Interactive Proximity Donor Wall Illumination

Team 18
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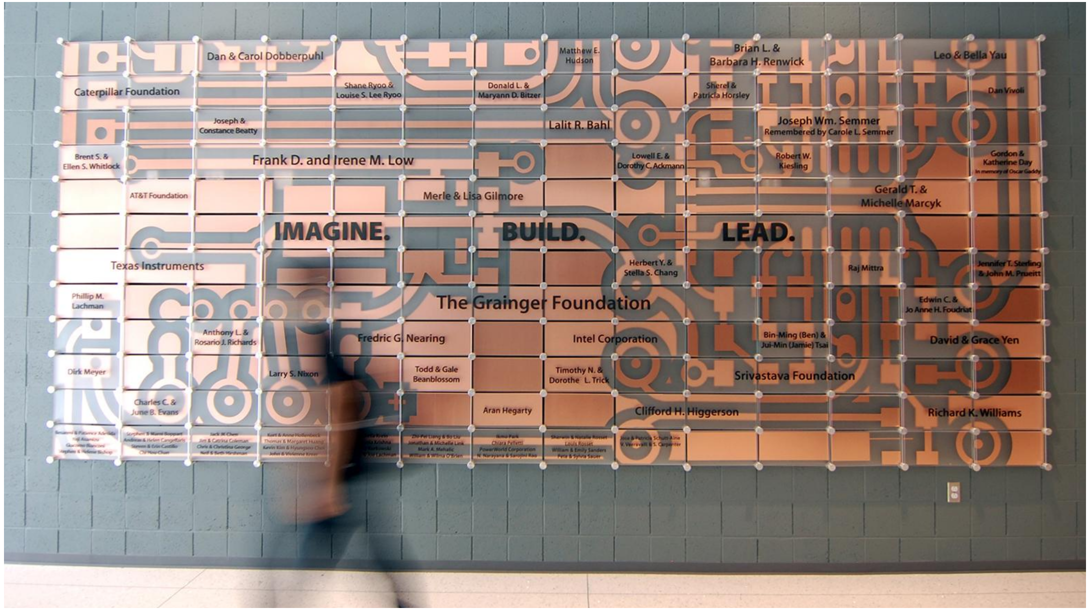
Agenda

- Introduction, Objective and Result
- Block Diagram
- Design and Validation
  - Physical Model
  - Microcontroller
  - Sensor
  - Power
- Conclusion
- Future Work

Introduction

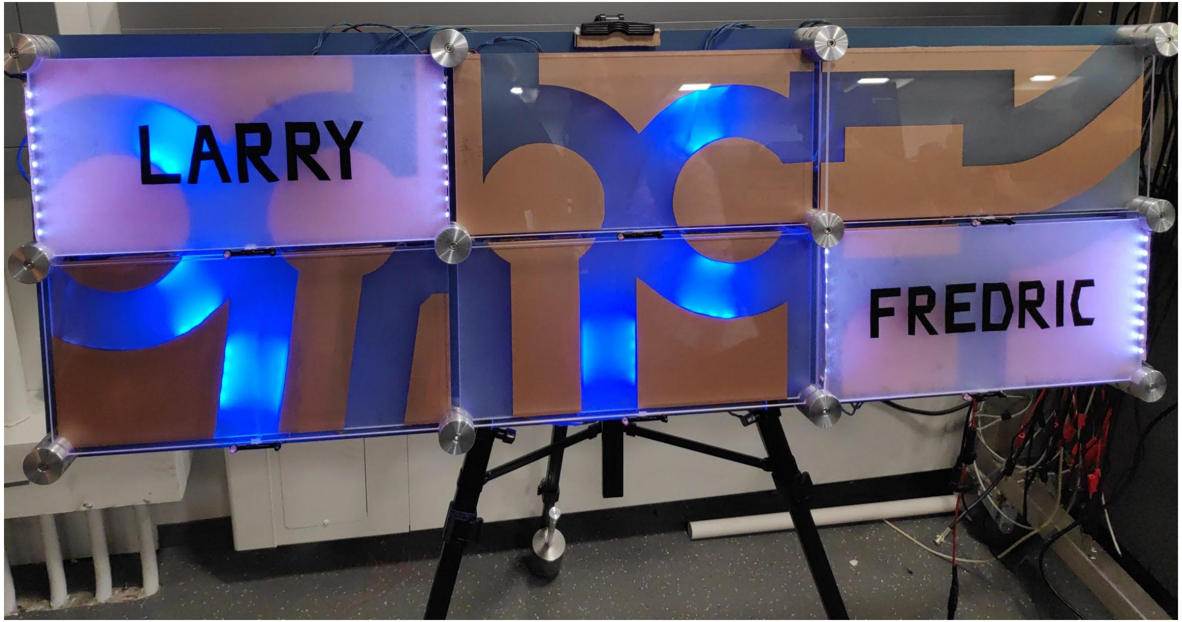
- Donor Wall
  - Located in the hall on 1st Floor of Electrical Engineering Building.
  - Often unnoticed by the audience
  - Minimum lighting



Donor Wall

Objective

- Dynamic illumination system
  - Add lighting
  - Engage
  - Interact

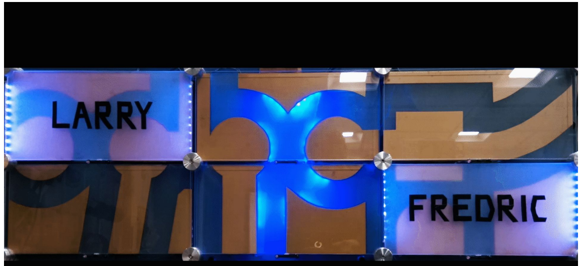


Finished Product

Result

Default Mode

Human Following Mode 1



Human Following Mode 2

Human Following Mode 3

All Override Mode 1

All Override Mode 2

Result

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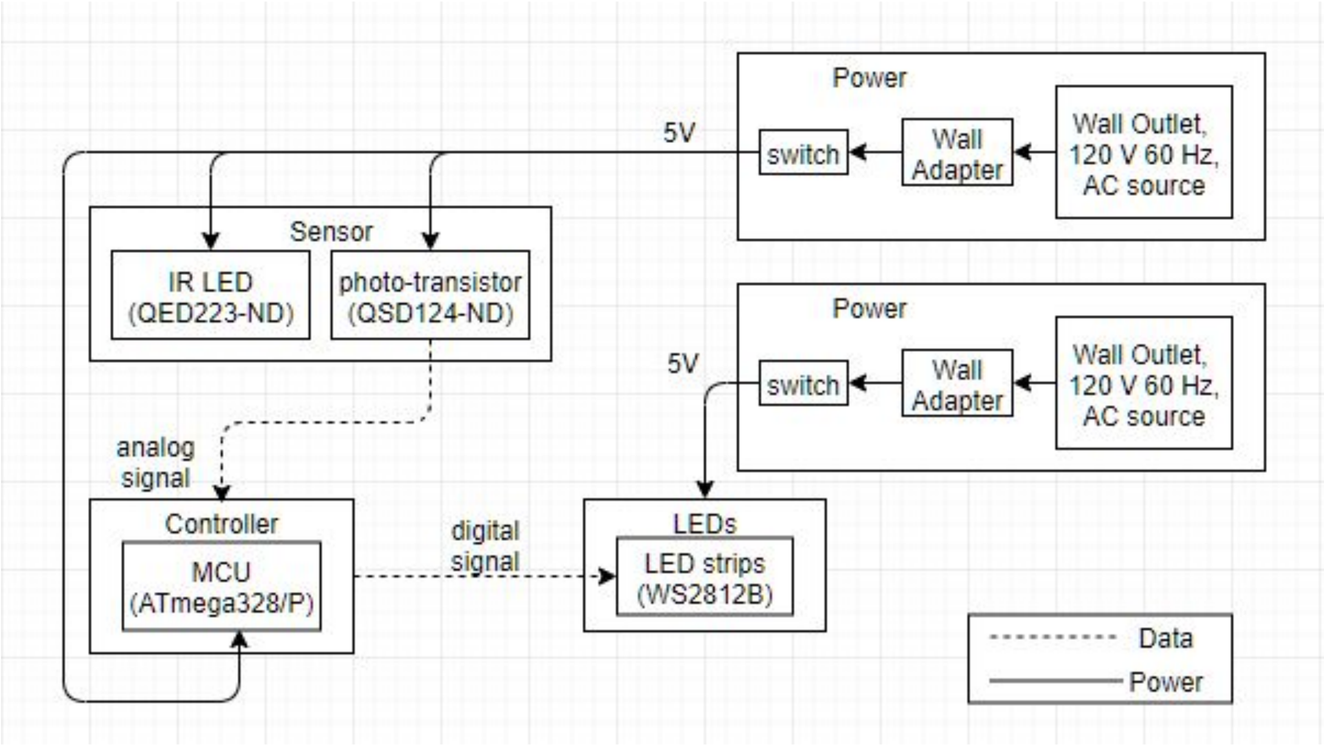
Block Diagram



