CAPSTONE EXPERIENCE 2012

Purdue Quarter Scale (PQSo12)

PURDUE UNIVERSITY

Agricultural & Biological ENGINEERING

Ashley Johnson (MSE), Yichen Li (MSE), Daniel Skelton (MSE), Jonathan Welte (MSE), Jacob Wert (MSE)

Problem Statement

The goal of the project is to design, fabricate, and test a frame, drive train, operator station, electronics system, and exhaust for the quarter scale pulling tractor that meets all the rules and regulations of the American Society of Agricultural and Biological Engineering (ASABE) 2012 International Quarter Scale competition(IQS).

PQSo12- Designed for Maximum Efficiency

Design Constraints & Criteria

- Tractor weight under 800 lbs
- Easily manufactured frame
- Efficient, dependable drive train
- Ergonomic operator's station
- Quiet (less than 91dB), lightweight exhaust
- Reliable electronics

Design Tools

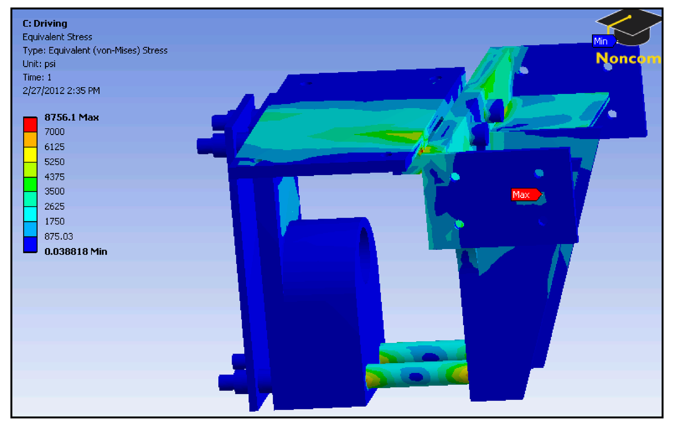
Multiple solution options evaluated

- Pro/Engineer – Used for 3-D modeling of tractor
- Microsoft Excel – Calculations & Design matrices used to visually show decision making process
- ANSYS – Finite Element Analysis (FEA) used to optimize components with regards to material options and weight

	Weight	Sound	Cost	Serviceability	Maneuverability	Safety	Ergonomics	Efficiency (Performance)	Reliability (Performance)	Pull (Performance)	Implementation	Score
	10	6	6	6	12	6	6	9	9	20	10	100
Electro-Mechanical CVT	9	9	8	9	8	8	7	8	7	9	7	**82**
IVT	6	5	7	6	9	7	8	5	7	9	8	**73**
Hydrostat	6	5	6	5	9	7	9	5	6	7	8	**68**
eIVT	7	6	7	5	9	7	8	8	7	9	8	**77**
Mechanical Gear	8	8	10	5	6	9	6	10	9	9	7	**80**

