

MODULE 2: Circuits, Signals and the Analog Discovery Board

SUMMER CHALLENGE

Electrical Engineering: Smart Lighting

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Overview

- Smart Lighting Kit
- Voltage and current
- What is a signal?
- Generating & observing signals
- Experiments
 - Using the Analog Discovery board & WaveForms
 - Time Domain Signals
 - Frequency Domain

Teams

Smart Lighting Kit



Smart Lighting Lab kit contents:

- 2 AD Boards
- 2 Arduino Boards
- 2 USB to microB-USB cables
- 2 Breadboards
- 2 Wiring kits
- Lens
- Flashlight
- Tape measure
- Protractor
- Headphones
- Parts Kit
 - Resistors and capacitors
 - Red, green and white LEDs
 - Photodiode(PD)
 - Operational amplifier (Op-Amp)
 - Exclusive-OR (XOR) gate
- Transceiver printed circuit board (PCB)
 - Board Components
 - 2 USB to serial cables (FTDI)



Course website:

<http://hulk.bu.edu/courses/SmartLight/2016/>

WaveForms Project:

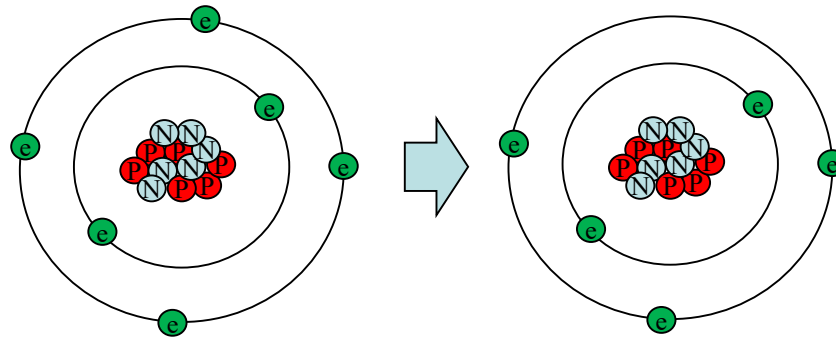
www.digilentinc.com/WaveForms/



Static Electricity

■ Atoms vs Ions

- Atoms consist of neutrons, protons, and electrons
- Neutrons are neutral, protons are positive, electrons are negative
- Ions are electrically charged atoms
 - (more or less electrons than protons)



■ Charge

- Measure of the difference in protons and electrons
- Typically measured in *Coulombs* [C]
- Charge causes objects to experience an attractive or repulsive force

“Dynamic” Electricity

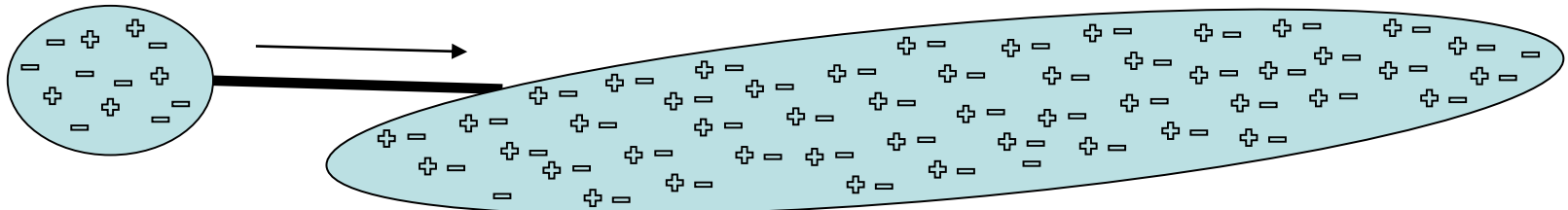
■ Insulators and Conductors

- Electrons in insulators have little freedom to move
- Electrons in conductors easily move from atom to atom
- **Insulators:** Rubber, Cotton, Wood, etc.
- **Conductors:** Silver, Copper, aluminum, etc.



