SAE Baja Data Acquisition System

Team E#5

Milestone #3
System-Level Design Review

November 25, 2014

Introduction

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The Design Team

Project Manager - Christopher Riker (CpE)
cdr11c@my.fsu.edu

- Ensures deadlines are met
- Maintains communication between team members
- Actively monitors and encourages project progress

Financial Manager - Dewey Williams (CpE)
dmw10g@my.fsu.edu

- Keeps inventory of project parts
- Maintains project budget ledger
- Requests funds and purchase orders from ECE department
- Writes and delivers sponsorship requests

Data Coordinator - Tyler Dudley (EE)
dudleyt2004@gmail.com

- Keeps meeting minutes
- Maintains an organized report archive
- Collects and organizes data from the DAQ prototype

DAQ Leader - Hebe Perez (CpE)
hp09d@my.fsu.edu

- Acts as an ambassador between the DAQ team and the SAE Baja team
- Assists financial manager with sponsorship requests
- Coordinates project tasks

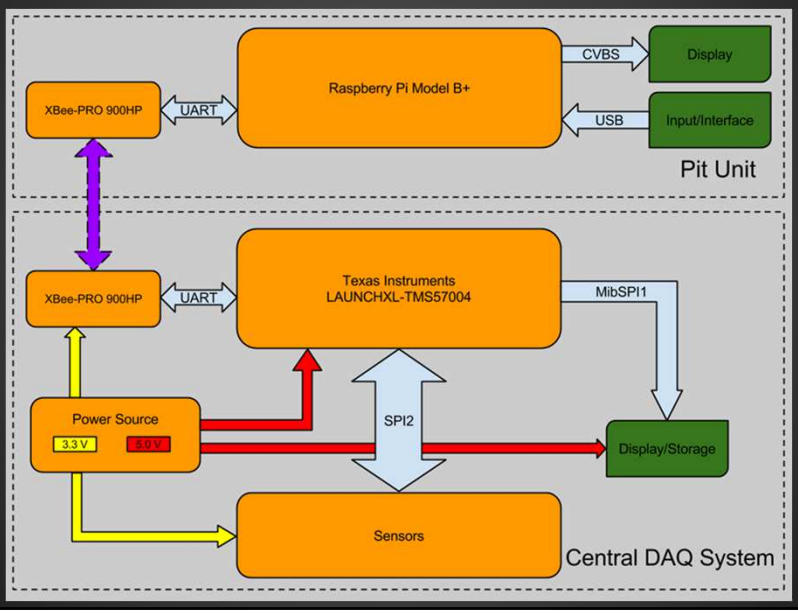
Background

- SAE International holds an annual Baja series competition
- Each team is supplied with 10 Hp Briggs & Stratton engine that cannot be modified in any way, and the team must build a reliable off road vehicle around it
- The vehicle is judged on various design characteristics, and competes in a number of performance based competitions
  - Acceleration
  - Hill Climb
  - Maneuverability
  - Endurance race
- The DAQ system will be designed to improve the FAMU-FSU COE Baja team's placement in the 2015 competitions

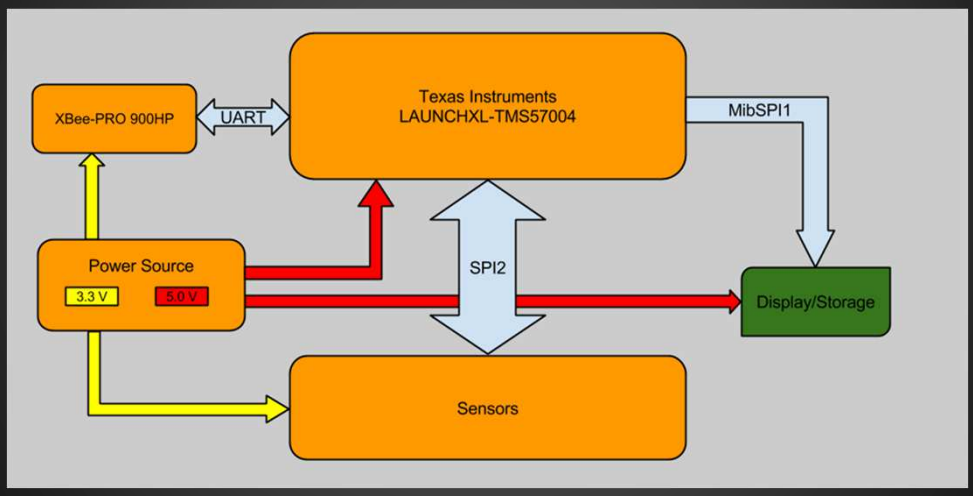
Expected End Product

- On-Vehicle Data Collection Unit
  - Securely mounted to the baja vehicle
  - Will collect, store, and display information about
    - Speed
    - Fuel level
    - Acceleration
    - Tire pressure
  - Will send data to the pit unit for display
  - Will warn the driver and pit when refueling/tire change is needed
- Pit unit
  - Will allow the pit crew to actively monitor the vehicle

