

Geometry Board Design

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DUNE Electronics Review

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ProtoDUNE PCB Design Metrics

- Head board thickness: 0.1875 in. (4.76 mm)
- Side and foot boards: 0.125 in. (3.18 mm)
- Dune was developed expecting 2% tolerance
- The prevailing industry standard is +/- 10%
- ProtoDUNE boards were closer to +/- 5%
- Low-cost quick-turn suppliers are inconsistent
- Quality suppliers cost more and take longer

ProtoDUNE PCB Design Metrics

- Minimum wire trace width: 0.012 in. (0.3 mm)
- ProtoDUNE used 0.012 traces in most places
- Short segments near wire solder pads: 0.030
- Geometry board designs for DUNE: all trace widths increased to 0.030 in. (0.8 mm)
- Spacing was kept as wide as possible to minimize crosstalk
- IPC guidelines followed for APA bias voltages

IPC-2221B guidelines for Long-Term PCB Reliability

- Based on many years of failure analysis performed at Sandia National Lab
- Defense against early dielectric breakdown
- Not a substitute for Physics of Failure analysis
- May help to avoid PoF to pass certification
- Violations are not bad in all cases
- Generally accepted: more spacing not better
- Spacing vs Voltage guidelines are a goal

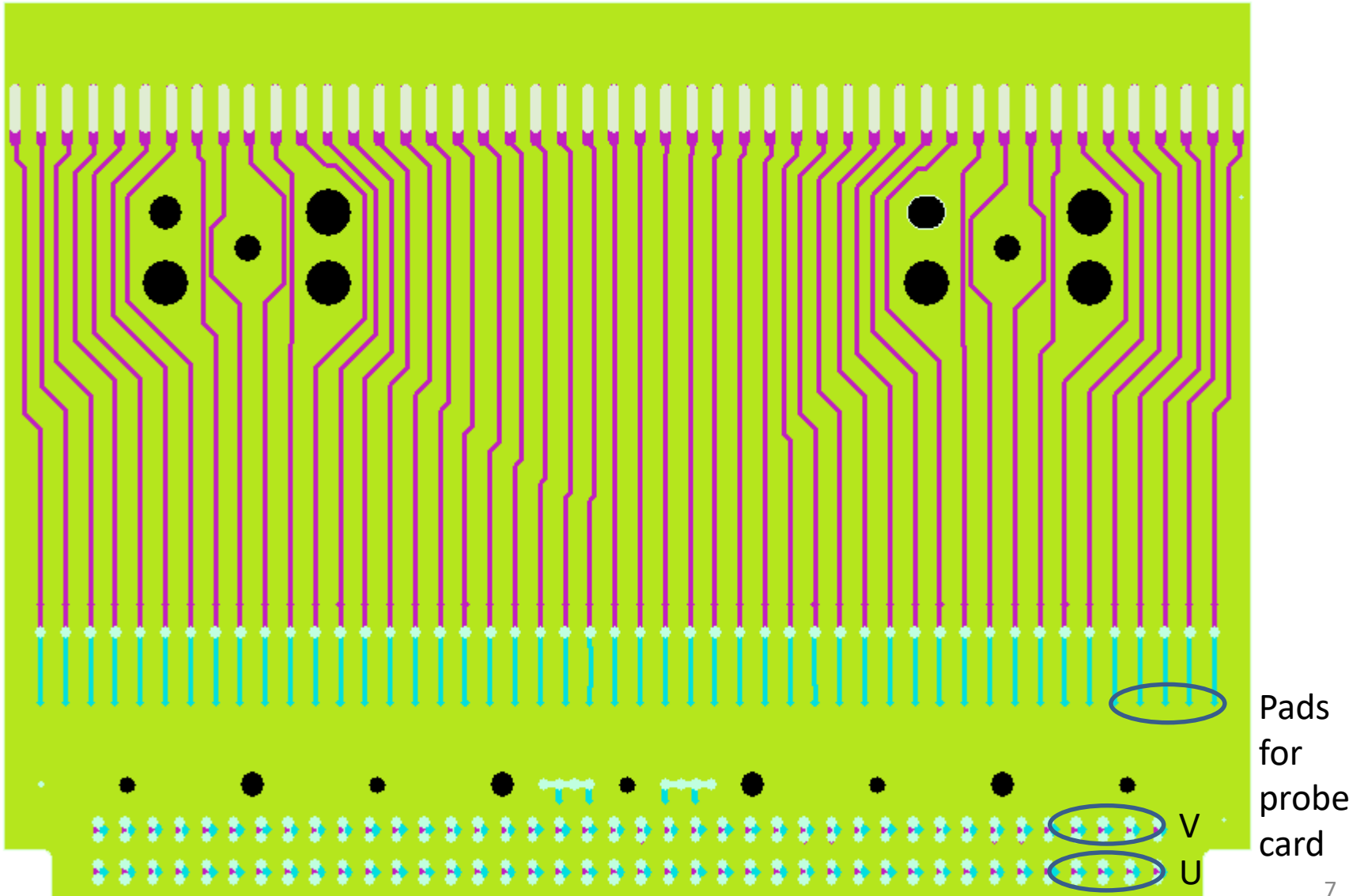
Spacing recommended for various voltage differentials encountered in DUNE

