

Capsense techniques

Eindhoven University of Technology
Industrial Design – Wearable Senses

Admar Schoonen
2016-07-21

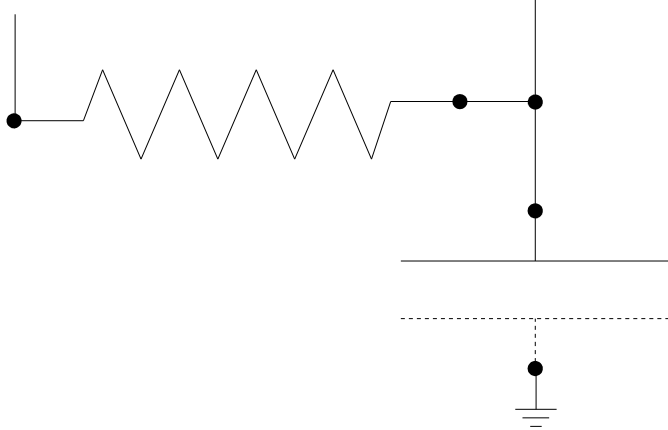
Contents

- RC method
- CVD method
- Digital filtering
- Button state machine

RC method: operation

To Arduino
transmit pin

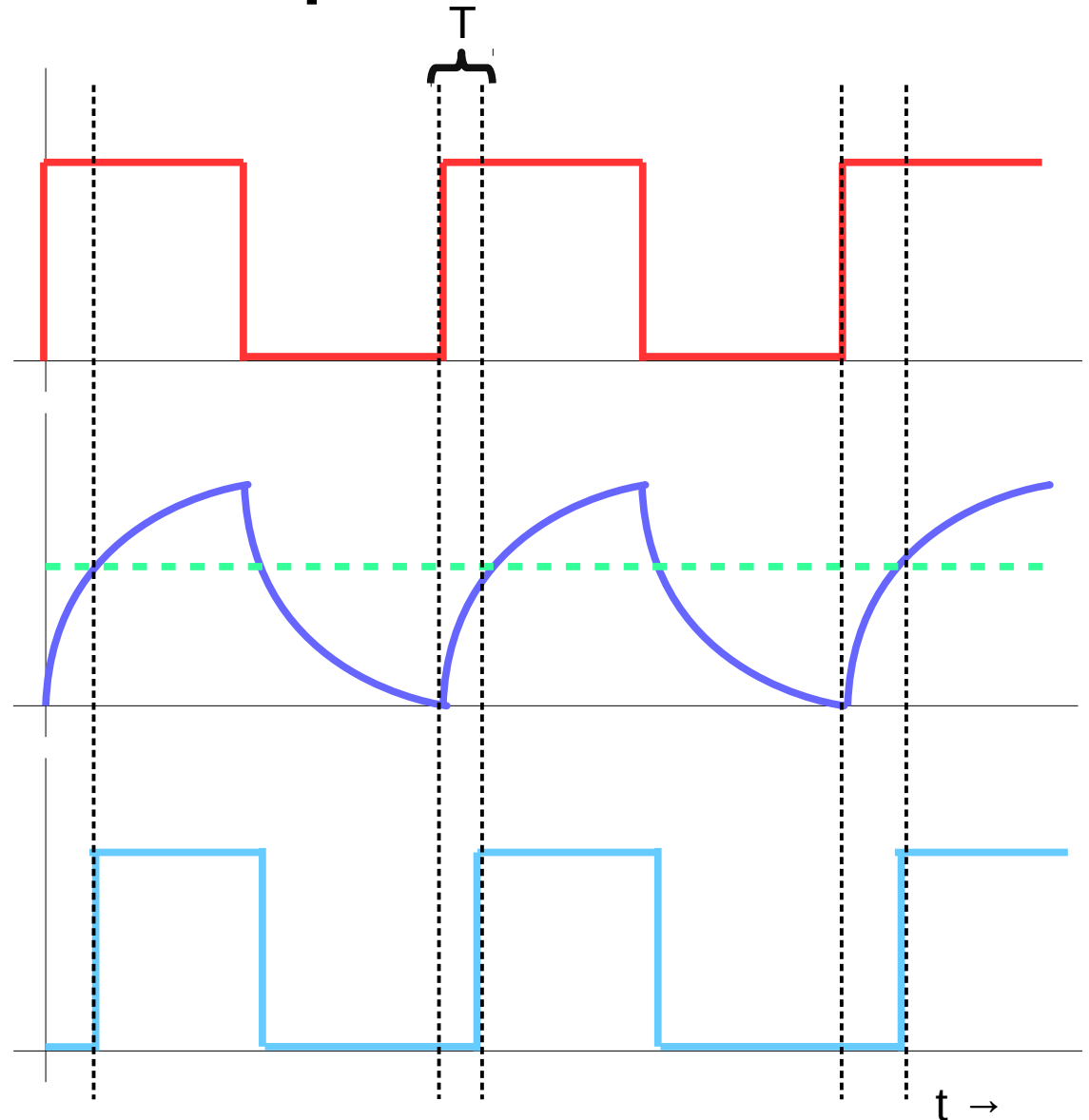
