Week 1

ECE2883 HPC

T. Collins / K. Johnson

Seminar room agenda

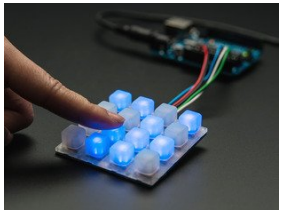
- Introduction
- Course structure
- Discussion about individual goals
- Some background for outside lab/homework

The big picture

- Interdisciplinary group of students
  - Variety of useful skills and approaches to problems
- Minimal prerequisites
  - But some of you have taken a digital logic theory course
- Subject-Matter Experts (SMEs) and non-SMEs
- Goal is to build an interesting interactive object (link)
  - Structure, “moving sculpture,” mechanism, audio-visual display, etc.
  - Must use “many” discrete devices (actuators, sensors)
  - Done in teams of ~5 students

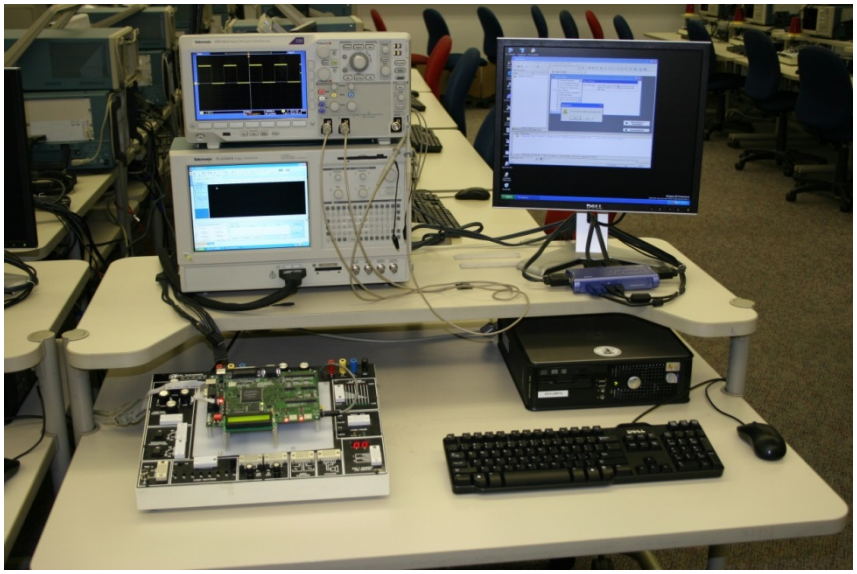
Project-based Learning

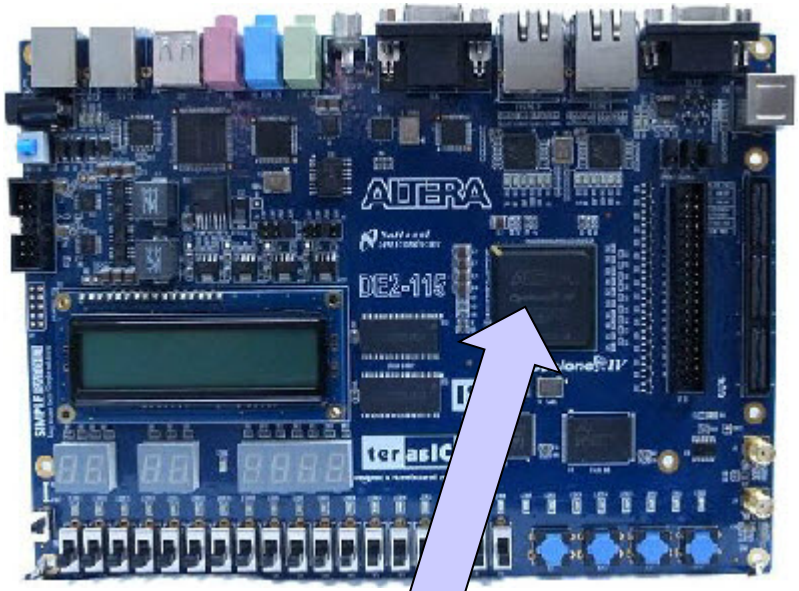
- This course is driven by the hardware needed for your projects



