TEAM CELL-U-LATER

End of Term Presentation

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UNIVERSITY OF South Carolina

College of Engineering and Computing

AGENDA

- Team Overview

- Subsystem Progress
  - Wireless Communication
  - User Interface
  - Onboard Processing
  - Power Distribution and Management

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PROJECT OVERVIEW

Project Mission: Create a data collection waystation that collects data from deployed sensor packages, computes structural health metrics, and sends the metrics through a commercial cellular network.

Project Description:

- Wireless communication between the waystation and the sensors.
- Onboard computing at waystation to calculate structural health metrics.
- Results passed on to a host PC via commercial cellular network

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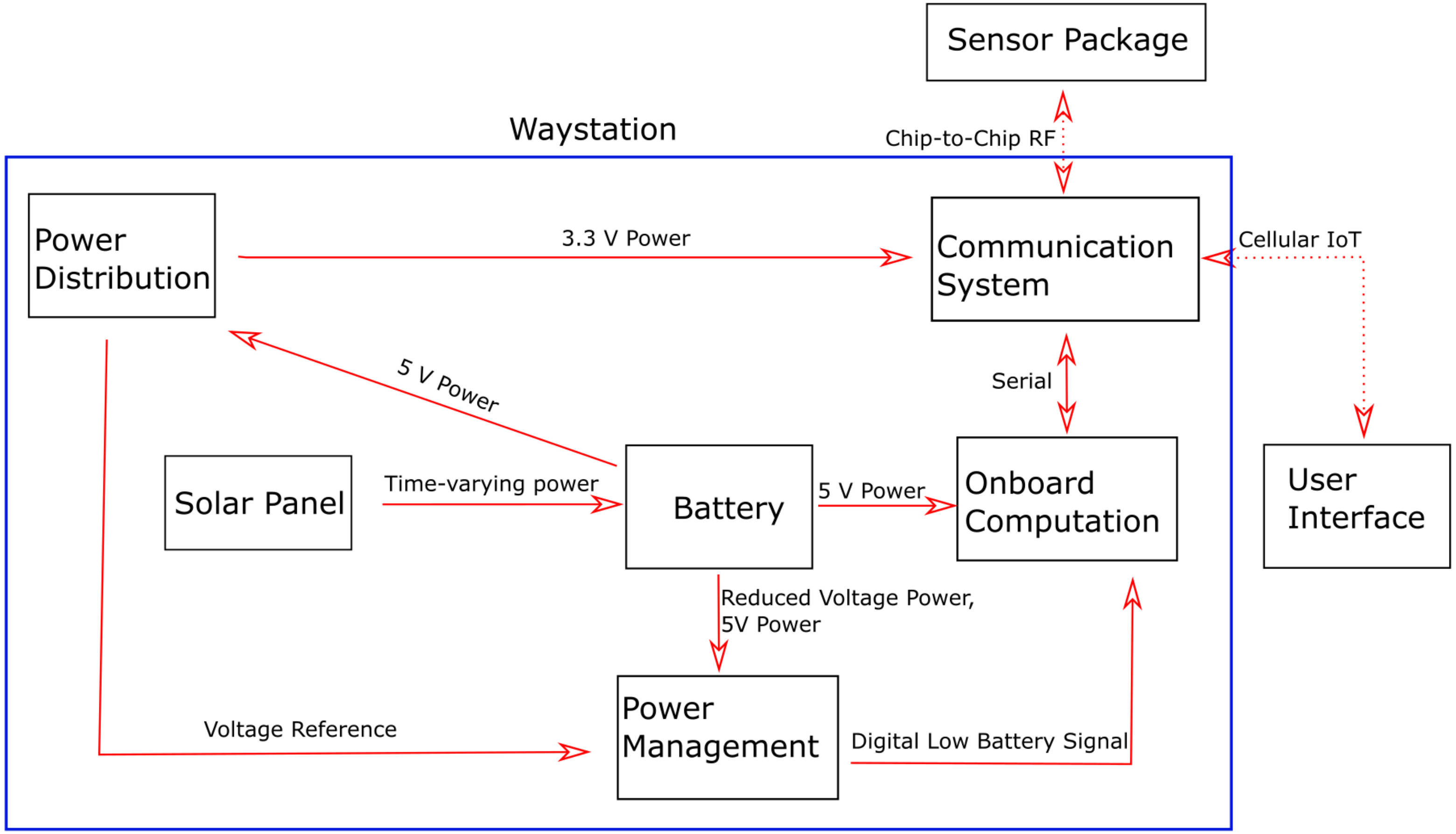
SYSTEM BLOCK DIAGRAM



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DESIGN PHILOSOPHY

- Physical Limitations: Size and Weight
- Monetary Limitations: Pricing
- Ease of Implementation
- ADD DIAGRAM

TEAM ORGANIZATION

- Project Sponsor: Austin Downey
- Team Lead: Kevin Crean

- Onboard Processing Subsystem: Kevin Crean
- Wireless Communication: Hudson Dye
- Power Distribution and Management: Davis Hobbs
- User Interface: Wyatt Hill

PROJECT STATUS: SCHEDULE

- Acquired all necessary parts to prototype entire system
- Completed subsystem demonstrations
- Meeting consistently at least once a week

PROJECT STATUS: FINANCIALS

Component	Price
Botletics SIM700A-LTE-Shield (2)	$65
Micro SIM card + IoT subscription	$5
LP311P Differential Comparator (2)	$3
OKR-T-3-W12-C Buck Converter (2)	$16
SUNER BC-10 Solar Panel	$56
Talent Cell 5V/12000mAh Lithium-ion Battery	$40
SAE– Barrel Jack adapter	$10
	$195

HIGH LEVEL PROBLEMS

- Transferring pre-packaged data to generic data files
- Power Management for regulated battery voltage
- Understanding new concepts
  - RF Communication/Protocol