Top Level Block Diagram

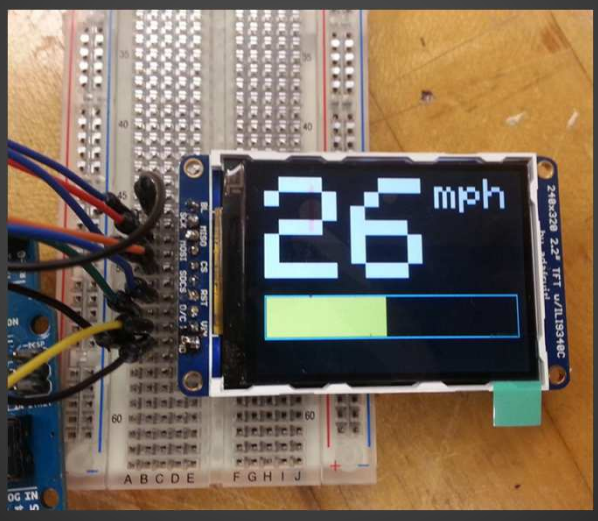


Central DAQ System



6 Christopher Riker

Display/Storage



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Display/Storage

Adafruit 2.2” TFT LCD Display w/ microSD

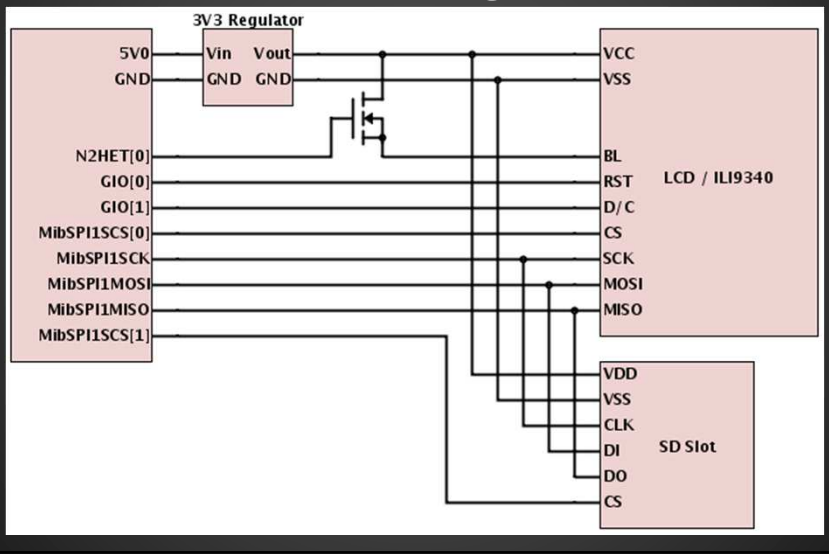
Relevant Specifications

- 2.2” TFT Color LCD Display
- 320x240 Resolution
- PWM Safe Backlight
- 5 V Input w/ On-board 3.3 V Regulator
- Integrated ILI9340 LCD Driver IC
  - 18-bit Color
  - Pixel-addressable VRAM Buffer
  - 4-wire SPI Interface
- Integrated microSD Slot

8 Christopher Riker

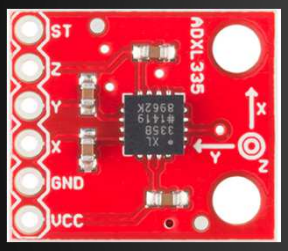
Display/Storage

Circuit Diagram



9 Hebe Perez

Sensors



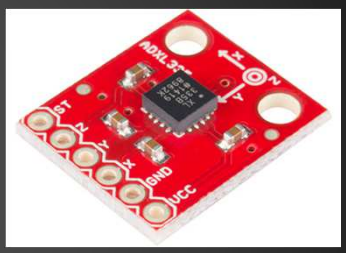
10 Hebe Perez

Accelerometer

Analog Devices ADXL335

Relevant Specifications

- Operating Voltage Range: 1.8 V - 3.6 V
- Supply Current: 350 µA
- Measurement Range: ± 3g
- Sensitivity: 270 - 330 mV/g
- Bandwidth (Out-of-Box): 50 Hz
- Cost: $14.95
- Vendor: SparkFun



Risk	Probability	Consequences
Bandwidth Too Low	Moderate	Will not be able to measure high-frequency vibrations
Enclosure Damage/Moisture	Low	Accelerometer will not function
Static Electricity Exposure	Low	Accelerometer will not function

