3-Point Hitch Controller
December 7

PEARL HARBOR
65TH ANNIVERSARY
Commemoration

DECEMBER 7, 2006

NEXUS
 CONTROLS
Presentation Overview

• Background Information
• Design Concepts
• Engineering Specifications
• Future Plans
Nexus Controls

- David Bevill, Bio-Mechanical Option
- E. Evans Chambers, Bio-Mechanical Option
- Lee Eldridge, Bio-Mechanical Option
- Adam Gossen, Bio-Mechanical Option

- Develop a functional, ergonomic, and innovative three point hitch controller
Introduction

• CNH is a leader in the agricultural and construction equipment industry
• Innovative needs of the future lead to the development of new products with latest technology
• CNH contacted OSU BAE Department to produce ground-breaking solutions for unique design challenges
Problem Statement

• Design and employ a three point hitch controller in order to maintain user defined implement position

• Design should involve minimal change to existing unit while functioning ergonomically

• Cost must be considerably lower than current optional laser guided control system
Statement of Work

• Select controlling mechanism to regulate 3 point hitch position to further the capabilities and performance of the Case 570 MXT

• Design shall include sensors to measure hitch position, controller to interface between sensors and laser system, and wiring, additional parts information, etc.
Patents & Market Research

- Patent 1: Towable Box Grader with Multi-Variable Axis
- Patent 2: Apparatus for Counteracting Vehicle Pitch Variation
- Patent 3: Dynamic Controller of Excess Down Pressure
- Patent 4: Hitch Control System with Spring Centered Lever

- Determined our intended design will not infringe upon current competitor machines
Customer Requirements

- Two modes of operation
  - Automatic
  - Manual
    - Manual control can over ride the automatic control function.

- Cost
  - Minimize
  - Off the shelf or in-house components
Customer Requirements Cont.

• Interface with existing system
  – Hydraulics
  – Electrical

• Down force capability
  – Controller mode must have down force like manual operation.
Design Concepts

• Potentiometer Location

Above: Picture of Rocker arm  
Right: Picture of Rocker arm pin and Potentiometer location

Pictures From CNH
Design Concepts Cont.

- Controller location
  - Inside the console
    - User interface on Console
  - Controller in a box hangs on ROPS
    - Pros: Easy to access and connect to machine.
    - Cons: Laser Controller box attaches at same position.
Design Concepts Cont.

• Safety
  – Controller would be inactive upon start of machine.
  – Set button
    • Must press the button after determining set point.
  – Resume button
    • Must press to return to Controller mode after using manual controls.
Design Concepts Cont.

• User input
  – Dial
    • Potentiometer
  – Cruise control method
    • Set the depth manually then press set button
    • Resume button to return to previous depth
• Unachievable set point
  – Controller depth setting is not reachable due to ground conditions.
  • Pump would go over relief
    – Oil would heat up
  • Rear of machine would lift up
    – Decrease in traction of rear tires
Design Concepts Cont.

• Laser controller and Potentiometer with controller on same machine.
  – Require a special wire harness to connect both options.
  – Would need a switch to select between the two systems.
  – Note: These options can not be used together at the same time!
Potentiometer

- Actual Device
- Actual Circuit Diagram
- Effective Circuit Diagram

http://en.wikipedia.org/wiki/Potentiometer
Potentiometer

- Linear Resistance
- Rate Change
  Voltage/Degree

\[ V_w = \Theta \left( \frac{5V}{150^\circ} \right) = \Theta \left( 0.033 \frac{V}{^\circ} \right) \]
Controller

• Output

\[
\text{Output}(t) = K_p \left( e(t) + K_{ip} \int_0^t e(\tau) d\tau + K_{dp} \frac{de}{dt} \right)
\]

• Accuracy – 12 Bit A/D

\[
\text{Voltage Increment} = \frac{5V}{2^{12}} = .0012 \ V \approx 1mV
\]
Height = f(Voltage)

(Idealized Case)

Angle Accuracy = \((0.001v) \div \left(0.0333\frac{v}{\circ}\right) = 0.03\)

\[\Delta H_{box} \approx 3 \text{ ft} \times \sin(\Delta \Theta_{box}) \approx 3 \text{ ft} \times \sin\left(\frac{1}{3} \Delta \Theta_{measured}\right)\]
Pulse Width Modulation

- Valve accepts PWM
- %ON/%OFF
- Mass of Spool/Stable Position
- Flow Rate Control
Solid State Device

- M.O.S.F.E.T
- Additional Drivers - Solenoid Current
- Applicable to “A” and “D”
- Allows for PWM

http://en.wikipedia.org/wiki/Mosfet
Circuitry

Dial Input

SET

CPU

P. S. = 5V

DC

5V

Sensor

Valve

P. S. = 5V

NEXUS CONTROLS
Recommended Solution

- Tri-Logic PLC Controller
  - For Testing & Design
  - Built-in PID Function
  - Multiple IO
  - Inexpensive & Robust

Reference Tri-Logic
Recommended Solution (cont’d)

• Input
  – 1 potentiometer for reading position
  – On/Off, Set, and Resume Functions
  – Manual control input (Already Provided)

• Output
  – PWM to control hydraulic system
  – Possible analog/digital gauge for set point and/or current position
Controller Logic & Simulation

- Controller logic will be very similar to that of an automotive cruise control
  - Logic will be developed in a flow chart
  - Programmed into controller using BASIC

- System will be simulated in Matlab
Future Schedule

- 1/1/07-1/30/07: Familiarize with machine & order parts
- 1/30/07-2/30/07: Build and install prototype
- 2/30/07-3/30/07: Implement, test, and debug controller
- 3/30/07-Finished: Finish up testing, make ready for presentation
## Proposed Budget

<table>
<thead>
<tr>
<th>Part</th>
<th>Estimated Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potentiometer</td>
<td>$50.00</td>
</tr>
<tr>
<td>Pin Kit</td>
<td>$15.00</td>
</tr>
<tr>
<td>Controller</td>
<td>$125.00</td>
</tr>
<tr>
<td>Pressure Transducer</td>
<td>$35.00</td>
</tr>
<tr>
<td>Boss &amp; Cover</td>
<td>$50.00</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$275.00</strong></td>
</tr>
</tbody>
</table>
Acknowledgements

Mr. Wayne Kiner
Dr. Marvin Stone
Dr. John Solie
Dr. Paul Weckler
Members of CNH
Any Questions?