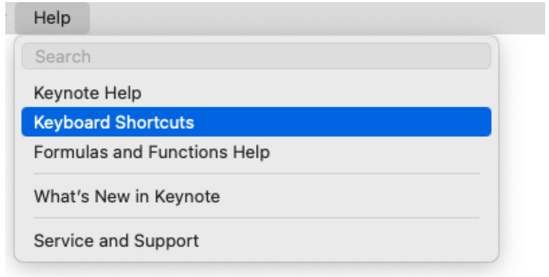
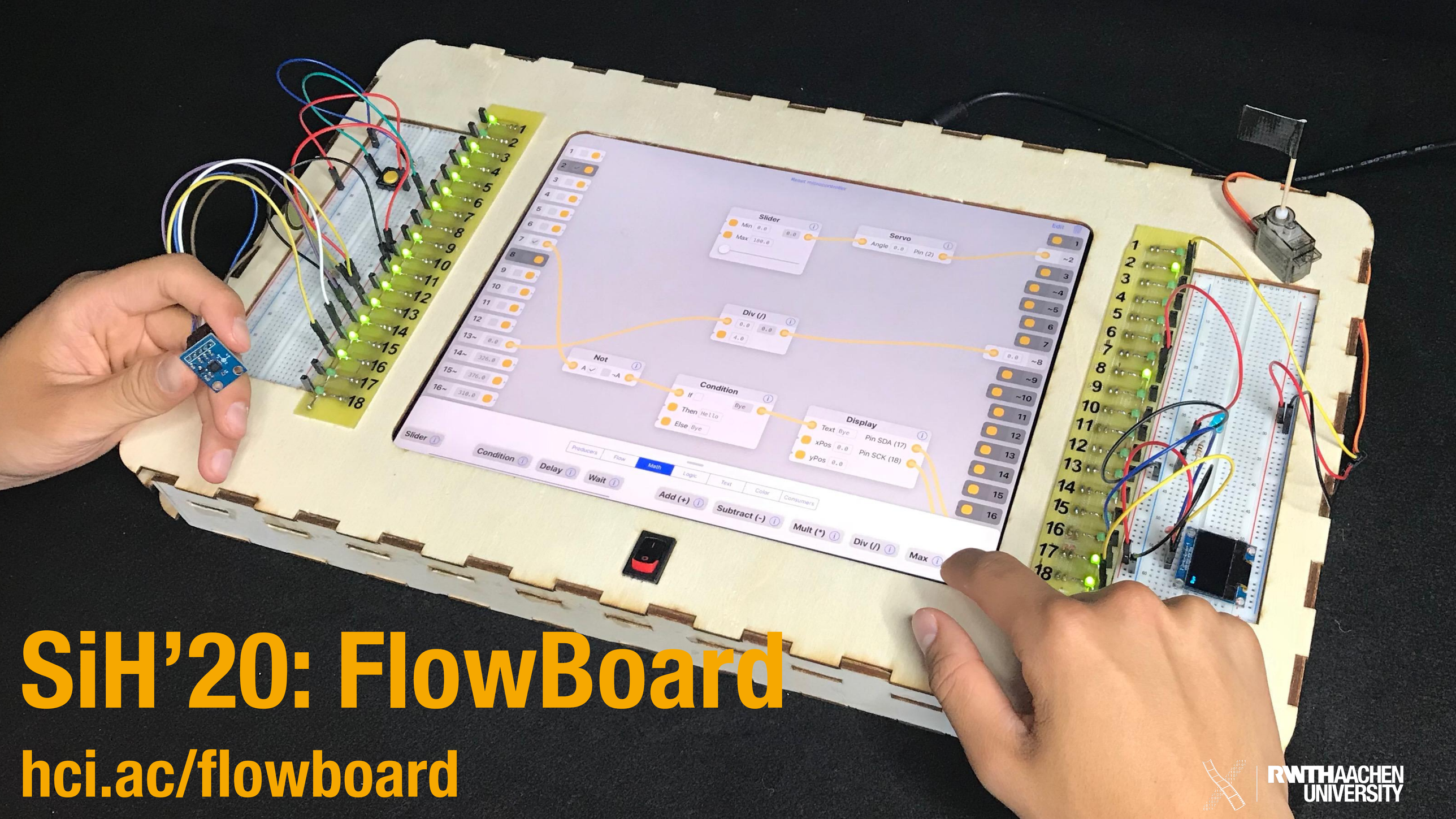
⌘-F1 **Toggle Mirroring**

