Preliminary Design Review

Engine Controller &
Ground-Data Acquisition Board

Project Overview

- We need a consolidated, reliable, high-speed, useful, and overall better looking control and sensor system
- i.e. I^2C communications is actually really good (as long as properly used in a PCB), some pressure sensors were not being read, etc.
- Moving into rocketry, a reliable and small form factor PCB is essential

Background

Project Requirements (targets/constraints to determine success)

- Qualities
  - Amperage must be able to handle pull from all of the sensors and valves
  - Valves be mechanically defined to be safe if power shuts off
  - Enough power for all components with some tolerance
  - Reliable; fast clock speeds
  - Compact enough for a rocket
  - Modular - add or take away components
  - Antialiasing - clear signals - noise reduction - biasing
- Quantities
  - 14 Valves
  - 8 Pressure Transducers
  - 3 Temperature Sensors
  - 1 Load Cell (maybe more?)

Signal & Noise

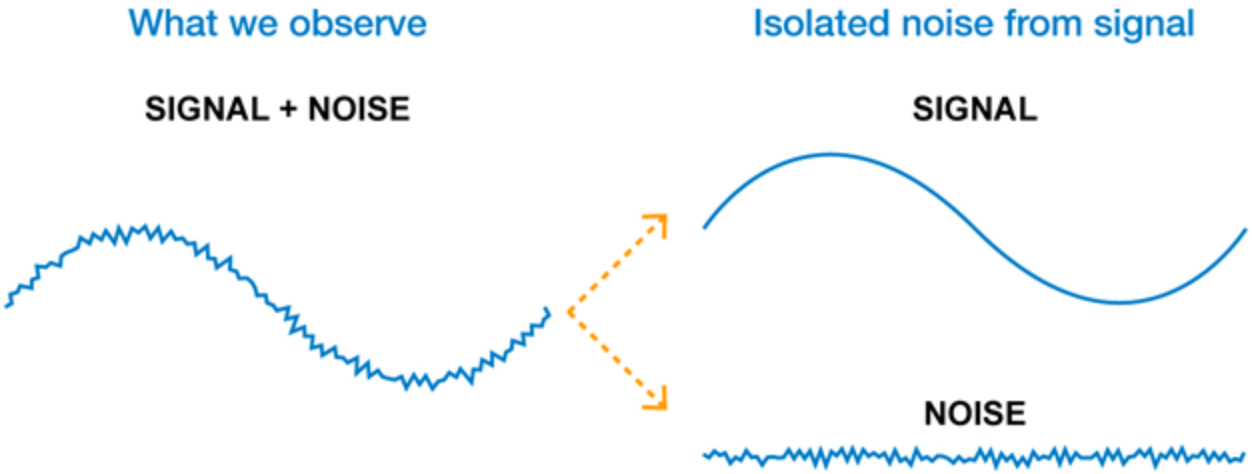
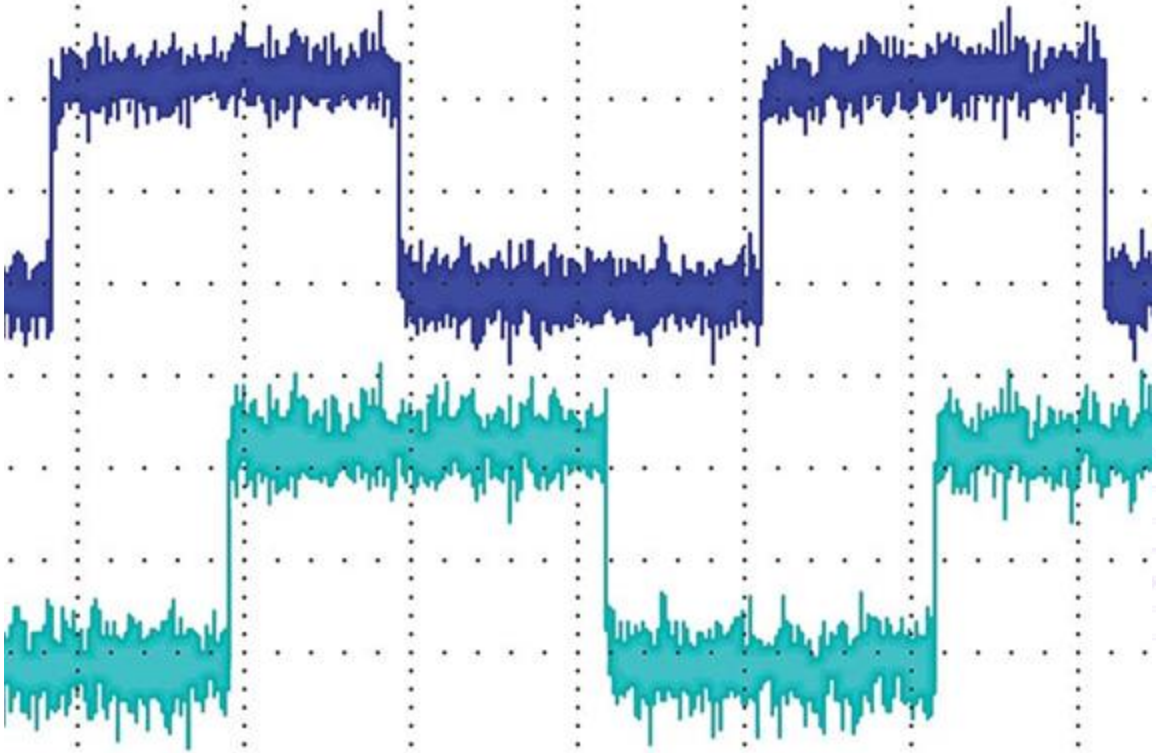
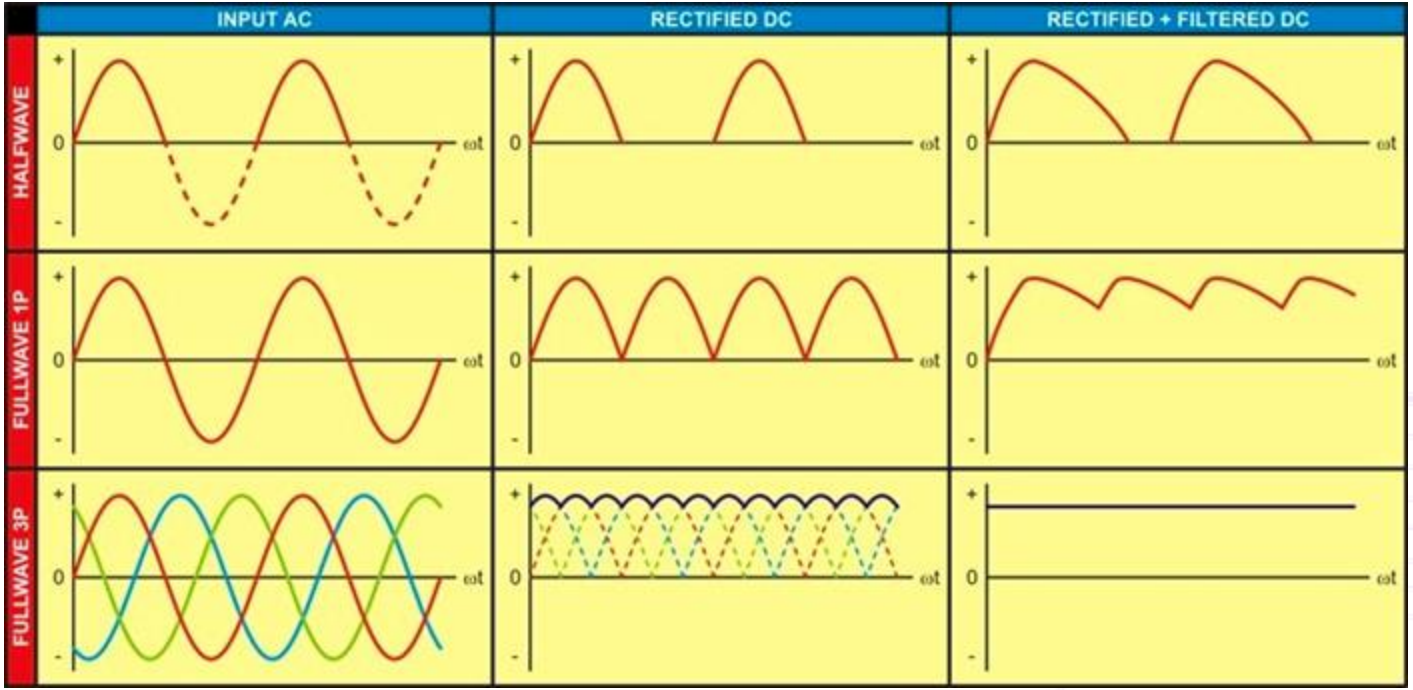


