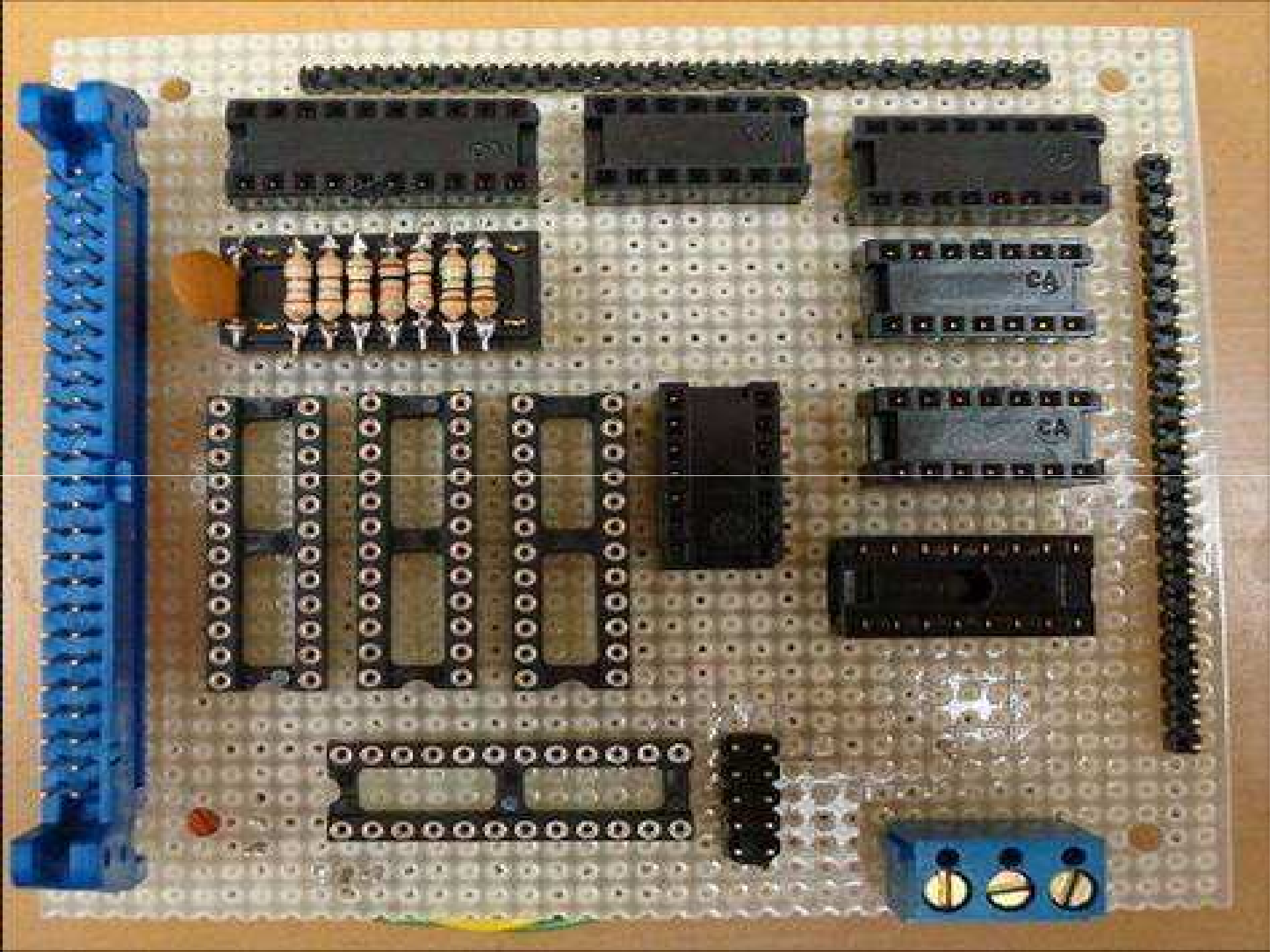


Truck Loading Using an Autonomous End-Loader

Senior Project Spring 2008

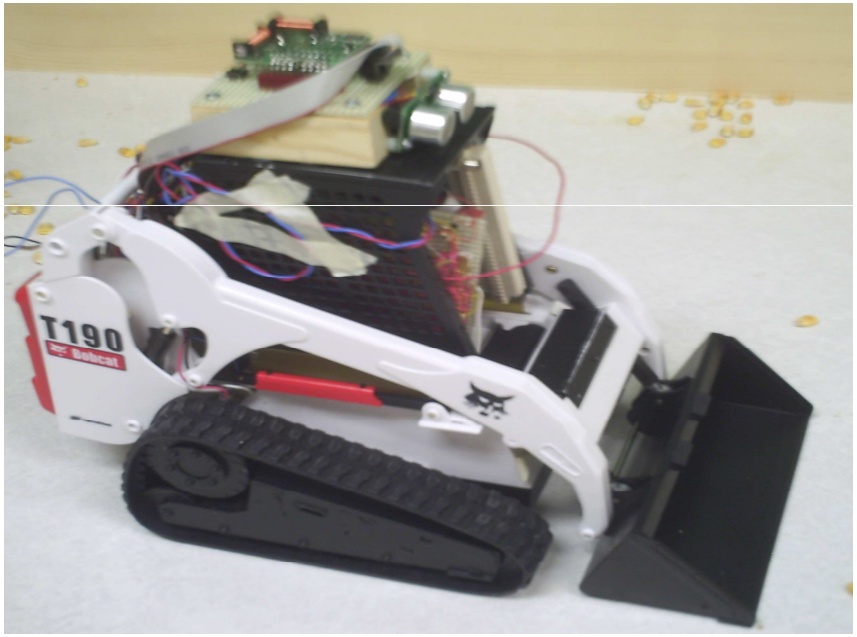
Kevin Hurley

Ryan Leman

Bradley University

EE 452: Senior Laboratory

Advisor: Dr. Schertz


T190
Bobcat

Overview

- Project Overview
- Project Goals
- Hardware
- Software
- Results

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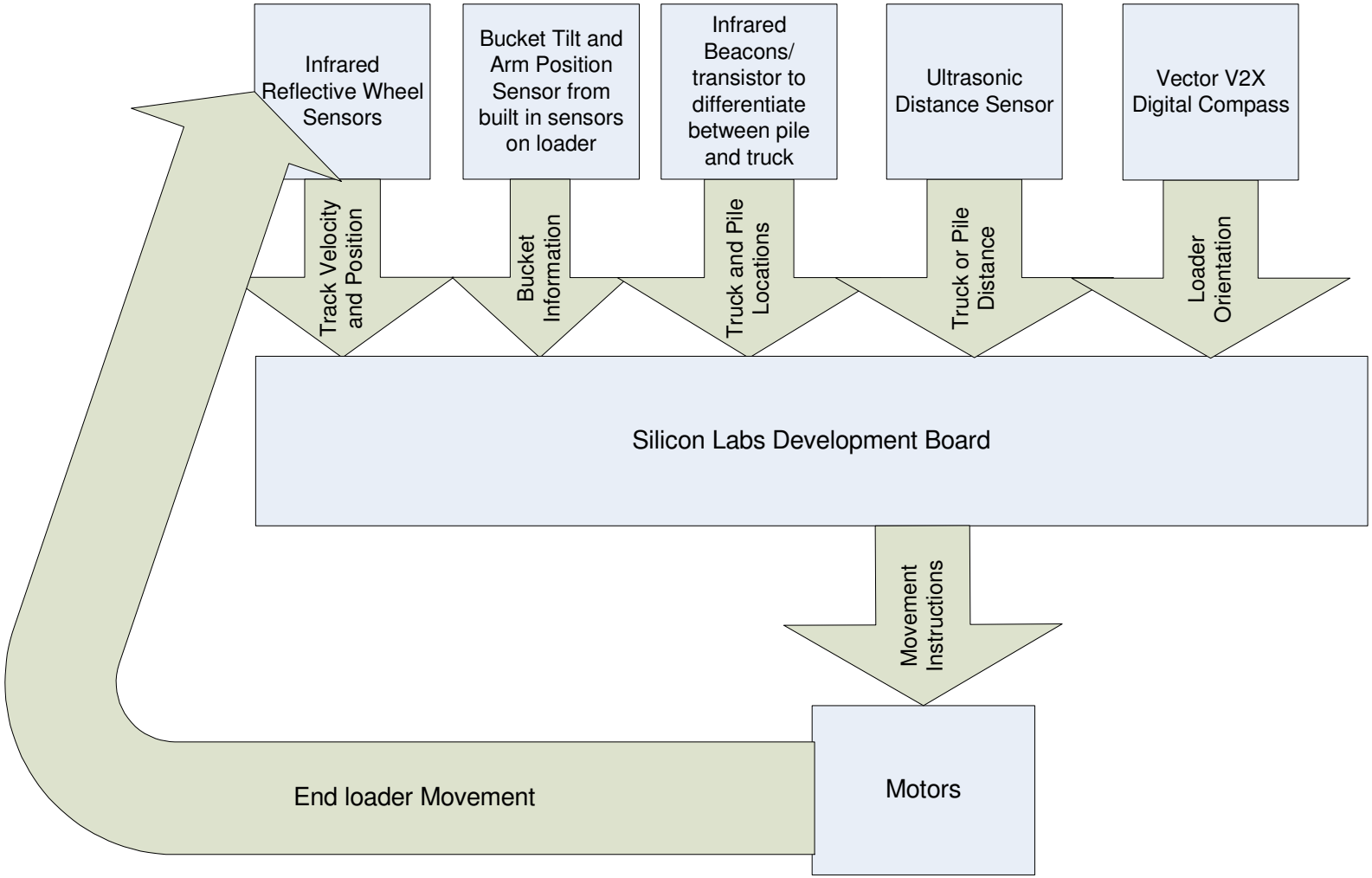
Overall System Block Diagram



Overview

- Project Overview
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Project Goals

