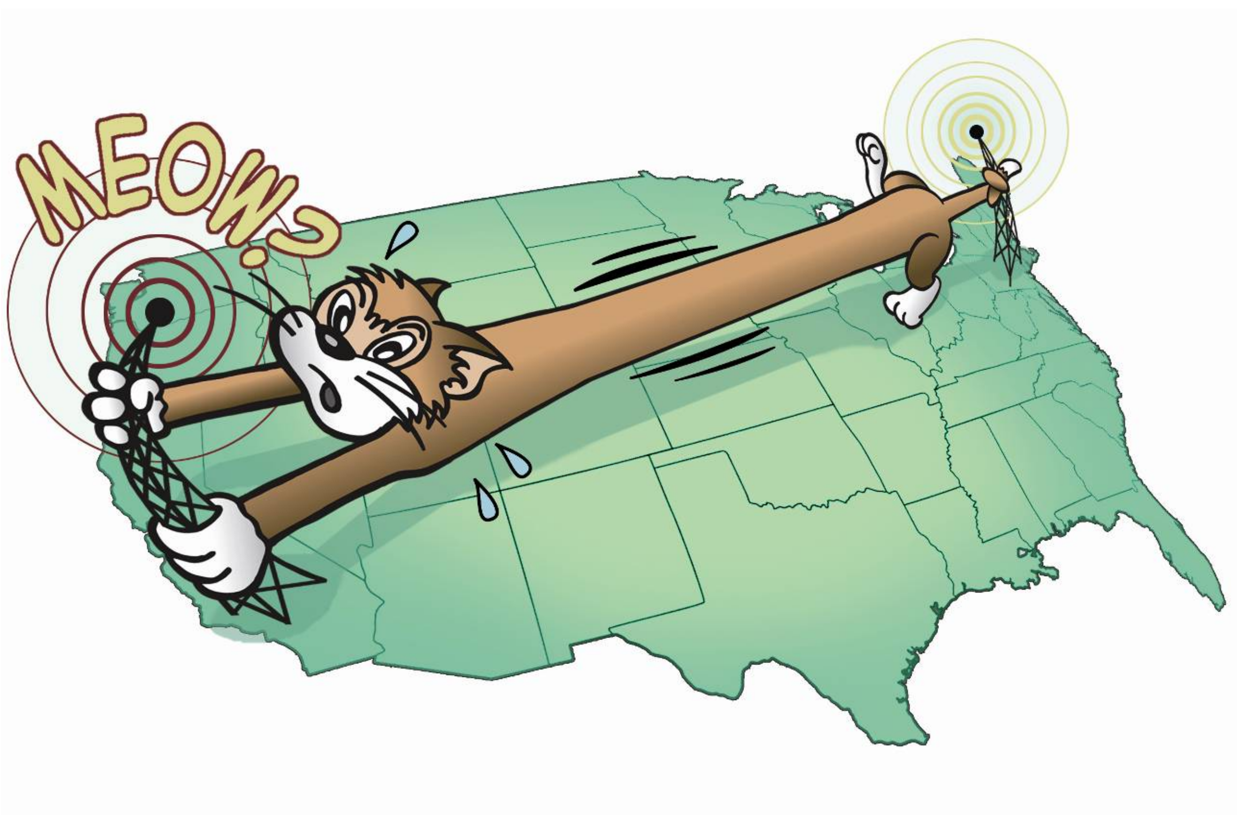
Wireless Transmission:

Wireless Burglar Alarm

TechXcite: Discover Engineering

Pratt School of Engineering
Duke University



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Module Overview

In this TechXcite: Discover Engineering module, youth design and build their own wireless alarm system. They use electrical engineering and mechanical engineering concepts to create an alarm system with a sensor to detect an intruder, a transmitter to send the signal, and a receiver to trigger an alarm to warn the user.

> **Activity 1**: Youth experiment with a simple switch that they must fit onto a door (or cabinet or box) to trigger an alarm.
> **Activity 2**: Youth build a transmitter and receiver that send and receive a signal via wires.
> **Activity 3**: Youth modify the wired transmitter and receiver by adding a radiofrequency chip to each that allows the alarm system to operate wirelessly. They explore how an antenna affects transmission range.
> **Activity 4**: Youth put the whole project together to allow the trigger created in Activity 1 to trigger a message they record to warn an intruder.

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TechXcite Program

TechXcite is a partnership between the Pratt School of Engineering at Duke University, the National 4-H Council/4-H Afterschool and North Carolina 4-H.

The program is directed by Drs. Gary Ybarra (PI) and Paul Klenk (Co-PI). Beginning in 2001, they co-created the successful Techtronics afterschool engineering program at Rogers-Herr Middle School and Lowes Grove Middle School in Durham, N.C. The TechXcite: Discover Engineering curriculum is building on this work by creating engineering learning modules in seven theme areas for use in afterschool programs nationwide. Together they have created an engaging, substantive, experiential and inquiry-based curriculum in engineering, technology and applied science for 4-H-supported middle school youth in afterschool programs across the nation. We hope to encourage youth in both rural and urban settings to pursue careers in engineering and technology.

If your program is interested in adopting any of the TechXcite: Discover Engineering learning modules, please contact us at techxcite@duke.edu.

Online Support

The TechXcite Web site (techxcite.pratt.duke.edu) contains additional material to help you implement this module. There are videos to guide you through facilitating the activities with students. You can download copies of the Instructor's Guide and Youth Handouts. You'll also find a list of sources for any materials you'll need. Finally, there are links to additional resources.

E-Mail and Phone Support

If you have questions about any of the material in this curriculum, please do not hesitate to ask. The Duke team is available to support you if you have questions about implementing the modules. Please contact our staff at techxcite@duke.edu. You can also call us anytime by calling the phone number listed on the Contact Us page on our website - http://techxcite.pratt.duke.edu/contact/index.php.

Using this guide

The first portion of this handbook is the Instructor's Guide for all of the activities in the module. It includes this introductory section and also the Instructor's Guide for each activity. This introduction contains general information about the TechXcite curriculum, what to expect in each activity's Instructor's guide and background on tools you will be using.

The Instructor'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 find basic information about the activity. This includes:

- Time Required
- Materials
- Group Size – This is the suggested number of students per group.
- Youth Handouts – These will need to be copied.
- Instructor Preparation – This describes what you need to do before the activity and approximately how much time it will take you.
- Learning Objectives
- Vocabulary

Introduction, Procedure and Activity Closure

Three sections form the body of the activity: Introduction, Procedure and Activity Closure. The Introduction and Activity Closure sections 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. The Procedure section is not scripted. It contains step-by-step instructions for facilitating the activity with a group of students.

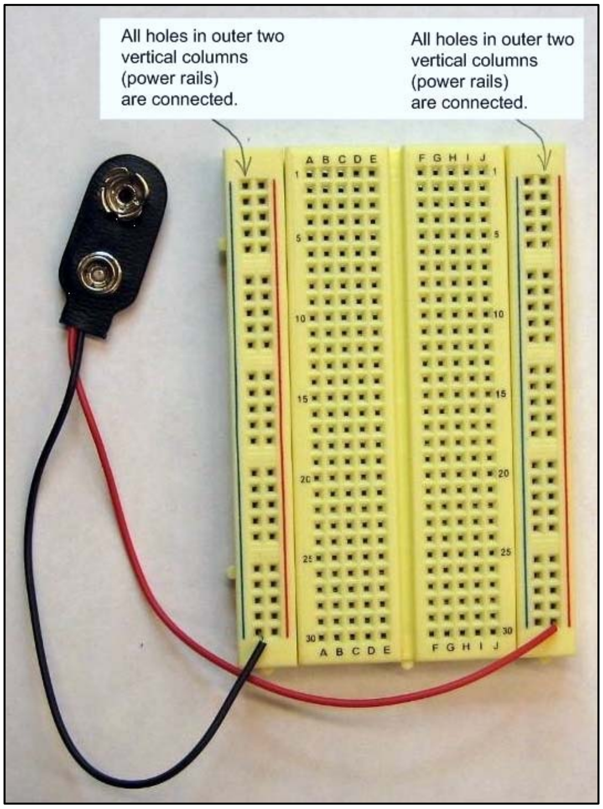
Cleanup

This section appears in activities in which cleaning up in a particular way will help reassemble the kit or prepare for the next activity. Following these instructions will keep the kit in proper order.

Assessment

This section tells you how to assess whether or not students understood the material presented to them in the activity. These assessments are generally based on students' answers to questions asked during the Activity Closure section.

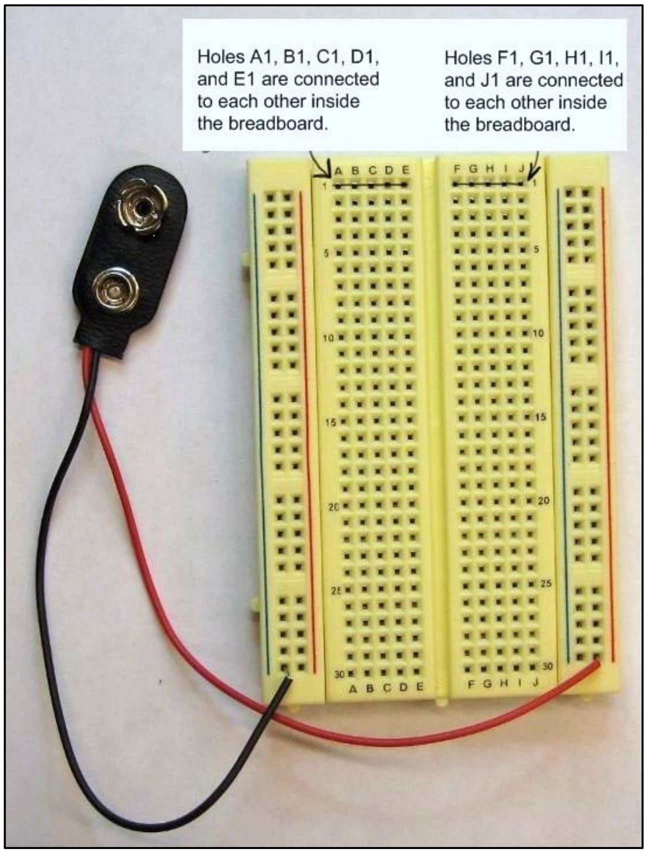
Tools Used in the Module – Electrical Breadboard
Instructions for using the electrical breadboard for creating and testing a circuit are provided in the Youth Handout for Activity 2 and are reproduced below.



All 25 holes in a column of a power rail are connected together inside of the breadboard. There are two power rails on the left side and two power rails on the right side. We will use one power rail on the left and one on the right.

We will make the blue power rail negative and the red power rail positive.

Note: On some breadboards, the red and blue power rails may be the reverse of what you see in this picture. Look closely at your breadboard to see where your red and blue rails are located.



All five holes in one row on one side of the center are connected together inside the breadboard. The five holes on one side of the center are NOT connected to the five holes on the other side.

Examples:

A1 is connected to D1.

A1 is NOT connected to A2.

A1 is NOT connected to F1.

Activity 1: Electric Door Trigger

Time Required: 45 minutes
Materials List

Group Size: 2-3
Each group needs:

- Two long wires (about 3' each)
- One short wire (about 6")
- One AA battery
- One lamp holder
- One lamp
- Small sheet of aluminum foil
- An object that will trigger the alarm when breached (such as a door, cabinet, box or other container; the activity script refers to the use of a door. If you choose something else, make the necessary adjustments to the instructions when facilitating the activity with students.)

To share between groups:

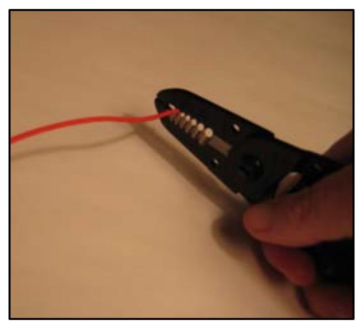
- Clear adhesive tape or electrical tape
- Wire strippers

Youth Handouts (1 per group)

- "Electric Door Trigger"

Instructor Preparation (10-20 minutes)

- Tear off strips of aluminum foil (one 4-inch strip for each group).
- If the wires have not been cut and stripped already, cut two long pieces of wire (about 3') and two short pieces of wire (about 6") per group. Use the wire stripper to remove the insulation from the last ½" of wire ends (see picture). You could show students how to do this during the activity if there is extra time.
- Select an object such as a door, cabinet, box or other container that can be rigged with an alarm.



Learning Objectives
After this activity, students should be able to:

- Make a circuit that lights a bulb using a wire and a battery.
- Explain why aluminum foil conducts electricity and demonstrate by building a circuit using an aluminum foil switch.

Vocabulary

Word	Definition
Battery	Source of electrical energy.
Circuit diagram	A plan that electrical engineers use to represent how components are connected together.
Lamp	A device that converts electricity into light.
Short Circuit	A direct connection between the positive and negative battery terminals (to be avoided!).
Switch	A device that turns electricity on or off.
Terminal	Positive or negative end of a device.
Wire	A conductor that carries electric current.

Introduction

Engineers use math and science as tools to design devices to solve problems. Throughout this project, you will be solving problems the same way a real engineer would. Your task will be to design an alarm system that will alert you to an intruder. Such a security system requires a sensor that will detect an intruder, a transmitter to send the signal, and a receiver to trigger a warning sound. Today we will build a trigger that will activate an alarm. In later activities, we will build both a wired and wireless receiver and transmitter to alert you via an LED (light-emitting diode) light. At the end of the project, you will record the sound that the alarm will make to warn the intruder.

