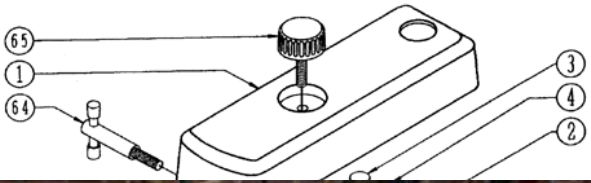
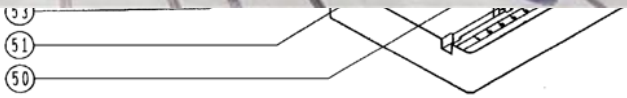
Boeing's Laser Multiplex System

Group 34
Wei Keong Eiew, Lei Jin & Nan Wang
ECE445 Senior Design
April 26, 2012

Motivation

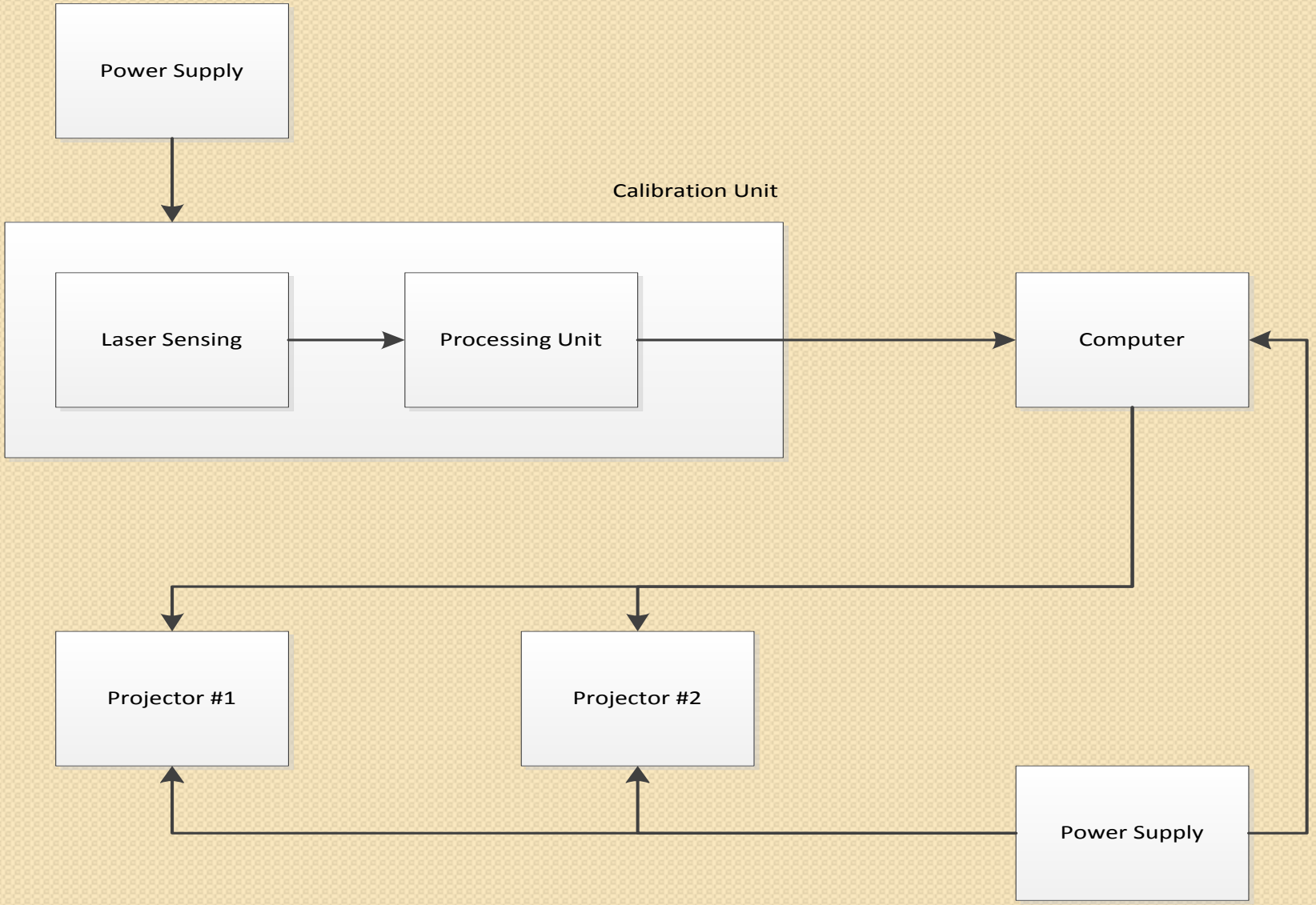




Objective

- The system can have both the accuracy of laser projectors and the speed of optical projectors
- A projection system that uses two laser projectors to display animation
- A calibration system to detect correct alignment of the two projectors

