II2302 project :

Ice detection sensor

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Sensor

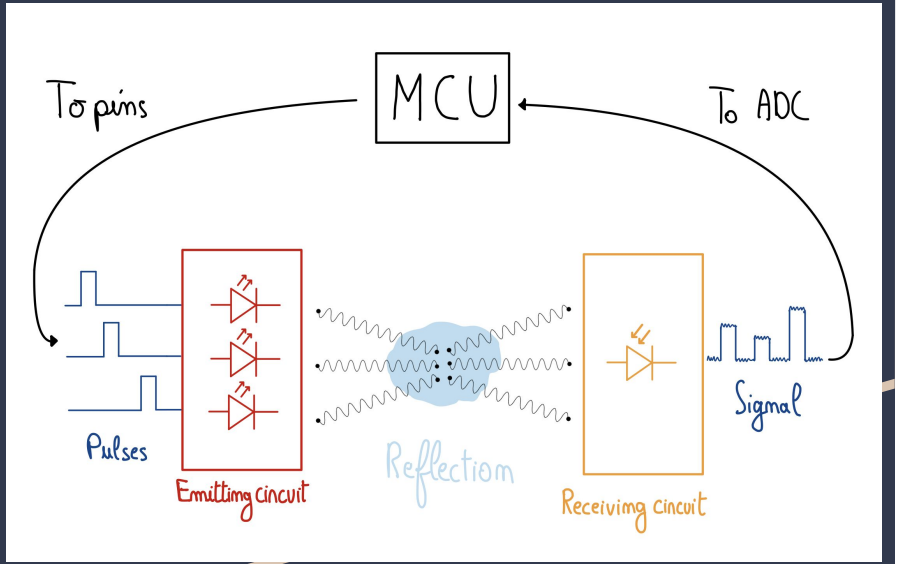
What should the sensor detect ?

- Ice
- Water on the surface
- Dry surface

Applications of the sensor :

- Bicycle accessory
- Ice detection on roads
- Vibrating handles and flashing lights for warning

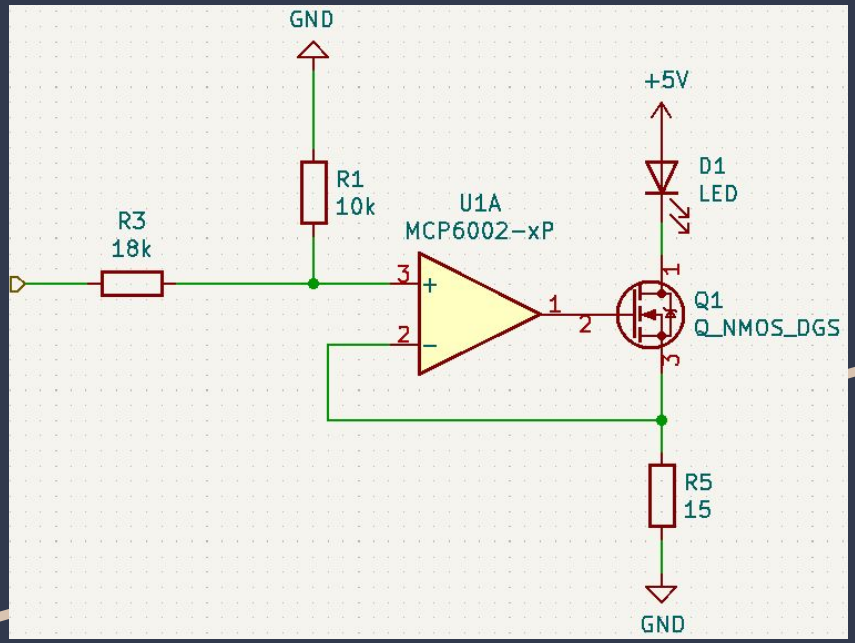
Implementation



- Measurement of backscattered power of IR reflections
- Three wavelengths are used
  - 1300 nm
  - 1450 nm
  - 1550 nm
- InGaAs (Indium gallium arsenide) photodiode for detecting reflections

