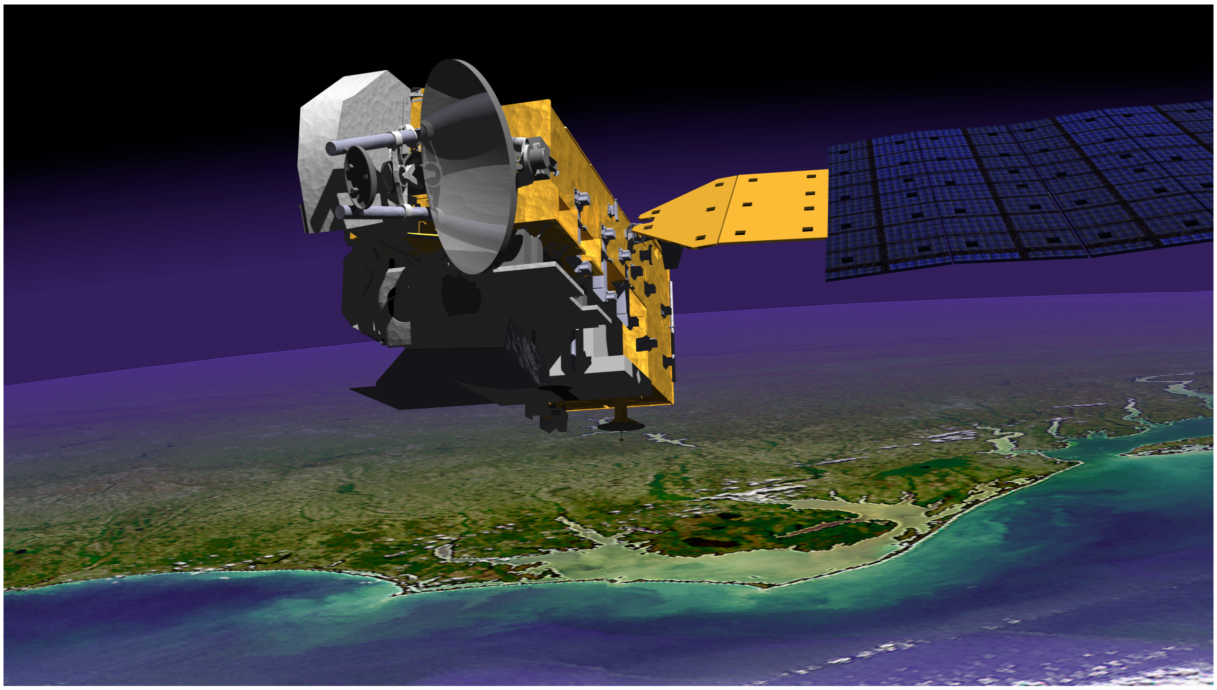
Sensors, Circuits, and Satellites
Lesson 4: Digital Communication



Sensors, Circuit, and Satellites is a collection of classroom lessons created by NASA's Aura mission education and outreach that explore the electromagnetic spectrum and NASA remote sensing instruments using student assembled circuits. These lessons integrate inquiry with active-learning experiences to engage students in the properties of electromagnetic energy and remote sensing. The investigations are sequenced to help the learner construct their knowledge about the electromagnetic spectrum while offering real world examples from NASA.

Credits:
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Lesson 4: Digital Communication

Summary: This lesson is a demonstration about electromagnetic energy and how that energy is transferred via visible and IR light waves to sound energy (digital signals). Students will investigate how the length of the wave affects how light energy is transmitted. Concepts of digital signal, visible, infrared or microwave waves are introduced.

Student Objectives: Students will analyze the difference between the transmission properties of different electromagnetic (light) waves using a digital sign.

Key Terms: electromagnetic spectrum, digital signal, visible, infrared and microwave.

Approximate Time: 45 – 60 minutes

Materials:

- littleBits™ components: power, microphone, audio cable, bright LED, and wire (for ease of use), also for the second circuit: power, light sensor, speaker, and wire
    - *ALTERNATIVE MATERIALS* –*
      From [Section 5, Active Astronomy Educator Guide from the SOFIA mission]
        - *Infrared Light Emitting Diode (LED)*
        - *0.22 **μ**F (microfarad) Capacitor*
        - *Audio Cable with 1/8" mini-plug on one end*
        - *5 Jumper Cables with alligator clips on both ends*
        - *AA Battery*
        - *AA battery holder*
        - *Receiver Circuit*
        - *Solar cell*
        - *Amplifier/Speaker*
        - *Audio Cable with 1/8" mini-plug on one end*
        - *2 Jumper Cables with alligator clips on both ends*
        - *9 Volt Battery for Amplifier/Speaker*
- Flashlight
- MP3 player
- Image of the electromagnetic spectrum
- White tissue paper, fabric pieces and plastic bags
- Video game controller

NGSS – Disciplinary Core Ideas

- **MS-PS4-2** Waves and Their Applications in Technologies for Information Transfer - Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials. [Clarification Statement: Emphasis is on both light and mechanical waves. Examples of models could include drawings, simulations, and written descriptions.] [Assessment Boundary: Assessment is limited to qualitative applications pertaining to light and mechanical waves.]