- Hardware
  - Determine and Mount Sensors
    - Pile and truck identifiers
    - Distance sensors
    - Speed and vehicle distance
    - Direction/compass
  - Drive Electronics
  - Design and Implement Circuitry

Project Goals

- Software
  - Locate Pile
  - Navigate to Pile
  - Scoop a Load
  - Locate Truck
  - Navigate to Truck
  - Dump load in Truck

Overview

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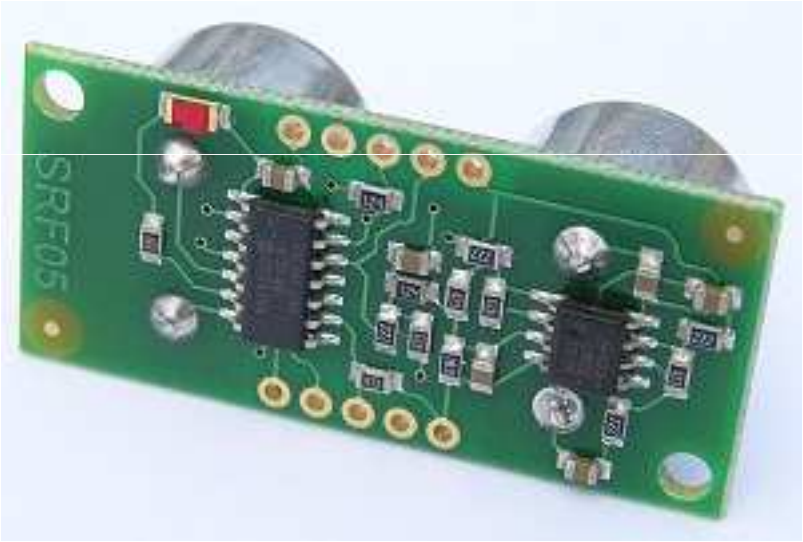
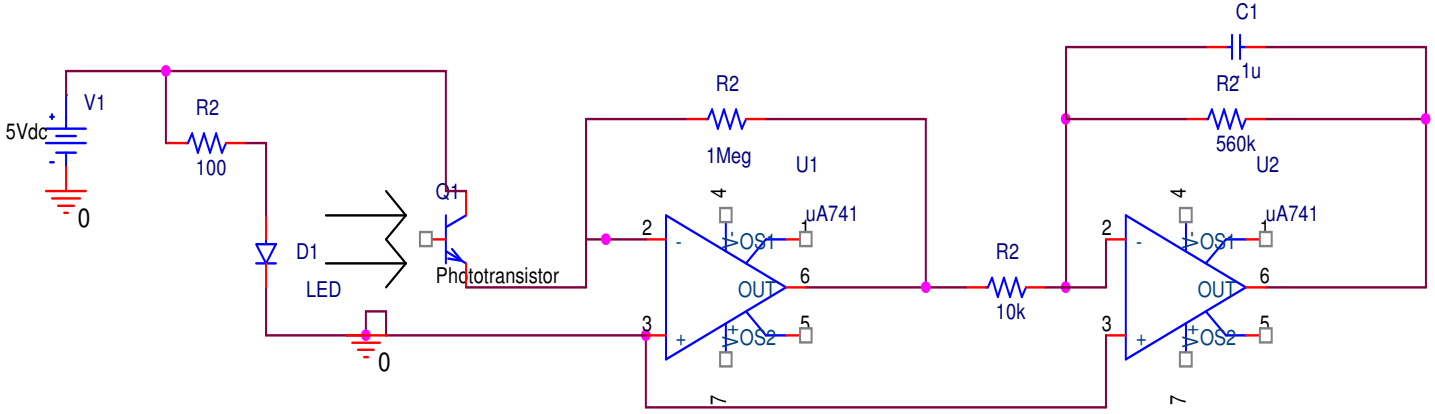
Ultrasonic Sensor

