Lab 2 - Capturing Inputs

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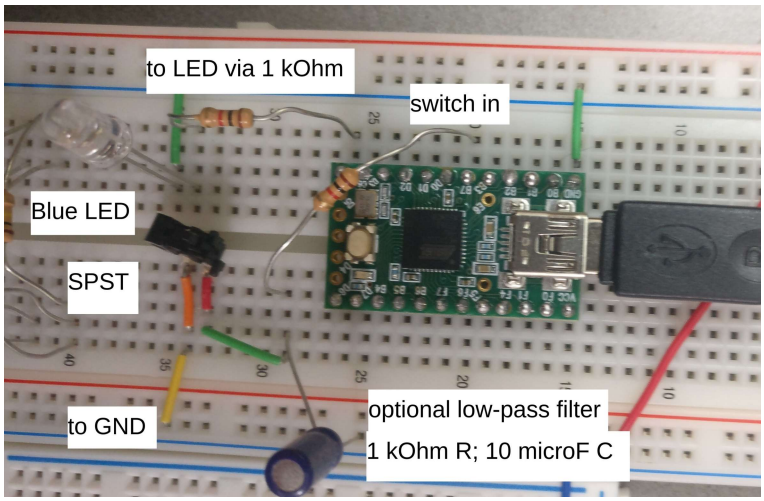
1. Switches, Debouncing and Input Capture

2.1.1 SPST Switch Wiring

Circuit Diagram



C Code

```
#include "teensy_general.h"
#include "t_usb.h"

int main(void){
    m_usb_init();

    set(TCCR1B, CS12); // set 256 prescalar
    teensy_clockdivide(0); //set the clock speed

    clear(DDRB, 7); // B7 is input
    set(PORTB, 7);  // set internal pullup

    set(DDRC, 7);  // C7 is output
    clear(PORTC, 7); // no LED

    while(!m_usb_isconnected()); // wait for a connection
    while(1){
        // detect if button is pressed
        if(!bit_is_set(PINB, 7)){
            set(PORTC, 7);
            teensy_led(ON);
            m_usb_tx_string("Bit is set\r\n");
        } else {
            // button is not pressed
            clear(PORTC, 7);
            teensy_led(OFF);
        }
    }
}
```

2.1.2 Debouncing the SPST

Add resistor and capacitor low-pass filter between the switch and the Teensy

Notes

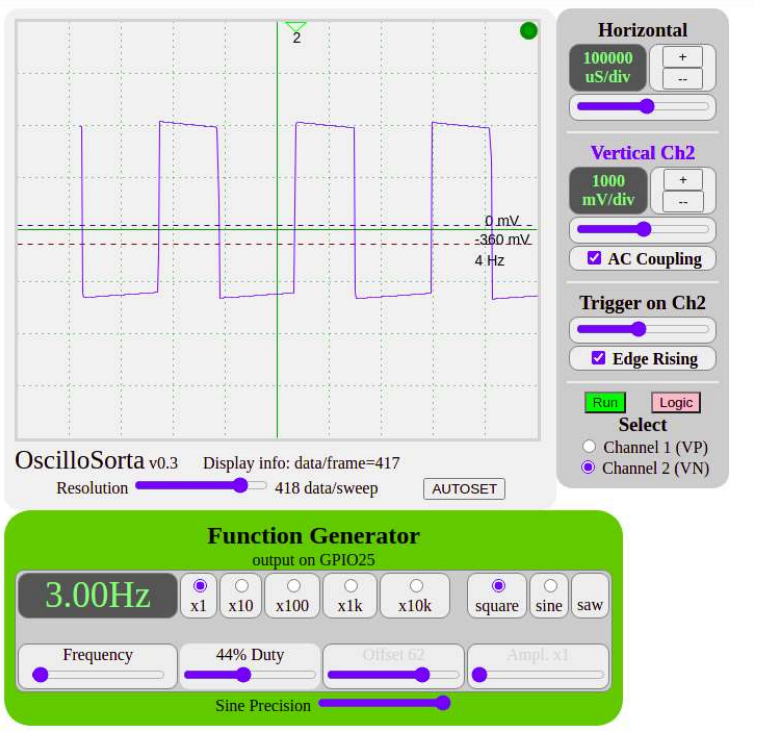
- Make sure you have a large enough RC time constant so that you don't see multiple bounces on a single press (i.e., 100Hz bounces)
- Not too large that you distort button presses that occur at roughly 10 times per second (faster than most humans can press).