WIRELESS COMMUNICATION SUBSYSTEMS

Hudson Dye

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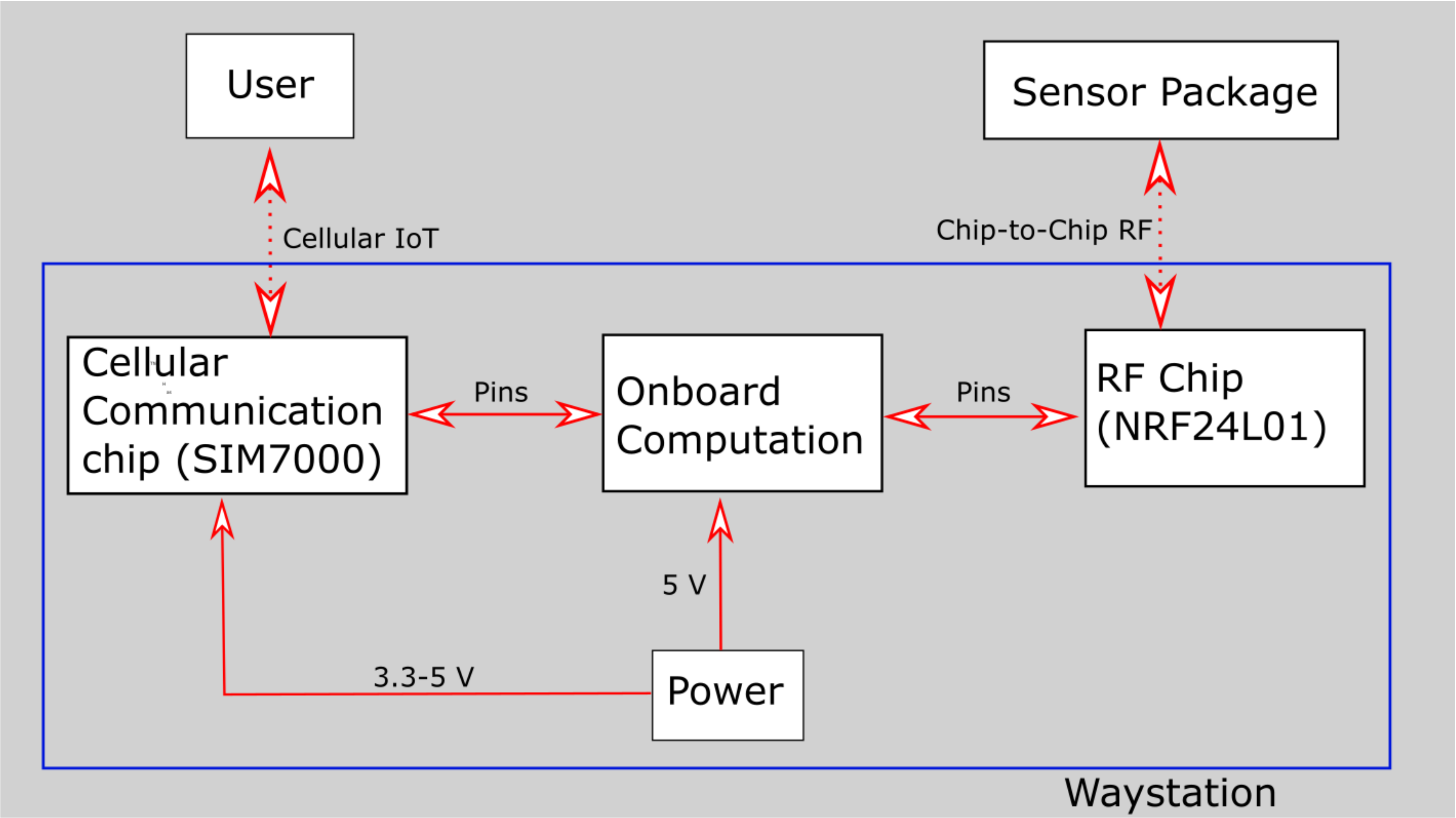
BLOCK DIAGRAM – COMMUNICATION FOCUSED



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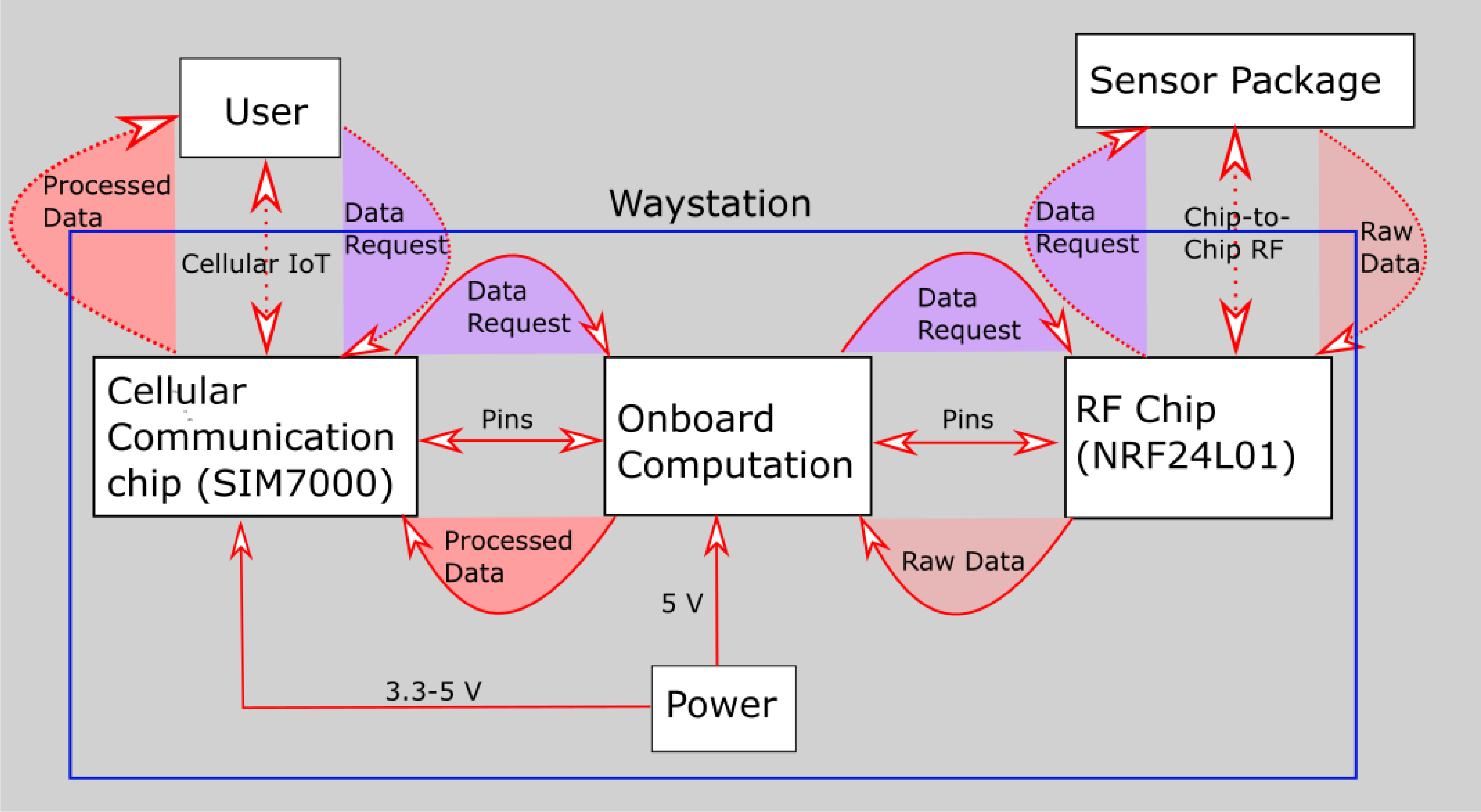
BLOCK DIAGRAM – INFORMATION FLOW