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Physical Model

- Actual portion
- Painting
- Cardboard for LEDs
- Wires hidden

Front Side

Back Side

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        - LED Program
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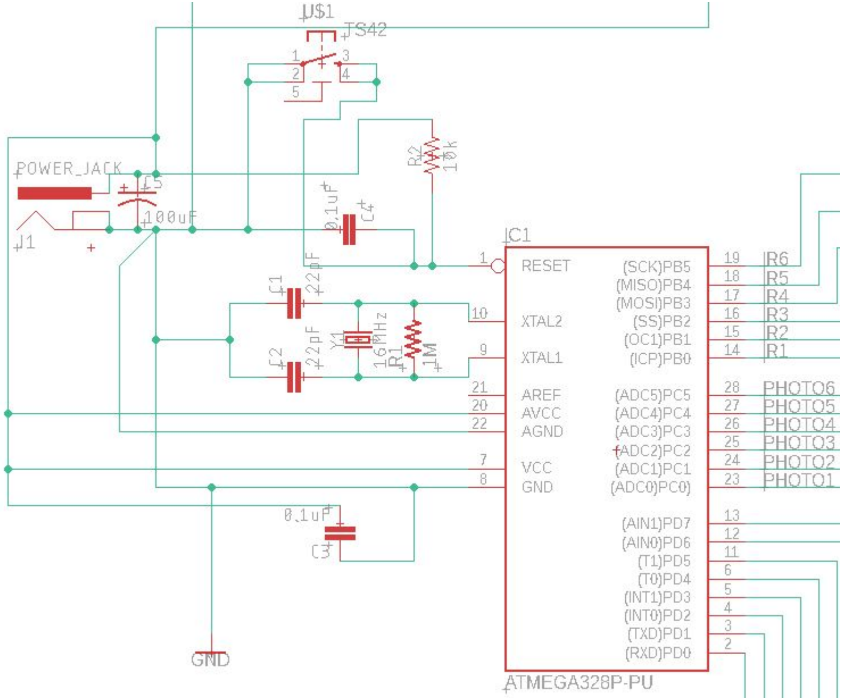
Microcontroller Circuit

- ATmega328P
- Redesigned based on the official document of Arduino Uno board
- Worked successfully as expected.



Microcontroller Circuit Diagram

LED program

- Software worked properly and showed satisfying effect.
- Challenge: Program space is not too large.
- Final successful Solution: Use shared functions between different modes as many as possible to reduce the program space.
- FastLED library. Treat each LED strip as a number array.
- Access to each LED by index in an array

LED program

Strip 3 Strip 2 Strip 1

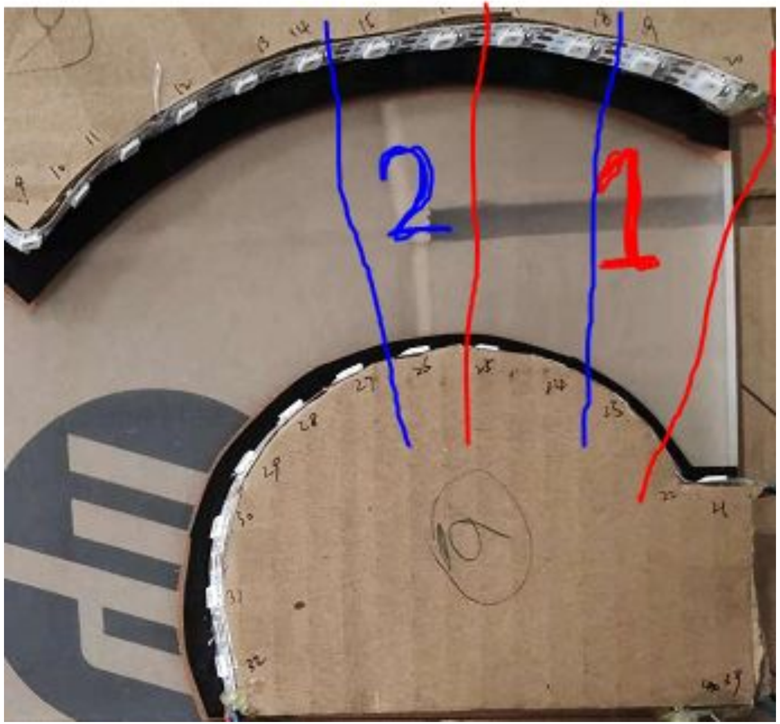
- Separate to 6 parts.
- Begin and end at the same time for each part.

LED program

- In each part, LEDs are grouped separately.
- Turn on and off each group one by one.

t1	3_20	3_19	3_18		3_23	3_24		
t2	3_18	3_17	3_16	3_19	3_24	3_25		
t3	3_16	3_15	3_14	3_17	3_25	3_26		
t4	3_14	3_13	3_12	3_15	3_26	3_27		
t5	3_12	3_11	3_10	3_13	3_27	3_28		
t6	3_10	3_9	3_11		3_28	3_29		
t7	3_71	3_70	3_30	3_31			part 1 up	
t8	3_38	3_37		3_42	3_41	3_40		
t9	3_37	3_36	3_44	3_43	3_42	3_41		
t10	3_36	3_35	3_46	3_45	3_44	3_43		
t11	3_35	3_34	3_48	3_47	3_46	3_45		
t12	3_34	3_33		3_49	3_48	3_47		
t13	3_33	3_32	3_69	3_68				
t14	3_32	3_69					part 1 down	

Example of part of LED group table



LED program

Example


```
void t1(){
  led_3[20] = CRGB::Blue;
  led_3[19] = CRGB::Blue;
  led_3[18] = CRGB::Blue;

  led_3[23] = CRGB::Blue;
  led_3[24] = CRGB::Blue;
}

void t2(){
  led_3[18] = CRGB::Blue;
  led_3[17] = CRGB::Blue;
  led_3[16] = CRGB::Blue;
  led_3[19] = CRGB::Blue;

  led_3[24] = CRGB::Blue;
  led_3[25] = CRGB::Blue;
}

void t3(){
  led_3[16] = CRGB::Blue;
  led_3[15] = CRGB::Blue;
  led_3[14] = CRGB::Blue;
  led_3[17] = CRGB::Blue;

  led_3[25] = CRGB::Blue;
  led_3[26] = CRGB::Blue;
}
```

```
void part1_left_right(){
  t1();
  t8();
  FastLED[2].showLeds(Brightness);
  delay(DELAY_LENGTH);
  clear_led3();

  t2();
  t9();
  FastLED[2].showLeds(Brightness);
  delay(DELAY_LENGTH);
  clear_led3();

  t3();
  t10();
  FastLED[2].showLeds(Brightness);
  delay(DELAY_LENGTH);
  clear_led3();

  t4();
  t11();
  FastLED[2].showLeds(Brightness);
  delay(DELAY_LENGTH);
  clear_led3();

  t5();
  t12();
  FastLED[2].showLeds(Brightness);
  delay(DELAY_LENGTH);
  clear_led3();
```

LED program

Shared part example:
Default mode and Human Following Mode

LED program

- Advantage:
  - Many functions are reusable for different modes at shared parts.
  - Reduced space! 87% of total program space for all LED code.
  - Easy to combine different parts together.
  - Trackable and manageable.

- Disadvantage:
  - Time consuming to group up LEDs.

Overall, Successful method. Enough space and satisfying visual effect.

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Sensor - Goal

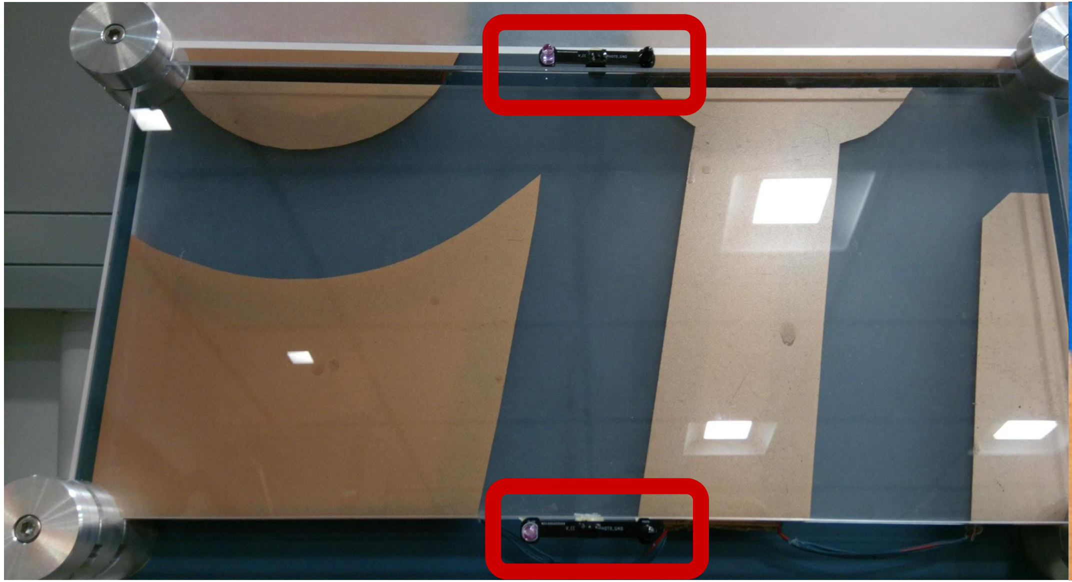
Objectives:

1. Filter noise
2. Max. working distance & sensitivity
3. Working distances: 100cm, 30cm

Result:

All objectives met with IR Sensor!

