Intro to Digital Design
L10: Course Wrap-up

Instructor: Naomi Alterman

Teaching Assistants:

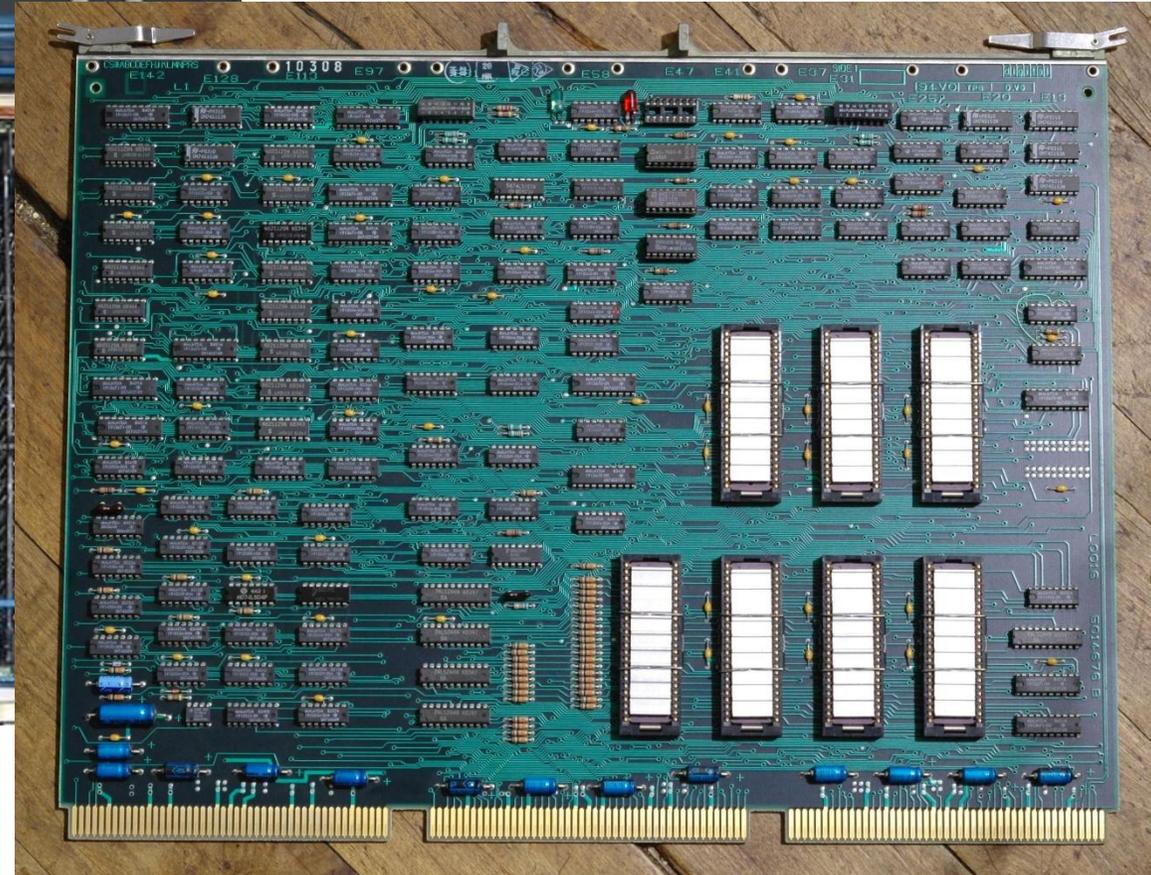Derek de Leuw   Isabel Froelich

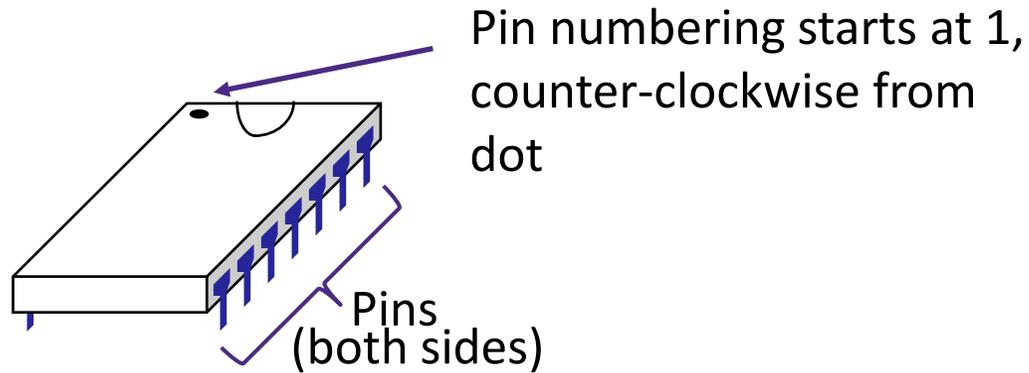Kevin Hernandez   Sathvik Kanuri

Aadithya Manoj

Outline
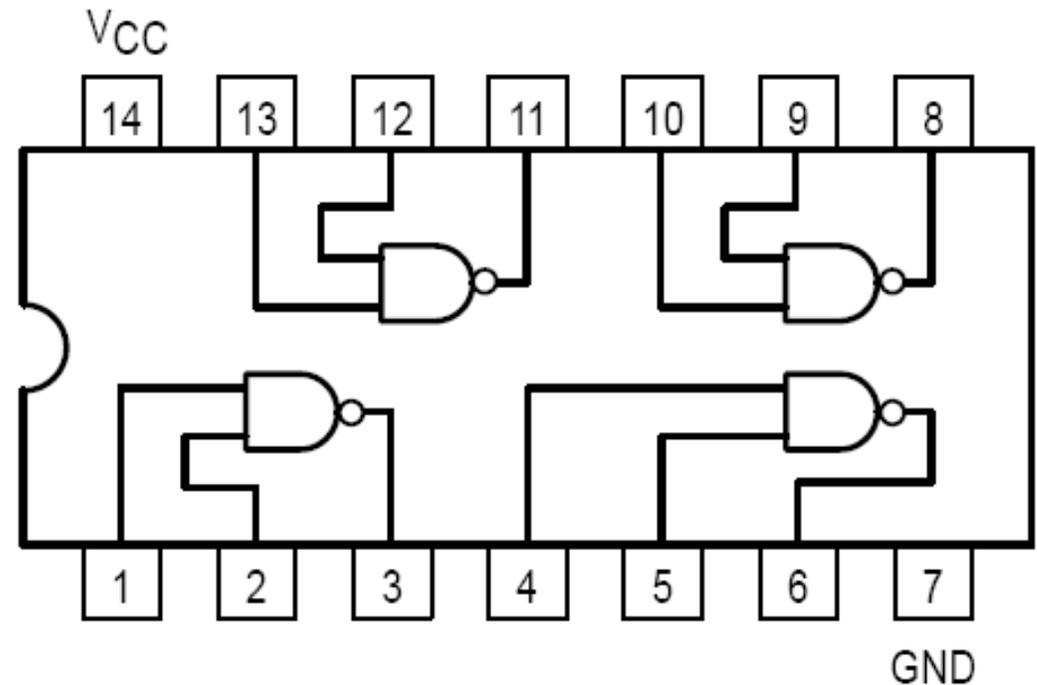
- ❖ **TTL & Breadboarding**