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WIRELESS SUBSYSTEMS

Cellular Communication

- Cellular chip + microSIM
- IoT connection to user

Chip-to-Chip RF

- NRF chip
- Previously implemented RF connection

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CELLULAR COMMUNICATION FUNCTIONS

- Read chip & source information
  - battery voltage, ID, etc.
- Read wireless environment information
  - registration status, RSSI, network time, etc.
- Send/Receive SMS
- post chip information to dweet.io

Goal: Send files to user via IoT

CELLULAR CHARACTERIZATION

- This slide may include evidence of functioning cellular IoT capabilities

LEARNING PROCESS

- Custom PCB necessary to use any microcontroller except Arduino
  - Use Arduino Uno for prototyping
- Spent ~25 hours testing faulty chip
  - Provided with free replacement extensive troubleshooting with CEO
  - Will need to play catch up during Christmas for RF portion
- This delayed RF communication implementation

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USER INTERFACE (UI) SUBSYSTEM

Wyatt Hill

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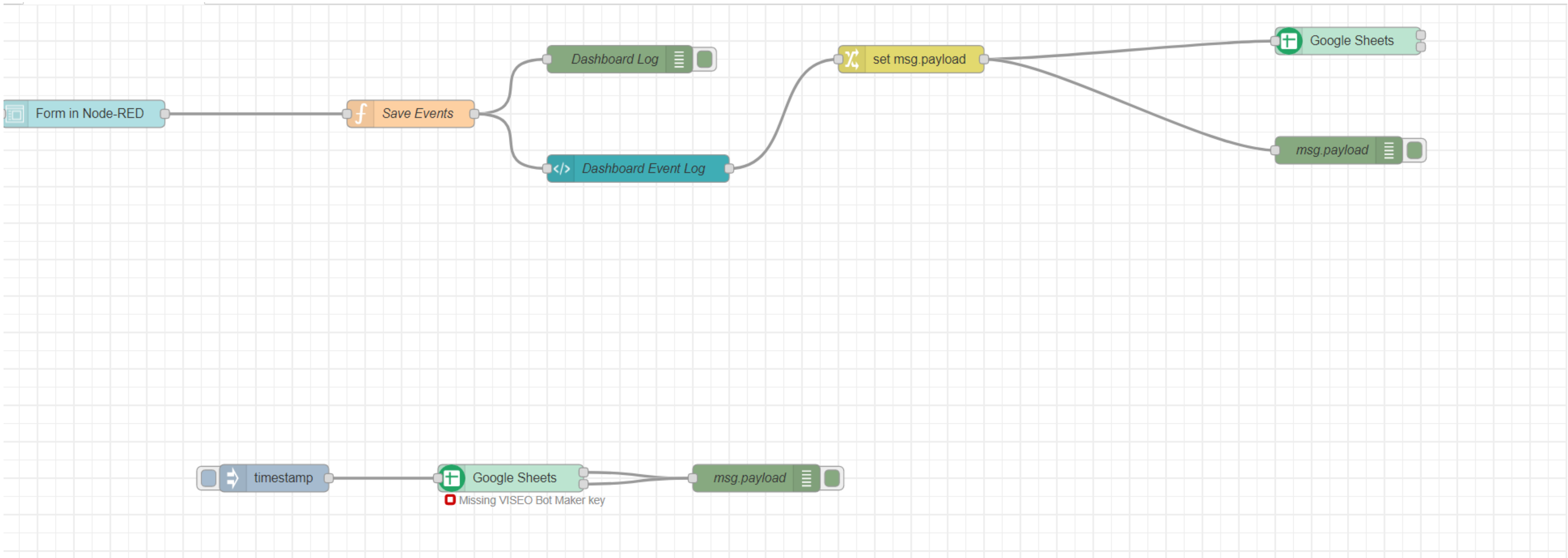
UI SUBSYSTEM OVERVIEW



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UI SUBSYSTEM FUNCTIONS

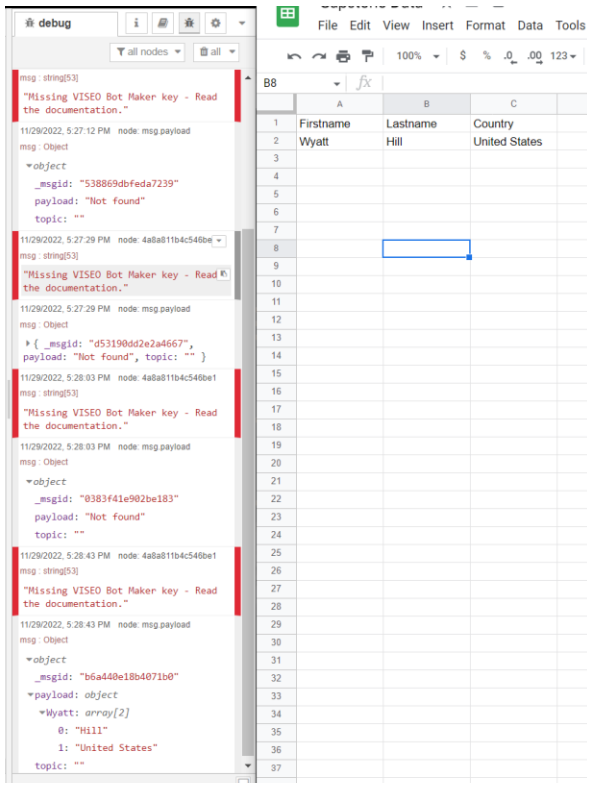
- Read Function
  - Ability to read and display data from data storage
  - Ability to select specific points and periods of data and read and display it from data storage.
- Write Function
  - Ability to write to data storage for use of the read function
  - Ability to write processed data real time when requisition is given