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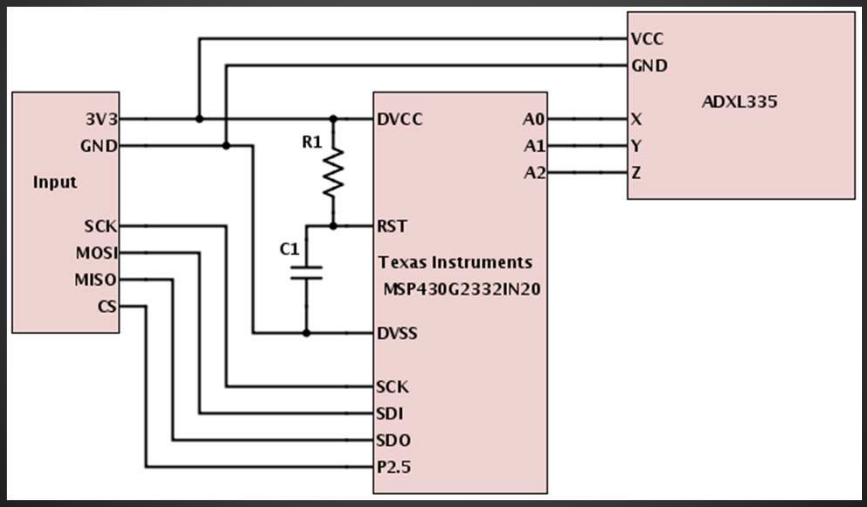
Accelerometer
Circuit Diagram

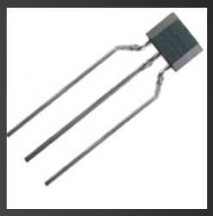


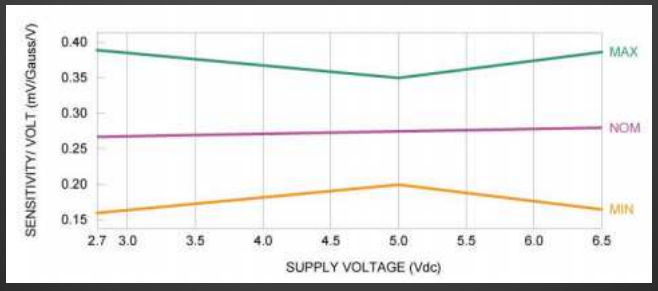
12 Hebe Perez

Hall Effect Sensor
Honeywell SS49E

Relevant Specifications

- Supply Voltage: 3 V - 6.5 V
- Supply Current: 6 mA (typical)
- Sensitivity: 1.0 - 1.75 mV/Gauss
- Output Voltage: 1.0 V - 1.75 V
- Low Cost: $2.37





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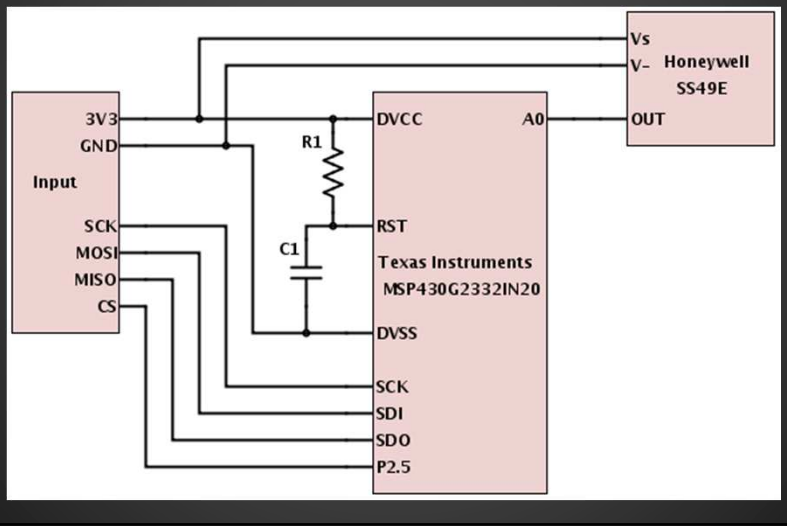
Hall Effect Sensor

Circuit Diagram



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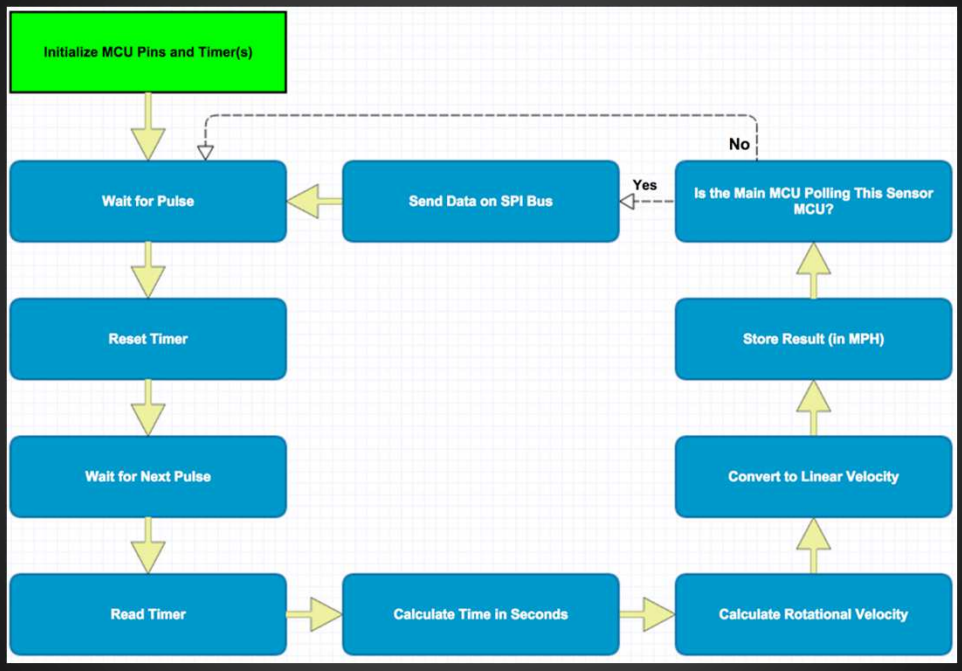