X **Exchange Displays**



More Shortcuts



SiH'20: FlowBoard

hci.ac/flowboard

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USB & HDMI Considered Harmful

Prof. Jan Borchers • Sketching In Hardware • Dublin, Oct 01, 2022

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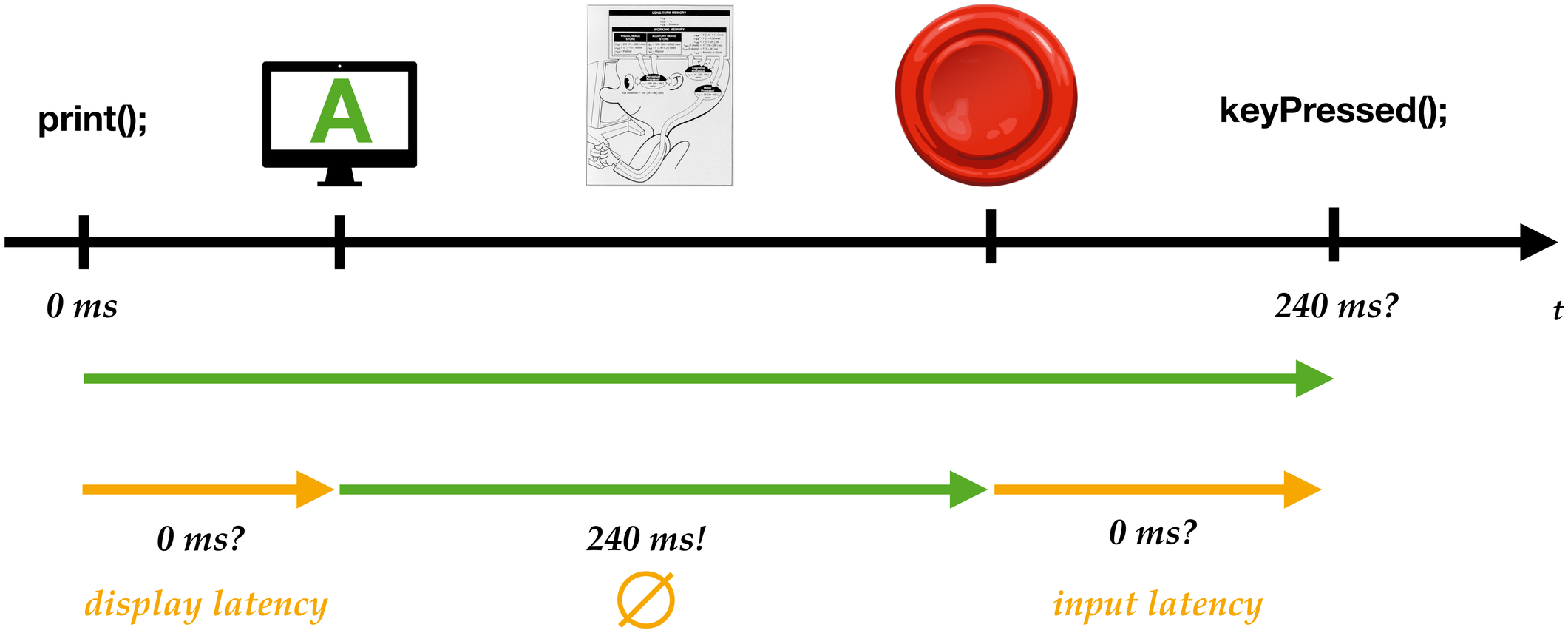