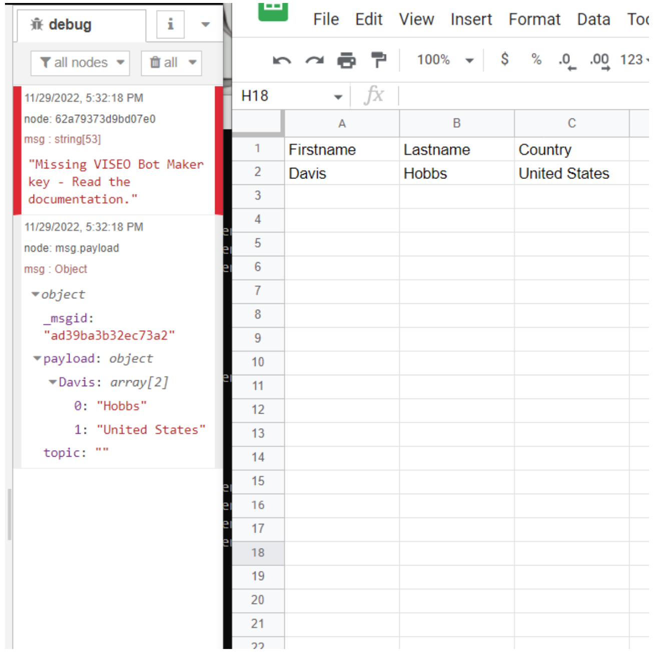
UI READ FUNCTION EXPERIMENT

- The Data sheet is loaded with mock data
  - First Name
  - Last Name
  - Country
- The read function is called from UI as in normal operation
- The debug window of the UI will be populated with mock data if the read function is successful

UI EXPERIMENTAL RESULTS

- 2 trials with different names and countries were successful





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UI SUBSYSTEM NEXT STEPS

- Work with Communication subsystem to achieve completion of write function.
- Implement user input window for read function of UI subsystem
- Integrate functions to successfully interface with local storage

ONBOARD PROCESSING SUBSYSTEM

Kevin Crean

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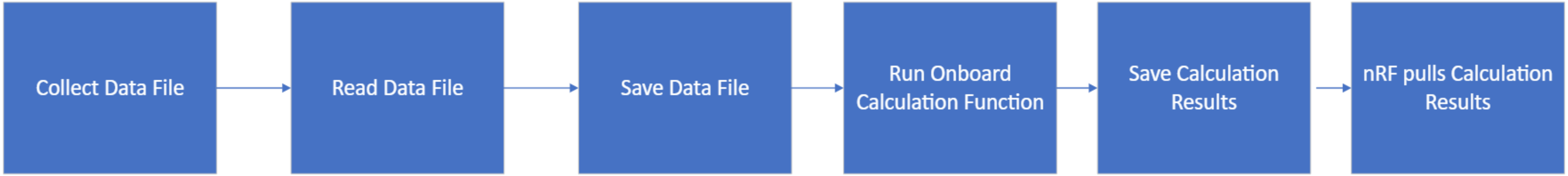
ONBOARD PROCESSING SUBSYSTEM OBJECTIVE

- Microcontroller receives and saves raw data to SD card.
- Code will perform the structural health metrics that are requested.
- Once metrics are calculated, processed data will be sent wirelessly to the user interface.



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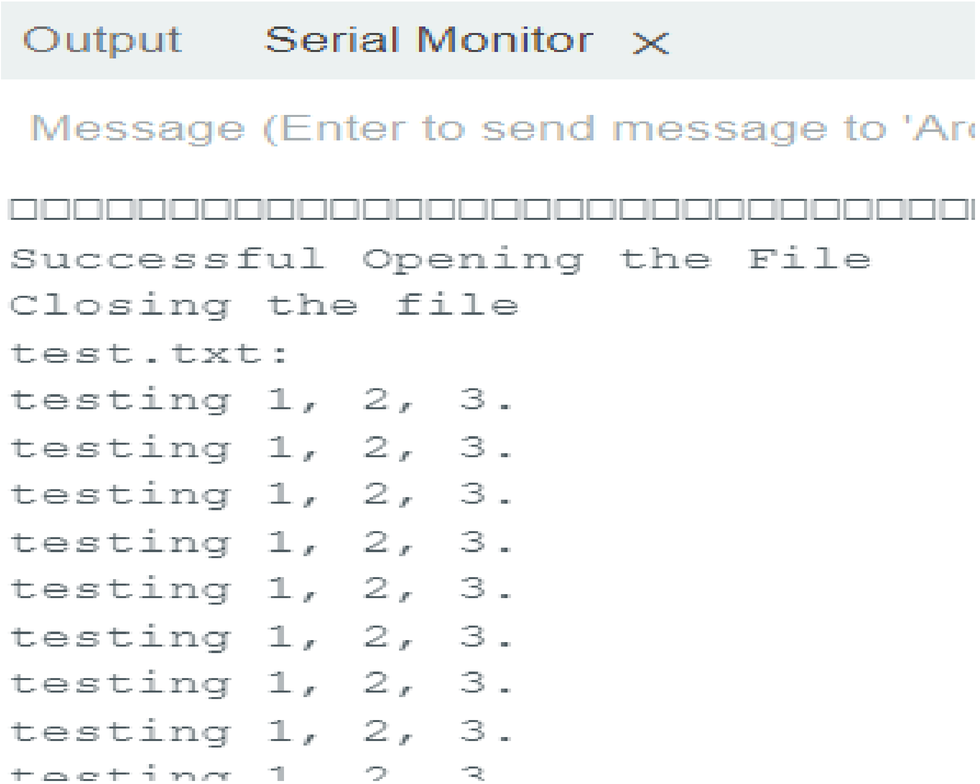
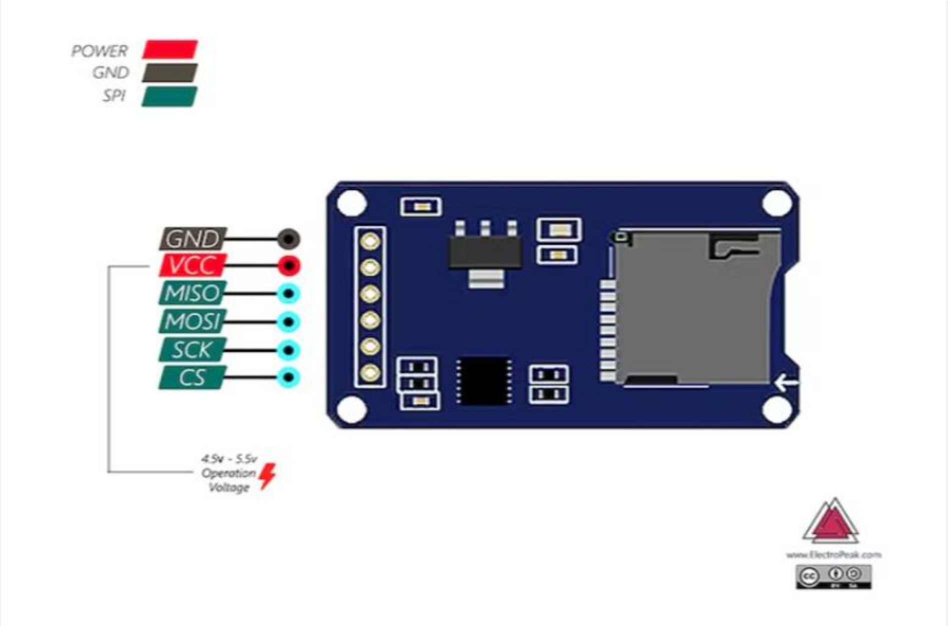
ONBOARD PROCESSING EXPERIMENT: READ AND WRITE SD CARD