- ❖ Course Wrap-up

- ❖ Quiz 3

TTL computers

Transistor-Transistor Logic (TTL) Packages

Pin numbering starts at 1, counter-clockwise from dot

Pins (both sides)

❖ Diagrams like these and other useful/helpful information can be found on part data sheets
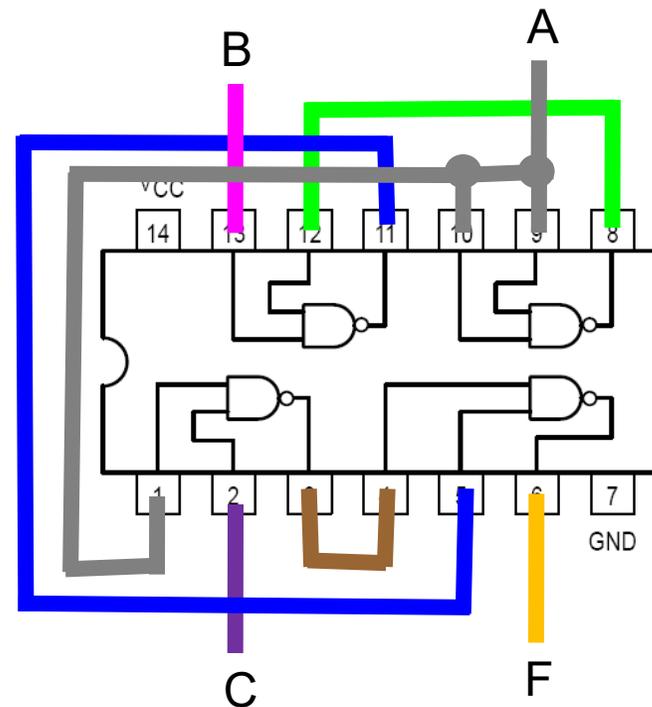
- It's really useful to learn how to read these

