The Digilent Analog Discovery

A lightweight tool for active learning of electrical circuits

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Motivation – Electrical Circuit Teaching

Electrical circuits is a competence taught at the early years of *any* Electrical Engineering course in the world.

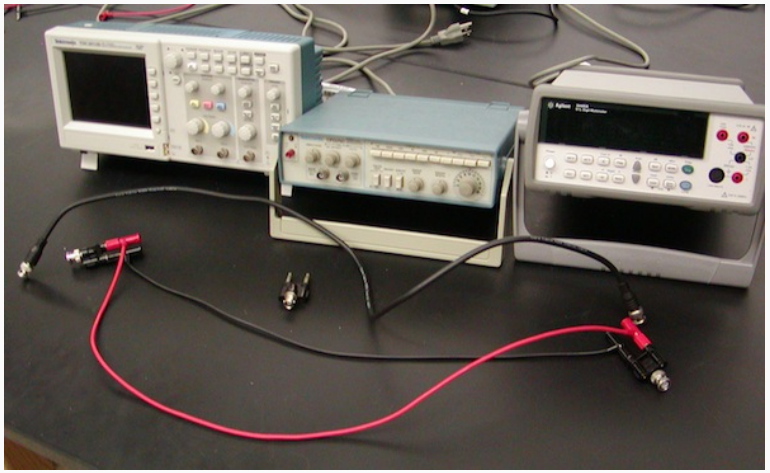
A real-world electrical circuit

Equivalent abstract representation

Electrical circuits are usually taught through:

- theoretical lectures – circuit representation and theoretical analysis
- practical lectures – circuit building and measurement in laboratories

Practical Electrical Circuit Analysis



Typical electrical circuits testbenchs

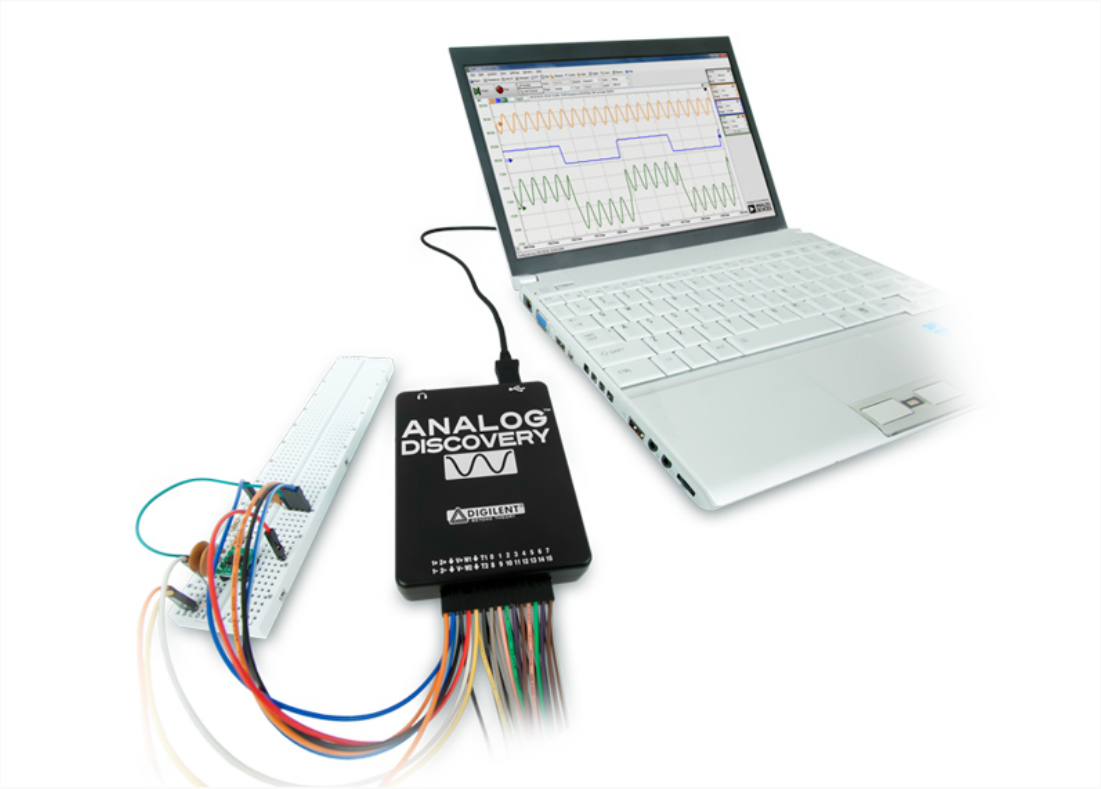
Practical classes of electrical circuits require specific equipment:

- Oscilloscope
- Power supply
- Signal generator

Equipment sets are called *testbenchs*. Typically, 5 to 10 testbenchs per laboratory.