- SRF05 Ultrasonic Sensor
- Output is a pulse – the width in uS/148 = inches to object
- Accurate to around 4 feet, down to less than half of an inch
- On-board Testing



Infrared Beacons and Transistor

- Current to Voltage Converter
- High gain with LPF to limit noise amplification
- Increased range to 3 feet
- On-board Testing
  - Location
  - Shielding
- Schmitt Trigger to clean up signal to TTL output

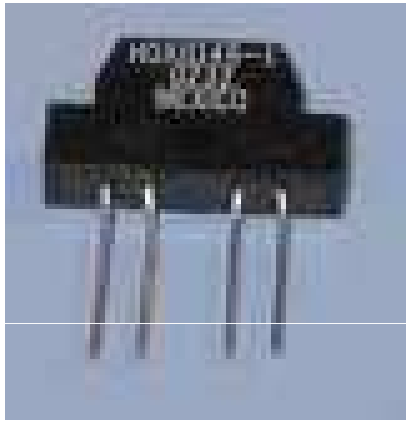


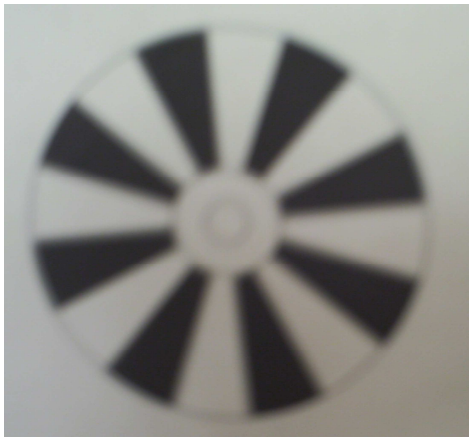
Vector V2X Digital Compass

- Direction to approach truck and load from
- Outputs pulse train based on clock output
- Accuracy Testing
- Mounting location

Infrared Reflective Sensors

- Current sensor (HOA010149-1) is smaller than original sensor - QRB1134
- Printed pinwheels to mount on wheel
- Schmitt trigger to clean up signal to TTL output
- Mounting location investigation





Vehicle Bucket Sensors

- Limit sensors included on vehicle will be used to stop bucket movement at limits
- AND the sensor output with the bucket drive command signal

Drive Electronics

- L293 Quad Half H-Bridge
- Allows control of motors with 0-5V PWM
- Outputs high current 7.2 V from battery to drive motors

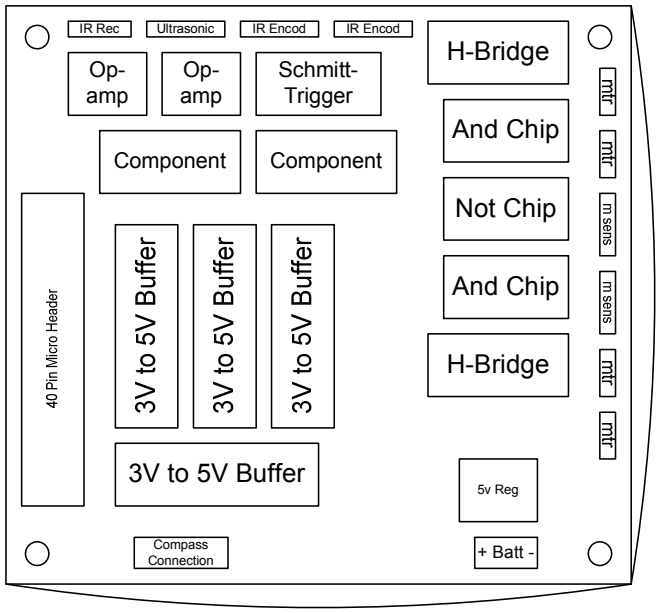
Voltage Regulation

- 4245A Bidirectional Translator
  - 3.3V to 5V
  - 5V to 3.3V
- MC7805 Voltage Regulator
  - 7.2V to 5V

Circuit Board Layout

- Designed board similar size to microprocessor
- Mounted inside modified cab of vehicle
- Compass mounted separately on top of cab
- Wire wrapping and solder used to complete circuitry

2 Boards:
Board 1: 4 " X 3.7 "
Board 2: 2.5" X 2.5"
Mounting holes shown in corners, not to scale



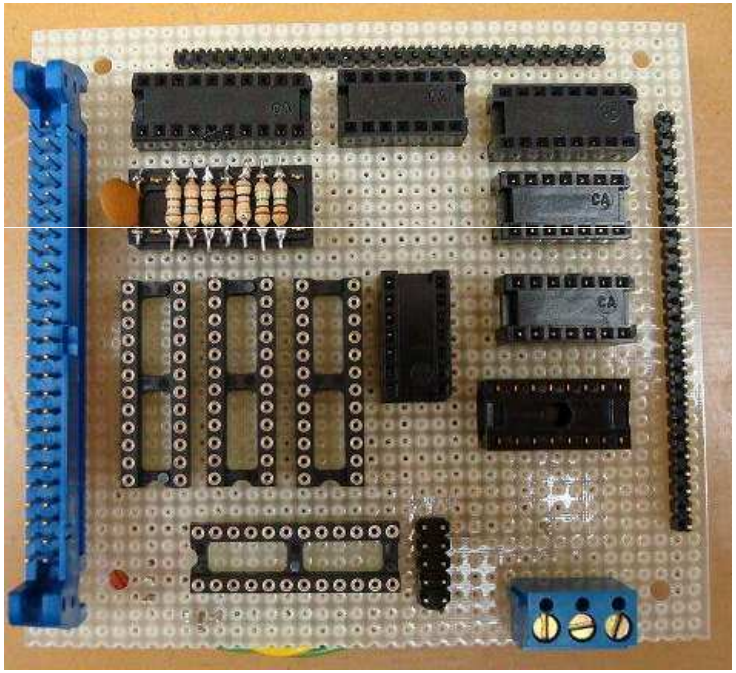
"Front" (Stick out of front loader)

