Rethinking Electronics Industry Workforce Development

Case Studies on High School and Middle School Students with Semiconductor Design and Advanced Electronics Prototyping

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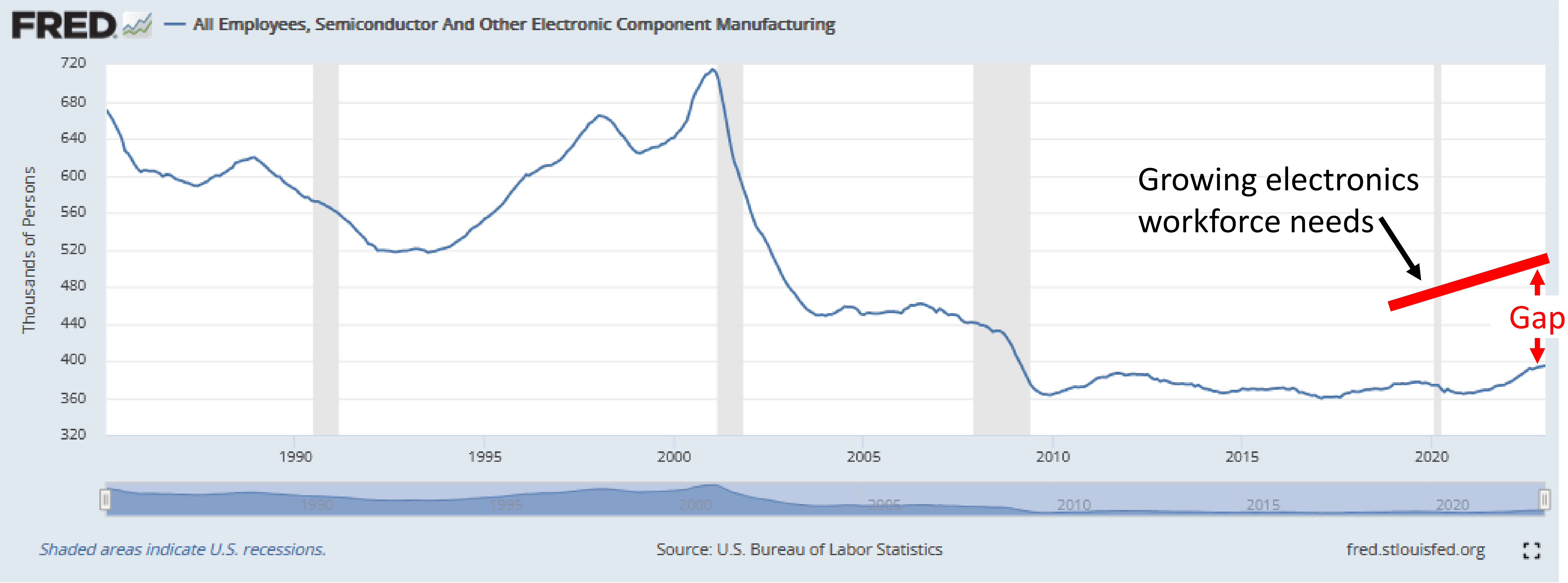
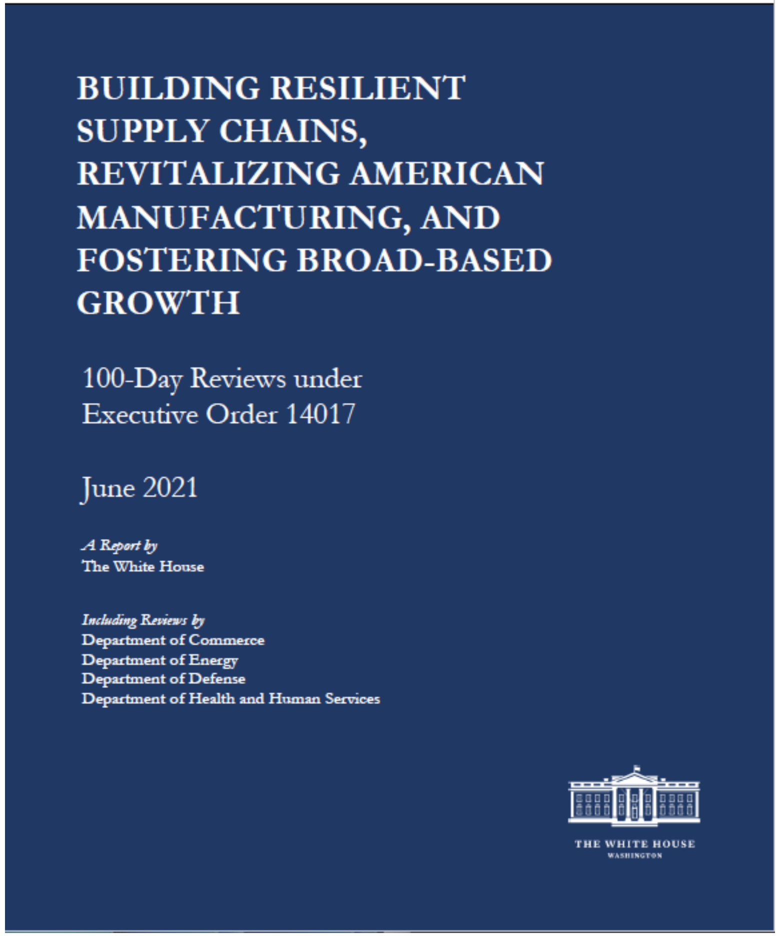
Semiconductor & Electronic Workforce



2021 Whitehouse Supply Chain Report


BUILDING RESILIENT SUPPLY CHAINS, REVITALIZING AMERICAN MANUFACTURING, AND FOSTERING BROAD-BASED GROWTH

100-Day Reviews under Executive Order 14017

June 2021

A Report by
The White House

Including Reviews by
Department of Commerce
Department of Energy
Department of Defense
Department of Health and Human Services

THE WHITE HOUSE
WASHINGTON

Build a diverse pipeline of engineers and computer scientists, which require years of STEM education:

- Congress should invest in evidence-based CTE programs in middle and high schools to ensure that students are prepared to be successful in a variety of fields, including in advanced STEM fields. Funds should increase access to computer science and create high quality career pathway programs in middle and high schools, prioritizing models that allow students to earn college credit or result in a credential, and that connect underrepresented students to STEM and in-demand sectors, including programs that leverage partnerships between schools, community colleges and employers.

https://www.whitehouse.gov/wp-content/uploads/2021/06/100-day-supply-chain-review-report.pdf

Doing Things Differently – Key Questions

- How do we **inspire** more people to enter the STEM workforce?
- Is it **possible** for high school/middle school students to learn advanced electronics & semiconductor design?
- How much can be **accomplished** by students during an eight-week pilot?
- What **mentorship** level of effort is needed to achieve student success?
- What opportunities exist to **lower the barriers** of entry for new electronics industry workforce?

