Light Modulation

This is photonics at its best.
This demonstration will engage, teach and connect.

Connect a flashlight to an iPod, MP3 or CD player and **transmit the sound on the light beam** to a solar panel connected to a speaker or earphones.

This is an amazing demonstration that should be seen by all Physics students once in their life!
It is not rocket science but is amazingly simple and effective!

Components required

A. Transmitter

- ★ LED Flashlight. Incandescent bulb flashlights will do the job too but LED flashlights are brighter and more efficient. Try to locate such a flashlight at a 'Dollar Store'. We paid $4.00 for ours. The internal battery holder should be a loose unit so it can slide out and can be soldered onto.
- ★ Flex double wire (~ 30 cm)
- ★ 3.5 mm stereo plug
- ★ iPod (we use a small iPod Shuffle but any MP3 player, CD player, Hi Fi or radio should work well)

A stereo plug has 3 segments ↓

3.5 mm stereo plug

B. Receiver

- ★ Solar panel. Almost any size will do. We use a 1V, 250mA size.
- ★ Flex double wire (~ 30 cm)
- ★ 3.5 mm stereo plug or socket (whatever is needed as an input to the speaker).
- ★ Amplified speaker(s). Computer speakers that are self powered (battery compartment or mains connection) or any iPod / MP3 speaker with external power. Ideally you will be looking at speakers with a 2 x 1W output.

Solar panel

or

iPod or MP3 speakers - should run on batteries

Computer speakers - they should be powered by batteries or the mains

C. Tools

★ Soldering iron
★ Solder
★ Drill and drill bit (diameter of flex wire)
★ Side cutter

Putting it together

The Transmitter

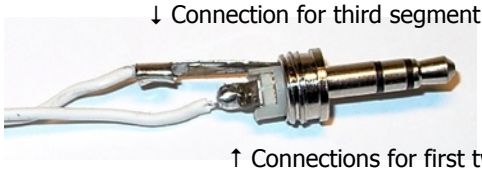
The aim here is to solder the flex wires **in parallel** to the battery holder in the flashlight. A wire is soldered to each terminal of the battery holder so the iPod will be connected in parallel to the batteries. You also have to drill a small hole through the aluminium casing of the flashlight (usually at the back) so the wire can enter the body. Determine where a hole will do no damage to the flashlight before you drill the hole.

← Wire soldered in parallel to the battery holder.

The other end of the flex wire is soldered to the stereo plug. As a stereo plug has three terminals, you have to solder one wire to **both the first and second segments of the plug**. The other wire goes to the third segment. (In iPod Shuffles the ear phone connection is used for charging and audio output so the positive of the batteries should be connected to the first two segments of the stereo plug). See photo below.

Be careful not to overheat the plug as the internal connections can't handle too much heat.

↓ Connection for third segment of plug.



↑ Connections for first two segments of plug. Connect these to the POSITIVE of the flashlight batteries if used with an iPod Shuffle

That's it! The transmitter is ready to go!

The Receiver

Our Photo Phone Kit uses and includes an audio pre-amplifier circuit connected to the speakers. This is not required but the use of a pre-amplifier adds to the sound quality and volume so the demonstration can be heard clearly by all students in the classroom.

We will proceed here with the instructions not including the pre-amplifier.

Simply connect the one end of the flex wire to the solar panel and solder the other end to the 3.5 mm stereo plug or socket (same type of connection as before). iPod speakers will require a 3.5 mm plug but most computer speakers will require a 3.5 mm socket.

That's it! Done!

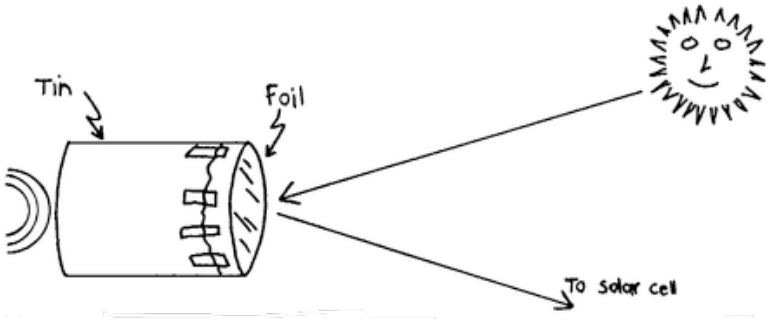
Testing the System

Connect the solar panel to the speaker input and switch the speaker on. Turn on the room lights and point the solar panel at the lights. You should here a 100 Hz humming sound on the speaker produced by the AC room lights. If not, check your receiver connections.