To Arduino
receive pin



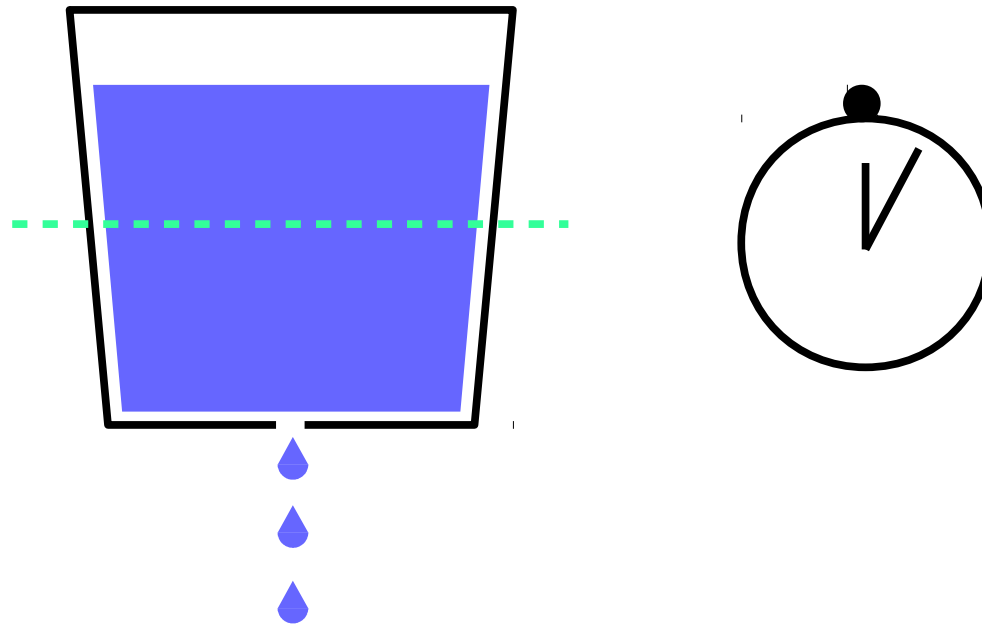
Reference voltage ($\sim 2.5V$):
above this level, signal is high
("1"), below it is low ("0")

Digital input as seen by Arduino

Time T between transmit pin going
up and digital input going up is
measure of capacitance