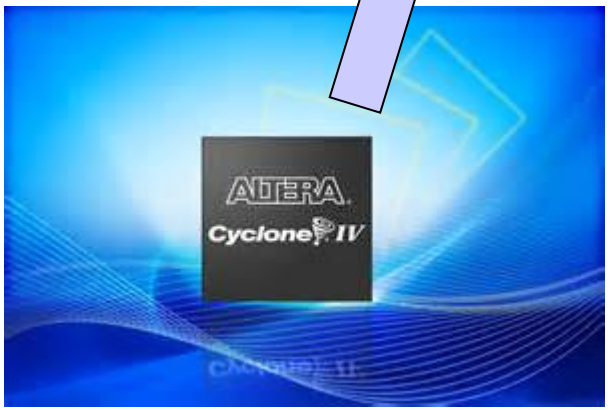
- You will have (at least):
  - Solenoids
  - Valves
  - LED arrays
  - Audio transducers
  - Keypads
  - Motors
  - Light projector
  - Mechanical structural components
  - A versatile digital logic “factory” to control things

The “factory”





- There’s really only one chip in one board that’s doing most of the work – an “FPGA”



What's an FPGA?

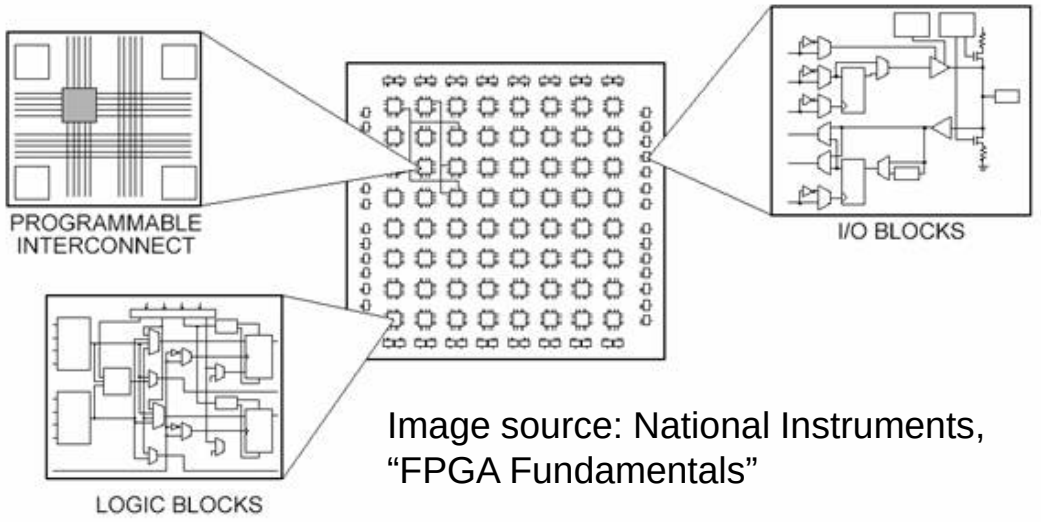


Image source: National Instruments, "FPGA Fundamentals"

- Long before there were mechanical 3D printers, there were the digital electronic equivalents, Field Programmable Gate Arrays
- Have grown from dozens of equivalent gates (in early "PALs") to >5 million in modern FPGAs
- Design in CAD → Then produce working prototype (in seconds)

Reasons FPGAs are not common knowledge

- FPGAs are everywhere, but not as visible or “approachable” as, say, 3D printers
- Digital design is not always intuitive
- Difference in complexity (vs. mechanical)
  - In mechanical CAD, even a novice can approximate something of interest
  - Digital electronic CAD has some technical hurdles
- Initial cost was high, 30-40 years ago

So, what's changed in 40 years?