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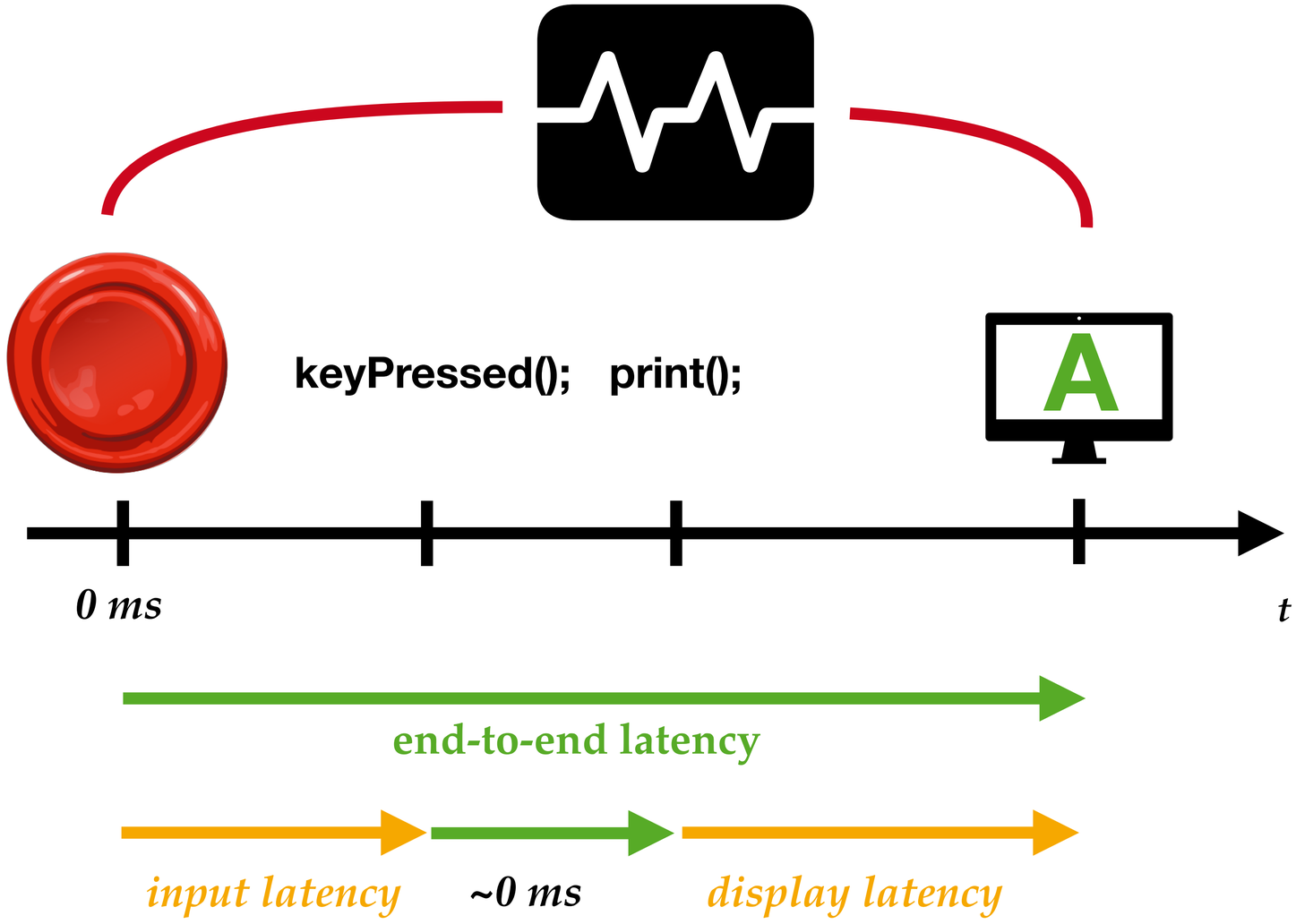
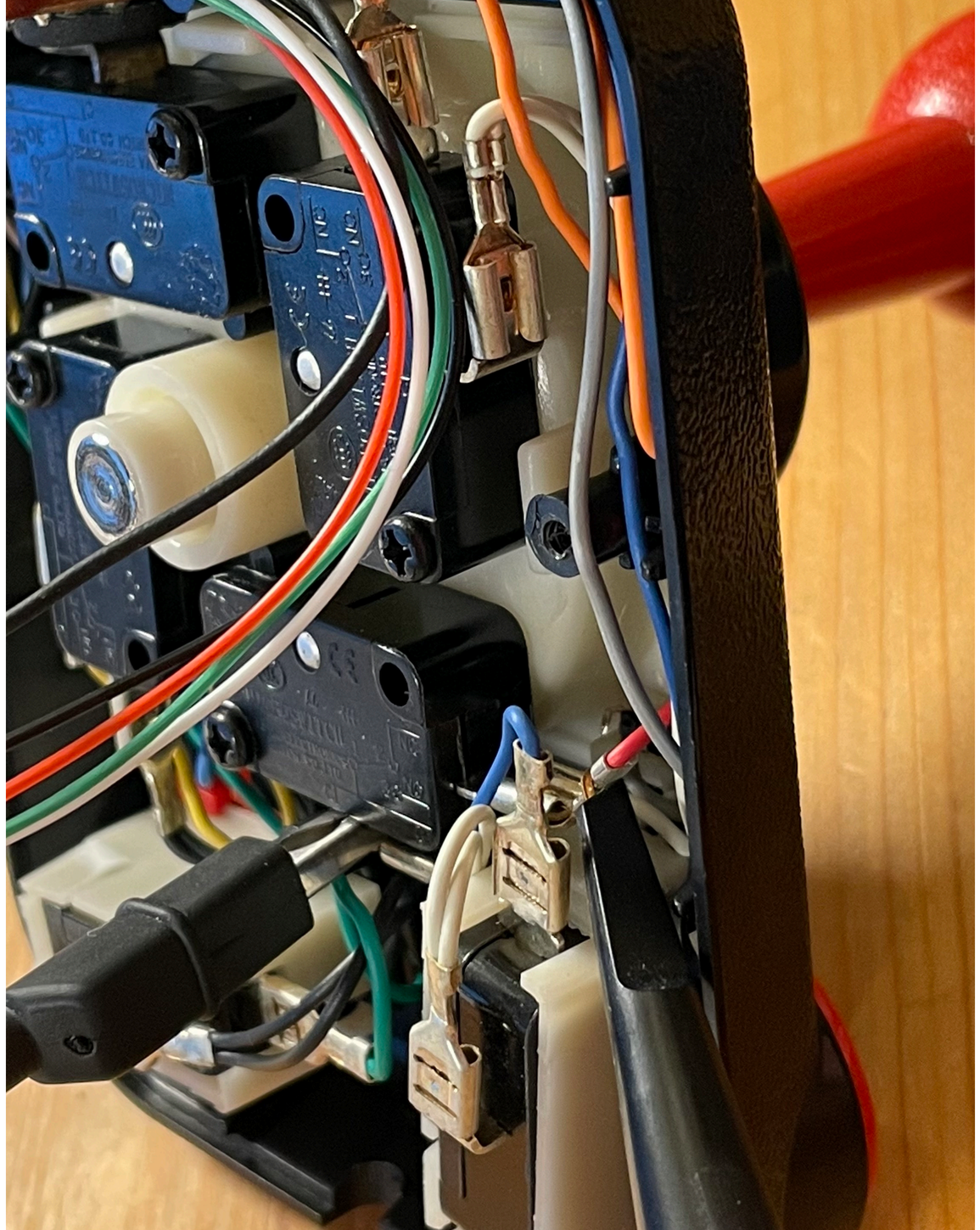