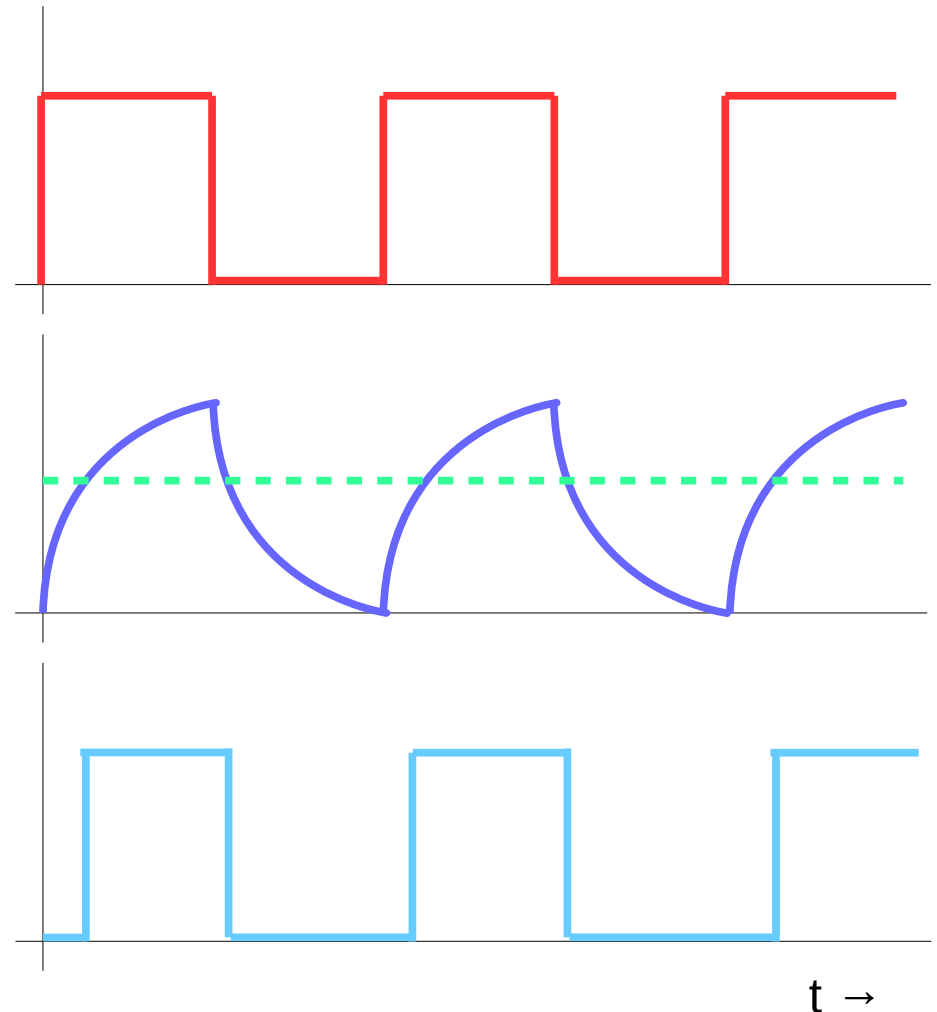
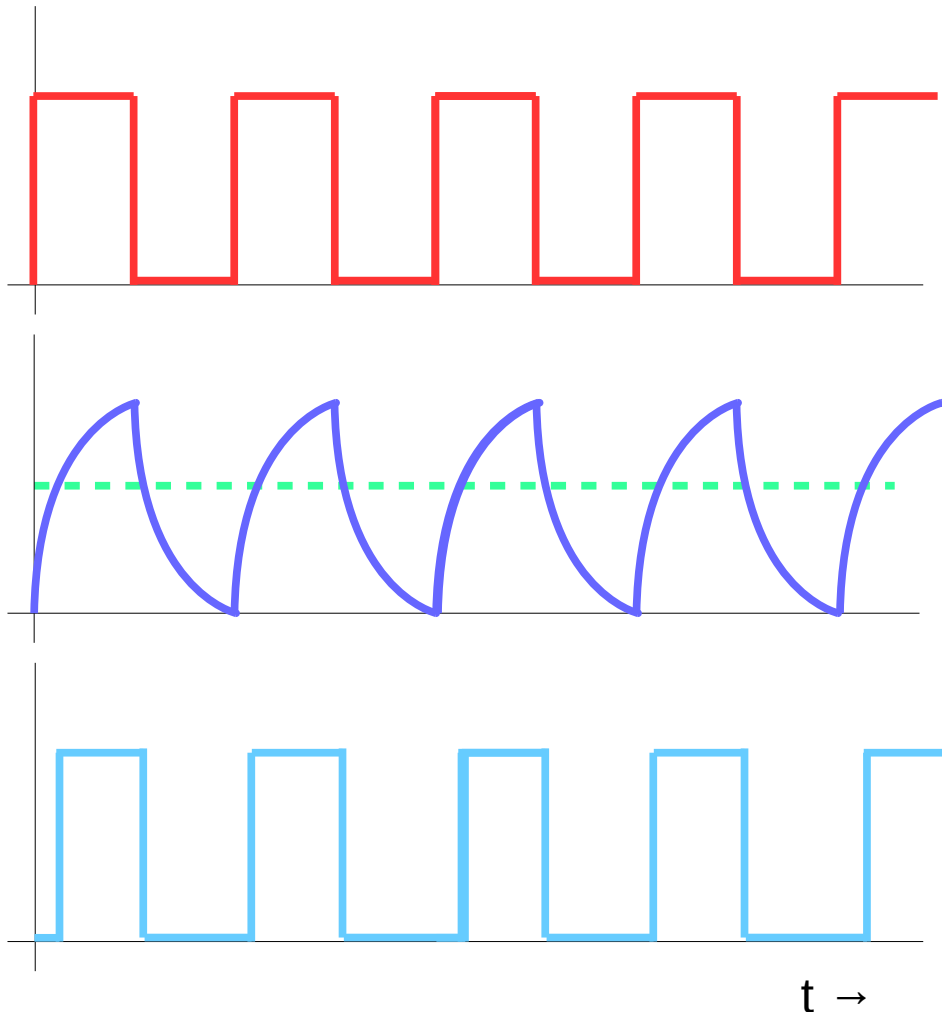
RC method: water bucket analogy