A Practical Approach – Jumping Right In

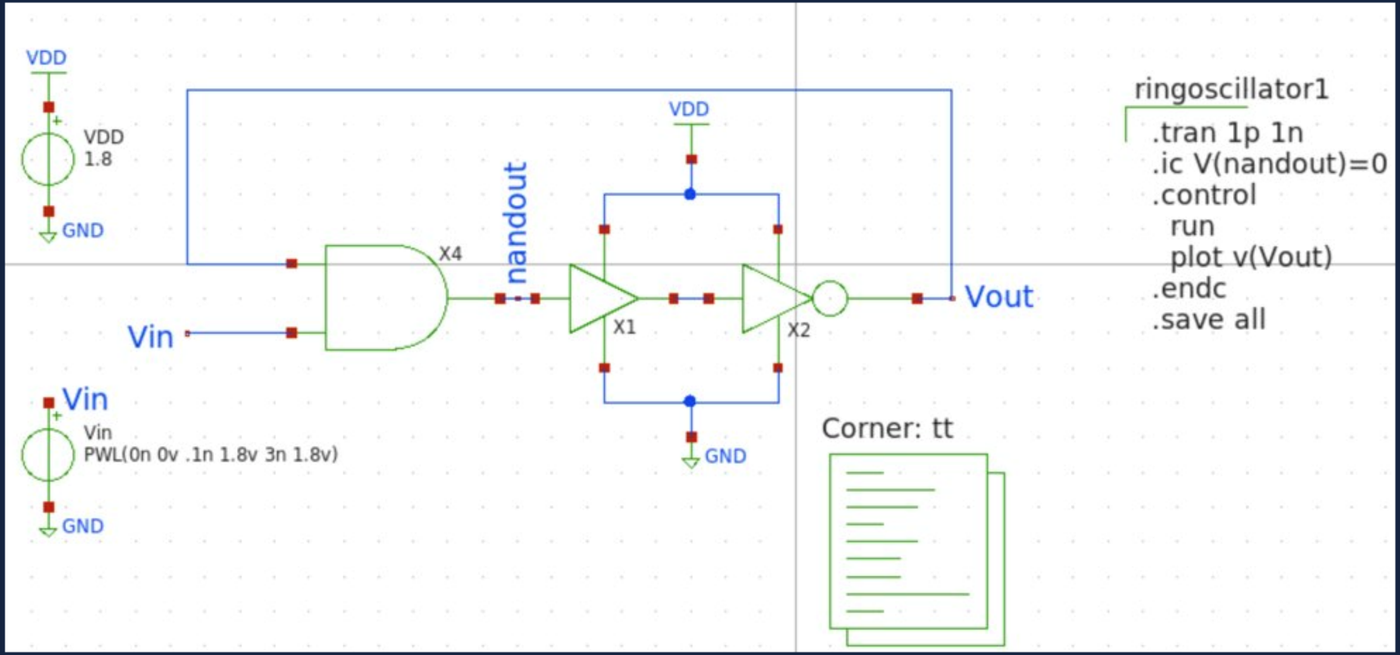
- 8-week Semiconductor Design pilot with high School student interns
  - Mix of student applicants, selected candidates with interest & self-directed learning
  - Analog & digital flows of constraint problem – transistors & ring oscillators
  - Skywater Open PDK and OpenFlow EDA design tool suite

- 40-hour Advanced Electronics Prototyping class with high School & middle school students
  - Class materials adapted from professional level cross-disciplinary training course
  - Electronics prototype development process
  - Didactic & practical sessions
  - Student chosen real-world problem and solution

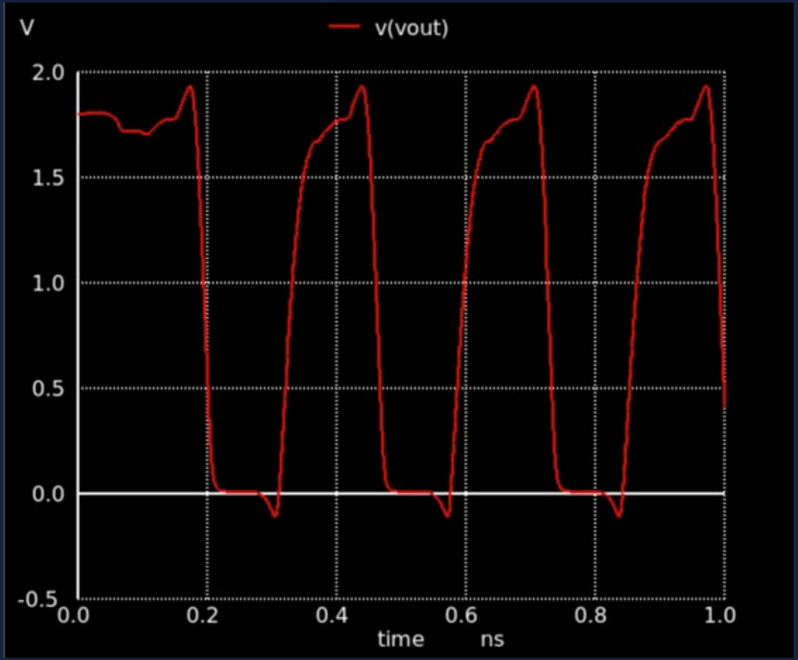
Semiconductor Design Pilot Process

1. Learn foundational knowledge on semiconductor manufacturing and design.
2. Custom transistor design and seven-stage ring oscillator using analog design flow.
3. Custom ring oscillators and layout using digital design flow.
4. Full integration of a 115-stage ring oscillator using the complete EDA tool suite.

