



TV Remote

Module Overview



This TechXcite: Discover Engineering module introduces youth to acoustical and electrical signals. An MP3 player produces an electrical signal that is converted to sound by a speaker. In this module, the electrical signal is converted to light and transmitted to a receiver. The light is then converted to an electrical signal and played through the speaker.

This curriculum is intended for use in informal settings, such as after-school programs and summer camps, for youth in the middle school grades. However, it has been successfully implemented in formal contexts, such as in-school activities including homeschool content, and youth older and younger than middle school grades.

Activity 1: Connect a music player directly to a small speaker.

Activity 2: Build a circuit to amplify the electrical signal from a music player, which increases the volume of the acoustical signal produced by the speaker.

Activity 3: Build a receiver that converts infrared light into sound and test it with a TV remote control.

Activity 4: Create a wireless transmission system by building a circuit that converts the electrical signal from an MP3 player to a light signal and then uses the receiver built in Activity 3 to convert the light signal to an acoustical signal.

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TechXcite: Discover Engineering



TechXcite is an informal engineering program partnering 4-H Youth Development/Family and Consumer Sciences at North Carolina State University, National 4-H Council and the Engineering K-PhD Program at Duke University's Pratt School of Engineering. It was initially funded by a five-year grant from the National Science Foundation.

In 2000, Drs. Ybarra and Klenk created an informal after-school engineering program at Rogers-Herr Middle School in Durham called Techtronics, which spread to additional schools across North Carolina and other states. The TechXcite: Discover Engineering curriculum builds on the Techtronics foundation by implementing hands-on, exploratory, engineering learning modules in 4-H Afterschool programs nationwide. Other after-school programs and even formal in-school and home-school programs have chosen to use the TechXcite curriculum. TechXcite is an engaging, substantive, experiential and inquiry-based curriculum centered on engineering, while using technology, applied science and mathematics learned in school. TechXcite's mission is to encourage youth in both rural and urban settings to pursue careers in engineering and technology.

TechXcite is the product of a collaboration of twelve 4-H leaders at land grant universities, two leaders at National 4-H Council and a team at Duke University.

Online Support

The TechXcite website (techxcite.org) contains additional material to facilitate implementation of this module. There are videos, Facilitator's Guides, Youth Handouts, and kit inventories with vendors and pricing for each item required. Although the curriculum is written with a focus on middle school youth, it has been successfully implemented at both the elementary and high school levels. Anyone can download copies of the Facilitator's Guide and Youth Handouts from our website. There are links to additional resources for information about the module topics and ideas for further activities and exploration.

Training Videos

Each module comes with a set of training videos found on its curriculum page (techxcite.org/curriculum). These videos serve as a companion to the Facilitator's Guide. An introductory video provides an overview of the material and concepts. The corresponding video for each activity then covers basic setup, procedure, and helpful tips for facilitating that activity. It's recommended that instructors watch all of the videos before starting the module.

Using this Guide



The Facilitator's Guide for each activity follows the same format. Below is what you can expect to find in each section. At the beginning, you will be given basic information about the activity. This includes:

- Time Required
- Group Size – Suggested number of students per group.
- Materials List
- Youth Handouts – These will need to be copied.
- Getting Ready– Includes what you need to do before the activity and approximately how much time it will take you.
- Learner Outcomes
- Vocabulary

Introduction and Activity Closure

The Introduction and Activity Closure are scripted. You may read these sections verbatim to students. Instructions that are not to be read to students, as well as answers to questions, are in brackets/*italics*.

Facilitating the Activity

This section contains step-by-step instructions for facilitating the activity. Students have their own procedure in the Youth Handouts.

Exploration Questions

Provides possible answers to the Exploration Questions found at the end of each activity in the Youth Handouts. After the students have a chance to answer the questions individually, instructors should hold a class discussion. The main purpose of this section is to encourage critical thinking and to promote the exchange of ideas.

Activity 1: Sound from a Speaker



Time Required: 45 Minutes

Group Size: 2

Materials List

Each group needs:

- Speaker
- Wire with headphone plug
- Breadboard
- Music player with headphone output

Youth Handouts:

- “Sound from a Speaker”

Getting Ready (10 minutes)

- Before starting the module, encourage students to bring in their own music players. This can be an iPod, mp3 player, or phone with standard headphone output. If you have access to a computer, you may use this for a group. If necessary, use the FM radios provided in the kit to make sure each pair has a player. They'll have more fun if they get to play their own music during these activities.
- Find and remove the speakers and wires with headphone plugs from the plastic bags in your kits.

Learner Outcomes

- Build a simple circuit using a breadboard.
- Explain that breadboards allow engineers to build circuits and change them quickly.
- Explain that a speaker changes an electrical signal into sound.
- Explain that speakers convert an electrical signal to an acoustical signal (sound).