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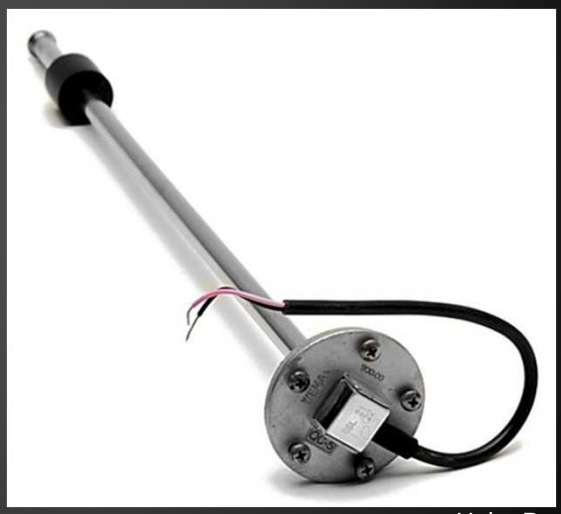
Fuel Level Sensor

Wema SSS/SSL Fuel Level Sensor

Relevant Specifications:

- Standard SAE Mounting Pattern
- Reads 240 Ω Empty / 33 Ω Full
- Made of SUS 316 Stainless Steel
- Reliable Reed Switch Design
- 13 mm Resolution



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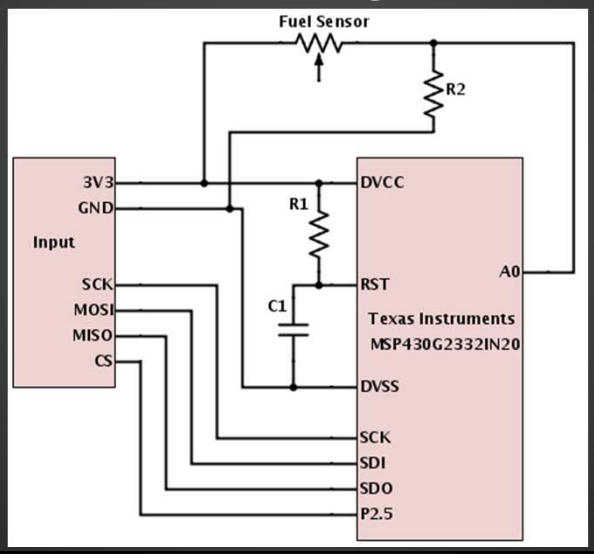
Fuel Level Sensor

Circuit Diagram



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Tire Pressure Monitoring System

Chrysler TPMS Sensors

- Factory Chrysler TPMS Sensors for 2013-2014 Model Years
- Donated by Arrigo Dodge Chrysler Jeep RAM in Fort Lauderdale
- Can accurately read PSI levels as low as 6 PSI
- Activated through proprietary means
  - Frame structure of return data is known
- Receives at 125 kHz, transmits at 433.92 kHz
- Manufacturers will be contacted for more information on how to activate the sensors