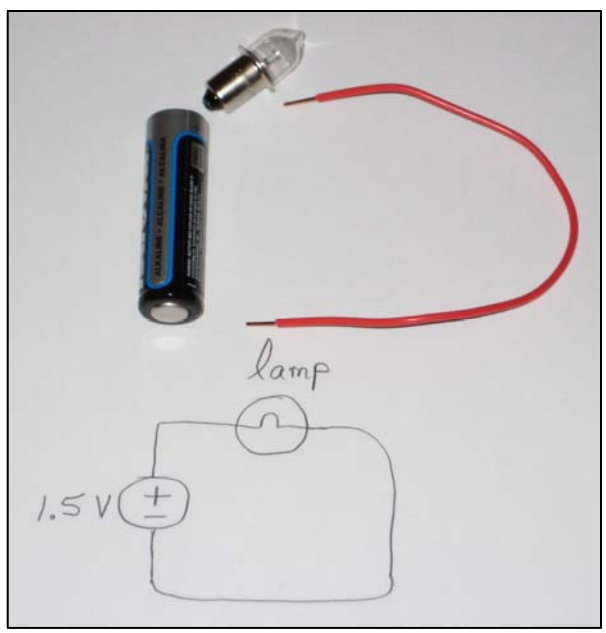
We will start by building the trigger circuit. The simplest electric circuit is a lamp circuit, something we use in our homes every day. You use a switch to turn a lamp on and off. We are going to build a lamp circuit and then make a simple switch out of aluminum foil to turn the lamp on when a door or box is opened.

Procedure

1. Place students in groups of two or three.
2. This activity has three parts. It will be best for students if you hand out only the materials necessary for each part.

Part A: Basic Lamp Circuit

3. Give each group a short wire, lamp and battery. They do not need the handouts yet. This portion of the activity could begin casually as students are coming into the classroom.
4. Ask students, “Can you light the lamp using this wire and battery?” Give them a few minutes to try to do this. If necessary, you can demonstrate, using the picture here as your guide.



5. Distribute handouts.
6. Ask students to look at their AA batteries closely. Tell them that the AA battery is a source of electrical energy. The ends of a battery are called terminals. All batteries have a positive terminal and a negative terminal. The positive terminal is marked with a + sign and has a small, round, metal tip. The negative terminal has a flat metal surface. Ask if they can see the + and - signs on the battery. Make sure everyone is able to find them.

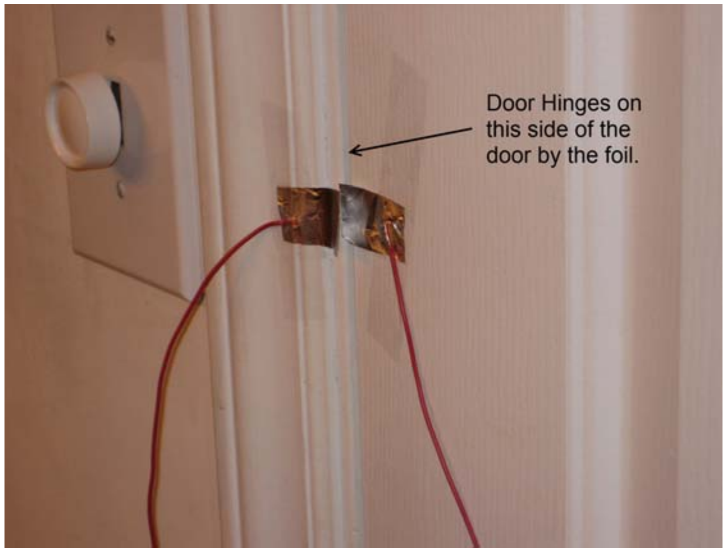
7. Tell students that they should never connect the positive and negative ends of a battery to each other directly. This will cause a **short circuit**, which will drain the battery quickly.
8. Ask students to inspect their lamps closely. The lamp converts electricity into light. It has two terminals—the metal tip on the bottom of the lamp holder is one terminal, and the lamp holder is the other (see arrows in picture). When the lamp's two terminals are connected to the positive and negative battery terminals, electricity flows in one and out the other.

Part B: Aluminum Foil Switch

9. Hand out the two long wires and a small piece of aluminum foil to each group.
10. Ask students to follow the instructions in Part B to build a switch using the foil.
11. Walk around and help students as they work through the activity. If students are not able to make their lamps light up, help them figure out why. Make sure the bottom terminal of the lamp is touching the battery.
12. If there is time, let students incorporate a second battery into their circuit. They must connect the positive terminal of one battery to the negative terminal of the second battery. This will make the light twice as bright.

Part C: Engineering Design Challenge — Door Trigger Switch

13. Once they have built the circuit with an aluminum foil switch, tell students it is time for them to design their trigger switches. Tell them that as engineers, they must complete the engineering design challenge on the last page of their handout. Assign each pair or group a door, cabinet or box. Encourage them to be creative.
14. Walk around and help students as they work through the activity. If students are not able to make their lamps light up, help them figure out why. An example is shown below for your reference.



15. If a group asks to use more aluminum foil, ask them to explain their design to you. You should provide students with extra foil only if they describe a design that requires the extra foil. Encourage their creativity by telling them you're excited to see what they have in mind.
16. If groups finish early, ask them to answer the question on the last page of the handout.
17. At the end of the activity, collect any reusable components (wire, batteries, lamps, lamp holders, unused aluminum foil, etc.).
18. Once most of the groups are finished building their door triggers, bring the class back together to discuss the experience.

Activity Closure

[*At the end of every engineering design challenge, ask students the following questions to prompt them to think about which design modifications worked well and which didn't. Their responses will vary.*]

1. Which designs worked best and why?
2. Which designs didn't work so well and why?
3. What would you do to improve your designs?

[*Below are some questions that are specific to this activity.*]

Would any of you like to explain how your door trigger switch works?

[*Encourage a few of them to show their switches to the group.*]

How might you improve your door trigger switch?

[*Let them think about it, and wait for one or two answers. Possible responses: Make it stronger. If they no one mentions strength, you could ask if anyone thinks the trigger would work 100 times or 1,000 times or ask if it would ever break. Another way they might think to improve the trigger would be to make it less visible to an intruder. Or they* *might say they would use better materials. In this case, ask "What materials would be better and why?" They should recognize that any materials that connect the circuit must be able to conduct electricity.*]

Describe how the lamp circuit works.

[*They should acknowledge that electrical energy from the battery flows through the wire, and the bulb converts the electricity into light.*]

How does a switch work?

[*They should be able to explain that a switch turns the light on or off depending on whether the two pieces of aluminum foil are touching each other.*]

Assessment
Assess students' comprehension based on their description in Activity Closure of how the lamp circuit works. If they have understood the material, they should respond that a lamp converts electricity into light. You might ask them to solidify the concept in writing or through a diagram.

Activity 2: Wired Communication

Time Required: 45 minutes

Materials List

Group Size: 2-3

Each group needs:

- Two long wires (about 3’, from Activity 1)
- Transmitter Bag
  - o Encoder chip with gold dot (R-8PE Encoder integrated circuit)
  - o 2 switches
  - o 2 resistors (100 kΩ - brown black yellow)
  - o 4 jumper wires (2”)
  - o Battery pack for three AA batteries
  - o Breadboard
- Receiver Bag
  - o Decoder chip with silver dot (R-8PD Decoder integrated circuit)
  - o 2 LEDs
  - o 3 jumper wires (2”)
  - o Battery pack for three AA batteries
  - o Breadboard
- 2 long wires (about 3’ each)
- 6 AA batteries

To share between groups:

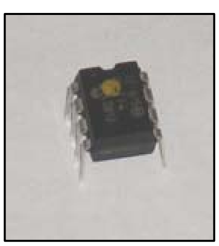
- Tape measure

Youth Handouts (1 per group)

- “Wired Communication”

Instructor Preparation (10 minutes)

- Organize the materials by laying out the transmitter and receiver bags, long wires, batteries and tape measure on a table.
- Check each transmitter bag to make sure it contains an encoder chip with a gold dot.
- Check each receiver bag to make sure it contains a decoder chip with a silver dot.



Note: The encoder and decoder chips look nearly identical, but the encoder chip has a gold dot and the decoder chip has a silver dot.

Learning Objectives

After this activity, students should be able to:

- Explain the purpose of the encoder and decoder chips in communication.
- Explain wired communication and its advantages and limitations.

Vocabulary

Word	Definition
Breadboard (prototyping board)	A device used to build and test circuits.
Decoder	A device that receives a signal and recovers the message that was sent.
Encoder	A device that converts a message into a signal suitable to transmit.

Introduction

Last time we met, you built a trigger circuit for an alarm system. The circuit turned on a light bulb to alert you to an intruder. Today we're going to figure out how to transmit that information to a remote location. We will explore how this can be accomplished using wires.

Can you think of examples of systems that transmit information using wires?

[*Allow students some time to think about this and provide some answers.*]

Wired communication systems are very common. They are used in applications such as telephones, Internet connections and cable televisions. We will be building a simple wired transmitter and receiver that will allow us to control lights on the receiver by using switches on the transmitter. As you know from last time, these switches can be as simple as two pieces of aluminum foil.

Procedure

1. Place students in groups of two or three.
2. Give students these instructions:
    a. These kits contain many small parts. Be careful not to lose any.
    b. Work with your partners while not disturbing other groups.
    c. Be careful not to disturb the components of other groups.
    d. Do not knock another group's table.
    e. Do not touch battery leads together.
3. Distribute handouts and ask students to read over the descriptions of the parts and their uses.
4. Distribute all electronic components except the battery pack (give students the battery pack after they have completed their transmitter and receivers).
5. Tell students to begin building their circuits, following the instructions on the handout. Walk around and help students as they work through the activity. Help students check to make sure their circuits are built correctly. If the transmitter/receiver pair doesn't appear to work correctly, ask students to disconnect the battery pack from the breadboard and go through the troubleshooting steps in the handout.

6. Bring the class back together once most of students have completed their circuits.

Activity Closure

What was the hardest part of putting the circuit together and why?

[*Give students time to answer.*]

You now have a transmitter and receiver that are connected by two wires. Imagine that at home, there is a similar transmitter in the kitchen that is connected by long wires to a receiver with two LEDs in your bedroom. You could use the switches in the kitchen to turn the two LEDs in the bedroom on and off. Imagine that someone in the kitchen wanted to send you a message in the bedroom using the system. You could develop a code for communicating. How many unique messages would it be possible to send between the receiver and transmitter? Describe how this system might work.

[*There are a number of correct answers. For example, there are four combinations of the two LEDs (on-on, off-off, on-off, off-on). Students may also realize that they can convey more than four different messages by turning one or both lights on and off, similar to Morse code. In this manner, they could transmit any number of messages.*]

Give me some examples of what messages you might transmit using this kind of system.

[*Give several students a chance to answer.*]

Next time, you will modify your transmitter and receiver to send the signal without wires.

Cleanup
1. At the end of the activity, ask students to keep the circuits assembled.
2. Ask students to disconnect the batteries and have someone collect them. The batteries go back in the boxes to keep the contacts from touching metal (this will prevent a short circuit that could cause the batteries to lose their energy).
3. Ask students to disconnect the transmitter from the receiver and put the two circuits in the two bags the components came in. These will be used in the next activity.
4. Collect the circuits from students.

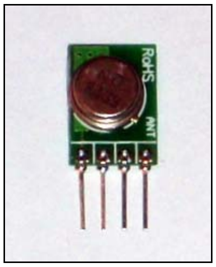
Assessment
You can determine whether students understood the material by evaluating their examples of the types of messages they might transmit. Make sure they have chosen messages that can be conducted from one fixed location to another, rather than from a fixed location to a cell phone or something else that is mobile. (They will be doing that in the next activity). When asked, students should also be able to explain that the purpose of the encoder and decoder chips is to allow multiple messages (two LEDs on or off) to be sent over two wires.

Activity 3: RF Wireless Communication

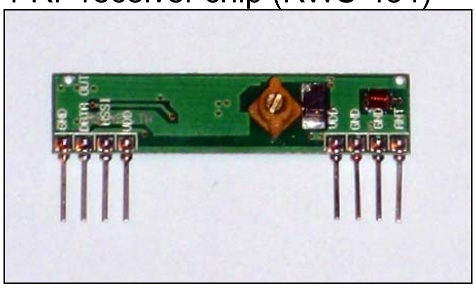
Time Required: 45 minutes
Materials List

Group Size: 2-3
Each group needs:

- Working transmitter and receiver circuits from Activity 2
- 1 RF transmitter chip (TWS-434A)



- 1 RF receiver chip (RWS-434)



- Jumper wires (2”)

To share between groups:

- Tape measure

Youth Handouts

- “Wireless Communication”

Instructor Preparation (10 minutes)

- Lay out the transmitter and receiver circuits students built in Activity 2.

Learning Objectives
After this activity, students should be able to:

- Explain that a radio frequency (RF) link can replace a wired link.
- Explain that an antenna extends the range of a radio frequency (RF) link.
- Discuss advantages and disadvantages of wireless versus wired communication systems.

Vocabulary

Word	Definition
Antenna	A device used to improve RF communication by radiating or capturing radio waves.
RF (radio frequency)	A type of invisible light often used to transmit information wirelessly.

Introduction
Last time we met, you built a wired communication system using a transmitter circuit and receiver circuit that were connected using two wires. This communication system allowed you to turn two LEDs on and off independently. Today we are going to make a wireless connection between the transmitter and receiver.

What devices can you think of that use radio waves to transmit information?

[*Radios might be the most common example they provide. Other wireless systems that use radio waves include systems for laptops, Bluetooth, keyless car entry, cell phones and radio-controlled (RC) cars.*]

You use many kinds of devices that transmit wireless signals using radio waves. Radio waves are known as radio frequencies or RF. Before we begin building RF wireless transmitters and receivers, let's talk briefly about a radio that would be in a car.