XILINX ALL PROGRAMMABLE™

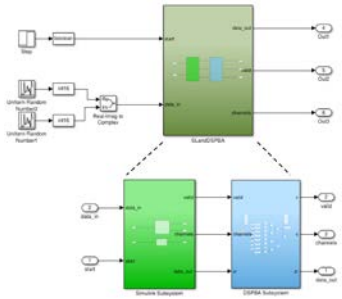
Atmel

Microsemi

QuickLogic

LATTICE SEMICONDUCTOR

ALTERA MEASURABLE ADVANTAGE™



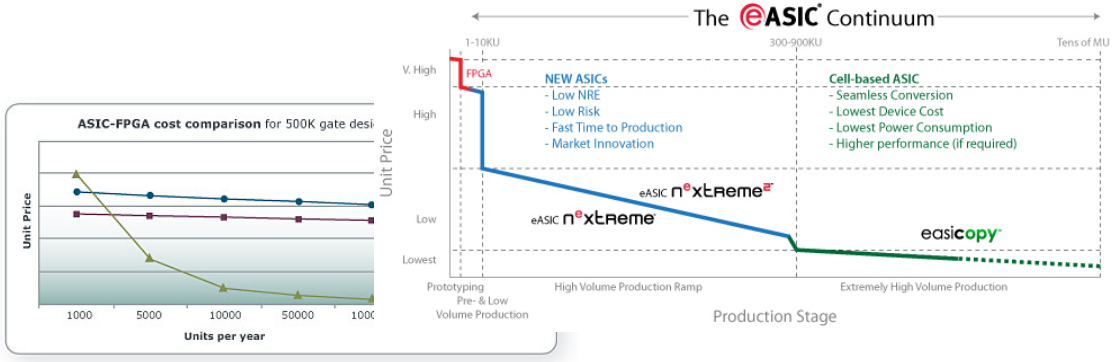
Mentor Graphics®

QUARTUS® II

VIVADO

Better, cheaper, easier CAD

More FPGAs for prototyping & small production

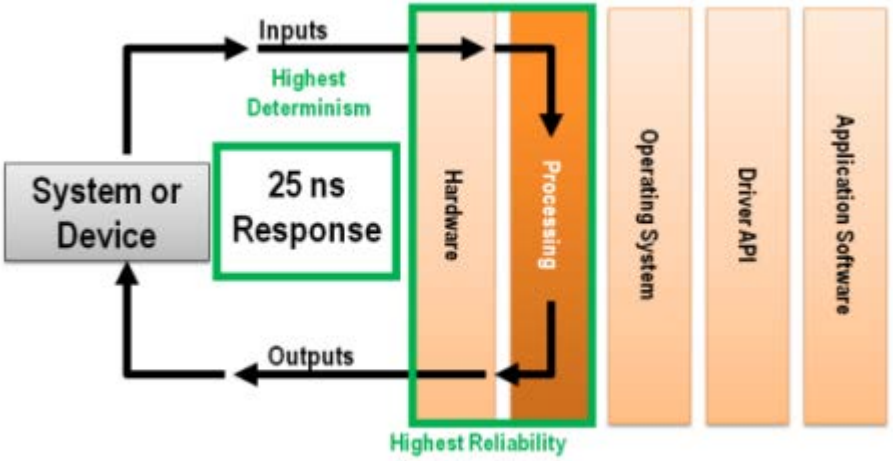


Declining silicon costs

The Maker Movement

X-FAB MIXED-SIGNAL FOUNDRY EXPERTS

What about microprocessors?

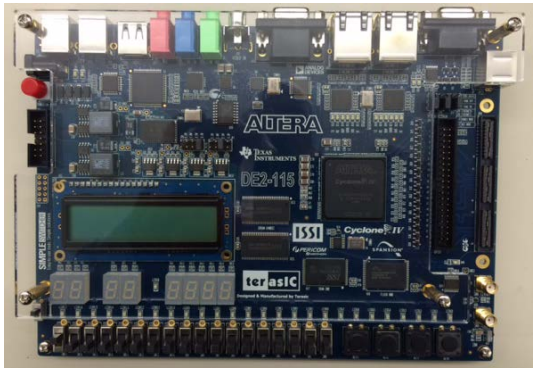


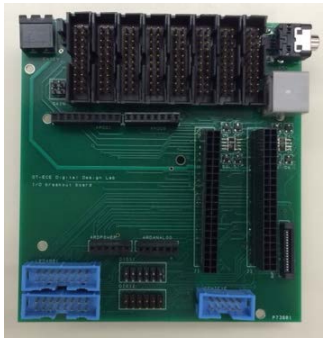
- Computers and their components are very flexible, but slower than dedicated logic
- But when needed, a microprocessor can be implemented in an FPGA alongside other devices