Verify RC Circuit

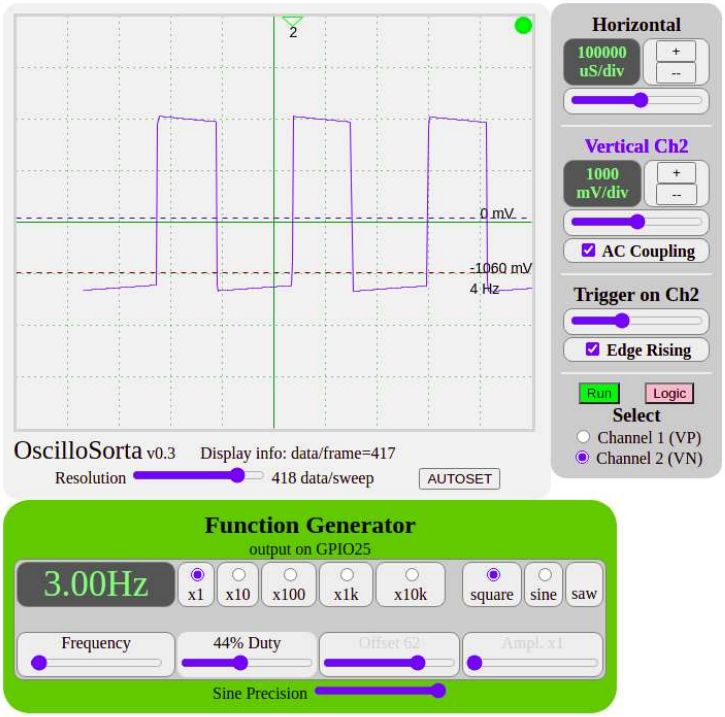
- Use the output of a square wave from a function generator into the RC circuit and view the output on an oscilloscope or your OscilloSorta.
- Notice how the signal changes as the frequency goes from below 10Hz to above 100Hz.
- Submit OscilloSorta images for each case. Ideally two traces:
  - one with output of input signal square wave
  - one with filtered output
- Show your calculation for the cutoff frequency of your low pass filter.