Decision matrix used to quantify transmission options

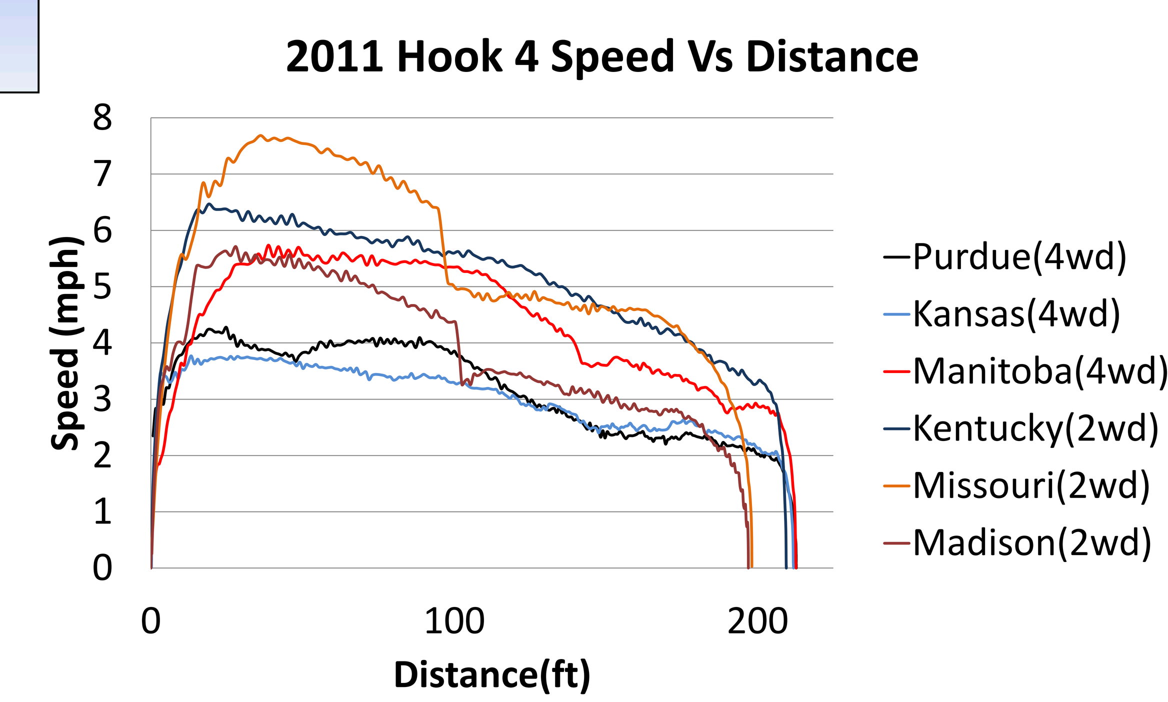
Drive Train

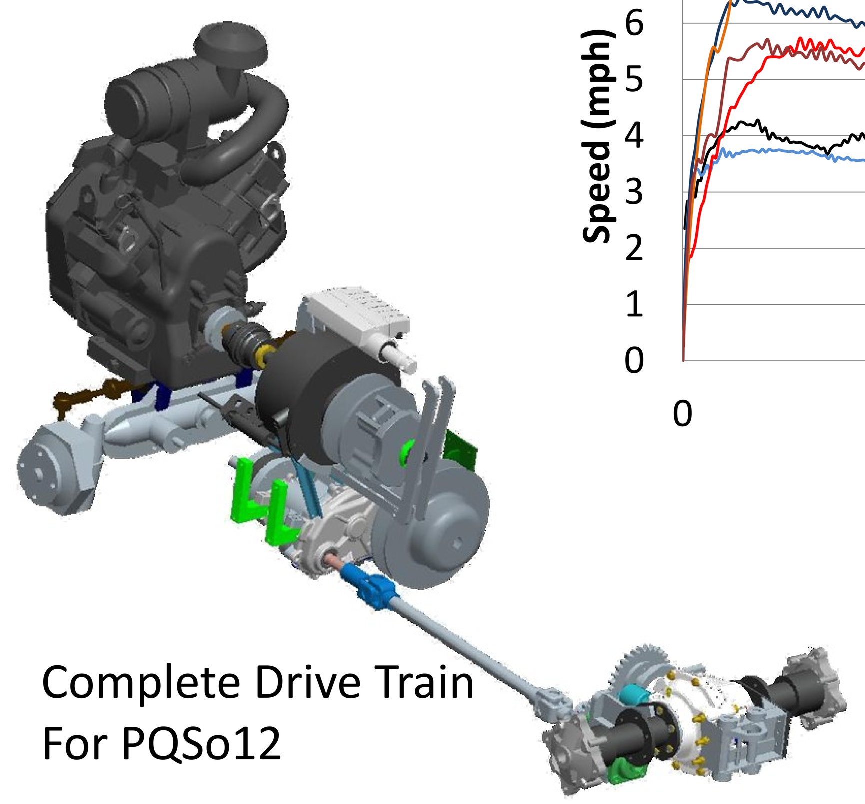


Front axle/engine mount

Objectives

- A light, efficient, and functional drive train system that meets the performance and safety needs of the tractor
- Build off experience gained from PQSo11





