Activity 4: IR Music Transmitter

Time Required: 45 minutes

Materials List
Group Size: 2
Each pair needs:
One each of:
- One Activity 4 bag containing:
  - 10 Ω Resistor (brown, black, black)
  - 4.7 kΩ Resistor (yellow, violet, red)
  - 220 Ω Resistor (red, red brown)
  - 1 kΩ Resistor (brown, black, red)
  - 100 Ω Resistor (brown, black, brown)
  - IR LED
  - Transistor (2N3904)
  - 50 kΩ Potentiometer

- These items are provided in a separate bag, but will be placed back in Activity 4 bag after activity for use in subsequent years:
  - 4.7 μF Electrolytic Capacitor
  - Earphone Plug with 6’ Cable
  - Seven 2” Jumper Wires

- 9 V Battery
- Battery Snap (in bag with breadboard)
- Breadboard

To share between every two groups:
- Multimeter
- Pliers

Student Handouts
- Activity 4: IR Music Transmitter

Learning Objectives
After this activity, students should be able to:
- Build an IR Music Transmitter circuit
- Identify and use a transistor
- Transmit music using infrared light

Introduction
Last time we met, you built a timer circuit using a 555 timer to transmit an infrared signal that caused the receiver to make various tones depending on the position of the potentiometer. This time you will build a different kind of infrared transmitter. This one will be a music transmitter. It will take the output of a music player and cause the infrared LED to get brighter and dimmer, transmitting the music. The infrared receiver circuit from activity 2 will receive the infrared signal and play the music out of the
speaker. The signal from any music player can be “jacked in” to the input of the transmitter.

**Vocabulary**

<table>
<thead>
<tr>
<th>Word</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transistor</td>
<td>An electronic device that amplifies a signal.</td>
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<tr>
<td>Audio Plug</td>
<td>A connector that jacks into a music player.</td>
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</tbody>
</table>

**Procedure**

**Instructor Preparation: (Time = 10 minutes)**

Check each multimeter and 9 V battery by turning the knob of the multimeter to the 20 V DC setting and touching the probes to the battery terminals. The multimeter should read more than 8.7 V. If the multimeter reads less than 8.7 V, try a second meter. If that still reads less than 8.7 V, try a new battery.

**During the Activity:**

1. Split students into groups of two.
2. Let the students know that there are many small parts in these kits. They should be careful while using them not to lose any. While working on this project, the students should work with their partners while not disturbing other groups. Students should also be warned to be careful not to disturb the components of other groups. Do not knock another group’s table.
3. Pass out electronic components. Tell the students not to connect the battery to anything until they are told to do so!
4. Walk around and help the students as they work through the activity.
   a. The batteries should be connected to the opto receiver and the music transmitter ONLY when the circuits are ready to be tested.
   b. If the opto receiver does not produce sound when the music transmitter is fired at the phototransistor in the receiver, have the students move the IR LED in the music transmitter directly up against the phototransistor in the opto receiver.
   c. It is a good idea to retest the opto receiver by firing the TV remote at it.
   d. If the student is still unable to get an output from the opto receiver, have him/her remove one of the battery leads from both of their breadboards and follow the trouble shooting procedure in the student handout.
   e. If the battery leads are hard to get into the breadboards, try twisting the strands of the wires to form a firmer end of the wire.
5. At the end of the activity, ask the students to put the components back in their original bags.
6. Collect the components from the students. The batteries go back in the boxes to keep the contacts from touch something metal and short circuiting.

**Processing and Activity Closure:**
[After most of the student groups have finished writing their descriptions of the circuit in the assessment, but before they clean up, it is important to go over the circuit.]

How does the sound come out of your music players? The music comes out of the player as an electrical signal. This is generally turned into sound by small speakers in your headphones that convert electrical signals into sound.

In your worksheets, you were asked to describe how the music gets from your music player to the speaker on your receiver circuit. What did you write down for this?

[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. Let them say what they think happens all the way through. Whether it is right or wrong, ask the other students if they agree with this. Then, if it’s right, you can confirm it for them. If there are portions that are right, confirm those sections for the class and tell them the parts that are not quite right. If you’re not sure if something they say is right or wrong, just tell them you don’t know but you will ask somebody. You can ask on the TechXcite forum for the “Your TV Remote” module online at www.techxcite.pratt.duke.edu. If none of it is correct you can provide the entire explanation below.]

