PITOT-STATIC PNEUMATIC FITTINGS WITH CONNECTIVITY DETECTION

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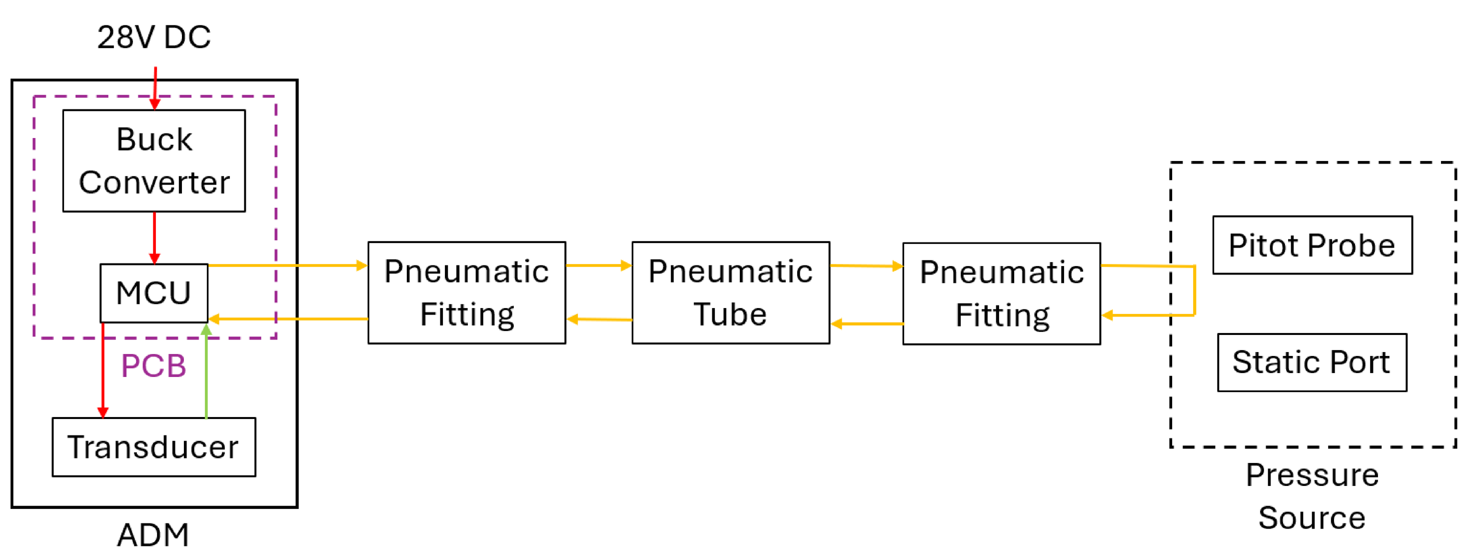
Pitot-Static Lines in Boeing Aircraft

- **Project Goal:** Design a pneumatic fitting for pitot-static lines that detects a full connection between all ends of the pneumatic line
- The Air Data Module (ADM) will output a connectivity flag to the Pilots indicating connectivity issues