Complete Drive Train For PQSo12

Specifications

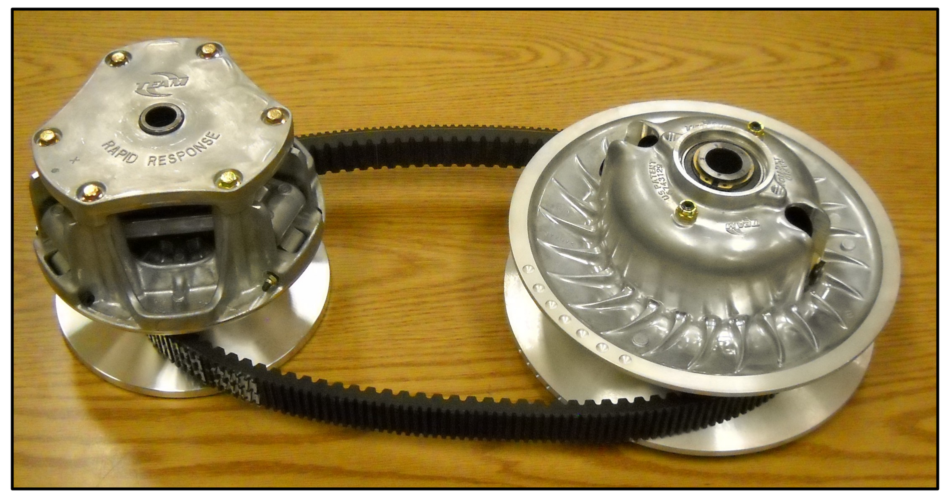
- 31 hp engine
- 3100ft-lbs of torque
- 11mph maximum wheel speed

Cost Summary

Section	Category	Purchased	Fabricated	Overhead	Total Cost
1	Engine System	$ 1,452	$ 17	$ -	$ 1,469
2	Transmission/Transaxle	$ 2,240	$ -	$ -	$ 2,240
3	Drive train	$ 545	$ 438	$ -	$ 983
4	Tires & Wheels	$ 207	$ -	$ -	$ 207
5	Steering	$ 569	$ -	$ -	$ 569
6	Frame	$ -	$ 652	$ -	$ 652
7	Body	$ 56		$ -	$ 56
8	Brake System	$ 228	$ 35	$ -	$ 263
9	Electrical System	$ 5,034	$ -	$ -	$ 5,034
10	Fasteners	$ 90	$ -	$ -	$ 90
11	Safety Equipment	$ 17	$ -	$ -	$ 17
12	Trim	$ 46	$ 150	$ -	$ 196
13	Miscellaneous	$ 13	$ -	$ -	$ 13
14	Final Assembly	N/A	$ 51	$ 41	$ 92
	TOTAL	**$ 10,497**	**$ 1,343**	**$ 41**	**$ 11,881**

Solution

- Implement a CVT to help with variations in track condition
- Use an electro-mechanically actuated CVT to ease the challenge of properly tuning the CVT
- The electro-mechanical CVT allows the engine to operate at peak power during the performance event
- Implement an automotive style clutch to increase the drivability of the tractor
- Use a Kubota MFWD axle with 60 degree steering angle
- Utilize a 3:1 planetary to the front drive shaft eliminates the need for two chain drops
- Use a Polaris Differential with 4.11:1 ratio and electronic locking differential
- A Polaris transmission powers the front and rear axles



TEAM CVT implemented on PQSo12

Kubota Front Drive Axle

Sponsor: Dr. John Lumkes
Technical Advisor: Michael Holland
Special thanks:
Dr. Bernie Engel, Scott Brand
Garry Williams, Dr. Dennis
Buckmaster, John Andruch