Where is the transmitter for an FM radio station?

[*The transmitter is at the radio station.*]

How many radios can receive the RF signal from the radio station at the same time?

[*There is no limit to the number of radios that can receive the signal at one time.*]

What is your favorite radio station?
[*Many of them will name a number on the dial. Explain this number is the frequency of the radio station in MHz (megahertz). For example, the station 106.1 is 106.1 MHz.*]

What would happen if there were two radio stations near each other that transmitted at 106.1 MHz?
[*There would be interference, and the radios tuned to this frequency would pick up both stations at the same time.*]

Now let's begin converting our wired communication system into a wireless system. Once it is wireless, we can monitor our trigger alarm system using the LEDs without wires.

Procedure
1. Place students back in the same groups of two or three from Activity 2.
2. Give students these instructions:
    a. These kits contain many small parts. Be careful not to lose any.
    b. Work with your partners while not disturbing other groups.
    c. Be careful not to disturb the components of other groups.
    d. Do not knock another group's table.
    e. Do not touch battery leads together.

3. Distribute handouts and electronic components.
4. Ask students to building their circuits, following instructions on the handout. Walk around and help students as they modify first the receiver circuit and then the transmitter circuit. Help students check to make sure their circuits are built correctly. If the transmitter/receiver pair doesn't appear to work correctly, ask students to disconnect the battery pack from the breadboard and help them follow the troubleshooting steps in the handout.
5. Make sure all students have a chance to test their receivers and transmitters. It is important for the class to use only one transmitter at a time. Once students begin finishing the transmitter circuits, have one group at a time test its transmitter circuit. If more than one transmitter circuit is used at a time, the signals will cross. Since all of the receivers will work with each transmitter, the entire class can test their receivers while one group is testing its transmitter.
6. Bring the class back together once most of students have completed their circuits.

Activity Closure

What are some things you can do with your wireless transmitter and receiver circuits that you couldn't do with your wired circuits?"

[*Possible answers: The circuits transmit over a longer distance; you don't have to navigate physical obstacles that would block installation of wires between the transmitter and receiver; with the wireless system, you can move the receiver around without tripping anyone on the wires.*]

How far was the wireless signal able to transmit? What was the effect of the antenna?

[*Give students time to answer based on their tests. Without the antenna, the signal could be transmitted only the distance across the classroom. With the antenna, the signal could travel the distance down a hallway.*]

What might be some advantages of the wired system you built compared to the wireless one you built today?"

[*Possible answers: the wired system is less expensive and more reliable; the wired system is more secure because other transmitters can't receive the signal.*]

Cleanup

1. At the end of the activity, ask students to keep the circuits assembled.
2. Ask students to disconnect the batteries and have someone collect them. The batteries go back in the boxes to keep the contacts from touching metal (this will prevent a short circuit that could cause the batteries to lose their energy).
3. Ask students to put the two circuits in the two bags their components came in. These will be used in the next activity.
4. Collect the circuits from students.

Assessment
Ask students to describe how the circuits they built today are different from the ones they built last time. They should say that the wires have been replaced with RF (radio frequency) transmitter and receiver chips. The range of these chips can be extended with antennas.

Activity 4: Sounding the Alarm

Time Required: 45 minutes

Materials List

Group Size: 2-3

Each group needs:

- Aluminum foil trigger (from Activity 1)
- RF transmitter circuit on breadboard (from Activity 3)
- RF receiver circuit on breadboard (from Activity 3)
- Sound recording module
- Two 2" jumper wires
- 4 wires with alligator clips

To share between groups:

- Clear adhesive tape
- Wire strippers (for prepping extra wires, if needed)
- Additional aluminum foil
- Additional long wires

Youth Handouts (1 per group)

- "Sounding the Alarm"

Instructor Preparation (25 minutes)

- Check the voice recording modules to make sure they are blank or that they don't contain any inappropriate messages. If one has an inappropriate message, you can erase it by recording a blank message.
- Take out each of the transmitters and receivers built by students in Activity 3.

Learning Objectives

After this activity, students should be able to:

- Explain why they have attached a sound module to their alarm system.
- Explain that the sound-recording module records sound on a chip on the circuit board.
- Define an engineering problem with specifications and constraints.

Vocabulary

Word	Definition
Decoder	A device that receives a signal and recovers the message that was sent.
Encoder	A device that converts a message into a signal suitable to transmit.
Prototype	An original, full-scale and usually working model of a new product or new version of an existing product. Engineers use prototypes to test new devices prior to mass-producing them.
RF (radio frequency)	A type of invisible light often used to transmit information wirelessly.

Introduction
Over the past few sessions, we've built an alarm system you could use in a number of locations. It transmitted information using a radio frequency transmitter and receiver. How far apart were the radio frequency transmitter and receiver able to communicate with each other?

[*Prompt them to think about their experiments with the transmitter and receiver during the last session. They will have found that without the antenna wire attached, the signal could be transmitted only the distance across the classroom. With the antenna, the signal could travel about the distance down a hallway.*]

When you listen to the radio in a car, where is the receiver and where is the transmitter? How far apart are they?

[*In this case, the transmitter is at the radio station and the receiver is in the car, which could be miles away from the station.*]

The radio signals in your car are the same types of signals we're using with our transmitter. The difference is that the radio station has a much more powerful transmitter, so your car can receive the signal from much farther away. As you work on your alarm system today, you could imagine that your transmitter has more power so that you could receive the signal farther away. For instance, you could be at school and be able to receive a signal that warned you of an intruder at home.

Today you are going to design an alarm system the way an engineer would. You must appropriately define the problem you are trying to solve and specify any performance requirements your design must have. You will then build a prototype to demonstrate and test your design.

It is OK if there are performance requirements that you identify as necessary for the alarm but that the prototype cannot meet. You need only describe what you would do to meet those requirements. For instance, you might need the alarm trigger to be invisible to the intruder. The aluminum foil on the prototype might be big and easy for an intruder to see, but you could explain that the actual contacts will be much smaller and that the metal will be embedded in part of the door and the floor.

After defining the problem you're trying to solve with an alarm system, you'll use the materials provided to put together a prototype alarm system to demonstrate your solution for the class.

Procedure
1. Demonstrate to students how to use the recording module by recording your voice on one of them. Press and hold down the record button until you hear the beep. Then start speaking. You will have 10 seconds of recording time.
2. Distribute materials and handouts. Instruct students to determine the design problem they will solve and describe it in the space provided on the handout.

Also tell them to decide their design specifications and constraints and describe them in the second box on the handout. [*Examples of aspects they might want to consider: How will the transmitter and receiver be housed? Is the transmitter outside? Will it get wet? Could it be kicked or stepped on? Who might be breaking in? Will this person scare easily? How big should the receiver be? Does it need to be pocket-sized?*]

3. Tell them to begin working, following the instructions on the handout.
4. While they are working on the activity, walk around and make sure that each group has defined a particular problem. Help them be as specific as an engineer would be when outlining the specifications. For example:
    a. If students specify that the receiver must be shockproof, ask them to be more specific. For example, they may intend that no electric shock be produced if the receiver is dropped or if something is dropped on it.
    b. If they specify that the receiver must fit in a pocket, ask them to provide dimensions of such a pocket.
5. Many students will finish recording relatively quickly. Ensure that students use two different triggers to connect the sound card. One should be for the transmitter and one should be for the sound alarm. They could also have two alarms, one for each switch on the transmitter. The first might be a silent alarm. Students can use these components to design the system.
6. When everyone's alarm systems are ready, work with groups separately so that only one transmitter is being used at a time.
7. Bring the class back together once most of students have completed their projects.

Activity Closure

[*At the end of every engineering design challenge, ask students the following questions to prompt them to think about which design modifications worked well and which didn't. Their responses will vary.*]

1. Which designs worked best and why?
2. Which designs didn't work so well and why?
3. What would you do to improve your designs?

[*Below are some questions that are specific to this activity.*]

Let's take turns describing your design problems and solutions.

[*Give different groups a chance to share.*]

What did you learn from building the prototype that you would incorporate into the final design? What other ideas might you incorporate into a final design to meet your specifications?

[*Encourage them to be specific.*]

Assessment

Evaluate students' design problems. They need to be specific problems but should not lend themselves to a single solution. Also, their designs should meet the specifications they described.

Activity 1: Electric Door Trigger

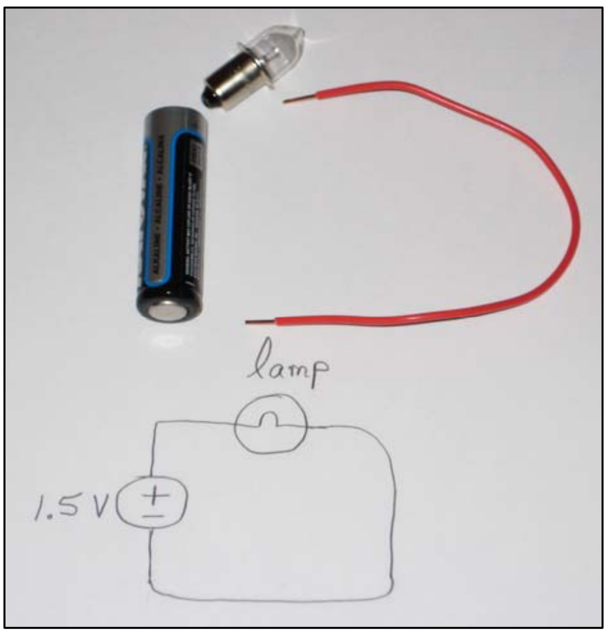
Name: ________________________

Date: __________

Part A: Basic Lamp Circuit

The AA battery is a source of electrical energy. The positive end, called a terminal, is marked with a + sign and has a small, round metal tip. The negative terminal has a flat metal surface. Look at your AA battery closely. Can you tell which terminal is negative and which is positive?

The lamp converts electricity into light. It has two terminals, and electricity flows into one end and out of the other. The metal tip at the bottom of the lamp holder is one terminal, and lamp holder is the other terminal (see arrows in picture at right). The lamp terminals are not specifically positive or negative, so it doesn't matter which end of the battery is connected to which terminal.



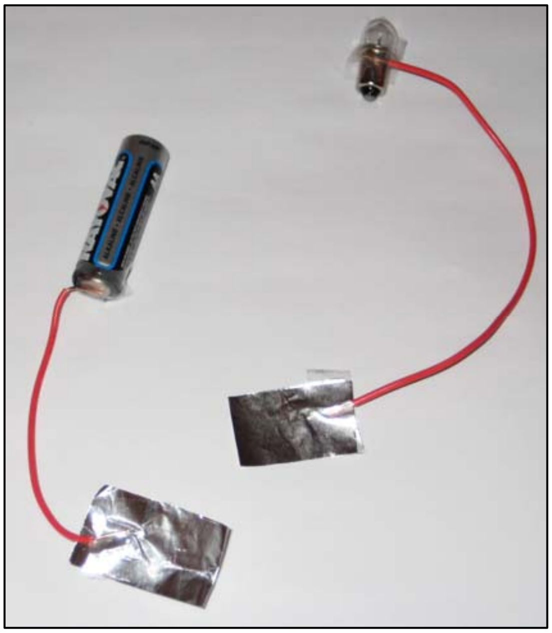
A circuit diagram is a plan that electrical engineers use to represent how components are connected together. The circuit diagram in the photo at the left shows a 1.5 V (volt) battery connected to a lamp with a wire.

1. Arrange the components as shown in the diagram.

2. Working together, figure out how to activate the light using the battery and the wire.

Be careful not to touch the ends of the wire to both battery terminals at the same time. This will cause a short circuit that will drain the battery.

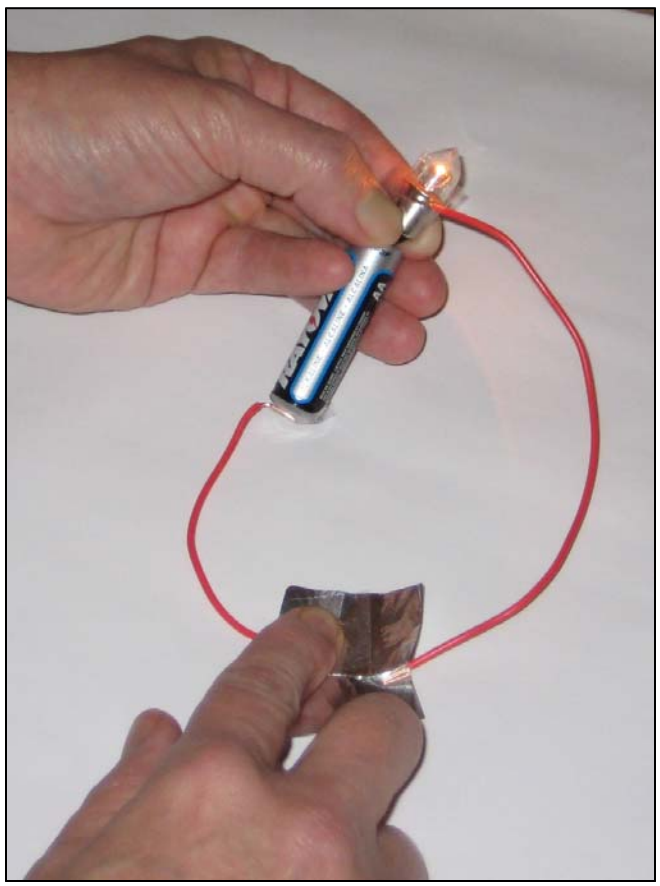
Part B: Foil Switch



Now you are going to use aluminum foil to make a switch that will activate the light.

Step 1: Using tape, connect the end of one wire to the lamp holder terminal and the other end of the wire to a piece of aluminum foil.