A new tool: Digilent's Analog Discovery

- A small-footprint device that packs many testbench functionalities
- *Analog* has connectors to interface with your circuit
- Controllable from PC via USB and using *Waveform* software
- **Portable** – test your circuits anywhere! No need for laboratory.



Analog Discovery for Teaching and Learning

I found at least four works describing application of this tool.

Instructional Demos, In-Class Projects, and Hands-On Homework: Active Learning for Electrical Engineering using the Analog Discovery

Authors: Mazzaro, G. J., & Hayne, R. J. (The Citadel, South Carolina).
Paper presented at 2016 ASEE Annual Conference & Exposition, New Orleans, Louisiana.

Abstract review:

- Authors created practical projects in two courses that were previously theoretical (**Fundamentals of Electrical Engineering** and **Circuits I**)
- Projects were in-class exercises and homework assignments (off-class) using *Analog* and *Waveform*
- Positive feedback from students and that *Analog* helps meeting teaching goals / competence acquisition

Context to use Analog Discovery

Motivation and context for Analog Discovery

1. First-year **Fundamentals of Electrical Engineering**
   - First-year syllabus has little exposure to practical work
   - Introducing freshmen to practical Electrical Engineering

2. Second-year **Circuits I**:
   - Syllabus misplanning at the second year
   - Second-semester *Electrical Laboratory* requires practical skills
   - First-semester *Circuits I* has no hands-on assignments

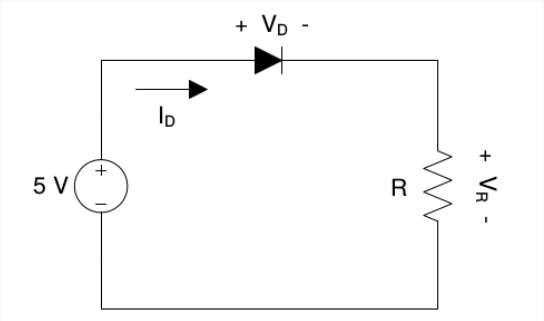
Reasons to select Analog Discovery

- Requires minimal electrical knowledge
- Controlled and operated by PC
- Cost is not prohibitive (around $ 150)

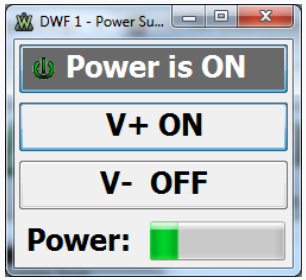
Application to Courses

First-year **Fundamentals of Electrical Engineering**

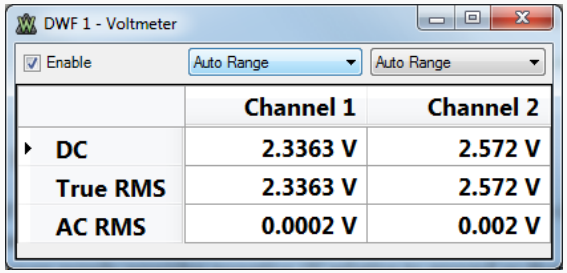
- In-class exercises to build simple circuits with LEDs.
- Introduction to *Analog* and *Waveform* via web-based tutorials.
- Students verify theoretical results on circuit with *Analog*.
- Assignments addressed both analog and digital circuits.



Exercise circuit.



Waveform - control.