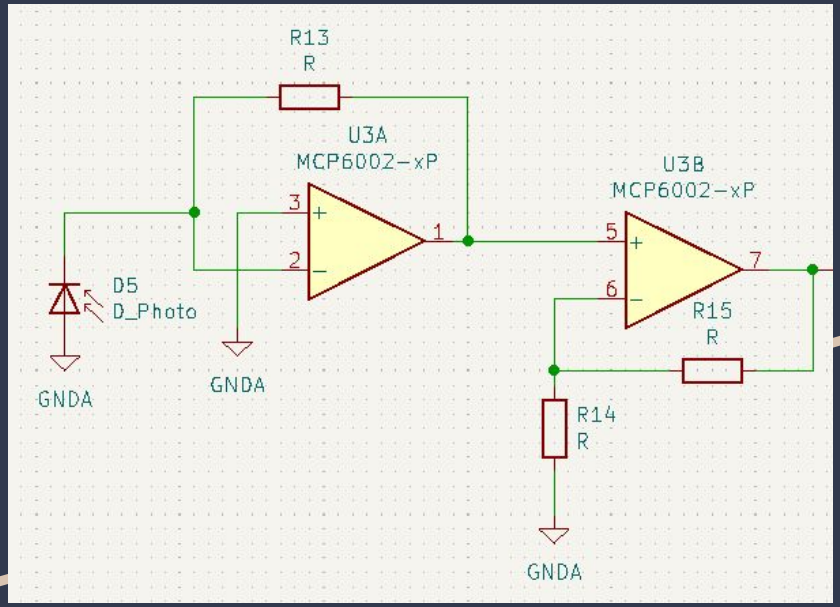
https://opg.optica.org/view_article.cfm

Emitting circuit



- Mosfet transistor sinking current from IR LED
- Turns on by voltage from MCU
- Stable and precise current

Sensing circuit



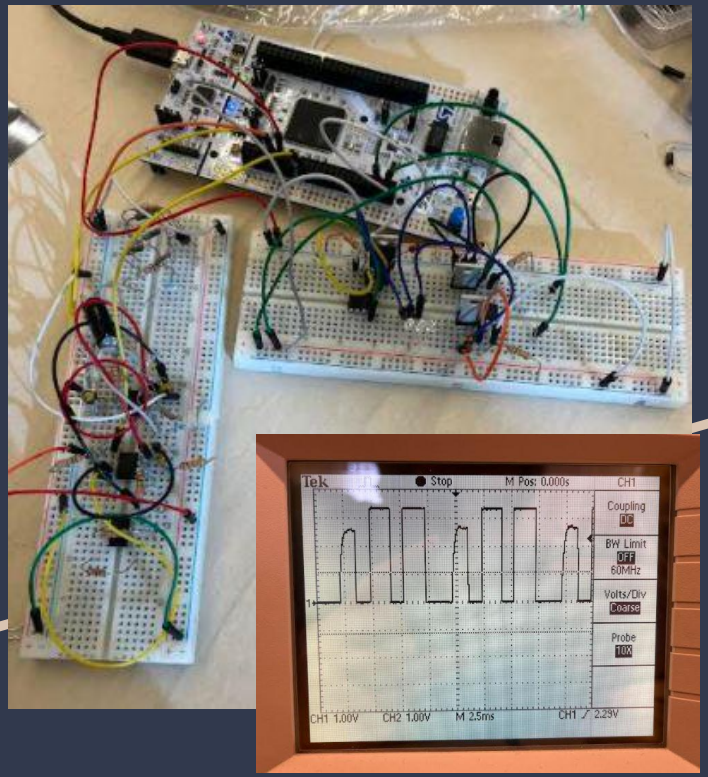
- Transconductance amplifier to sense the photodiode
- Non-Inverting amplifier to increase gain.
- DC-offset is a problem.

Software

```
}
else{
    led_turned_off_state(GPIO_nm1440_GPIO_Port, GPIO_nm1440_Pin, &led_2_on);
}

if(test > LED_1300_START_OFFSET && test < LED_1300_STOP_OFFSET){
    led_turned_on_state(GPIO_nm1300_GPIO_Port, GPIO_nm1300_Pin, &led_3_on);
}
else{
    led_turned_off_state(GPIO_nm1300_GPIO_Port, GPIO_nm1300_Pin, &led_3_on);
}

test++;

if(test >= LED_FULL_PERIOD){
    test = 0;
    HAL_GPIO_WritePin(LD2_GPIO_Port, LD2_Pin, GPIO_PIN_RESET);
    HAL_TIM_PWM_Stop(&htim9, TIM_CHANNEL_1);
    HAL_TIM_PWM_Stop_IT(&htim9, TIM_CHANNEL_1);

    HAL_GPIO_WritePin(LD1_GPIO_Port, LD1_Pin, GPIO_PIN_SET);
    send_buffer(dc_data, dc_data_size, 0);
    send_buffer(led_1_data, led_1_data_size, 1);
    send_buffer(led_2_data, led_2_data_size, 2);
    send_buffer(led_3_data, led_3_data_size, 3);
    buffer_sent = 1;
    HAL_GPIO_WritePin(LD1_GPIO_Port, LD1_Pin, GPIO_PIN_RESET);

    dc_data_size = 0;
    led_1_data_size = 0;
    led_2_data_size = 0;
    led_3_data_size = 0;
}
```