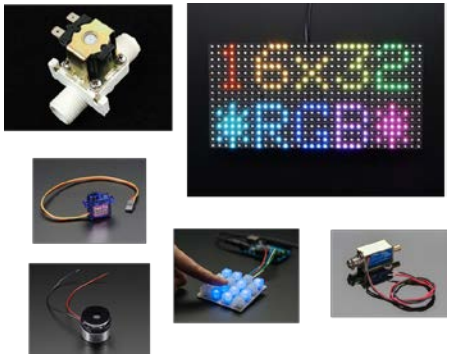
Image source: National Instruments, “FPGA Fundamentals”

Key hardware components

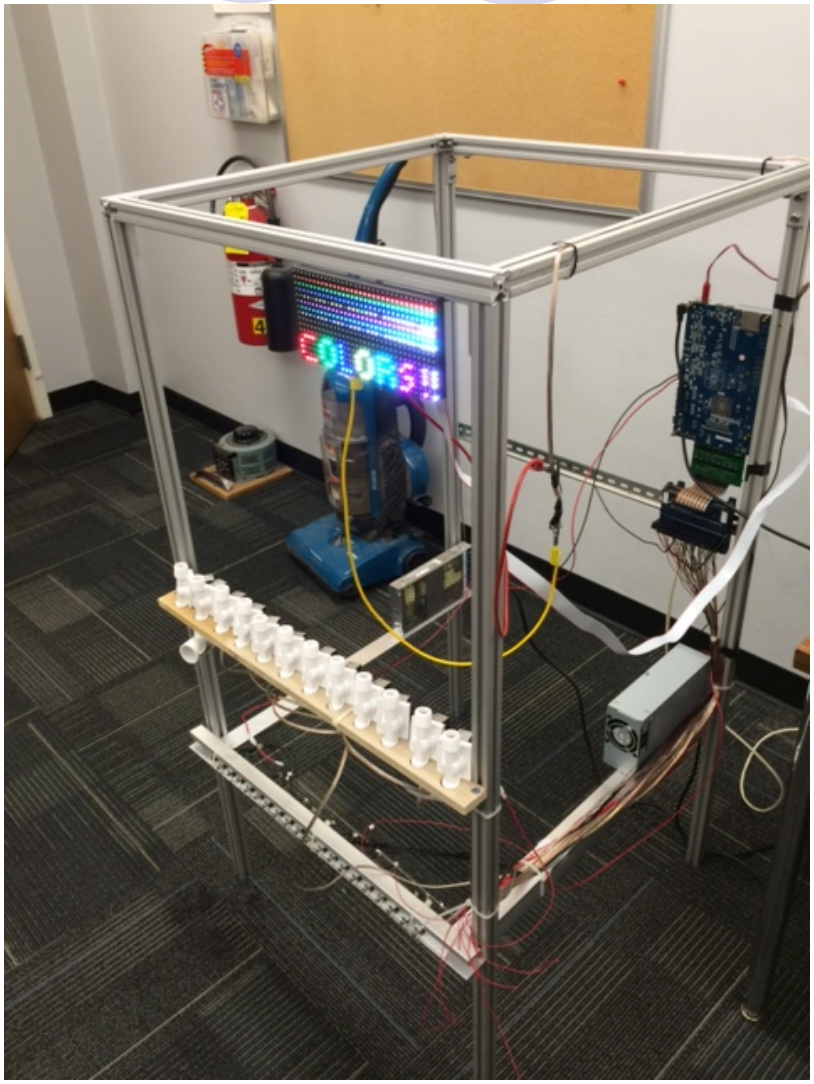
- The various electromechanical and electro-optical devices
- One “flexible” FPGA on a development board
- Two “daughterboards” that bring out individual signals with usable current/voltage levels

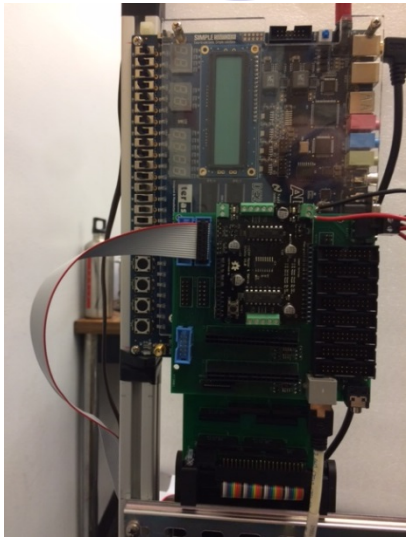






Test setup





- Uses same components available to you
- Verifies new boards are working

Where will the lab happen?