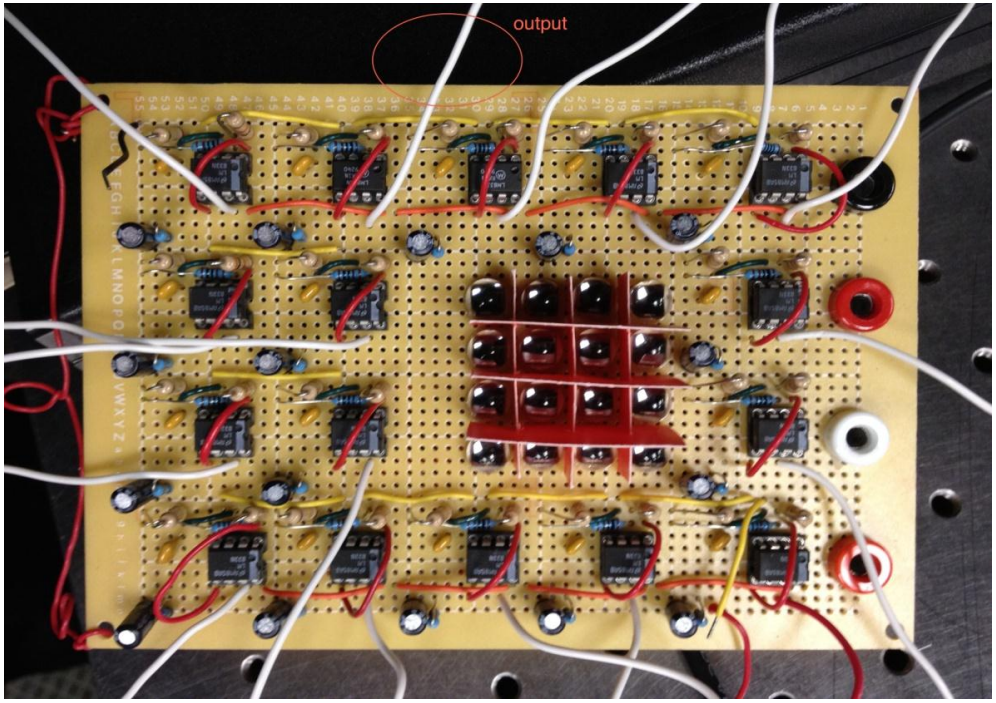
Block Diagram



Calibration Unit

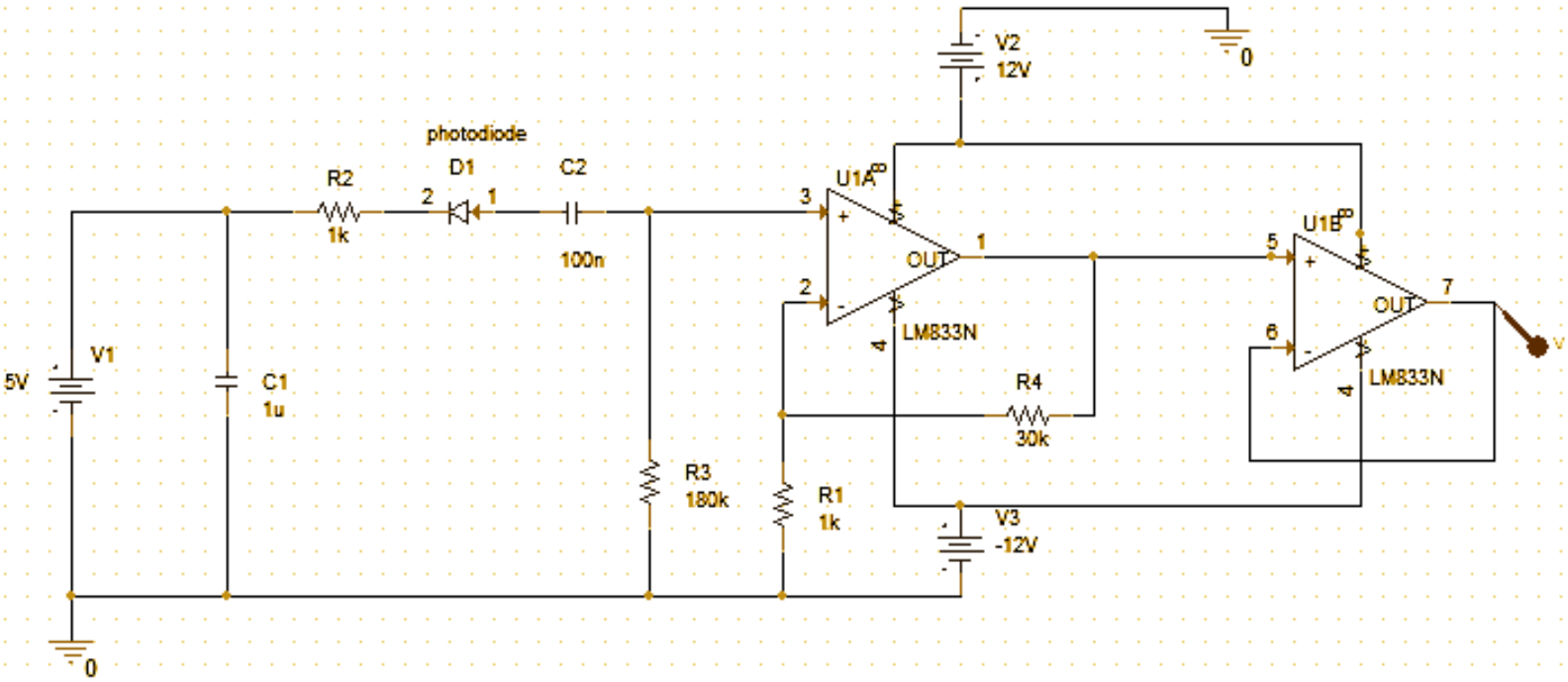
- Test pattern sent to projectors
- Shine laser on sensing circuit
- Signal output to the microcontroller
- Analyzed data to the computer
- Results display on the monitor

Photodiode Sensing Circuit



- 5V, 12V and -12V power in
- Photodiodes produce current
- 16 analog signals send to microcontroller

Photodiode Circuit Schematic



- Decoupling capacitor = 1uF
- 1k resistor protecting photodiode
- Cut-off frequency 8.8 Hz