1) The electrical signal from your music player is converted into an invisible infrared light signal by the infrared light emitting diode (IR LED) in the transmitter circuit. If we wanted to transmit this over a longer distance, we would need to use a brighter IR LED or we would have to focus the invisible light using a lens.

2) The invisible infrared light signal must hit the photo transistor in the receiver.

3) The photo transistor in the receiver converts this invisible infrared light signal into an electrical signal.

4) Then, the amplifier in the receiver circuit takes this electrical signal and makes it larger using energy from the battery.

5) Finally, this larger electrical signal drives the speaker which turns electrical energy into sound energy.

Additional Resources
Chaney Electronics – BBK-3 44 in 1 Communications and Opto Lab Kit
http://www.kitsuse.net

For more information about how speakers work:
http://electronics.howstuffworks.com/speaker.htm

Assessment
1) Please indicate the percentage of groups whose circuits were able to transmit music to the receiver. This will be used to assess whether or not students were able to build the circuit correctly. It will also be used to assess whether or not the students learned that music can be transmitted via infrared light. Finally, it will also be used to assess the activity itself to determine how well it works.
2) Collect or copy page 44 of the student handout. Their descriptions of how the sound goes from the music player to the speaker will be used to assess their basic understanding of the circuit. We will be looking for the following:
   a. Does the student state that the music comes out of the music player as an electrical signal?
   b. Does the student state that the IR LED gets brighter and dimmer to create an invisible light (infrared) signal that carries the sound from one circuit to the other?
   c. Does the student state that the photo transistor turns the invisible light (infrared) signal into an electrical signal?
   d. Does the student state that the amplifier on the receiver takes that electrical signal and makes it stronger so we can hear it when it comes out of the speaker?
   e. Does the student recognize that the speaker takes the electrical signal and turns it into sound that we can hear?

References
Chaney Electronics, 44 in 1 Communications and Opto Lab Manual, 1997.

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Activity 4: IR Music Transmitter Student Handout

Name: ________________________

Date: __________

In this activity you will build an infrared (IR) opto music transmitter. The signal from any music player can be “jacked in” to the input of the transmitter. The sound signal modulates the intensity of IR light, which carries the sound to the opto receiver. The opto receiver then amplifies the audio signal and the sound comes out of the speaker.

Parts List
R1: 10 Ω Resistor (brown, black, black)
R2: 4.7 kΩ Resistor (yellow, violet, red)
R3: 220 Ω Resistor (red, red brown)
R4: 1 kΩ Resistor (brown, black, red)
R5: 100 Ω Resistor (brown, black, brown)
P1: 50 kΩ Potentiometer
C1: 4.7 μF Electrolytic Capacitor
L1: IR LED
Q1: Transistor (2N3904)
Earphone Plug with 6’ Cable
9 V Battery
Battery Snap
Breadboard
2” Jumper Wires

You know how to identify the resistors from Activity 1 by using the resistor color code.
You know how to identify the pot, the electrolytic capacitor and the IR LED from Activities 2 and 3.

The 2N3904 transistor has a black body with a flat front and three leads coming out of the bottom of the body.

The earphone plug is a standard 1/8th inch mini plug that fits most portable music players. The other end of the cable has two wires that can be inserted into a breadboard.
Overview

The **opto transmitter** circuit you will build has the following **schematic**.

![Schematic Diagram](image)

The black dots emphasize that a physical connection is made. The wire that goes from the middle lead of the pot (P1) to the middle lead of the transistor (Q1) does **not** connect to the wire between R3 and P1 even though the wires cross because there is **no black dot at the cross point**!

As you build the circuit on your breadboard, you should look back at the schematic frequently to relate the schematic drawing to your breadboard circuit.

When you have built the entire IR music transmitter circuit, it should look like the picture to the left.
**Building the IR Music Transmitter Circuit**

Rotate your breadboard so that the top of the breadboard is to your right and the +9 V red power supply rail is directly in front of you.

The first component to place on your breadboard is Q1, the 2N3904 Transistor. Spread the leads out if needed. With the flat side of the transistor body facing you, insert the left lead of Q1 in hole F24, the middle lead in hole F22, and the right lead in hold F20. Connect R5 (100 Ω brown, black, brown) between the right lead of the transistor and the +9 V power supply rail.