keyPressed(); print();
A
0 ms
t
end-to-end latency
input latency
~0 ms
display latency



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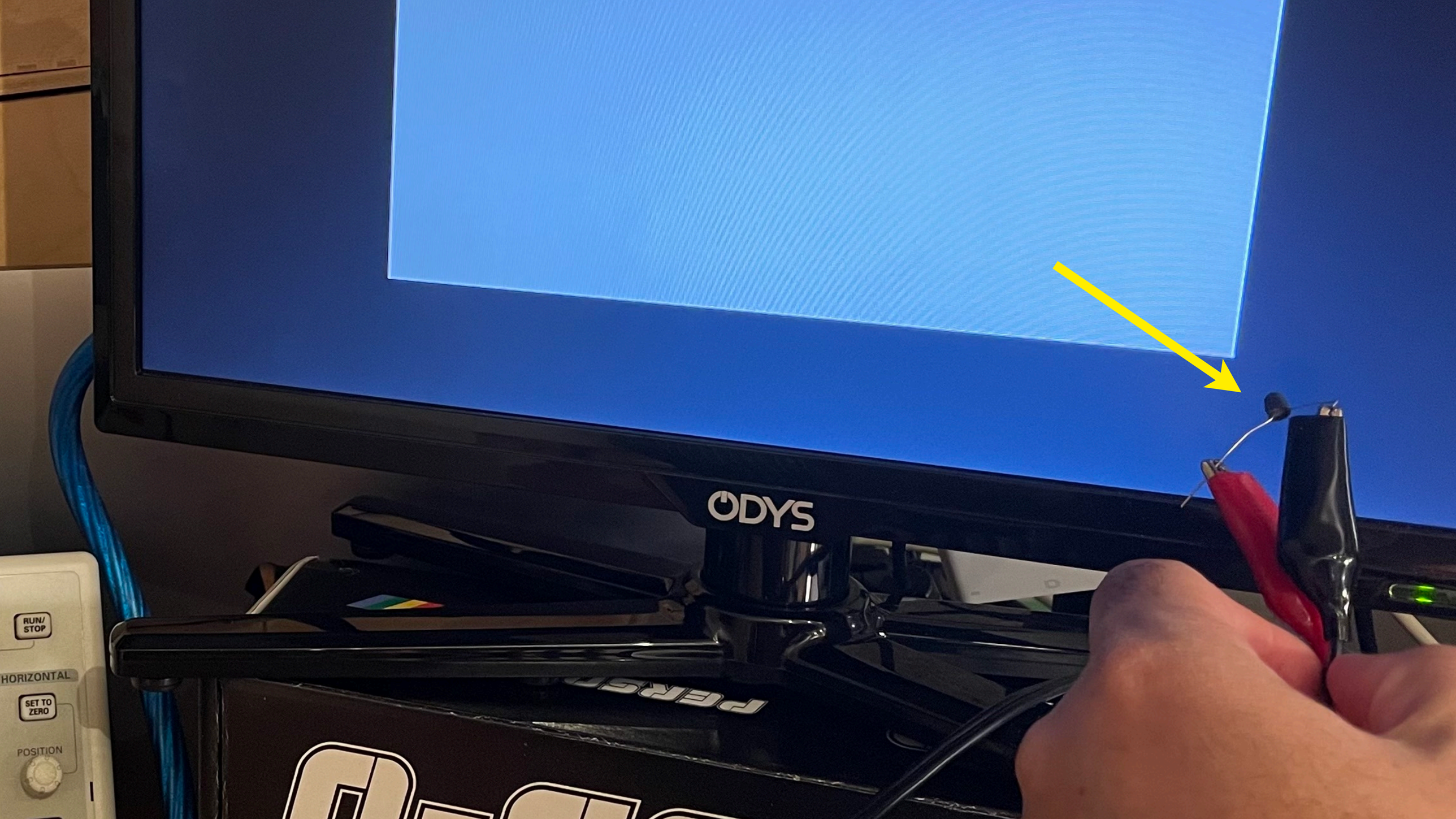
ODYS
RUN/
STOP
HORIZONTAL
SET TO
ZERO
POSITION

Code (Z80 Assembler)

```
Loop:
     in a,(31)      ; Read Kempston joystick input
     out (254),a    ; Set the border color accordingly
     jr Loop
```


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Acceptable end-to-end latency:

$\ll$ 100 ms!