Vocabulary

Word	Definition
Breadboard	A platform used to build electric circuits.
Engineer	A person who applies scientific knowledge to solve practical problems. The work of engineers forms the link between scientific discoveries and their application to human needs and quality of life.
Speaker	A device that converts electricity into sound.

Activity 1: Sound from a Speaker



Introduction

During the next few activities, we are going to explore how your music players transmit sound. How do you usually listen to music on a portable player, such as an iPod? *[Headphones]*

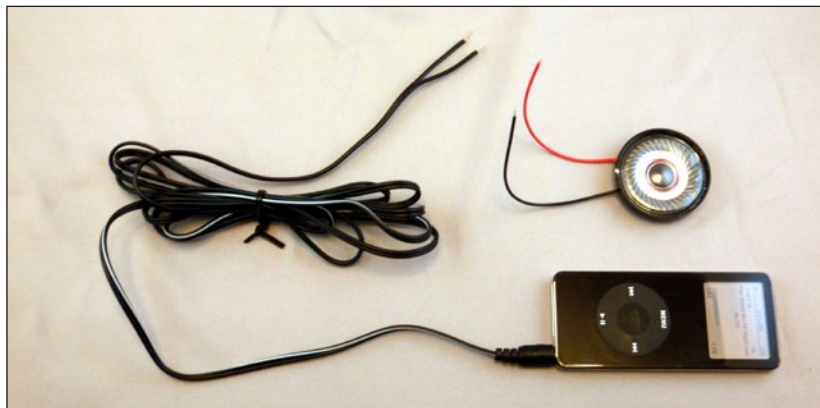
How does the music player transmit the sound to headphones? *[Electricity]*

There are tiny **speakers** inside the headphones that convert the electricity into sound. Today we are going to see what happens when we connect that electricity to slightly bigger speakers.

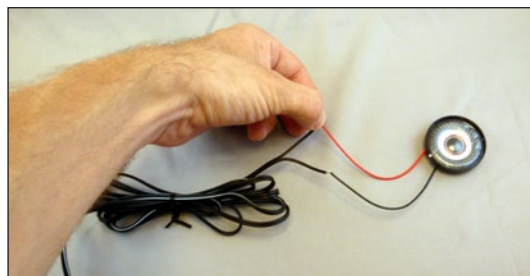
Facilitating the Activity

Part A: Playing Music Through a Speaker

1. Place students in pairs.
2. Give handout to each pair of students.
3. Distribute the speakers and wires with attached headphone plugs. Give music players to any students who did not bring their own.



4. Instruct students to be careful with the speakers, as the wires pull off easily.
5. Ask students to see if they can make the music play through the speaker. Allow them to spend some time trying to figure this out on their own. If they have trouble, you may demonstrate as shown below.



Activity 1: Sound from a Speaker

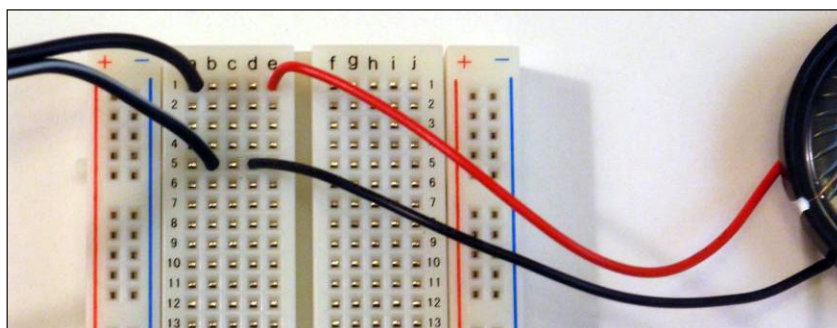


Part B: Using a Breadboard

6. Give each group a **breadboard**.
7. Show students how to insert and remove a wire from a hole in the breadboard. If the wires are hard to get into the breadboards, tell students to try straightening the short metal end of the wire and then carefully push it straight down into the hole.
8. Explain that, by using these holes, you can connect a circuit without having to hold it together with your hands. However, not all holes of the in the board are electrically connected together. For example, holes A1 through E1 are electrically connected together, but A1 and B1 are not.
9. Instruct students to electrically connect the speaker and music player using the breadboard.

The music player should be turned on and plugged into the headphone output while they experiment. That way, when the circuit is hooked up correctly, sound will play from the speaker. *[You can start them off by telling them to insert one wire from the speaker and one wire from the headphone output into holes A1 and E1, respectively.]* Make sure students discover the following:

- a. Each horizontal row is connected in sets of five.
- b. There is no connection across the centerline of the board (A1-E1 are connected to each other and F1-J1 are connected to each other).
- c. Each horizontal row is separate (E1 is not connected to E2).