		Uncoated	Coated	Embedded
ΔV Volts	Locations	mm / in.	mm / in.	mm / in.
400	U to Gnd	2.5 / 0.10	0.8 / 0.032	0.25 / 0.010
500	Tension Test	2.5 / 0.10	0.8 / 0.032	0.25 / 0.010
700	G to Gnd	3.5 / 0.14	1.4 / 0.056	0.75 / 0.030
900	X to Gnd	4.5 / 0.18	2.0 / 0.080	1.25 / 0.050
1000	Tension Test	5.0 / 0.20	2.3 / 0.092	1.50 / 0.059
1300	X to U	6.5 / 0.26	3.2 / 0.130	2.25 / 0.090

X Head Board (Top Side Metal)

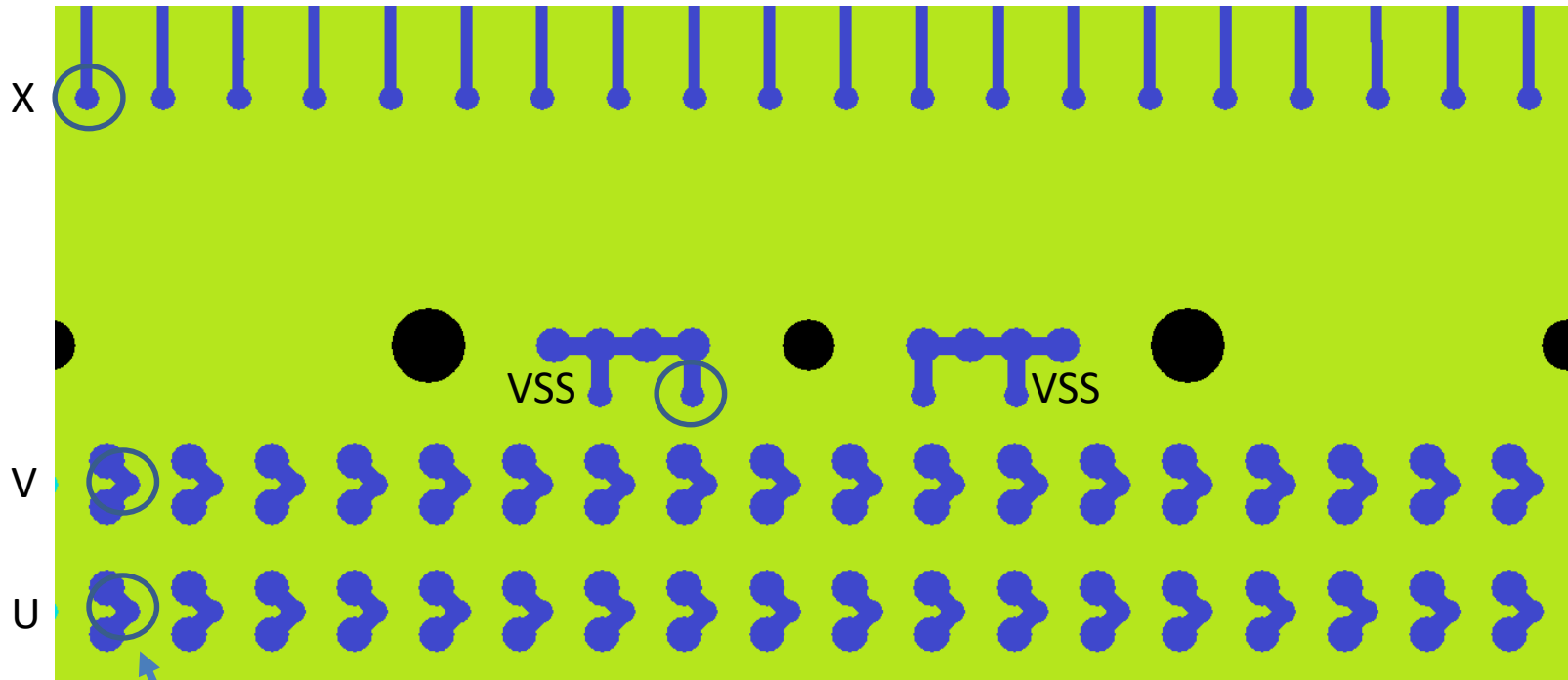


X Head Board (Top and Bottom)



X Head Board (Bottom)

Bottom-side pads are for a probe card mounted in place of a CR board. The probe card uses spring-loaded contacts and is held in place with 5 fasteners.