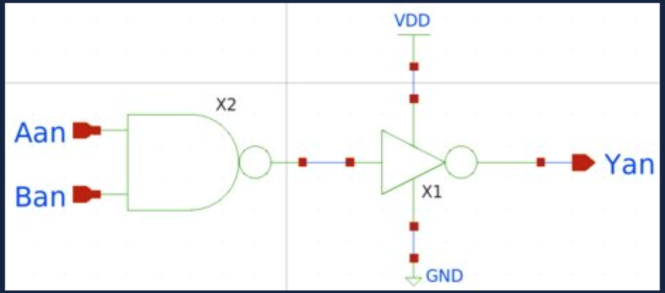
Xschem Ring Oscillator



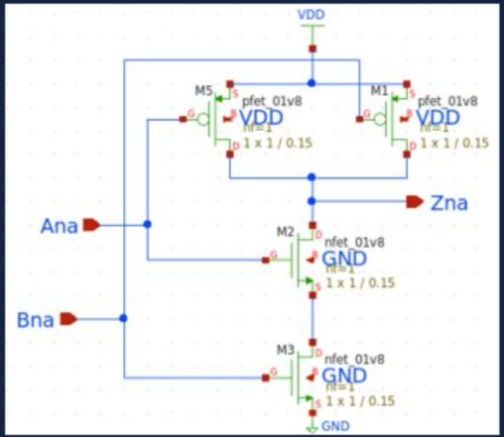
Simulation



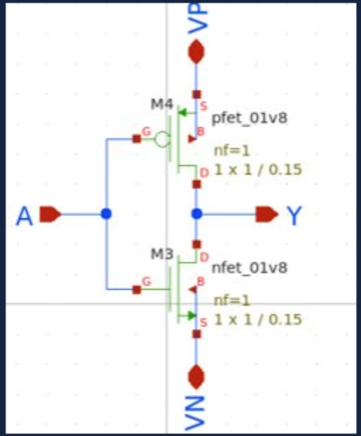
AND Gate



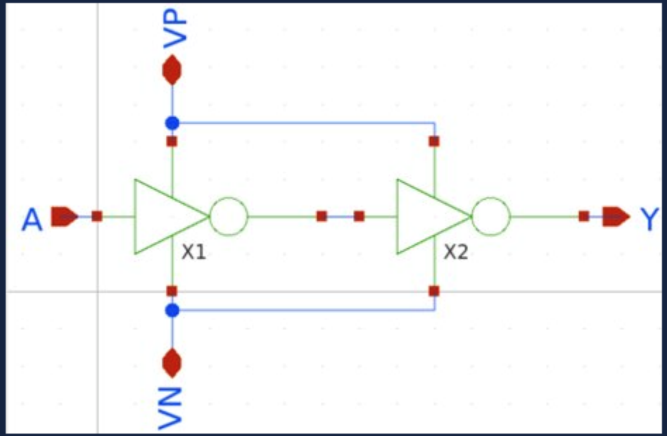
NAND Gate



Inverter



Buffer



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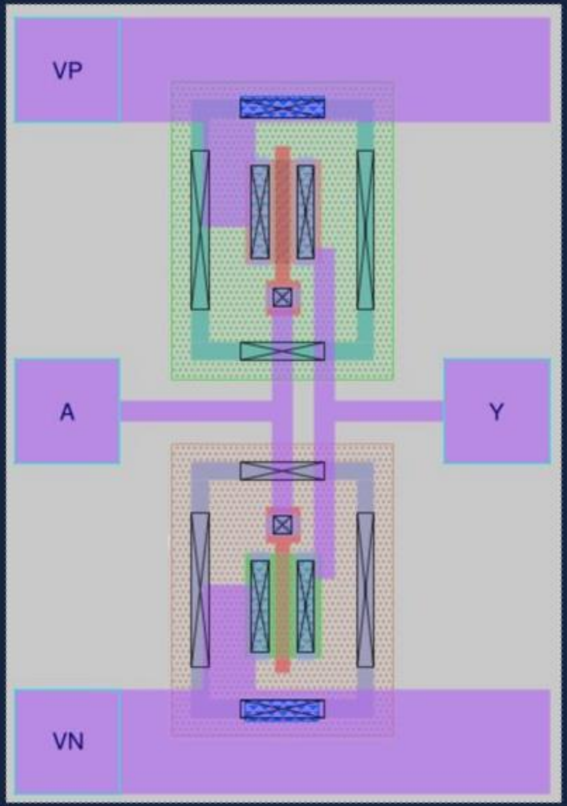
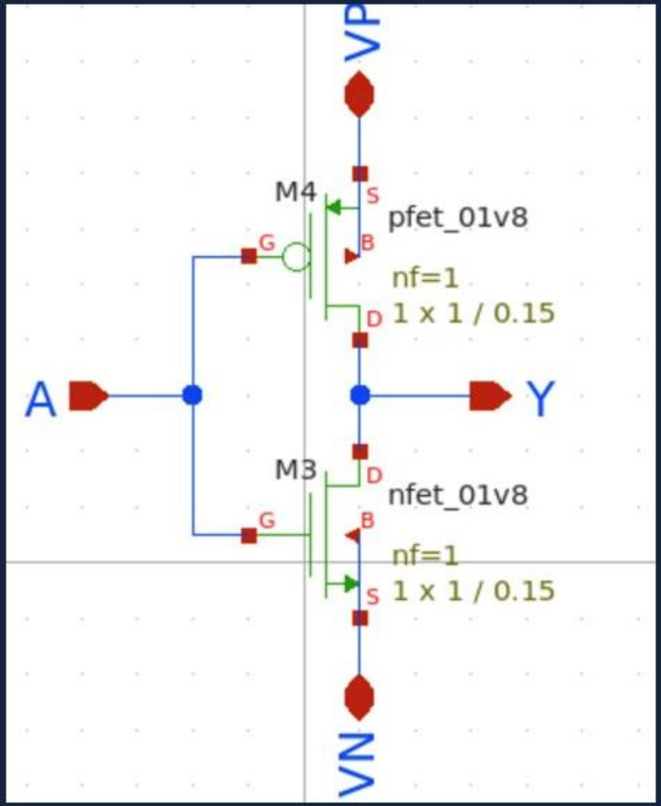
Layout vs Schematic (LVS) with Netgen



NETGEN

```
Subcircuit pins:
Circuit 1: inverter                         |Circuit 2: inverter
--------------------------------------------|-------------------
Y                                           |Y
A                                           |A
VN                                          |VN
VP                                          |VP
--------------------------------------------------------------
Cell pin lists are equivalent.
Device classes inverter and inverter are equivalent.
Circuits match uniquely.
Property errors were found.
The following cells had property errors:
 inverter
```




```
* NGSPICE file created from inverter.ext - technology: sky130A

.subckt sky130_fd_pr__pfet_01v8_LGS3BL a_n73_n64# a_n33_n161# a_15_n64#
X0 a_15_n64# a_n33_n161# a_n73_n64# w_n211_n284# sky130_fd_pr__pfet_01v
.ends

.subckt sky130_fd_pr__nfet_01v8_64Z3AY a_15_n131# a_n175_n243# a_n33_91
X0 a_15_n131# a_n33_91# a_n73_n131# a_n175_n243# sky130_fd_pr__nfet_01v
.ends

.subckt inverter A Y VN VP
XXM4 VP A Y VP sky130_fd_pr__pfet_01v8_LGS3BL
Xsky130_fd_pr__nfet_01v8_64Z3AY_0 Y VN A VN sky130_fd_pr__nfet_01v8_64Z
.ends
```

```
** sch_path: /foss/designs/Ringosc/xschem/inverter.sch
.subckt inverter A Y VN VP
*.ipin A
*.opin Y
*.iopin VN
*.iopin VP
XM3 Y A VN VN sky130_fd_pr__nfet_01v8 L=0.15 W=1 nf=1 ad='int((nf+1)/2
+ pd='2*int((nf+1)/2) * (W/nf + 0.29)' ps='2*int((nf+2)/2) * (W/nf + 0
+ sa=0 sb=0 sd=0 mult=1 m=1
XM4 Y A VP VP sky130_fd_pr__pfet_01v8 L=0.15 W=1 nf=1 ad='int((nf+1)/2
+ pd='2*int((nf+1)/2) * (W/nf + 0.29)' ps='2*int((nf+2)/2) * (W/nf + 0
+ sa=0 sb=0 sd=0 mult=1 m=1
.ends
.end
```

