

ELEC 1908 - Electronics Lab  
Fibre Optics & Communication

April 5<sup>th</sup>, 2013

# 1 Part A

## 1.1 Audio Link

In this lab we wish to transmit an audio signal over a long distance with minimal use of repeaters. A fibre optic cable is an excellent choice for this and will be used with both a transmit and receive circuit as shown in Figures 1 and 2. The LEDs used to transmit and receive are infrared which are invisible to the eye. To check if they are transmitting one can use a high tech CMOS infrared detector (eg. the camera on your cell phone). Your task is to build the transmit and receive circuits and to explain the following :

- What does each piece of the circuit do ?
- Why does light stay inside a fibre optic cable ?
- How is the information encoded / transmitted along it's path ?

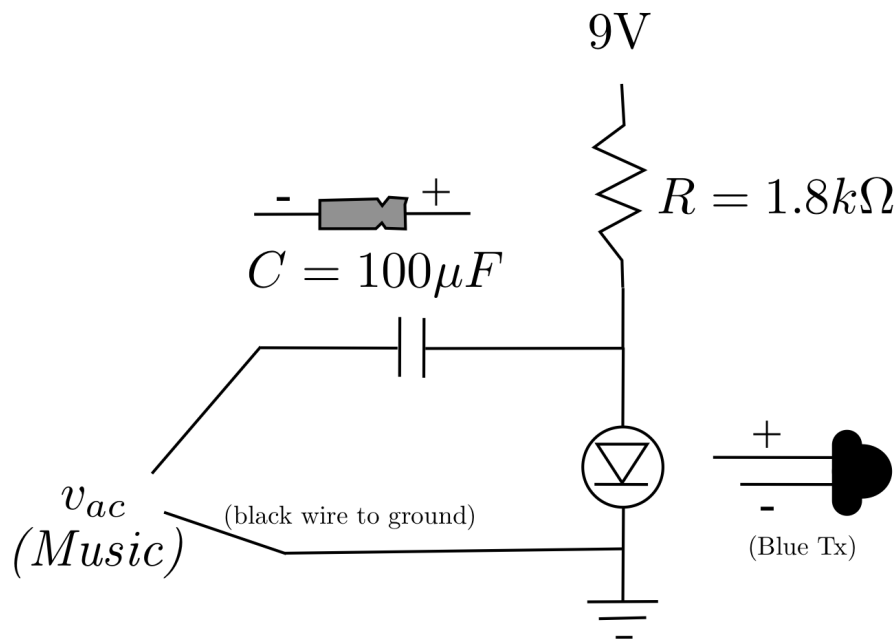


Figure 1: Circuit for transmitting audio signals over a fibre optic cable.

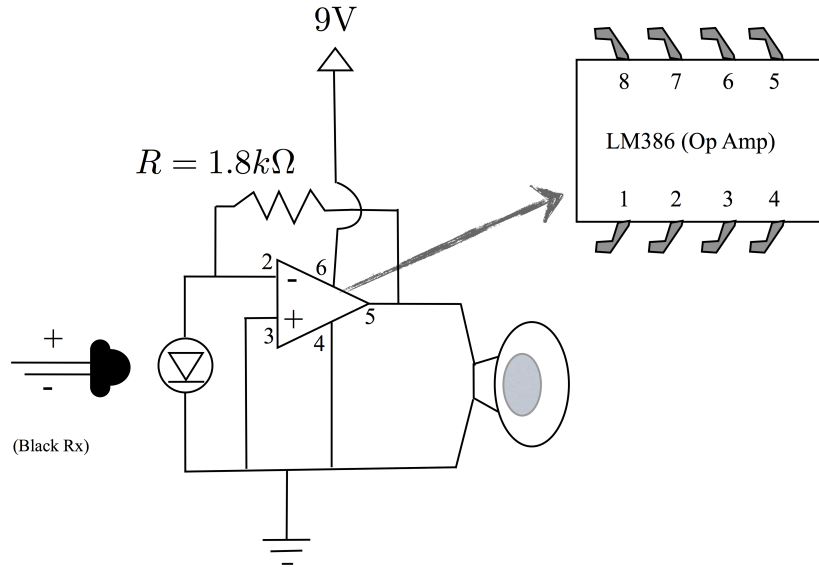


Figure 2: Circuit for receiving audio signals over a fibre optic cable. If the output signal is too small try using a larger resistor to get more gain ( $5.6k\Omega$  seemed to work well).