- Read and Write to test file contained on SD Card
- Print out Results on Serial Monitor
- Serial Peripheral Interface (SPI) Protocol.





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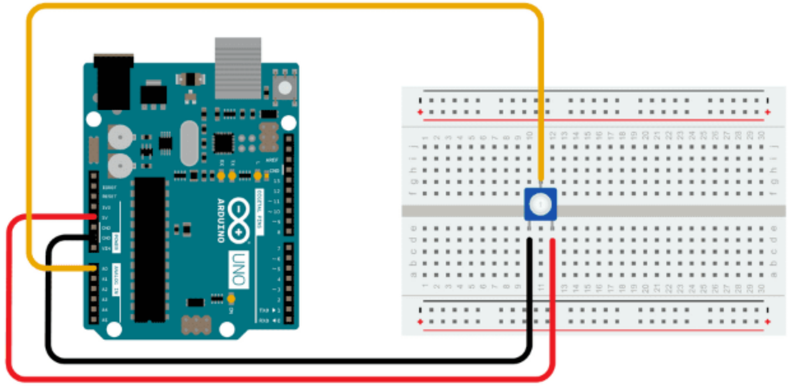
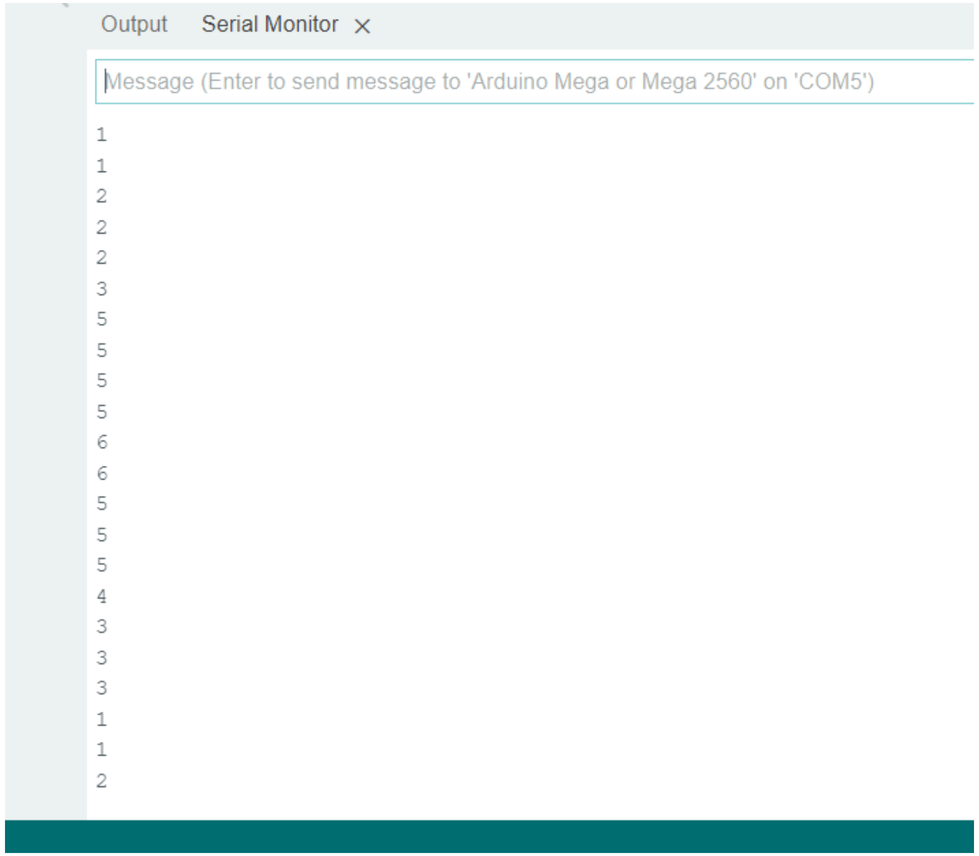
ONBOARD PROCESSING EXPERIMENT: MEAN FUNCTION

- Stores Data in an Array
- Finds the Average Value
- Running Average Function





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ONBOARD PROCESSING PROBLEMS AND CONCERNS

- Learning Arduino Programming Language
  - Some parts taking longer than expected
- Fast Fourier Transform Function
  - Low Resolution that Arduino Mega 2560 R3 will be able to compute
- Switching to a Raspberry Pi
  - Potentially Delay Gantt Chart Schedule

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ONBOARD PROCESSING NEXT STEPS

- Combine and Adjust Mean Function Calculation Code with Read/Write SD Card Code
- Write Fast-Fourier Transform Function
- Microcontroller communication with nRF module
- Using a Raspberry Pi instead of the Arduino Mega 2560 R3