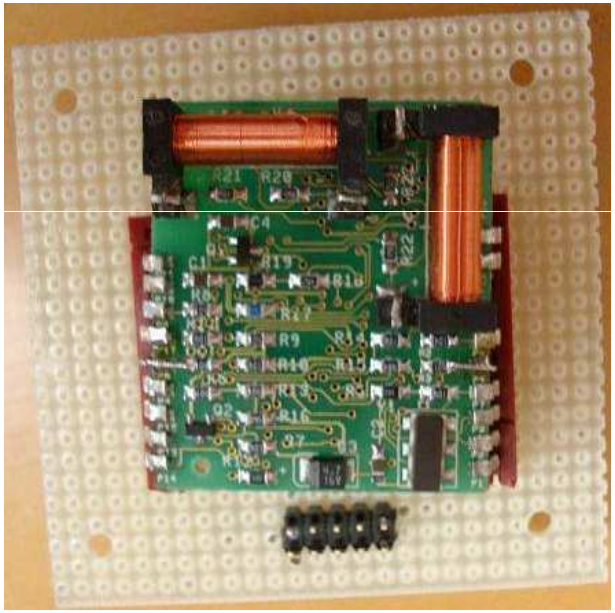
"Back" (Furthest inside vehicle)

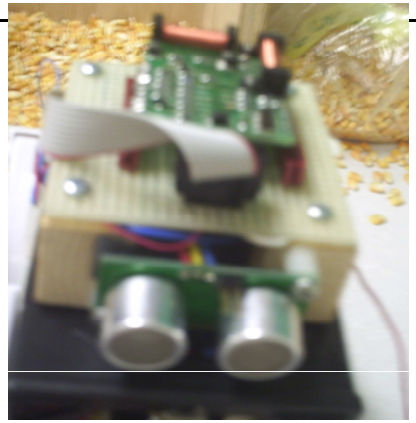
3.7"

4"