RC method: signals

No hand present (C is small)

Hand present (C is large)



RC method: issues

- Time between pulses can vary a lot depending on presence of hand (can vary from $\sim 1\mu\text{s}$ to $\sim 500\mu\text{s}$)
- Update rate at $500\mu\text{s}$ is very slow \rightarrow limited filtering possible
- Variable update rate makes filtering difficult

RC method: pros & cons

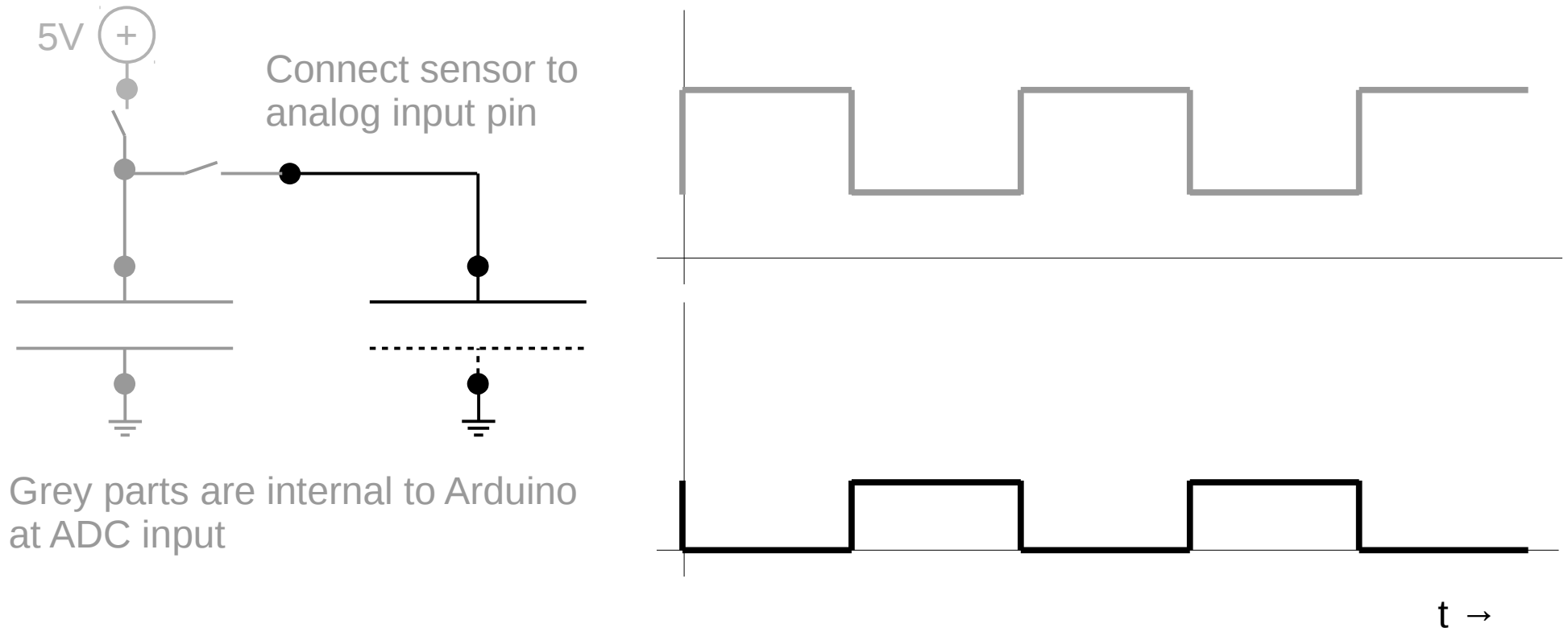
Pros:

- Works on any 2 digital pins
- Simple
- Low cost
- Open source

Cons:

- Slow or variable update rate
- Filtering is limited or difficult

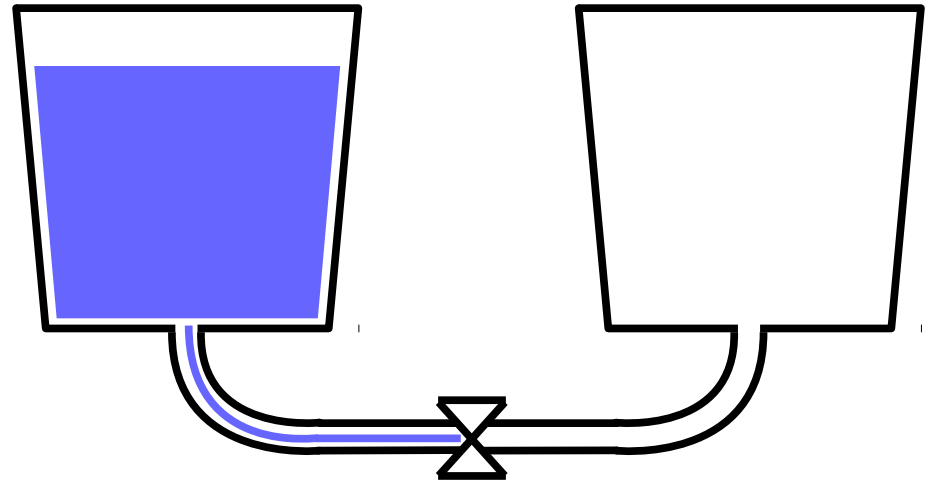
CVD method: operation



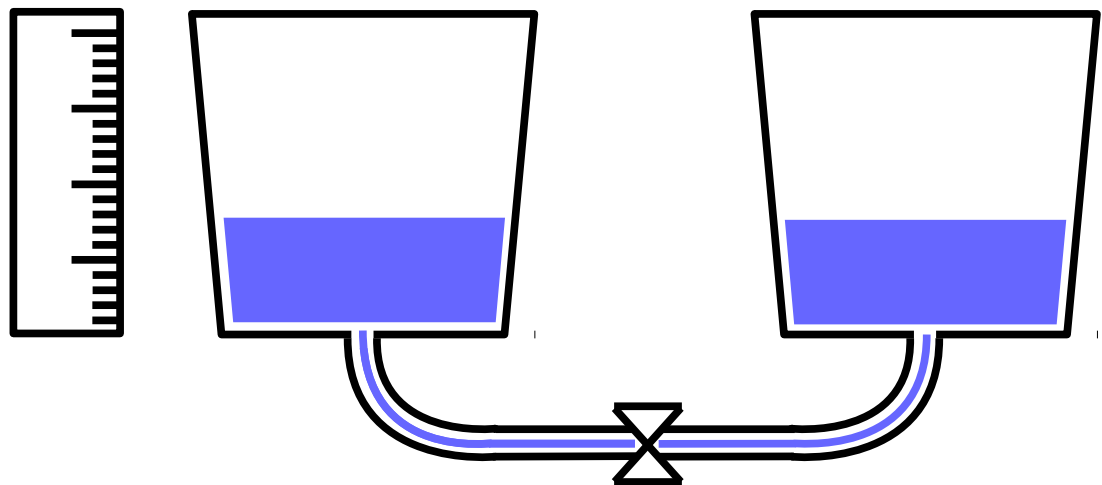
Use internal sample & hold capacitor of ADC as reference capacitor. Charge internal C&H, then spread charge over C&H and sensor and finally measure voltage.