- **MS-PS4.3: Information Technologies and Instrumentation**
  Digitized information can be transmitted over long distances without significant degradation. High-tech devices, such as computers or cell phones, can receive and decode information—convert it from digitized form to voice—and vice versa. [Clarification Statement: Emphasis is on a basic understanding that waves can be used for communication purposes. Examples could include using fiber optic cable to transmit light pulses, radio wave pulses in wifi devices, and conversion of stored binary patterns to make sound or text on a computer screen.] [Assessment Boundary: Assessment does not include binary counting. Assessment does not include the specific mechanism of any given device.]

NGSS – Cross-cutting concepts

- Structure and Function: Structures can be designed to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used.
- Patterns: Graphs and charts can be used to identify patterns in data.

Engage: (Teacher can demo, or ask for student volunteer).

1. Shine a flashlight on to the light sensor in the receiver circuit and try to make a noise.
2. Ask the students: What happens? Can you make a noise?
3. Guide students to notice that the flashlight will make a clicking sound when the signal (light waves from the flashlight) is interrupted. When the flashlight moves away, or moves back on you will get a sound - off and on.

Explain:

Share with the students that when the sensor turns off and on, there is a change in the signal to electrical energy. This is just like the binary code used by computers and other devices to encode information. Signals can be coded into a series of pulses. The signal can only be on or off. These are called **digital signals**.

Explore:

1. Put together your first circuit: Transmitter (Power + Microphone and audio cable + MP3 + Bright LED) + wire for ease of use

2. Put together your second circuit: Receiver (Power + Light sensor + Speaker) +wire for ease of use

3. Play your music and hold the Bright LED bit over the light sensor and the light modulates

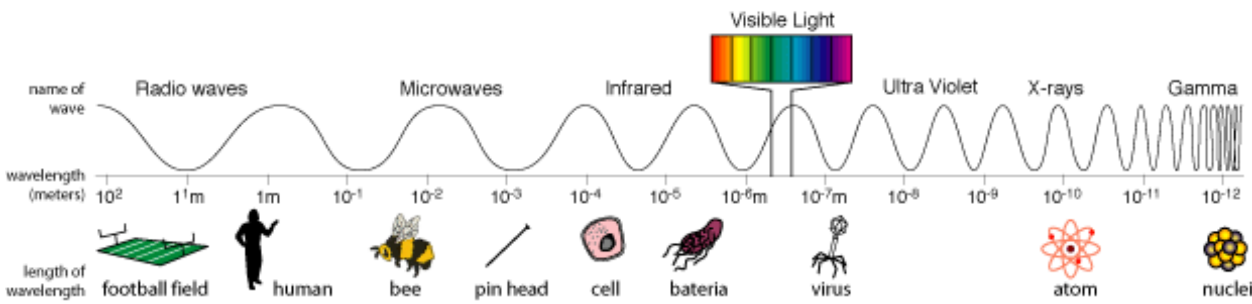
4. Now change bright led to the IR LED bit over the light sensor - does it sound different? How so? Record your findings in your journal. Why do you think this is happening?

** If using alternative materials, see set-up instructions on pages 73-76 of Section 5 in the Active Astronomy Educator Guide to complete steps 1 & 2*

Explain: First let's look at how the energy is being transmitted. What is the first energy source? The battery. The battery energy is transmitted to the data stored electronically on MP3 player, then to the light. The light energy is transferred to sound energy at the speaker.

So why is there a difference in the bright light and the IR light? Record student ideas.

Let's take a look at the electromagnetic spectrum (show image).



https://science.nasa.gov/ems/01_intro

We use electromagnetic waves everyday. Do you know of anything that uses electromagnetic waves? Listen to student ideas. Electromagnetic waves are emitted by many natural and man-made sources. These waves are a part of our daily lives, whether we are aware of them or not. We are warmed by the electromagnetic emissions of the sun (sunburn?) and we see using the part of the electromagnetic spectrum that our eyes detect as visible light. Infrared light is not part of the visible light spectrum, but as you can see, still emits waves that can be detected by sensors, and other instruments.

Let's take a look at the electromagnetic spectrum (show image).

Give student or pairs of students a copy of the image above. Have them record some observations about the chart. Then, ask the class - What do you notice about how light waves are arranged on the spectrum? Long to short – left to right.
Is there a difference between the IR waves and the visible light waves?
What else do you notice about this chart?

In the next part of the investigation we are going to investigate how the length of the wave affects how light energy is transmitted.

Explore: For each type of light, we will test how it transmits energy through three different substances: tissue paper, fabric and a plastic bag (Students complete "Data Collection Visible Light and Infrared Light" Sheet).

CONNECTION: NASA communicates with satellites, astronauts, and even Rovers on Mars by digital signals using electromagnetic waves. (Welcome to the digital age - digital communication is part of our daily lives.) All the waves that make up the electromagnetic spectrum travel at exactly the same speed through space, which is the speed of light.

Data Collection Visible Light and Infrared Light

Material between transmitter and receiver	Observations w/bright LED bit (visible light)	Observations w/IR LED bit (infrared light)
White tissue paper		
Fabric		
Plastic bag		

Data Collection Microwave Light

Material between transmitter and receiver	Observations w/microwave light
White tissue paper	
Fabric	
Plastic bag	