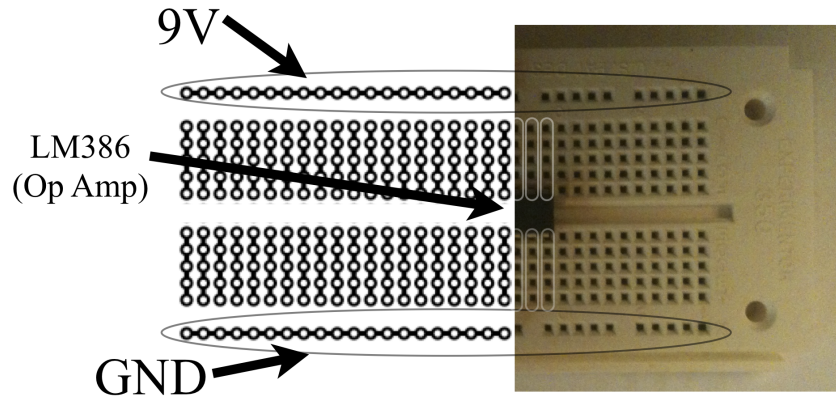


Figure 3: Diagram of a breadboard, showing where the pins are connected. All pinouts from a single connection are shorted to each other, or as in a Spice node list, share the same node. A correctly placed op-amp straddling the middle bridge is shown.

## 2 Part B

### 2.1 Multiplexer

We have now successfully transmitted a signal using infrared light. A thought occurs to you that you might attempt to send multiple signals along a single fibre optic cable. Examine the multiplexer and use the lamp to see what colours come out of the ends depending on the input cable. Create a copy of the following table, 1 and describe a) how a device similar to this may aid in our new task, and b) how might this device work (ie. physically, how are the signals split / combined).

Table 1: Example table for the mutliplexer, be sure to replace ‘colour 1’ with the colour of the cable, and record the colour of light which is emitted

in \ out	Colour 1	Colour 2	Colour 3
Colour 1	— — — — — — —		
Colour 2		— — — — — — —	
Colour 3			— — — — — — —

## 3 Part C

### 3.1 Signal Attenuation

With an optical signal Tx/Rx system, and a method for sending multiple signals, we must now determine how far these signals can be transmitted. This is described as the loss of the cables, and its value can vary depending on the colour of light being transmitted. The signal strength at a distance from the source can be described in the following equation :

$$I(x) = I_0 e^{-\alpha x} \quad (1)$$

With  $I$  being the intensity of the light, which is also proportional to the signal power and recorded voltage. This means that a signal is reduced to approx 37% or  $e^{-1}$  of its original power after  $1/\alpha$  meters. We will now determine the attenuation constant for three different wavelengths. Using three different coloured LEDs and at least three different cable lengths record the receive voltages across the different cable lengths. Having measured receive voltages for different cable lengths, one can extract the attenuation constant of the light.

- Why must the send and receive LEDs be the same colour for proper transmission ?
- Why must one not change the transmit voltage during all the measurements for that same colour ?
- What is the attenuation constant for each colour ?
- Using an approximate wavelength for each colour, make a plot of attenuation constant vs. wavelength
- What are other loss factors affecting this setup ?