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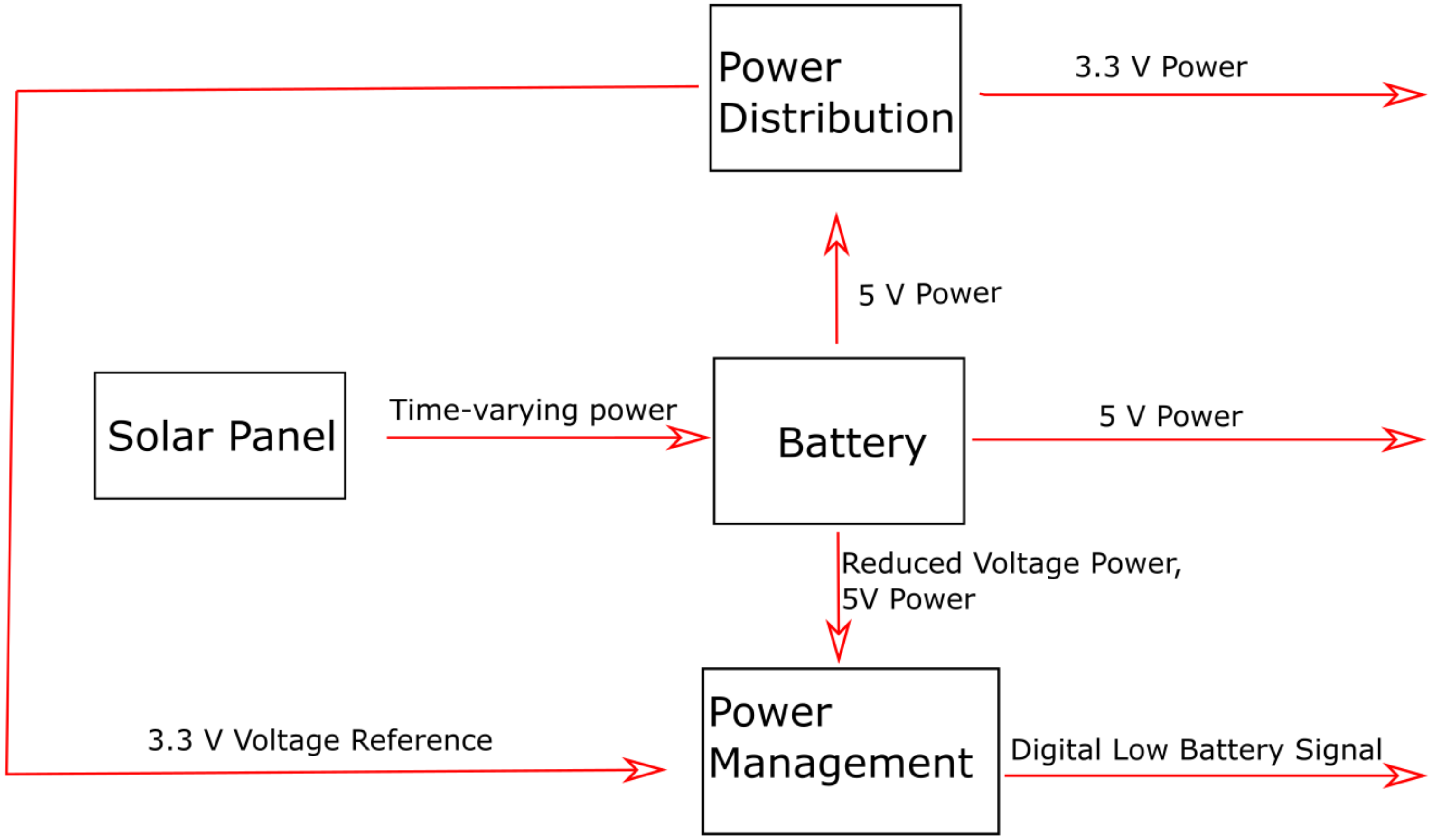
POWER DISTRIBUTION AND MANAGEMENT (PDM) SUBSYSTEM

Davis Hobbs

PDM SUBSYSTEM OVERVIEW



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PDM SUBSYSTEM OBJECTIVES

- Power Supply
  - Establish a ~5 V power source to supply the microcontroller
  - High capacity with solar recharge capabilities
- Power Distribution
  - Establish a ~3.3V power source to supply the comms hardware
  - Capable of enduring rapid changes in load
- Power Management
  - Signal the microcontroller when the battery is at low capacity

SUBSYSTEM HARDWARE: POWER SUPPLY

- A 5V Talent Cell Battery was selected
  - Internal 5V regulator to reduce voltage ripple
  - Internal battery management system allows for solar panel integration
  - Sufficient capacity for 4 days of operation using data sheet values
- The battery is supported by a 12 W Suner Solar Panel
  - Interfaces with battery via an SAE connector
  - Designed for Li Battery charging

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SUBSYSTEM HARDWARE: POWER DISTRIBUTION

- OKR buck converter supplies power to comms hardware.
  - Reduces ~5V battery voltage to ~3.3V
  - Up to 93% efficient power conversion
  - Highly effective at responding to pulsed loads
- Converter has been experimentally validated to supply loads mimicking the comms hardware