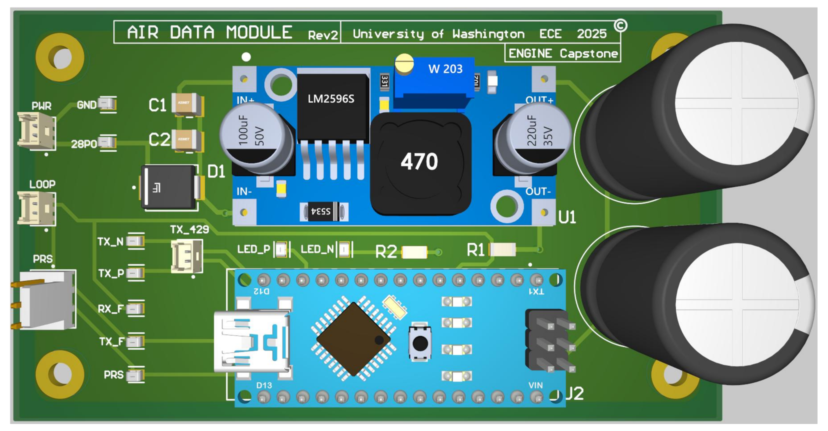


High Level Requirements

- Power: Run on 28VDC, under 3W, tolerates 250ms outages
- Pressure & Connectivity: Measure pressure (0 inHg to 37 inHg), detects pneumatic connection with digital output
- Environmental Conditions: Operates -2,000 to 50,000 ft; handles 55°F–80°F temps, withstands 32°F for at least 12 hours
- Durability: Withstand vibration, noise, and radiated electromagnetic fields
- Interface: Output via ARINC 429, SPI, I2C, or UART (ARINC 429 preferred); include visual connection indicator
- Mechanical Design: Fit 6×5×3"; mounts flat/upright; one-side connectors
- Mounting & Handling: Shall incorporate easy access; asymmetric design prevents. Incorrect installation
- Weight: Weigh less 2.5 lbs. lighter design preferred

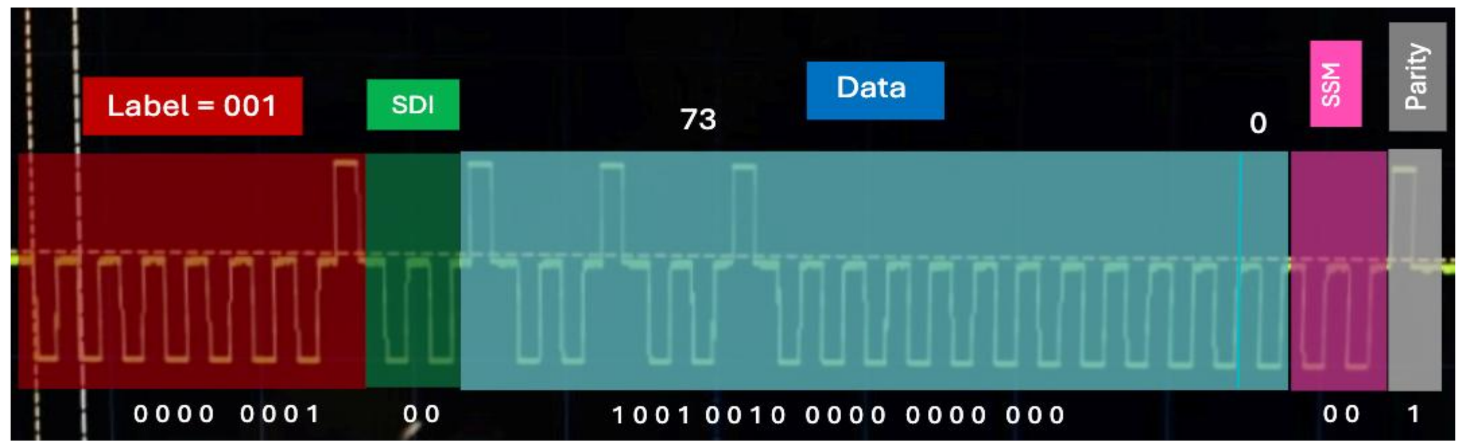
Connectivity Detection

- Closed-loop Detection: Pin connectors form an electrical loop only when pneumatic connections are correctly made
- Dual-purpose Fittings: Custom fittings handle both pneumatic flow and connection status sensing
- ADM Integration: The ADM features a PCB with an Arduino MCU, buck converter, and circuit protection components
- Real-time Status: Connectivity is monitored continuously and reported instantly