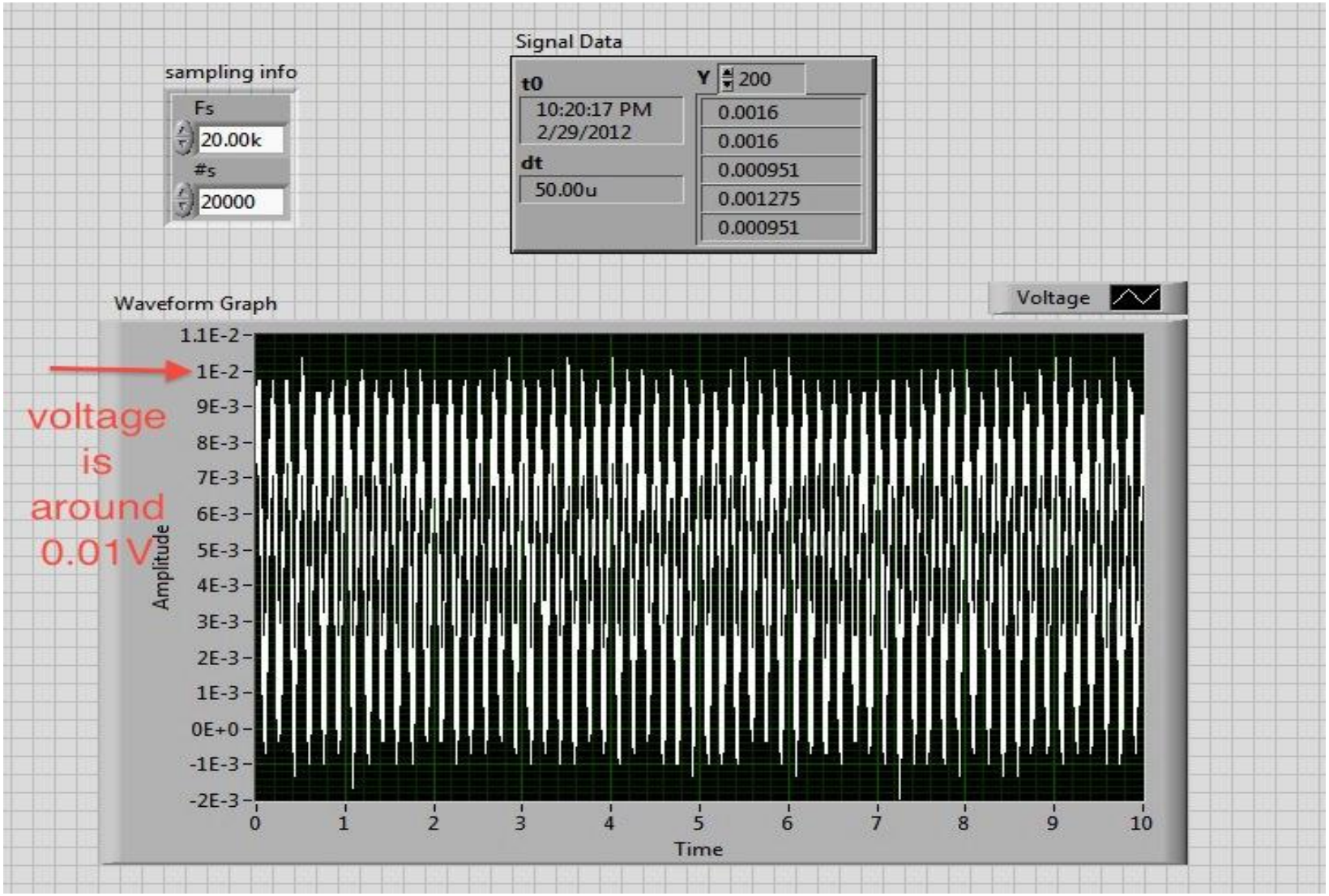
- Voltage amplifier with DC gain =30
- Buffer stage

Limitation-Resolution

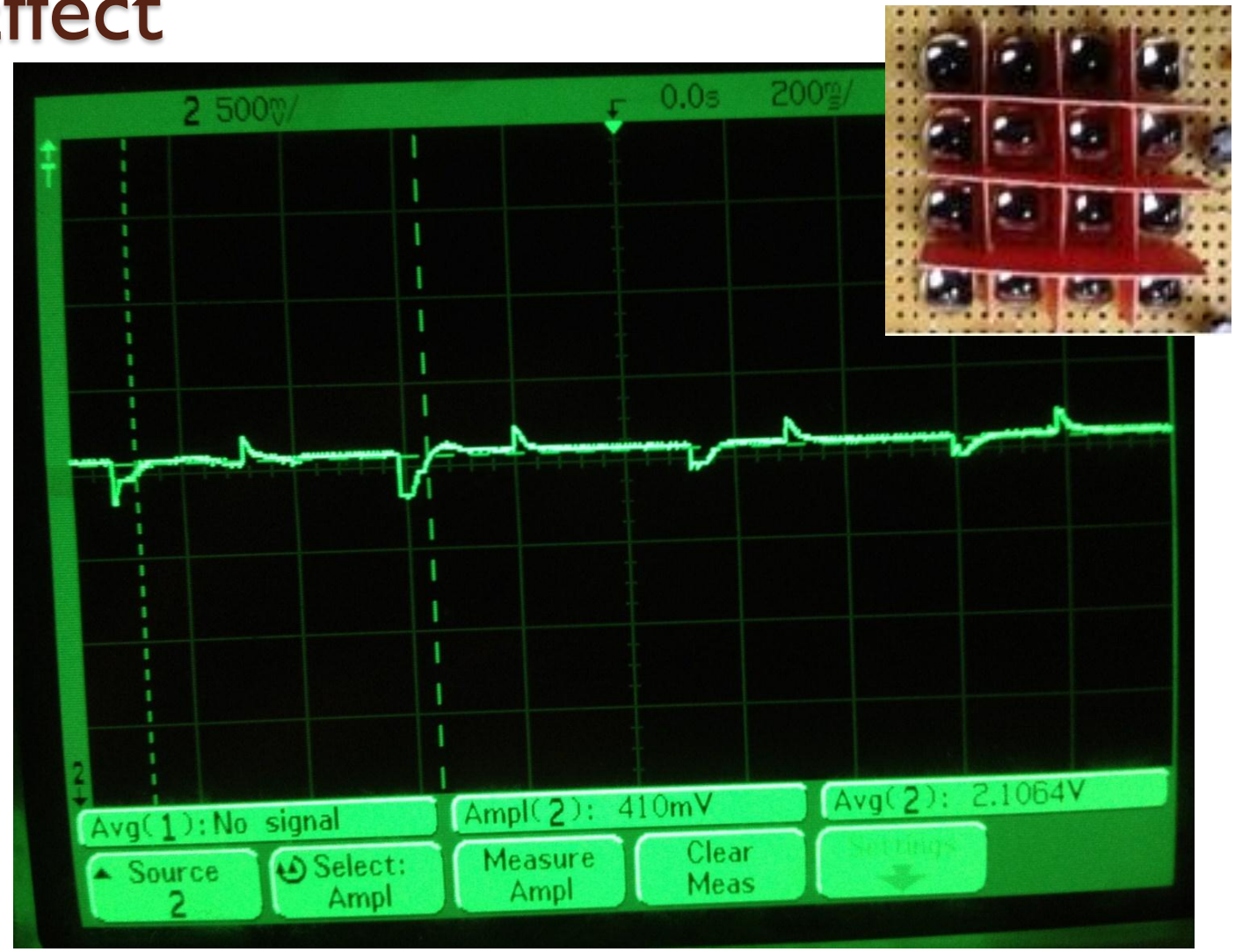
- Minimum detected length is 0.4 inch
- Maximum detected area is