10. Next, explain that the vertical sets of holes with red and blue stripes are called power rails. These are connected vertically all the way up and down the board. They are not connected across the board. These power rails will be used to connect the battery to the circuit in later activities.

Ask students, “Will we connect the positive end or negative end of the battery to the red rail?” *[Positive is connected to red, while negative is connected to blue. Students with electricity experience will likely associate red with positive.]*

11. Collect the speakers, headphone wires, jumper wires, and any music players loaned to students.

Activity 1: Sound from a Speaker

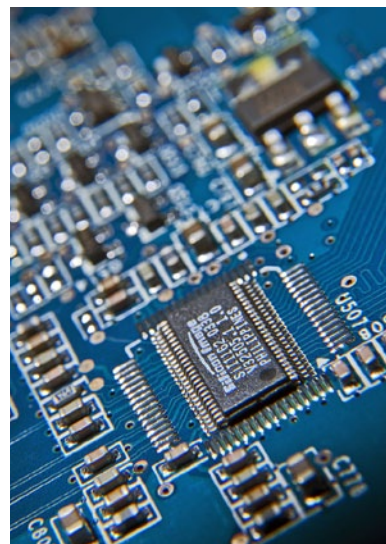


Activity Closure

Electrical **engineers** use breadboards to build circuits before turning them into their final versions.

Have you seen a circuit board like this before? Where? *[Show the picture to the right, or if you have one, any circuit board from an electrical device. Give students a chance to name some devices in which they've seen circuit boards.]*

On printed circuit boards—found in devices such as phones, computers, and music players—wires and components are permanently connected together. It takes a special tool, called a soldering iron, to remove a wire and put another one in place. On a breadboard, however, a wire or component may be removed and another one inserted without any special equipment, making it extremely easy to design and test circuits.



Circuit board by Harland Quarrington [OGL], via Wikimedia Commons

Exploration Questions

1. How is the breadboard similar to a piece of wire?

[Breadboards and wires can both be used to electrically connect components and create circuits. However, breadboards are preferred by electrical engineers over wires because they are a lot easier to manage, especially when the circuit designs become more complex.]

2. What did you notice about sound when the larger speaker was connected?

[The sound was quieter. This is because the electrical signal coming from the music player is designed specifically for the tiny speakers found inside headphones. When it's connected to a larger speaker, there isn't enough energy or power in the signal to drive the larger speaker. In the next activity, we will build an amplifier circuit to remedy this.]

Activity 2: Amplifying Sound



Time Required: 60 Minutes

Group Size: 2

Materials List

Each group needs:

- 3 Capacitors (10 μ F electrolytic)
- Amplifier chip (LM 386 electrolytic)
- Resistor (24 k Ω ; red, yellow, orange)
- Speaker
- Battery snap
- Battery (9 V)
- Wire with headphone plug
- Music player with headphone output
- Breadboard

Each class needs:

- Jumper wires (2")

Youth Handouts:

- "Amplifying Sound"

Learner Outcomes

- Identify the amplifier chip and explain that it increases the electrical signal to make the sound from the speaker louder.
- Identify the polarity of an electrolytic capacitor.

Vocabulary

Word	Definition
Capacitor	A device that stores energy and stabilizes voltage.
Schematic diagram	A symbolic diagram that shows how to connect electronic components together to form a circuit.
Resistor	A device that resists the flow of electricity
Troubleshooting	The process of diagnosing the source of a problem.