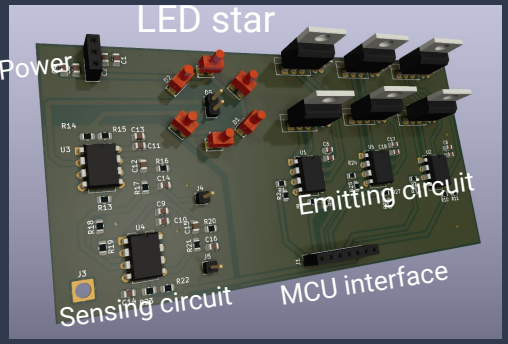
- Pulse LEDs sequentially
- Measure reflections with 12-bit ADC
- Store results in array
- Send array to computer at the end of sampling

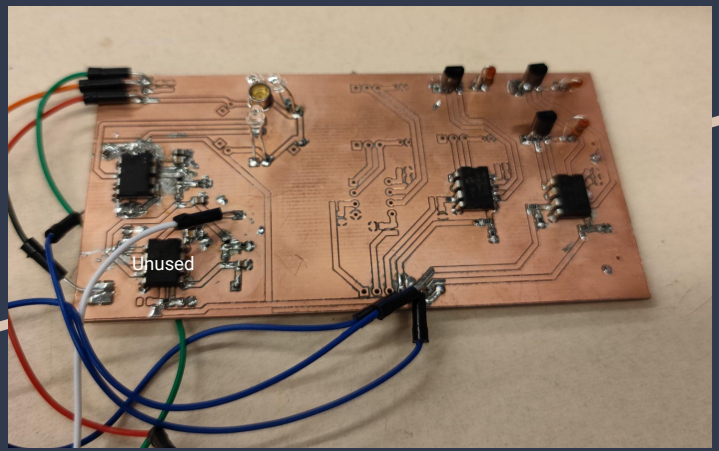
Design process



- Constructed circuit on breadboards
- LEDs and photodiode on separate boards
- Testing of received signal strength on oscilloscope