FIGURE 2. Isolated Noise from Signal

Signal & Noise



Signals + Noise



Signals & Noise

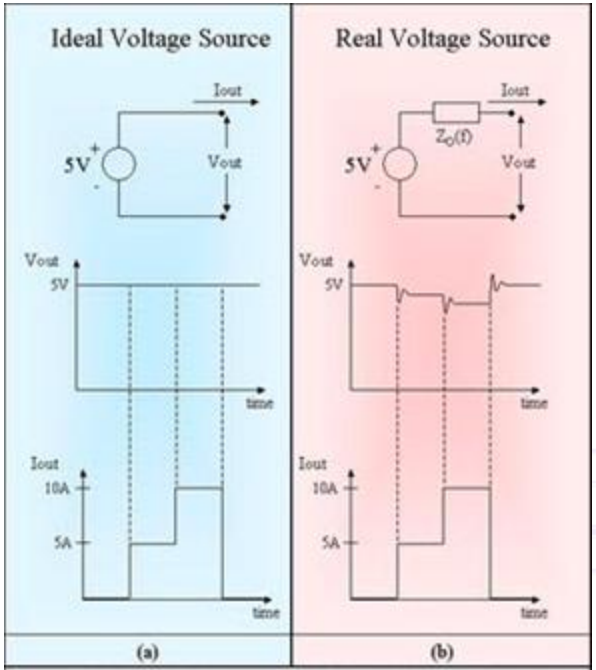


Figure 1: With an ideal voltage source (a), the 5V is unperturbed by current changes. The real voltage source (b) shows dynamic voltage responses followed by static DC level changes as a result of output current changes interacting with non-zero output impedance.

Signal & Noise

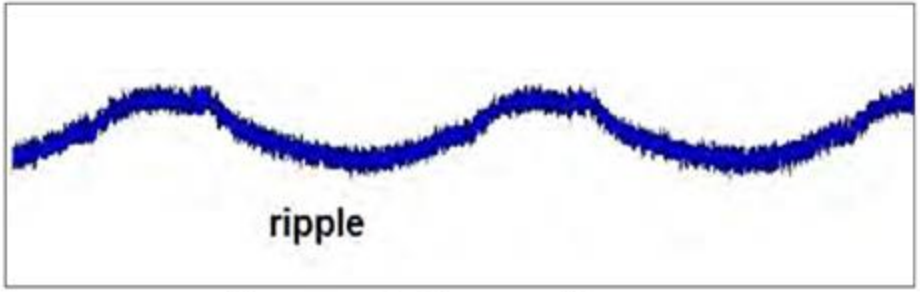


FIGURE 2: OUTPUT RIPPLE

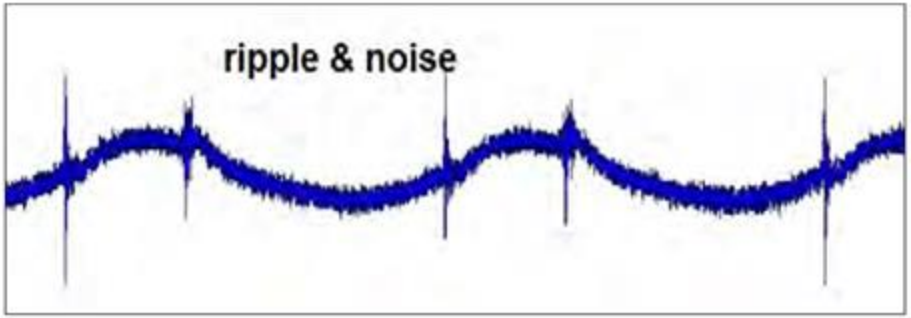


FIGURE 3: OUTPUT RIPPLE AND NOISE

Conceptual Design Outline

- Make electrical schematics for:
  - Solenoid drivers
  - Thermocouple circuits
  - Pressure transducer circuits
  - Load cell circuits (may not be needed?)
  - Connector circuits
  - Microcontroller connections
  - Noise-reduction measures

Example Circuits

2.1 Thermocouple Measurement With Pullup and Pulldown Bias Resistors

In this topology, the thermocouple DC voltage is biased using matched pullup and pulldown resistors. This is a common method for biasing and allows for burn-out detection.