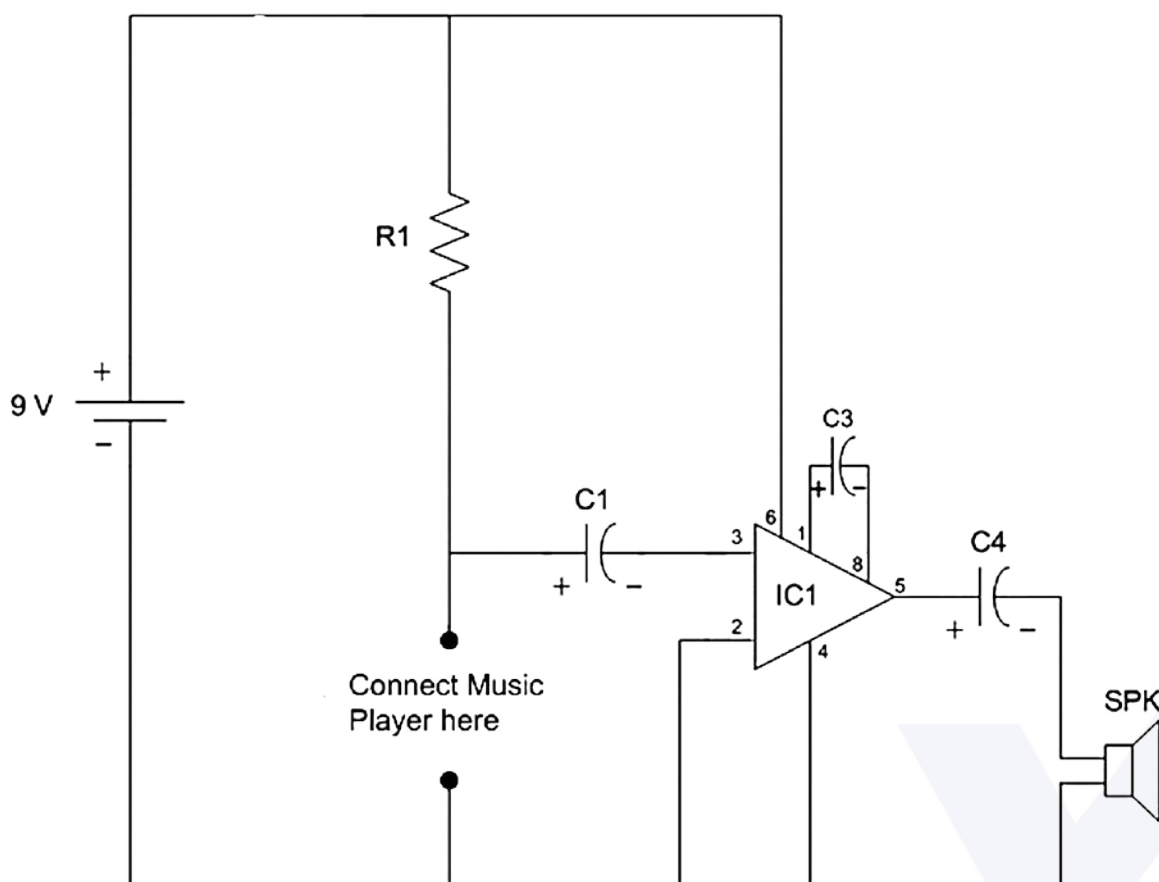
Activity 2: Amplifying Sound



Introduction

In the first activity, you connected a speaker directly to a music player to hear the sound. But even at the highest volume, the music was hard to hear. What do you think we need to do to make that sound louder? [Give students a chance to think about this and answer.]

Today we are going to make the music louder by using a small amplifier circuit to increase the strength of the electrical signal coming from the music player.



To build the amplifier circuit you will need a **schematic diagram**. [Show students the image above.]

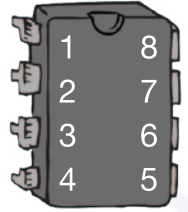

A schematic diagram is a plan that electrical engineers use to represent how electrical components are connected together. The lines represent the wires and each symbol is a different type of component (see the “Electronic Component Guide” in the Youth Handouts for details).

Step-by-step instructions will be given in the handout, along with the schematic diagram, which will guide you through the circuit-building process.

Activity 2: Amplifying Sound



Facilitating the Activity

1. Place students in pairs. These can be the same pairs as last time or different pairs.
2. Distribute TechXcite Music Transmitter kits, breadboards, and wires with headphone plugs. Do not give students a battery until they have completed the circuit.
3. Have students reconstruct the circuit they built on the breadboard in Activity 1 to make sound play through the speaker. This will be a good review.
4. Ask students which holes are connected. *[Each horizontal row is connected in sets of five. A1 through A5 are connected to each other. A6 through A10 are connected to each other. There is no connection across the centerline of the board. A5 is not connected to A6. Vertical columns are connected from top to bottom and are called power rails.]*
5. Give a handout to each pair of students.
6. Hold up an amplifier chip for students. Tell them, "Be careful when attaching the amplifier chip to the board. You do not want to bend the pins. Look at the close-up picture of the chip. The chip has 8 pins, as shown in the diagram. Starting at the notch on the top, the pins are numbered counterclockwise. It is important that the chip be oriented with the notch up for this activity."
 
7. Demonstrate for students where to place the amplifier chip on the breadboard, as described in Step 1 of the handout.
8. Hold up a **capacitor** for the students. Tell them, "Capacitors store energy. These capacitors are designed to have a positive and negative side. That means that you must put the positive and negative wires in the correct holes. The negative side has a stripe down the side. The directions will explain where the negative side with the stripe goes, so pay attention to it."
 