■ Electric Current

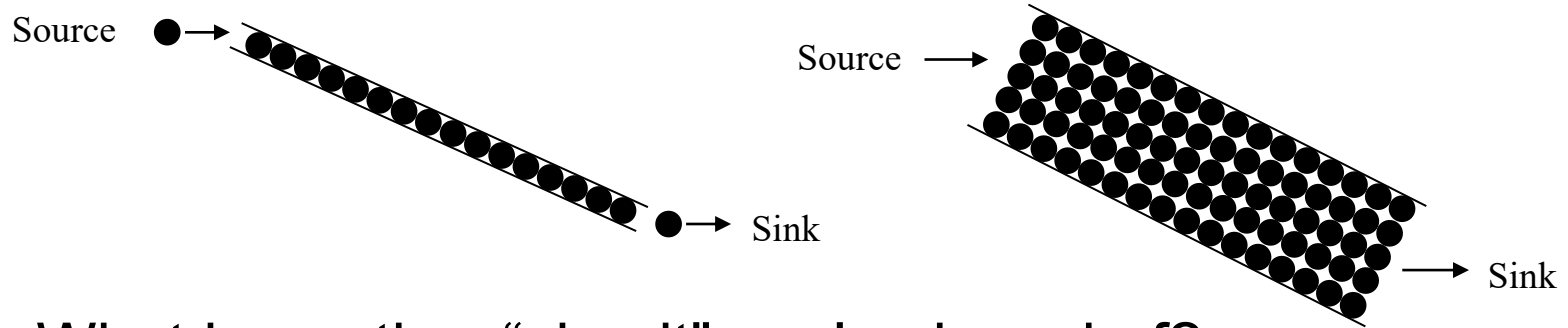
- Electric force tends to disperse charge if possible



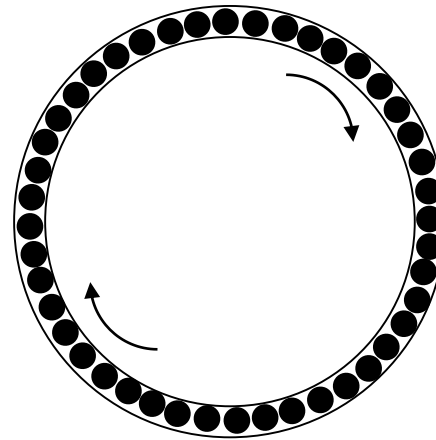
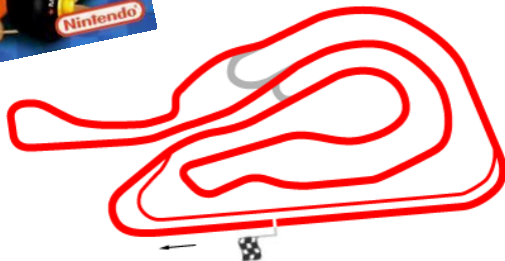
- Current is the rate of flow of charge
- Current is measured in Amperes [A] or [C/s]
- Current is *opposite* the flow of electrons!

Circuits

- Continuous flow requires an “infinite” source of electrons



- What is another “circuit” you’ve heard of?

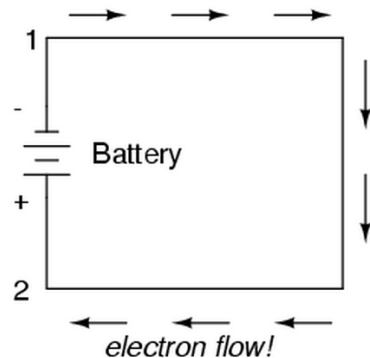
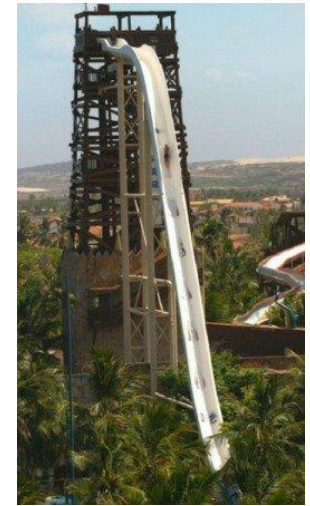


What is flow rate of marbles in this scenario?

What is missing?