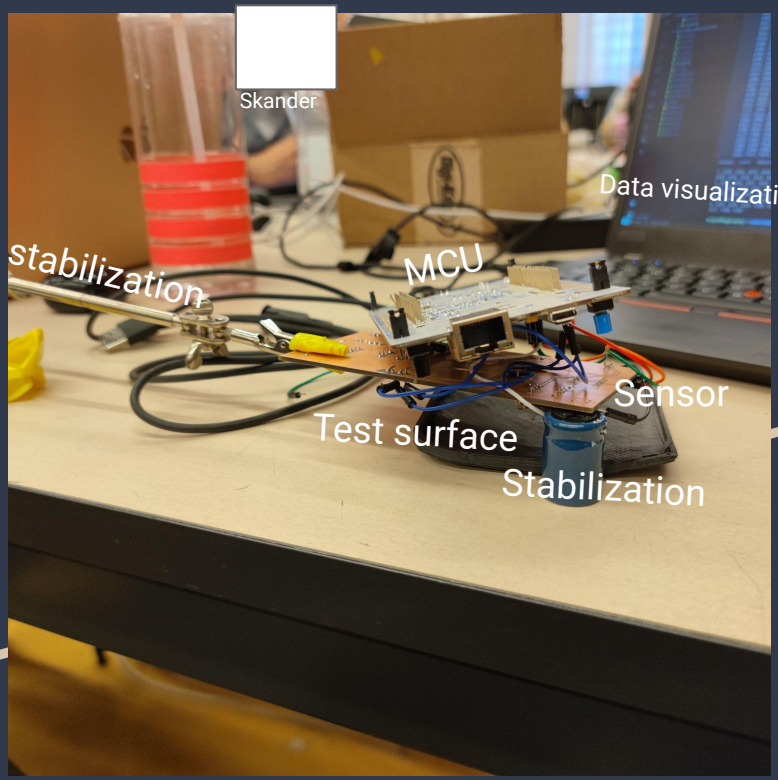
PCB





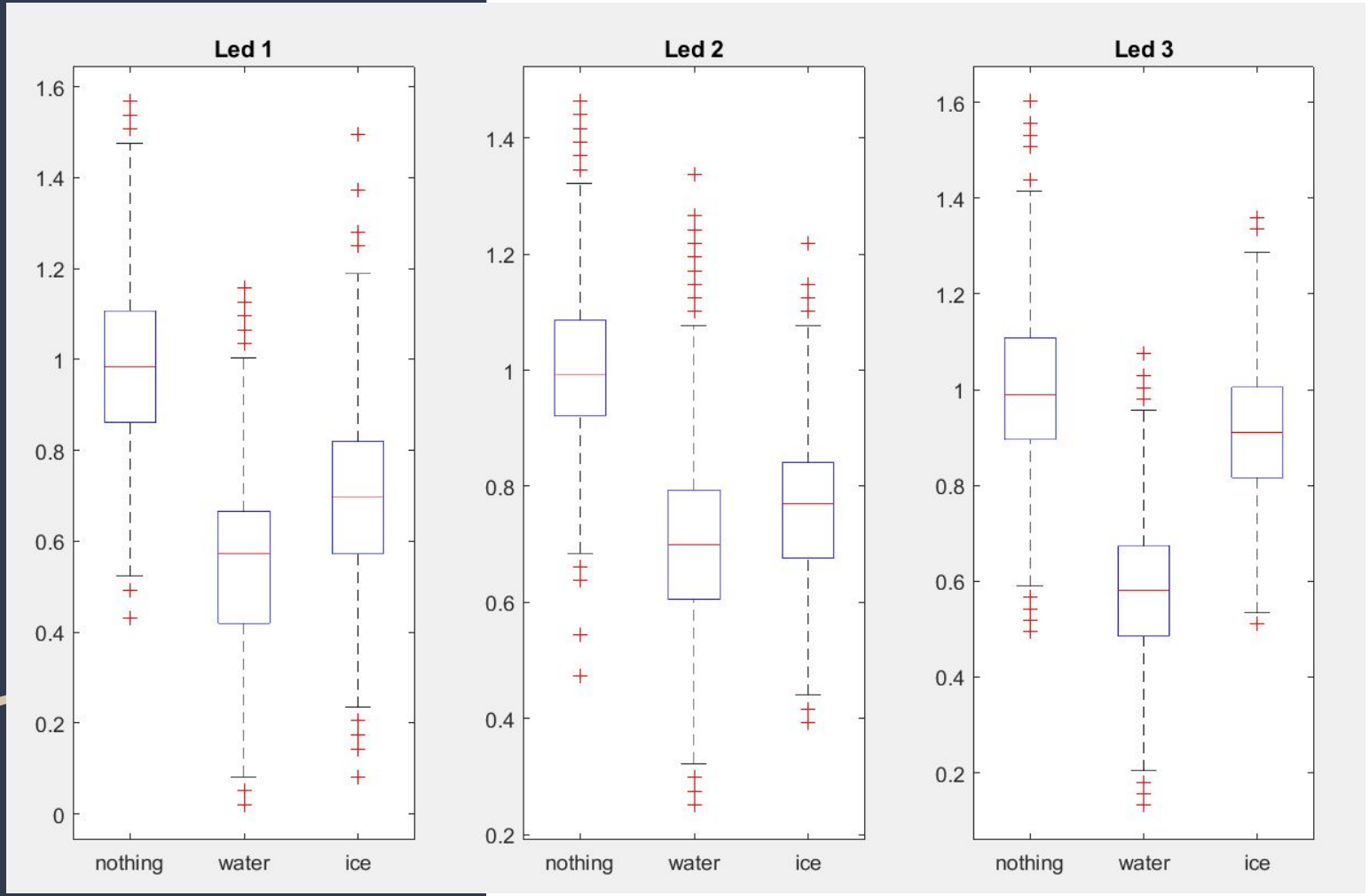
- Six LEDs (only three soldered)
- Two cascaded opamps are unused.
- LEDs surround photodiode
- Connectors to MCU board