9. Instruct students to follow the directions in the handout to build the amplifier circuit. Walk around and help students as they work through the activity.
10. Students must complete the circuit and have you check it before they get a battery. You do not have to catch all mistakes, but looking for a few easy errors can help. Ask the following questions:
 - a. Are there any rows that have only one hole filled out of five? If so, that piece is not connected to anything else, which is a problem.
 - b. Are the battery snap wires correctly connected to the power rails? The red wire should be in the right power rail and the black wire should be in the left power rail.
 - c. Is the chip oriented correctly with the notch upward?
 - d. Are the capacitors inserted with the positive and negative ends in the correct directions?
 - e. Is the battery dead? Try replacing the battery.
 - f. If all else fails, replace the capacitors and amplifier chip, checking each of them one-by-one.
11. Once the circuit is given an initial check, give the group a battery and have them test their circuit.

Activity 2: Amplifying Sound



12. If the circuit does not work, immediately disconnect the battery and go through the connections one-by-one with the students to **troubleshoot** the circuit.
13. Optional: Ask students, "What happens with the circuit when you remove the capacitor across pins 1 and 8?" *[The sound gets quieter. This is the equivalent of turning the volume down because the amplifier does not amplify as much.]*
14. When the activity is completed, collect the batteries and put them back in the boxes. This will keep the contacts from touching something metal and draining the battery.
15. Instruct students to put their completed amplifier circuits with their breadboards back in the plastic bag along with a small piece of paper with their names on it. They will use this circuit in the next activity.

Activity Closure

In this activity you learned that an amplifier circuit can be used to boost a weak electrical signal, allowing your speaker to produce a louder sound. Signal amplification occurs in almost all electrical systems. For example, if you want to send a telephone signal from America to Europe on an underwater cable, you must have amplifiers placed every 10 to 20 miles along the path. That way, as the signal weakens, it gets boosted back up again before being retransmitted to the next section of cable.

During this activity you also learned that an electronic circuit must be wired up without a single error, otherwise the it will malfunction. No matter how hard engineers try, it is impossible to make something perfect on the very first attempt so troubleshooting becomes an important skill for all engineers to develop.

Exploration Questions

1. How does the amplifier circuit work?
[Give students a chance to describe how they think the circuit works and then fill in any details for them. The amplifier chip takes the electrical signal from the music player and uses energy from the battery to increase the power of the signal. The amplified signal makes the speaker play louder than it would if the signal came directly from the music player.]
2. How can you determine the polarity of a capacitor (which wire is negative and which is positive)?
[The first way to determine capacitor polarity is to look at the length of the leads. The longer lead is positive. The second way is to look for a stripe running down the body of the capacitor. The stripe—which may have tiny minus signs inside it— is on the negative side.]
3. What does troubleshooting mean?
[Troubleshooting is the process of solving a problem. Generally, troubleshooting involves a logical process of elimination, starting with the most general (and most obvious) possible issues and then narrowing down to more specific issues.]

Activity 3: IR Music Receiver



Time Required: 30 Minutes

Group Size: 2

Materials List

Each group needs:

- Amplifier circuit (From Activity 2)
- Phototransistor
- Music player with headphone output
- Battery (9 V)
- Tape measure

Each class needs:

- Jumper wires (2")
- TV Remote(s)

Youth Handouts:

- "IR Music Receiver"

Getting Ready (5 minutes)

- If you can, borrow a few extra infrared remote controls for TVs, VCRs or other electronic devices. It will be useful to have several when students are testing their circuits.

Learner Outcomes

- Explain that a phototransistor changes the flow of electricity based on the amount of light hitting it.
- Explain that infrared light is light that is invisible to the human eye.

Vocabulary

Word	Definition
Infrared (IR)	A form of light that the human eye cannot see.
Phototransistor	A device that converts light into electricity.

Activity 3: IR Music Receiver



Introduction

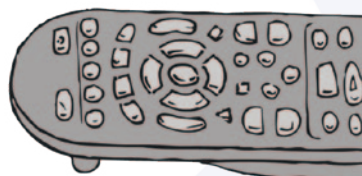
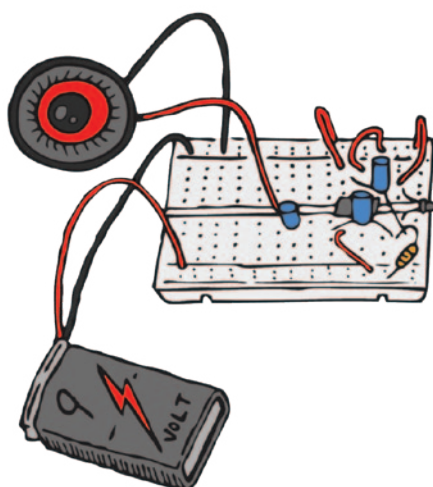
In the first two activities, we took an electrical signal from a music player, turned it into sound, and then amplified it. In the next two activities, we are going to build a wireless music transmitter and receiver.

