Optical Signals: Using light to control the operation of televisions, etc. and to send music through the air.

Table Set-up with a variety of devices

Target Audience: Parents of elementary school students (grades 3-6) and Middle and High School Students

Objectives:

1. Introduce optical communication through the use of the ubiquitous IR remote control, including demonstrating how to observe the pulses with a digital camera
2. Demonstrate the optical transmission and reception of audio signals, both using free space and optical fibers.
3. Introduce the general concept of digital signal encoding using remote controls
4. Provide interaction with engineering students.
5. (Optional) Introduce the Mobile Studio as an example of a modern engineering measurement tool and show the time dependence of the optical and audio signals

BOM: 3 or more infrared (IR) remote controls from TV, stereo, etc., an MP3 player (iPod is ideal), a digital camera (mobile phone camera is ideal for demo purposes), optical transmitter circuit (see resources for details) and optical receiver circuit (see resources for details), plastic optical fiber, Mobile Studio (optional) and computer (optional).

Item	Source /website	Price (if known)
Infrared (IR) Remote controls from TV, Stereo, etc.	Radio Shack	Price range $1.00 - $15.00
MP3 / Ipod	Best Buy	Price range $30 - $300.00
Digital Camera		
Optical Transmitter		
Optical receiver circuit		
Fiber Optic element	http://www.scientificsonline.com/fiber-optic-element.html	$12.95 each

Set Up: For any table, connect the MP3 player to the transmitter input, align the transmitter output LED to the receiver photodiode (can also be phototransistor or LED, see resources for details), select music to play that matches the relatively poor frequency dependent properties of the circuits (The Beatles ‘Paperback Writer’ works well) and place the remote controls and optical fiber nearby. A Mobile Studio and computer can also be added to monitor the signals from the MP3 player, the transmitter and receiver circuits.

Activities:

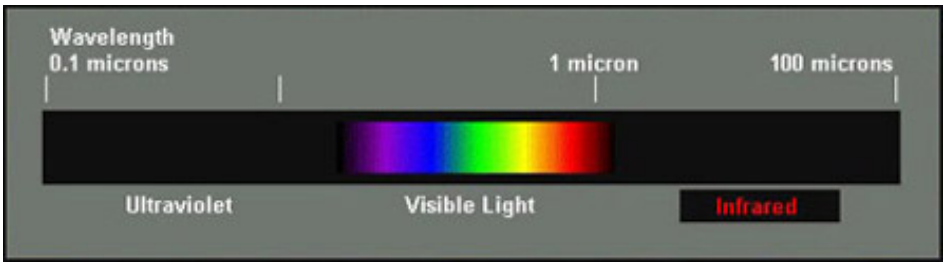
1. Introduce mentor(s) and general purpose of activities
2. Seeing the IR light flashes from a remote: Using one of the remote control devices and the digital camera, aim the remote at the camera and observe the light flashes. See if you tell the difference between the flashes sent by different buttons. (Usually not – only the main flash structure can be seen. The individual flashes occur too fast to be seen by humans but the TV can tell the difference and they can be observed using a measurement device like the Mobile Studio.)
3. Hearing the IR light flashes from a remote: Using the same remote control device, aim the remote at the receiver circuit for the audio transmitter and receiver combination (diagram below). The device that receives the IR signal is a photo diode (it looks like an LED). You should be able to hear the pulses of light given off by the remote. Describe what they sound like.

4. Transmitting music on a beam of light: In the last step, the receiver was tested. If sound was produced by the remote, the receiver is working. Turn on the music source (e.g. and iPod) connected to the input cable for the transmitter and select a song to play. Be sure the volume control is set as high as possible. Make sure that the LED on the transmitter is pointing directly at the photo diode receiver (looks like an LED). You should be able to hear the music from the speaker connected to the receiver.
    a. Block the light from the transmitter to the receiver. The sound from the speaker should stop.
    b. Move the transmitter and receiver apart. The sound should become weaker.
    c. Aim the transmitter so it does not send a signal to the receiver. The sound should go away.
    d. Use the optical fiber to direct the light from the transmitter to the receiver. That is, place one end of the fiber by the transmitter LED and the other end by the photodetector. You should be able to hear the music again.
    e. Re-align the transmitter and receiver and cover the entire experiment (transmitter and receiver) with some kind of material that blocks the background light from the room or turn the room lights off. The sound should become stronger. This is because the photo diode senses the increase in light due to the signal from the transmitter. If the room is too bright, it has a hard time seeing the light.
5. (Optional) Use the Mobile Studio to measure the time-dependent audio signal from the MP3 player, the electrical signal driving the output LED and the audio signal at the receiver speaker. Ideally, the output from the MP3 player and the signal at the speaker should be identical, but they will not be in this case. Our ears will hear the sound as being similar because the differences will generally occur at frequencies so high that we cannot hear them.
6. Discuss what has been learned about IR light and the use of light for optical communication.
7. Take general questions on the experience of being an engineering student

Outcomes:

1. Audience will be better informed about digital communication, especially using light pulses.
2. Audience will be able to provide an example of how engineers approach problem solving and/or the development of a new product.
3. Audience will be better able to understand and appreciate the other activities offered at the event.
4. Audience will be better informed about the properties of light, Smart Lighting and its potential to impact the quality of their lives through the generation, sensing and control of light.
5. Audience will have an increased understanding and enthusiasm for what engineers do and for an engineering career.
6. Audience will visit the website of the Smart Lighting ERC.

Resources:



Infrared Light – What is Infrared Light? It is light beyond red that is not visible to us. IR is given off by hot things. (There is also ultraviolet light that is beyond blue. UV light gives us sun tans.) What do we know about IR light?

- Cannot be seen by humans
- Can be seen by digital camera
- Remote control sends IR light flashes to TV or any other device i

Pushing a button on a remote control causes a particular sequence of light flashes to be sent to the TV or other device that is being controlled. The flashes are like a secret code that only the TV can understand and that we cannot see.

An example of an IR remote control observed using a digital camera (http://sci-toys.com/scitoys/scitoys/light/invisible/invisible.html)

Simple Optical Transmitter and Receiver

1. The transmitter and receiver circuits are described in great detail in the write up for Project 4 in the RPI course ENGR-4300 Electronic Instrumentation which can be found at http://www.ecse.rpi.edu/courses/S11/ENGR-4300/EIexp-proj-lect/proj_4.pdf The project information also shows where to connect the Mobile Studio if used in this activity.
2. The original reference for this project is Gordon McComb's book *The Laser Cookbook* which is available used on Amazon and elsewhere.
3. The design of the transmitter and receiver can be easily modified to accommodate using only LEDs or other constraints. Contact Prof. Connor for additional info.

TVBGone Remote: download the smaller of the two files found at http://hibp.ecse.rpi.edu/~connor/SmartPowerandLight/Audio/ which is a recording of the sounds produced by the TVBGone remote control which can shut off any TV sold in North America. Once you get that working, you can download the longer file, which has the complete signal from the remote. You can listen to this signal and watch it on the Mobile Studio. What kind of a structure do you see to the signal? Can you see how it is able to send coded messages to electronic devices like TV sets? Information on the TVBGone can be found at http://www.tvbgone.com/cfe_tvbg_main.php

Takeaways:

A handout with an online link to all information. The link information is a mechanism for encouraging the interested public to visit the website of the Smart Lighting ERC and should also help connect the audience to information on engineering, engineering careers, and K-12 STEM education.