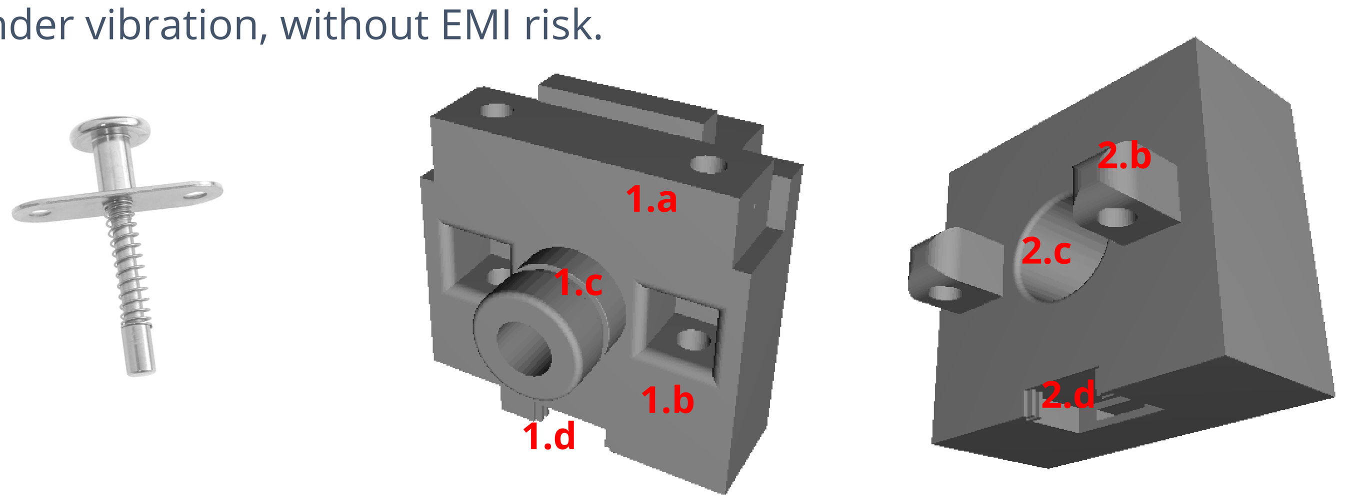
Digital Transmission – ARINC 429

- Designed custom ARINC 429 transmitter on Arduino UNO for simulating avionics data
- Encoded 32-bit frame: label 001 (octal), SDI, 18-bit ADC, flag, SSM, parity
- Firmware assembles word, computes odd parity, toggles differential outputs
- Complied with ARINC 429 low-speed spec: LSB-first and inter-word timing
- Achieved stable 13.5 kbps rate via cycle-accurate delay routines



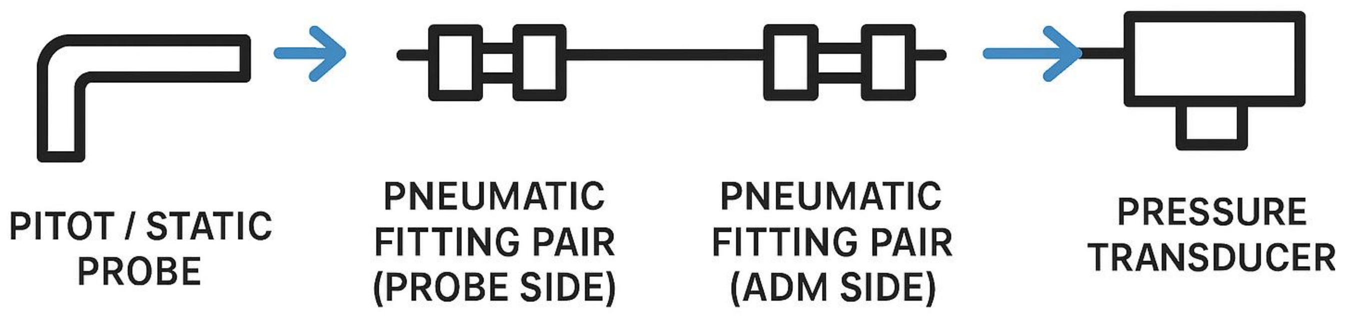
Mechanical Design & Locking Mechanism

- Secure Connection: Spring-loaded plunger latch ensures a firm pneumatic fit.
- Guided Assembly: Rod and mating features (1.b / 2.b) align and lock parts automatically.
- Sealed Airflow: External seal at 1.c ensures clean pressure transfer to the transducer.
- Reliable Electrical Contact: Magnetic pin connectors (1.d / 2.d) maintain connection under vibration, without EMI risk.