Mapping truth tables to circuit boards

❖ Given a truth table:

1) Write the Boolean expression

2) Minimize the Boolean expression

3) Draw as gates

4) Map to available gates

5) Determine # of packages and their connections

(4)
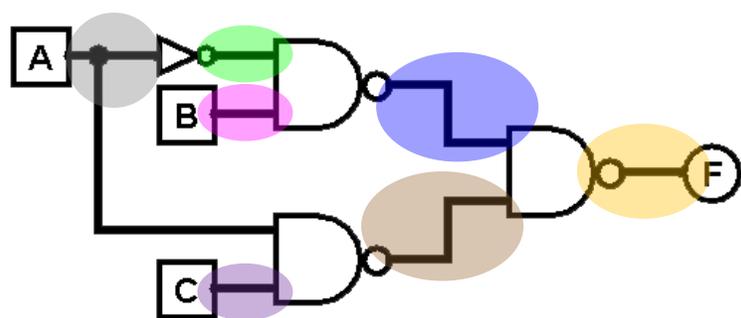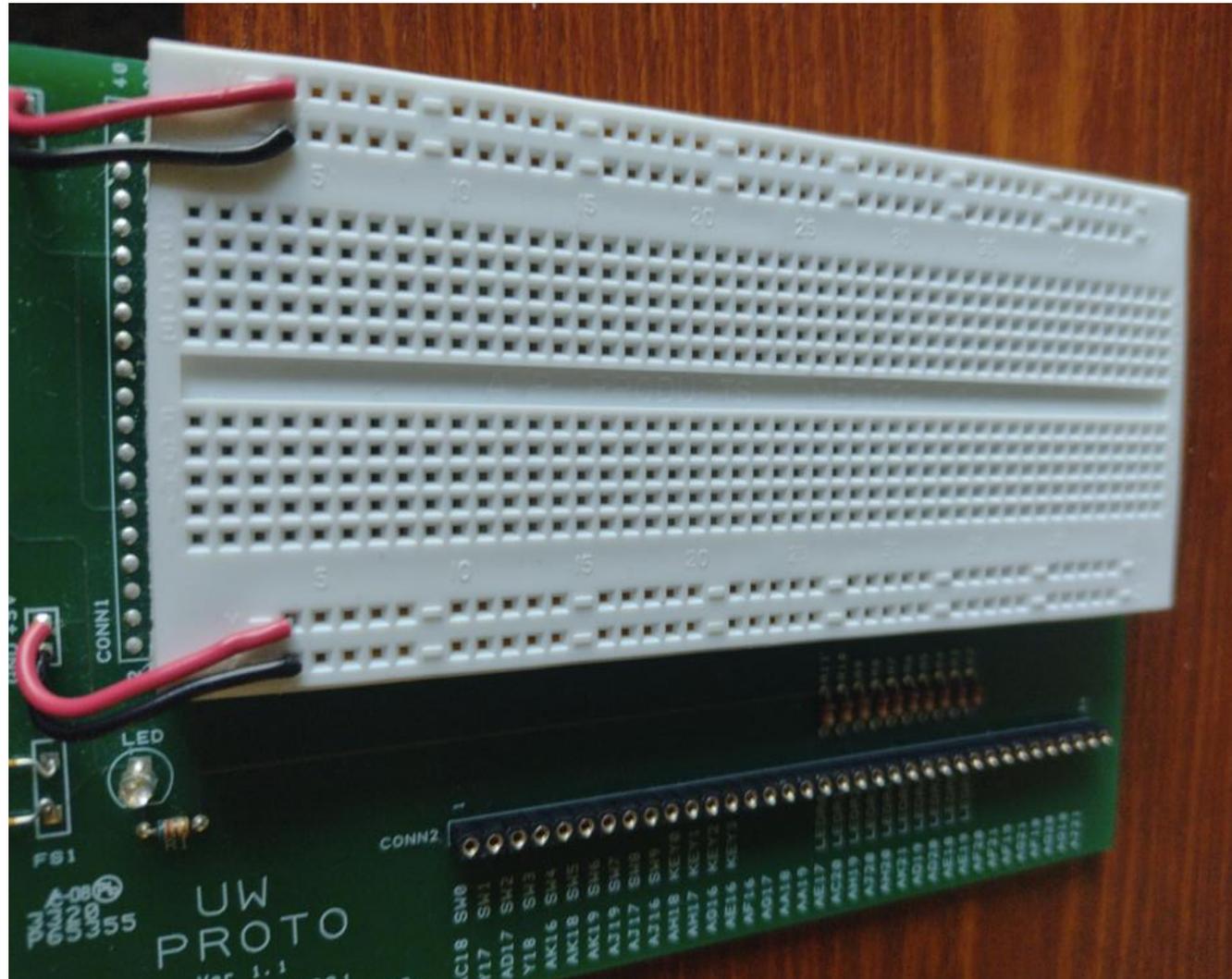