2.1.1 Schematic

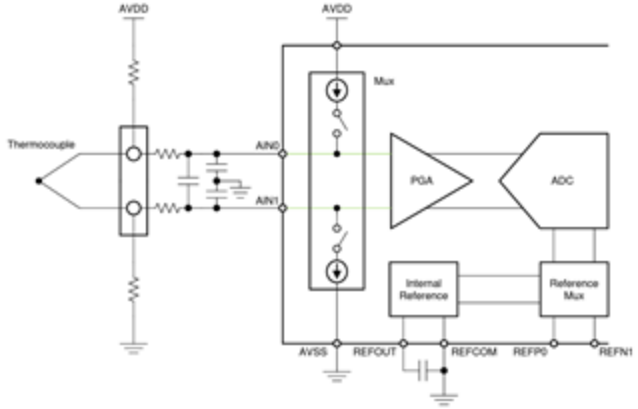


Figure 2-1. Thermocouple Measurement Circuit With Pullup and Pulldown Resistors

2.1.2 Pros and Cons

Pros:

- Simple biasing
- Biasing resistors allow for burn-out detection without separate measurement

Cons:

- Requires two external resistors for biasing
- Biasing current flows through the thermocouple and resistive leads, creating additional error

Example Circuits

Defining the Circuit

The amplified pressure transducer signal is connected to an ADC. Since the ADC connects to a microprocessor or DSP, final calibrations can be done in software. Therefore, the 0 – 1 psi range should span the center of the range of the ADC. For calculating gain, the output range of the amplifier is 0 – 2.5 V. Figure 1 is the schematic of the amplifier circuit for this application.

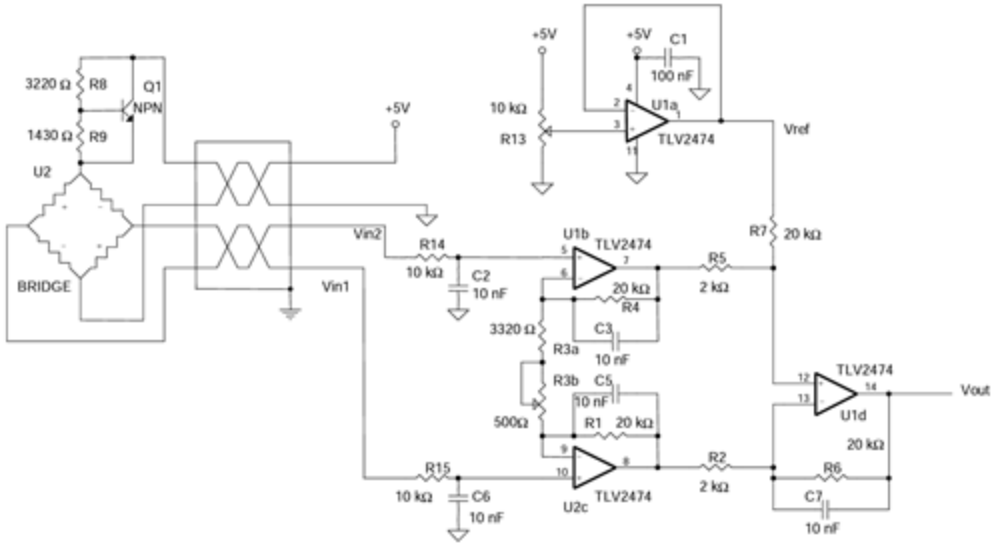
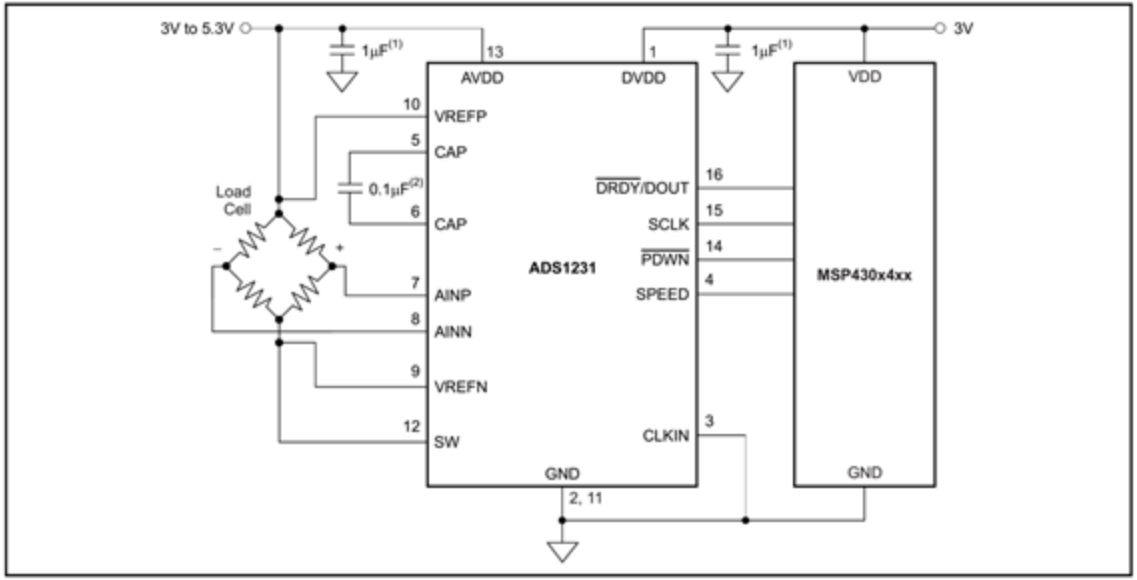