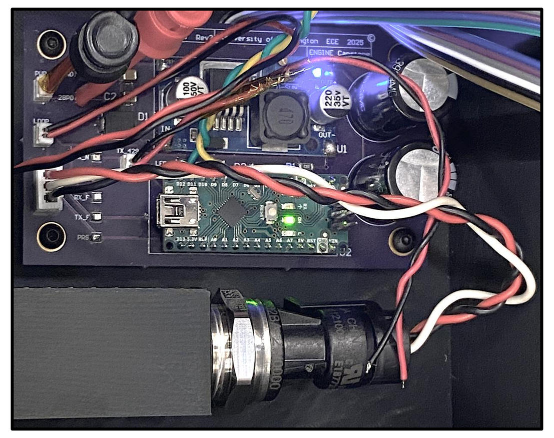
Sealed Pressure Line

- System Flow: Diagram shows full pressure pathway
- Fitting-to-Fitting: O-ring around central cylinder ensures a leak-proof seal
- Tubing Interface: Push-in fitting sealed with tape, screwed into body
- Transducer Connection: Transducer directly mounted with sealing tape for airtight contact



Testing Results

Testing was conducted in a lab setting using an oscilloscope to verify ARINC 429 signal integrity, bit timing, and parity accuracy. Environmental conditions were simulated with sub-zero exposure and applied vibration. Power resilience was tested by inducing 250 ms outages during active transmission. Mechanical stability was evaluated using a provisional method due to limited access to formal testing equipment. Pneumatic connectivity was verified through repeated fitting cycles, with consistent digital and visual output responses.



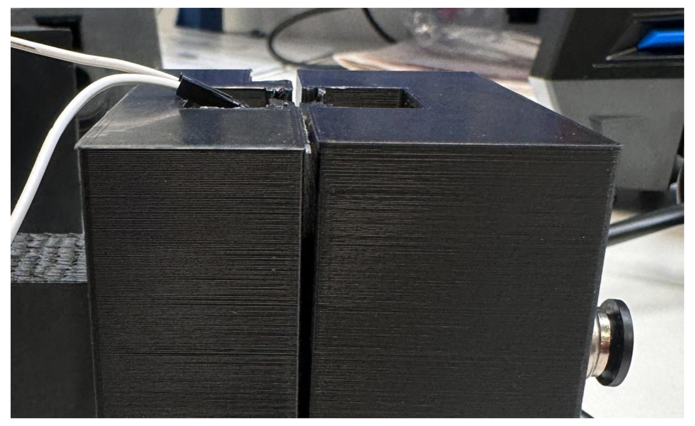
- Stable 13.5 kbps ARINC 429 transmission with valid parity and timing
- Operated reliably in sub-zero and high-vibration conditions
- Maintained data integrity after brief power interruptions
- Responded accurately to fitting changes via digital and LED outputs
- Withstood informal mechanical stress testing under motion and shock

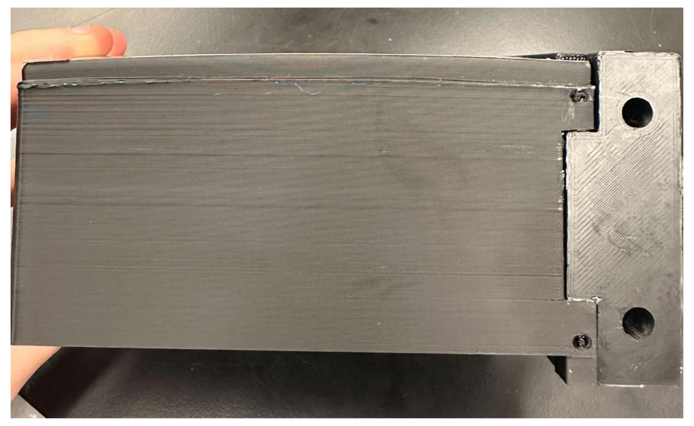
Conclusions & Future Work

Project was designed as a proof-of-concept with a Major focus on design. Many possible implementations were explored through Trade Study:

- Time-Domain Reflectometer
- Hall Effect Sensors
- Modifications to the existing solution

Closed Loop Detection with pin connectors proved most successful design researched, simple and did not lose functionality compared to more complex designs. However, it was difficult to make it so the pin connectors would only attach on full connection. This was due to imperfect 3D prints.





Small magnets on pin connectors help reduce this discrepancy
Mechanical locking structure worked for the purposes of showing closed loop detection circuit

- No inherent mechanical benefit over the current fitting by Hydraflow
- Hydraflow fitting is designed to twist and settle into position, and does not pair well with a pin connector design, could investigate other options to make closed loop connection (conductive plates)

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