### 3.2 Example method to determine line attenuation

Use the transmit and receive circuits built in section 1, but instead of connecting them to an audio output and a speaker, connect them to a waveform generator and a multimeter. We will be transmitting a sine wave over the optic cable, whose amplitude we can measure from the receiving circuit. Make sure your multimeter is set to AC voltage

$$\begin{aligned}
 I(x) &= I_0 e^{-\alpha x} \\
 \ln(I(x)) &= \ln(I_0 e^{-\alpha x}) \\
 \ln(I(x)) &= -\alpha x + \ln(I_0) \\
 y &= mx + b
 \end{aligned} \tag{2}$$

Table 2: Example readings taken from different cable lengths (for one colour of LED)

Length (m)	Voltage (V)	ln V
0.1	9.37	0.972
0.5	7.69	0.886
1.3	3.79	0.579
2.5	2.19	0.341

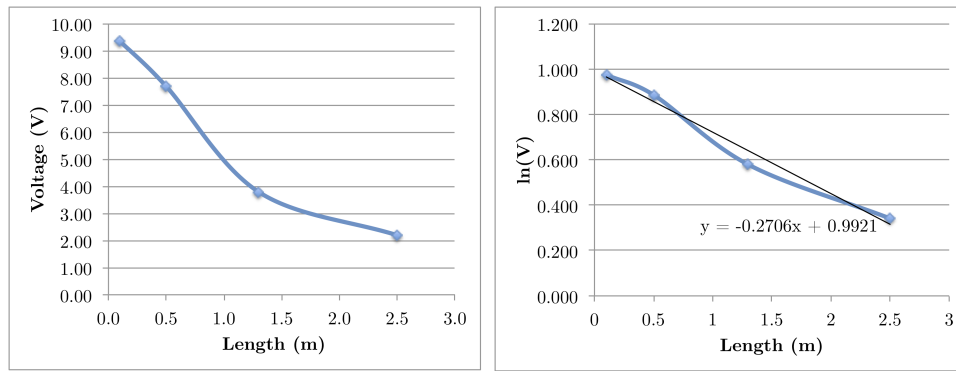


Figure 4: Plots used to find attenuation, adding a trendline and displaying the equation.

### 3.3 Using the Waveform Generator

We will be using the waveform generator shown in Figure 5. To adjust the amplitude of the signal, first hit the "Ampl" button, then use the wheel to adjust the amplitude of the signal. To adjust the frequency of the signal, hit the "Freq" button and use the wheel to adjust the frequency. Scrolling the wheel will only adjust a single digit in the value being adjusted, to switch between digits use the left and right arrow buttons.

For this lab you can use the default 1kHz frequency, but you will likely need to increase the amplitude (do this slowly, you shouldn't need to go above 500mV).

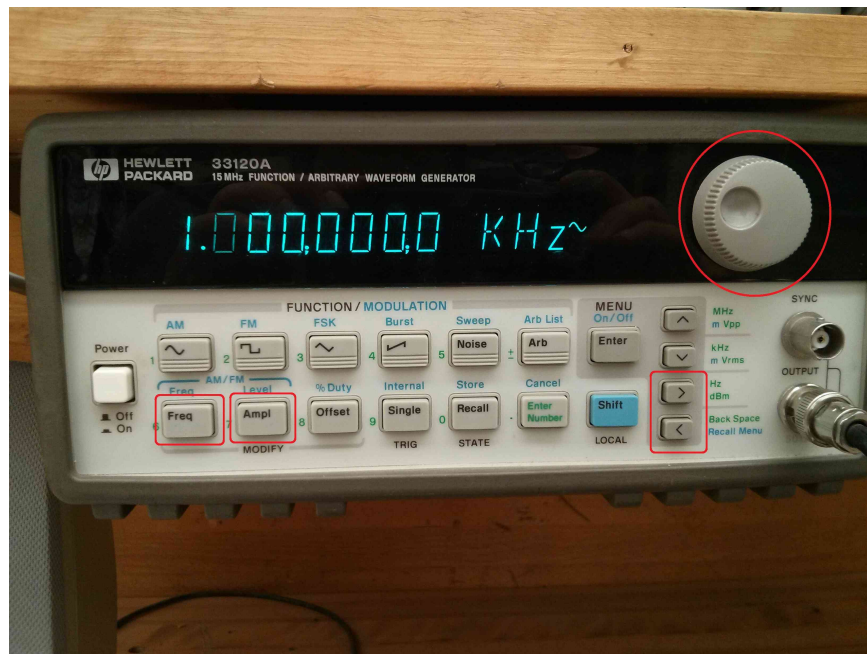


Figure 5: Waveform generator used for the lab