Voltage

- Another Analogy: Water Slide
 - Pump moves water back to the top
 - Pumping water to the top requires energy
 - This increases the *Potential Energy* of the water
 - As water flows down the slide, it releases stored energy
 - Water at the top of higher slides has more PE relative to ground
- Relation to electric circuits
 - Batteries act as the “pump” in an electric circuit
 - Electric Potential, or *Voltage* [V], is the Electric PE per unit charge

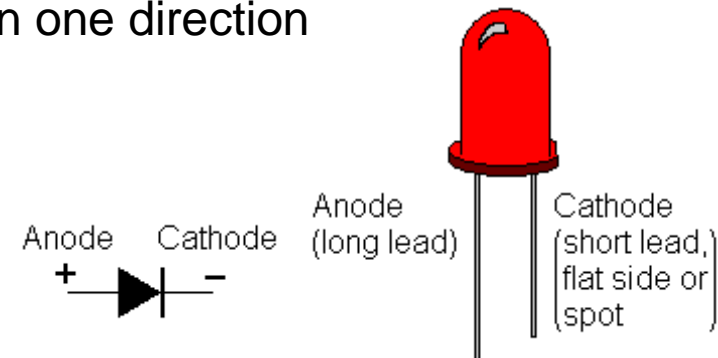


Buildup of charge at the battery terminal forces electrons to move through the circuit

Electrons flow from the negative terminal to the positive terminal

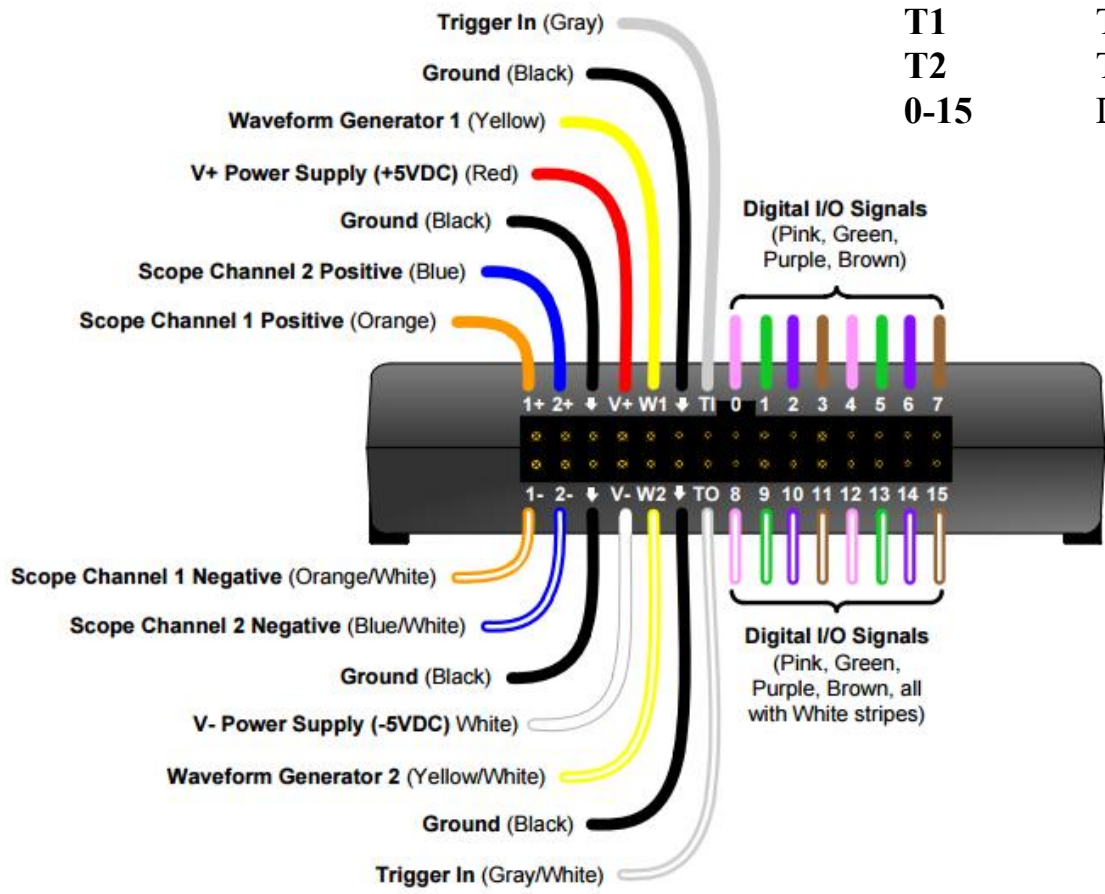
Voltage

- Differential
 - Potential energy is related to the “drop” from one level to another
 - Voltage is the electric potential *difference* between two points
- Ground
 - In the water slide analogy, the ground can be a common reference
 - Similarly, electrical “ground” can be a common reference
 - Ground isn’t always exactly the same across devices!
- Polarity
 - Some devices only allow current to flow in one direction
 - LEDs are polarized components.