- In first 5-6 weeks, mostly in Van Leer E283
  - Lab is used for a much larger course, ECE2031
  - We will try to identify one or two time periods where ECE2883 can have preferred access
- Each team will be able to take most of their hardware home
- As projects are built, activity can move elsewhere
  - Any GT ThinkBig communities represented?
  - Small room nearby – E266
  - Dr. Collins lab space off of 10th Street

Grades

- Final grade based on
  - 20% - Assignments, including online assessment, summaries of lab results
  - 30% - Two written exams
  - 50% - Design project, including proposal, final presentation and demo, poster
- This course has a significant lab/writing/design component, so there is no final exam

Communications

- Piazza – will be linked on course web site
- When you are unable to resolve problems, faculty and staff are available
  - Collins – Office hours F 4-6
  - Kevin Johnson – Van Leer E276
  - And by appointment
- The course website and Piazza are the ultimate sources of the latest information
  - Email gets lost or bounced
  - You are responsible for checking these places!
  - Don’t expect much T-Square action

Homework Assignments

- Will be posted on Piazza
  - Possibly also mentioned in class, lab
  - Usually refer to course web site or other online locations
- Example: You have a relatively easy one that will be posted soon
- Complete by next Thursday, so we can discuss
  - There is nothing to turn in for this one

Lab Assignments

- Will also be posted on Piazza and usually include links to course web site
- Next week, everyone will cover some basics of simple circuits and use of equipment
  - Self-paced, with handouts
  - Simple results to turn in
- Can we identify no more than three 1-hour periods, one of which can be attended by each student?
  - Monday between 12-9
  - Tuesday or Thursday 11-12
  - Friday between 12-3

Lab after next week

- For four weeks, there will be two learning tracks in the lab
- Also self-paced, but faculty can try to be there at the key times we identify

SMEs

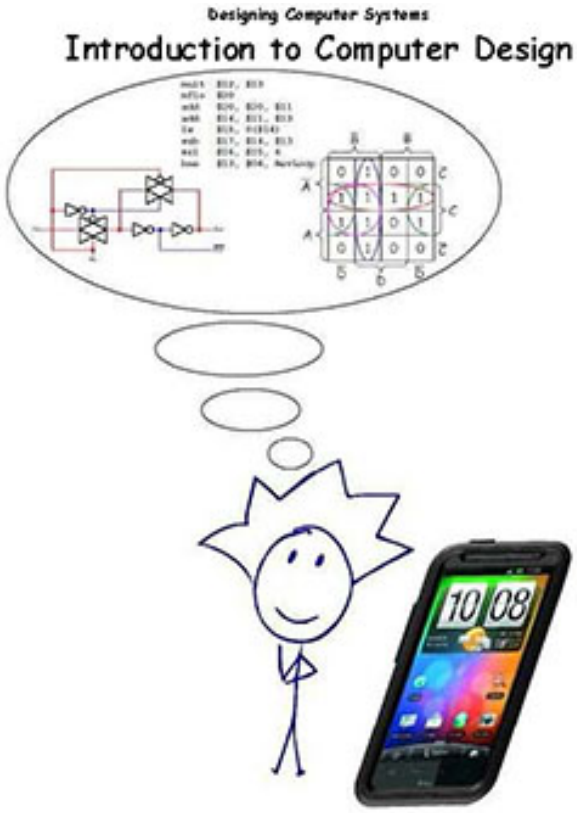
- Learn Quartus II CAD
- Implement combinational & sequential circuits
- Learn VHDL and implement more designs

Non-SMEs

- Learn about simple circuits, solenoids, etc.
- Learn about combinational circuits
- Learn Quartus II CAD
- Learn about sequential circuits