  0.4 inch X 0.4 inch = 0.16 inch^2

Voltage Output under Natural Light with DC Block

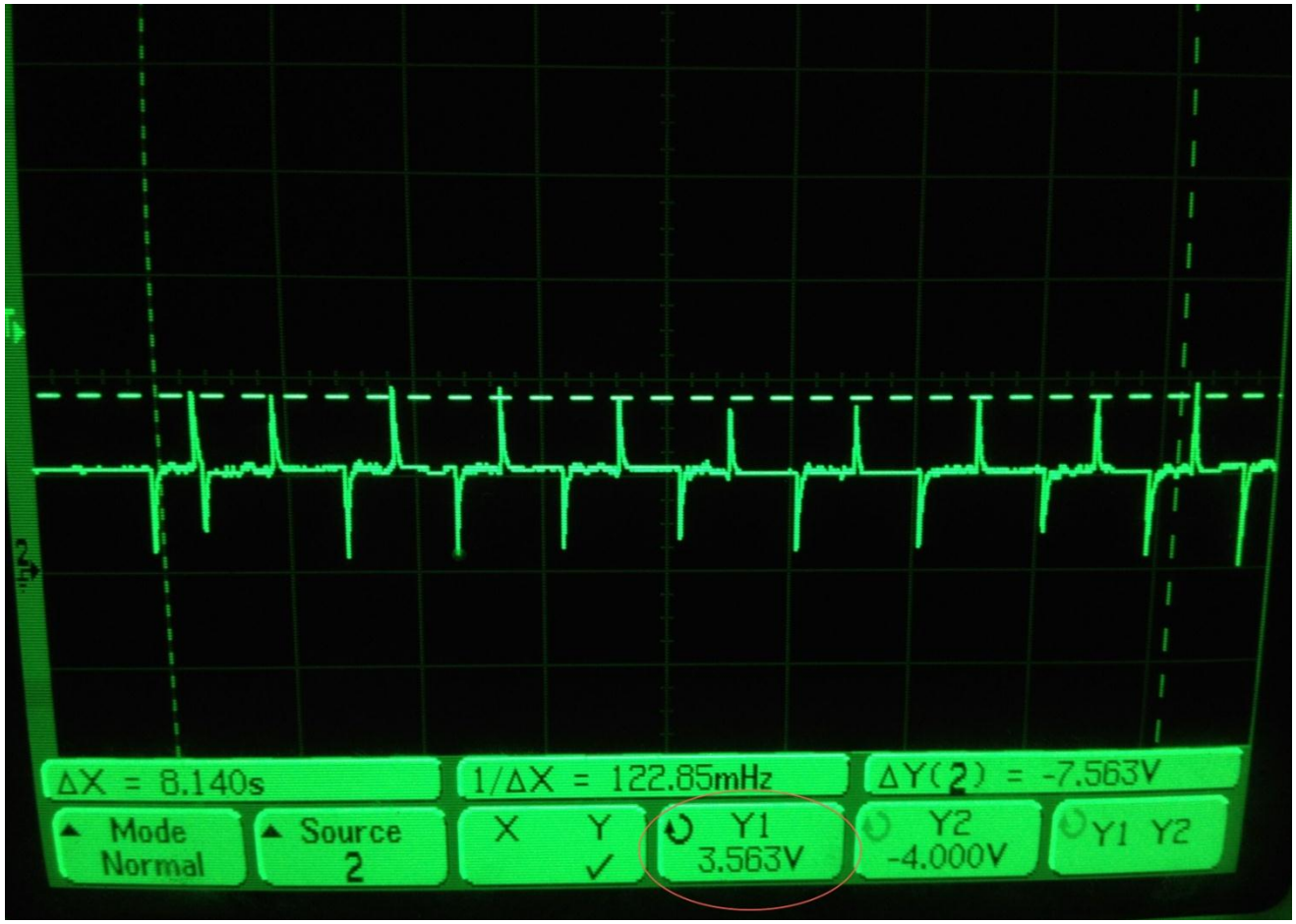


Cross-Section Boards Reduce Laser Effect



$V_{affect} = 2.5V$ $V_{affect-new} = 0.41V$

Voltage Output When Laser Shining On



$$V_{laser} = 3.563V$$

Processing Unit

- Consists of three PIC18F4550 chips
- The 16 analog outputs are connected to two of the PICs (13 outputs to 1st PIC; 3 outputs to 2nd PIC)
- The 3rd PIC – provides a square wave with a frequency of 0.25Hz (named Clk) to the two PICs

Cont.

