LAB 3 - TASK 1

In Part I of this course, we used a model of an infrared communication channel when designing our communications system. In this task, we will estimate the frequency response of this channel by transmitting a sinusoidal wave with unit amplitude through the channel. The output of the channel will be a sinusoid with the same frequency, but scaled in magnitude. This scaling factor is known as the amplitude response of the channel. We will measure the effect of scaling by the amplitude response of the channel at different frequencies by measuring the peak to peak amplitude of the received sinusoidal signal.

```
%%
% Exponential factor controlling step response of channel
a = 0.93;

% normalized frequency of the signal (cycles/sample)
freq = 0.0005;
% length of the input waveform
nsamp = 4200;
% sample indices
n=0:(nsamp-1);
% create a sinosuidal function with frequency freq and nsamp sam
tx_wave = cos(2*pi*freq*n);

% send the signal through the channel
rx_wave = txrx(tx_wave,a,'pureexp');
```

Unanswered

Figure 1

5.5 Lab 3 - Frequency Response
Lab due Nov 16, 2015 at 15:30 UTC

- Topic 6: The Discrete Fourier Transform
- MATLAB download and tutorials
- MATLAB Sandbox

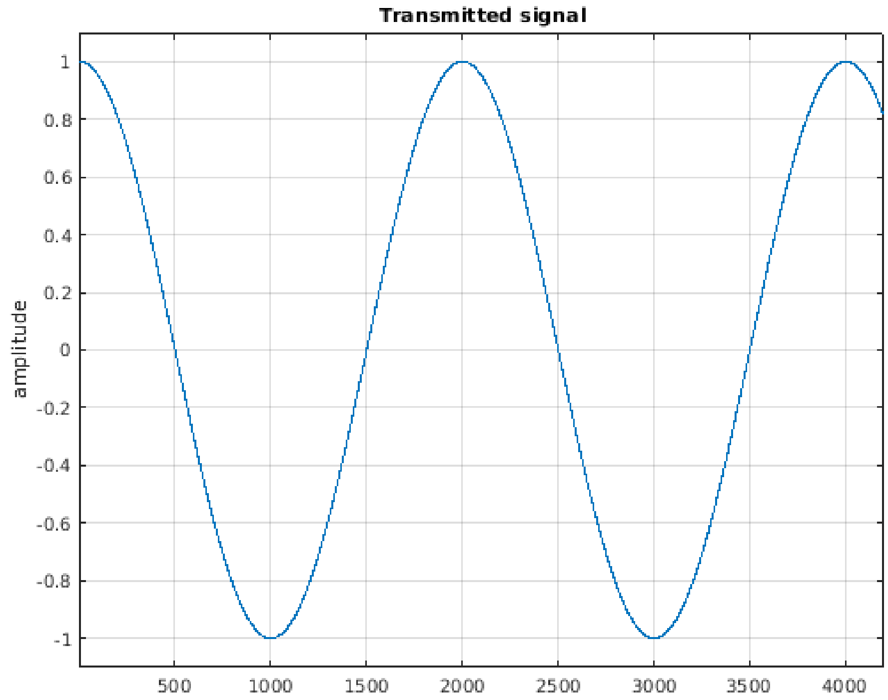
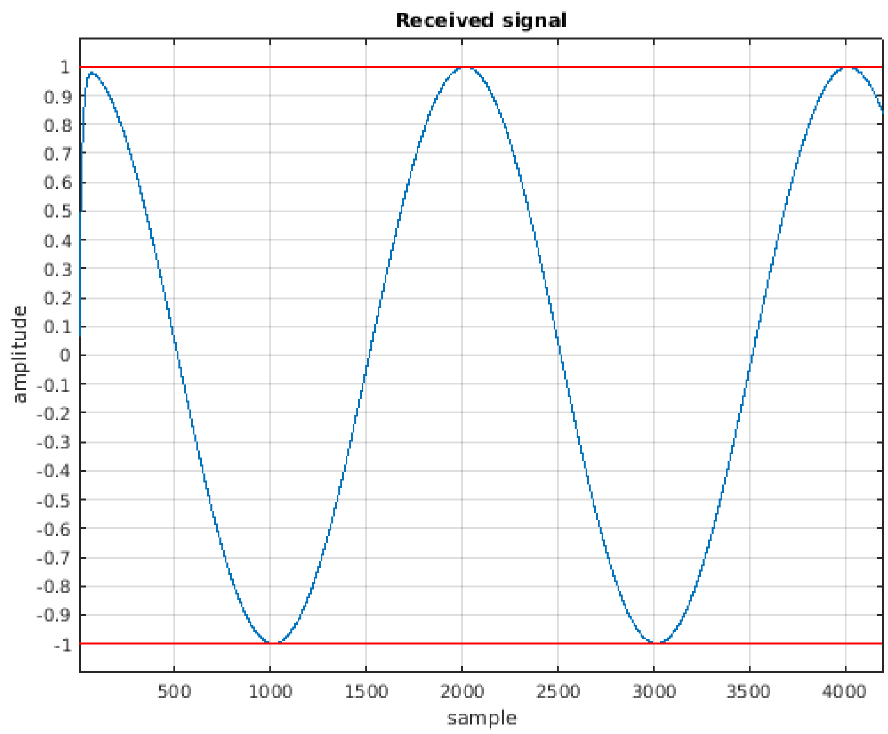


Figure 2



Run Code

INSTRUCTIONS

The MATLAB code above creates a unit amplitude cosine wave with frequency **freq**, transmits it through a model of the infrared (IR) channel, and creates plots of the input and output to the channel. We will observe that after an initial startup (transient) period, the output of the channel is a cosinusoidal signal with the same frequency as the input. However, it is scaled in amplitude. The scaling factor is frequency dependent, and is known as the amplitude response of the channnel, or equivalently as the amplitude of the frequency response.