Step 2: Now tape one end of the other wire to the battery's negative terminal (which is easier to tape to than the positive terminal) and the other end of that wire to the second piece of foil. You can fold the foil to make it sturdy.



Step 3: Hold the battery so that one terminal touches the other terminal of the lamp.

Step 4: Touch the two pieces of aluminum together. This makes a complete circuit, and the lamp should light up. The aluminum foil pieces represent a switch. When the switch is closed (touched), the circuit is closed and the lamp lights up. When the switch is open (untouched), the circuit is open and the lamp does not light up.

Part C: Engineering Design Challenge — Door Trigger Switch

Your challenge is to design a door trigger switch using the circuit you just built. This switch will only turn the light on for now. Later in the project, you will make a switch that triggers an alarm to tell you that somebody has opened a door.

Engineering Design Problem:
How can you use a switch to determine if a door has been opened?

Design a switch in which two pieces of aluminum foil touch when the door is opened. Your instructor will assign you a door (or a cabinet, box or other object) that needs a protection switch.

Engineering Design Constraints and Specifications:

a. You may tape aluminum foil to the door, wall or floor.
b. If possible, the switch should complete the circuit if the door is open just a little bit or if it is open all the way.

Testing your Design
Test the switch by attaching the two contacts that make up the switch to the lamp and battery in the same way that you did in Part B.

How could you improve the design of your trigger switch? Record your answer here.

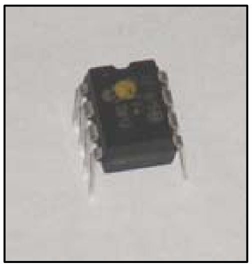
Activity 2: Wired Communication

Name: ________________________

Date: __________

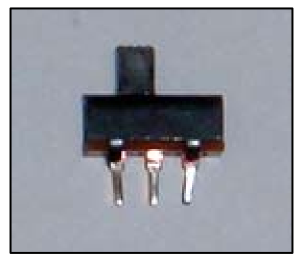
In this activity, you will be building a wired communication system. One circuit will take your message input, in the form of two switches, and convert it into an electrical signal to send over a wire. Another circuit will receive the message through that wire and display it on two LEDs. You will then be able to set the switches so the lights will turn on and off.

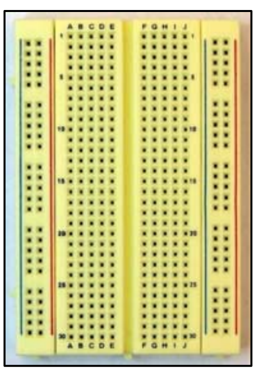
Parts Descriptions



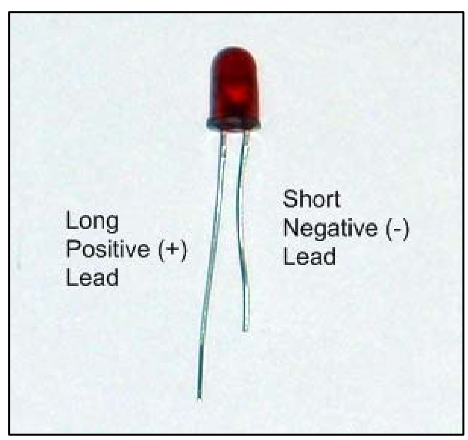
Encoder and Decoder Chips
The encoder and decoder chips look nearly identical, but the encoder chip has a gold dot and the decoder chip has a silver dot. Each decoder has 8 pins. If you orient the chip with the notch at the top, the pin numbers are counted going counter-clockwise around the chip, starting with the top left. The pin numbers are referred to in the circuit diagrams and in the step-by-step instructions.

Slide Switches
The slide switches (pictured at right) have three terminals. We will be using only two of these terminals. When the switch is closed, it means that the two terminals are connected together. When the switch is open, it means they are not connected. The inside of the switch has two metal pieces that join together when the switch is closed. These components work in the same way as the aluminum foil pieces you used in the previous activity—the foil pieces came together and touched, completing the circuit.



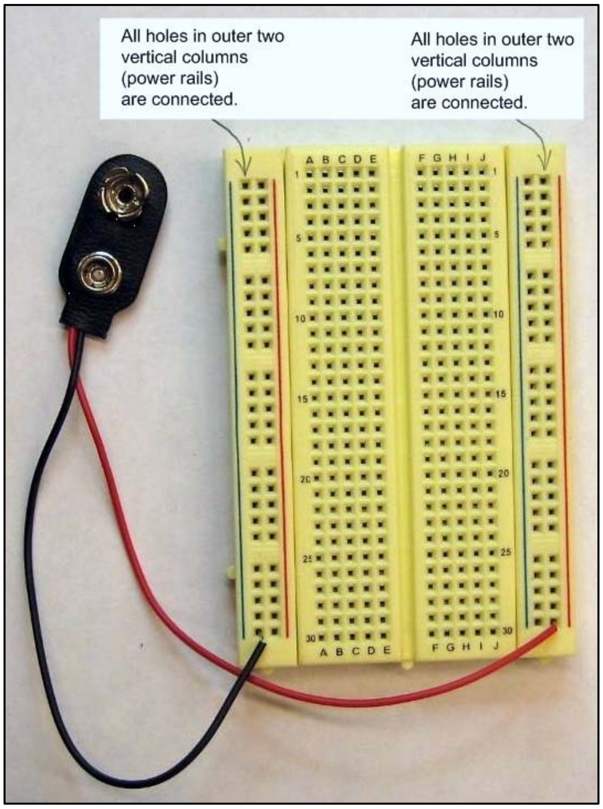


Breadboard
A breadboard or prototyping board (shown at left) is used by electrical engineers to build and test circuits. The holes make it possible for engineers to easily test circuits. They can connect and disconnect components quickly by putting them in the holes or taking them out. You will build your circuits on breadboards.



LED
A **Light Emitting Diode**, or **LED**, converts electrical energy into light of a single color. An LED has two metal leads. The longer lead is positive and the shorter lead is negative. A red LED is shown at right.

Navigating your Breadboard



All 25 holes in a column of a power rail are connected together inside of the breadboard. There are two power rails on the left side and two power rails on the right side. We will use one power rail on the left and one on the right.

We will make the blue power rail negative and the red power rail positive.

Note: On some breadboards, the red and blue power rails may be the reverse of what you see in this picture. Look closely at your breadboard to see where your red and blue rails are located.

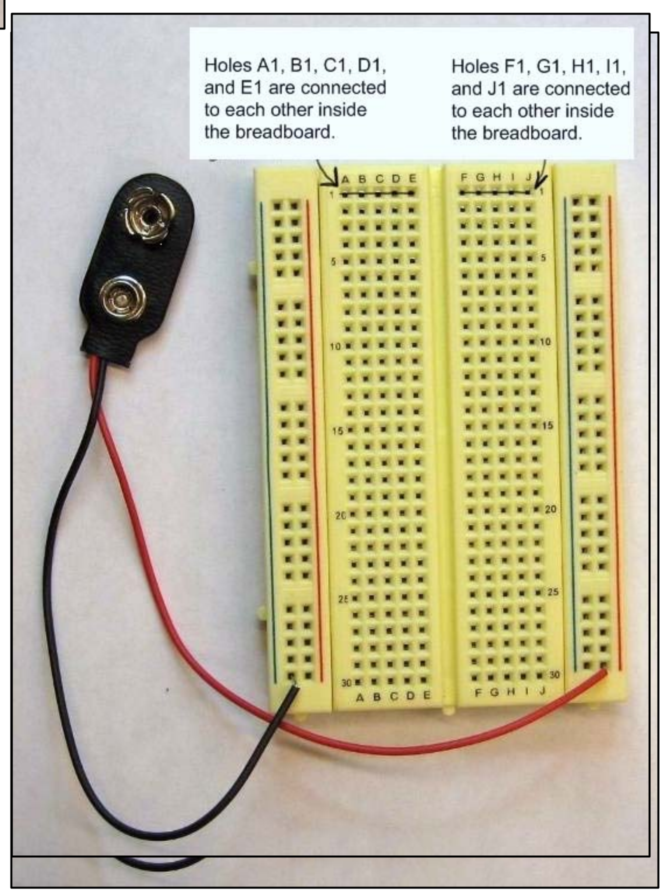
All five holes in one row on one side of the center are connected together inside the breadboard. The five holes on one side of the center are NOT connected to the five holes on the other side.

Examples:

A1 is connected to D1.

A1 is NOT connected to A2.

A1 is NOT connected to F1.



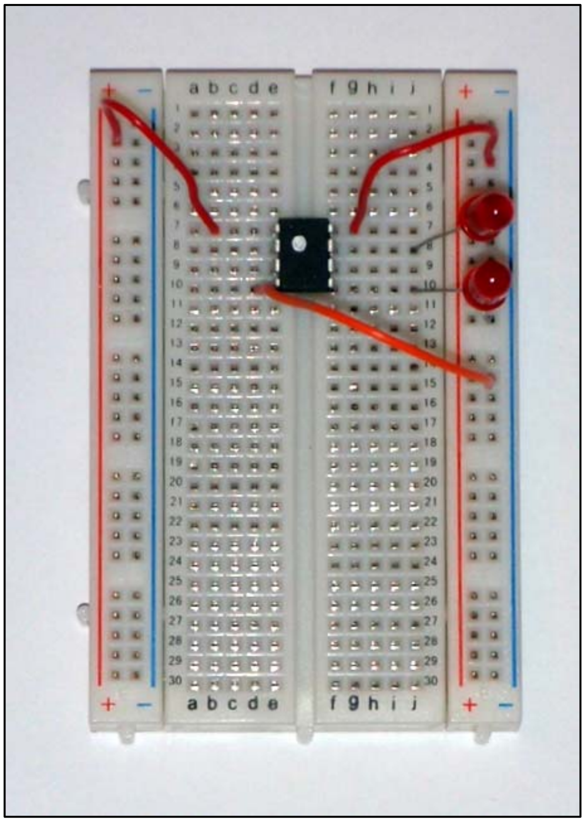
Building the Receiver Circuit

To build the receiver circuit, you will place the decoder chip on the breadboard and then connect each of the chip's pins with the proper component. Once connected to the transmitter circuit, the LEDs will turn on and off based on the signal sent by the transmitter. Follow the steps below. A photo and electrical engineering circuit diagram are shown on the next page.

Step	Component	Placement Location	Why did I just do that?
1	Decoder chip (silver dot)	• Place chip across middle of breadboard as shown. • Notch should face top of board. • Bottom **pins 4 and 5 should be in row 10**.	• The chip needs to split the middle of the board so that each of the 8 pins is connected to a separate row.
2	2" jumper wire	• Connect **B7** to anywhere on **left red** power rail.	• Connect pin 1 of the decoder chip to anywhere on the red positive power rail on the left. • This provides power to the decoder chip.
3	2" jumper wire	• Connect **D10** to anywhere on **right blue** power rail.	• Connect pin 4 of the decoder chip to anywhere on the blue negative power rail on the right. • This provides power to the decoder chip.
4	Red LED	• Insert long wire from LED into **J10** and short wire into anywhere on **right blue** power rail.	• LEDs have positive and negative leads. The longer, positive lead connects to pin 5 of the decoder chip. • The negative lead connects to the blue negative power rail on the right. • Current flows in only one direction through an LED, which is why the positive and negative sides matter. • This allows the LED to display one output of the decoder chip.

5	Red LED	• Insert long wire from LED into **J8** and short wire into anywhere on the **right blue** power rail.	• LEDs have positive and negative leads. The longer, positive lead connects to pin 7 of the decoder chip. • The negative lead connects to the blue negative power rail on the right. • Current flows in only one direction through an LED, which is why the positive and negative sides matter. • This allows the LED to display the second output of the decoder chip.
6	2" jumper wire	• Connect **G7** to anywhere on **right blue** power rail.	• Connect pin 8 of the decoder chip to anywhere on the blue negative power rail on the right. • This provides power to the decoder chip.
7	Battery pack	• Don't connect battery pack yet. It will be connected **after** you have connected transmitter circuit to receiver circuit. Next, build transmitter circuit according to directions on pages 9 and 10.	