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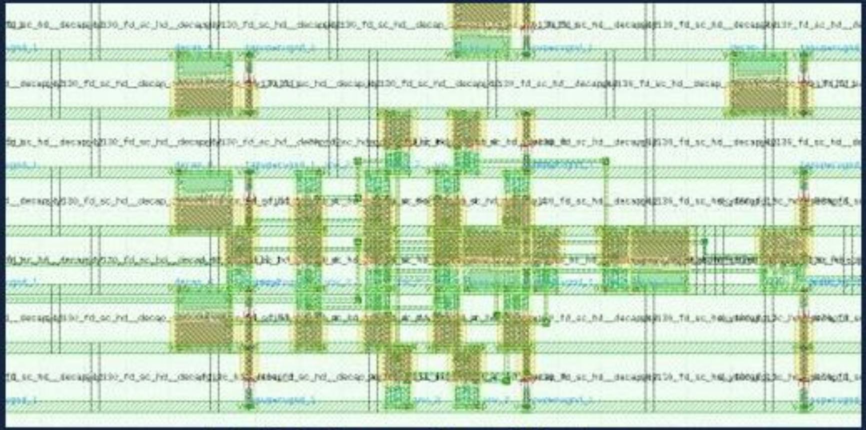
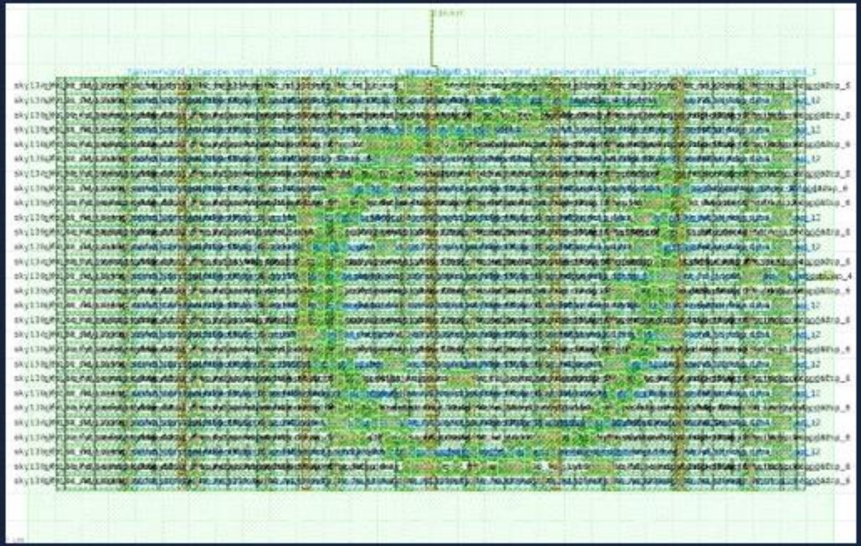
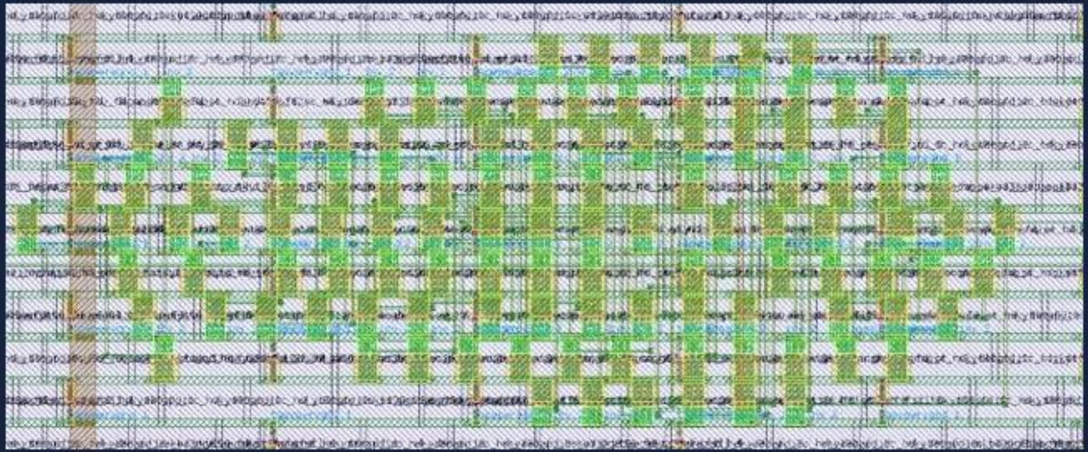
Flow and getting design on the chip

19 Ring Oscillator



115 Ring Oscillator





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Prototype Development Process

Concept
- What do you want this widget to do?

Requirements
- What are the functional details?

Architecture
- Diagram on connected functions

Specification of Components
- Bill of Materials

CAD Schematic / Netlist / Layout

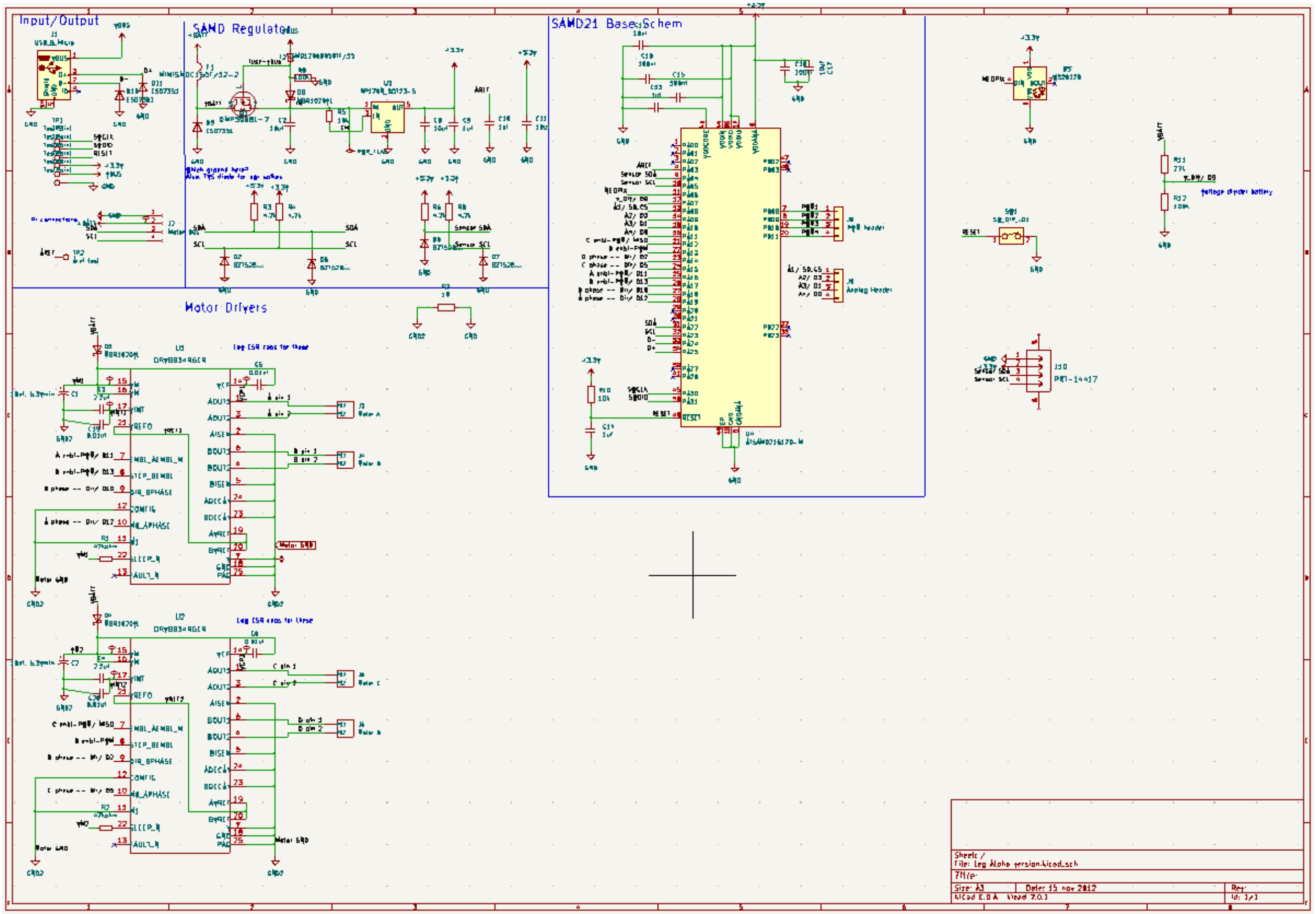
Design Review
- Compatibilities
- Circuits & DFM