Figure 1. Op-Amp Circuit for the Pressure Transducer to ADC Application

Example Circuits

Weigh Scale System

Figure 24 shows a typical ADS1231 application as part of a weigh scale system.



(1) Place a 0.1μF or higher capacitor as close as possible on both AVDD and DVDD.

(2) Place capacitor very close to the ADS1231 CAP pins for optimal performance.

Figure 24. Weigh Scale Example

Conceptual Design Outline cont.

- Validate schematics w/ professionals
- Perfboard/protoboard validation (could be omitted?)
- Validate schematic-to-PCB feasibility (done w/ software)
- Define PCB size, shape, and stackup (taking into account trace impedance, dielectric properties, via transitions, etc.)
- PCB layout
- Manufacturability validation
- Order PCBA
- Solder
- Test
- Integrate

Design considerations (trade study)

Design options	Scores (5 = excellent, 3 = passable, 1 = poor)						SCORE TOTALS
	Inexpensive	Easy to make	Fast	Integration	Software ease of use	I/O	
Arduino	5	N/A	2	2 (depends on board)	4	5 (depends on board)	18
Teensy	4	N/A	5	5	4	3	21

Plan/Timeline

Task	Subtasks	Length	Due Date	Notes:	
Electrical Schematics	Design	1 Month	07/18/2023	Solenoid Drivers	Connector Circuits
	Schematic -> PCB Validation			Thermocouple Circuits	Microcontroller Connections
	Professional Validation			Pressure Transducer Circuits	Noise-Reduction Measures
	Revision			Load Cell Circuits	
	Finalizations			Connector Circuits	
Build Readiness Review			07/22/2023		
Prototyping	Perfboard Mapping	1 Month	08/23/2023		
	Physical Build				
	Testing				
	Revision				
	Finalization				
Integration Readiness Review			TBD		
PCB Design	Size + Shape	1 Month	10/01/2023		
	Stackup				
	Layout				
	Simulation				
	Manufacturability Evaluation				
	Order + Solder				
	Testing				
	Integration				

Challenges

- Understanding the circuitry needed to generate clean signals from every component
- Communication delays between us and people needed to validate our designs could be a block
- Part shipping delays
- Learning techniques to design and simulate circuits
- Debugging code

Wins

- Learned a lot about resources available (i.e. TI) to make circuits
- Learned about what circuitry goes into producing clean signals
- Seeing more and more how circuits I’ve learned in theory through classes are applied in these situations
- Skills and knowledge I’ve learned through research are becoming useful in Project Liquid
- Found a company, Crane Aerospace & Electronics, solely doing avionics stuff

Questions?

PDR feedback doc:
https://docs.google.com/document/d/1Eby5X9SZoP20nPqU9fZrJWJIh0qpv3wJRp9ZNUTgv2g/edit