Payload Sensor Module

Project Whitepaper
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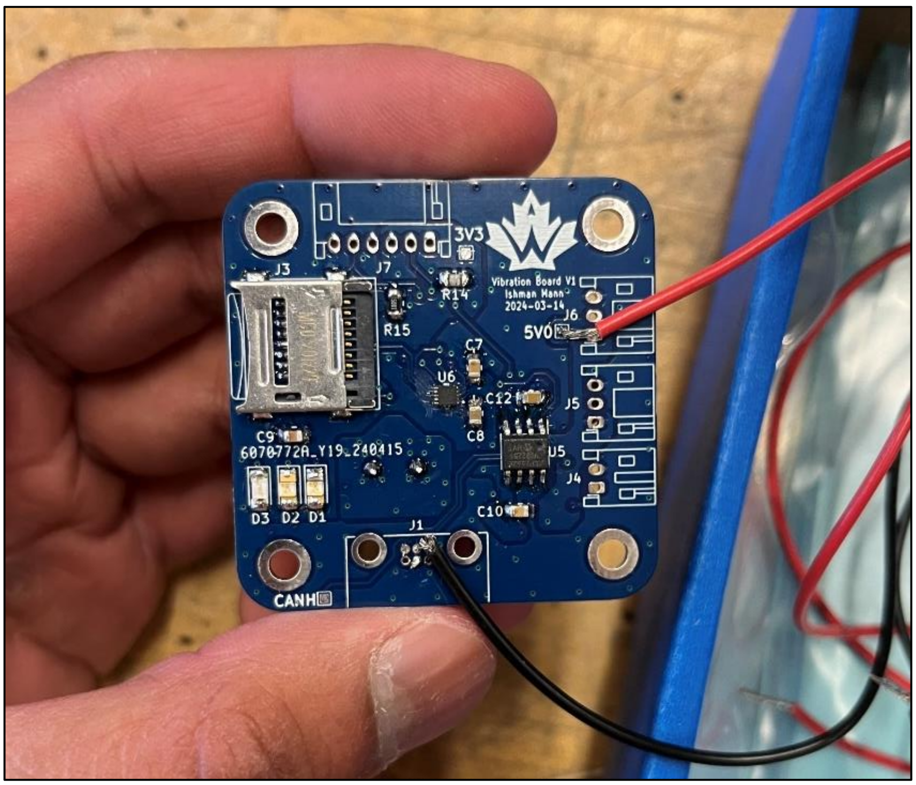

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Project Overview

Context

Payload Sensor Module (PSM) was designed to acquire and store data from a suite of sensors so as to facilitate 2 mid-flight experiments in Waterloo Rocketry's 2024 rocket.

The first experiment was to quantify the effects of different mechanical fasteners on vibrations experienced by a metal plate in the payload area. This experiment was prompted by the importance of good fastener selection, as poor selection may result in loosening due to vibrations in flight.

The second experiment was designed to test the viability of in-flight blood transfusion for passengers during emergencies. A peristaltic pump setup in the payload mimicked the human cardiovascular system by circulating fluid. The flow and temperature of this fluid would be recorded by PSM.

Requirements

Requirement	**Justification**
PSM shall be capable of micro-SD data storage.	Experimental data will arrive in large volumes. Data should be stored locally to save telemetry and CAN bus bandwidth.
PSM shall support CAN communication.	Rocket electrical systems us a CAN bus. Instructions will be issued via CAN.
PSM shall include a 3-axis accelerometer with >2kHz sample rate and >8g range.	Vibrations in 3D must be recorded for the first experiment. 2 to 5kHz accelerometers are affordable per manufacturing constraints.
PSM shall support connection of a flow sensor with a >100Hz sample rate.	Fluid flow for the second experiment may be measured using a flow sensor.
PSM shall support connection of 2 analog pressure transducers.	Fluid flow for the second experiment may be measured using pressure-to-flow conversion calculations.
PSM shall support connection of an analog thermistor.	Temperature must be recorded for the second experiment.