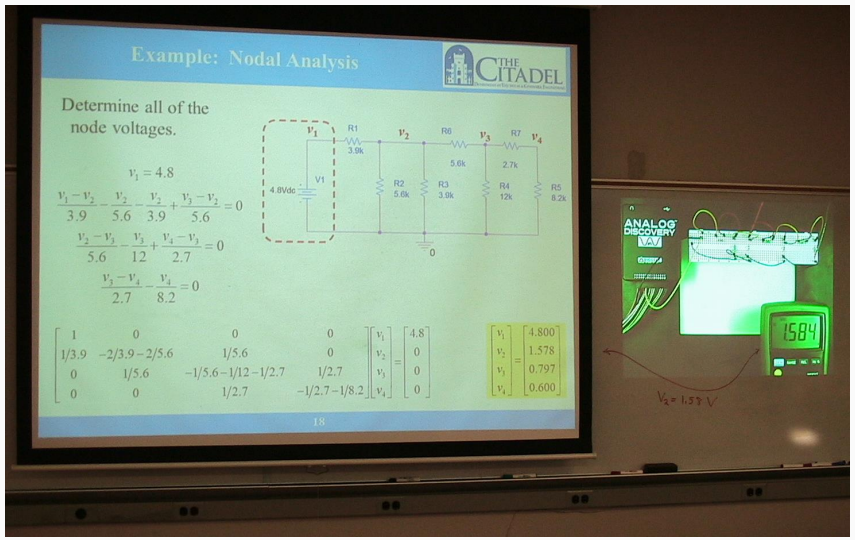


Waveform - measurements.

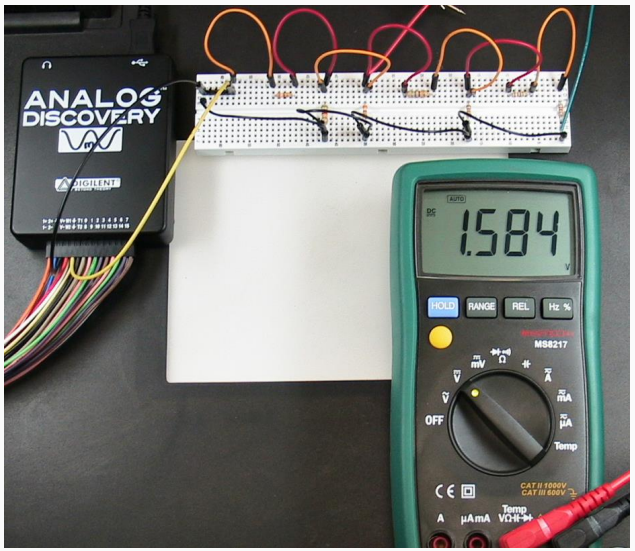
Application to Courses

Second-year **Circuits I**

- 6 homework assignments counting for 10% of grade.
- Assignments had written, simulation and circuit building portions
- Lecturers introduced assignments at the theoretical class.
- First edition: teams of two. Second edition: individually.



In-class introduction.



Experimental setup.

Student Performance and Feedback

First-year **Fundamentals of Electrical Engineering**

- Average grade of practical exercises was 92%.
- “I enjoyed the many different labs that we did.”
- “The course did a good job holding my attention.”
- “I enjoyed the hands-on learning style of the labs and lessons.”

Second-year **Circuit I**

- Each project was completed by at least 85% of students; overall completion rate was 92%.
- “I liked that we now build physical circuits in the class.”
- “I enjoyed the demo assignments in the course.”
- “I love the Diligent-Waveforms projects as well as the PSpice simulations.”