CVD method: water bucket analogy

- Close valve
- Fill reference bucket (charge S&H capacitor)

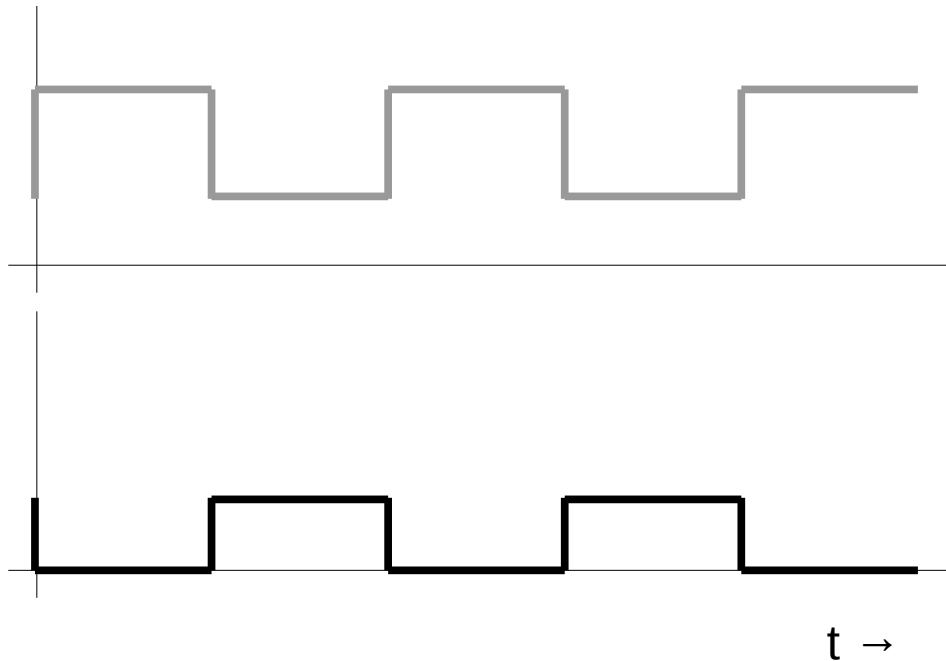


- Open valve: water will distribute over both buckets (charge distributes over S&H and sensor)
- Measure water level