Table 1. Payload Sensor Module requirements

Architecture

The MCU channels all data from the sensors to the micro-SD card in a sequence and format specified in firmware. The flow sensor and accelerometer share the I2C bus. Given the lower sampling requirements of the flow sensor, most of the I2C bandwidth may be used by the accelerometer.

Data sampling and storage begins when a start command is issued via CAN. Likewise, data sampling halts once a stop command is issued.

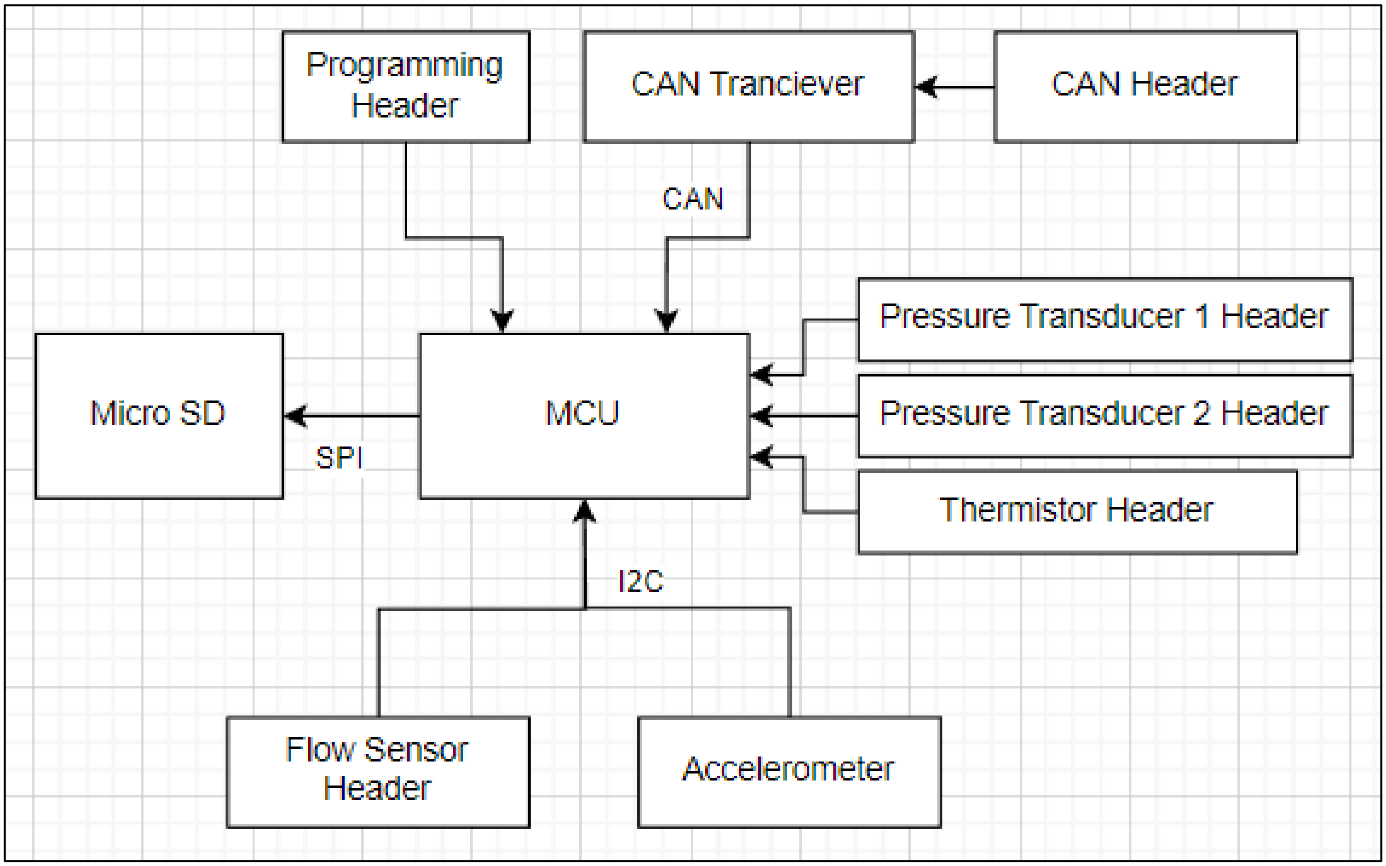

Figure 1. System architecture.