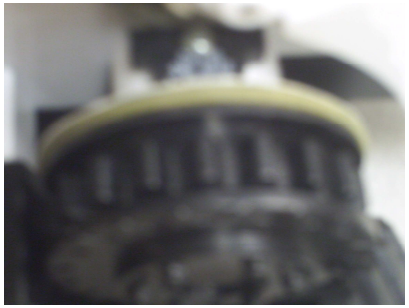
Circuit Board Layout

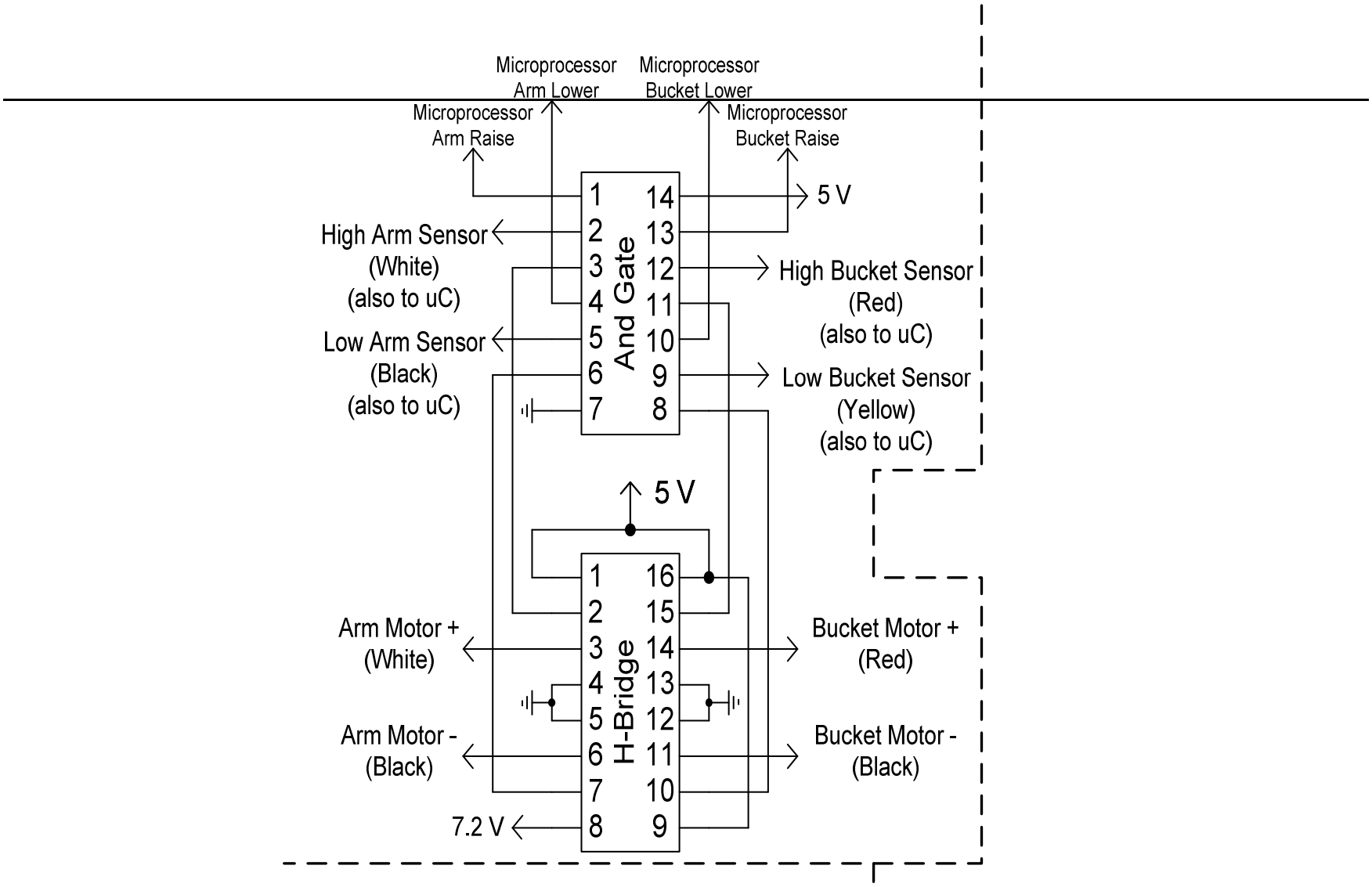


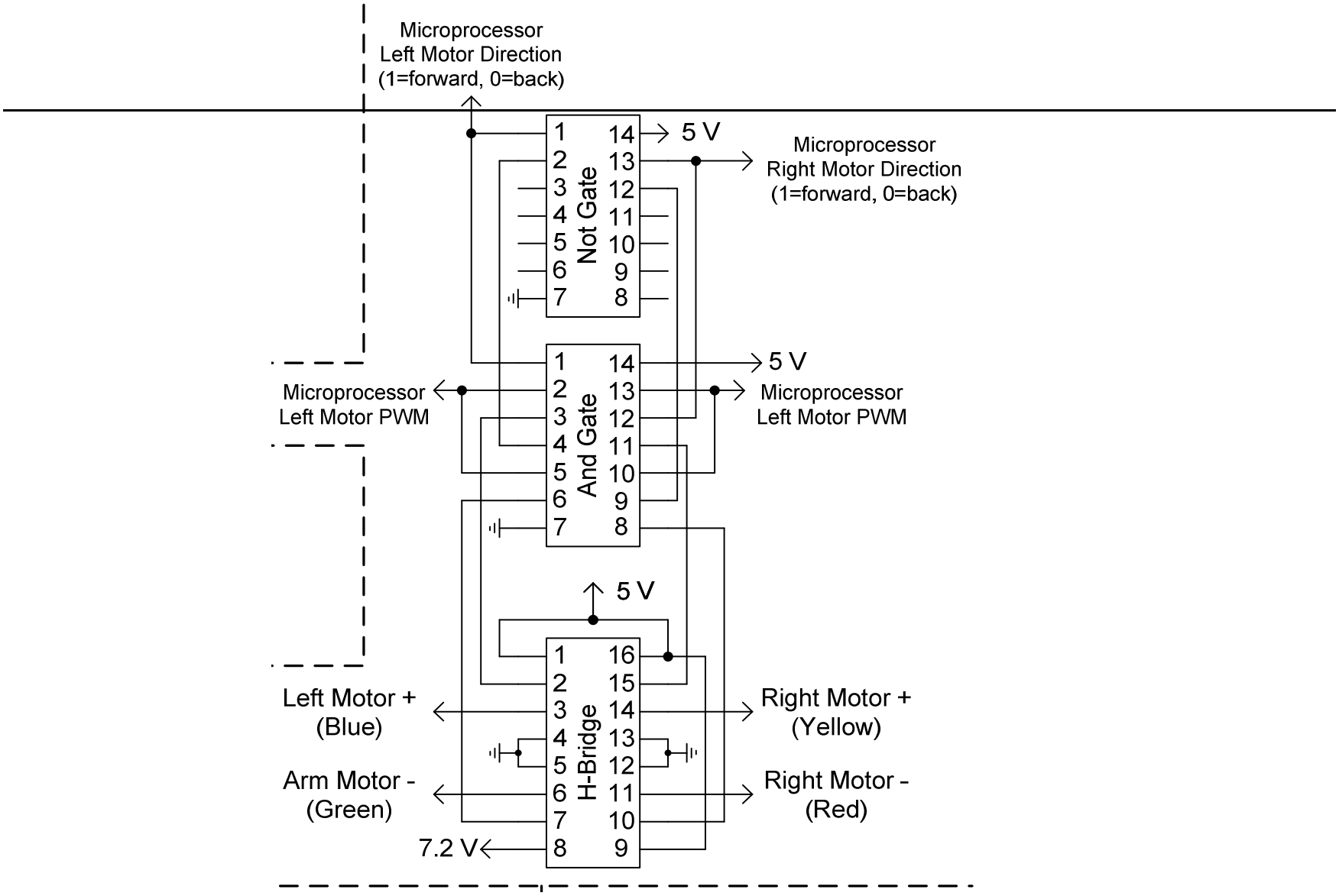


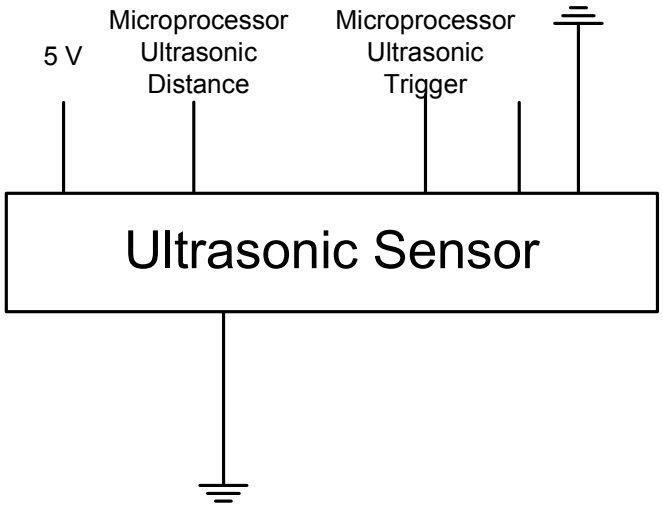


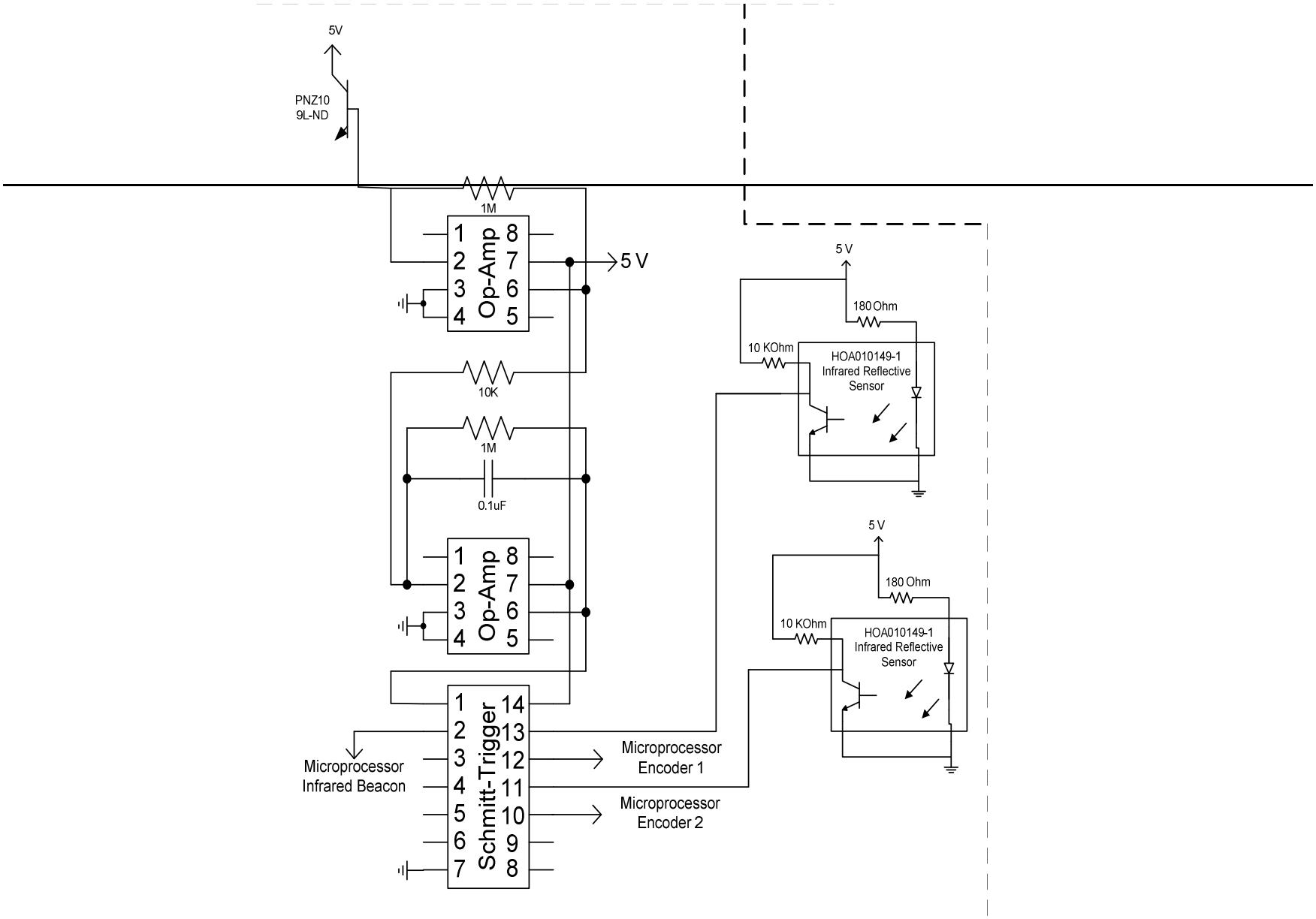

T190




Microprocessor
Arm Lower
Microprocessor
Bucket Lower
Microprocessor
Arm Raise
Microprocessor
Bucket Raise
1
2
3
4
5
6
7
14
13
12
11
10
9
8
And Gate
5 V
High Arm Sensor
(White)
(also to uC)
Low Arm Sensor
(Black)
(also to uC)
High Bucket Sensor
(Red)
(also to uC)
Low Bucket Sensor
(Yellow)
(also to uC)
5 V
1
2
3
4
5
6
7
8
16
15
14
13
12
11
10
9
H-Bridge
Arm Motor +
(White)
Arm Motor -
(Black)
7.2 V
Bucket Motor +
(Red)
Bucket Motor -
(Black)


Microprocessor
Left Motor Direction
(1=forward, 0=back)
Not Gate
1
2
3
4
5
6
7
14
13
12
11
10
9
8
5 V