3Hz Wave

Raw

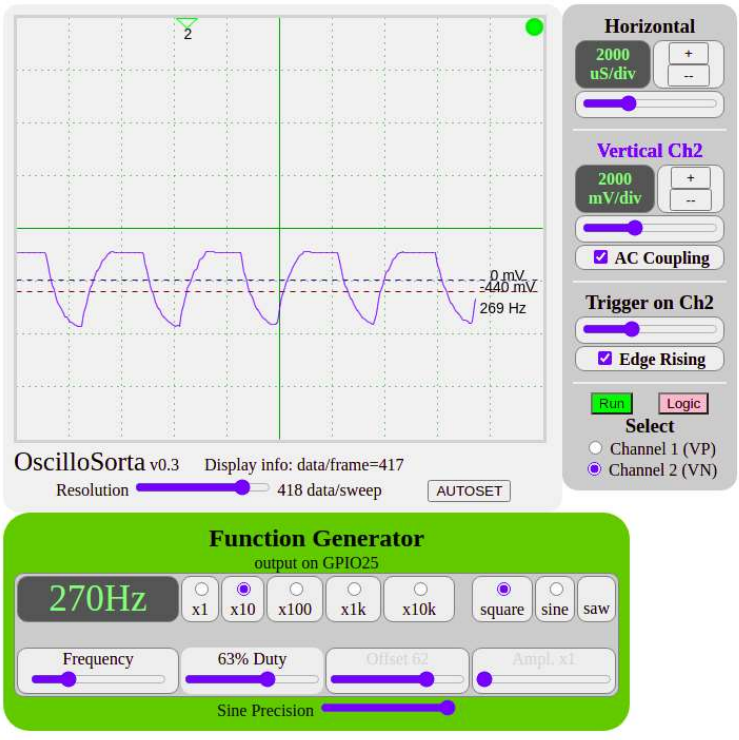


Filtered

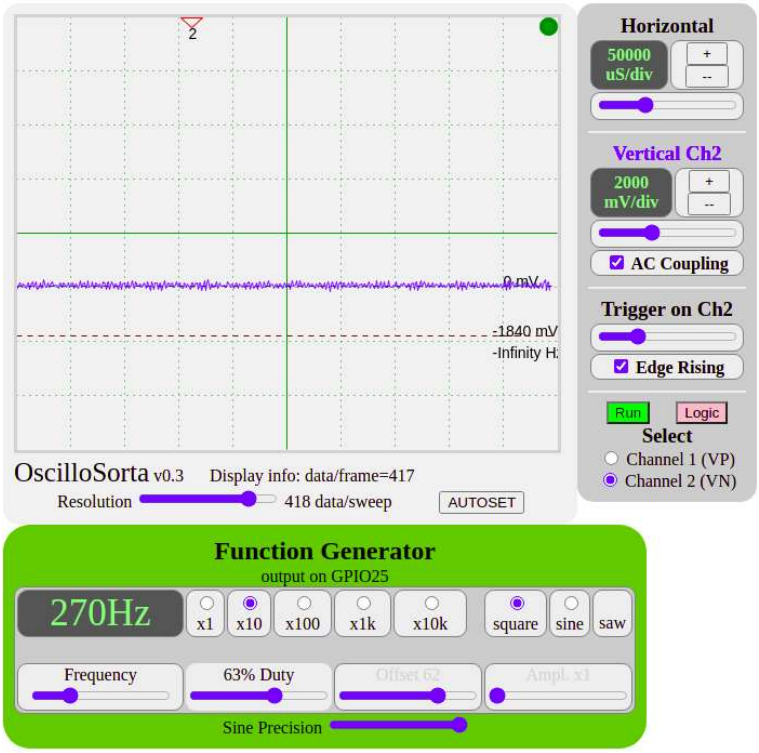


270Hz Wave

Raw



Filtered

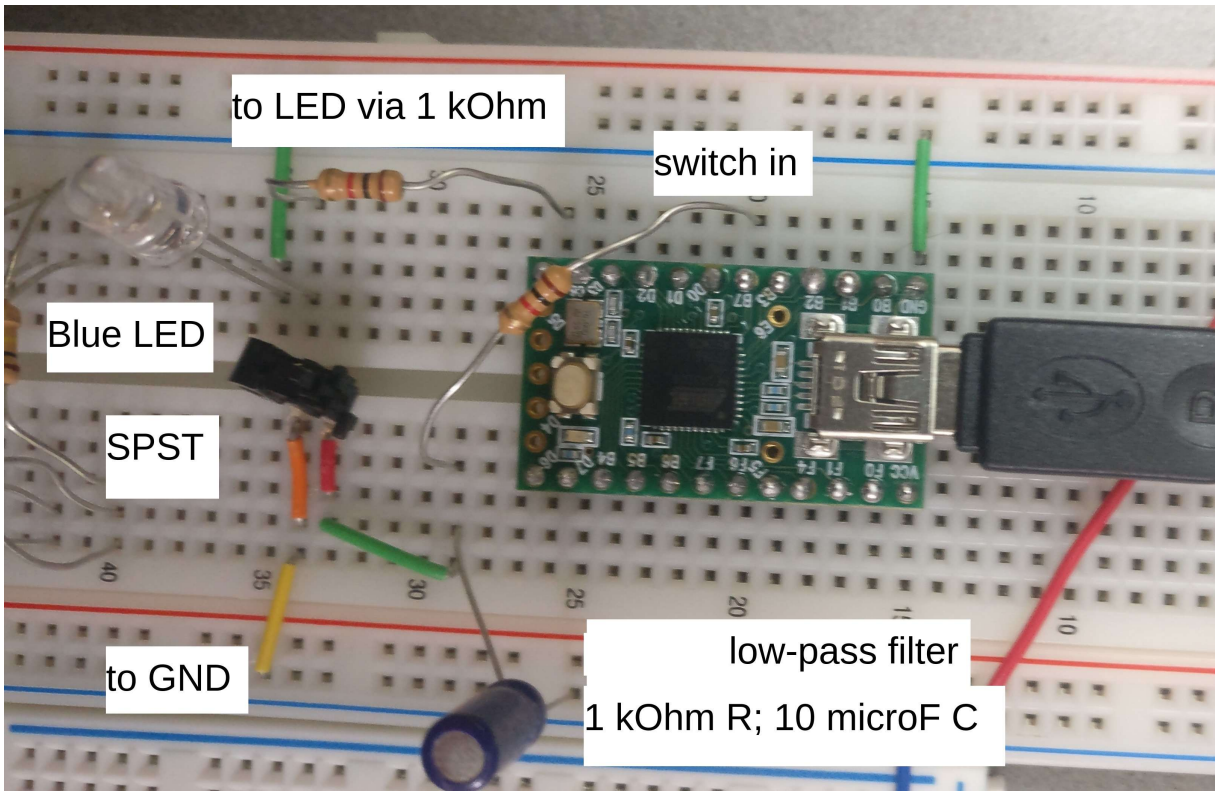


Cutoff Frequency Calculation

Cutoff Frequency = `1/(2*pi*R*C) = 15Hz` for:

- 1 kOhm Resistor
- 10 microFarad Capacitor

Schematic w/ Low Pass Filter



Human Reaction Speed

Change the code so that it:

1. prompts the person when to start
2. measures 5 presses
3. prints out the average time between the 5 presses in milliseconds

Test Runs

Tries	Fastest Time (ms)
1	312
2	259
3	559
4	367
5	412

C Code

```
#include "teensy_general.h"
#include "t_usb.h"
#include <string.h>
#include <stdbool.h>
#include <stdio.h>

#define DEBUG_PRINTS 1
#define MIN_TIME 1563 // 100ms in clock ticks
#define CLOCK_SPEED 16e6
#define PRESCALAR 1024

unsigned int button_presses[5]; // record tcnt3 values for each press
int press_i; // ix of button press being recorded
bool prev_state; // true when switch is depressed
bool prompt_shown;

void compute_results(){
    float sum_t = 0;
    for(int i = 1; i < 5; ++i){
        sum_t += (button_presses[i] - button_presses[i-1]);
    }

    sum_t *= (PRESCALAR);
    sum_t /= (CLOCK_SPEED*4.0);
    sum_t *= 1000;

    m_usb_tx_string("||====== Avg. Time: ");
    m_usb_tx_uint(sum_t);
    m_usb_tx_string(" (ms)  =======||\r\n");

    prompt_shown = false;
}

void toggle_print(){
    m_usb_tx_string("||======   Button Press  ==========||\r\n");
}

void display_prompt(){
    m_usb_tx_string("||======   Start Pressing!   ======|| \r\n");