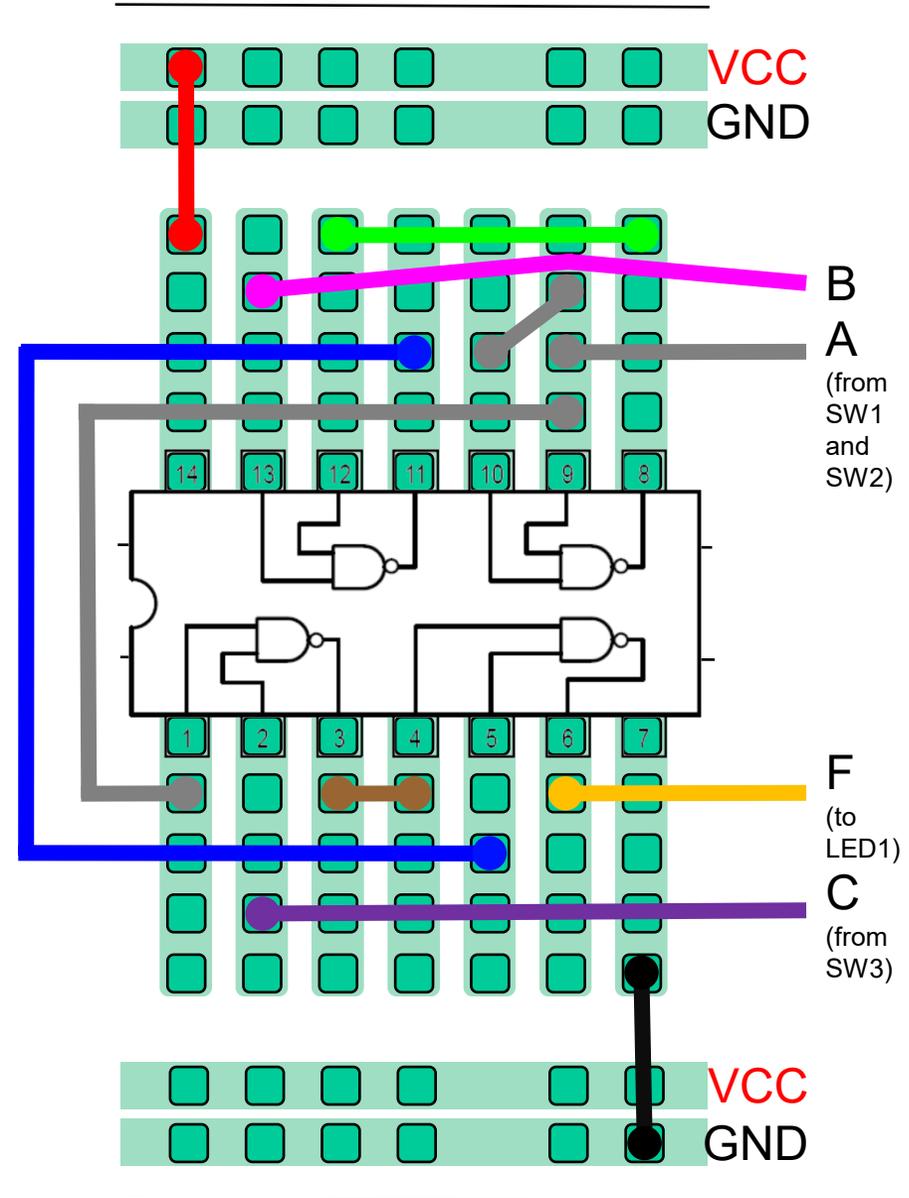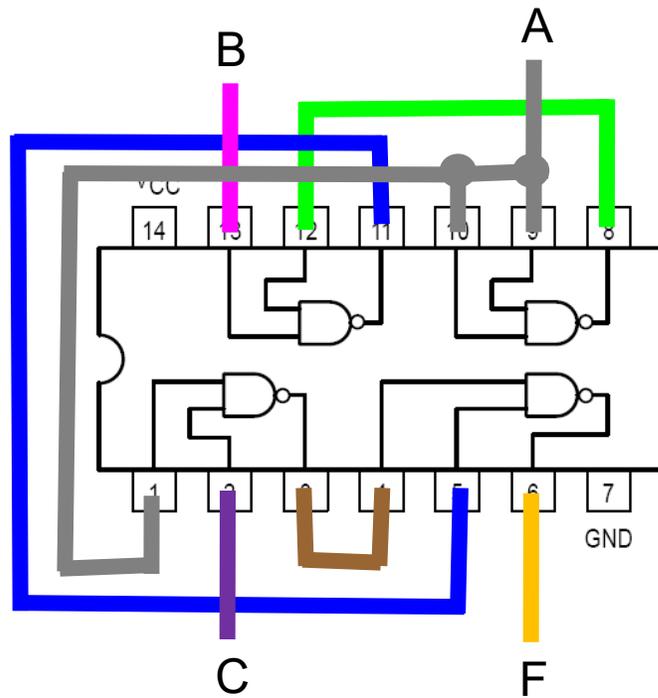
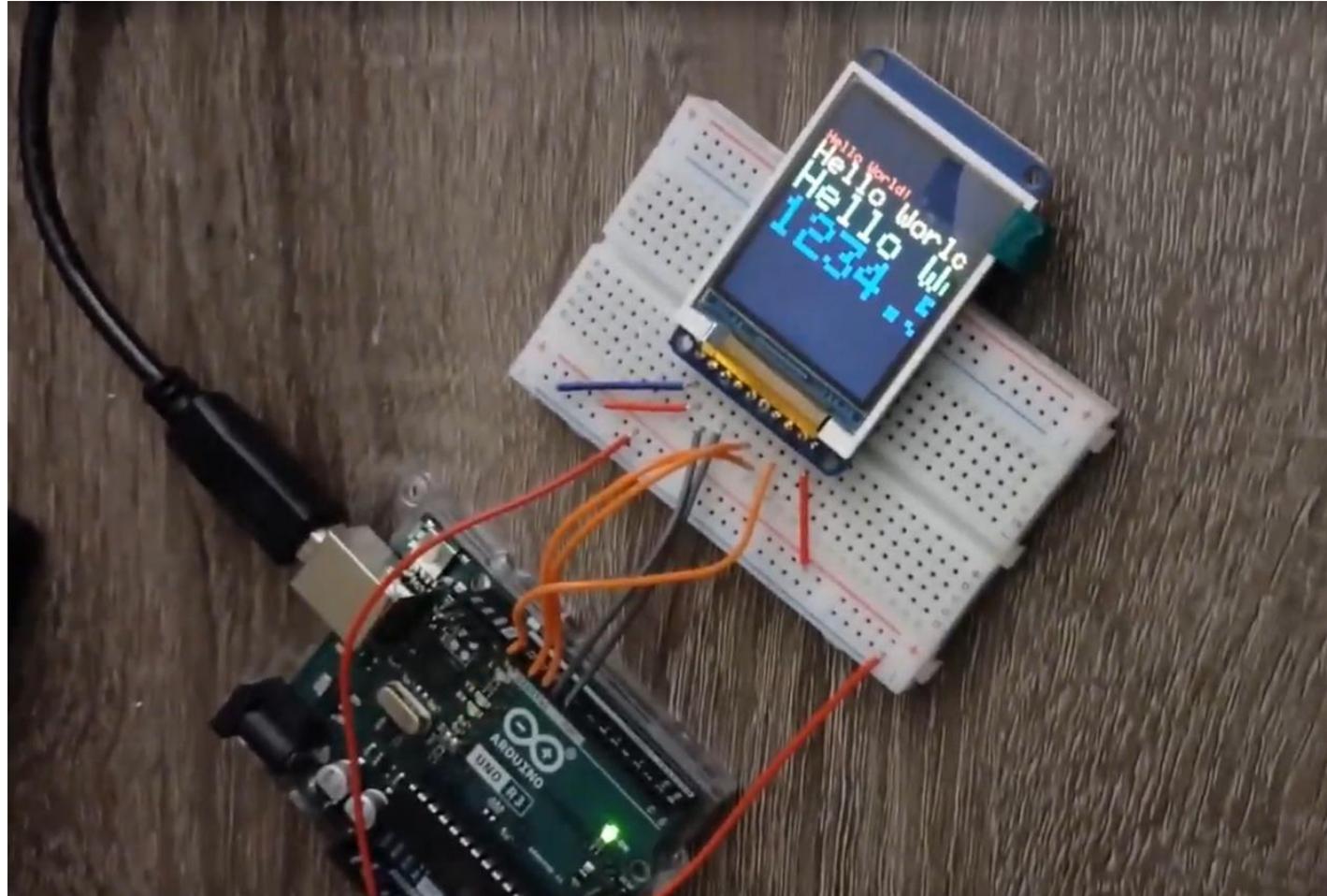*7 nets (wires) in this design*

