Cold Amp DC Power

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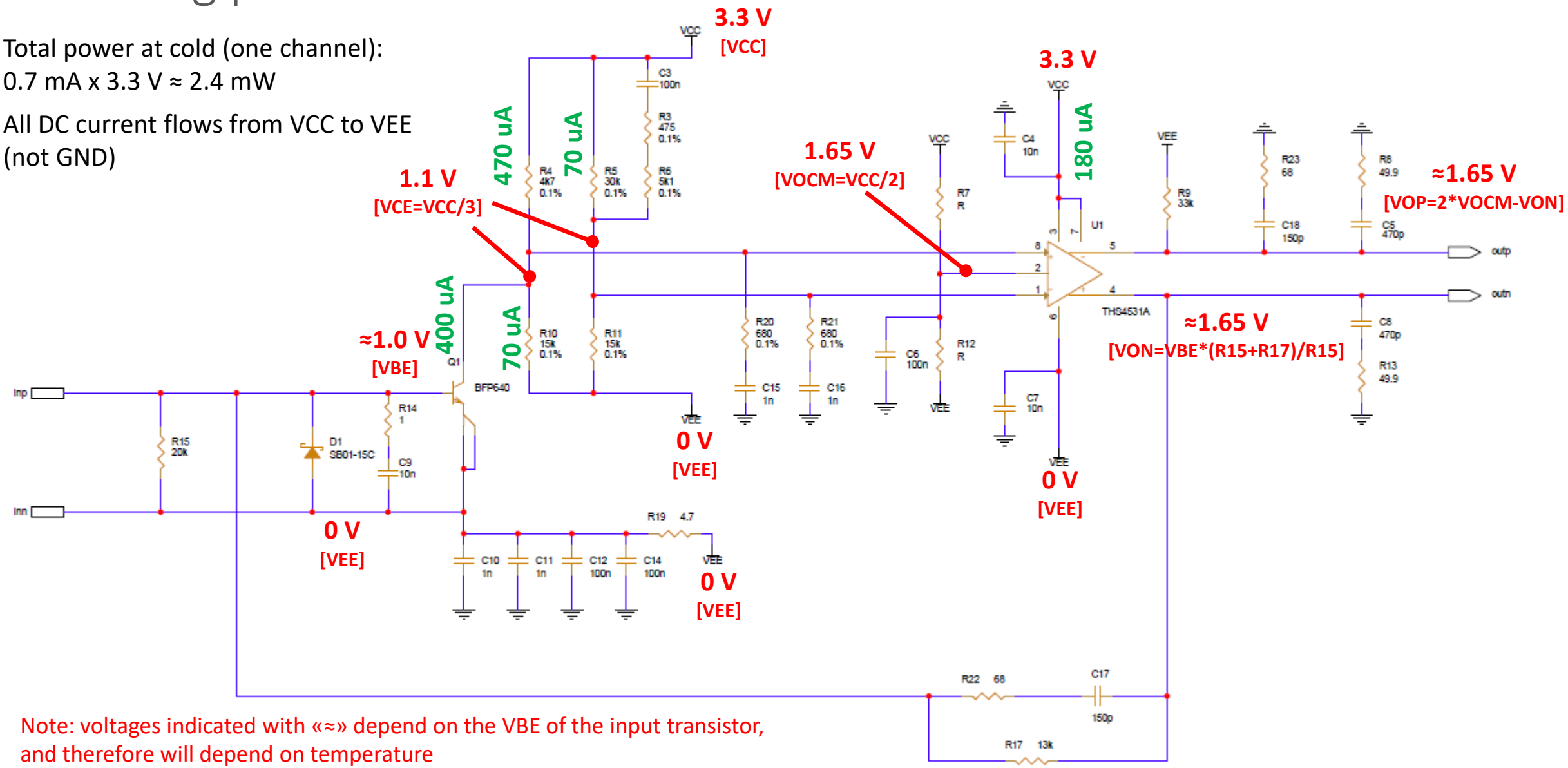
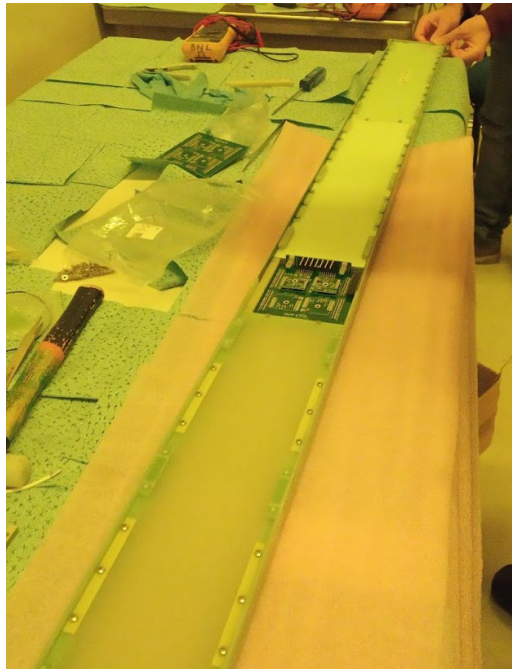
DC working points