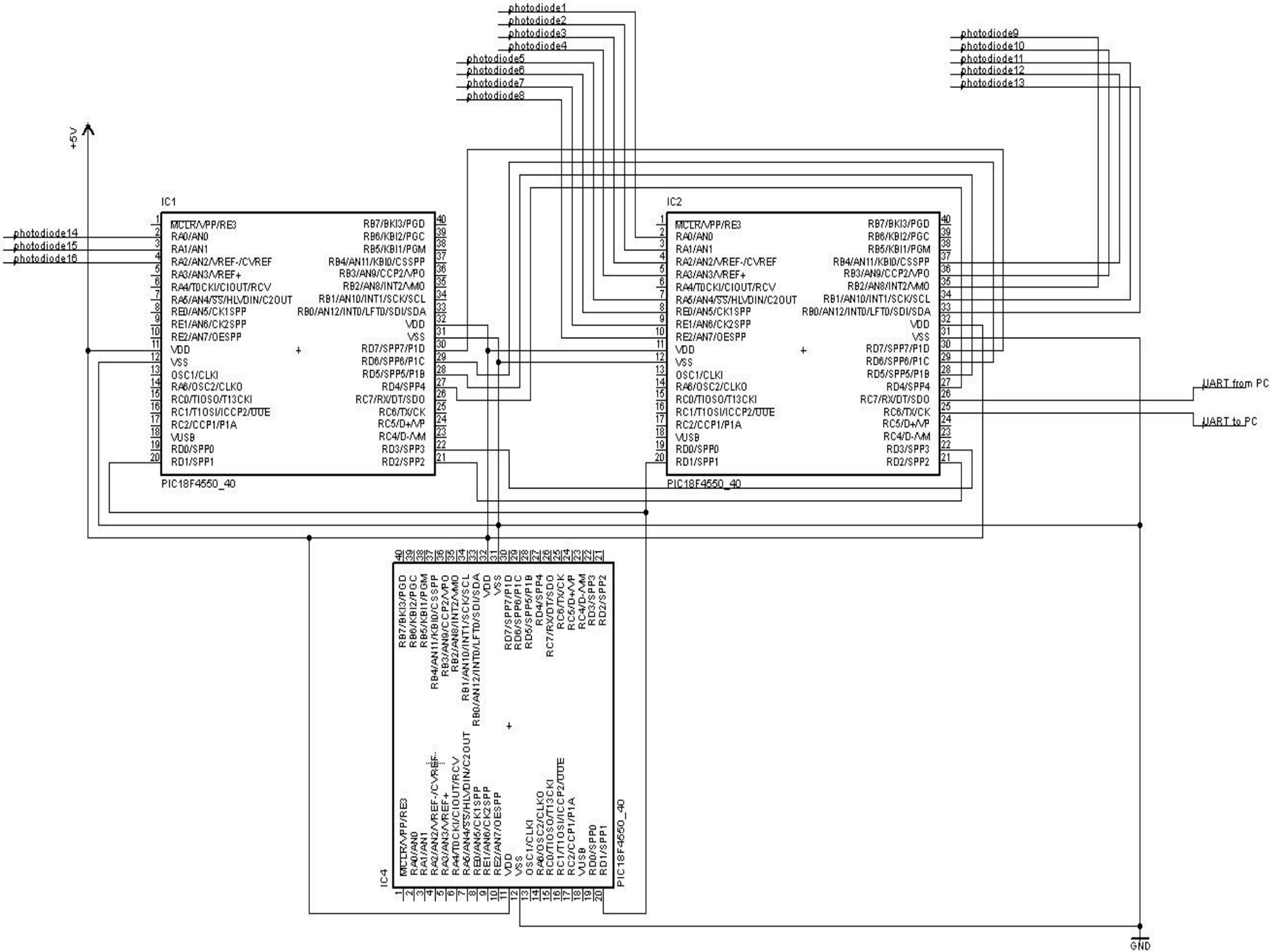
- The PICs count the total number of transitions from logic 0 to logic 1 when Clk is high for each analog input.
- Threshold voltage were all set at 3.4V
- However, each output from photodiodes has different voltage level (with laser presence or without laser)

Why count transitions?

- Because the lasers will be tracing a pattern at some frequency
- In order for this to work:
- The two lasers should trace a same pattern
- One of the lasers should trace at a frequency which is a multiple of the other laser's frequency
- They should start tracing at different starting coordinates

Cont.

- After number of transitions are known, the corresponding case is determined
  - Case 1: laser 1 traced through
  - Case 2: laser 2 traced through
  - Case 3: both lasers traced through
  - Case 4: no laser traced through
- A variable is used to store the result for each photodiode


photodiode1
photodiode2
photodiode3
photodiode4
photodiode5
photodiode6
photodiode7
photodiode8
photodiode9
photodiode10
photodiode11
photodiode12
photodiode13
+5V
IC1
IC2
photodiode14
photodiode15
photodiode16
MCLR/VPP/RE3
RA0/AN0
RA1/AN1
RA2/AN2/VREF-/CVREF
RA3/AN3/VREF+
RA4/T0CKI/C1OUT/RCV
RA5/AN4/SS/HLVDIN/C2OUT
RE0/AN5/CK1SPP
RE1/AN6/CK2SPP
RE2/AN7/OESPP
VDD
VSS
OSC1/CLKI
RA6/OSC2/CLKO
RC0/T1OSO/T13CKI
RC1/T1OSI/ICCP2/UOE
RC2/CCP1/P1A
VUSB
RD0/SPP0
RD1/SPP1
RB7/BKI3/PGD
RB6/KBI2/PGC
RB5/KBI1/PGM
RB4/AN11/KBI0/CSSPP
RB3/AN9/CCP2/VPO
RB2/AN8/INT2/VMO
RB1/AN10/INT1/SCK/SCL
RB0/AN12/INT0/LFT0/SDI/SDA
VDD
VSS
RD7/SPP7/P1D
RD6/SPP6/P1C
RD5/SPP5/P1B
RD4/SPP4
RC7/RX/DT/SDO
RC6/TX/CK
RC5/D+/VP
RC4/D-/VM
RD3/SPP3
RD2/SPP2
PIC18F4550_40
UART from PC
UART to PC
IC4
GND

Between Processing Unit and PC

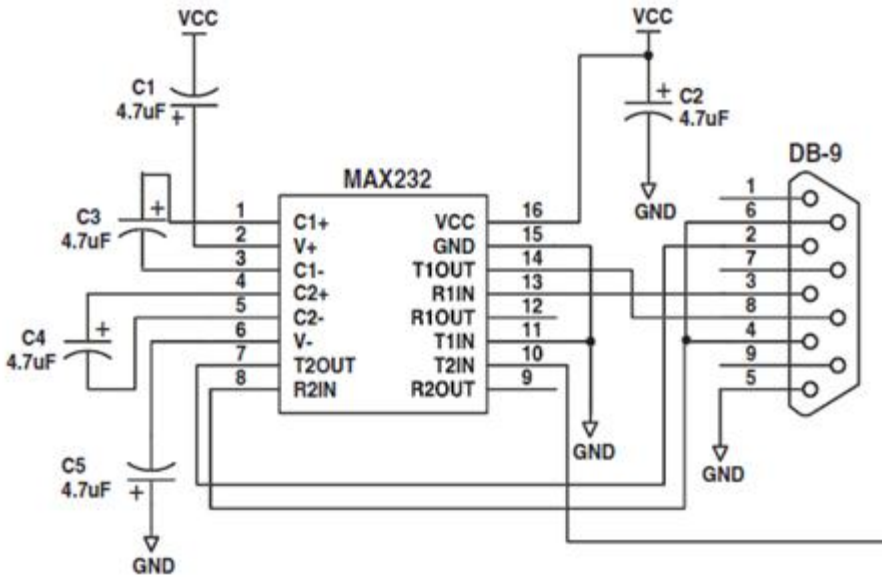
- 8 bit/ asynchronous mode
- 9600 baud rate
- 19 bytes of data
- Start byte: 0xff