Prototyping with breadboards

Breadboarding circuits

Breadboarding Modern Components

Breadboarding Modern Fashion
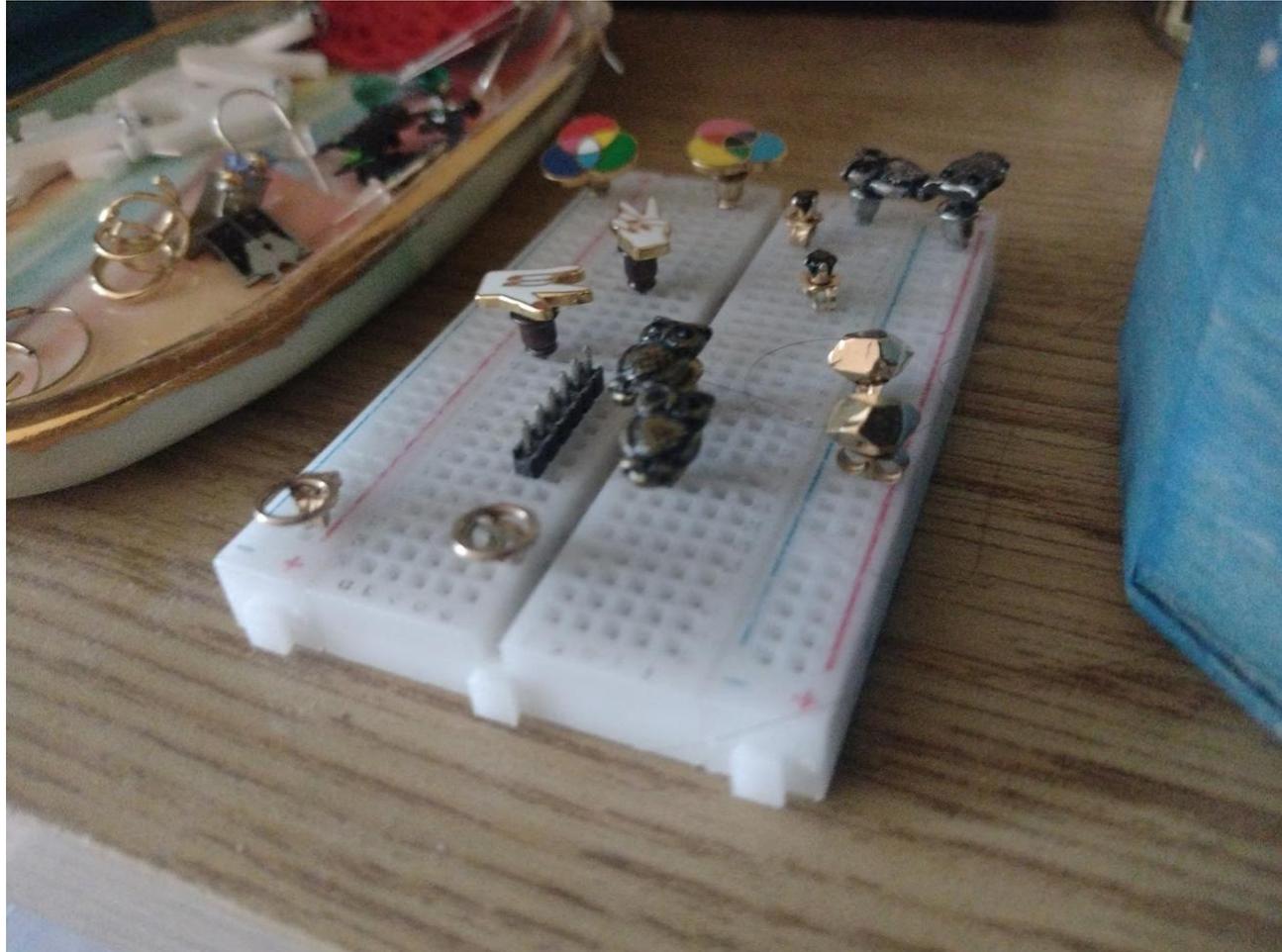
Outline

- ❖ TTL & Breadboarding
- ❖ **Course Wrap-up**
- ❖ Quiz 3

Course Wrap-Up

❖ Combinational Logic

- Karnaugh Maps

❖ Sequential Logic

- Timing Considerations

❖ Finite State Machines

❖ Routing Elements

- Multiplexor, Encoder, Decoder, Demultiplexor

❖ Computational Building Blocks

- Adders, Registers, Shift Registers, Counters

❖ *SystemVerilog*

Digital Workhorses

❖ Multiplexors

  ▪ Logic – can implement arbitrary logic as LUTs

  ▪ Routing – select between many simultaneous computations

❖ Flip-flops

  ▪ Store information

    • registers, shift registers, counters, FSMs, RAM cells

  ▪ Synchronization of system

    • "Holds up" signals so feedback loops only iterate once per clock cycle

  ▪ Filter out circuit hazards and glitches

  ▪ Gotta watch out for metastability

Takeaways

❖ Hardware design is all about computation in space rather than computation in time