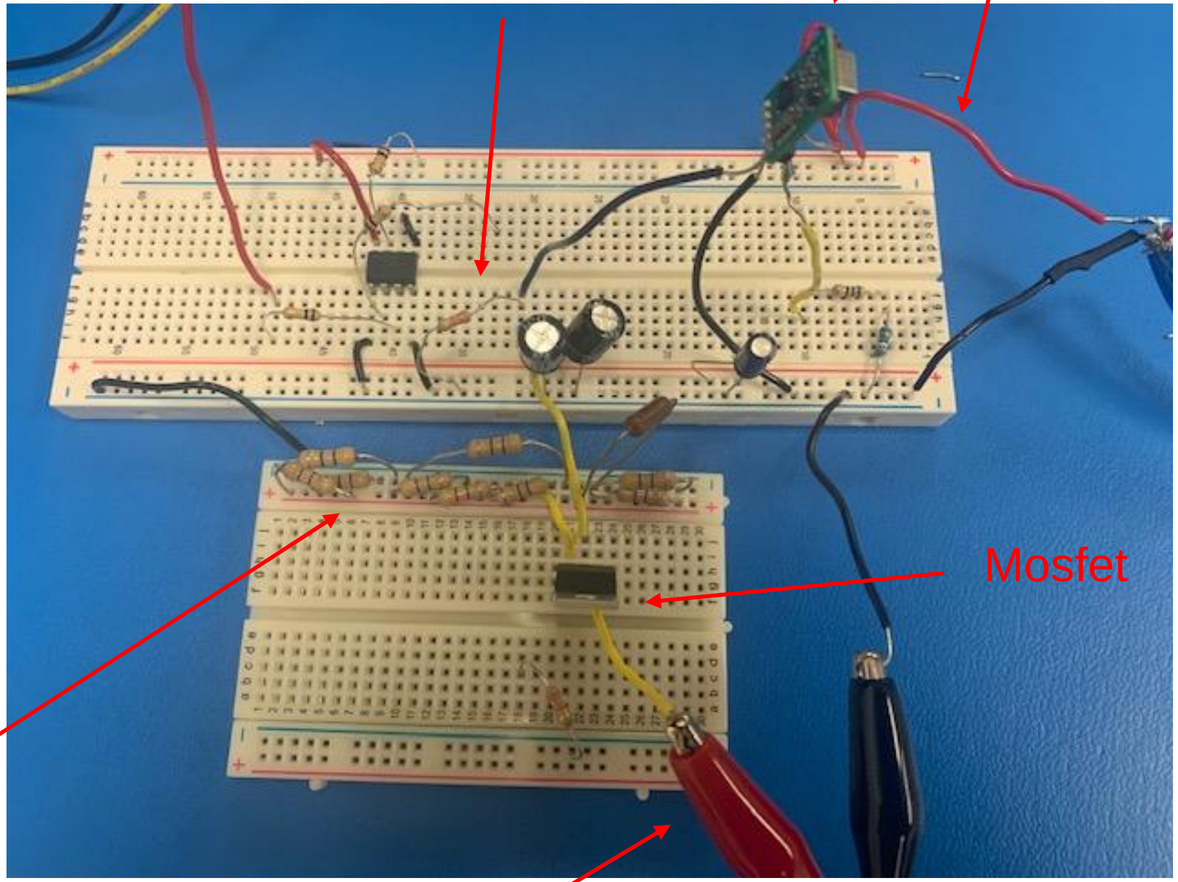
DISTRIBUTION SYSTEM EXPERIMENT

- The distribution system was given a load meant to mimic comms hardware power draw.
- This load was turned on and off at 15 Hz.
- The effect of dynamic loading on distribution output voltage was monitored.

Buck Converter

Battery: 5 V

Base Load



Mosfet

High current load

Mosfet Gate Signal

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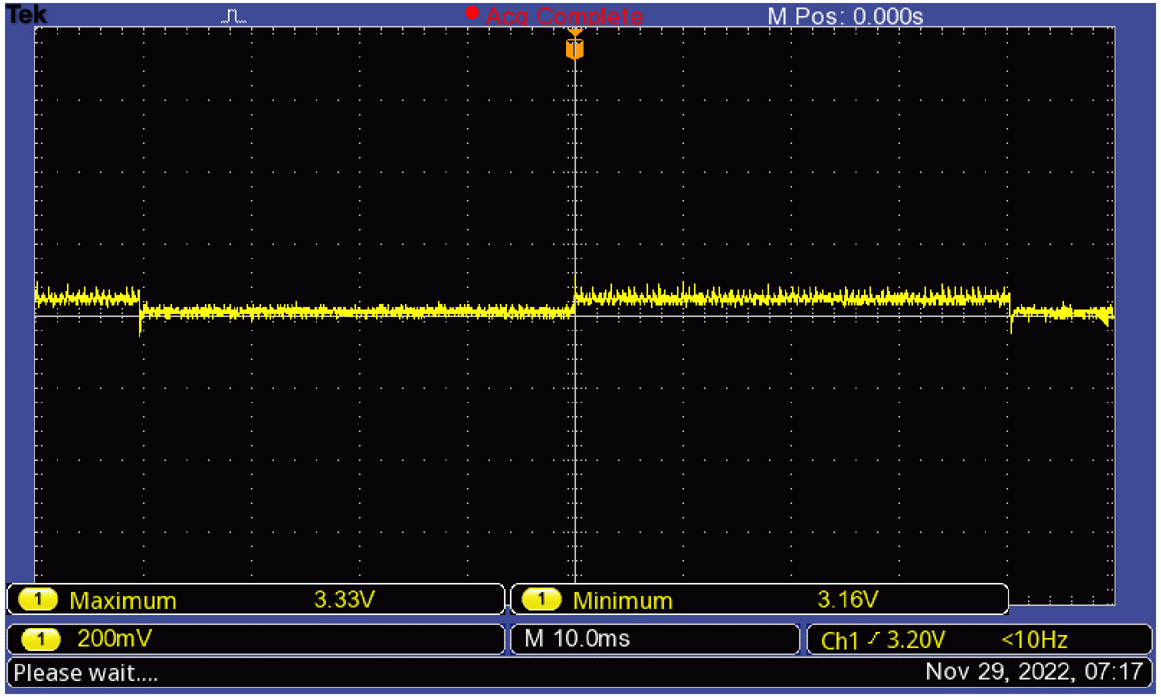
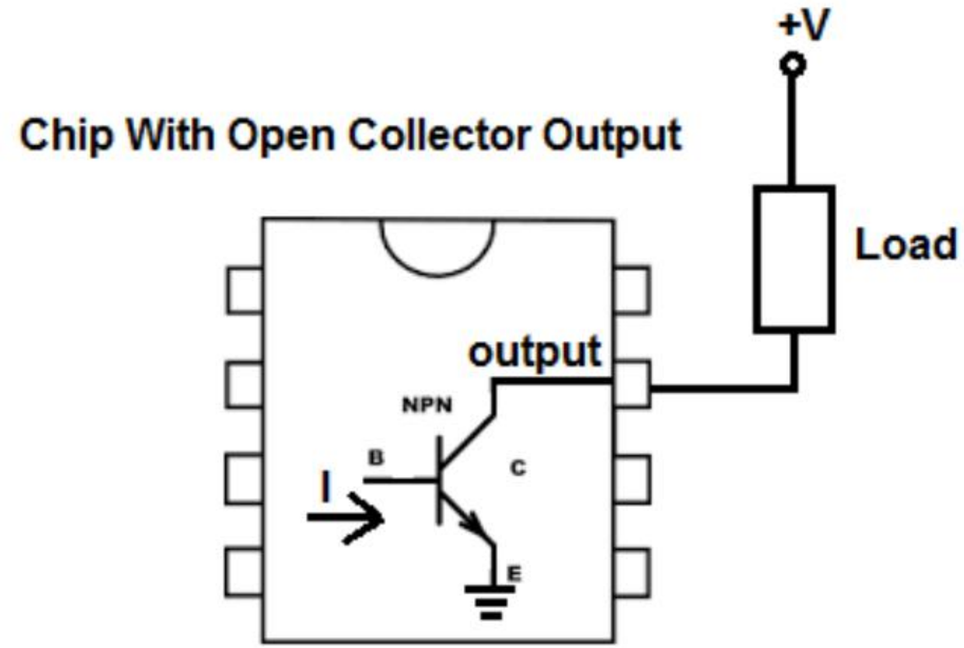
EXPERIMENTAL RESULTS

- The buck converter can successfully reduce battery supply voltage
- The distribution subsystem provided a max load voltage range of 3.35 – 3.14 V
  - This range falls well within the 3.0 – 3.6 V range acceptable by the comms hardware.