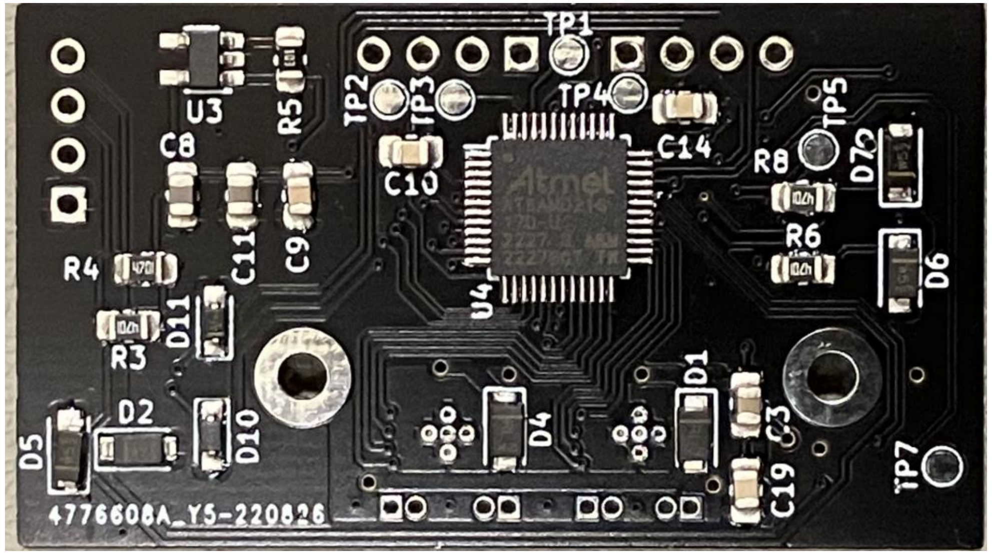
Manufacturing

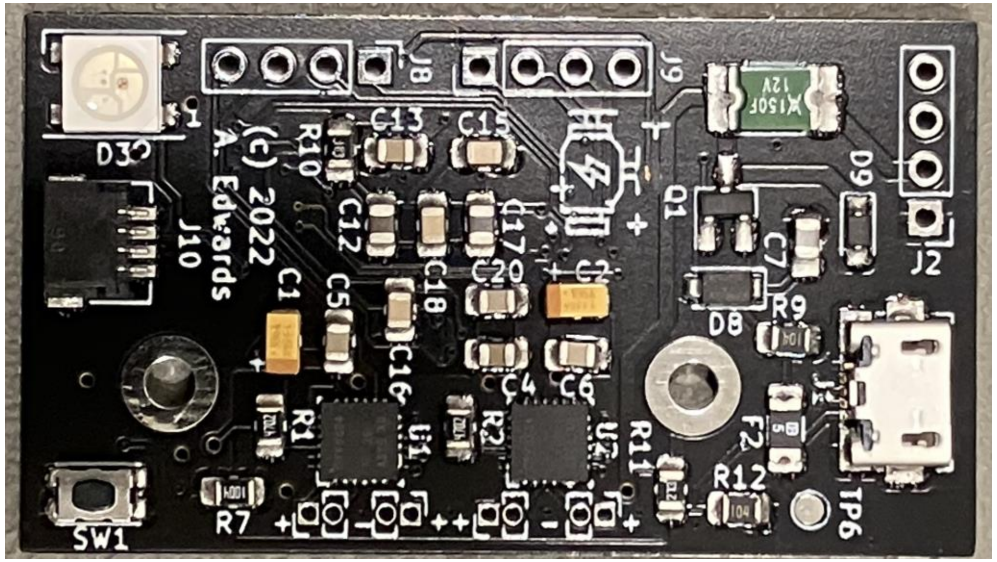
Assembly

Test

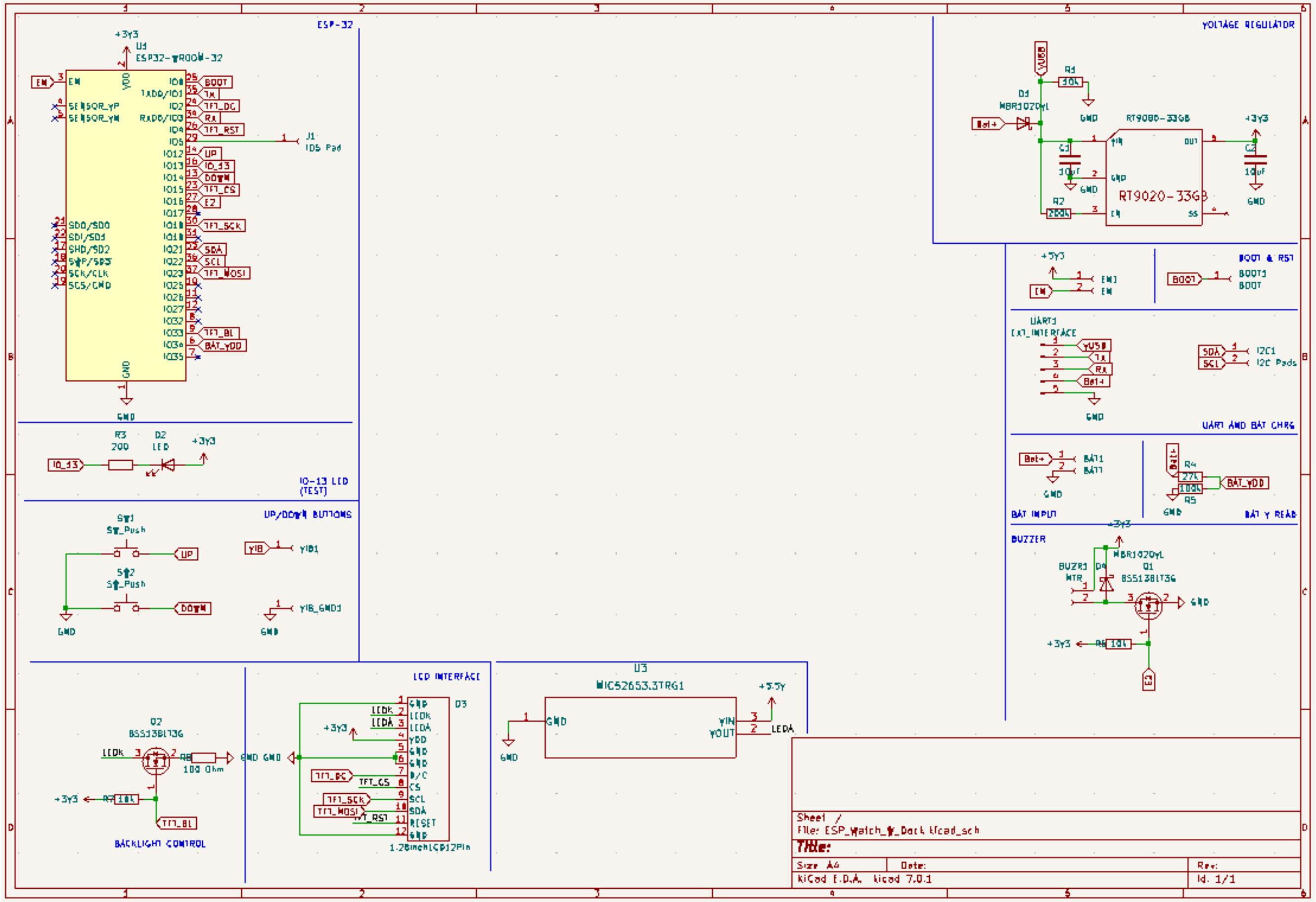
10th Grade: 4 Channel DC Motor Controller