    prompt_shown = true;
}
```

```
void record_press(bool new_state){
    if(prev_state != new_state){
        // only record down presses
        if(new_state){
            if(press_i == 0 ||
                TCNT3 - button_presses[press_i-1] > 3*MIN_TIME){
                button_presses[press_i] = TCNT3;
                toggle_print();
                press_i++;
            }
        }
    }
    prev_state = new_state;
}

int main(void){
    m_usb_init();

    // set 1024 prescalar
    set(TCCR3B, CS32); set(TCCR3B, CS30);

    teensy_clockdivide(0); //set the clock speed

    clear(DDRB, 7); // B7 is input
    set(PORTB, 7);  // set internal pullup

    set(DDRC, 7);  // C7 is output
    clear(PORTC, 7); // no LED

    prev_state = false;
    prompt_shown = false;

    while(!m_usb_isconnected()); // wait for a connection

    while(1){

        if(press_i == 5) compute_results();
        if(!prompt_shown) {
            memset(button_presses, 0x00, sizeof(button_presses)); // clear array
            press_i = 0;
            display_prompt();
        }

        // detect if button is pressed
        if(!bit_is_set(PINB, 7)){
            record_press(true);
            set(PORTC, 7);
        } else {
            // button is not pressed
            record_press(false);
            clear(PORTC, 7);
        }
    }
}
```

Extra Credit: Improve Granularity (Not Attempted)

Determine and implement the finest time resolution that you can measure these time presses using input capture 3 assuming the slowest a person will be is 0.5 seconds.

