using tin/lead solder (215C reflow temperature)
- Solder through-hole parts with Selective Solder
- Wash boards and bake dry
- Test all coupling caps for leakage at 1.0 kV
- Press in Mill-Max connector pins
- Test all resistors and capacitors warm, cold, warm

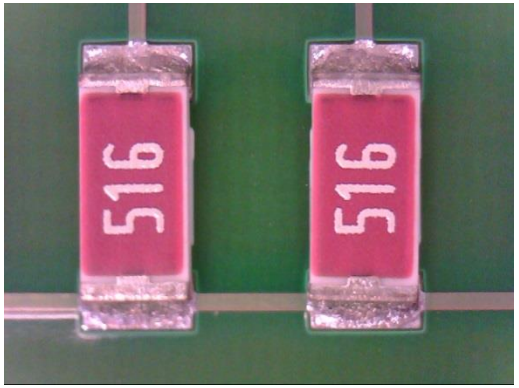
V-P Reflow With Lead-Free Solder

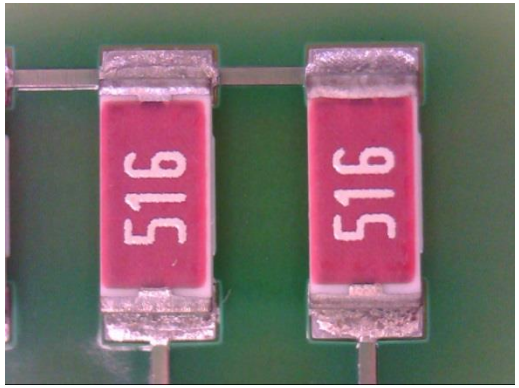




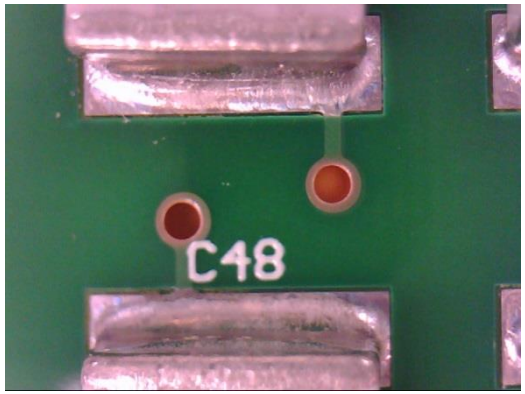


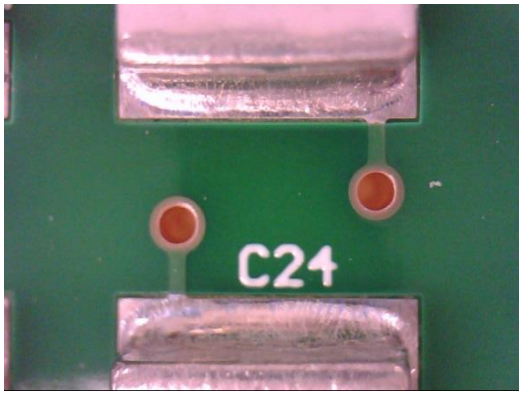


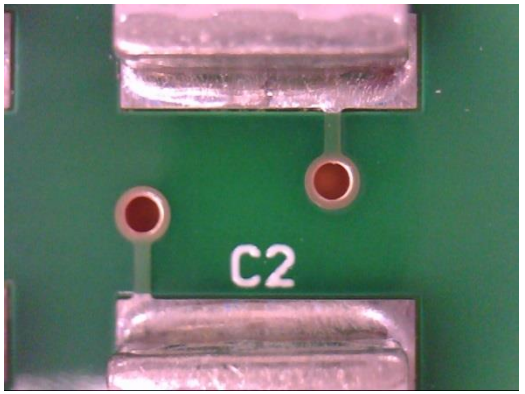


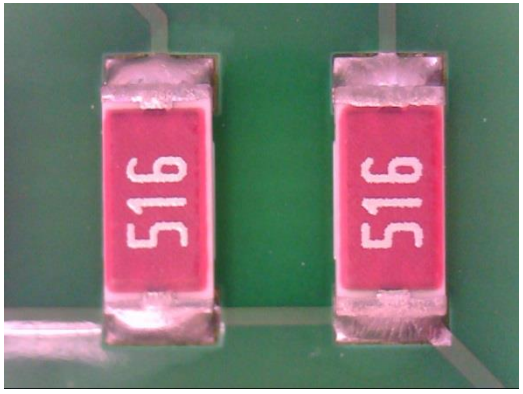


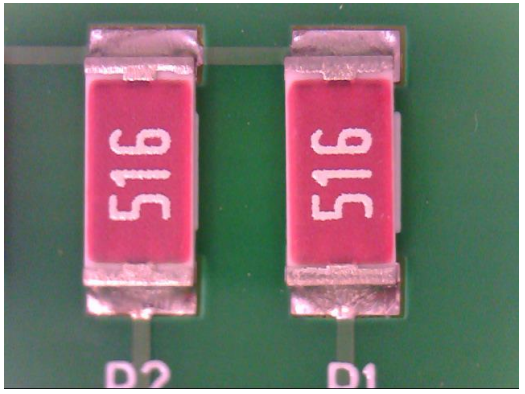
V-P Reflow With Tin/Lead Solder











Selective Soldering

Similar to wave but uses a small fountain

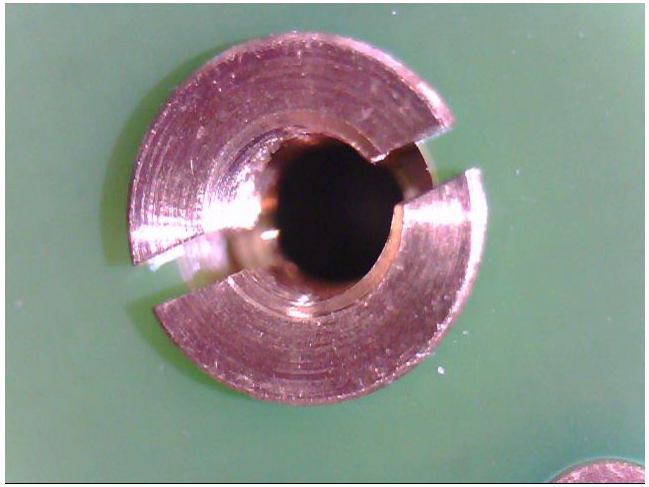
Threaded Inserts

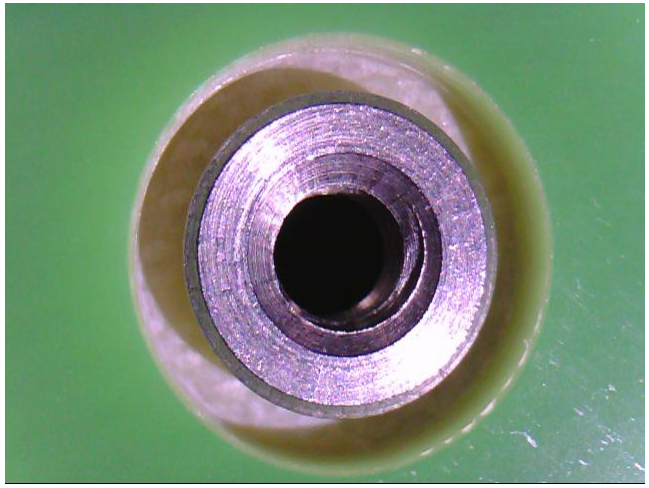
- Pressed into holes after soldering and testing
- Used with five screws to mate CR boards with the head-board stack
- About 200 pounds was needed to mate all Mill-Max components in ProtoDUNE boards
- Improved M-M components require much less force to mate, around 50 pounds per CR board
- Inserts are also used in X and G head boards

Threaded Inserts

- The old style used in ProtoDUNE was supposed to expand but often didn't adequately. They sometimes caused screws to bind, produced metal debris, and occasionally worked loose from the board. They were also too easy to break.

- The new style used in DUNE is swaged into place using a press.





Mill-Max Receptacles (With Tails)

- Pressed into holes after soldering and testing
- 132 locations nested in among other parts
- For ProtoDUNE a hand-operated arbor press with a blade attachment could set 4 to 5 receptacles at a time when the insertion force averaged around 20 pounds
- The operation required good aim and strength
- New designs used in DUNE require up to 50 pounds of insertion force

Hand-Operated Arbor Press

- Probably still OK for X and G head boards
- Not for CR boards (risk of damage too high)

CNC Press

- Quickly seats threaded inserts and Mill-Max parts without lots of operator skill and care required
- Constructed by modifying a CNC router table

Backup Slides