AD Board Pinout

- 1+/- Analog Input 1 (Oscilloscope and Voltmeter)
- 2+/- Analog Input 2 (Oscilloscope and Voltmeter)
- ↓ Ground
- V+/- 5V DC Supply
- W1 Analog Output 1 (Waveform Generator)
- W2 Analog Output 2 (Waveform Generator)
- T1 Trigger 1
- T2 Trigger 2
- 0-15 Digital Input and Output

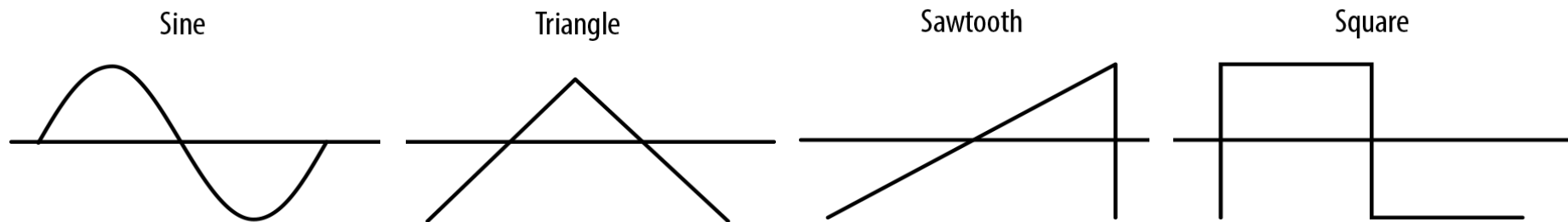


Experiment I

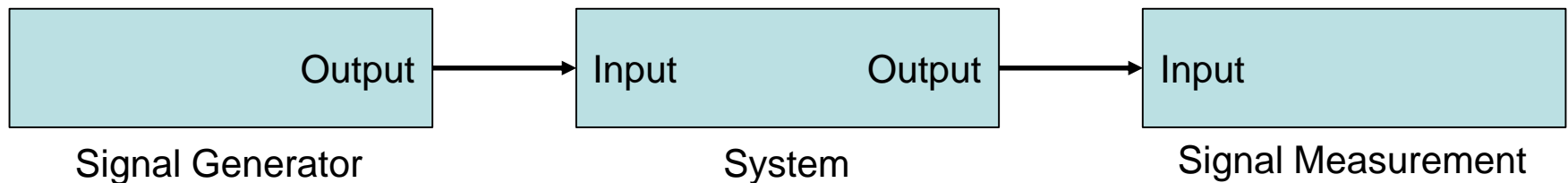
- WaveForms Introduction
- Digital I/O

Signal Analysis

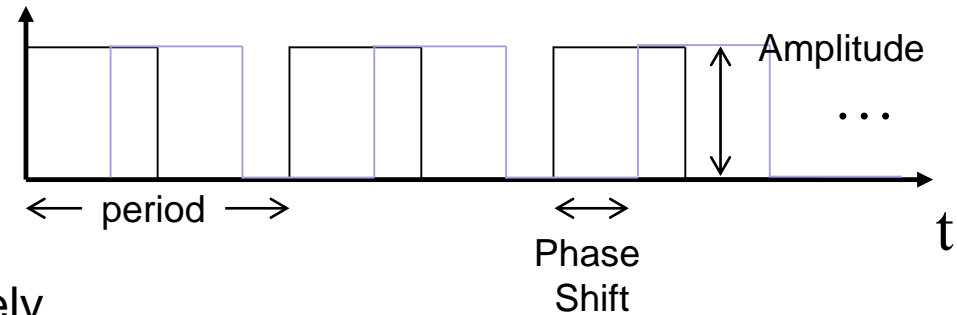
- What is “Time Domain”
- Types of Signals
 - As EE’s, we want to convert to ELECTRICAL signals!
- Digital vs Analog (Discrete vs Continuous)