Microprocessor
Right Motor Direction
(1=forward, 0=back)
And Gate
5 V
Microprocessor
Left Motor PWM
Microprocessor
Left Motor PWM
5 V
H-Bridge
16
15
14
13
12
11
10
9
Left Motor +
(Blue)
Arm Motor -
(Green)
7.2 V
Right Motor +
(Yellow)
Right Motor -
(Red)


5 V
Microprocessor Ultrasonic Distance
Microprocessor Ultrasonic Trigger
Ultrasonic Sensor


5V
PNZ10
9L-ND
1M
Op-Amp
5 V
10K
1M
0.1uF
Op-Amp
Schmitt-Trigger
Microprocessor
Infrared Beacon
Microprocessor
Encoder 1
Microprocessor
Encoder 2
5 V
180 Ohm
10 KOhm
HOA010149-1
Infrared Reflective
Sensor
5 V
180 Ohm
10 KOhm
HOA010149-1
Infrared Reflective
Sensor

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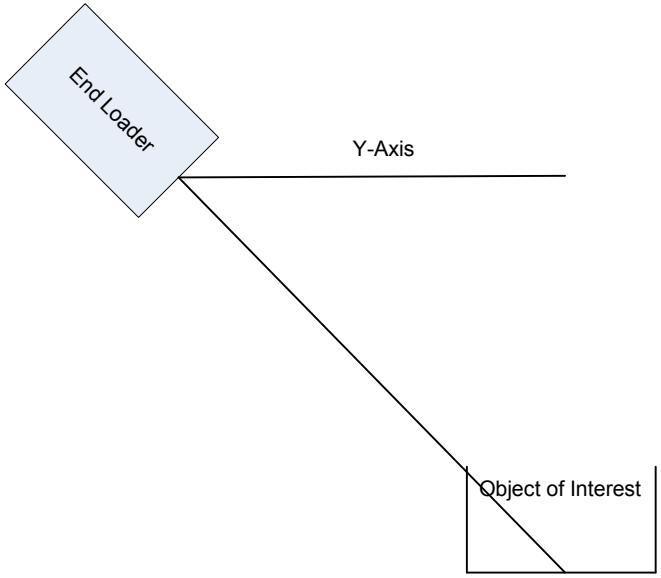
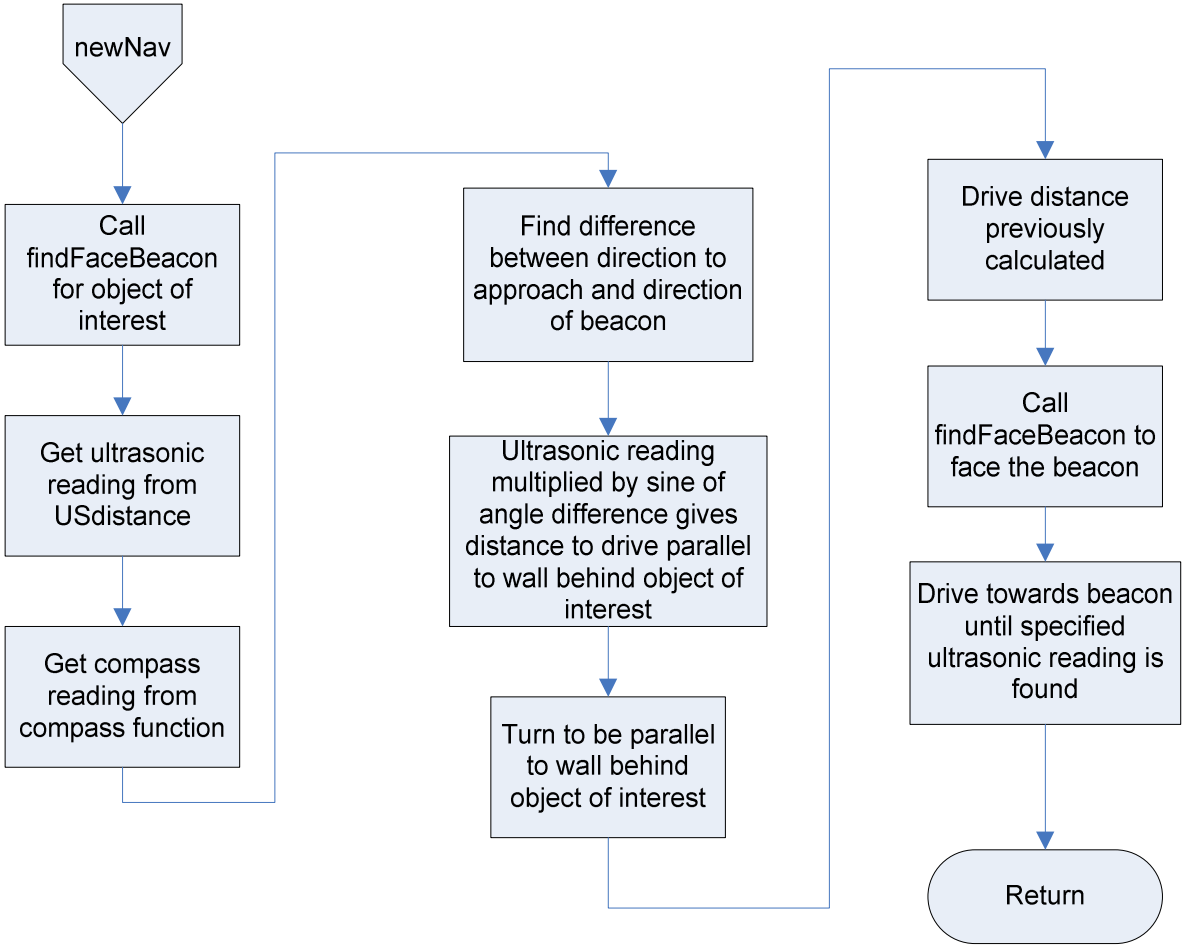
Function Overview: Navigation Routine