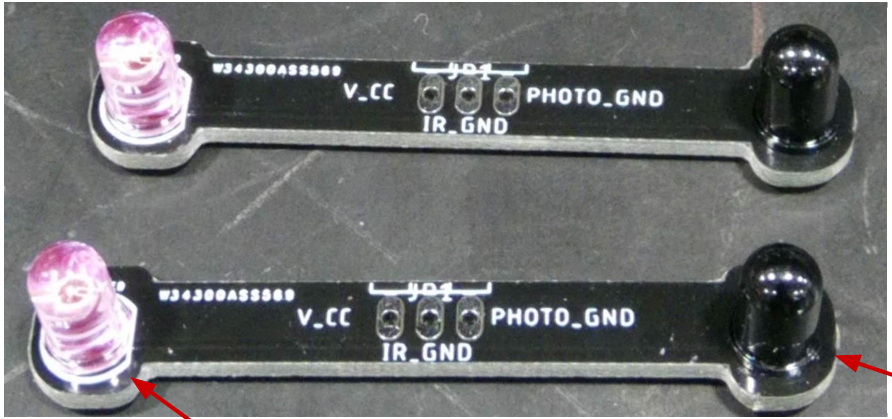
Sensor - Hardware Physical View

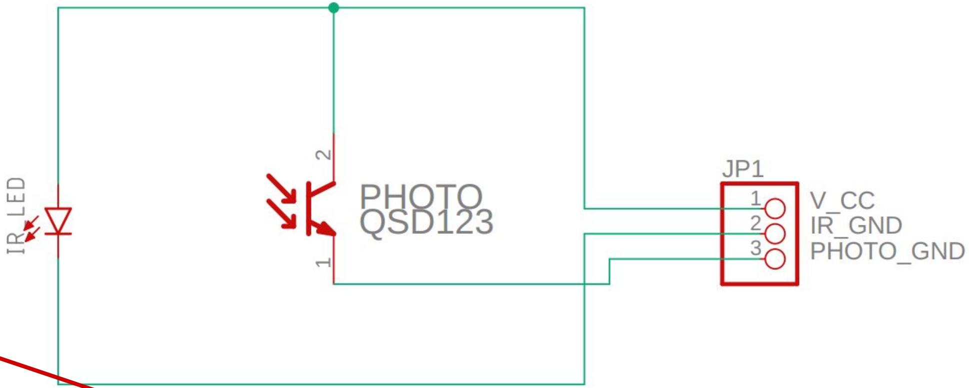


Sensor Close-up Views

Main PCB

Sensor - Closer Look

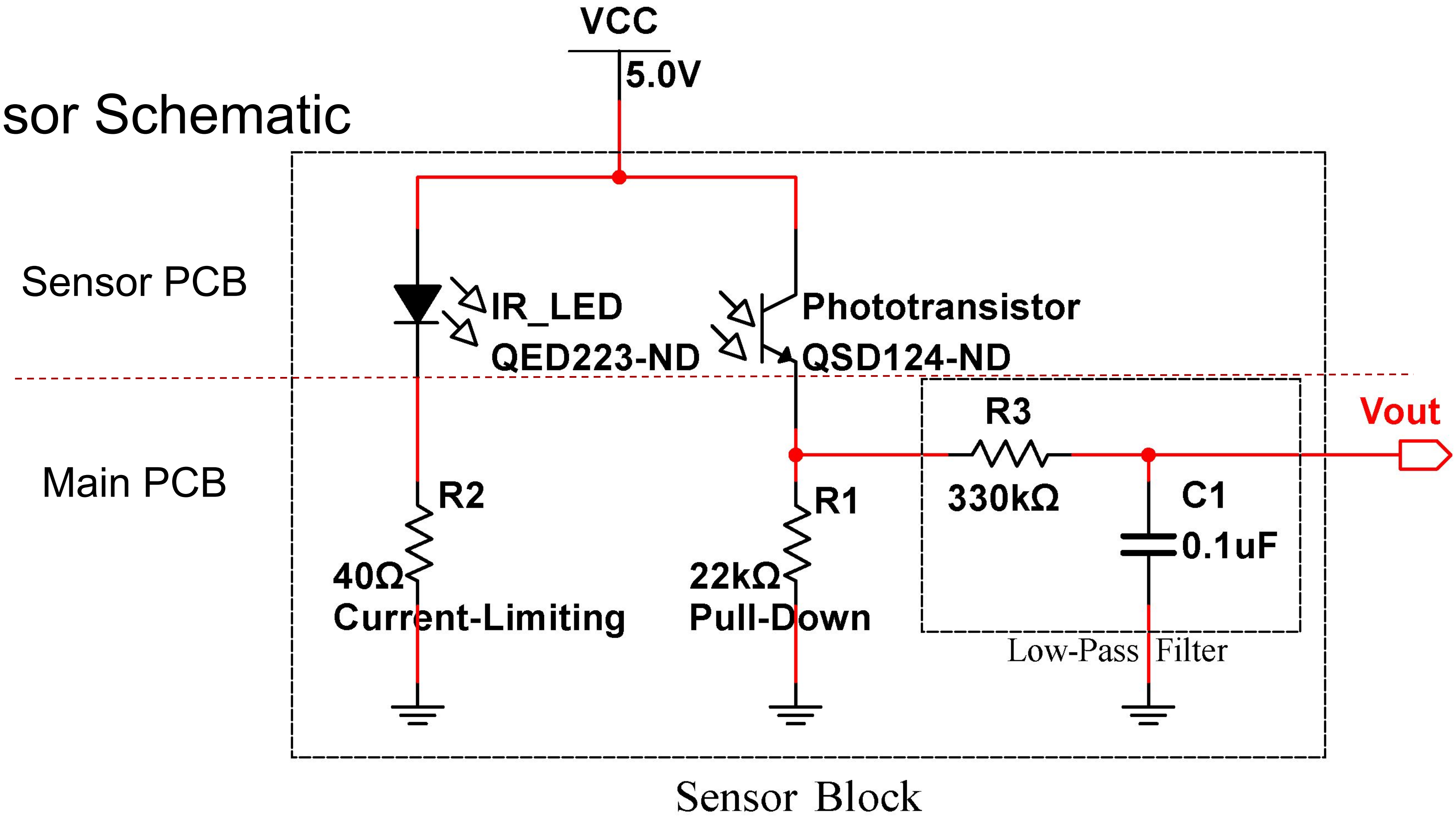




IR LED (QED223-ND):
peak emission wavelength of 890nm, wide emission angle of 30°

Phototransistor (QSD124-ND):
peak sensitivity wavelength of 880nm, narrow reception angle of 24°

