Midterm 2 - clatter policy
Keep turning in the HWs!

Synchronous Digital
- don't care about $v(t)$ except at specific times,
- clock ticks every $T = \frac{1}{f}$ seconds
  - 100ns for cheap mP
  - 100ps for fastest digital
- voltages are still analog, but we "look" at them only on the clock
  
  $v(t) \Rightarrow x(nT) = x_n, \ n \in \mathbb{Z}$

$\begin{align*}
\begin{array}{c}
\text{almost always} \\
\begin{array}{c}
 x_n = 0 \Rightarrow v(nT) = 0 \\
 x_n = 1 \Rightarrow v(nT) = V_{dd}
\end{array}
\end{array}
\end{align*}$

at least ideally
in reality, voltages are rarely at the rails

\[ \frac{V_{DD}}{R_L} = \frac{V_0}{R_L} \Rightarrow \frac{T}{L} \]

\[ \frac{X}{R_L} \]

with $C_p$ and $R_L, R_S$
we'll see exponentials,
when do they go to
\[ 0, V_{DD} ? \]
Answer: 1000.

Data sheets:
- $0 < V < 0.2V_{DD}$ "logic 0" $x_n = 0$
- $0.8V_{DD} < V < V_{DD}$ "logic 1" $x_n = 1$
- $0.2V_{DD} < V < 0.8V_{DD}$ invalid

Should never happen.

Example: pressure sensitive switch

Options:
- Click $V_{threshold}$
- $V_{min} = 0.5V_{DD}$
- Hysteresis

What if you want the switch to be "press" over a range of values (e.g., a musical key)?

What range? $\infty$, 12 is 12 enough?

How about 30, 123?

$\infty$, 12, ... 10003?!

ADC

Study:

Discrete values "quantized"
Once way to make an ADC

\[ \begin{align*}
    V_{DD} & \quad V_{in} \\
    R & \quad \frac{1}{4} \\
    \frac{1}{2} R & \quad \frac{1}{4} \\
    \frac{1}{4} R & \quad \frac{1}{4} \\
    \frac{1}{8} R & \quad \frac{1}{4} \\
\end{align*} \]

"Thermometer code"

Q: How many possible states of the 3 outputs?

A: 4

\[ \begin{align*}
    000 \\
    001 \\
    011 \\
    111 \\
\end{align*} \]

Can you do the same thing w/ \( \sim 100 \) resistors/computers

\[ \text{set} \ n \ 100 \ \text{states} \]

Do you need 100 binary values (bits) to share that? No.

Learn to count in binary

\[ \begin{align*}
    \text{base } 10 & : \quad 537 = 5 \times 10^2 + 3 \times 10^1 + 7 \times 10^0 \\
    10 \text{ binary } & : \quad 1 \times 2^2 + 0 \times 2^1 + 1 \times 2^0 \\
\end{align*} \]

How high can you count on 1 hand? \( 2^5 \) states

\[ 0 \ldots 2^5 - 1 = 31 - 1 \]

\( 2^{10} \) states = \( 1024 \) states

How many fingers do I need to represent the number of states in the lab ADC?

A: 2

\[ \begin{align*}
    \text{Analogue} & \quad \text{ADC} \quad \text{digital} \quad \text{MP} \quad \text{digital} \quad \text{DAC} \quad \text{analyse} \\
    [\text{mV}] & \quad \text{SW} \times 10 \quad \text{[mV]} \\
    0 & \quad 2 \quad 30 \quad 30 \\
    1 & \quad 2 \quad 20 \quad 10 \\
    1 & \quad 2 \quad 10 \quad 10 \\
\end{align*} \]

Why filter?

\[ f_s = \frac{1}{T} = 1 \text{kHz} \]

\[ V_i = 1 \]

\[ V_{in2} = \cos(\omega t) \quad \omega = 2\pi \text{ fkHz} \]