Our wireless transmitter will use either visible or **infrared (IR)** light. Can you think of anything that uses infrared light? *[Possible answers: Remote controls, some laptops (for sending information), the Nintendo Wii, and other wireless devices that work when they are pointed at each other.]*

Today we will build the receiver. This circuit will receive an infrared signal and convert the light into sound. At the end of the activity, you will test your circuit to see if it can receive a signal from a TV remote.

Facilitating the Activity

1. Place students in pairs and distribute materials.
2. Ask students to make sure their circuits from Activity 2 still work.
3. Give a handout to each pair of students.
4. Hold up a phototransistor and explain that a **phototransistor** changes the flow of electricity based on the amount of light hitting it.
5. Instruct students to follow the directions in the handout to modify their amplifier circuits to receive an infrared signal. Walk around and help students as they work through the activity.
6. Students are to test their receivers by pointing a standard infrared TV remote control at the phototransistor. If you have only one or two remotes, make sure the various student pairs share the remote as they are testing their circuits.
7. When the activity is completed, collect the batteries and put them back in the boxes. This will keep the contacts from touching something metal and draining the battery.
8. Instruct students to put their completed amplifier circuits with their breadboards back in the plastic bag along with a small piece of paper with their names on it. They will use this circuit in the next activity.



Activity 3: IR Music Receiver



Activity Closure

In the circuit you just completed, the signal is transferred from the TV remote to your receiver via infrared (IR) light, which is invisible to the human eye. The receiver then turns that light into an electrical signal, which is then turned into sound by the speaker.

Specifically, the TV remote creates a signal by turning the infrared light on and off in a regular pattern. The phototransistor then senses the light turning on and off and turns the IR energy into electrical energy. A similar receiver in your TV would use that electrical energy to change the volume or the channel. In this case, the IR receiver amplifies the electrical energy and uses it to drive the speaker. We hear the beeping sound produced by that signal.

Exploration Questions

1. What is the purpose of the phototransistor in the circuit?

[Short answer: The phototransistor turns lights into electricity. Long answer: The phototransistor receives the signal coming in over the light waves and turns it into an electrical signal that can then be fed to the amplifier.]

2. What is the farthest distance the remote can be fired and still trigger a sound in the receiver? What could you change in the receiver circuit to increase this distance?

[The farther away the remote (or transmitter) is from the receiver, the weaker the signal. The trigger distance can be increased by adding another amplifier to the receiver to boost the incoming signal. You could also use a lens to catch more of the infrared light and focus it on the phototransistor.]

3. Why do you think engineers use infrared light for remote controls?

[One of most obvious reasons for the use of infrared—over visible light in particular—is that humans can't see infrared so it's not annoying. Another reason is that it won't get as much interference from ambient light (i.e. other lights in the room won't confuse the system).]

Activity 4: IR Music Transmitter



Time Required: 60 Minutes

Group Size: 2

Materials List

Each group needs:

- Receiver circuit (From Activity 3)
- 5 Resistors (100 Ω ; brown, black, black)
- Infrared LED
- Red LED
- Transistor
- Potentiometer (50 k Ω)
- Capacitor (10 μ F)
- Wire with headphone plug
- Battery snap
- Battery (9 V)
- Breadboard
- Music player with headphone output

Each class needs:

- Jumper wires (2")
- TV Remote(s)

Youth Handouts:

- "IR Music Transmitter"

Getting Ready (5 minutes)

- If you can, borrow a few extra infrared remote controls for TVs, VCRs or other electronic devices. It will be useful to have several when students are testing their circuits.

Learner Outcomes

- Explain that light can be used to send a signal.
- Explain that the transmitter circuit takes an electrical signal from the music player and turns it into a light signal.
- Explain that the receiver circuit takes the light signal and converts it to an electrical signal that is then amplified and turned into sound by the speaker.

Activity 4: IR Music Transmitter



Vocabulary

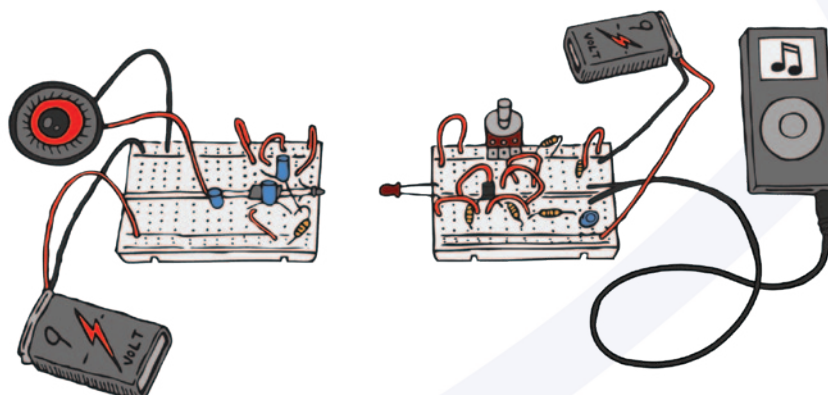
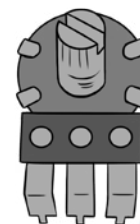
Word	Definition
Light Emitting Diode (LED)	A device that converts electrical energy into light of a single color.
Potentiometer	A resistor with three terminals, the third being an adjustable center terminal; used to adjust voltages in radios and TV sets.
Transistor	An electronic device that amplifies a signal.

