# Exploring Infrared Radiation Using a Television Remote Control

Most of us use our television's remote control without giving it a second thought. But when you think about it, remote control devices are quite remarkable. They not only turn your television on and off, but they control the channel, volume, and picture characteristics from across the room. Remotes are also used to operate VCR's, DVD players, fans, and gas fireplaces. Our reliance on remote devices is nothing short of amazing. On average, each household in America now has four remote control units and the number is growing.

How do these devices work? What exactly does the controlling? Are remotes interchangeable? In this activity you will answer these and other questions by examining one type of remote control unit, the infrared remote.

At one end of any IR remote you will see a plastic window. Behind this window are one or more infrared diodes. In some instances, no window is used and the diode is exposed. When energized, the diode emits infrared radiation, or IR, a form of electromagnetic radiation that is usually associated with heat. All warm objects emit IR. However, a diode produces IR when electrons make transitions between different types of quantum levels. This type of emission does not involve heat.

While our eyes are not sensitive to IR, light-sensitive detectors known as photocells may be used to detect it. Photocells are light sensitive semiconductors that convert IR, and as well as visible light, into an electrical signal. Used in conjunction with a television, a photocell's output may be used to control the set's operation.

The following experiments are meant to shed light on the workings of a remote.

I. "Seeing" IR. Even though your eyes cannot detect IR directly, a digital camera can! In lieu of the film used in a conventional camera, a digital camera uses a CCD (charge coupled device) chip, a sophisticated cousin of the photocell. Like photocells, CCDs are sensitive to IR.

Put your remote in front of the lens of a digital camera and press a key on the remote. What do you see in the camera's monitor? Examine the image produced when you press other keys. Do different keys produce different images?

II. "Hearing" the Remote Control. Connect a photocell to the input of the amplifier/speaker unit. After turning on the amplifier, direct the photocell toward either an incandescent or fluorescent lamp. A humming sound indicates that the system is operating correctly. Now darken the room, direct the remote toward the photocell, and depress a key on the remote. Describe the sound produced. Listen to the sound produced by depressing other keys on the remote. Do you detect any difference in the sounds? If not, how do you suppose difference keys can have different functions? The solution to this mystery will be revealed a bit later.
If a variety of remotes are available, compare the sounds produced by the different remotes. Do they all sound the same? If not, describe differences in the sounds produced.

III. Measuring Beam Divergence. Aim your remote directly at your television and depress the "on" button. Can you still control the television with the remote not pointed directly at the set? To find out, try to turn the set off (or change channels) with the remote pointed off to the side of the television. Does it work? Gradually point the remote farther off to the side of the television while using the remote. Using a protractor, measure the angle between an imaginary straight line drawn to the television and the direction of the remote at which it fails to control the television. This angle is a measure of the divergence of the IF beam emitted by the remote.

A more precise way of measuring the spreading of the remote's beam involves the use of the photocell and the amplifier/speaker system. Keeping the photocell parallel to the plane of the front of the remote, move the photocell along a line from one side of the remote to the other. The points on either side where the sound produced by the remote ceases define the outer limits of the beam.

IV. Reflecting IR. Can infrared radiation be reflected? To find out, simply aim the remote at various objects in the room starting with the walls. Does the remote have an effect on the television when it is not directly pointed at it? Try to identify the path taken by the infrared radiation when you are using a reflected beam to control the television. What are the limitations to using reflection to control the television?

V. Cracking the Remote Control Code. In part II of this activity you might have been surprised by the similarity of sounds produced by different keys on the remote. How does a remote control so many functions when the all the keys produce similar signals? Perhaps a closer look at a remote's output is in order.

Displaying the output of a photocell on an oscilloscope or a PC with a voltage interface provides a means for a more detailed examination of the IR signal from a remote. To accomplish this, connect the photocell to the input of either the oscilloscope of the voltage interface. Set the sweep on the either type of the display to 10/s and adjust the maximum scale reading to 0.5 v.

While directing the remote at the photocell, depress the remote's Power On/Off key. Observe the trace on the screen. If possible, print the trace. Examination of the trace will reveal a "string" of both single and double pulses. Going from left to right, write down the pulse code sequence. For example 2-1-1-1-2…etc.

Repeat the procedure for the One key, Nine key, and a key of your choice. Compare the pulse strings. Are they all the same? Do you findings explain the remote's ability to control so many aspects of the television's operation?