Overall Appreciation

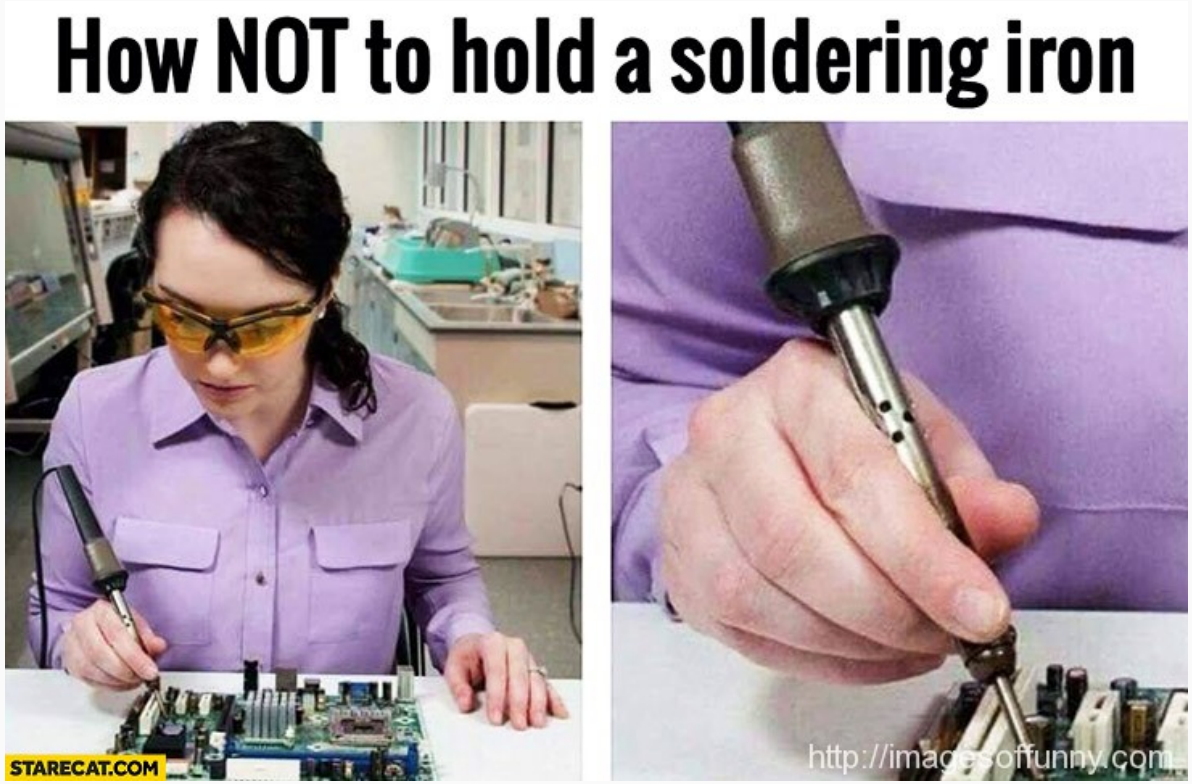
The authors claim that Analog Discovery helps:

- achieve desired outcomes laid out by the Accreditation Board for Engineering and Technology (ABET)
  - “apply knowledge of mathematics, science, and engineering”
  - “design and conduct experiments, as well as to analyze and interpret data”
  - “use the techniques, skills, and modern engineering tools necessary for engineering practice”

- students to acquire the expected competences and attain the learning objectives of:
  - **Fundamentals of Electrical Engineering:** build a resistor-LED circuit, measure a DC voltage, calculate a DC current, build an IC counter circuit, etc.
  - **Circuits I:** measure a resistance, build a resistive circuit, measure a DC voltage, etc.

Dangers to be Aware

Dangers of doing practical work off-laboratory:



- Students may miss practical insights (and not even be aware of it)
- Students may feel unconfortable with clarifying some practices
- Teacher does not assess the students' practical skills

Final Remarks

Analog Discovery:

- A portable, PC-controlled device to replace electrical testbenchs
- Affordable tool to introduce students to Electrical Engineering basics

The article:

- Authors report application of *Analog* to a first-year course (in-class exercises) and a second-year course (homework assignments)
- Course grades and student feedback shows success of the strategy

What else can you do with it?

- Re-arrange lecture scope (e.g., from practical to theoretical)
- Flip the classroom (study material before class, exercises during class)

Works reporting use of Analog Discovery

- Mazzaro, G. J., & Hayne, R. J. (2016, June), Instructional Demos, In-Class Projects, and Hands-On Homework: Active Learning for Electrical Engineering using the Analog Discovery Paper presented at 2016 ASEE Annual Conference & Exposition, New Orleans, Louisiana.
- Holland, S. S., & Prust, C. J., & Kelnhofer, R. W., & Wierer, J. (2016, June), Effective Utilization of the Analog Discovery Board Across Upper-Division Electrical Engineering Courses Paper presented at 2016 ASEE Annual Conference & Exposition, New Orleans, Louisiana.
- Robertson, J. M., & Meehan, K., & Bowman, R. J., & Connor, K. A., & Mercer, D. A. (2013, June), Exploiting a Disruptive Technology to Actively Engage Students in the Learning Process Paper presented at 2013 ASEE Annual Conference & Exposition, Atlanta, Georgia.
- Yousuf, A., & Wong, A., & Edens, D. W. (2013, June), Remote Circuit Design Labs with Analog Discovery Paper presented at 2013 ASEE Annual Conference & Exposition, Atlanta, Georgia.