- Input vs Output



Signal Analysis



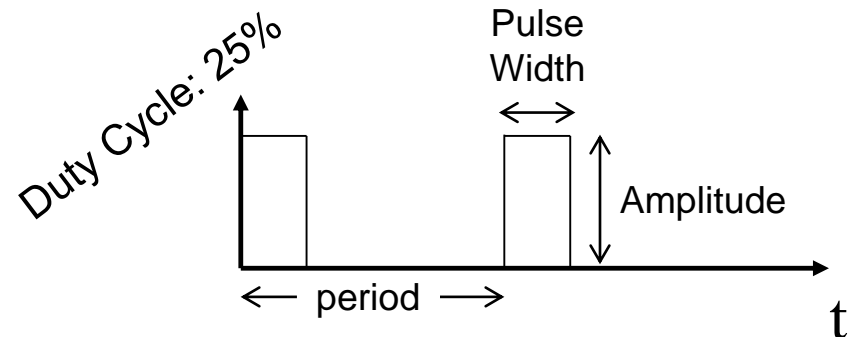
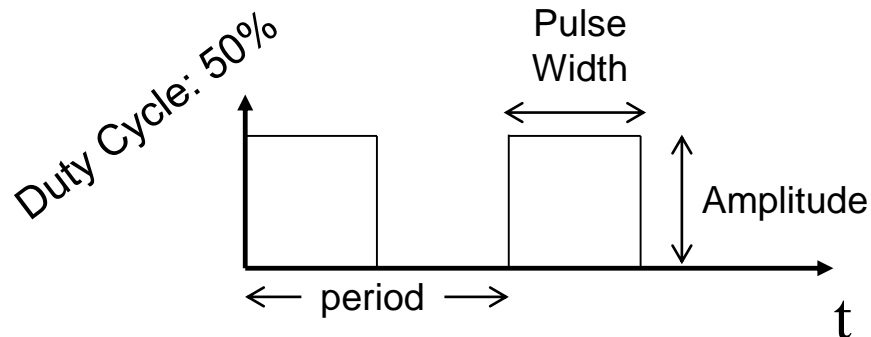
- **Waveform**
 - Signals repeated indefinitely
- **Amplitude**
 - Peak to Peak Amplitude vs Semi-Amplitude
- **Period and Frequency**
 - Period: Duration of repeating component of the signal [s]
 - Frequency: Number of repetitions per second [Hz]
- **Phase**
 - Ranges from 0 to 360 degrees
- **Single Ended (SE) vs Differential (DIF)**
 - SE: Voltage difference between a point and “ground”
 - DIF: Voltage difference between point A and point B
- **AC vs DC coupling**

Digital Signal

- Discrete level signals
 - Consider 2-level (binary) signals that are “on” or “off”
 - How many states do a car’s tail lights have?
 - Variations in time send information!