The initial code first creates the input signal **tx_wave**, which is composed of **nsamp** samples of a cosine wave with angular frequency **freq**. Then, we send the signal through a model of the IR channel, which is implemented by the function **txrx**. This model assumes that the IR channel is a linear time invariant system with step response

$$s(n) = (1 - a^{n+1})u(n)$$

where $u(n)$ is the unit step function. The parameter a is controlled by the MATLAB variable **a** in the code.

To inspect how the channel affects the transmitted signal, we plot the transmitted signal in Figure 1 and the received signal (**rx_wave**) in Figure 2. If you run the code, you may notice that at the beginning (near n = 0), the received signal does not look exactly like a cosine signal. This is because the output signal only looks like a cosine signal if the filter has been running for a very long time. When the filter first starts up, it takes some time until the output looks like a cosine. This initial difference is known as the transient response. In order to avoid artifacts introduced by the transient response, we will examine the output only after a period of time where we allow these transient effects to die away. This time period depends upon the step response. The longer the step response takes to settle to its final value, the longer this transient period. For the channel here, the transient effects are negligibly after 200 samples.

The effect of the amplitude response of the channel at the selected frequency can be determined by measuring the peak-to-peak amplitude of the received signal. The peak-to-peak amplitude is equal to the difference between the maximum and minimum values of the signal. Since a cosine wave with amplitude A varies between $-A$ and $+A$, its peak-to-peak amplitude is $2A$. When measuring the amplitude experimentally, we usually measure the peak-to-peak amplitude, rather than the maximum value, since the peak-to-peak amplitude does not change if the received signal has an offset that moves the average value away from zero, while the maximum changes.

To assist your measurement, we plot two red lines that identify the maximum and the minimum amplitudes (peaks) of the received signal. As discussed above, to avoid artifacts due to the transient response, we wait 200 samples before looking for the maximum and minimum values. We also have to make sure that there are enough samples so that we can observe one complete cycle of the cosine. Since we use a cosine with normalized frequency **freq**= 0.001, one period is 1000 samples. Thus, we set **nsamp** = 1200 to account for the transient response and one period. Since we will only be dealing with cosines with frequencies greater than or equal to 0.001 here, the periods are shorter than 1000 samples. Thus, we can leave **nsamp** unchanged and still be sure that we observe at least one period. However, if you wish to simulate lower frequencies, you should increase the value of **nsamp** accordingly.

Your task is to experiment with the code by modifying the exponential parameter **a** of the channel, the angular frequency **freq** and the number of samples **nsamp** to see how the plots change. Use the insight gained to answer the questions below.

LAB 3 - TASK 1 QUESTION 1 (1/1 point)

Modify the frequency (**freq**) of the transmitted cosine to examine the input and output of the channel when the frequency varies among the values 0.001, 0.005, 0.012, 0.03 and 0.06.

What is the peak to peak amplitude of the output when freq = 0.001?

2 ✔ **Answer:** 1.99

2

What is the peak to peak amplitude of the output when freq = 0.005?

1.8 ✔ **Answer:** 1.84

1.8

What is the peak to peak amplitude of the output when freq = 0.012?

1.4 ✔ **Answer:** 1.39

1.4

What is the peak to peak amplitude of the output when freq = 0.03?

0.7 ✔ **Answer:** 0.72

0.7

What is the peak to peak amplitude of the output when freq = 0.06?

0.4 ✔ **Answer:** 0.38

0.4

You have used 1 of 3 submissions

LAB 3 - TASK 1 QUESTION 2 (1/1 point)

What type of filter is the channel?

- (•) Low Pass ✔
- ( ) Band Pass
- ( ) High Pass

You have used 1 of 2 submissions

LAB 3 - TASK 1 QUESTION 3 (1/1 point)

Set the frequency to **freq**= 0.02. Try modifying the exponential factor **a** of the channel.

How does the value affect the peak to peak amplitude of the channel output?

- (selected) If **a** increases, the peak to peak amplitude decreases. ✔
- If **a** increases, the peak to peak amplitude increases.

EXPLANATION

Higher the exponential factor a is, lower the maximum amplitude is.

You have used 1 of 1 submissions

LAB 3 - TASK 1 QUESTION 4 (1/1 point)

Set the value of freq to 0.0005 and experiment with the code by modifying the number of samples **nsamp**.

How many samples are required to show two complete cycles of the sinusoidal function? Consider only the transmitted signal here.

- 1500
- 2000
- 3000
- (selected) 4000 ✔

EXPLANATION

Considering that freq is the angular frequency, the number of samples required to show one cycle are 1/freq, so that, to show two cycles we need 4000 samples.

You have used 1 of 2 submissions