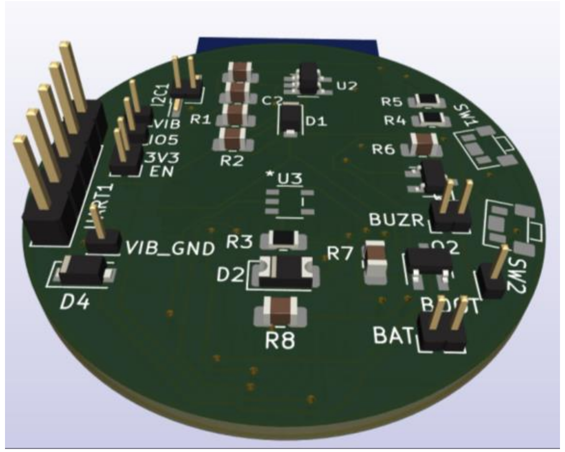


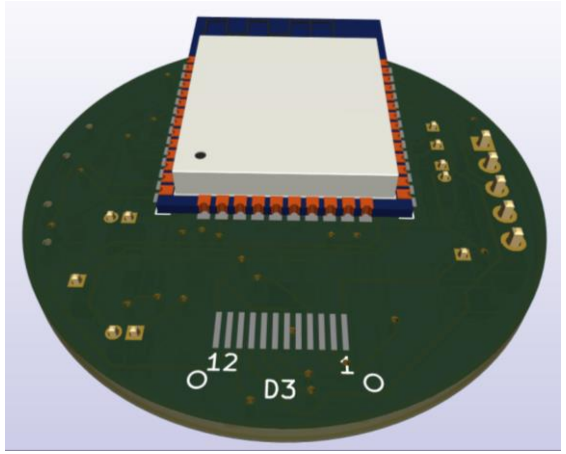


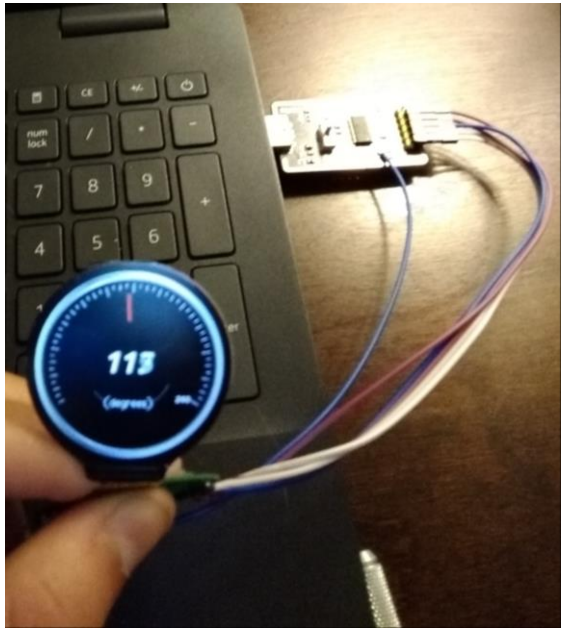


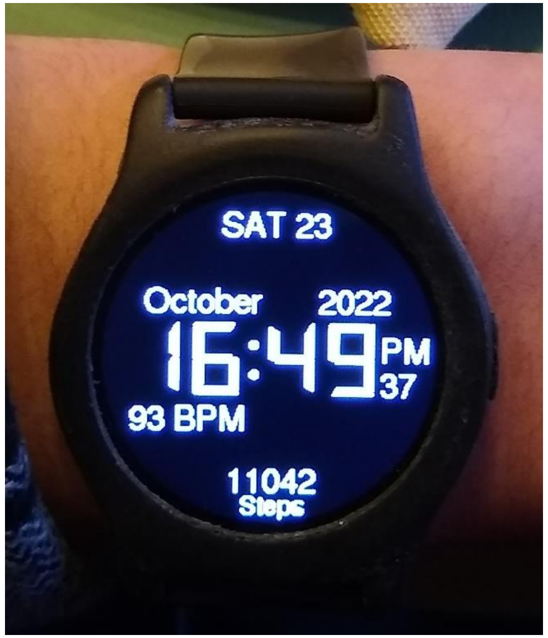
10th Grade: Smart Watch



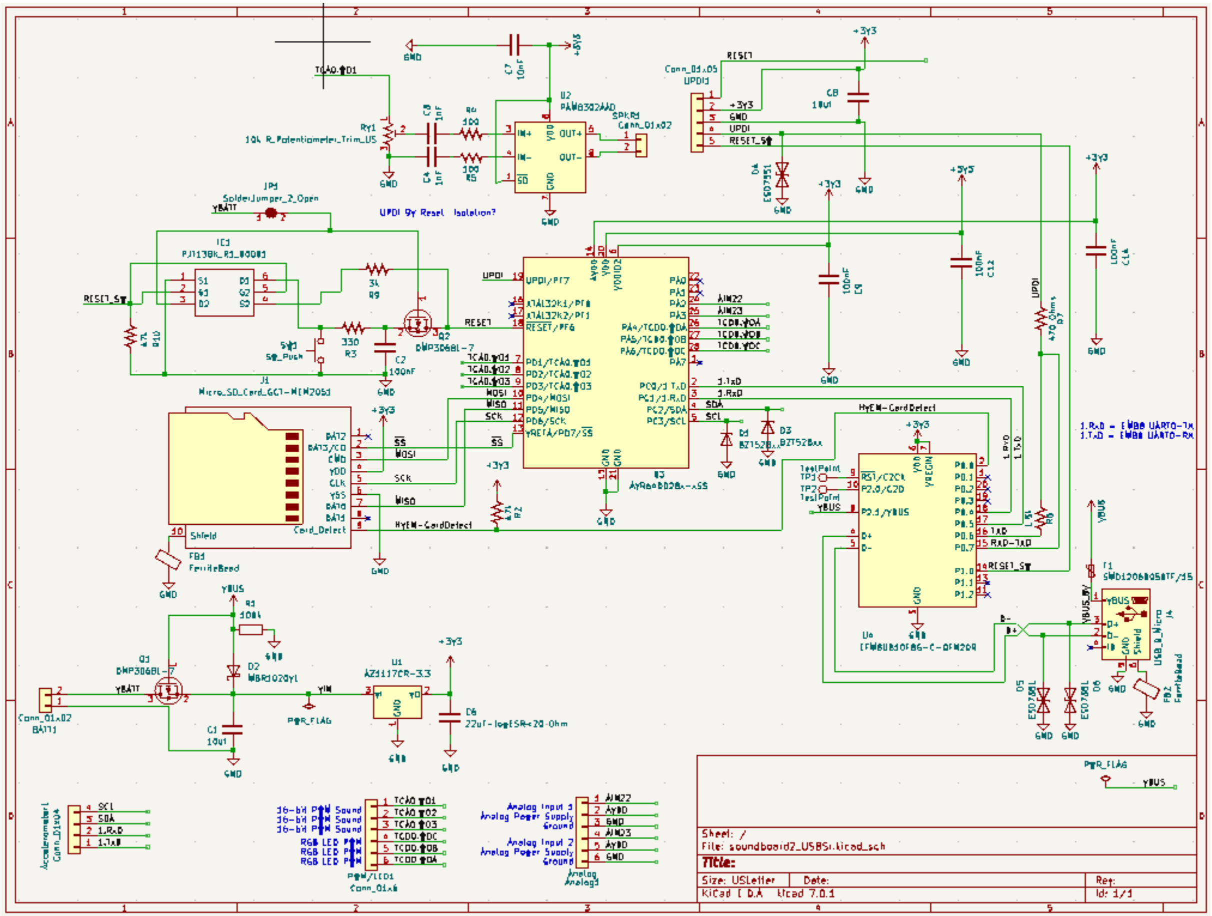


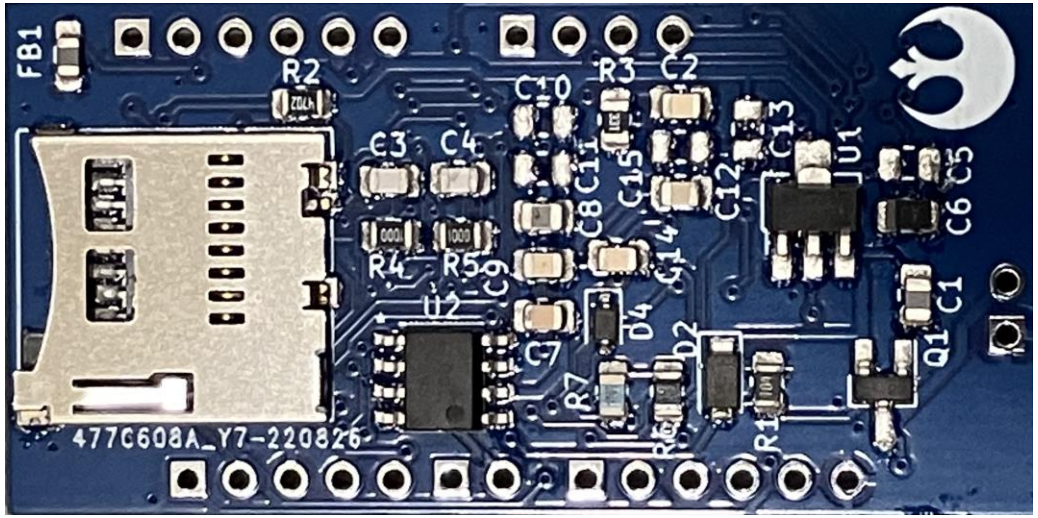


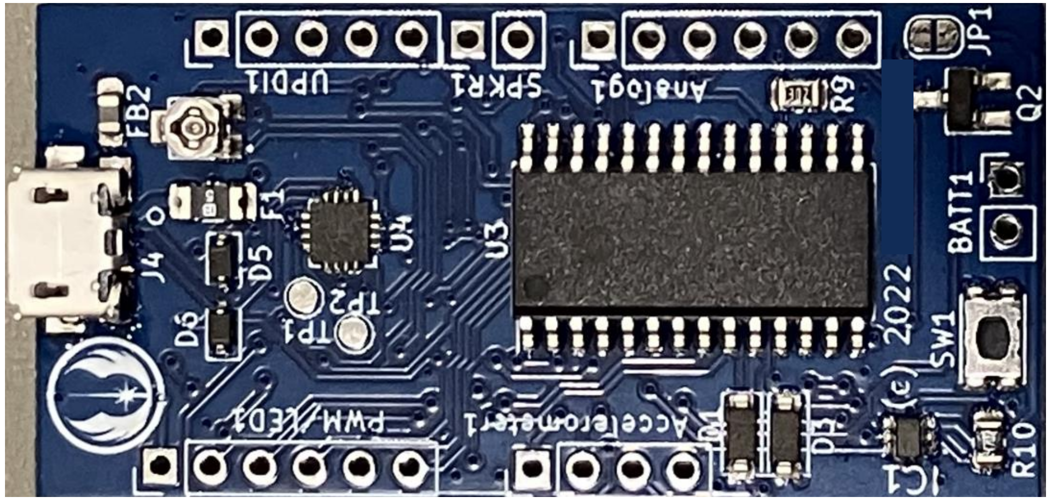




7th Grade: Lightsaber Soundboard







Student Perspectives

- School STEM experiences need to inspire technical innovation
- School STEM experiences need focused depth & breadth
- Student ideas on how industry and schools can partner better:
  - High school career fairs
  - Regular engagement with industry members
  - Conduct industry specific STEM camps or industry-led short courses

Rethinking Electronics Workforce Development

- Integrated approach to electronics workforce education
  - Streamline foundational knowledge acquisition
  - Apply to real-world problems (experiential learning)
- Inspire curiosity, self-directed learning, and purpose
- Meet students where they are
- Longer-term mentoring relationships

A “shift left” perspective towards high school and middle school workforce development can significantly contribute to building a more robust talent pipeline