Connect a wire jumper from hole H24 to H30.

Connect the IR LED from F30 to E30 with the longer lead (+) in F30 and the shorter lead (-) in E30. Connect a wire jumper from A30 to ground (blue negative power supply rail).

Compare your circuit on the breadboard with the [schematic](#).

Connect R3 (220 Ω red, red brown) between hole J26 and the +9 V power supply rail.

Connect a wire jumper from hole F26 to hole E21.

Connect a wire jumper from hole H22 to hole H15.
Connect wire jumpers as follows:

- F15 to E19
- D17 to D14
- A5 to ground (neg. supply rail)

Connect R4 (1 kΩ brown, black, red) from A14 to ground.

Connect R2 (4.7 kΩ yellow, violet, red) from G15 to G10.

Connect C1 (4.7 μF Electrolytic Capacitor) from hole H10 to H5 making sure that the negative lead is in hole H5.

Connect R1 (10 Ω brown, black, black) from hole F5 to hole C5. We are almost finished!

Insert the pot with the stem pointing away from you with its lead in holes: A21, A19 and A17.

Remember, when you insert the pot in the breadboard, make sure it is inserted all the way down.
Connect the earphone plug cable into the breadboard as follows. Look at the leads at the end of the cable closely. One of the leads has a white stripe on its insulating jacket. This is the positive lead. The other lead is just black insulation and is the negative lead.

You are going to insert the positive lead into hole G5. Grab the positive lead with the needle nose pliers and gently insert the lead into hole G5. Grab the negative lead with the needle nose pliers and gently insert the lead into hole E5.

Finally, connect a 9 V battery to a battery snap and connect the battery to the power supply rails.

The circuit should now be operating. To test the circuit, aim the IR LED at the photo-transistor of the opto receiver that you built in the 2nd activity. Position the IR music transmitter so that the IR LED is 0.5 inches away from the photo-transistor of the opto receiver.

Obtain a portable music player. Listen to it through headphones and make sure it is producing loud and clear audio music or speech.
Connect the music player to your IR music transmitter by connecting the earphone plug to the headphone jack of your music player. Turn up the volume on your music player. Rotate the stem of the pot on your transmitter circuit. You should hear music coming out of the speaker in the receiver. If you do not hear any sound out of the speaker, you will need to **troubleshoot** your IR music transmitter-receiver system.

**If your circuit does not work, immediately disconnect one of the battery snap leads from the breadboard of BOTH the transmitter and the receiver.**

**Troubleshooting (Go through this process if your circuit fails to operate)**

Troubleshooting is the process of figuring out why a circuit does not work.

1) The most common problem is a wiring error. Check your transmitter circuit to make sure that every wire and component lead is going into the hole you think it should go into.
2) The second most common error is a polarity mistake. Check the polarity of C1 and the IR LED.
3) Is the battery dead? Use the voltmeter to measure the voltage across the battery terminals. Is it 9 V or higher? If not, replace the battery.

The problem with the circuit must be one of the mistakes listed above. You must go through each step carefully until you find and correct the problem.

**System Operation, Exploration and Description**

Twist the pot stem in the music IR transmitter circuit until the sound produced by the speaker is as clear as possible.

**Answer:**

Explain how the sound goes from the music player to the speaker.

**Answer:**
Disassembling the Circuit

Return the circuit components to their proper storage bags as instructed. Do not mix the components from the receiver and the music transmitter.

For the Receiver from Activity 2:  
All of your small components from the receiver breadboard will go in the Activity 2 bag except the battery snap.

For the Music Transmitter from Activity 4:  
All of your small components from the transmitter breadboard will go in the Activity 4 bag except the battery snap.

You will now disassemble both your transmitter and your receiver. Remove the potentiometer, resistors, jumper wires, capacitors and IR LED. Care must be taken when removing an IC from the breadboard. The easiest way to do this is to use a pair of needle nose pliers to extract the IC as shown in the figure below.

Grip the IC on the ends with the needle nose pliers. Do not squeeze the pliers too tightly, as this can damage the IC.

Hold the breadboard down with your other hand.

Carefully pull the IC direct out of the breadboard.

The idea is to avoid bending the pins of the IC.

The battery snap and breadboard from both circuits will go in a bag together. Return both batteries to your instructor.