Sensor Schematic



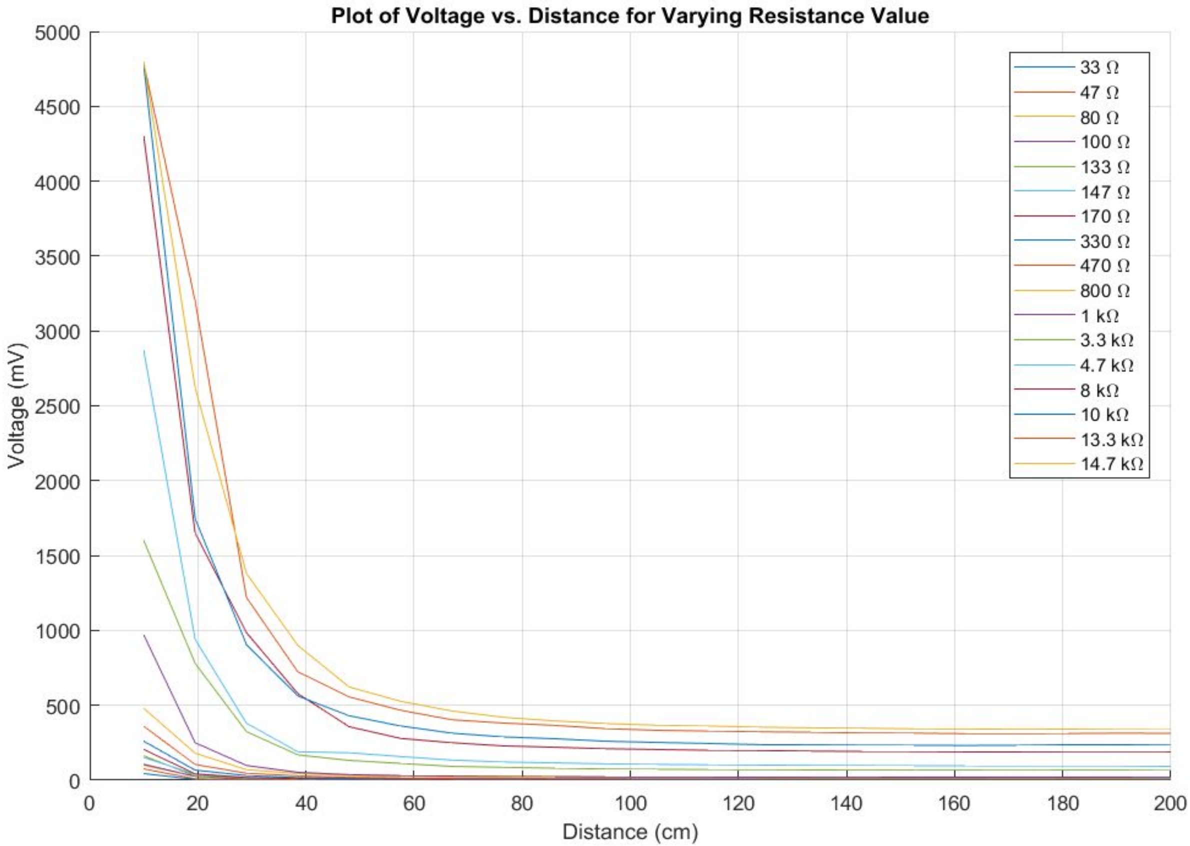
Sensor - Output Voltage Range Depending on Pull-Down Resistor

Conclusions:

- ↑ R, more exponential curve
- AREF of 1.1V

Analogue Reference	Analog Resolution
5V	$\frac{5V}{1024} = 0.00488V/Digital\ Units$
3.3V	$\frac{3.3V}{1024} = 0.00322V/Digital\ Units$
1.1V	$\frac{1.1V}{1024} = 0.00107V/Digital\ Units$

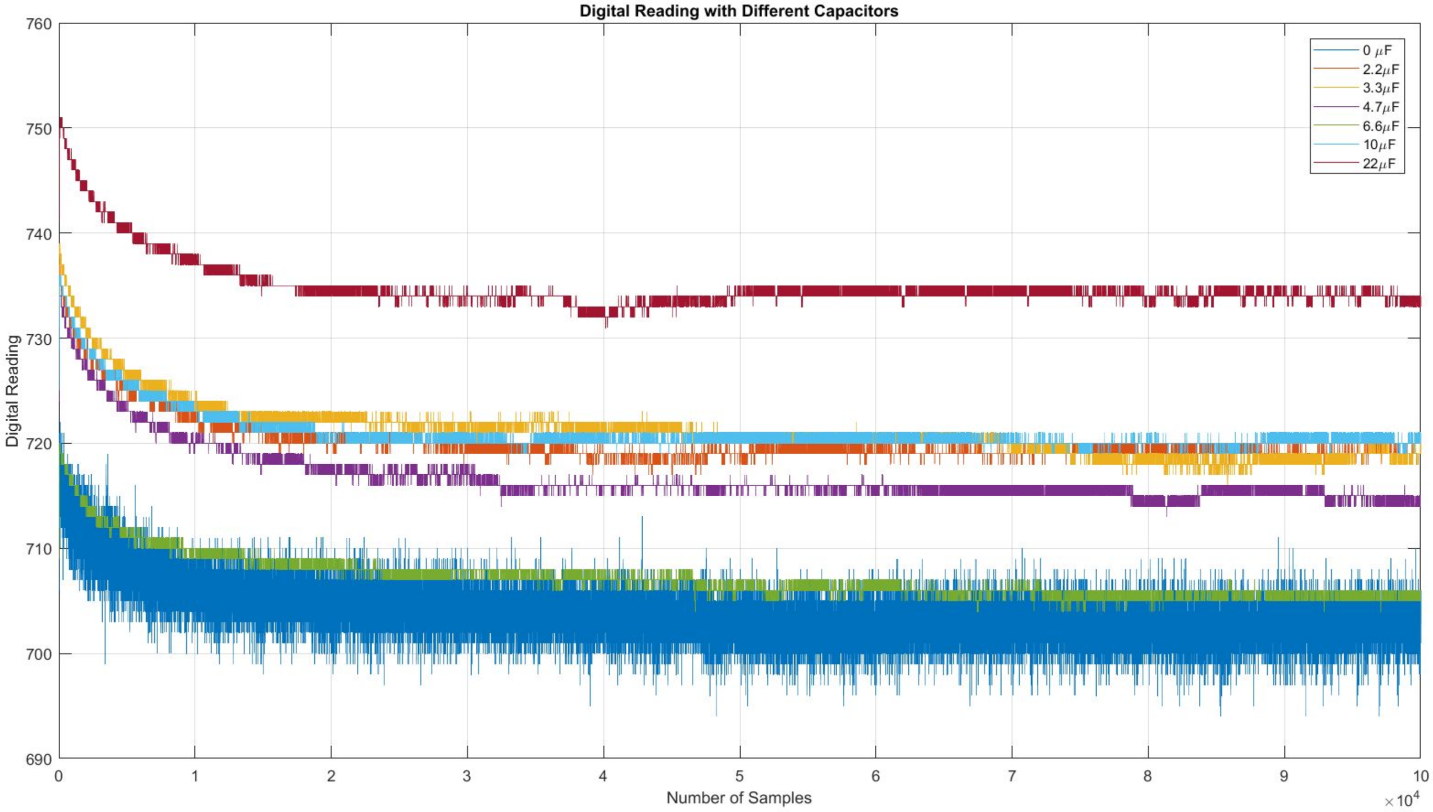
TABLE I: Analog Resolution with Different AREF



Sensor - Initial Low-Pass Filter Design

Conclusions:

- Good results with electrolytic 10uF
- 2 mins. to stabilize



Sensor - Final Low-Pass Filter Design

$$f = \frac{1}{T}$$

$$f = \frac{1}{\frac{1893.152ms}{9periods} \times \frac{1s}{1000ms}}$$

$$f = 4.75397Hz$$

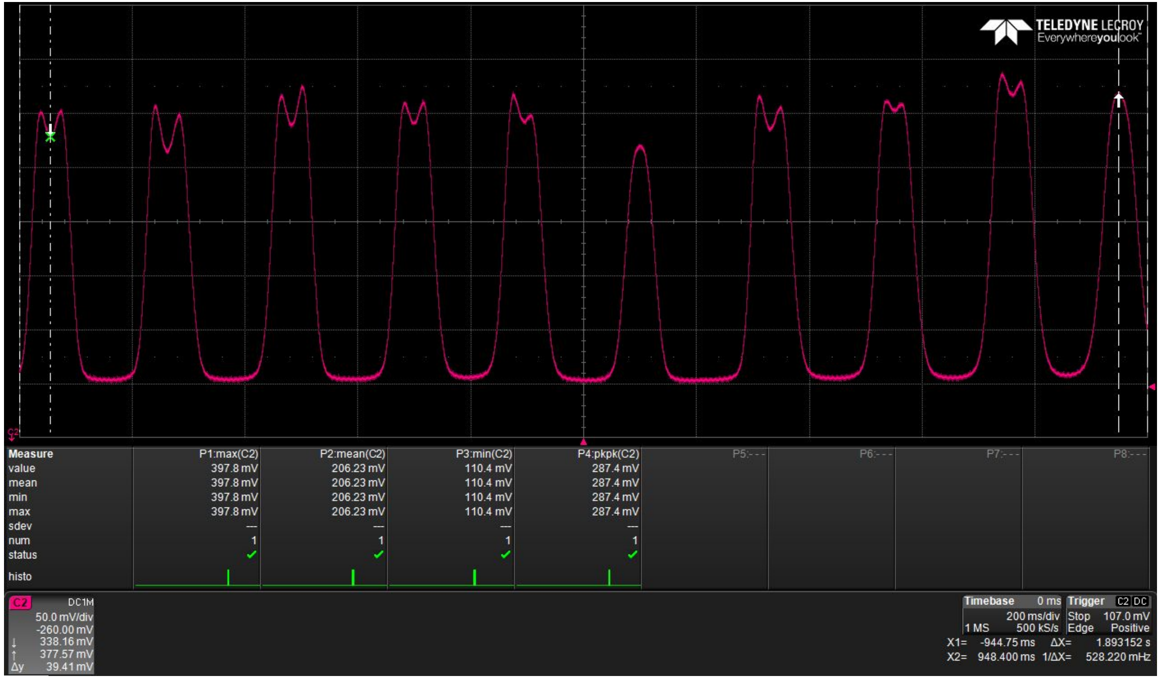
$$f_{cut-off} = \frac{1}{2\pi RC}$$

$$4.75397Hz = \frac{1}{2\pi R \times 0.1\mu F}$$

$$R = 334783\Omega \approx 330k\Omega$$

Result

Stable digital readings with rare ±1 digital fluctuations

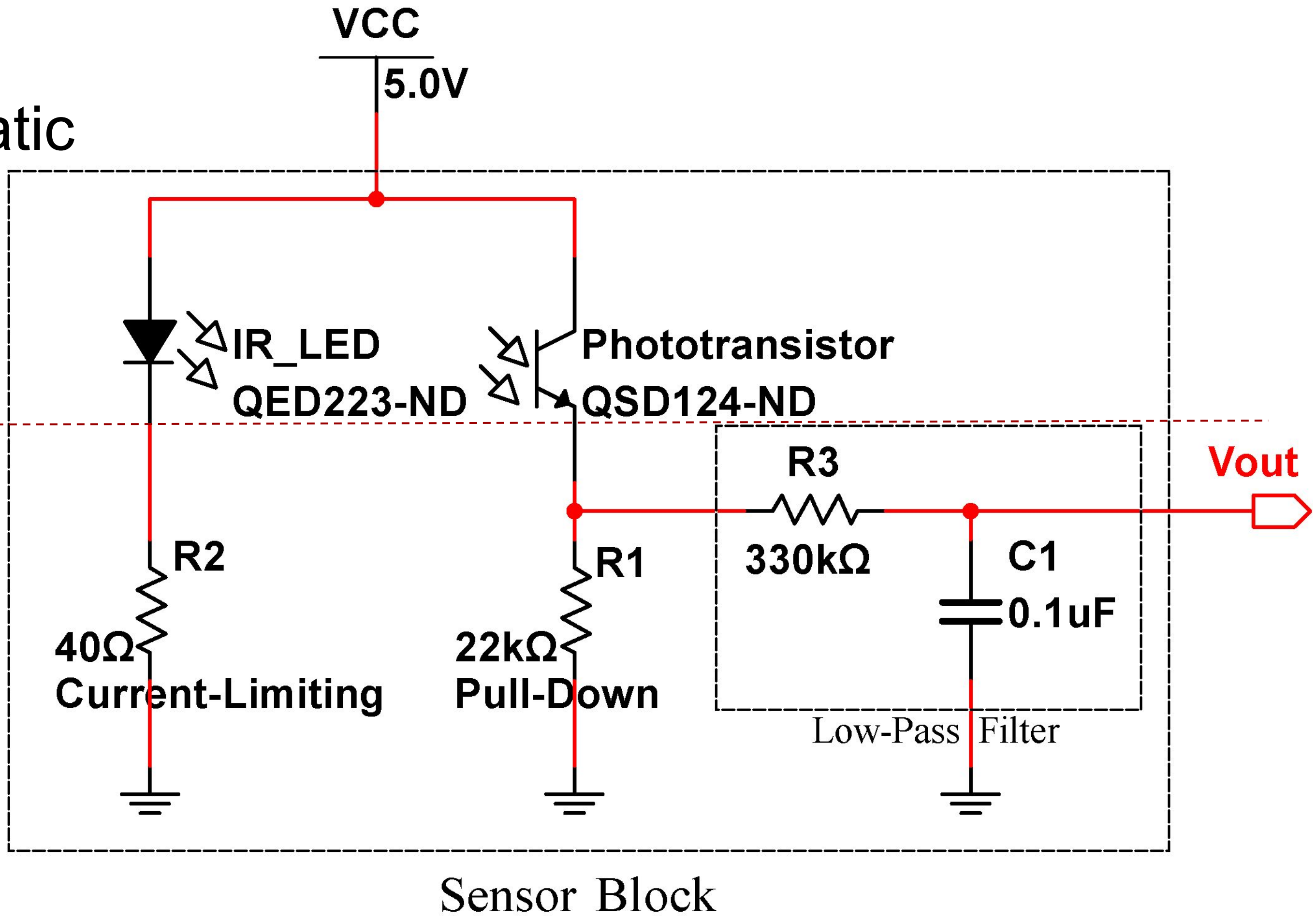


Teledyne LeCroy's HDO 4054-MS Oscilloscope

Sensor Schematic

Sensor PCB