Experiment setup

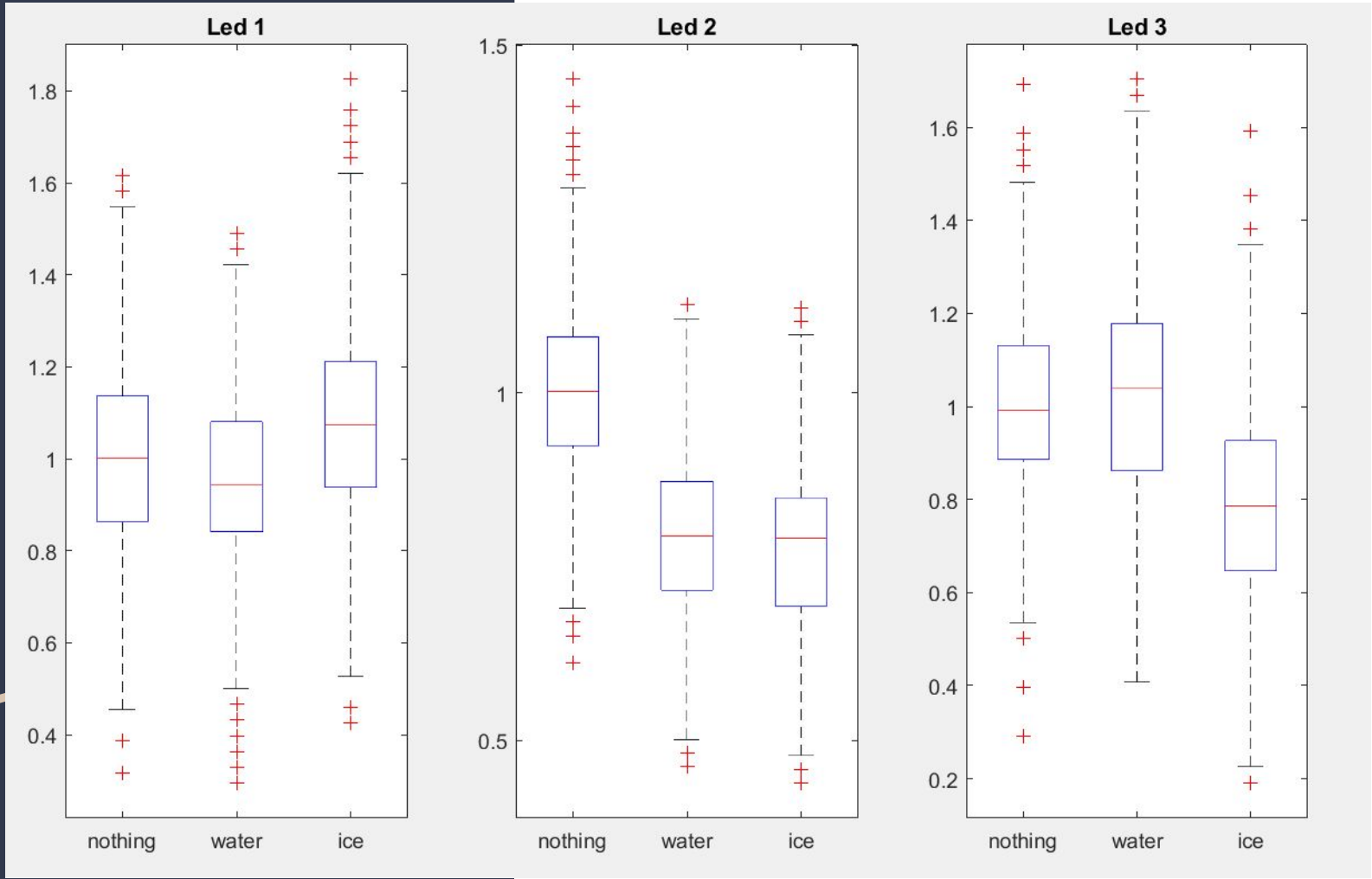


- Repeatable experiment setup
- Stabilization is important
- Serial connection to computer
- Three 3D-printed test surfaces