- Prior to function, a button press is used to indicate direction to approach load and truck
- Initially find where to drive to approach object of interest directly
  - findFaceBeacon
  - USdistance
  - Compass
  - Trigonometry
- Drive Y-Axis
- Drive X-Axis
  - Correction if beacon is lost
  - Scoop/Dump follows

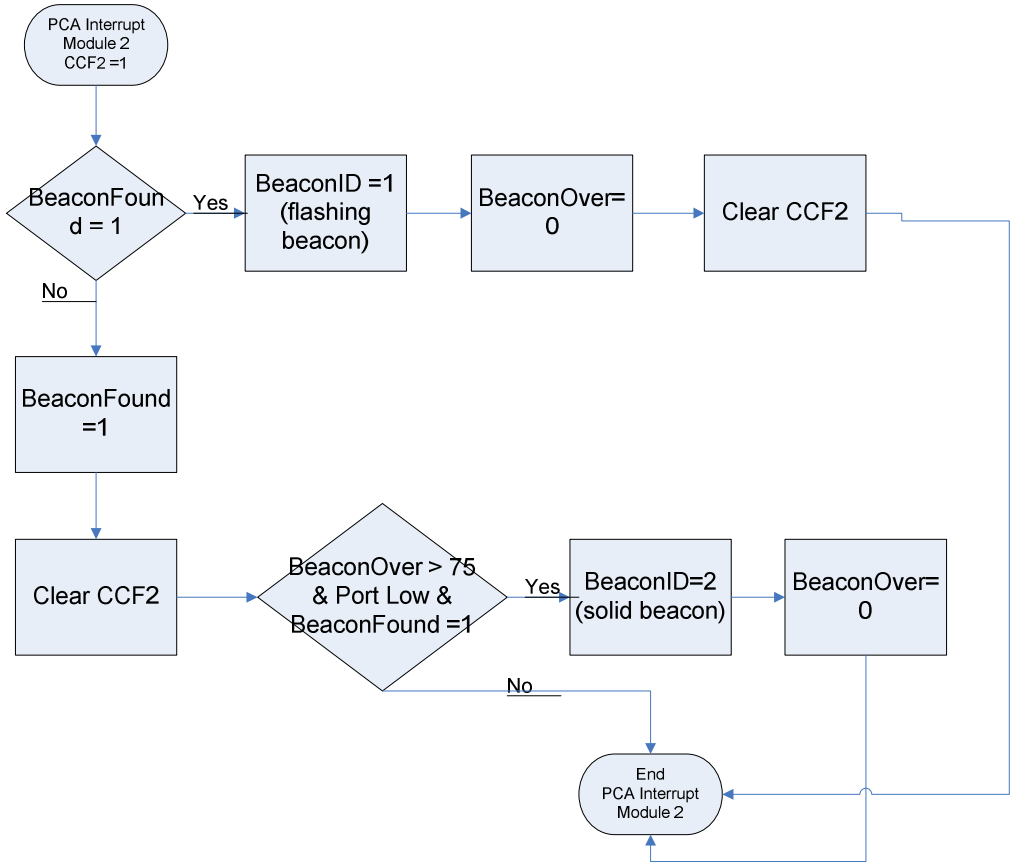


Navigation Routine Flow Chart



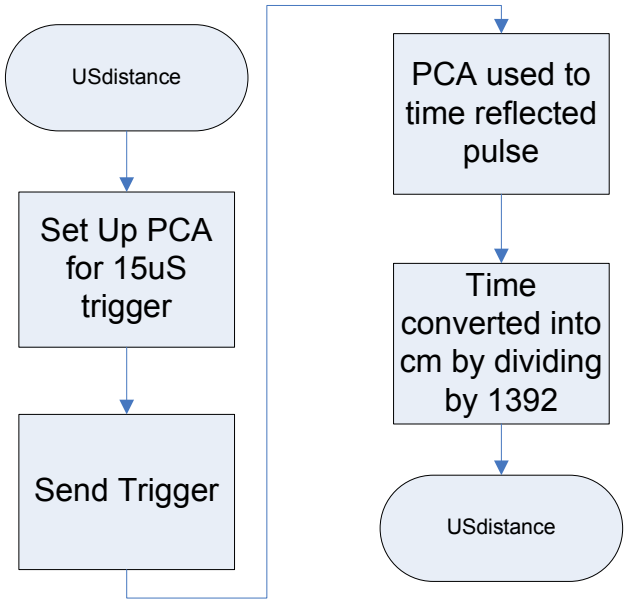
Function Overview: Beacon Locating

- Uses setPWM to rotate tracks in opposite directions
- Transition on PCA module 2
- Sets a flag
- Records overflows

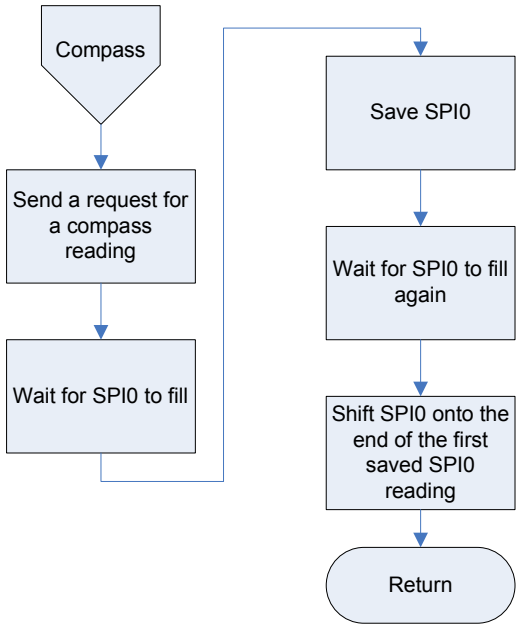


Function Overview: Distance Readings

- Signals ultrasonic range finder to take a reading
- Measures reflected pulse
- Converted to cm