  Next 16 bytes: 4 bits(coordinates)
  4 bits(case result)

  18th byte: 0x00 or 0x01 (indicate if aligned)

  Last byte: 0xff

- MAX232 is used to convert UART data such that the data can be read by a standard RS232-port



Serial Port Data Convention

Start Byte	Color Byte 1 to 16	Status Byte	Stop Byte
0xff	*See Interpretation *	0x01 or 0x00	0xff

Color Byte Interpretation:

- Higher 4 bits represents the number of photodiode
- Lower 4 bits represents the lighting condition of the current photodiode

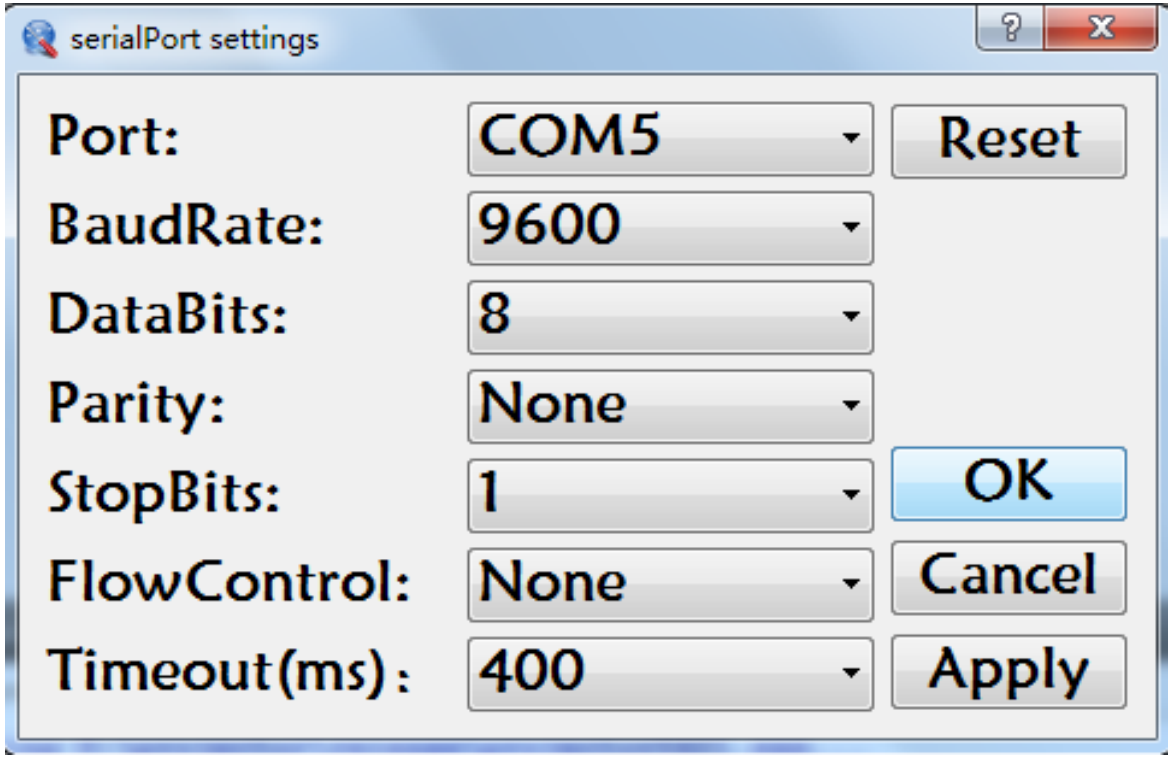
  0000 = Grey : No laser light is shining on the current photodiode
  0010 = Green: Both lasers are projecting on the current photodiode
  0100 = Blue: Only laser 2 is projecting on the current photodiode
  1000 = Red: Only laser 1 is projecting on the current photodiode

Limitation

- Cannot precisely control the scanning frequency of the Laser projector by software
- Each laser projector does not exhibit identical refresh rate at each time
- One of the newer model have significantly larger refresh rate than the older one