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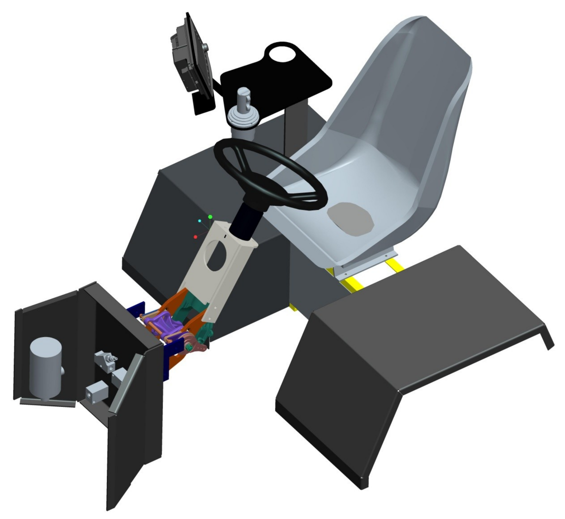
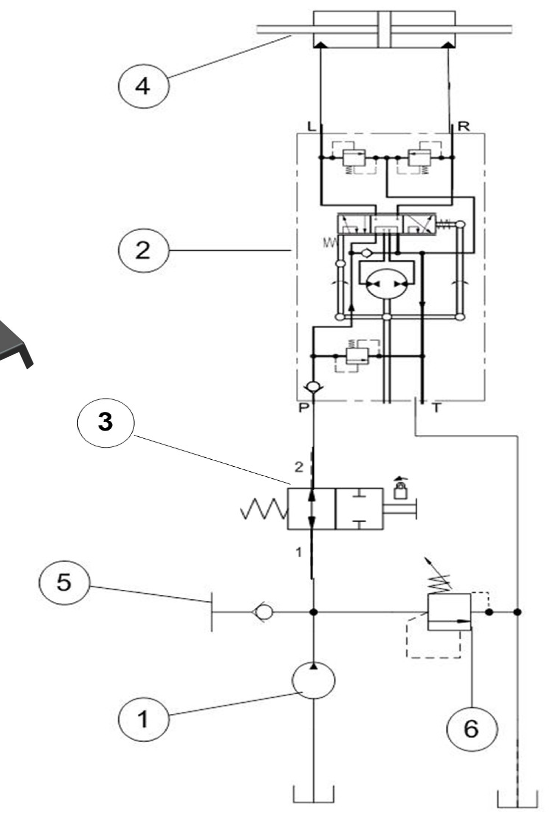
Operator Station

Objectives

- •Operator station which accommodates easy egress and ingress
- •Adjustable to increase comfort for all operators
- •Efficient and safe brakes and power steering



Model of Operator Station



Hydraulic Steering System Schematic

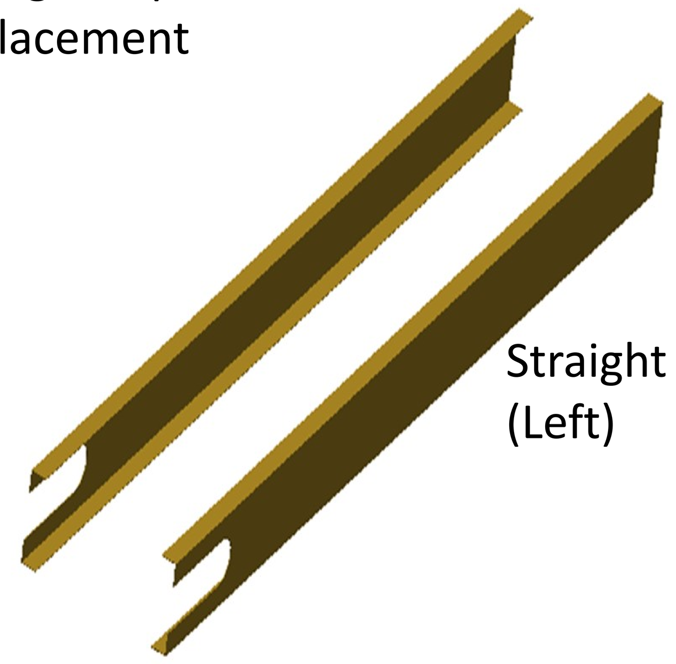
Solution

- •Sliding- rotating- cushioned seat and adjustable steering column provides comfortable positions for all operators
- •Implement a power steering system to minimize the steering effort of the operator and ensure the driver's safety
- •Operator station isolates the operator from moving components
- •Ergonomically designed brake and clutch pedal placement