Electrical Overview

Power Architecture

PSM power architecture is shown below. Note that a clean 5V is supplied by the CAN header, with minimal common-mode noise. Input filtering was simplified to decoupling capacitors.

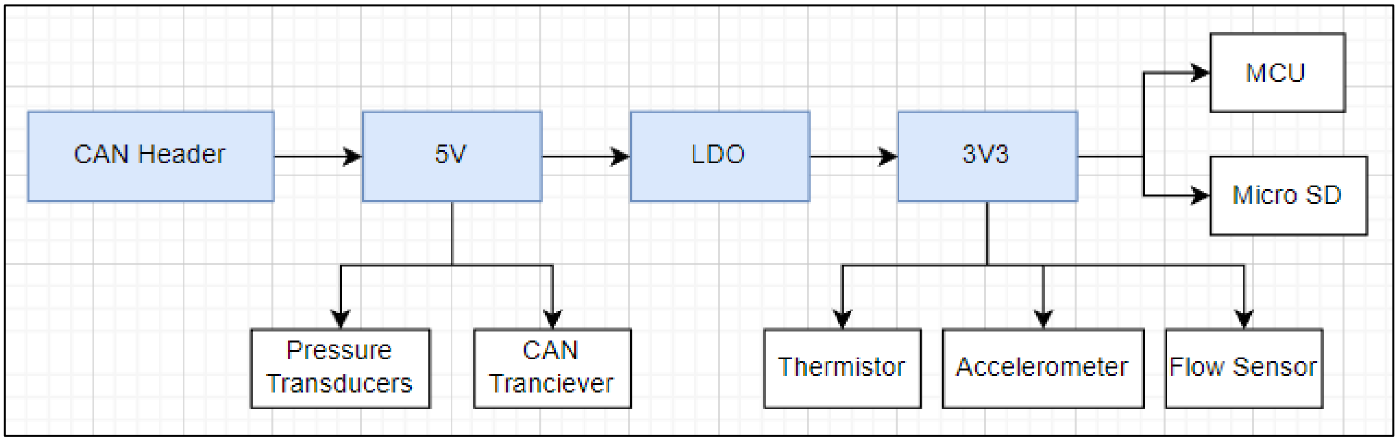

Figure 2. Power architecture.

Component Selection

MCU

The PIC18F26K83 MCU was selected, as it offers support for CAN, SPI, and I2C drivers, as well as adequate internal memory and programming flexibility. The MPLAB IDE could be used for code generation as needed.

CAN Transceiver

MCP2562 is a suitable transceiver for PIC microcontrollers.

Accelerometer

The 16g 3.2kHz FXLS8974CF accelerometer was selected as it meets the first experiment's requirements. This accelerometer offers the highest possible sampling rate for a DFN Package, which falls within Waterloo Rocketry's manufacturing capabilities. It offers both I2C and SPI modes, and 12 bits of resolution per sample.

Flow Sensor

The SLF3S-4000B flow sensor is suited for 50-200Hz sampling and can measure a flow rate of up to 600ml/min, adequate for the second experiment.

Pressure Transducers

The MIPAN2XX100PSAAX pressure transducer is recommended for 100PSI with a resolution of 0.05%. This is adequate for pressure-to-flow conversion calculations in the second experiment.

Thermistor

The MA100BF103BN thermistor reads values from 0-50°C, which encompasses all expected temperatures in the rocket payload.

