Demodulation of phase shift keying and higher order PSK ($m = 4$)

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This lab is about demodulating phase shift keying and PSK with more angles (we do four angles). At the end you should have demodulated the pacman from the last assignment and then written at least a modulator with $m = 4$ phases and started the demodulator for $m = 4$ PSK.

1 BPSK - demodulation

1. Generate a carrier signal with the same frequency (10 samples / cycle) as before which has the same length as the bpsk signal.

2. Mix the carrier signal with your bpsk signal and check that you see a shift in DC when a phase change happens.

3. Filter the resulting signal with a lowpass filter:

   \[
   b = \text{fir1}(100,0.05);
   \]

   \[
   \text{lp\_demod} = \text{filter}(b,1,\text{mixer});
   \]

   which generates you a lowpass filter with cutoff frequency $f_c = 0.05$ and the operation “filter” filters your signal. Experiment with different cutoff frequencies so that the demodulated signal looks smooth. The term 100 determines the order of the filter. The higher the order the better the damping but the longer the processing delay (roughly half the order). You should see a demodulated signal which looks like the one shown in Fig 1.

4. Sample the lowpass filtered signal for the different symbols and piece together the pacman image. Check that all pixels are properly detected.

   Check the image with \texttt{imshow(image)};

5. Try out images from other groups.

2 PSK for $m = 4$ modulation and demodulation

Rewrite your entire program so that it transmits two bits/symbol with a $m = 4$ constellation as presented in the lecture. The bits should be Gray encoded.

Some tips:

1. As a good practise use \texttt{cos} for the signal generation and not \texttt{sine}.

2. Use a phase lookup table for your bit values ranging from 0...3:

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phase_lookup = [ pi/4+0*pi/2, pi/4+1*pi/2, pi/4+2*pi/2, pi/4+3*pi/2 ];

check that this lookup table complies with the Gray encoding (this one doesn’t!).

3. Generate carrier signals which are cos for inphase and -sin for the quadrature signal and mix them with the received signal so that you obtain two lowpass filtered signal which then can be sampled.

4. For decoding back to numbers you can either use two nested if statements or a matrix.

5. Debug your system systematically by using test signals at the 4 different angles and make sure the right numbers are being decoded before you apply your algorithm to the pacman image.

At the end you should have saved half of the transmission time by using two bits / symbol.

You should at least manage the BPSK demodulation and the m=4 PSK modulation today in the lab and if not that work in your own time till next week.