Main PCB

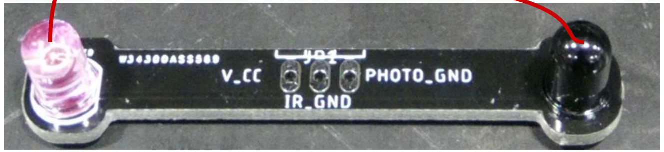


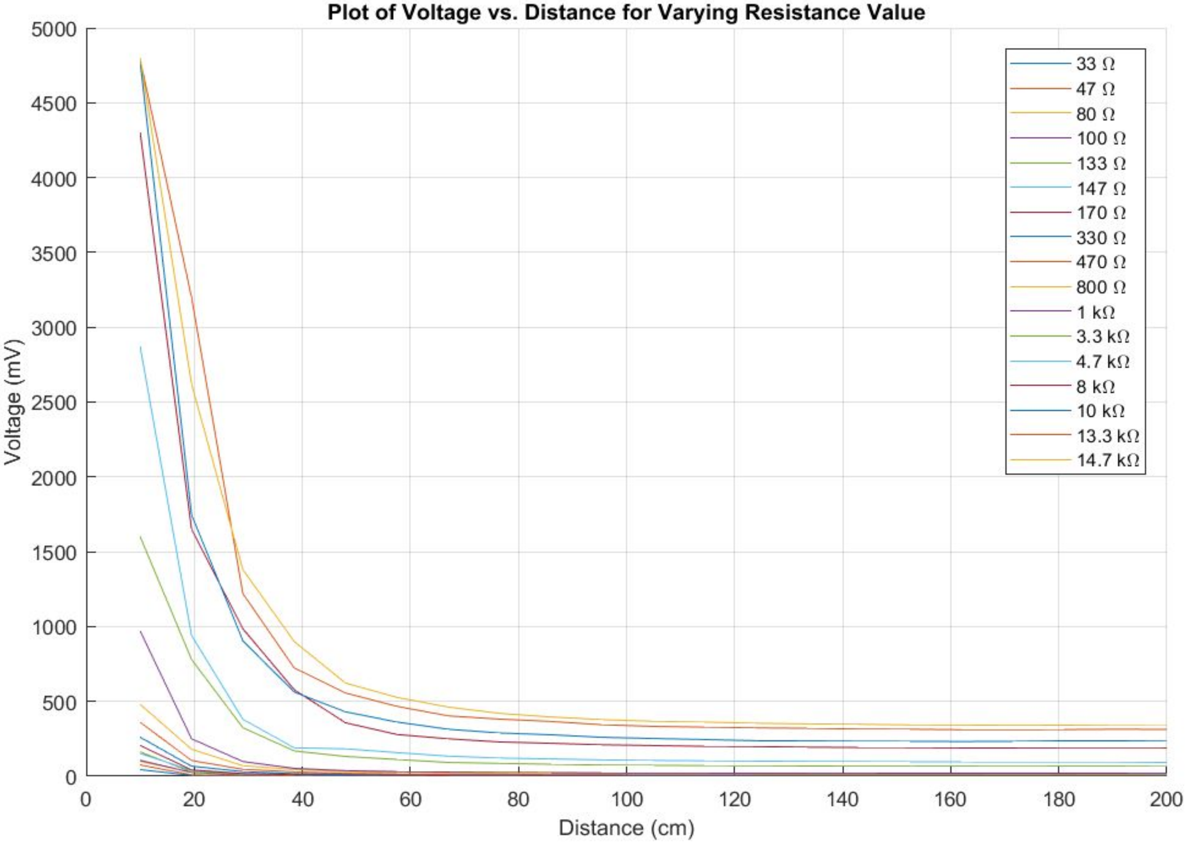
Sensor - Pull Down Resistor

$R_{Pull-Down}$ determines the IR sensor's detectable range

output voltage range

$d_{IR-Photo}$ $R_{Pull-Down}$



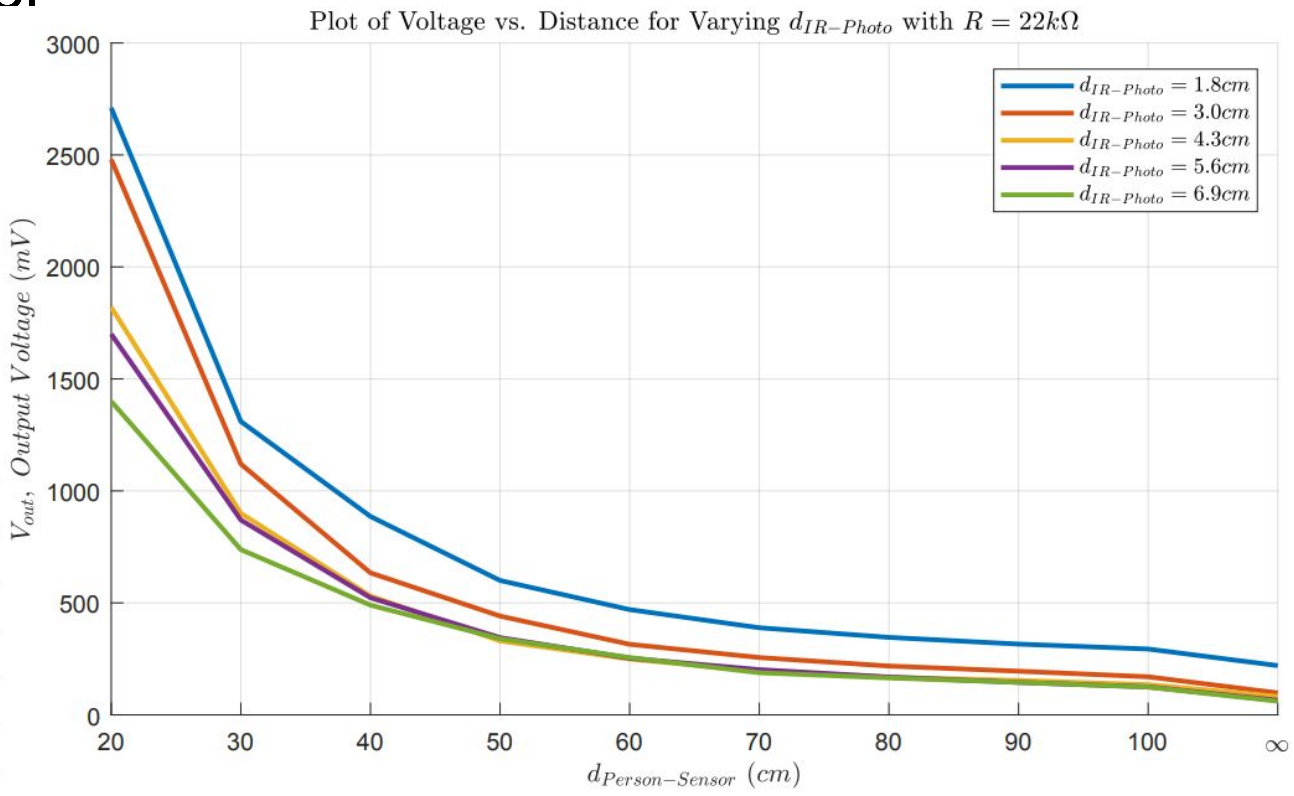


Sensor - Voltage Dependence on Distance Between IR LED and Phototransistor

↑ Distance Between IR LED & Phototransistor: ↓ Min. Voltage

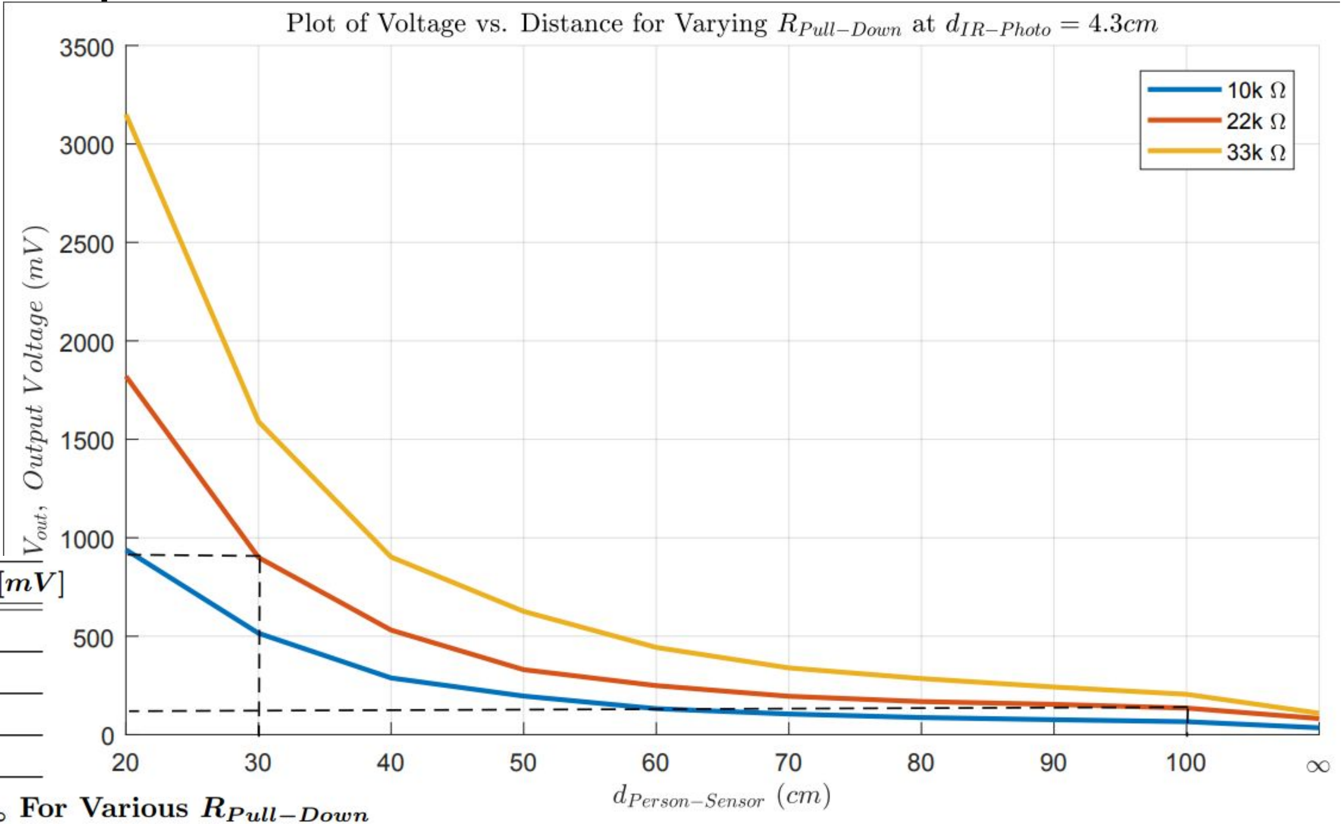
Table 3: Minimum V_{out} of IR Sensor (Nothing in 2m from the IR sensor) with $R_{Pull-Down} = 22k\Omega$