Circles show 1-mm diameter pads where probe cards make contact

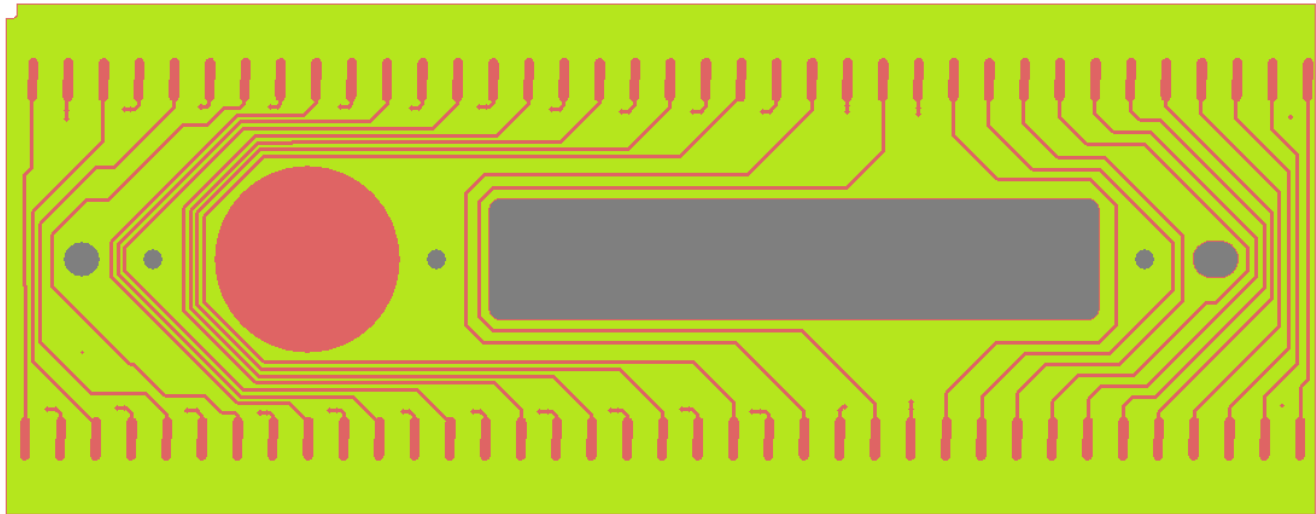
X Head Board Design Check

Features	Minimum Separation (S) mm	Possible ΔV Volts	Meets IPC?	Safety Limit ¹ = S * 1kV/mm Volts
U and V traces (long-term)	2.5 uncoated	400	Yes	2500
ΔU and ΔV (wire tension)	2.1 uncoated	500	No	2100
ΔX (wire tension)	2.2 uncoated	500	No	2200
ΔX (wire tension)	0.81 coated	500	Yes	N/A

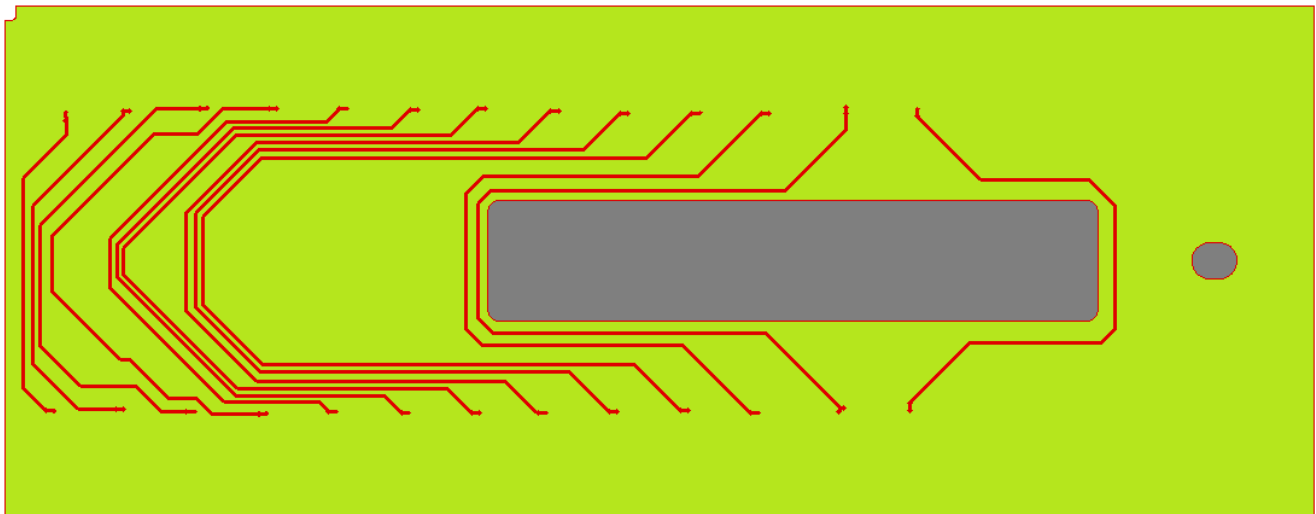
1. Dielectric breakdown in air requires more than this voltage (for uncoated traces only)

V Side Board With Slot

Top Layer



Internal Layer



V Side Board Design Check

Features	Minimum Separation (S) mm	Possible ΔV Volts	Meets IPC?	Safety Limit ¹ = S * 1kV/mm Volts
ΔV (wire tension)	5.8 uncoated	500	Yes	
ΔV (wire tension)	0.80 coated	1000	No	N/A
ΔV (wire tension)	0.80 internal	1000	No	N/A

1. Dielectric breakdown in air requires more than this voltage (for uncoated traces only)

V Side Board Design Check

- A sample board had 2000 Volts applied between all adjacent traces on the top and internal layers for 15 minutes with no breakdown (Hi-Pot test threshold 100 nA)
- This board will be re-designed to reduce or eliminate occurrences where adjacent wire traces are biased more than 500 Volts during electronic wire tension testing

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