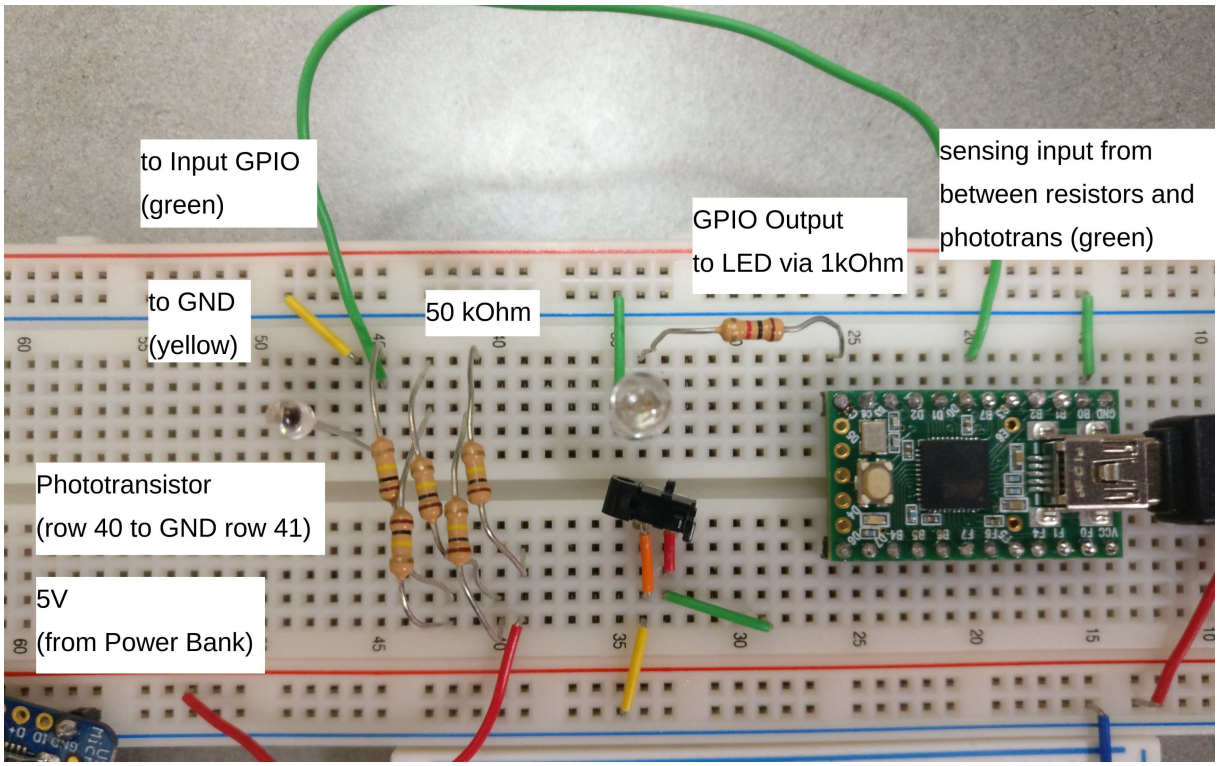
2. Phototransistors

2.2.1 Creating Circuit

Phototransistor Behavior w.r.t. Light

- With no light, the phototransistor outputs logic low
- With normal light, the phototransistor outputs logic high
- If curcuit does not have a pull-up, `PINB` will be high when no light and low in normal light
- As resistance is increased, the phototransistor becomes more sensitive, following Ohms law
- The relationship between the sensitivity of the phototransistor and the resistance in series with is defined by Ohm's law `V = IR`

Circuit Diagram



C Code

```c
#include "teensy_general.h"

#define CLOCK_SPEED 16e6
#define PRESCALAR 1024

int main(void){
    // set 1024 prescalar
    set(TCCR3B, CS32); set(TCCR3B, CS30);

    teensy_clockdivide(0); //set the clock speed

    clear(DDRB, 7); // B7 is input

    set(DDRC, 7);  // C7 is output
    clear(PORTC, 7); // no LED

    while(1){

        // detect if light
        if(bit_is_set(PINB, 7)){
            set(PORTC, 7);
        } else {
            clear(PORTC, 7);
        }
```