Appendix A: PCB Layout

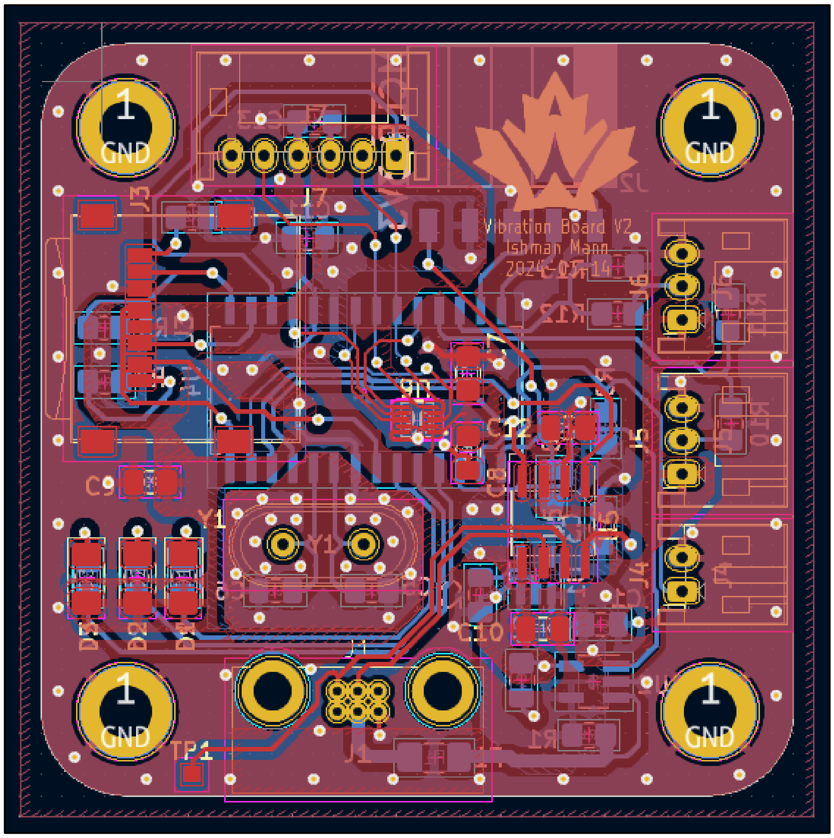

Figure 3. Top layout.