Introduction

Last time, we converted the sound amplifier circuit into an infrared receiver, which took the infrared signal from a TV remote and turned it into sound. In this activity, we are going to build a circuit that takes the electrical signal from our music players and flashes a **light emitting diode (LED)** with the music. Your receiver will then receive this light signal and turn it into sound.

Facilitating the Activity

1. Place students in pairs and distribute the TechXcite Music Transmitter kits, breadboards, and wires with headphone plugs. Do not give students a battery until they have completed the circuit.
2. Give a handout to each pair of students.
3. Hold up the **potentiometer** and explain that it acts like a resistor except that you can change the resistance by turning the knob (also known as a variable resistor). There are 3 pins to connect. The outer pins are exactly the same, so the direction does not matter when installed on the breadboard.
4. Hold up the **transistor** and explain that the transistor is used like the amplifier chip to increase the signal. Note that the transistor also has 3 pins. It is important the transistor be inserted correctly so that pins 1, 2, and 3 are in the correct places, as shown in Step 1 of the handout.
5. Instruct students to follow the directions in the handout to build and test the transmitter. Walk around and help students as they work through the activity.



Activity 4: IR Music Transmitter



6. Students must complete the circuit and have you check it before they get a battery. You do not have to catch all the mistakes, but looking for a few easy errors can help. Ask the following questions to help them troubleshoot any problems:
 - a. Are there any rows that have only one hole filled out of five? If so, that piece is not connected to anything else, which is a problem.
 - b. Are the battery snap wires correctly connected to the power rails? The red wire should be in the right power rail and the black wire should be in the left power rail.
 - c. Is the chip oriented correctly with the notch upward?
 - d. Are the capacitors inserted with the positive and negative ends in the correct directions?
 - e. Is the battery dead? Try replacing the battery.
 - f. If all else fails, replace the capacitors and amplifier chip, checking each of them one-by-one.
7. Once the circuit is given an initial check, give the group a battery and have them test their circuit.
8. If the circuit does not work, immediately disconnect the battery and go through the connections one-by-one with the students to troubleshoot the circuit.
9. When the activity is completed, collect the batteries and put them back in the boxes. This will keep the contacts from touching something metal and draining the battery.
10. Put all the components of the receiver in the Music Receiver kits, including the jumper wires. When removing the amplifier chip, be careful not to bend the pins.
11. Put all the components of the transmitter in the Music Transmitter kits, including the jumper wires.

Activity Closure

In the transmitter-receiver circuit, how does the music get from the music player to the speaker?

[Allow students to answer if they think they know. You can have one person go through the entire process, or after one person has explained the transmission component, you can ask somebody else to continue. Whether the explanation is correct or incorrect, ask the other students if they agree with it. Why or why not?]

Here's how it works. First, the electrical signal from your music player is converted into an invisible infrared (or visible red) light signal by the LED in the music transmitter circuit. The light signal then hits the phototransistor in the receiver. The phototransistor in the receiver converts the invisible infrared (or visible red) light signal into an electrical signal. Then, the amplifier chip in the receiver circuit takes this electrical signal and makes it stronger, using energy from the battery. Finally, the amplified electrical signal drives the speaker, which turns electrical energy into sound energy.

Activity 4: IR Music Transmitter

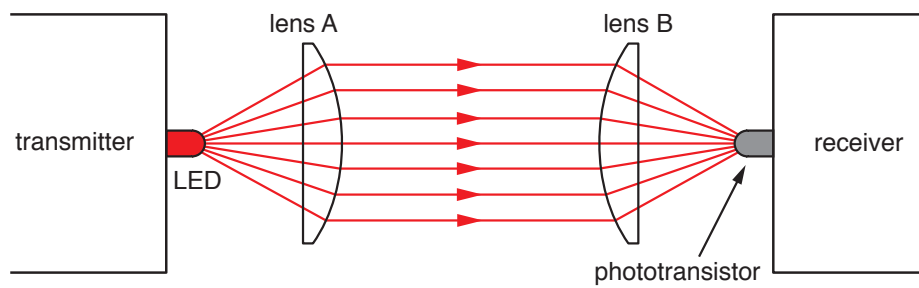


Exploration Questions

1. What is the farthest distance the transmitter can be fired and still trigger a sound in the receiver? What could you change to increase this distance?