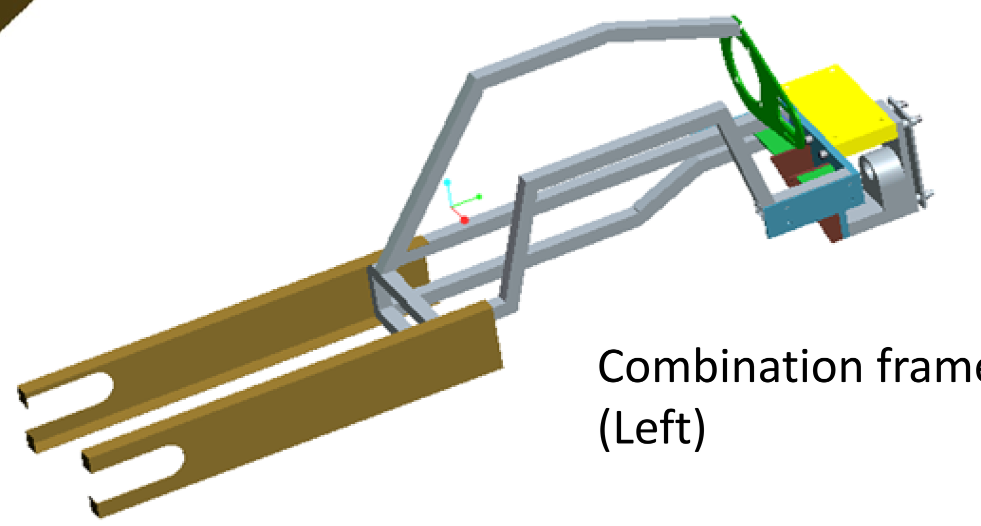
Frame

Objectives

- •Frame under 50 lbs to allocate more weight for ballasting
- •Easily manufactured components
- •Rigid structure to support other sub-assemblies
- •Model concepts in Pro/E with ANSYS verification



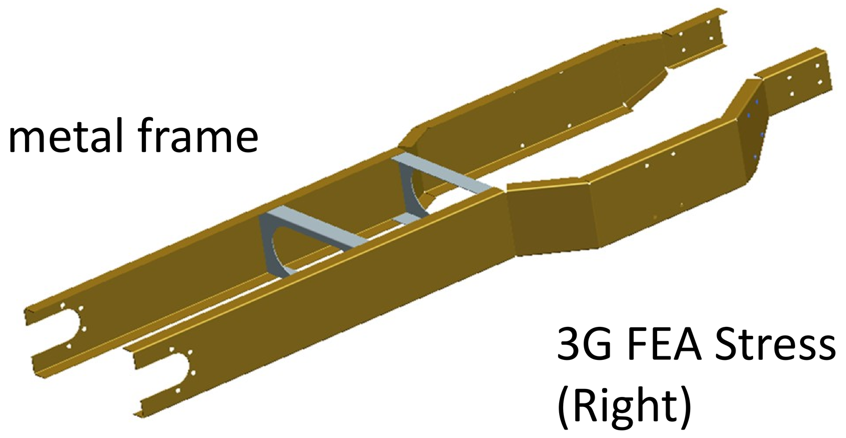
Straight bent sheet metal (Left)



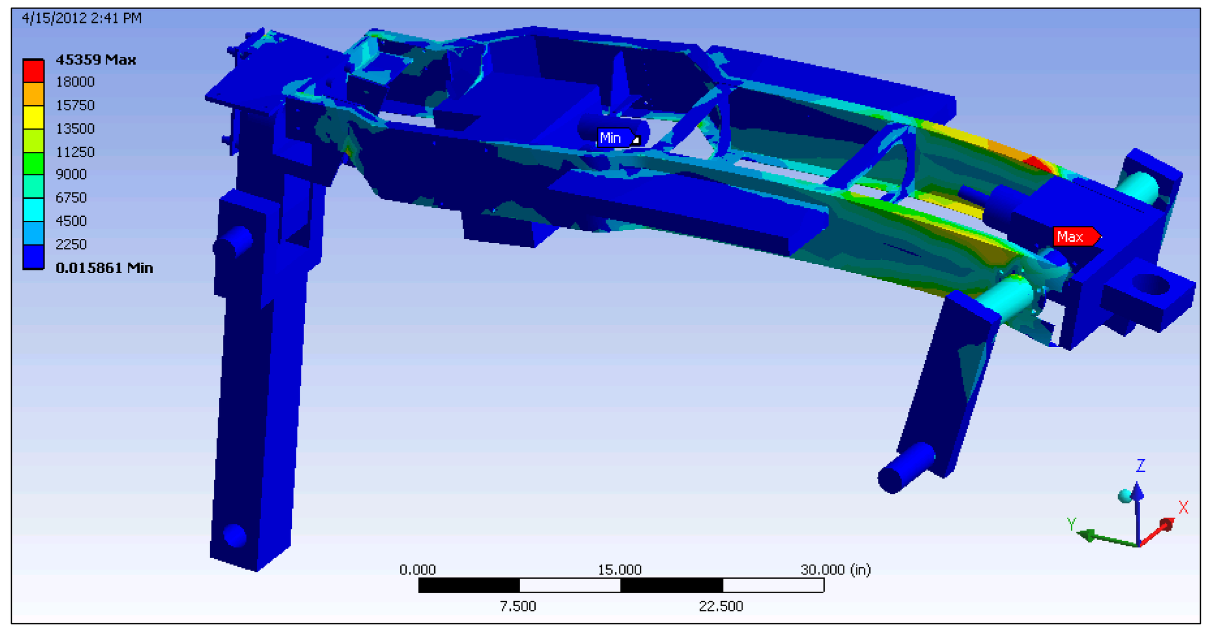
Combination frame (Left)