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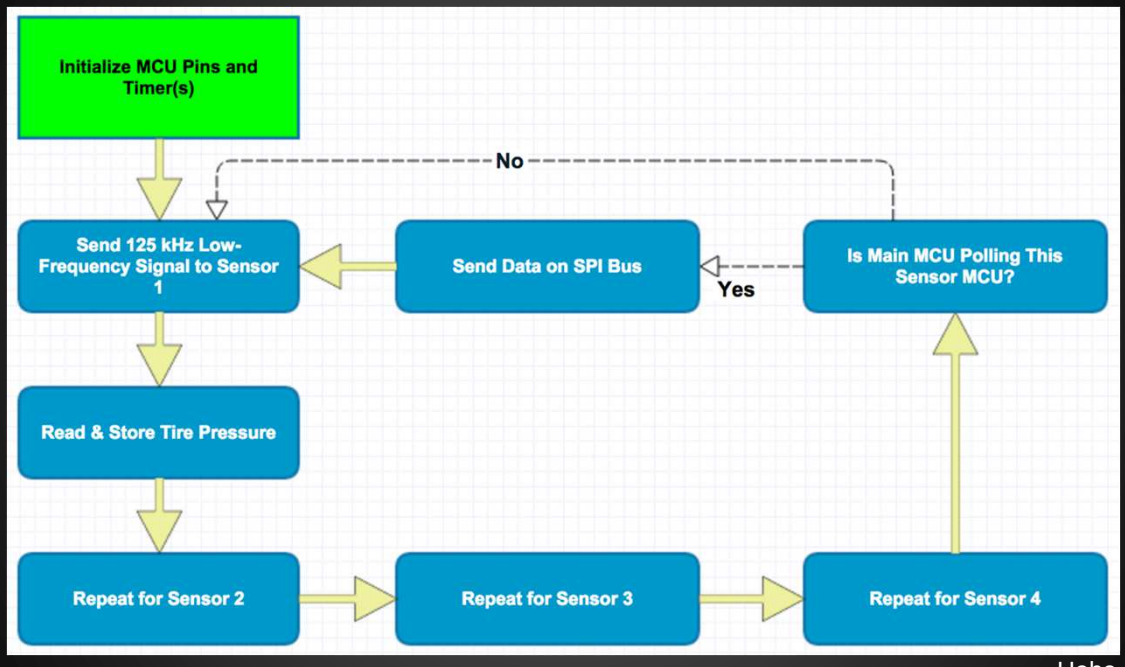

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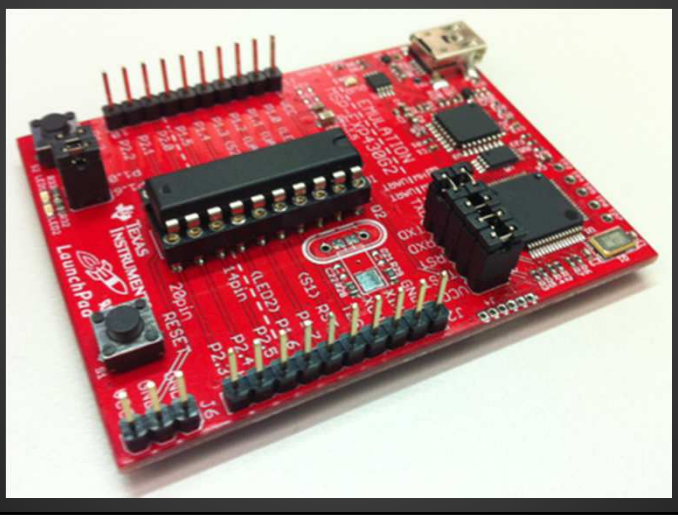
Sensor Microcontrollers

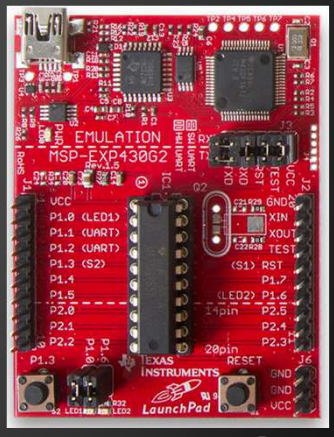


Sensor Microcontrollers

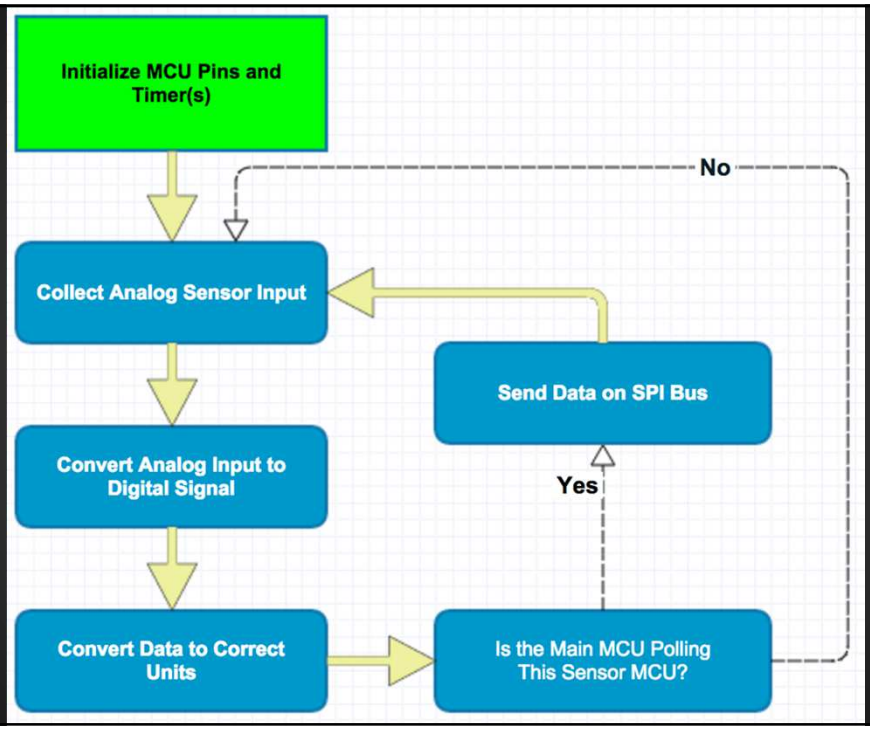
Texas Instruments MSP430G2332

Relevant Specifications

- 16-bit RISC Architecture
- 16 MHz Internal Oscillator
- 3.3 V Supply Voltage
- Hardware SPI or I^2C via USI
- 8 Channel 10-bit ADC
- 20 pin PDIP Package Available