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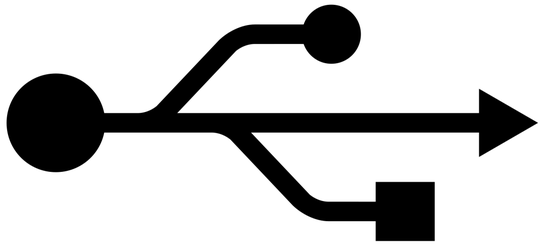
MacBook Pro



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HDMI

130–160 ms

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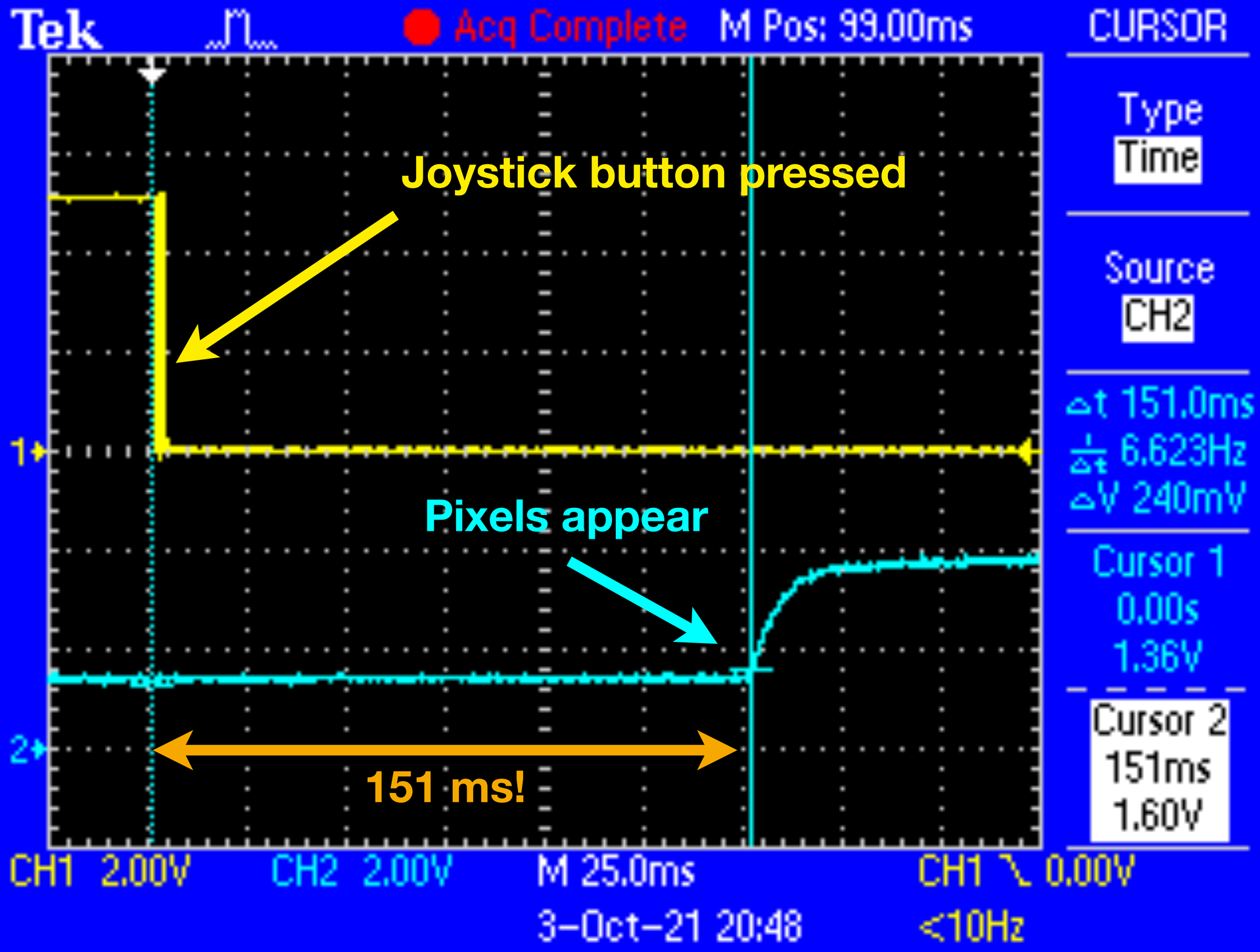
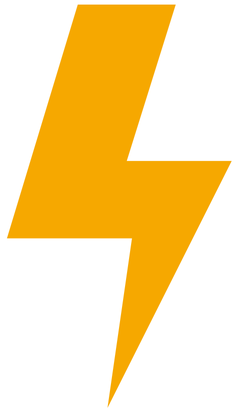