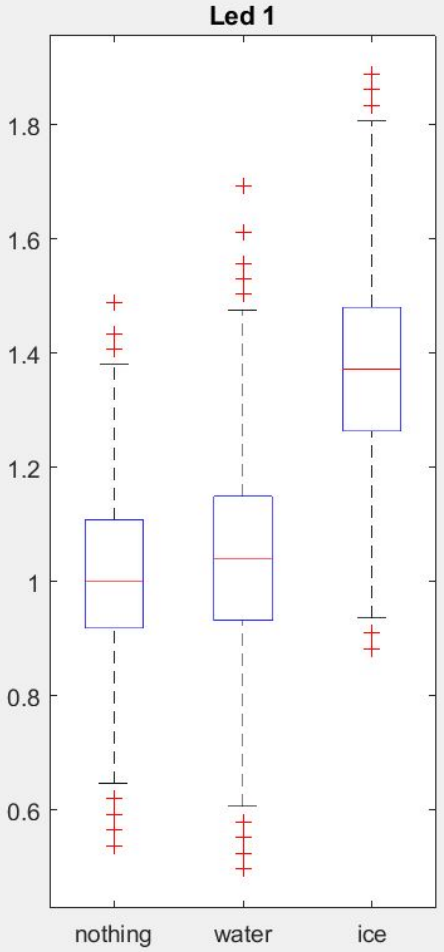
Data

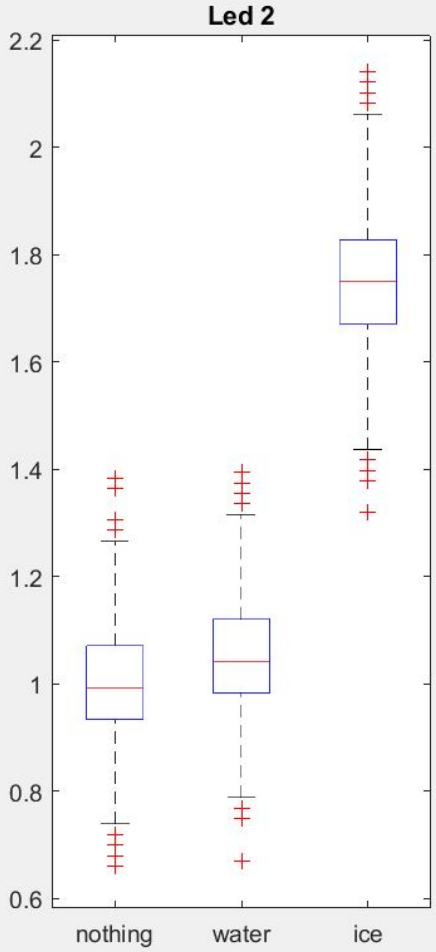

Led 1
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
nothing
water
ice
Led 2
1.4
1.2
1
0.8
0.6
0.4
0.2
nothing
water
ice
Led 3
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
nothing
water
ice

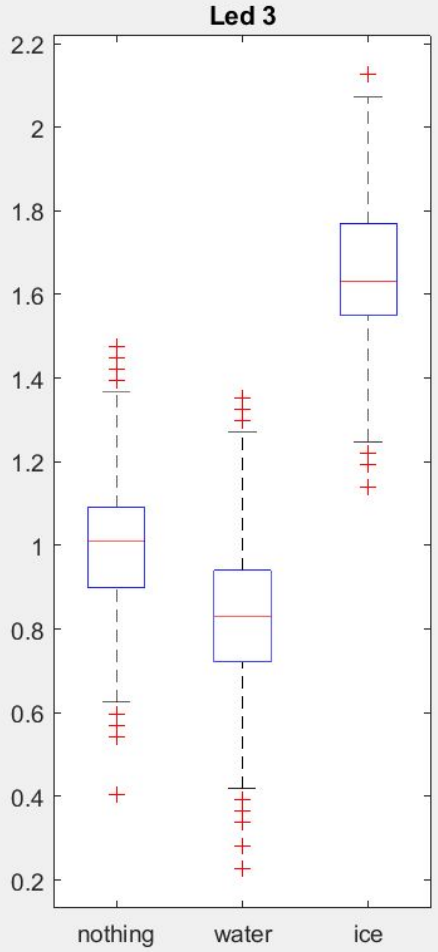
Data


Led 1
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
nothing
water
ice
Led 2
1.5
1
0.5
nothing
water
ice
Led 3
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
nothing
water
ice

Data


Led 1
1.8
1.6
1.4
1.2
1
0.8
0.6
nothing
water
ice


Led 2
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
nothing
water
ice


Led 3
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
nothing
water
ice

Areas of improvement

- More power and spread of power could improve performance
- Get sensing cascade to work (eliminate DC-offset)
- improvement of test environment
- we can still see differences between ice and the rest within each measurement

Thanks for listening