[The trigger distance can be increased by using an amplifier to increase the energy going into the LED, resulting in a brighter light. You could also place a lens in front of the LED to help focus the beam of light on the phototransistor.]

The most efficient configuration is placing a lens on both the transmitter and the receiver. The lens in front of the LED collimates the light into a beam and the lens on the receiver focuses the light into a single point on the phototransistor, as seen in the illustration below.]



2. What is the disadvantage of using a lens on the transmitter?

[Light that misses the phototransistor doesn't do any good, so using a lens to collimate and focus the beam will make the signal stronger and allow it to be received from farther away. However, if a lens is used, the beam of light from the LED must be pointing right at the phototransistor. If it's off, even by a little bit, the whole system won't work. Everything in engineering is a trade-off.]

Tools Used in this Module



Electrical Breadboard

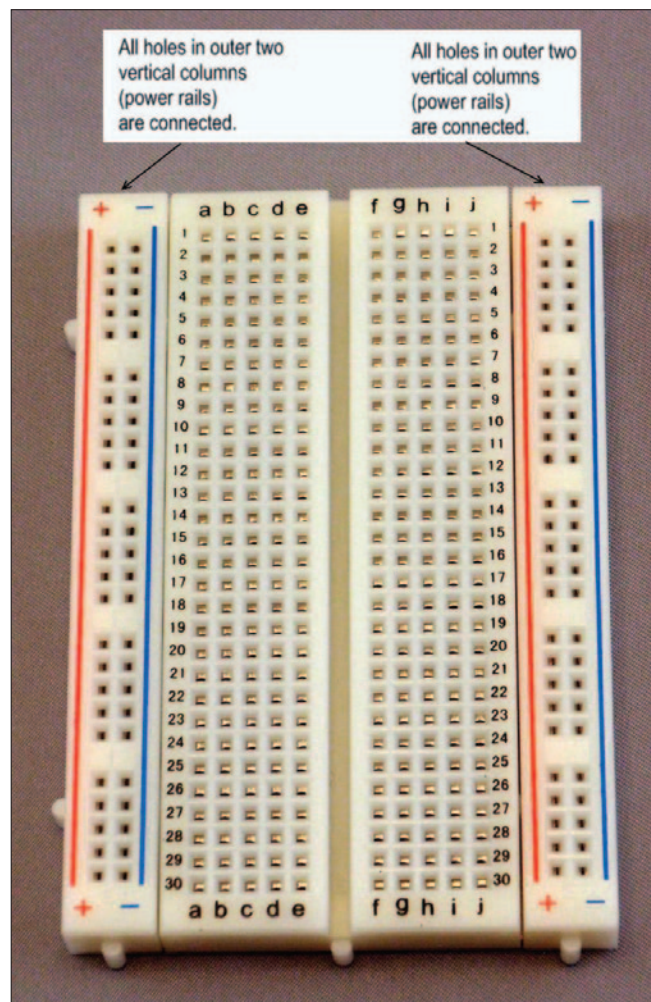
Breadboards are used to build and test electrical circuits. Wires can be inserted into the holes to connect components in a circuit.

All holes in each of the outer vertical columns (power rails) are electrically connected inside of the breadboard. There are two power rails on the left side and two power rails on the right side. Generally, the blue power rail is negative and the red power rail is positive.

In the center, there are rows of holes labeled A-J. All five holes in a single row are connected inside the breadboard. Opposite halves of the breadboard are not connected.

Examples:

- A1 is connected to D1
- A1 is NOT connected to A2
- E1 is NOT connected to F1



Glossary

**Breadboard**

A platform used to build electric circuits.

Capacitor

A device that stores energy and stabilizes voltage.

Engineer

A person who applies scientific knowledge to solve practical problems. The work of engineers forms the link between scientific discoveries and their application to human needs and quality of life.

Infrared (IR)

A form of light that the human eye cannot see.

Light Emitting Diode (LED)

A device that converts electrical energy into light of a single color.

Phototransistor

A device that converts light into electricity.

Potentiometer

A resistor with three terminals, the third being an adjustable center terminal; used to adjust voltages in radios and TV sets.

Resistor

A device that resists the flow of electricity

Schematic diagram

A symbolic diagram that shows how to connect electronic components together to form a circuit.

Speaker

A device that converts electricity into sound.

Transistor

An electronic device that amplifies a signal.

Troubleshooting

The process of diagnosing the source of a problem.

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