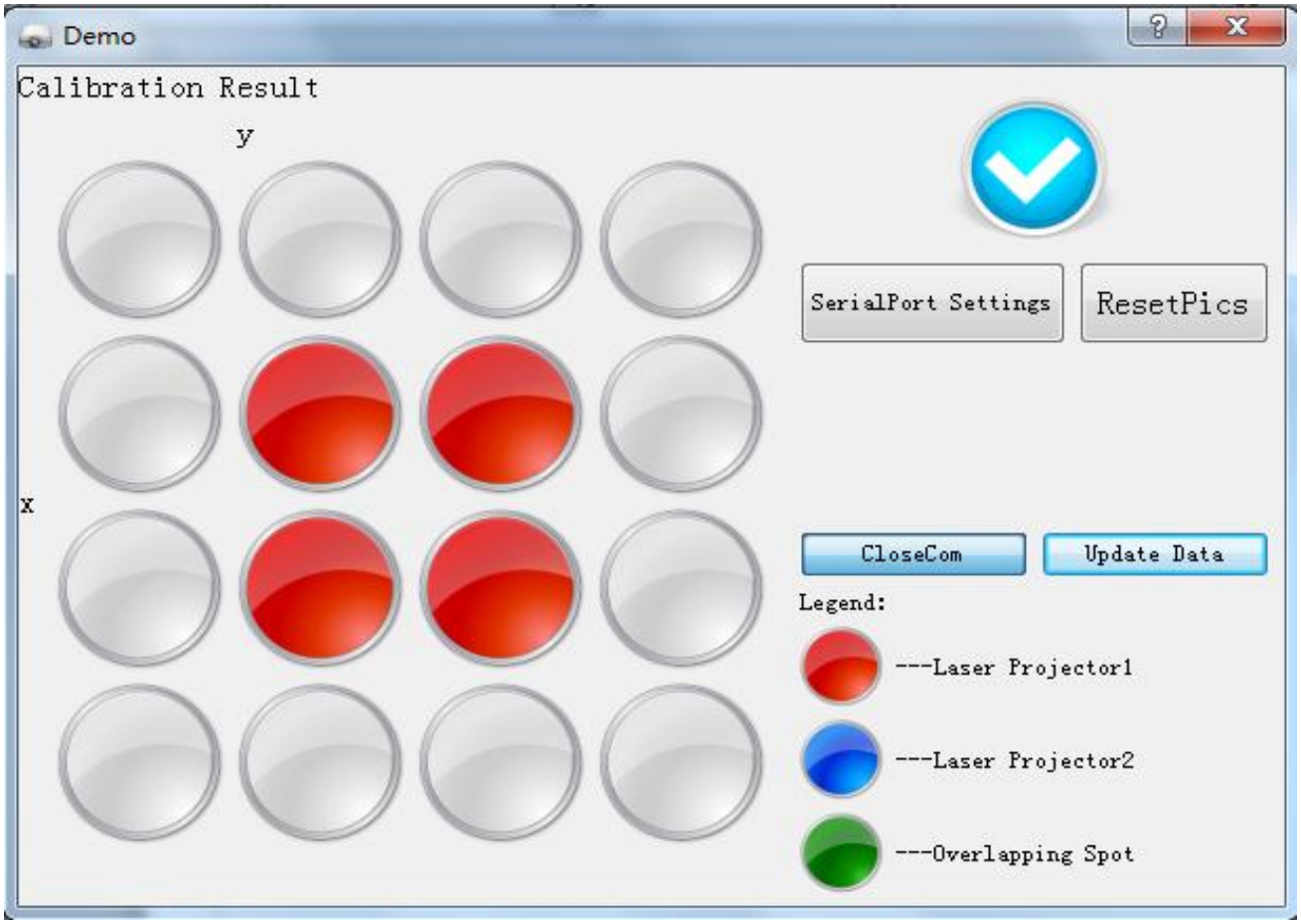
Therefore, two laser projectors have to be calibrated separately.