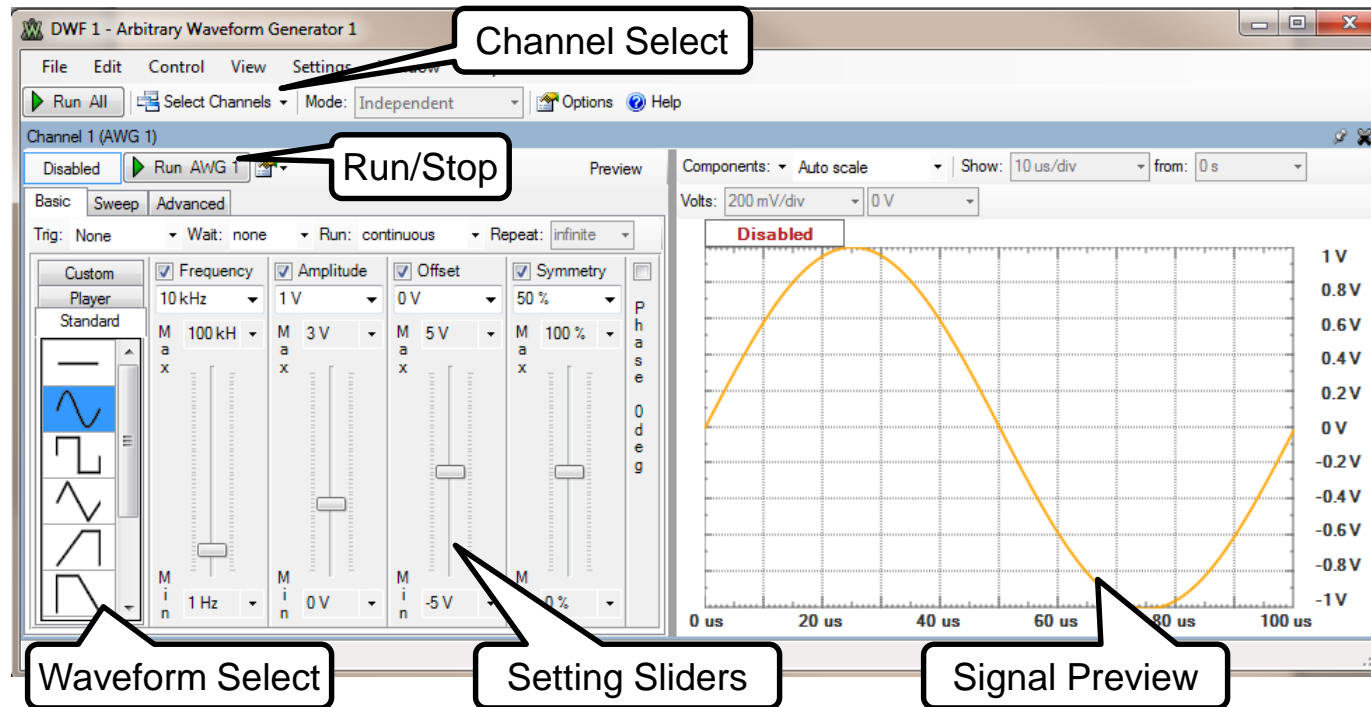
- Pulse Width and Duty Cycle



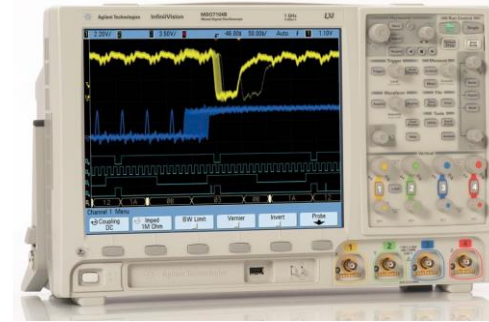
Signal Generation



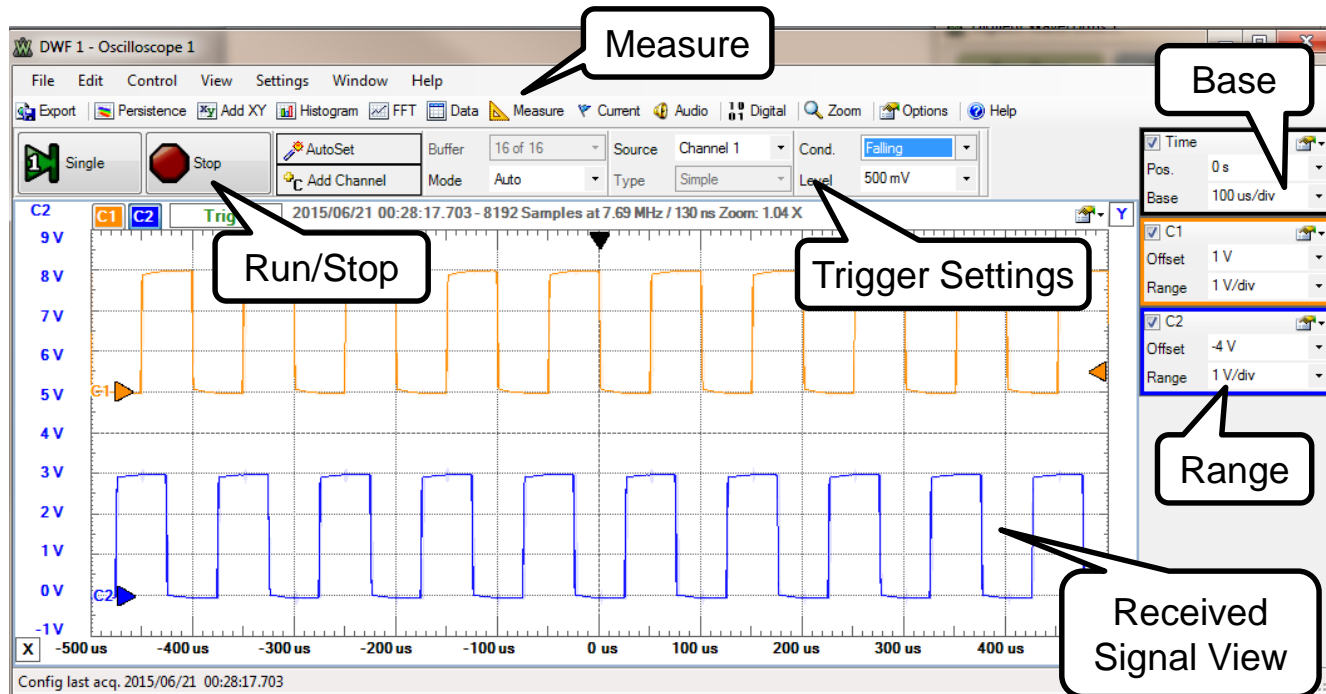
Function Generator



Signal Observation

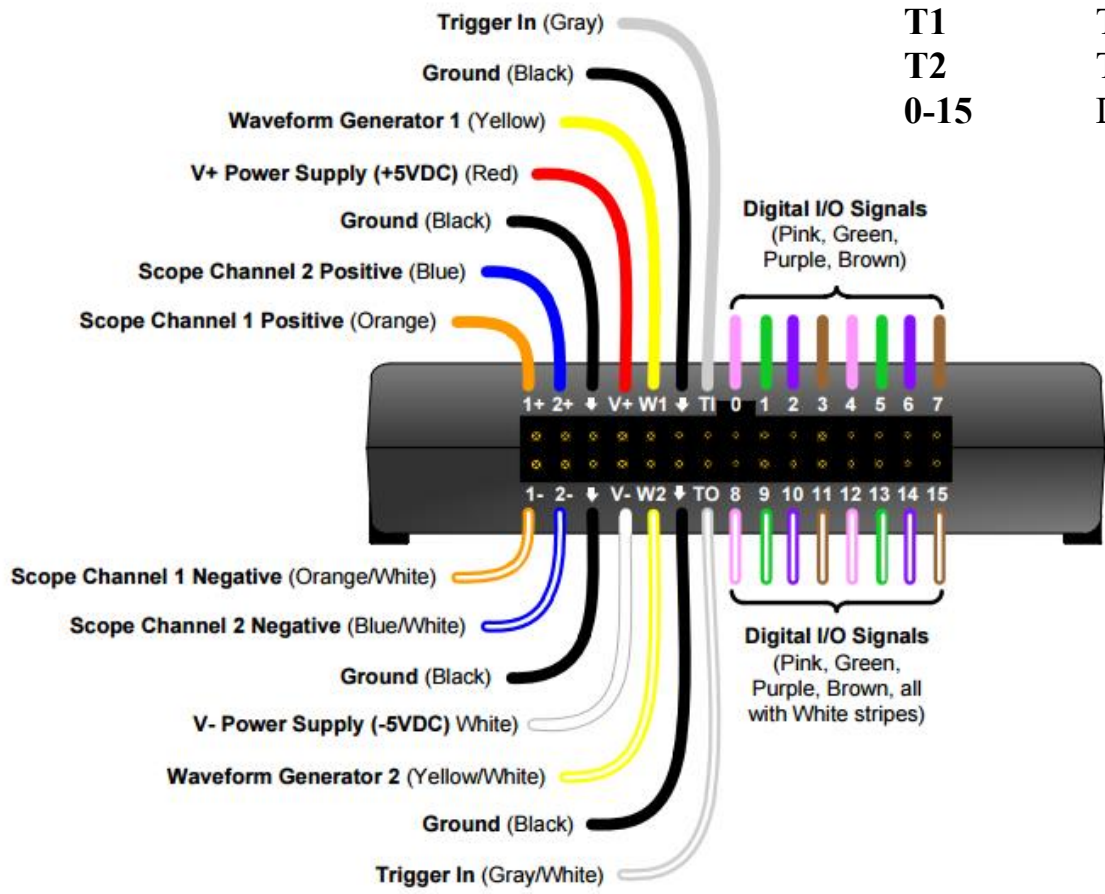


Oscilloscope



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Experiment II

- WaveForms Signal Generation (Digital)
 - Function Generator
 - Oscilloscope
- NOTES
 - *Connect the output of one analog discovery to the input of another*
 - *Take screen shots of your work! (PrtSc, then paste in paint)*

Recap

- References:
 - <http://www.physicsclassroom.com/>
 - <http://www.allaboutcircuits.com/>

- What did you  today?