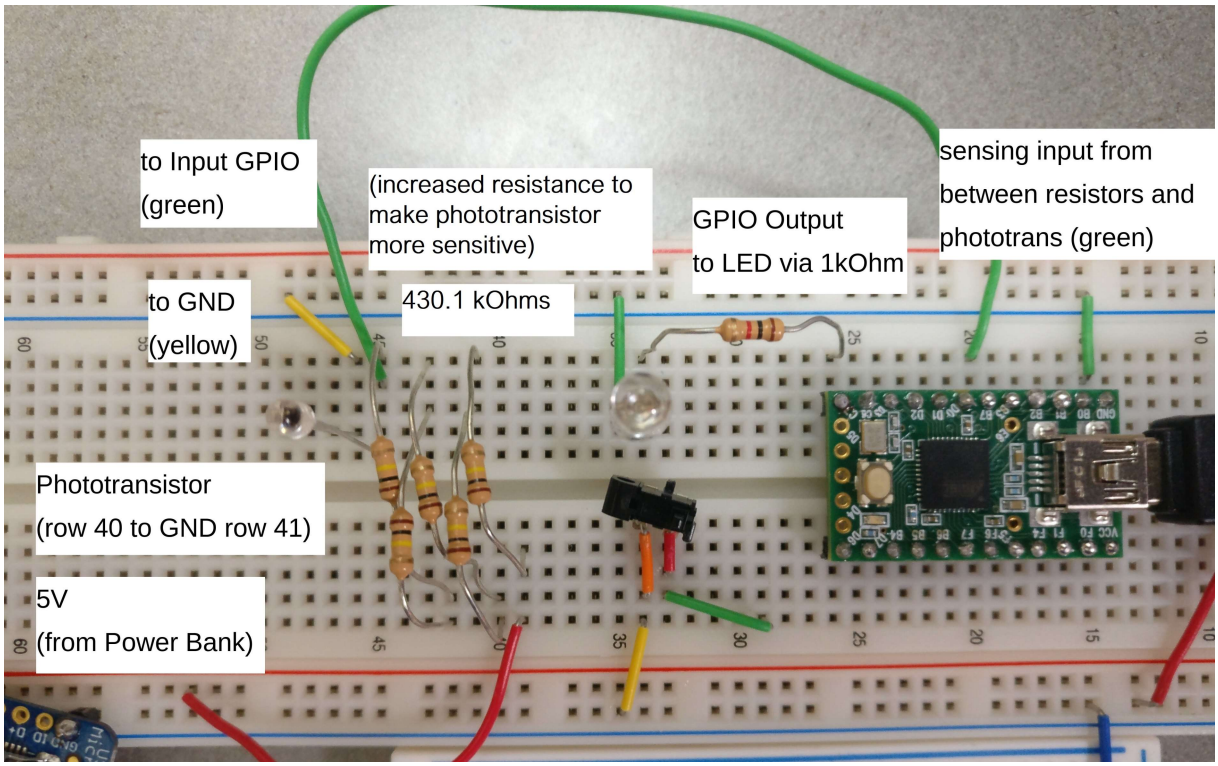
```
    }
}
```

Video Demo of LED Phototransistor

2.2.2 Tuning Gain of Transistor

Video Demo of Hand-Waiving

Schematic



C Code

```
#include "teensy_general.h"

#define CLOCK_SPEED 16e6
#define PRESCALAR 1024

int main(void){
    // set 1024 prescalar
    set(TCCR3B, CS32); set(TCCR3B, CS30);

    teensy_clockdivide(0); //set the clock speed

    clear(DDRB, 7); // B7 is input

    set(DDRC, 7);  // C7 is output
    clear(PORTC, 7); // no LED

    while(1){

        // detect if light
        if(bit_is_set(PINB, 7)){
            set(PORTC, 7);
        } else {
            clear(PORTC, 7);
```

```
        }
    }
}
```