Programmed with a TI Launchpad MSP-EXP430G2



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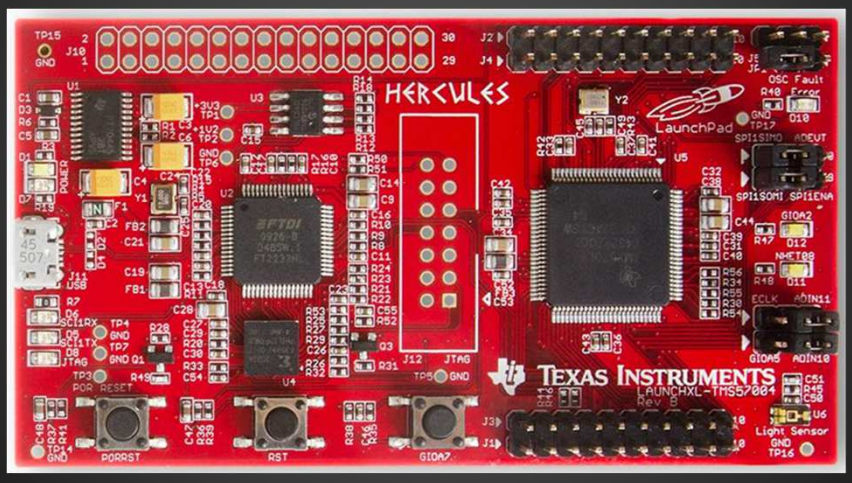
Main Microcontroller



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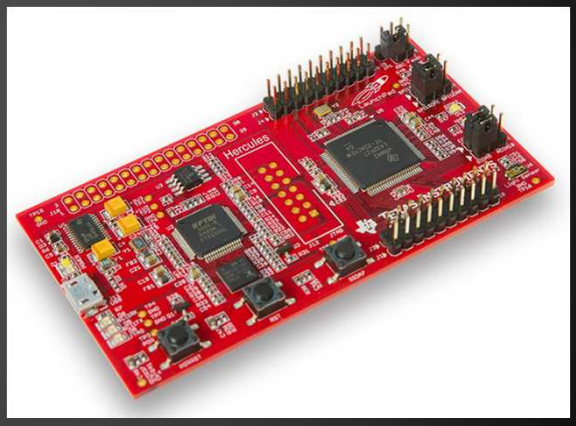
Main Microcontroller

TI Launchpad Hercules TMS57004

Relevant Specifications

- Features the Hercules TMS570LS0432 MCU
  - 32-bit RISC MCU
  - Dual ARM Cortex-R4 CPUs in Lock-Step
  - Designed for Automotive and Safety Applications
  - 3 SPI Interfaces
    - 1 Multi-Buffered SPI (mibSPI)
    - 2 Standard SPI
- Standard TI 40pin “Booster Pack” Headers
  - Additional 60pin header to break out remaining MCU pins
- On-board Emulation



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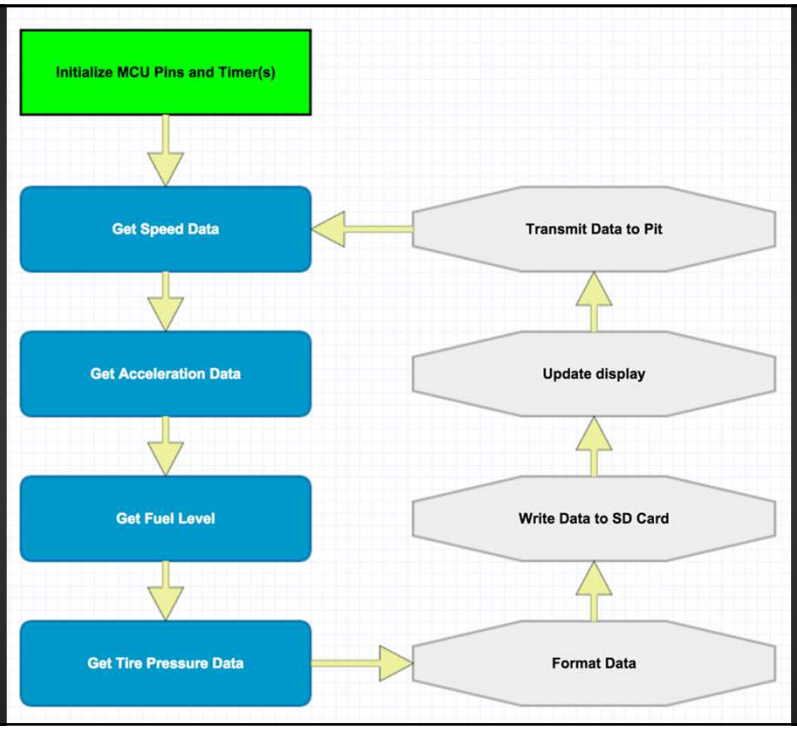