Tek
Acq Complete
M Pos: 99.00ms
CURSOR
Type
Time
Source
CH2
Δt 151.0ms
1/Δt 6.623Hz
ΔV 240mV
Cursor 1
0.00s
1.36V
Cursor 2
151ms
1.60V
Joystick button pressed
Pixels appear
151 ms!
1
2
CH1 2.00V
CH2 2.00V
M 25.0ms
CH1 ∖ 0.00V
3-Oct-21 20:48
<10Hz

+ 40–120 ms

Jitter 

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0–20 ms

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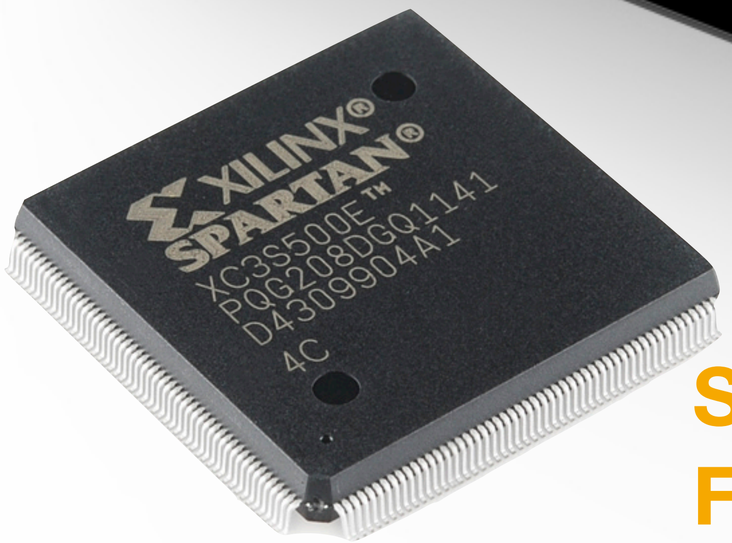

Spectrum Next (2020): FPGA

0–20 ms

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Tachistoscope

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Summary

- Latency is crucial in every interactive system
- Any latency is bad (reality: 0 ms), but stay well below 100 ms
- Performance ≠ Latency, Throughput ≠ Latency
- Experimenters & Interaction Designers: Watch your end-to-end latency (try the ***Is It Snappy*?** app)
  - HDMI adds lag, USB adds lag *and jitter*
  - Analog (Composite Video, VGA) and **software-free** digital signals (Atari joystick) don't
- Things *were* better back in the day—but FPGA can bring them back :)
- Special thanks to Franz-Josef Michiels, Graham Wideman, Andrew Gregson, and Sir Clive Sinclair
- https://hci.ac/latency

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