If all is well, keep the speaker on and turn off the lights (it needn't be dark so the blinds on the windows needn't be closed). Connect the flashlight to the iPod's (or other source's) output / ear phone socket and push the 'play' button. Turn the flashlight on and aim at the solar panel. You should clearly here the sound from the speakers . . . If not, adjust the iPod's volume.

Extention

★ Tin Can Transmitter



Open a tin can at both ends (or use a thick paper tube) and stretch aluminium foil tightly over one end. Hold the foil in place with tape or a rubber band. Be sure the shiny side of the foil faces outward. Test the transmitter by reflecting sunlight from it onto a wall some distance away. The reflected sunlight should form a distinct spot. If not, the foil is not stretched tight enough. For best results the transmitter should be mounted on a tripod to aid aiming at the target (solar panel of the receiver) and the use of a thin rubber membrane (e.g. latex) instead of the foil, with a small piece of mirror glued to the centre of the membrane.
Speaking into the open end of the tin / tube will vibrate the foil or rubber and send a modulated light signal to the receiver.

★ Test the "light listener" (receiver) by pointing the solar panel toward different light sources, such as :
- an infrared TV remote control;
- our RGB ball;
- candle flame at night;

- lightning flashing at night;
- sunlight filtering through leaves;
- headlights of cars, especially when moving on a rough or bumpy road.

★ Have students experiment with lenses, mirrors and other types of flashlights to improve the distance of the transmitter.

★ The 220V alternating power supply has a frequency of 50Hz. This means that the polarity gets reversed 50 times a second and the lights thus turn on and off 100 times a second. The humming sound produced by the solar panel is a 100Hz humm due to this alternating current effect. Demonstrate that a direct current light source has no effect on the solar panel by using the flashlight when it is disconnected from the audio source. Cut the beam with your fingers.

What is Amplitude Modulation?

Light is electromagnetic radiation and therefore can carry audio signals. On 19th February, 1880, Alexander Graham Bell and Sumner Tainter, prof. Bell's laboratory assistant, became the first people to transmit their voices over a beam of light. Bell called his invention the **photo phone** and said it was fundamentally a greater invention than the telephone. He used a selenium detector in series with a battery and telephone receiver.

In our set-up: The flashlight batteries provide a strong but constant DC current to the LEDs. So the LEDs glow with a fixed brightness. When the iPod is turned on, it adds a weak but fluctuating electrical signal to the constant current from the battery. So the LEDS now flicker in sync with the output from the iPod. The stronger battery current of the flashlight is 'superimposed' with the weaker signal from the iPod. These fluctuations are picked up by the solar panel and are turned into electrical pulses that are turned back into sound by the speaker.

This process is known as intensity or **amplitude modulation** (AM). It is the same principle used for transmitting AM radio signals. In radio transmission, FM or frequency modulation is more popular.

Modern communication systems use modulated signals carried on laser beams in clear fiber-optic cables. As visible light has higher frequencies than radio waves, they can carry much more information.

Acknowledgements

I constructed my first photo phone back in 1989 inspired by a description in the first book below:

Doherty, P., Rathjen, D. (1991) The Exploratorium Science Snackbook. San Francisco: Exploratorium Teacher Institute. p 67
Doherty, P., Rathjen, D. (2002) Square Wheels. San Francisco: Exploratorium Teacher Institute. p 51

Prof Bunsen Science sells a **Photo Phone Kit** that includes a solar panel, components for the pre-amp and other parts.

See the Photo Phone Kit in action in our video. Follow the Video link on our website.

Have fun!
Carl