$d_{IR-Photo}$ [cm]	V_{out} [mV]
1.8	220
3.0	98
4.3	82
5.6	65
6.9	61



Sensor - Voltage Dependence on Pull-Down Resistor

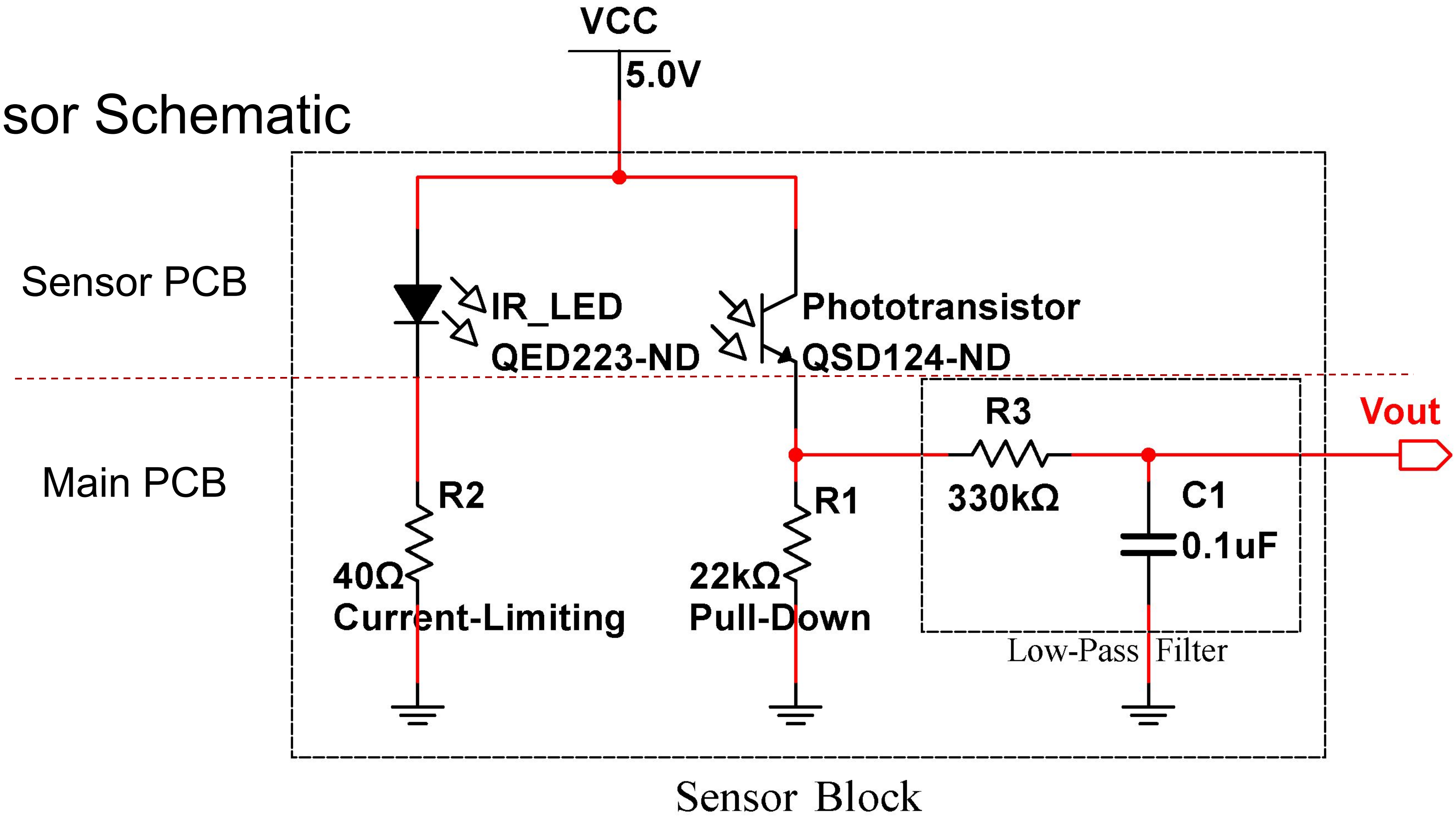
↑ Pull-Down Resistor:
↑ Slope change



$R_{Pull-Down}[k\Omega]$	$\Delta V_{d=100cm-d=\infty}[mV]$
10	~ 30
22	$\sim 60\ or\ 70$
33	$\sim 100\ or\ 110$
47	~ 138

Table 4: Measured $\Delta V_{d=100cm-d=\infty}$ For Various $R_{Pull-Down}$

Sensor Schematic



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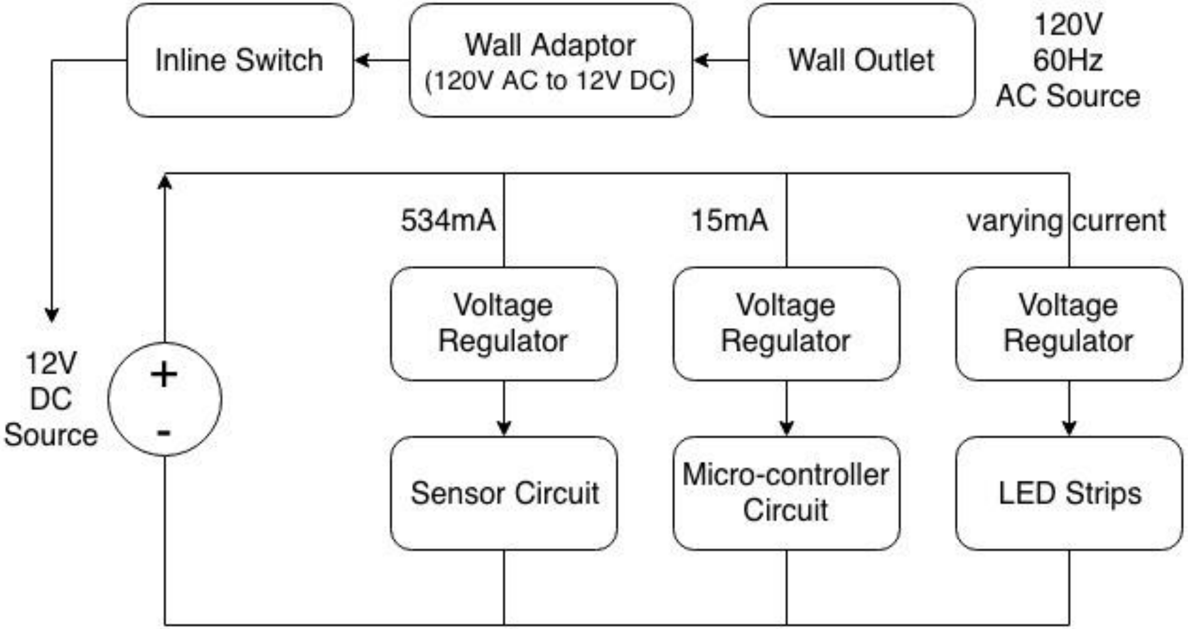
Power Module - Original Design