Solution

- •Use 14 gauge bent sheet metal
- •CNC plasma cut parts decreases assembly time
- •FEA analysis verification
- •Max Von Mises stress under 3G loading, 18,000 psi
- •Frame designs concepts are shown to the right



Bent sheet metal frame for PQSo12 (Right)



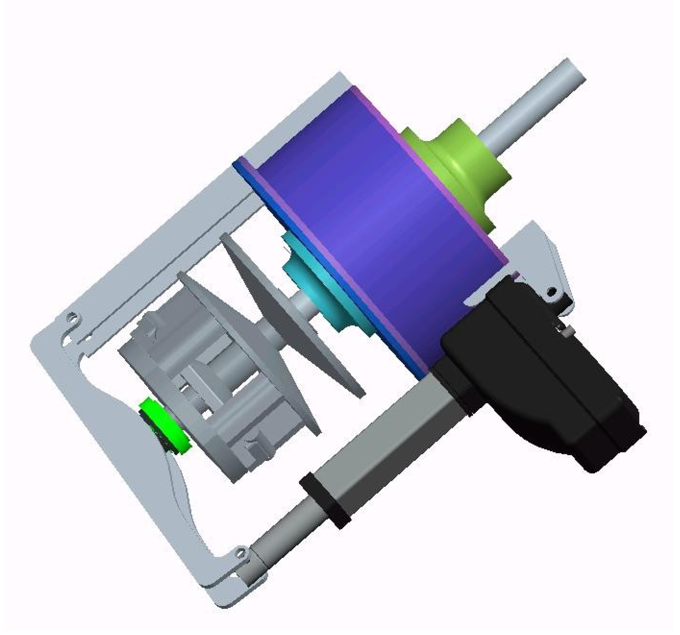
3G FEA Stress validation (Right)

Electronics

Servo Throttle Control

Objectives

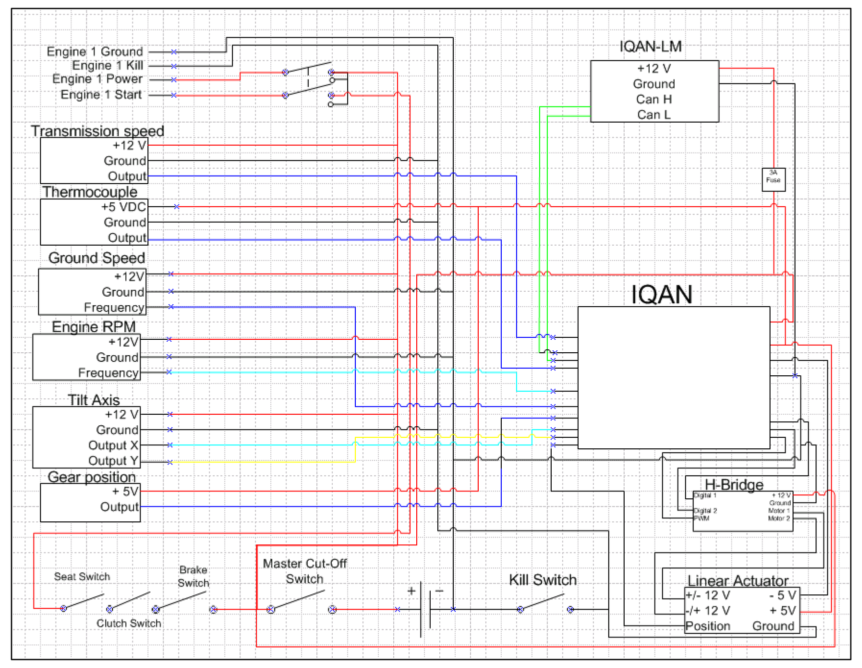
- •Construct a functioning electronic safety system which includes ignition components, seat safety switch, and throttle control
- •Electro-mechanically actuated CVT using IQAN controls
- •Stand-alone design for independent operation of systems