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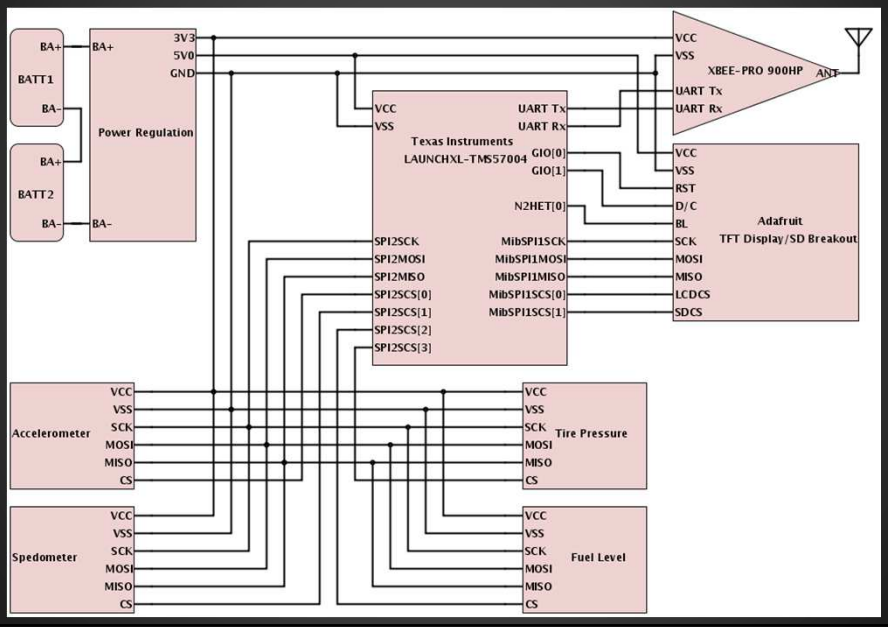
Main Microcontroller



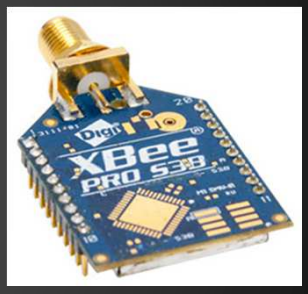
Wireless Data Transmission

Wireless Vehicle-to-Pit Transmission

XBee-PRO 900HP

Relevant Specifications

- Supply Voltage: 2.1 V to 3.6 V
- Transmit Current: 215 mA
- Receive Current: 29 mA
- Sleep Current: 2.5 uA
- Frequency Band: 902 to 982 MHz - Software selectable
- RF Data Rate: 10 Kbps or 200 Kbps
- Outdoor/Line-Of-Sight Range: Up to 4-miles w/ 2.1 dB dipole antennas @ 200 Kbps
- Transmit Power: 250 mW



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Power Source

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Power Source

Tenergy $LiFePO_4$ Rechargeable Battery

Relevant Specifications

- 3.2 V Nominal Cell Voltage
  - Two cells are connected in series for 6.4 V overall
- Up to 24 Ah Charge Capacity
- Up to 10 Year Lifespan
- Low Cost “Smart” Chargers Available

Voltage regulator ICs will be used to create regulated 5 V and 3.3 V outputs

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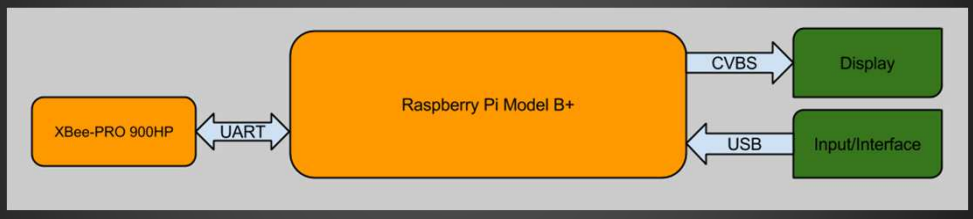
Pit Unit



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Pit Unit
Overview

- Pit Unit will consist of a CPU and a Display and collect data wirelessly from the vehicle and display it via a UI
- Display will be connected to the CPU via composite video
- XBee will be connected to the pit unit via UART