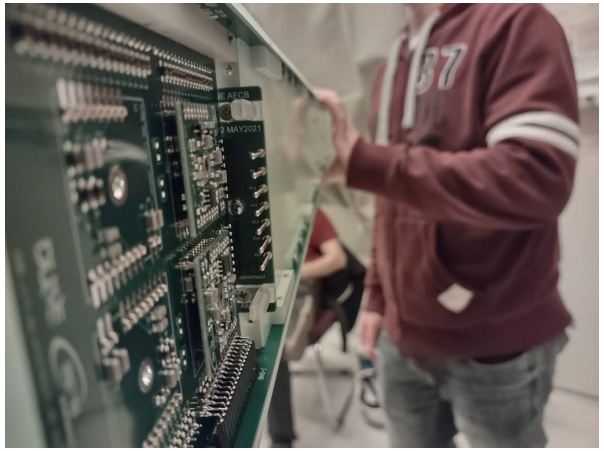
- Total power at cold (one channel):
  0.7 mA x 3.3 V ≈ 2.4 mW
- All DC current flows from VCC to VEE
  (not GND)



Note: voltages indicated with «≈» depend on the VBE of the input transistor, and therefore will depend on temperature
VBE ≈1.0V at 77K/87K, ≈0.7V at 300K

Power density

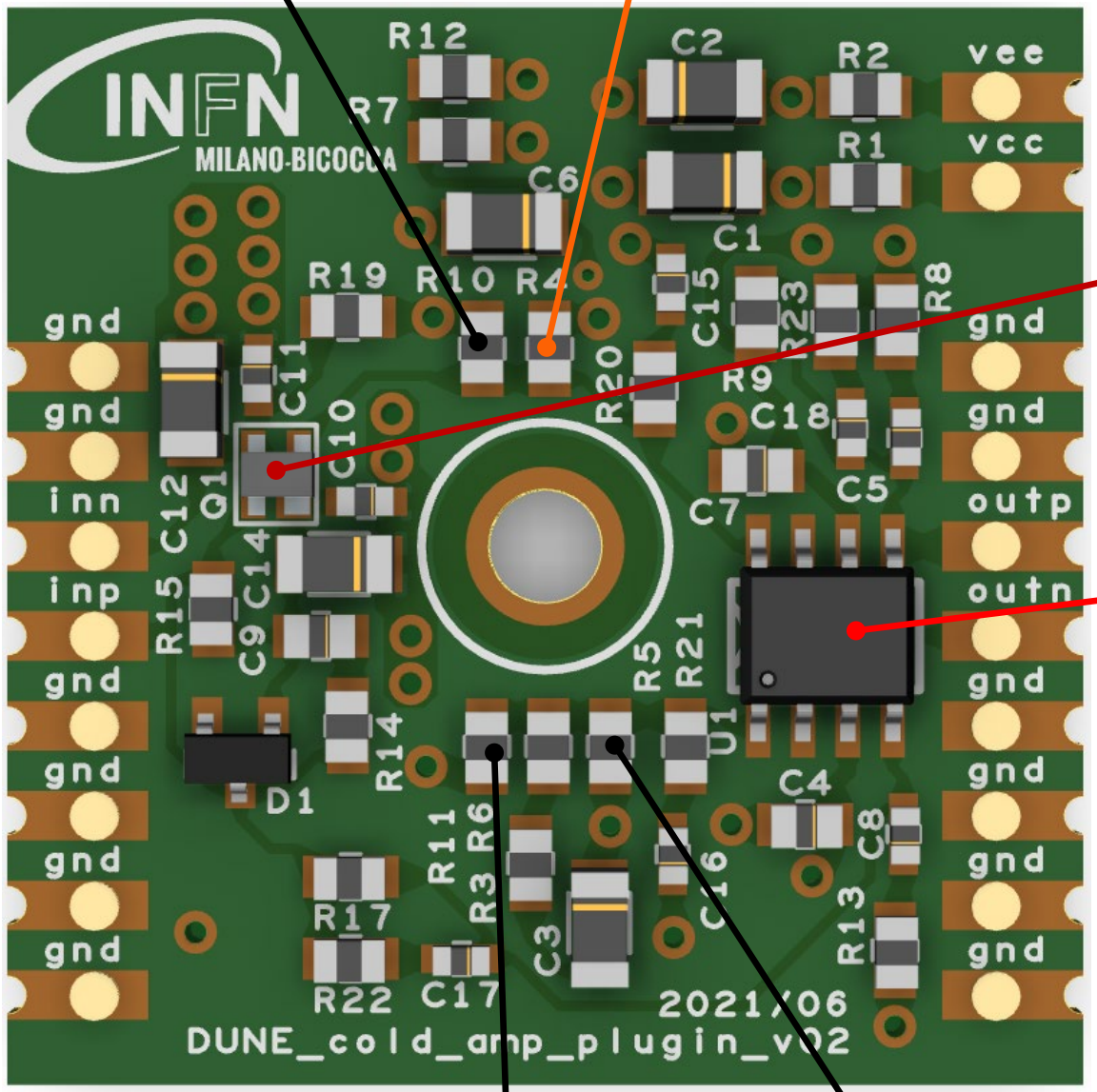




R10: 0.08 mW [0603]

Bias resistor R4:
1 mW [0603]

0603 size: 1.55*0.85 = 1.3 mm²
Power density: 0.75 mW/mm²



Input transistor Q1:
0.45 mW [SOT343]

SOT343 size: 2.1*1.25 = 2.6 mm²
Power density: 0.17 mW/mm²

Opamp U1:
0.6 mW [SOIC8]

SOIC8 size: 4.9*3.9 = 19 mm²
Power density: 0.03 mW/mm²

R11: 0.08 mW [0603]

R5: 0.15 mW [0603]

LAr boiling limits

- Bo Yu, Test of liquid argon boiling at simulated depths [DUNE-doc-16670]
- The «shallower» module (worst case for causing bubbles) is at ≈1 m below LAr surface
- Difficult to set a threshold, however 40 kW/m^2 [=40 mW/mm^2] seems to be a safe limit
- The highest power density in the cold amplifier is below 1mW/mm^2

Summary [slide taken from Bo Yu's document]

- A small pressure vessel has been constructed to test the liquid argon boiling properties at a simulated up to 14m depth.
- First round of the test results showed that the ProtoDUNE CE module does not create bubbles outside of the box if submerged more than ~1m below the liquid surface.
- At about 14m below the liquid surface, and with a heater power density of 40kW/m^2, tiny bubbles were observed on the surfaces of the heaters, but they did not survive away from the heater surfaces.
- At 7m depth (bottom of the ProtoDUNE cryostat), with 40kW/m^2 power density, bubbles can be seen leaving the heater surfaces, but disappeared after travelling for a few centimeters.
- Unless the new generations of CE chips have much higher power density than 40W/m^2, it is highly unlikely to see LAr boiling at the bottom of the DUNE FD (~13m deep). Even at the bottom of NP04 (~7m), the bubbles will survive only a few centimeters after leaving the heater surface.