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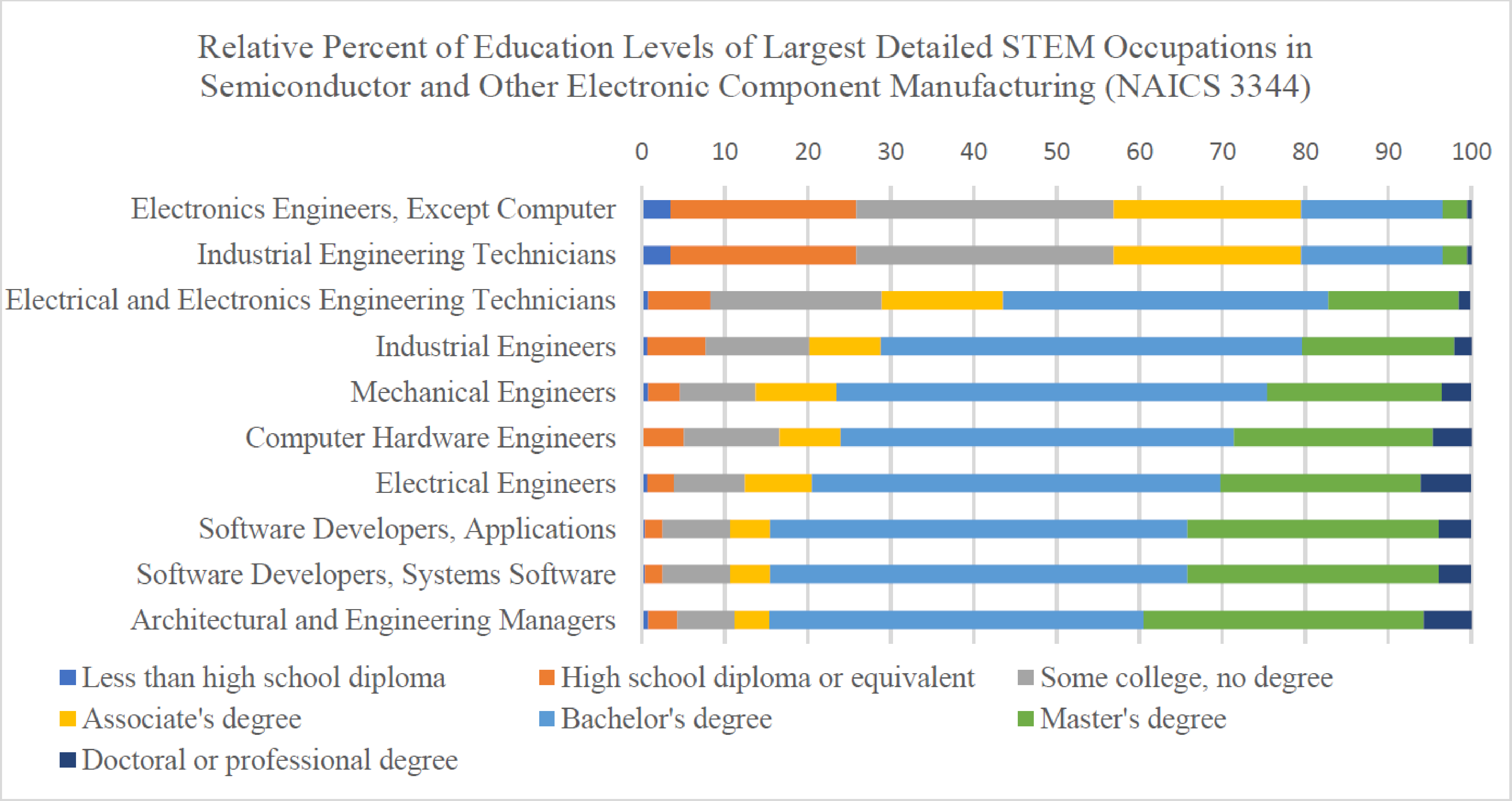
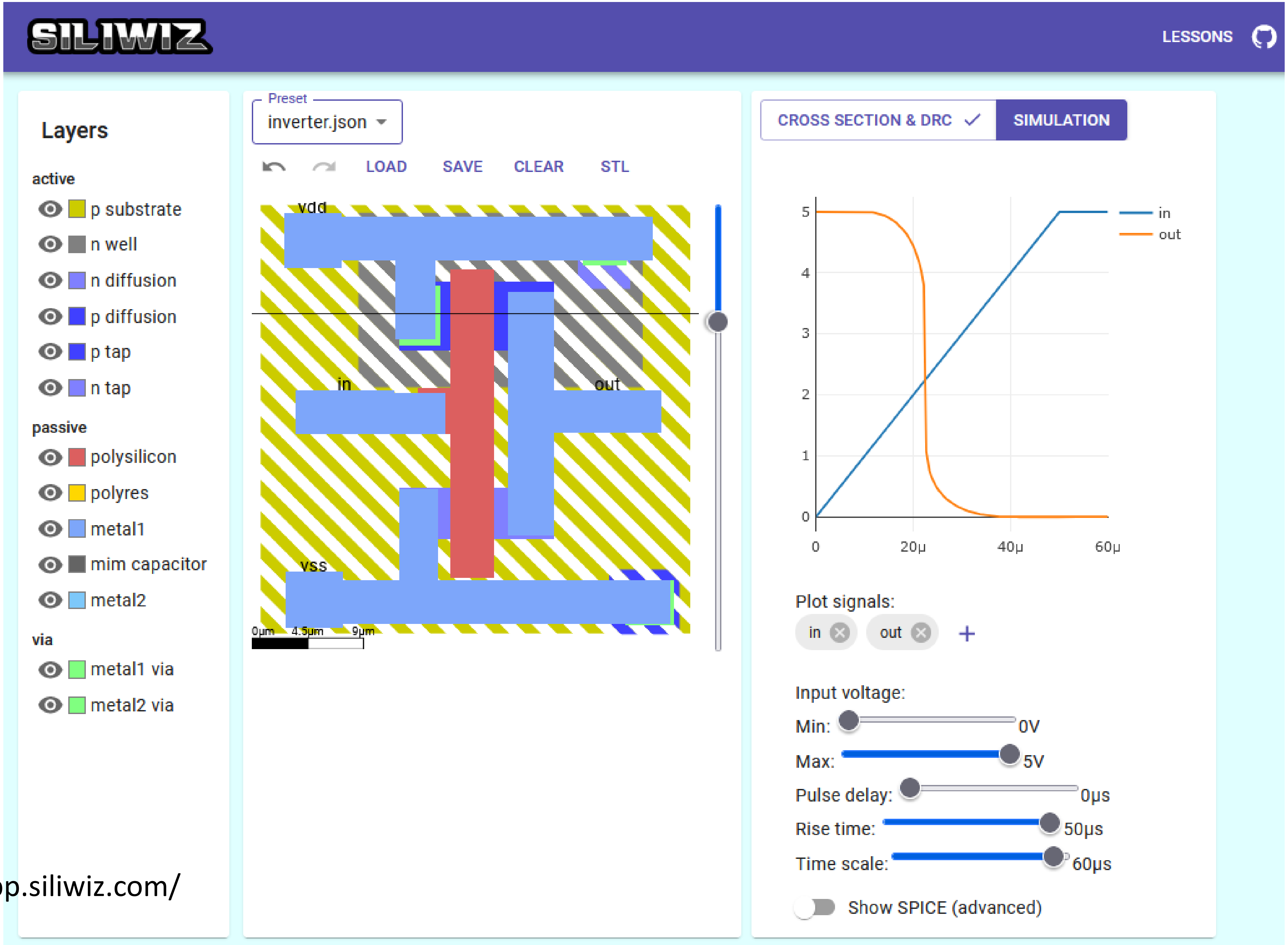


Source: 2015 and 2016 American Community Survey Public Use Microdata, U.S. Department of Commerce[231]

https://www.whitehouse.gov/wp-content/uploads/2021/06/100-day-supply-chain-review-report.pdf



Source: https://app.siliwiz.com/

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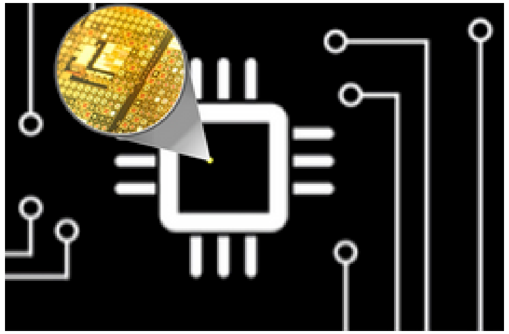
New for 2023

Back to bASICs



Source: https://beaverworks.ll.mit.edu/CMS/bw/BWSI_Course_bASICs

Beaver Works Summer Institute will offer a brand new course on open source semiconductor design and fabrication this summer. This course will give students a fundamental and working knowledge of the building blocks of today's electronic world—knowledge that will benefit the student no matter what they decide to pursue academically. Students will receive hands-on experience on how to design and arrange semiconductors on a nanometer scale to perform a specific function. Students will start with a blank canvas (silicon substrate) and learn how to take a specification through the entire design process—including foundry manufacturability. Once complete, the student's design will be sent to a foundry for fabrication. Six months later we'll host a class reunion and the students will be provided a dev kit with their custom design permanently etched in silicon—a milestone to be treasured for a lifetime