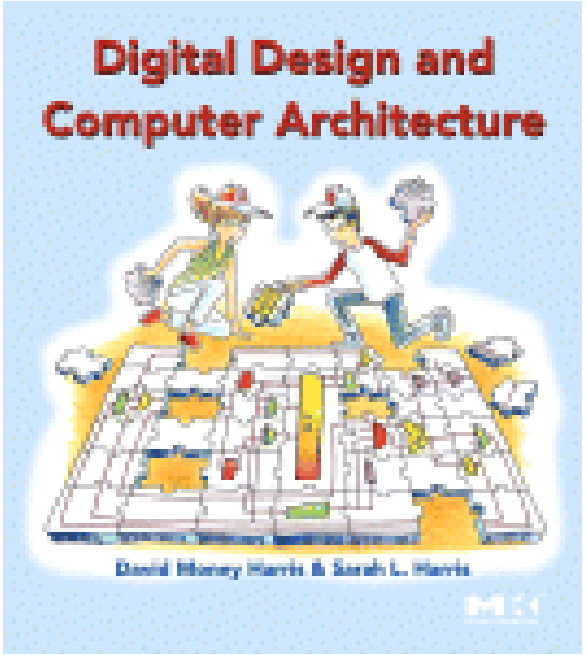
eBook

- Authors: Wills & Wills
- Free, downloadable PDF
- First reading assignment will be posted tonight
  - Review for SMEs, New for most non-SMEs
  - Nothing due to be turned in



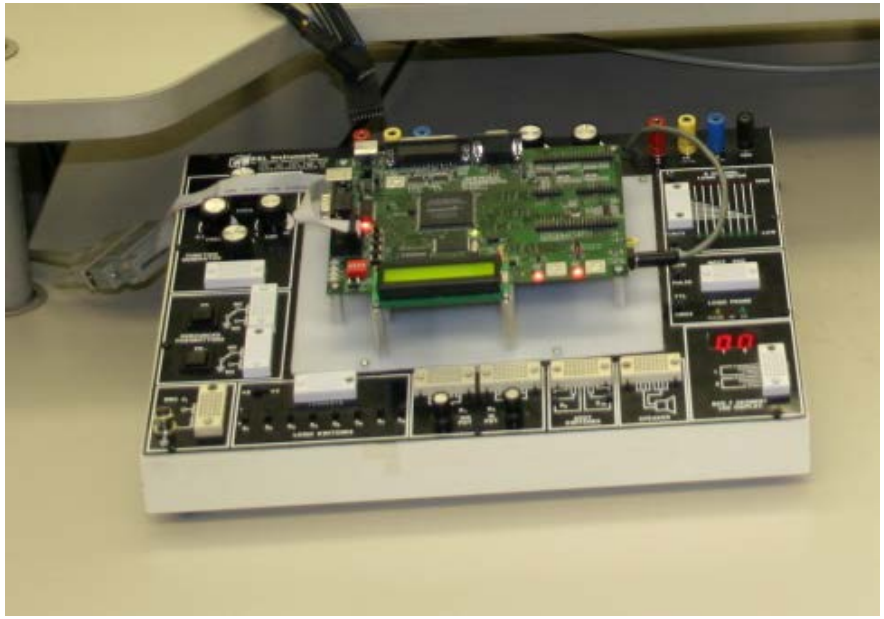
Another electronic resource

- Authors: Harris & Harris
- Linked to course site
- A better textbook than the one used in ECE2020
- Some assignments will be made, probably optional (supplemental)



CADET

- Supplies power to DE2
- Has additional switches, LEDs, a *function generator*, and more



Constant DC voltage measurement

- Can be done with a voltmeter or multimeter
- Or an oscilloscope
- Or a logic probe (approximately)
- Typical uses:
  - Make sure we have power
  - Check a constant logic value

Timescales

- What is “fast” ?
- Grace Hopper
  - Wikipedia
  - Nanoseconds –
- Another way to look at a nanosecond
  - Just what IS a fraction of 10^{-9} ?

Nanoseconds are convenient

- Our gates switch on the order of a nanosecond (from tenths of a nanosecond up to tens of nanoseconds)
- Our signals rise and fall on the order of a nanosecond (the actual time spent changing)
- Our signals move through our really short wires in fairly small fractions of a nanosecond (remember Admiral Hopper….)

Things to keep in mind

- Our project hardware is really slow by comparison
- We don’t need the speed of the FPGA as much as we need its many pins
- Designing independent devices in the FPGA to sense and control our projects will be more elegant than a program running on a single computer
- We’ll come back to this later….

Discussion

- What would each of you like to get out of this course?