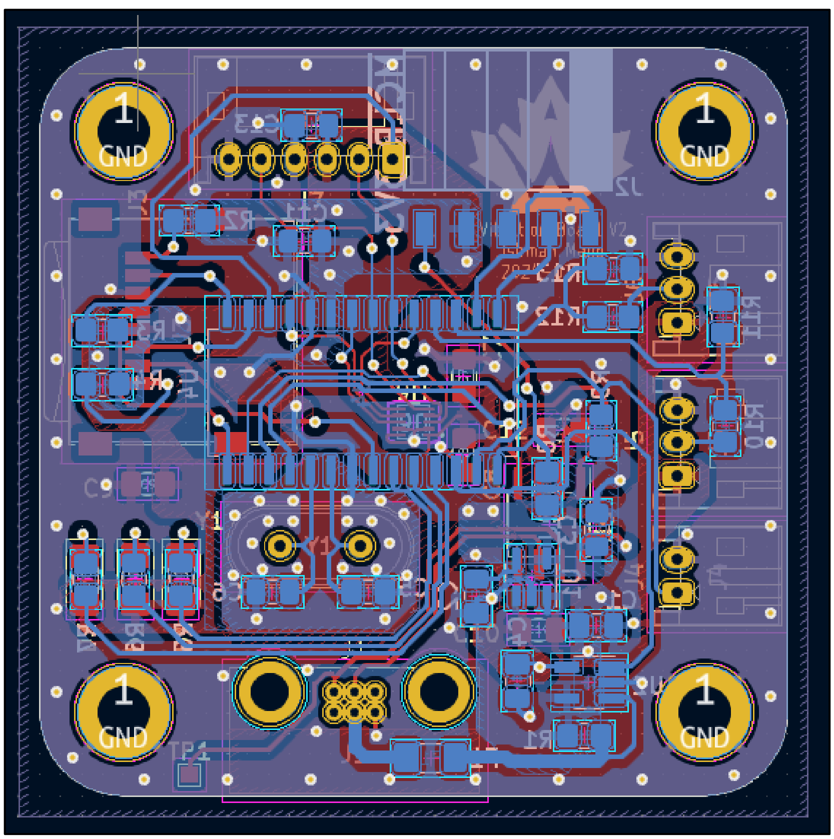

Figure 4. Bottom layout.