Graphical User Interface



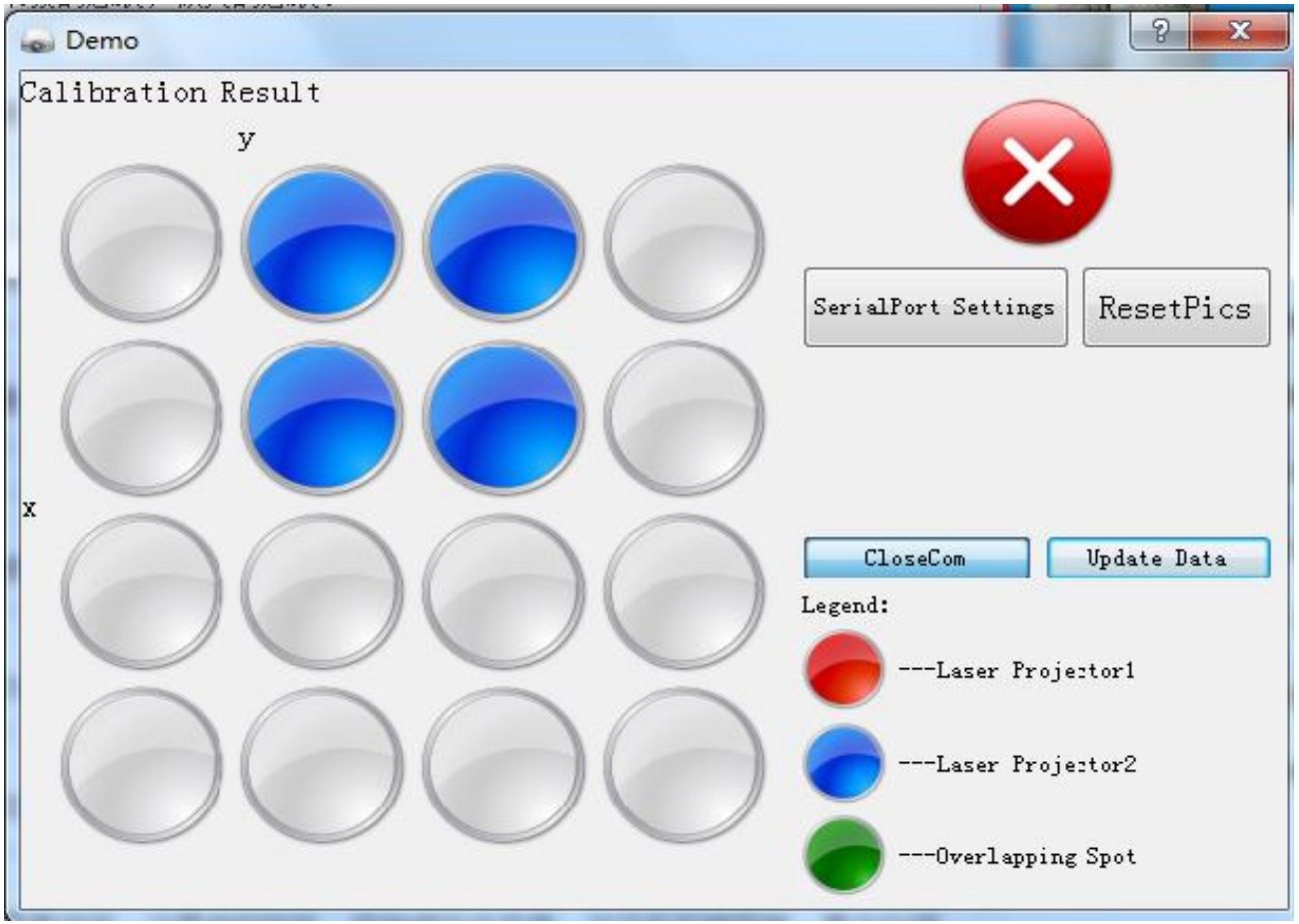
Setting up Serial Port Connection

Graphical User Interface

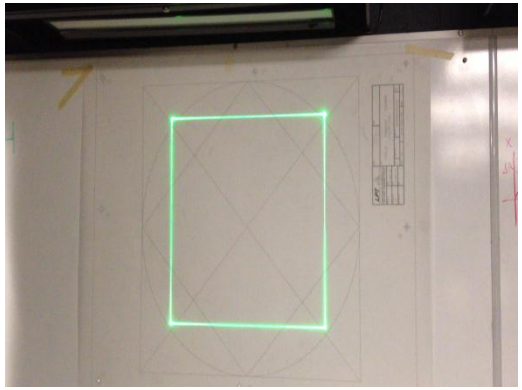


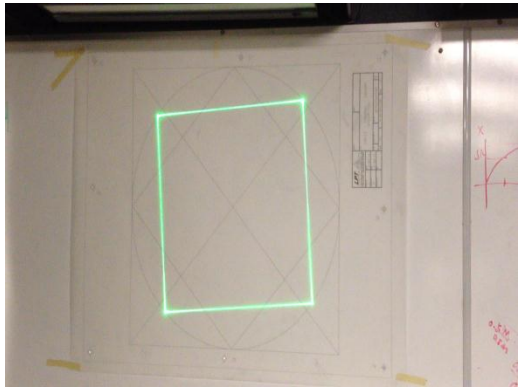
Laser Projector 1 is aligned correctly

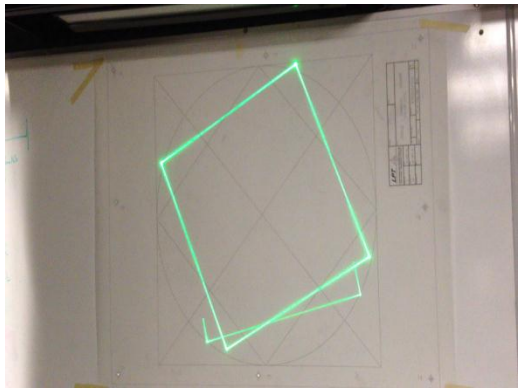
Graphical User Interface



Laser Projector 2 is misaligned



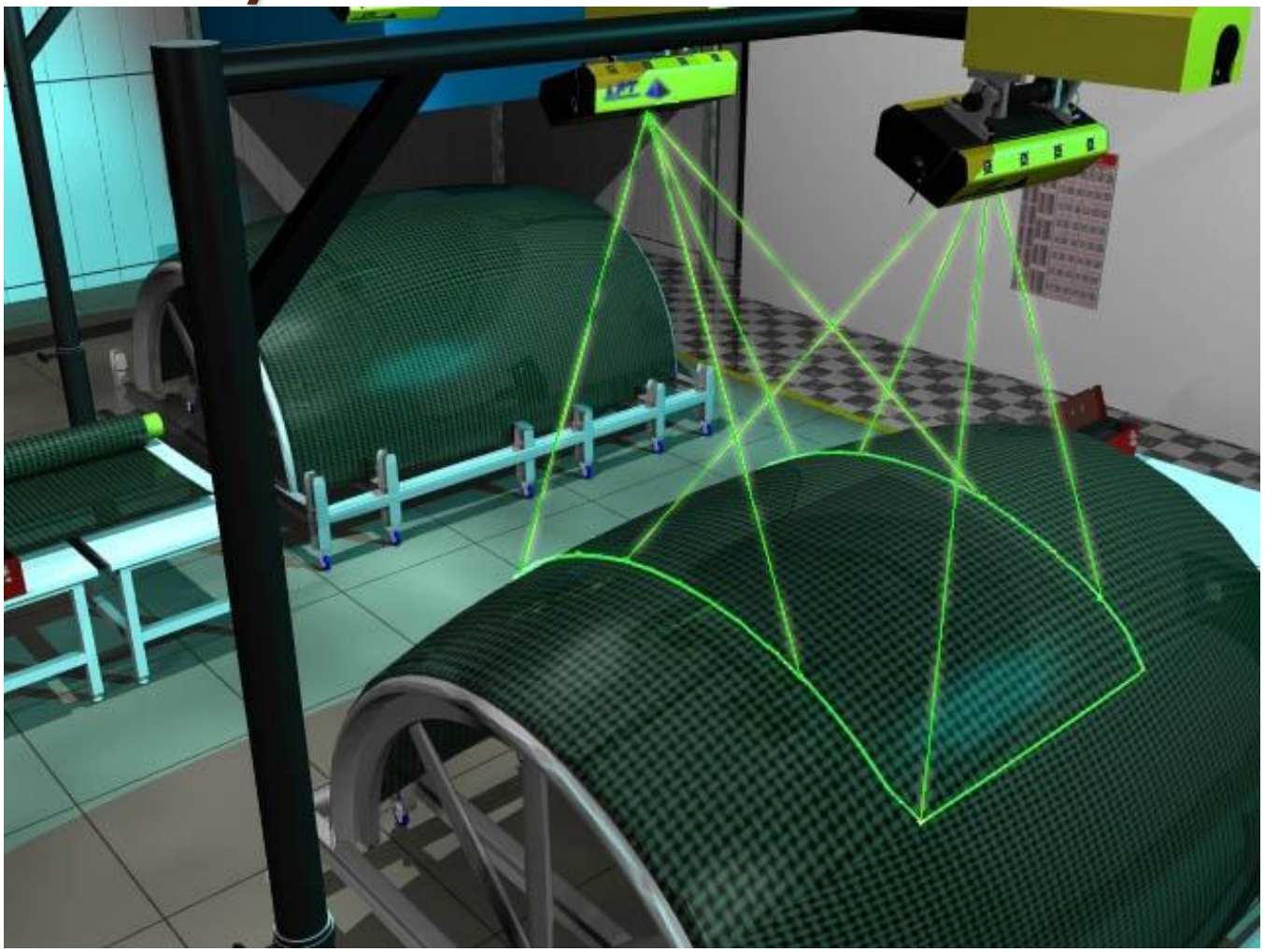




Accomplishments

- A Calibration unit that helps align two laser projectors
- Control the laser projectors through a PC using a JAVA API

Application:
Assembly Instruction Animation



Credits

- Professor P. Scott Carney
- Jane Tu
- Parts Shop Personnel
- Alex Suchko
- Philip Freeman, Phillip Tillman & Kenneth Owens from the Boeing Company


thank you!