Receiver Circuit

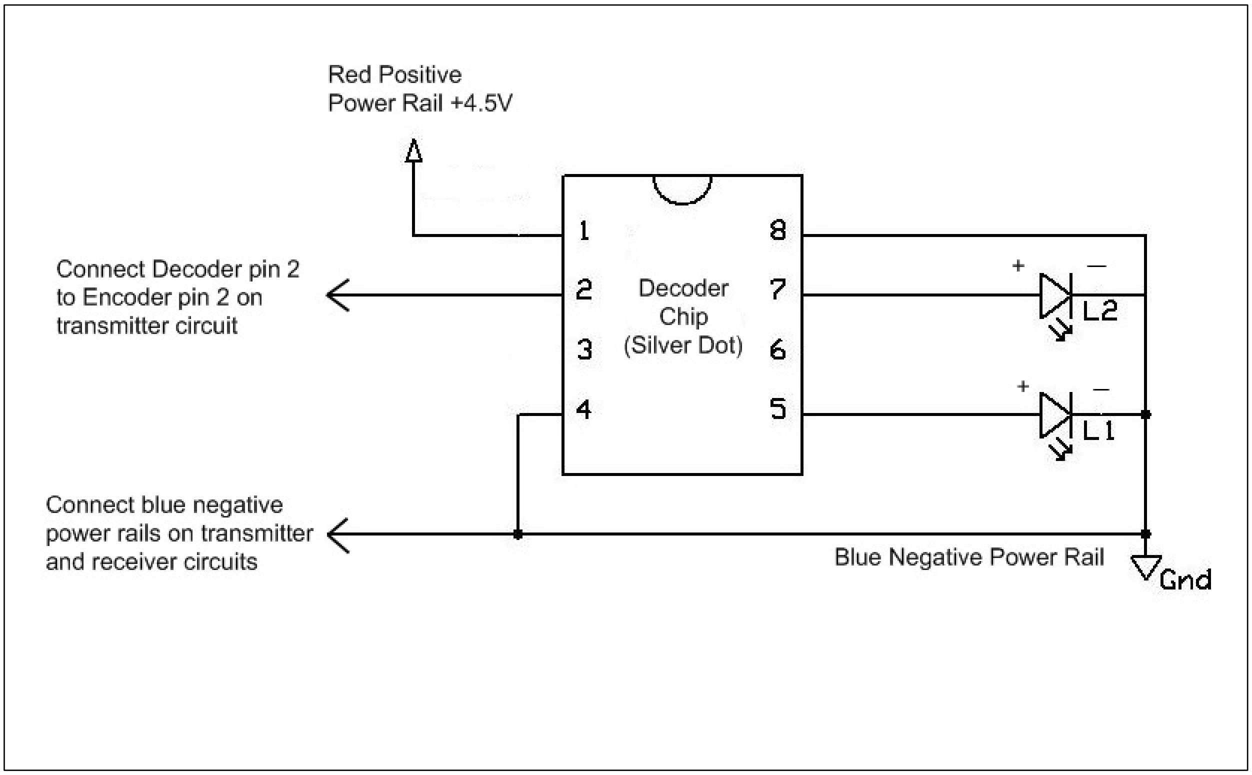


Receiver Parts

- 1 decoder chip with silver dot
  (R-8PD decoder integrated circuit)
- L1, L2: Red LEDs
- 2" jumper wires
- 3 AA batteries
- Battery case
- Breadboard

When your receiver circuit is completed, it will look like the one shown in this picture. The circuit diagram is shown below.

Receiver Circuit Diagram

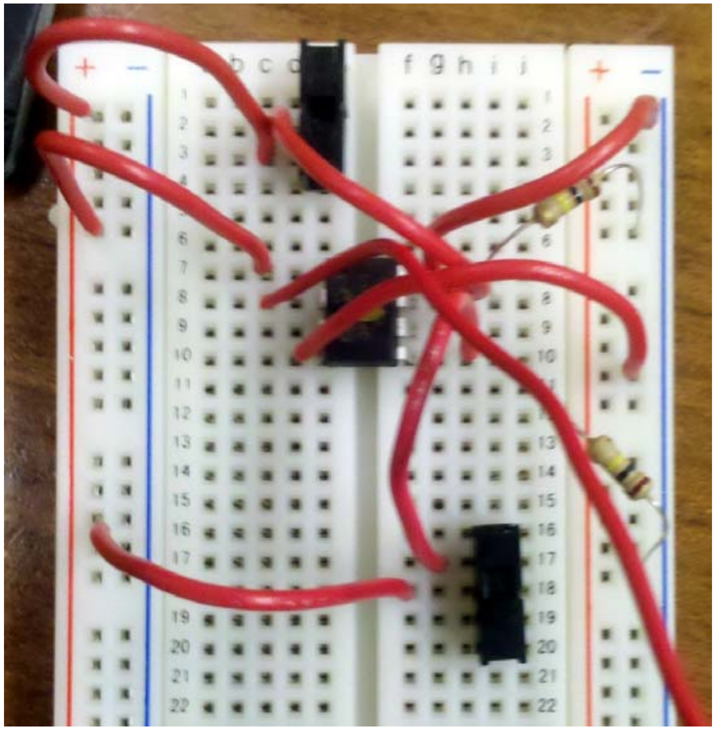


Building the Transmitter Circuit

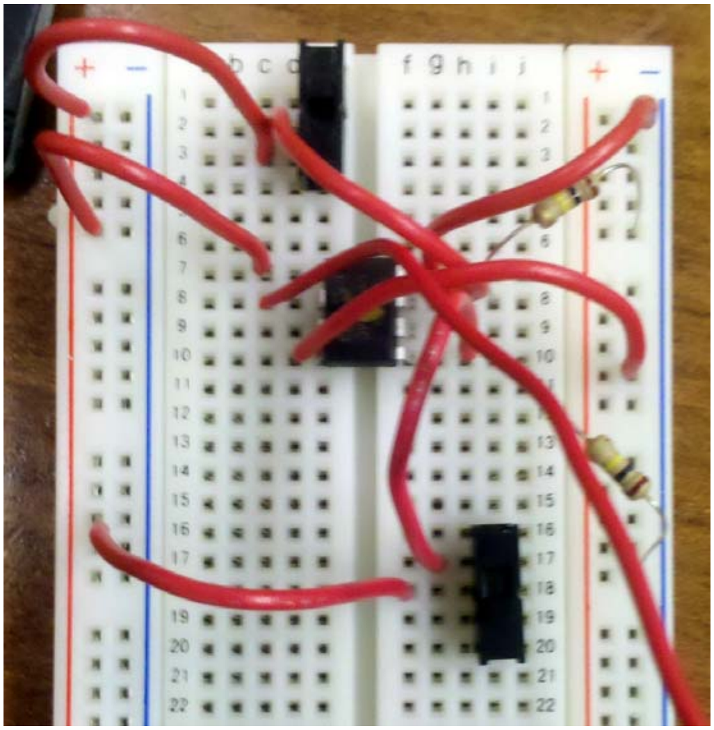
To build the transmitter circuit, you will put the encoder chip in place and then connect each of the pins of the chip with the proper component, just as you did with the receiver circuit. The switches allow you to tell the transmitter what message to send. The resistors limit the flow of electricity when the switches are on so that the LEDs do not break. In later sessions, you will be replacing one of the switches with your trigger so that the transmitter will tell the receiver when the door (or box or cabinet) is opened.

Step	Component	Placement Location	Why did I just do that?
1	Encoder chip (gold dot)	• Place chip across middle of breadboard. • Notch should face top of board. • Bottom **pins 4 and 5 should be in row 10**.	• The chip needs to split the middle of the board so that each of the 8 pins is connected to a separate row.
2	2” jumper wire	• Connect C**7** to anywhere on **left red** power rail.	• Connect pin 1 of the decoder chip to anywhere on the red positive power rail on the left. • This provides power to the encoder chip.
3	2” jumper wire	• Connect **D10** to anywhere on **right blue** power rail.	• Connect pin 4 of the encoder chip to anywhere on the blue negative power rail on the right. • This provides power to the encoder chip.
4	S1	• Place pins of switch into **i17**, **i18** and **i19**. Ensure that pins are in correct holes by looking under the switch as you begin to insert it into breadboard.	• Place switch S1 on breadboard. Direction is not important. • This switch will be used to send one signal.
5	S2	• Place pins of switch into **E1**, **E2**, and **E3**. Ensure that pins are in correct holes by looking under the switch as you begin to insert it into breadboard.	• Place switch S2 on breadboard. Direction is not important. • This switch will be used to send the second signal.
6	2” jumper wire	• Connect **F18** to anywhere on **left red** power rail.	• This connects S1 to red positive power rail on left. • The switch, when connected, is at positive 4.5 V.

7	2" jumper wire	• Connect **C3** to anywhere on **left red** power rail.	• This connects S1 to red positive power rail on left. • The switch, when connected, is at positive 4.5 V
8	2" jumper wire	• Connect **C2** to **G8**.	• Connect the middle pin of switch S2 to pin 7 of the encoder chip. • Switch S2 changes the voltage at pin 7 from 0 V to 4.5 V, providing a signal for the encoder to send.
9	2" jumper wire	• Connect **G17** to **H10**.	• Connect the middle pin of switch S1 to pin 5 of the encoder chip. • Switch S1 changes the voltage at pin 5 from 0 V to 4.5 V, providing a signal for the encoder to send.
10	R1	• Connect resistor **J10** to anywhere on **right blue** power rail.	• Connect 100 kΩ resistor (brown, black, yellow) R1 between pin 5 of the encoder chip and right negative power rail. • The resistor ensures that S1 does not create a short circuit between the positive and negative power rails.
11	R2	• Connect resistor **I8** to anywhere on **right blue** power rail.	• Connect 100 kΩ resistor (brown, black, yellow) R2 between pin 7 of the encoder chip and right negative power rail. • The resistor ensures that S2 does not create a short circuit between the positive and negative power rails.
12	2" jumper wire	• Connect **G7** to anywhere on **right blue** power rail.	• Connect pin 8 of the encoder chip to anywhere on the blue negative power rail on the right. • This provides power to the encoder chip.
13	Battery pack	• Don't connect battery pack yet. Move on to next section.	



Transmitter Circuit

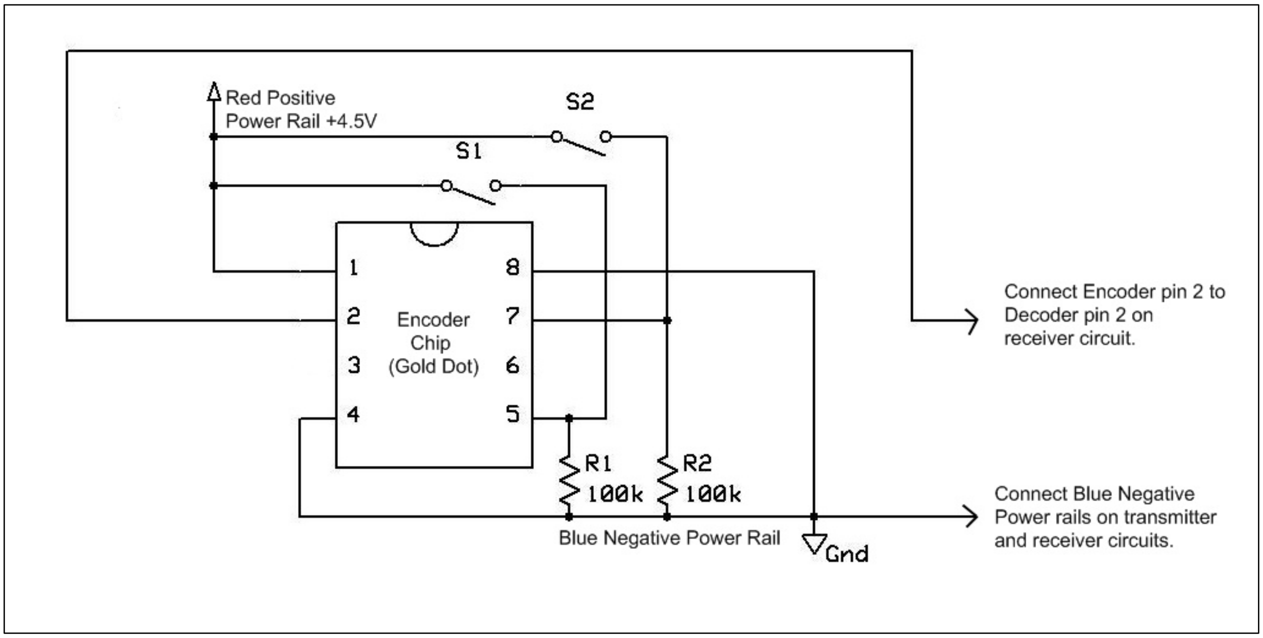


Transmitter Parts

- Breadboard
- 2” jumper wires
- 1 encoder chip with gold dot (R-8PE Encoder integrated circuit)
- S1, S2: Slide switches
- R1, R2: 100 kΩ Resistors (brown, black, yellow)
- 3 AA batteries
- Battery case
- 2 long wires (about 3’ each to connect to the receiver)

When your transmitter circuit is completed, it will look like the one shown in this picture. The circuit diagram is shown below.