Appendix B: Schematic

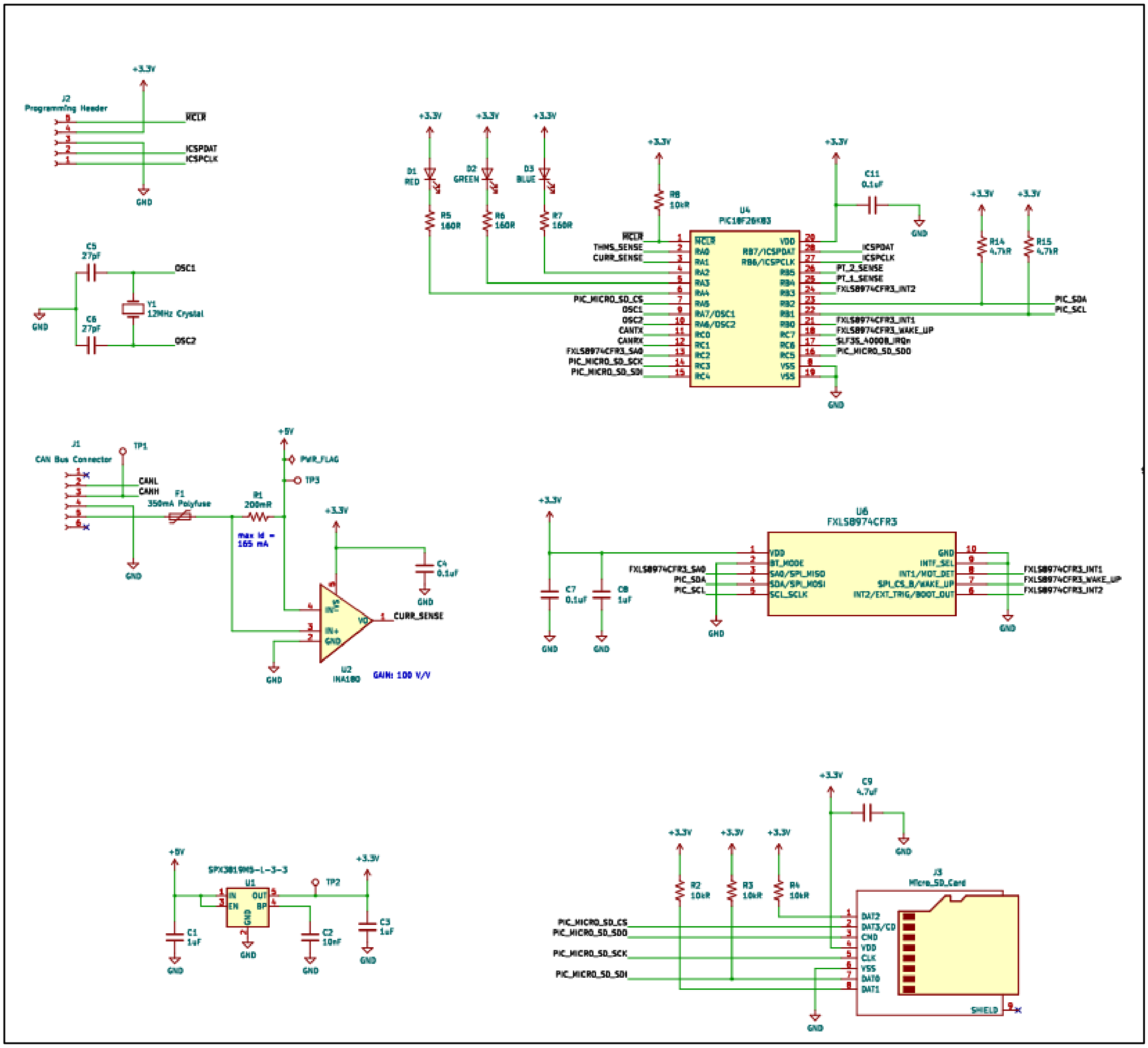

Figure 5. Schematic: MCU, accelerometer, micro-SD, LDO, current sense, and oscillator.

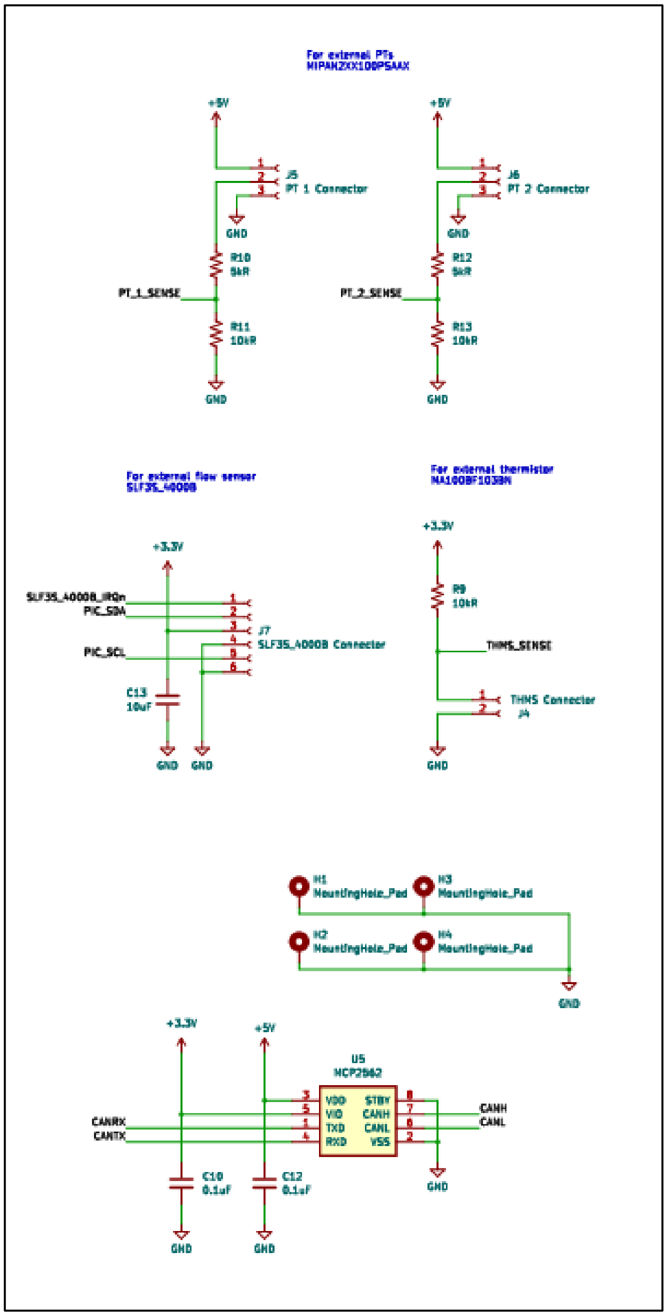

Figure 6. Schematic: CAN transceiver and headers for flow sensor, pressure transducer, and thermistor.