❖ Modern EE tools and design methods let us do a lot without needing to know much about actual circuitry
  - Verilog is a "high level" way to produce the "lowest level" of computing components!
  - Sufficient level of abstraction for many cases

❖ … but it's a leaky abstraction, and the hardware details are important
  - Timing especially – synchronization, metastability
  - Design affects speed, power, size

Takeaways

- ❖ You now know how to design and implement complex digital circuits!
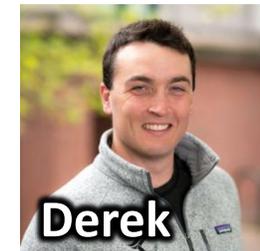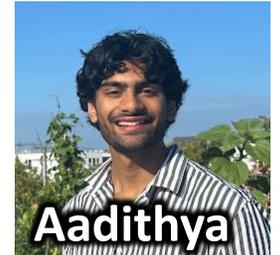   - ■ DE1-SoC ($377): http://www.terasic.com.tw/cgi-bin/page/archive.pl?Language=English&No=836

Final Words

❖ **Please** fill out course evaluation before the end of the week!

 ▪ Due by the 15th; let's improve this class together 🙏

❖ Future classes

 ▪ EE 205/215 – details of electronics

 ▪ EE/CSE 371 – digital design techniques and considerations (algorithms, communication, complexity)

 ▪ EE/CSE 469 – computer architecture (CPU design)

❖ Hope you had fun this quarter!

❖ Huge thanks to your TAs!

Derek

Aadithya

Isabel

Kevin

Sathvik