- Advantage
  - freedom
- Problem
  - Current rating

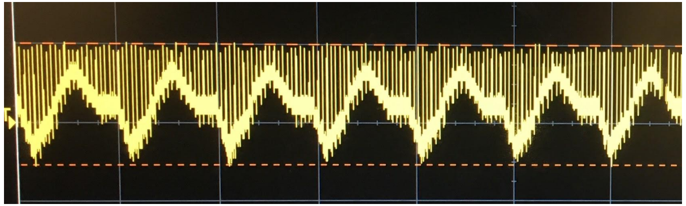
50mA per LED
20 LEDs x 50 mA = 1 A



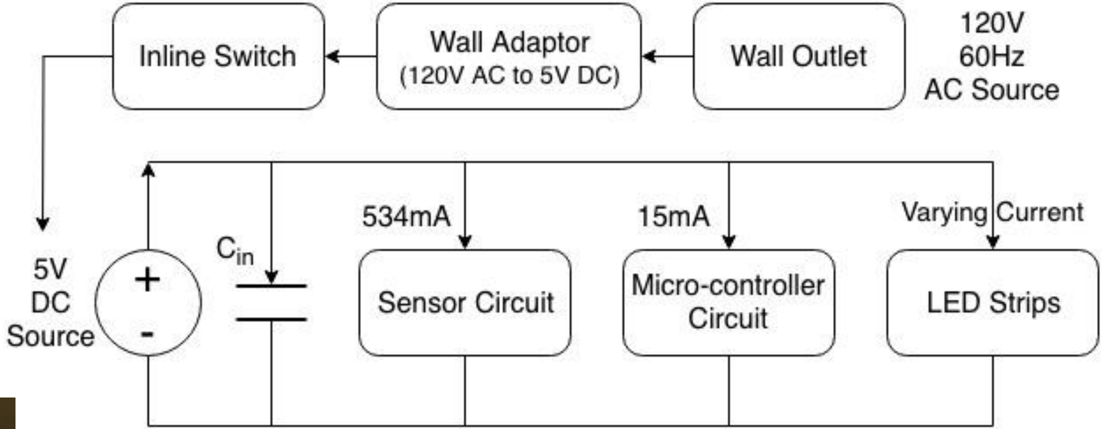
Original Power Module Design

Power Module - Modified Design

- Advantage
  - Simplified
  - Higher current
- Problem
  - Varying voltage



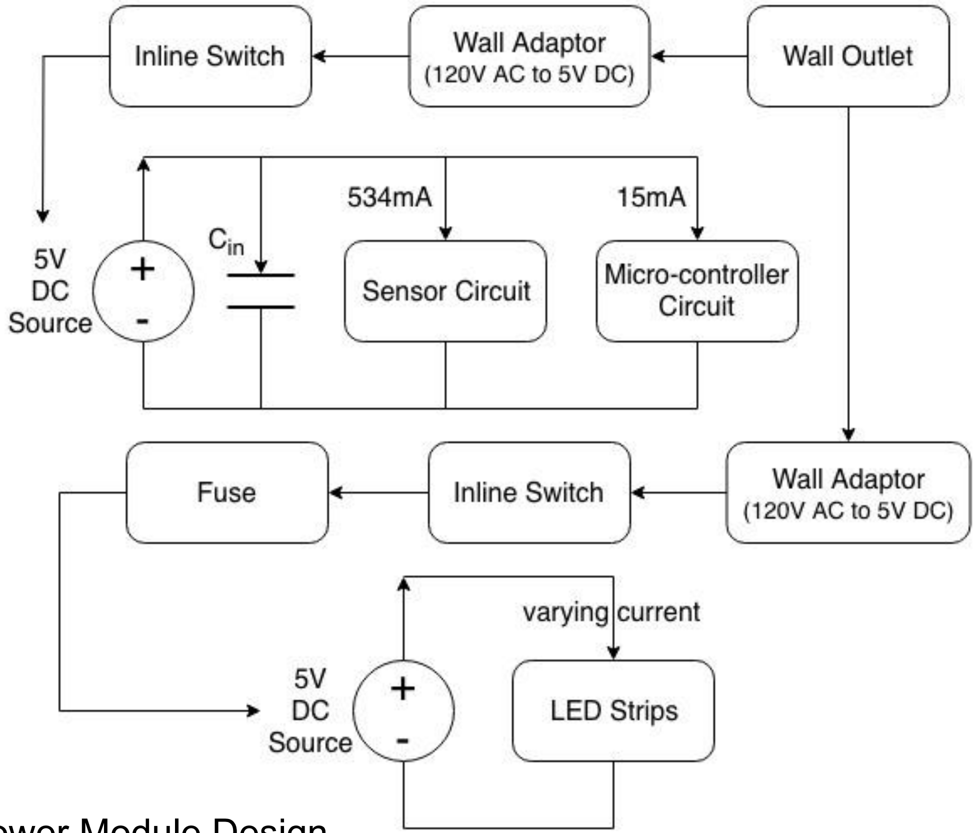
Varying Voltage of LED Voltage



Modified Power Module Design

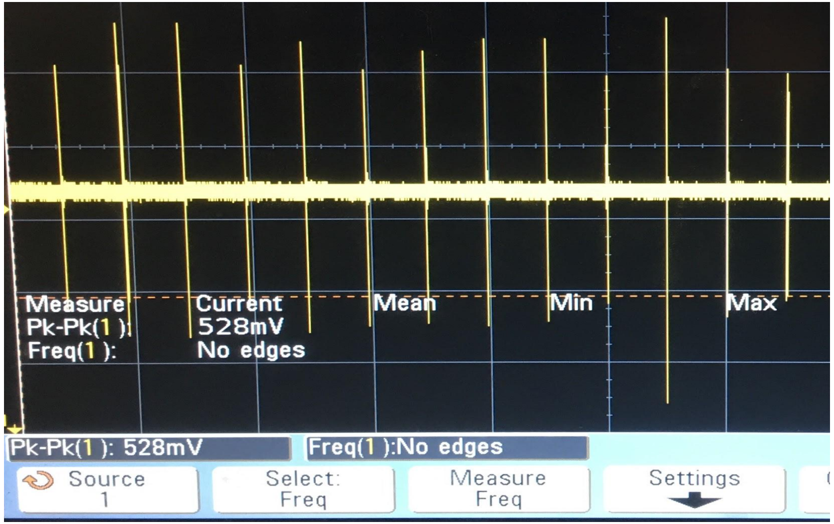
Power Module - Final Design

- Advantage
  - Tailored to Modules
- Disadvantage
  - Two power sources

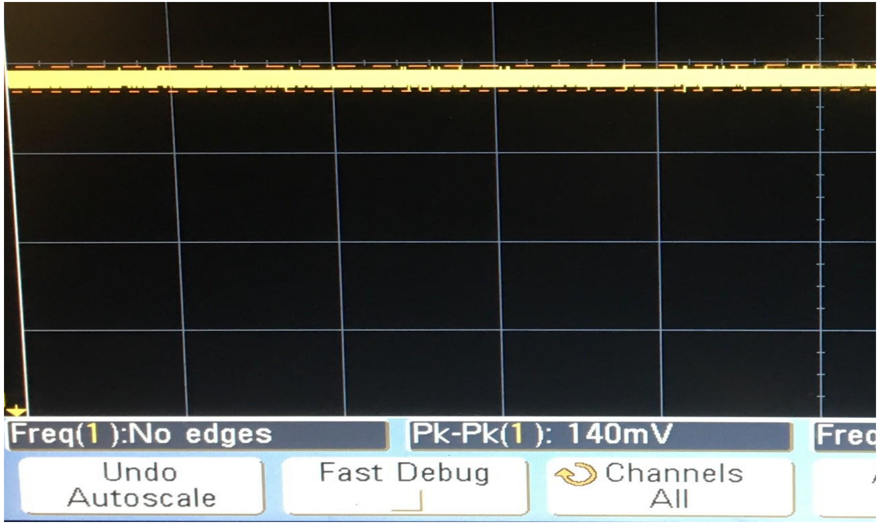


Final Power Module Design

Power Module - Decoupling Capacitor



No Decoupling Capacitor



With Decoupling Capacitor, 0.47uF

- Satisfies requirement in R & V table with single 100uF electrolytic capacitor

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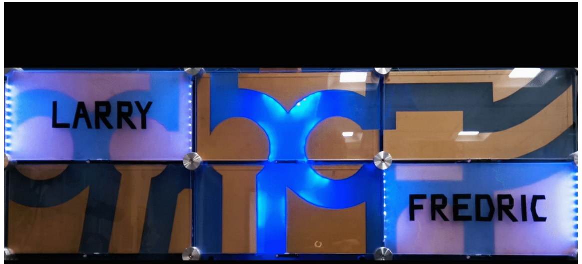
Conclusion - Wrap up

Default Mode

Human Following Mode 1



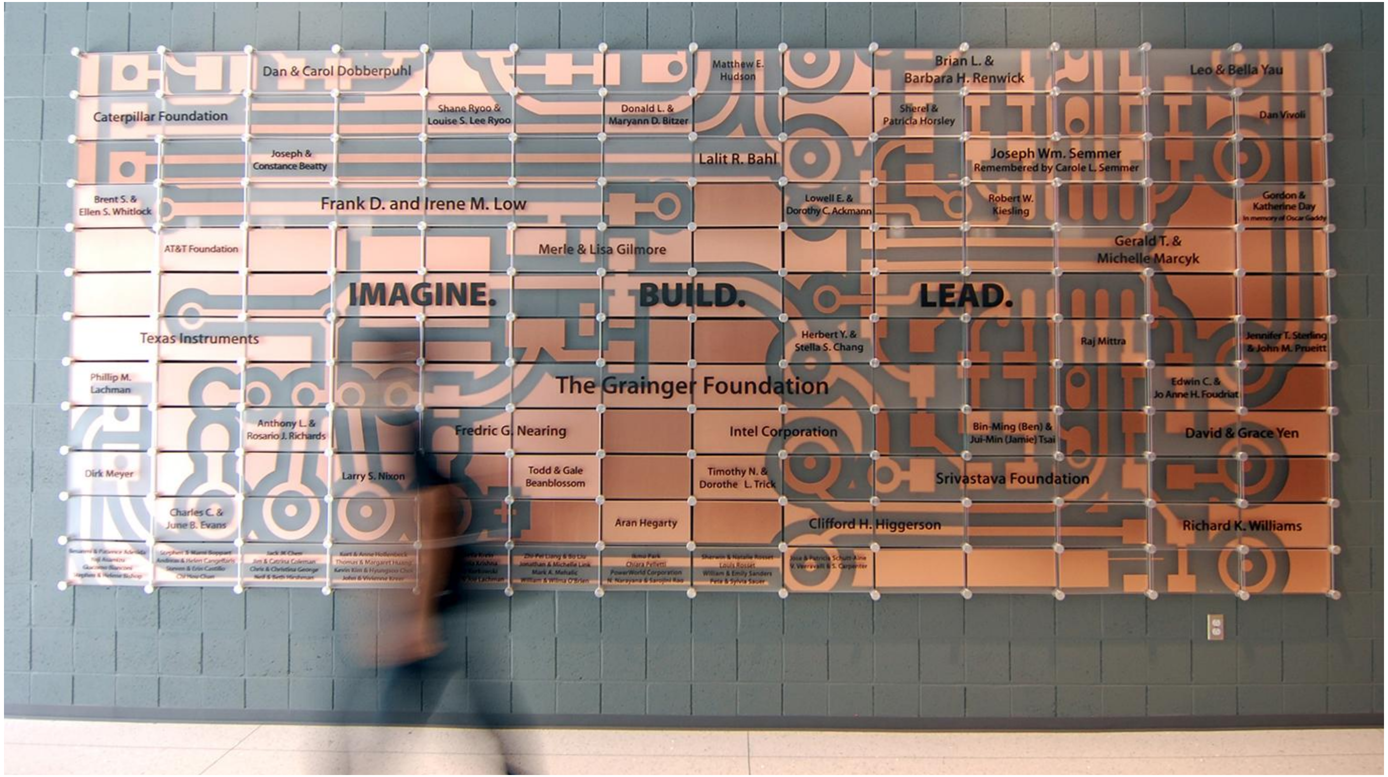
Human Following Mode 2

Human Following Mode 3

All Override Mode 1

All Override Mode 2

Conclusion - Future Work



Thank You!

Any Questions?

IR Sensor - Current-Limiting Resistor

40Ω

minimum power rating:

$327.54mW$

40.2 OHM 0.6W 1% Used

Table 1: IR LED Performance's Dependence on Ambient Temperature

T_A, Ambient Temperature [°C]	I_e, Normalized Radiant Intensity [1]	I_f, Forward Current [mA]	V_f, Forward Voltage [V]
15 (Min. Weather)	1.3	103	1.82
22.5 (Avg. Weather)	1.1	101	1.78
30 (Max. Weather)	0.99	95	1.75
60 (Max. Heat Temp.)	0.9	90	1.62

Table 2: IR LED's Current-Limiting Resistor Calculation

T_A, Ambient Temperature [°C]	R, Resistance [Ω], $R = \frac{V_R}{I_R}$	P, Power [mW], $P_R = V_R I_R$
15 (Min. Weather)	30.8738	327.54
22.5 (Avg. Weather)	31.88	325.22
30 (Max. Weather)	34.2105	308.75
60 (Max. Heat Temp.)	37.6	304.2