SUBSYSTEM HARDWARE: POWER MANAGEMENT

- The LP311P comparator was selected
  - Tracks battery voltage fade
  - Alerts microcontroller of low battery voltage
  - Microcontroller provides signal voltage to avoid overvoltage
- This subsystem was experimentally validated



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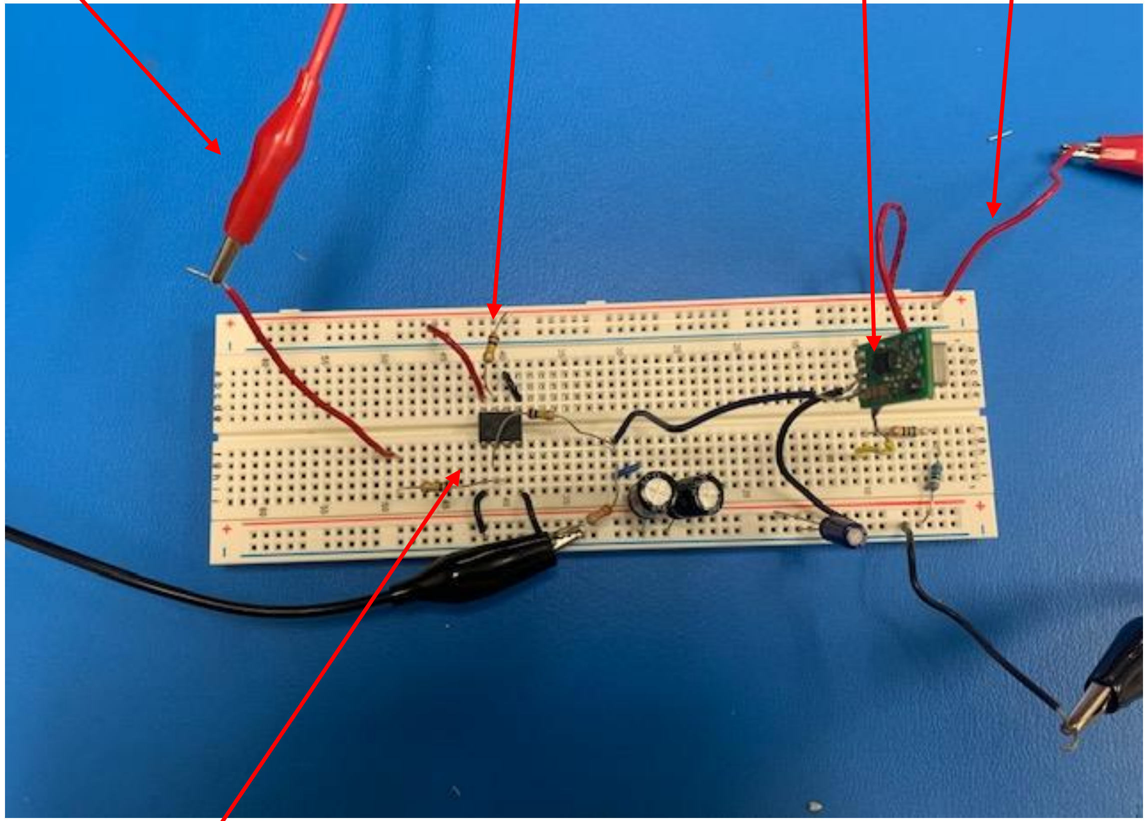
POWER MANAGEMENT EXPERIMENT

- The power management hardware was supplied with a 3.3 V reference signal
- A power supply was used to mimic battery voltage fade
- The output signal of the comparator was monitored



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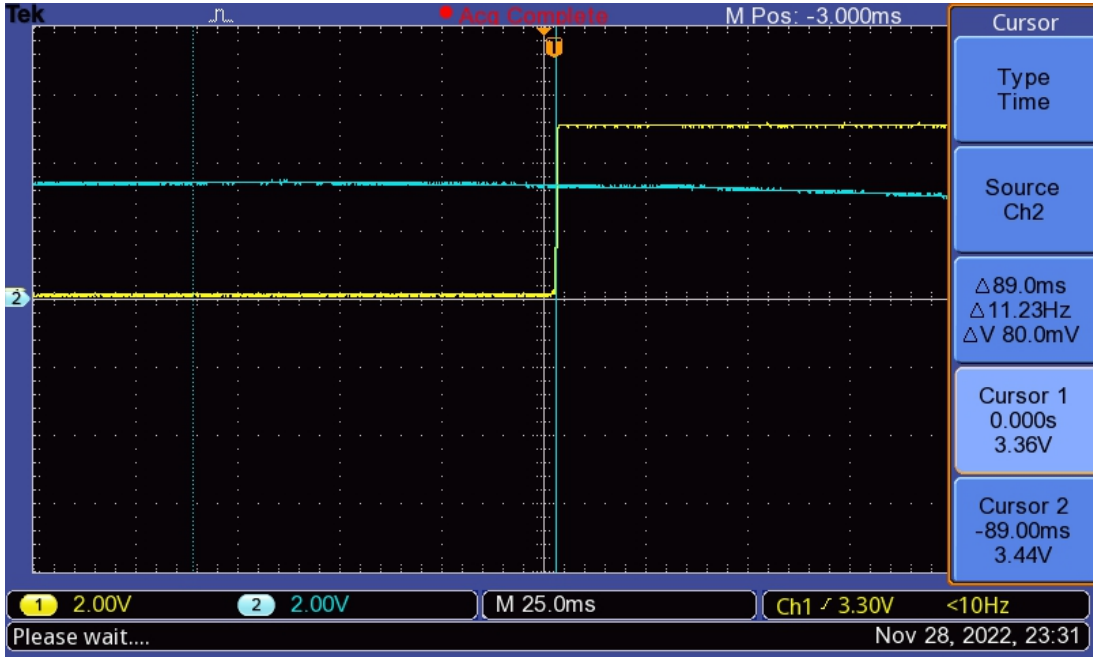
POWER MANAGEMENT EXPERIMENTAL RESULTS

- Demonstrated to Professor Smoak
- A digital signal does change from 0 V to 5.15 V when the input falls below the reference
- This validates the signal is accurate under static load conditions



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PDM SUBSYSTEM: NEXT STEPS

- The original design of the power management system did not anticipate regulated battery voltage
  - Necessitates a redesign of the power management system
- The solar panel's ability to charge the battery will be tested
- Distribution hardware should be integrated with the comms hardware to test functionality