Transmitter Circuit Diagram

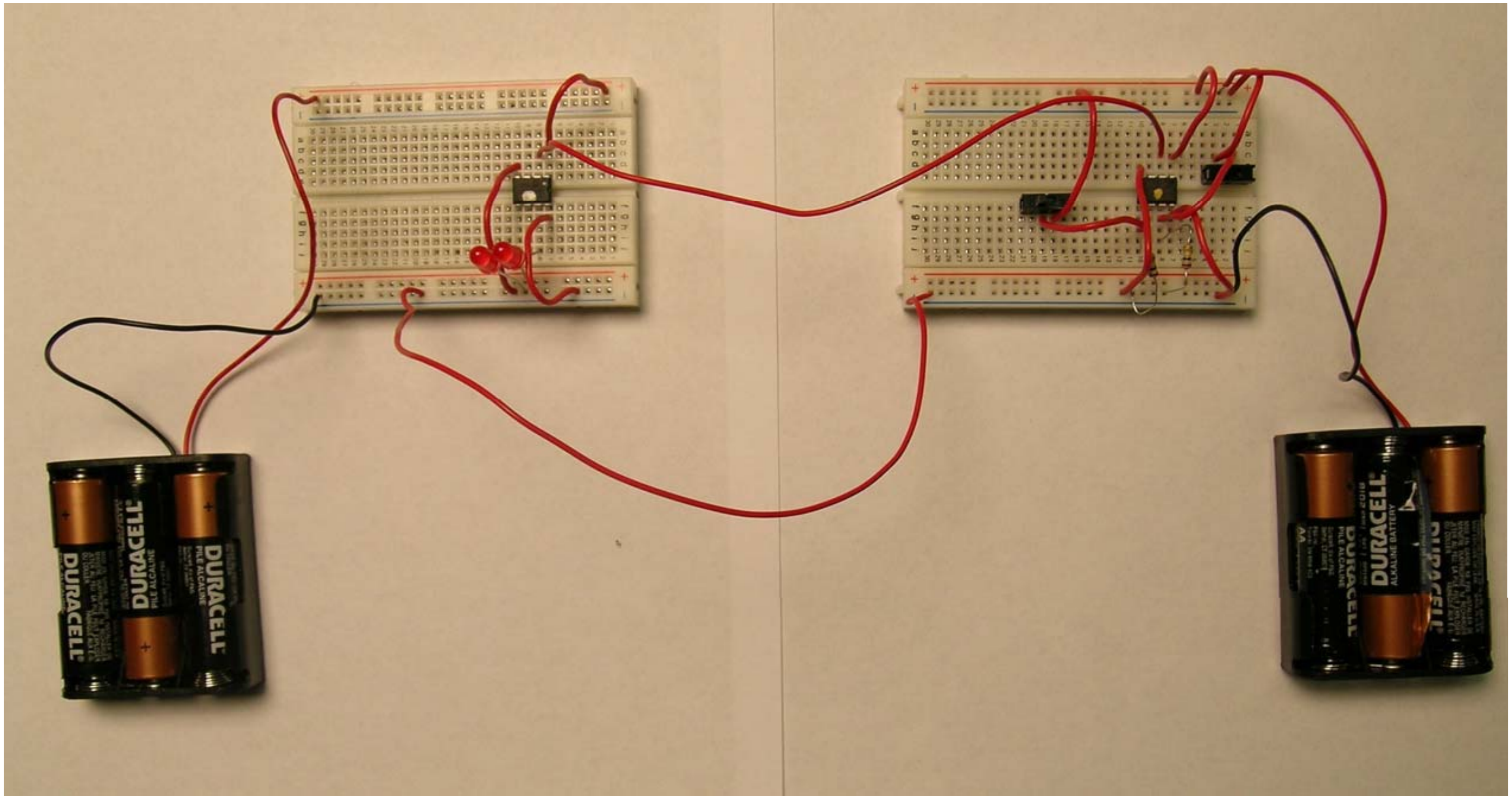


Connecting the Transmitter and Receiver

You will now connect the transmitter to the receiver. Once connected, each switch should operate one of the two LEDs. You will use the two long wires to connect the transmitter and receiver circuits. The transmitter and receiver can be as far apart as these wires allow. The switches on the transmitter code contain information that is sent over the two long wires from the transmitter to the receiver.

Step	Component	Placement Location	Why did I just do that?
1	Long wire	• Connect **transmitter right blue rail** to **receiver right blue rail**.	• Connect long wire from the transmitter blue negative power rail to the receiver blue negative power rail. • Connecting the negative power rails of the two circuits ensures that negative is at the same voltage for both circuits (this is referred to as “ground” in electrical engineering).
2	Long wire	• Connect **transmitter C8** to **receiver C8**.	• Connect the other long wire from pin 2 of the encoder chip to pin 2 of the decoder chip. • This wire transmits the signal from the encoder chip to the decoder chip. In this case, the signal tells whether switches S1 and S2 are on or off and tells the decoder to turn each LED on or off.
3	Receiver battery pack	• Connect red wire of battery pack to anywhere on **receiver left red positive power rail**. • Connect black wire of battery pack to anywhere on **receiver right blue negative power rail**.	• This provides power for the receiver.
4	Transmitter battery pack	• Connect red wire of battery pack to anywhere on **transmitter left red positive power rail**. • Connect black wire of battery pack to anywhere on **transmitter right blue negative power rail**.	• This provides power to the transmitter circuit. • If we used a long wire connecting the left red positive power rails in the two circuits, we would not need two battery packs for this activity. However, in the next activity, we will remove the wires to transmit the signal wirelessly and we will need both battery packs.

Once the two circuits are connected, you can test the transmitter and receiver. Do this by flipping the switches on the transmitter. Each switch should control a separate LED on the receiver. If either of the LEDs does not work, move on to the troubleshooting section to figure out what is wrong.



When your receiver and transmitter are finished, they should look like the ones in this picture.

Troubleshooting

If one or both LEDs are not working when you move the switches, you will need to troubleshoot your circuit. Troubleshooting is the process of figuring out why a circuit does not work. It is a very important part of being an electrical engineer. The problem with the circuit will be one of the mistakes listed below. Go through the following steps until you find and correct the problem.

Step 1. Make sure the LED is not inserted backwards. The shorter, negative lead should be connected to the blue negative power rail.

Step 2. Make sure the transmitter circuit has the encoder chip (gold dot) and the receiver circuit has the decoder chip (silver dot).

Step 3. Are there any rows in either breadboard with only one hole out of five filled? If so, that component is not connected to anything. Look at the circuit diagram/instructions and see what it should be connected to.

Step 4. Make sure each component is connected to the correct component. Start with the encoder and decoder chips. The following tables describe what each pin should be connected to. Note that some of the components are connected through jumper wires rather than directly to the pin. After checking the connections to the chips, check the other connections in the circuit.

Encoder Chip Pin Table

Pin	Connections
1	• Red positive power rail • Switch S1 • Switch S2
2	• Encoder chip pin 2 should be connected to decoder chip pin 2 on other breadboard (receiver circuit).
3	• Not connected to anything
4	• Blue negative power rail
5	• Switch S1 • 100 kΩ resistor (brown, black, yellow)
6	• Not connected to anything
7	• Switch S2 • 100 kΩ resistor (brown, black, yellow)
8	• Blue negative power rail

Decoder Chip Pin Table

Pin	Connections
1	• Red positive power rail
2	• Decoder chip pin 2 should be connected to encoder chip pin 2 on other breadboard (transmitter circuit).
3	• Not connected to anything
4	• Blue negative power rail
5	• Longer positive lead of LED L1
6	• Not connected to anything
7	• Longer positive lead of LED L2
8	• Blue negative power rail

Step 5. Check to see if the batteries are dead. Try a different battery pack or new batteries.

Step 6. Check for connections that are in the correct location but might be loose.

Step 7. If all else fails, try replacing the encoder and decoder chips one at a time.

Exploring the Wired Transmitter and Receiver

You now have a transmitter and receiver that are connected by two wires. Imagine that at home, there is a similar transmitter in the kitchen that is connected by long wires to a receiver with two LEDs in your bedroom. You could use the switches in the kitchen to turn the two LEDs in the bedroom room on and off. Imagine that someone in the kitchen wanted to send you a message in the bedroom using the system. You could develop a code for communicating. How many unique messages would it be possible to send between the receiver and transmitter by turning the LEDs on and off? Describe below how you would send the messages.

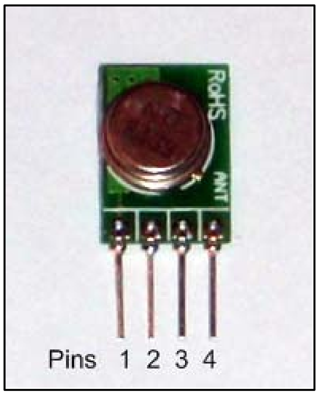
Activity 3: Wireless Communication

Name: ________________________

Date: __________

In this activity, you will be modifying your wired communication system to make it wireless. Your wireless transmitter/receiver pair will function the same, but it will transmit data over a radio frequency (RF) link instead of a wire. The only additional components in these circuits are the RF transmitter chip and the RF receiver chip.

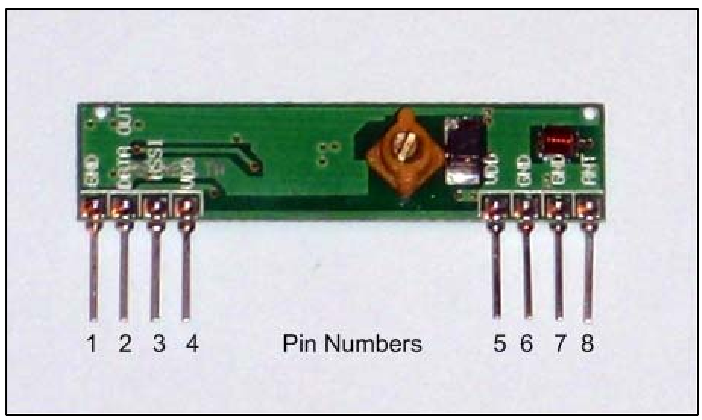
Parts Descriptions



RF Transmitter Chip
The RF transmitter chip is shown at the left. This chip takes the electrical signal from the decoder and radiates it as a radio signal. This radio signal is transmitted in all directions.

RF Receiver Chip
The RF receiver chip is shown at the right. This chip receives the radio signal sent by the transmitter. It is connected to the decoder where the wire was previously connected.

Radio signals are sent at different frequencies. This receiver operates at the same radio frequency as the transmitter: 433 MHz.



Building the RF Receiver Circuit

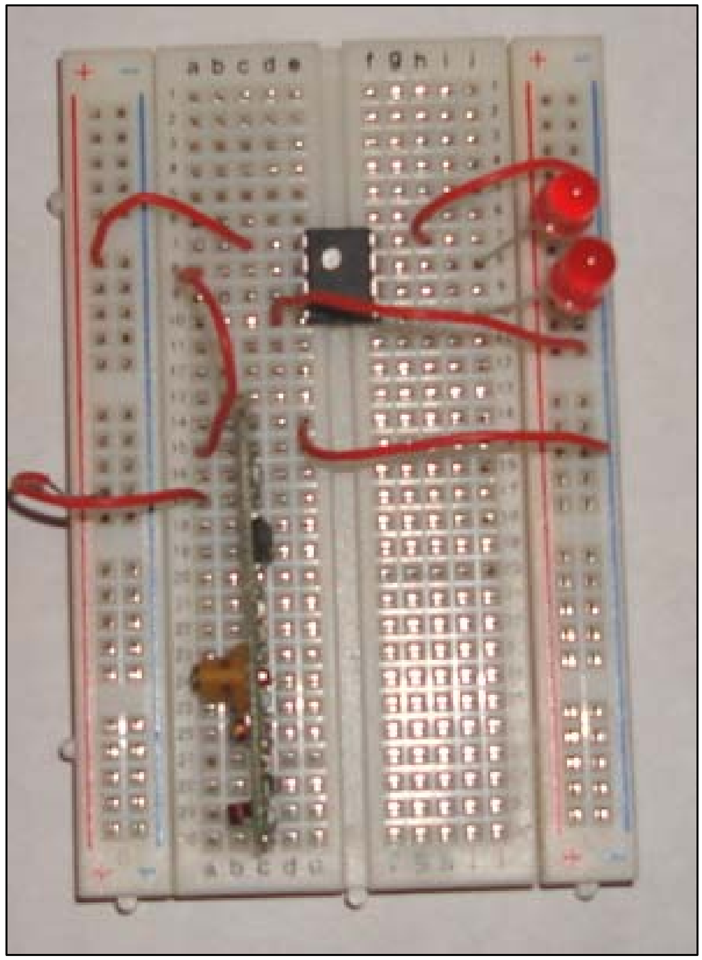
Before modifying your current receiver circuit, connect your transmitter and receiver circuits from the previous activity to make sure they are still working. If they do not work, follow the troubleshooting steps on the Activity 2 handout. You are going to remove the wire links between the transmitter and receiver and replace the wires with radio frequency (RF) transmitter and receiver chips. Disconnect the battery pack before you begin. Follow the steps below to modify the circuit.

Step	Component	Placement Location	Why did I just do that?
1	Battery pack	• If connected, disconnect battery pack from transmitter and receiver.	• Working on the circuit while the power is connected can damage components.
2	Long wires	• If connected, disconnect two long wires connecting transmitter and receiver circuits.	• This version is going to transmit the signal wirelessly. The RF transmitter and receiver chips will replace wire.
3	RF receiver chip	• Insert the RF receiver chip so that the writing and copper wire loop face left and so that bottom pin is in bottom row of breadboard (row 30). • Pin 1 should be in **C14** and pin 8 in **C30**.	• Insert the RF receiver chip into the breadboard. Make sure all the pins are in the same column of the breadboard and are not bending. Do not put the RF receiver chip in a power rail. • Similar to what we did with the decoder chip, we are now setting ourselves up to build a circuit to support the RF receiver chip.
4	2" jumper wire	• Connect **E14** to **right blue** rail.	• Connect pin 1 of the RF receiver chip to anywhere on the blue negative power rail on the right. • This provides power to the RF receiver chip.
5	2" jumper wire	• Connect **A17** to **left red** rail.	• Connect pin 4 of the RF receiver chip to the red positive power rail on the left. • This provides power to the RF receiver chip.
6	2" jumper wire	• Connect **A16** to **C8**.	• Connect pin 2 of the RF receiver chip to pin 2 of the decoder chip. • This carries the signal, received by the RF chip wirelessly, from the RF receiver to the decoder chip.
7	Battery pack	• Don't connect battery pack yet. It will be connected **after** you have completed transmitter circuit. Next, build transmitter circuit according to directions. You can also test your receiver using a transmitter made by one of the other students.	