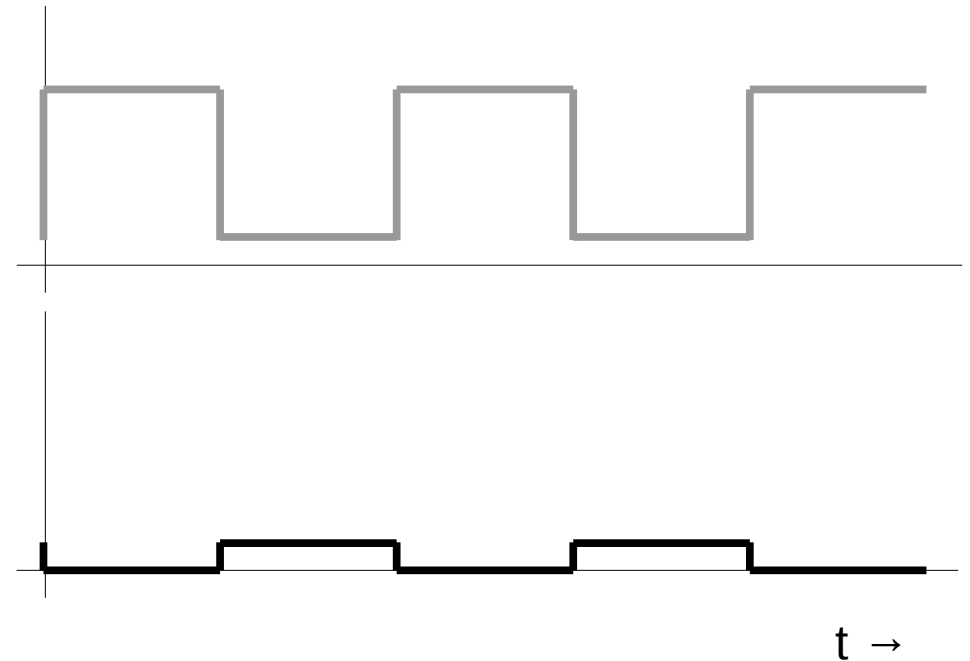


CVD method: signals

No hand present (C is small)



Hand present (C is large)



CVD method: issues

- Requires an internal ADC that is connected to a GPIO
- MCU should be able to switch pin between digital output and analog input while ADC is connected
- Works with most MCUs that have an ADC connected to GPIO through a multiplexer
 - Including Arduino
 - Does not work with ESP8266 (?)

RC method: pros & cons

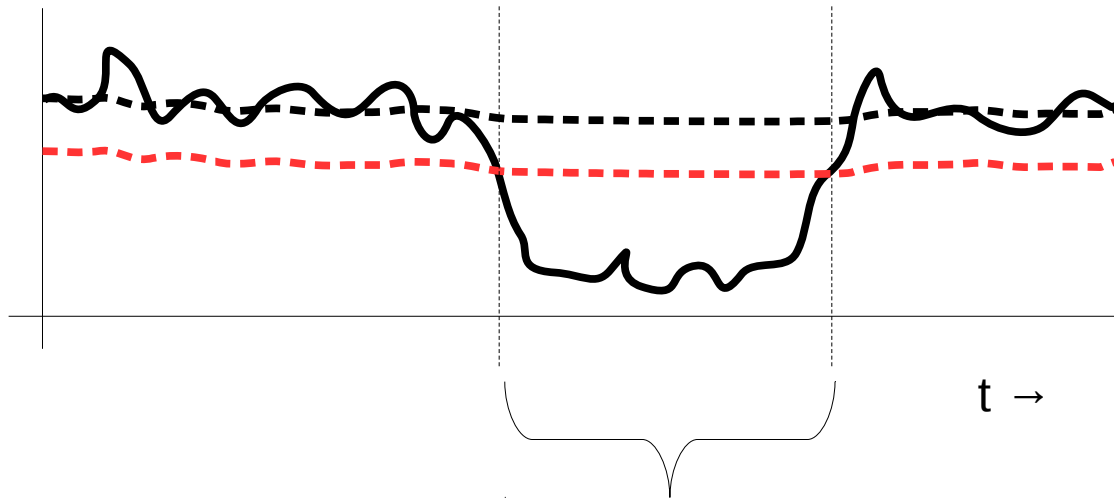
Pros:

- Works on any analog input
- Fast and predictable timing
- Allows diverse filtering
- Ultra low cost

Cons:

- Does not work if MCU does not have analog multiplexer / GPIO combination
- Patent by Microchip (but Arduino uses Atmel and Microchip recently bought Atmel)

Digital filtering



Touch detected: do not
update baseline

- Raw signal
- - - - - Filtered signal (baseline)
- . - . - . Threshold (baseline – fixed value)

Digital filtering

Possible filters:

- Simple single pole exponential decaying filter
 - This is what I usually use
 - This is also only filter available at my github
- FIR filter
- Median filter
- Rate limiting filter
 - Slow but very good against conducted noise

Button state machine