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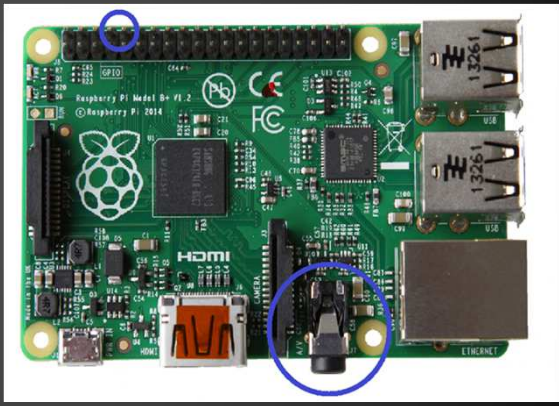
Pit Unit
Raspberry Pi B+

Relevant Specifications:
- 700 MHz Low Power ARM CPU
- Dual Core VideoCore IV Multimedia Co-Processor
  - Capable of more advanced UI
- 40-pin Expansion Header
- Onboard UART
- 3.5mm Combined A/V port



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Enclosures

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Enclosures

Plano 147000 Polycarbonate Case

Relevant Specifications

- Internal Dimensions: 12.25” x 7.125” x 4.875”
- Waterproof
- Latch closure for easy access to components

Houses batteries, power regulation, and main MCU

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Enclosures

Estone Waterproof Project Enclosure

Relevant Specifications

- 3.94" x 2.68" x 1.97"
- Waterproof
- Low cost
- Mounting flange for attaching to the vehicle

Houses individual sensor components

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D. Expense	PN/Description	Distributor	Qty	Per Unit	Total Price
Hercules MCU	LAUNCHXL-TMS57004	Texas Instruments	1	$19.99	$19.99
Sensor MCUs	MSP430G2332IN20	Mouser	10	$1.86	$18.60
Accelerometer	ADXL335	SparkFun	1	$14.95	$14.95
Fuel Sender	WEMA SSS/SSL Fuel Level Sender	WEMA USA	1	$40.00	$40.00
Xbee-PRO 900HP	XBP9B-DMST-002	Digi International	2	$39.00	$78.00
LiFePO4 Battery	LiFePO4 Battery Packs	All-battery.com	2	$26.99	$53.98
Battery charger	LiFePO4 Charger	Batteryspace	1	$19.95	$19.95
Magnets (x30)	Bundle	Amazon.com	1	$6.88	$6.88
Hall effect sensor (x5)	US1881	Amazon.com	1	$4.49	$4.49
Blank PCB	5.9in x 5.9in	Jameco	3	$3.95	$11.85
Adafruit LCD Display	2.2" Serial TFT SPI LCD w/ SD Breakout	Adafruit	1	$24.95	$24.95
Pit Computer	Raspberry Pi (B+)	SparkFun	1	$39.95	$39.95

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D. Expense	PN/Description	Distributor	Qty	Per Unit	Total Price
5V Voltage Regulator	ROHM 5V LDO Voltage Regulator	Mouser	2	$1.76	$3.52
3.3V Voltage Regulator	ROHM 3.3V LDO Voltage Regulator	Mouser	2	$2.17	$4.34
20-DIP Socket	3M 20 pin DIP socket	Mouser	8	$0.42	$3.36
Micro SD Card	SanDisk 8GB Micro SD Card	Amazon.com	2	$6.55	$13.10
Headers - 2.54mm		SparkFun	3	$1.50	$4.50
10-pin Headers- 2mm		SparkFun	4	$1.00	$4.00
Xbee Explorer USB	WRL-11812 ROHS	sparkfun	1	$24.95	$24.95
Xbee Breakout Board	BOB-08276 ROHS	sparkfun	2	$2.95	$5.90
On-Vehicle MCU Enclosure	Plano 146000 Waterproof Case	Plano	1	$21.60	$21.60
MSP430 Dev Kit	MSP-EXP430G2	Texas Instruments	1	$9.99	$9.99
				Extra Parts	**$50**
				Shipping	**$150**
				Expenses Subtotal	**$628.85**

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Risk Assessment

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Financial Risks

Risk	Probability	Consequences	Strategy
Component Destruction	High	Tolerable to Serious	• Structurally sound enclosures • Mounting points • Care taken to avoid connecting components to power sources incorrectly
Component Failure	Low	Tolerable to Serious	• Limit excessive use
Project Cost Overrun	Low	Serious	• Worst-case scenario budget analysis done • Steps taken to acquire donated components

Safety Risks

Risk	Probability	Consequences	Strategy
Mounting Failure	Low	Catastrophic	• Work with SAE on mounting hardware and points • Screws secured with thread locking adhesives
Water Damage	Low	Catastrophic	• Care taken to properly house components • Fuses • Care taken when working on any electrical systems

Design Risks

Risk	Probability	Consequences	Strategy
TPMS	High	Tolerable	• Contact representatives to obtain information about data types and frame information • Reach out to industry professionals to find a workable solution
Wireless Vehicle-to-Pit Communication	Moderate	Tolerable	• Transmission whenever vehicle in range
Sensor PCBs	Moderate	Tolerable	• Keep circuit designs as easy-to-mill as possible • Through-hole components only • Perfboard may be used • Design paradigm may be changed

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