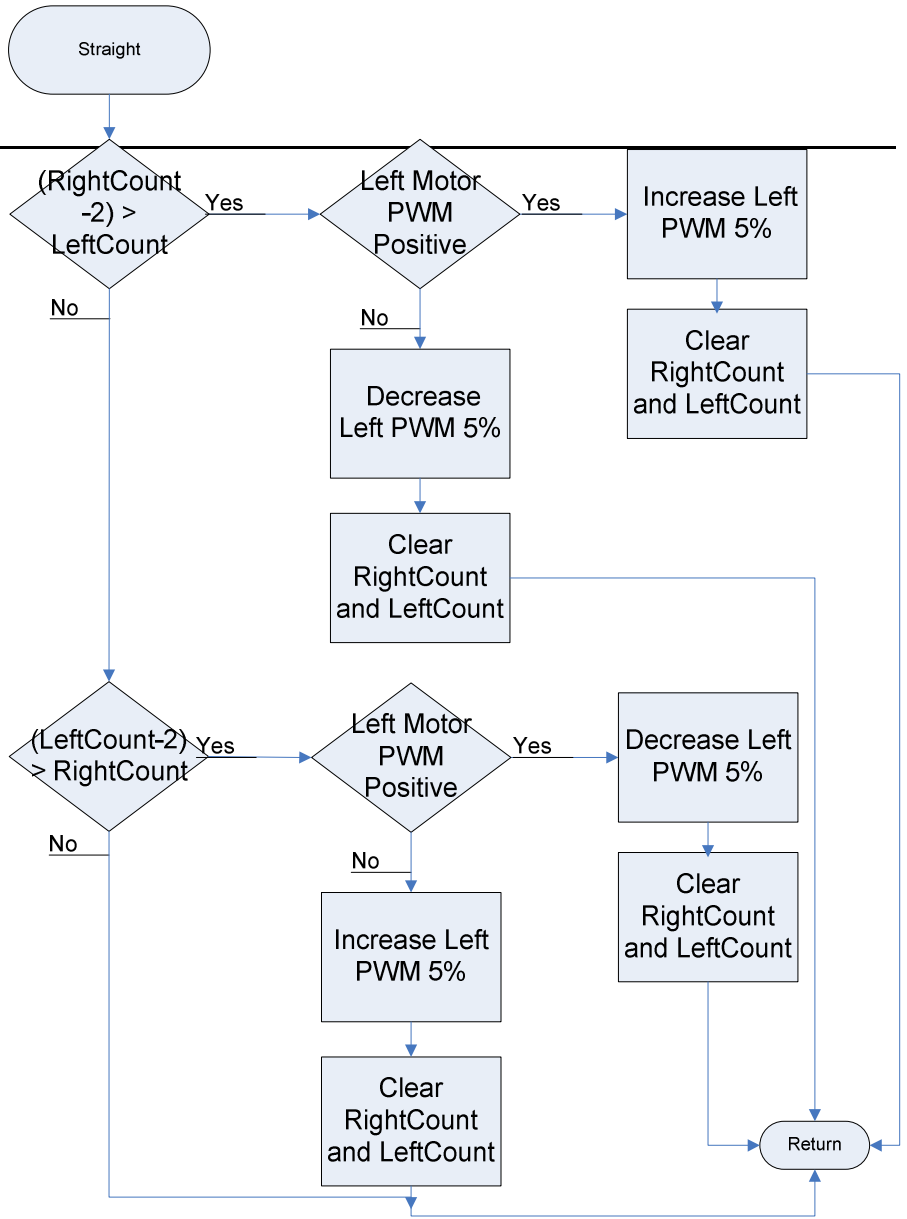
Function Overview: Orientation Information



- Requests compass reading
- Waits for serial peripheral interface buffer to fill
- Empties buffer
- Waits for buffer to fill again
- Combines to form a 16-bit reading

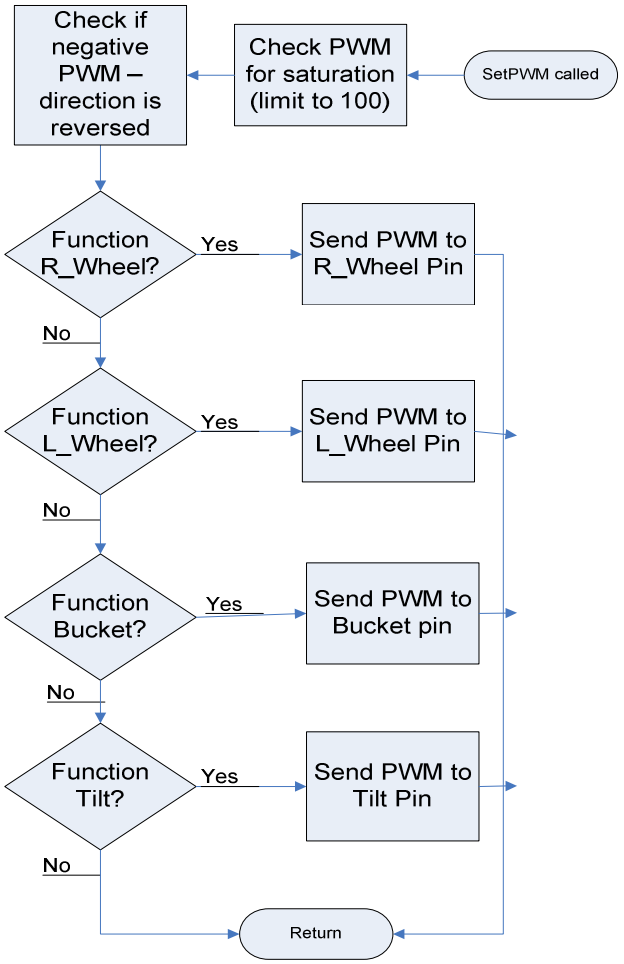
Function Overview: Infrared Reflective Sensors

- Tracks pulses
- Ensures vehicle drives straight
  - Watches pulses received from each track
  - Alters left track PWM



Function Overview: Motor Control

- Controls tracks with PWM
  - Forward or reverse
  - PCA modules 3 and 4 compare feature
- Controls bucket and tilt
- Turn off any motor



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WARNING: NOTHING TO OUTPUT

BFRAME DECODER LAG

Results and Conclusions

- Significant hardware development and troubleshooting time
  - Poor socket connections
  - Infrared beacon noise and limited range
- Finished with functional software
  - Compass readings easily altered by positioning of bucket, wires, etc.
    - Ensured consistent bucket positioning when compass readings are taken
    - Averaging for compass readings
  - Operates as expected
  - Can navigate when truck and load are not aligned with vehicle starting position

Future Expansion

- Image Processing
  - Removes Infrared LED issues
  - Allows for better navigation
- Cooperative vehicles
- Larger scale
- Web-based control

Questions