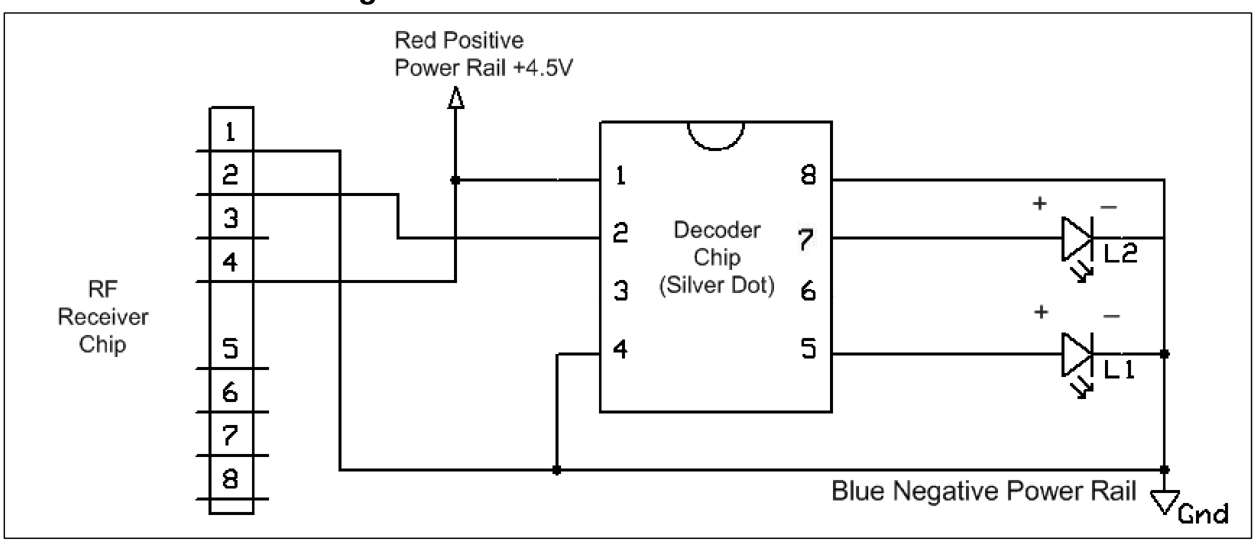
RF Receiver Circuit

Receiver Parts

- 1 receiver circuit with decoder chip (silver dot) from Activity 2
- 1 RF receiver chip
- 2" jumper wires
- 3 AA batteries
- Battery case



RF Receiver Circuit Diagram



Building the RF Transmitter Circuit

Now you are going to modify your transmitter circuit to use the RF transmitter chip in the same way you modified the receiver circuit. Only one transmitter may be tested in the room at a time, so your instructor may ask that you bring your transmitter up to the front of the room to test it.

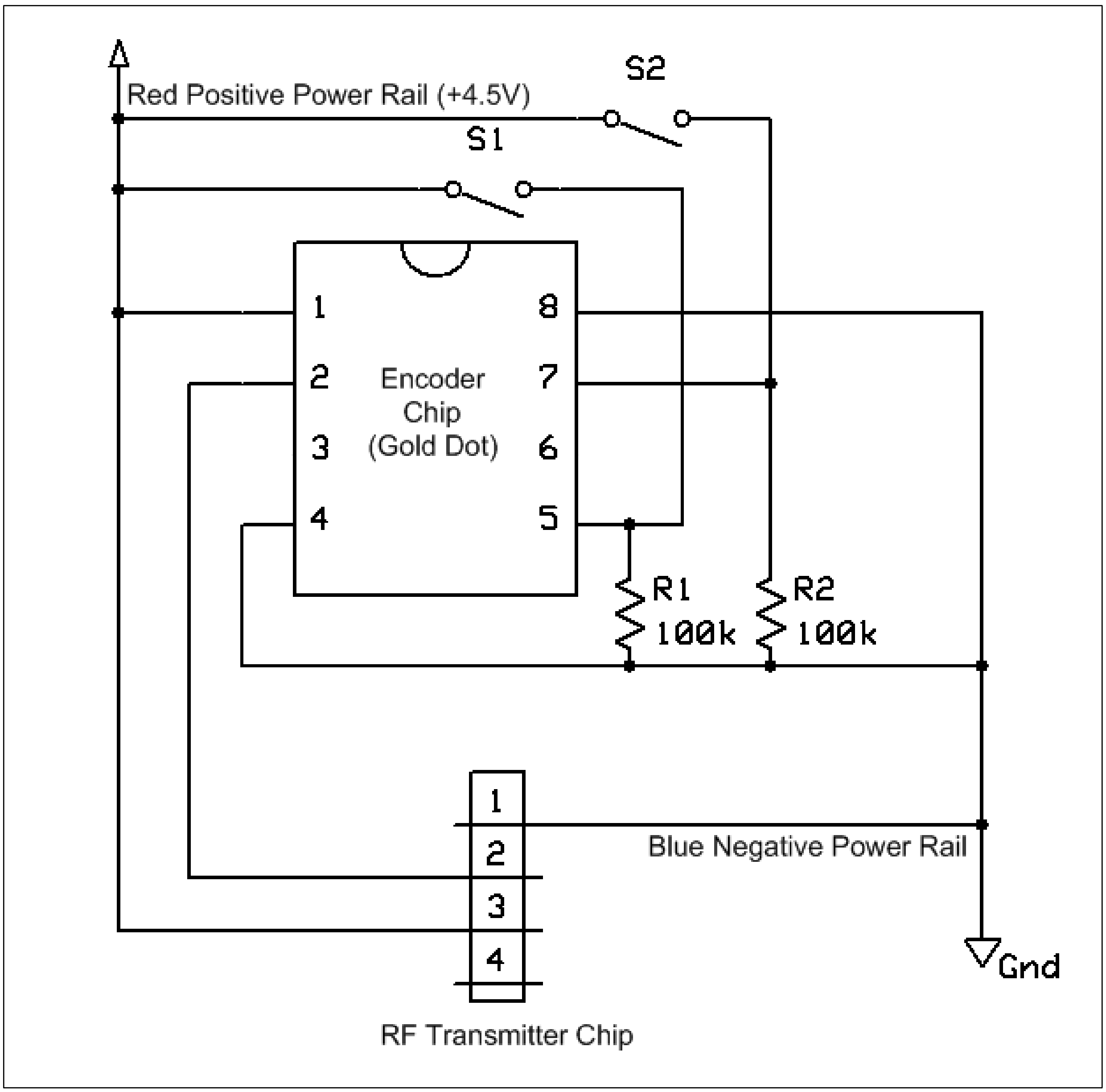
Step	Component	Placement Location	Why did I just do that?
1	Battery pack	• If connected, disconnect battery pack from transmitter and receiver.	• Working on the circuit while the power is connected can damage components.
2	RF transmitter chip	• Insert RF transmitter chip so that the writing and silver disc face left and so that bottom pin is in row 20. • Place **pin 1 in C17** and **pin 4 in C20**.	• Insert the RF transmitter chip into the breadboard. Make sure all the pins are in the same column of the breadboard and are not bending. Do not put the RF transmitter chip in a power rail. • Similar to what we did with the decoder chip, we are now setting ourselves up to build a circuit to support the RF transmitter chip.
3	2” jumper wire	• Connect **E17** to **right blue** power rail.	• Connect pin 1 of the RF transmitter chip to anywhere on the blue negative power rail on the right. • This provides power to the RF transmitter chip.
4	2” jumper wire	• Connect **A19** to **left red** power rail.	• Connect pin 3 of the RF transmitter chip to the red positive power rail on the left. • This provides power to the RF transmitter chip.
5	2” jumper wire	• Connect **A18** to **C8**.	• Connect pin 2 of the RF transmitter chip to pin 2 of the encoder chip. • This carries the encoded signal from the encoder chip to the transmitter. The RF transmitter then transmits that signal wirelessly to all RF receiver chips on that radio channel.
6	Battery pack	• Instructions for connecting your battery packs are on following page.	

RF Transmitter Circuit

RF Transmitter Parts

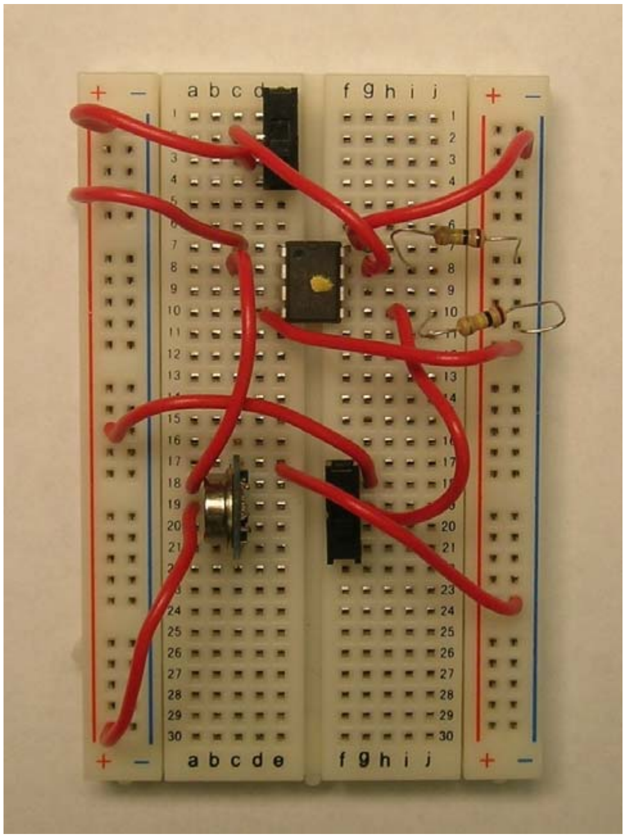
- 1 Transmitter circuit with encoder chip (gold dot) from Activity 2
- 1 RF transmitter chip
- 2” jumper wires
- 3 AA batteries
- Battery case

RF Transmitter Circuit Digram

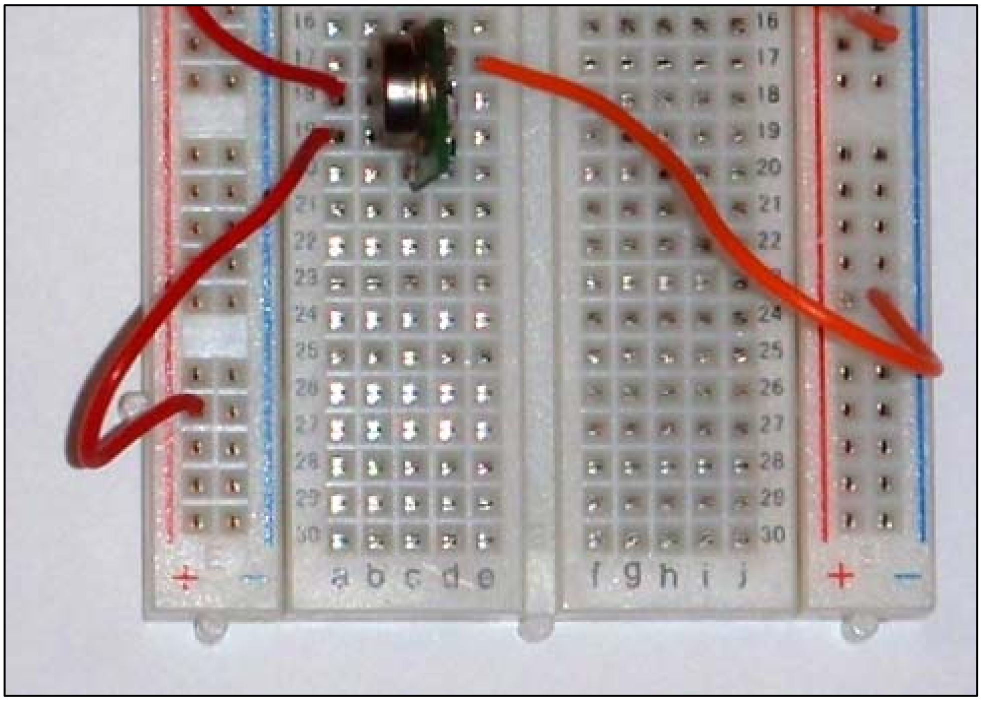


RF Transmitter Circuit Photos

Complete RF transmitter circuit without battery pack (right).



Closeup of RF transmitter chip connections.



Testing your RF Transmitter and Receiver

Your wireless circuit should function the same as the wired one from Activity 2. The only difference is that you've replaced the wired connection between the breadboards with a wireless one. The electrical signal goes from the encoder chip to the RF transmitter chip, which then transmits the radio signal. The RF receiver chip receives the radio signal and sends the electrical signal to the decoder. The decoder interprets the signal and determines which LEDs to turn on.

Step	Step Description	Instructions
1	Connect Receiver battery pack	• Connect red wire of battery pack to anywhere on left red positive power rail of receiver. • Connect black wire of battery pack to anywhere on right blue negative power rail of receiver.
2	Connect Transmitter battery pack	• Connect red wire of battery pack to anywhere on left red positive power rail of transmitter. • Connect black wire of battery pack to anywhere on right blue negative power rail of transmitter.
3	Test circuit	• Try flipping each switch to make sure it controls an LED "on" receiver.
4	Troubleshooting	• If either LED does not work, move on to the troubleshooting section to figure out what is wrong.

Troubleshooting

It is possible that one or both of the LEDs will flash, rather than shining constantly. This is normal. If one or both LEDs don't work at all when you move the switches, you will need to troubleshoot your circuit. Troubleshooting is the process of figuring out why a circuit does not work. It is a very important part of being an electrical engineer. The problem with the circuit will be one of the mistakes listed below. Go through the following steps until you find and correct the problem.

Step 1. Follow troubleshooting steps from Activity 2.

Step 2. Make sure RF transmitter and RF receiver chips are both inserted so the writing is on the left.

Step 3. Check connection to each pin of RF transmitter and RF receiver chips using the instructions above as a guide.

Exploring the Wireless Transmitter and Receiver

Only one group at a time can test its transmitter circuit. The reason is that all of the RF receivers in the room are on the same radiofrequency or radio channel. Your transmitter will transmit to all of your classmates' receiver circuits. For that reason, ask your instructor when you can test your transmitter circuit.

How reliable is the wireless communication? Turn one of the LEDs on and try to block the signal by putting objects between the transmitter and receiver. Are you able to break the connection? (If the LED starts flashing, this typically means the receiver is not getting a strong signal.)