CVT Actuation

Solution

- •Utilize Parker IQAN controls to reduce development time and increase customizability of the sensor monitoring system
- •Fail safe wiring system for complete control of the tractor

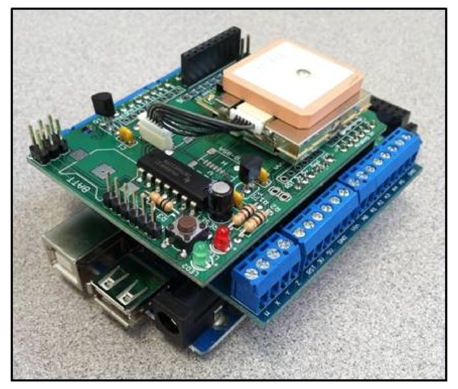


Electrical Schematic

Data Acquisition

Objectives

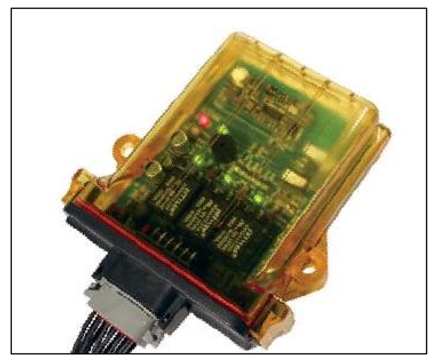
- •A functioning stand-alone data logger using low cost components
- •Design should allow for the system to be used in various environmental settings and applicable on other pieces of equipment
- •System should not require operator input except for data retrieval



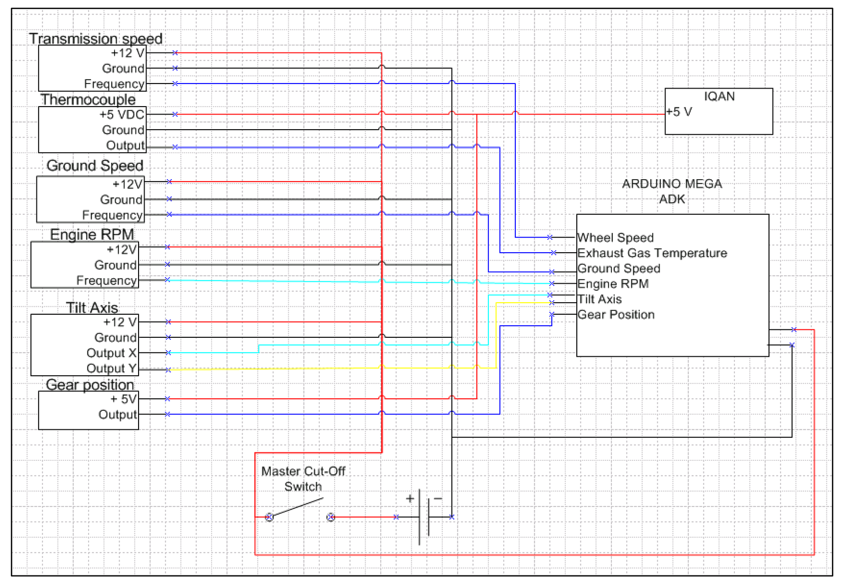
Arduino Mega ADK Microcontroller

Solution

- •Implement Arduino Mega ADK (open sourced microcontroller) with GPS and sensor input shields
- •Utilize a plastic Deutsch enclosure to protect system from the environmental elements
- •Utilize sensors from the tractor and stores data on a SD card



Deutsch Enclosure



Electrical Schematic

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