Potential Experiments	**Observations**
How far can you move the transmitter from the receiver before they start to lose the wireless connection with each other?	
Insert a wire (2" jumper or longer) into the breadboard row connected to pin 4 of the RF transmitter chip (RF transmitter circuit hole E20). This will act as an **antenna**. An antenna improves RF communication by radiating or capturing radio waves. Record how far apart you can move the transmitter and receiver and still maintain a wireless connection.	
You can also try using an antenna on the receiving end by putting a wire (2" or longer jumper wire) into pin 8 of the RF receiver (RF receiver circuit hole E30). Record how far apart you can move the transmitter and receiver and still maintain a wireless connection.	

What are advantages of using an RF transmitter and receiver compared to a wired transmitter and receiver? Record your answer here.

What might be some advantages of the wired system you built last time compared to the wireless system you built today?

Activity 4: Sounding the Alarm

Name: ________________________

Date: __________

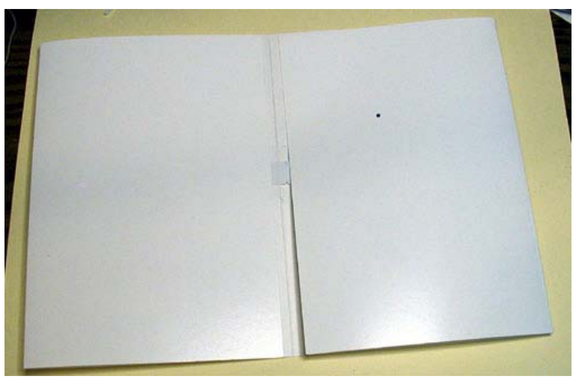
In this activity, you will be defining an engineering problem, in this case finding a way to protect something of value using a wireless burglar alarm system. You will build a prototype demonstrating how your system solves the problem you defined. A prototype is an original, full-scale and usually working model of a new product or new version of an existing product. Engineers use prototypes to test new devices prior to mass-producing them. Your prototype may incorporate a recording module, a transmitter and receiver circuit, and multiple trigger switches.

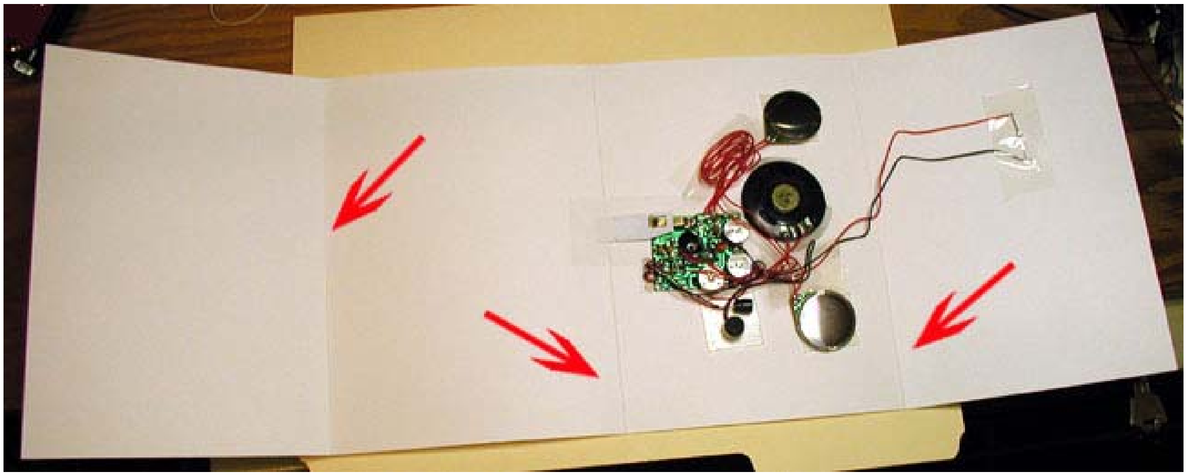
You'll begin by learning how to use the sound-recording module. Then you will use the recorder, the circuit and the trigger switches to build the prototype.

Using the Sound Recording Module

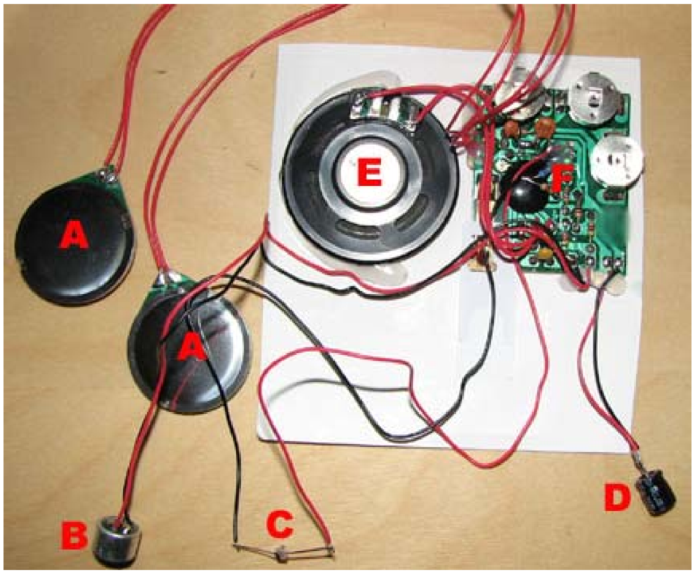
Note: Your card may be slightly different than the one pictured here. If it is different, follow the instructions provided with the card you've been given.

Step 1: Open card. The sound recording module is on the right side. Carefully tear open this part of the card if it has not been opened already.



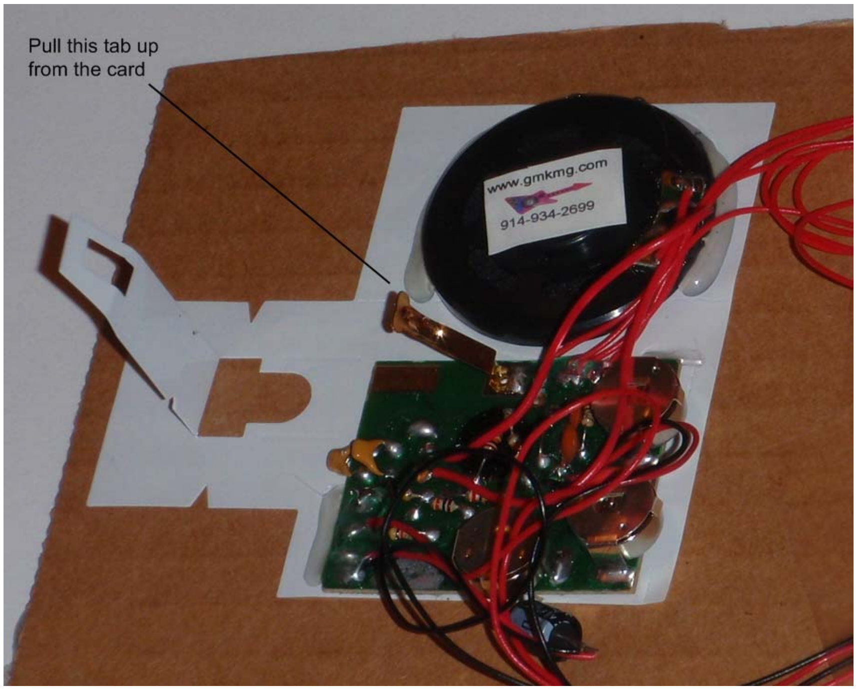


Step 2: Identify each part of module labeled A-F in picture below. (a) record buttons; (b) microphone; (c) red LED record indicator; (d) audio filter; (e) speaker; (f) circuit board.

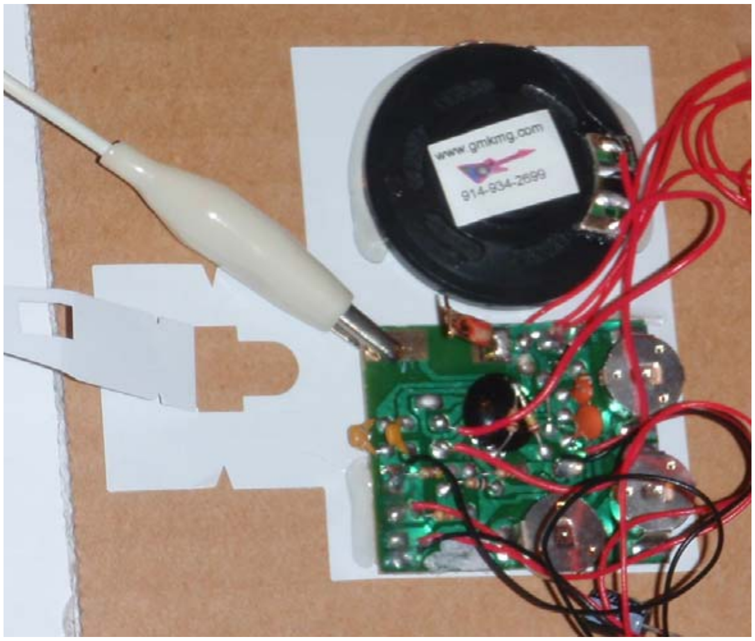


Step 3 – Recording: Press the two record buttons labeled “A” together until they click and LED labeled “C” lights up. This indicates the module is recording. Speak into microphone labeled “B”. You will have 13 seconds of record time.

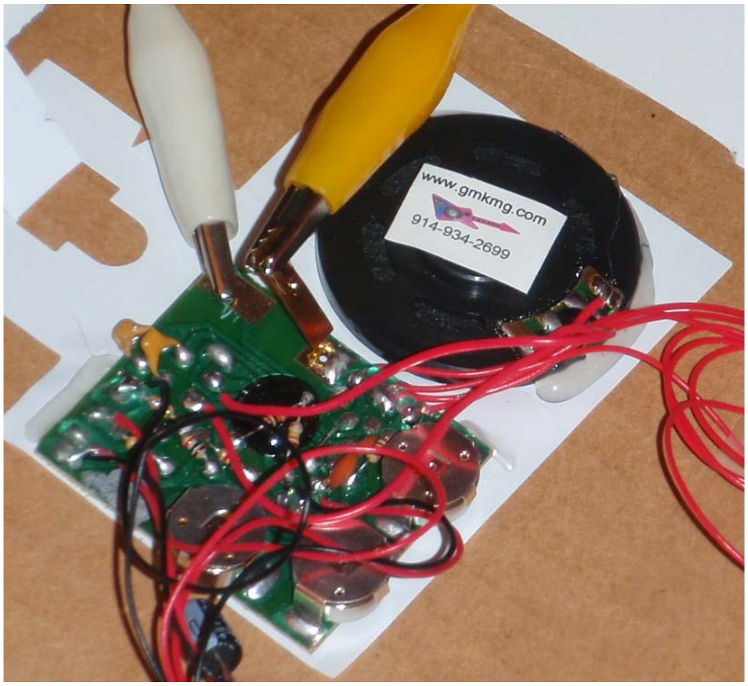
Step 4 – Playing: If it has not already been opened, pull up tab that completes the circuit when card opens. This is the switch on the card. Pressing this tab down will play the current sound on the card. See below.



Step 5: Connect one alligator clipped wire to the lower metal contact that is on top of circuit board (see picture below).



Step 6: Connect another alligator clipped wire to the metal tab you pulled up in Step 4.



Step 7: Touch the ends of the two alligator clipped wires together and the card will play, if there is a recorded message on it. This demonstrates that the circuit is completed.

Engineering Design Challenge
Sounding the Alarm

Engineering Design Problem:
In most TechXcite activities, the engineering design problem is provided to you. In this activity, you will define your own problem. In the box below, state a problem that you will be solving with your alarm system. Describe where you will use your alarm (a door, room, box, etc.) and what the security system will be protecting.

Engineering Design Constraints and Specifications:
Engineers design their solutions to problems within specific constraints and specifications. In the box below, describe the specifications for your alarm—in other words, what you expect your alarm to do once complete. The prototype you build in this activity does not need to look exactly like the actual product, but it should demonstrate precisely how the product will function.

Describe your specifications and any constraints on your design:

Spend some time in your group deciding what your final product will look like and how it will be designed.

Explain in the space below how your RF wireless alarm system works to warn you that somebody has breached your security. What are the major parts of your system and how do they work?

You will build a prototype to explain your ideas to the class. If there are any features in your design that you cannot manufacture in your prototype, describe these in the box below also. For instance, you might want to put a waterproof enclosure on the alarm so it can be mounted outdoors, give it extra durability or make it a particular color. Explain why these features would be desirable.

Build Your Alarm Prototype

These materials* are available for your prototype:

a. One or more door switches.
b. Sound recording module that can be connected to a door switch.
c. Wireless RF transmitter and receiver circuit to provide one or two warnings.

* You might want to use additional materials, such as something that will make your alarm blend in with its surroundings. You are allowed to find and use additional items that will help you design and test your prototype. Ask your instructor before taking items in the room.

Warn the Intruder:
You will record an appropriate warning message for your alarm on the card module. Then you will need to create a second door trigger to connect your card just like in activity 1. You can't attach the sound card to the same trigger as the transmitter.

Connecting the receiver to the door:
Step 1: Remove jumper wire currently connected to **Hole H10** from transmitter board (if not in H10, this could be in G10, I10 or J10).

Step 2: On transmitter circuit, insert one end of a 2" jumper wire into row containing pin 5 of encoder chip on the transmitter circuit *(Hole G10).*

Step 3: Insert one end of another 2" jumper wire into red positive power rail *(left red rail).* There should now be two jumper wires sticking out of the board.

Step 3: Use alligator clips to connect the two contacts from door trigger circuit to the two jumper wires that are sticking up. You may use longer wires if necessary. Ask your instructor for these.

Step 4: Remove switch S1 *(pins in I17, I18 and I19)*. The trigger switch is replacing this.

At this point, when the door opens, the RF transmitter will turn on LED L1, warning you of an intruder.

You will present your design to the class and use your prototype to help explain your design.