AV332: Digital Communication Lab

Lab 5
Introduction to Digital Modulation Techniques — Date: 15th and 20th September 2016

1 Baseband line coding

1.1 Task 1 (Compulsory)

Pre-lab tasks:

1. Review at least four baseband line coding schemes. Write down the time domain description of the waveforms used for transmitting a binary 0 and 1. Write down the power spectrum of the line code assuming that the input bits are chosen randomly, with the fraction of 0s and 1s being $\frac{1}{2}$ each.
2. Consider bipolar and unipolar NRZ line codes. Suppose the bit duration for the line code is T_b seconds. Suppose such a line code is used for signalling over a baseband channel (LPF) with cutoff frequency of f_c. Write down the power spectrum of the baseband channel output.

In lab tasks:

1. Let the bit sequence which needs to be transmitted be $\ldots 01010101 \ldots$ (alternating zeros and ones). Generate a bipolar NRZ code for representing this bit sequence with a bit duration of $T_b = 0.001$s using your Emona kit. Record the power spectrum of this waveform.
2. Suppose the bipolar NRZ code is passed through a low-pass filter with cutoff frequency of f_c. Record what percentage of the input power is passed through the channel as T_b for the NRZ code is varied. Choose $\frac{1}{T_b} = \frac{f_c}{2}, f_c, 1.1f_c, \frac{3}{2}f_c, 2f_c, 3f_c$.

1.2 Task 2 (Optional)

Pre-lab tasks:

1. The received baseband line code is sampled and then the samples are applied to a decision device (thresholder with threshold at 0) to obtain the estimates of the received bits. Usually the sampling is done at the middle of the bit period (each bit duration is T_b). However, sampling may be subject to timing errors and errors due to noise. Suppose we transmit the baseband line code with an additional dc shift of $0.5V$ through the baseband channel (LPF with cutoff frequency of f_c). Comment on the minimum value of T_b so that there are no bits received in error if the sampling instant lies within a range of $\pm 0.1T_b$ of the middle of the bit period. Note that the additional dc shift of $0.5V$ is a "model" for noise at sampling instants.

In lab tasks:

1. Let the bit sequence which needs to be transmitted be $\ldots 01010101 \ldots$ (alternating zeros and ones). Generate bipolar and unipolar RZ line codes corresponding to this bit sequence.
2. Experimentally find out the minimum value of T_b asked for in the first prelab task.

2 Binary amplitude shift keying

2.1 Task 1 (Compulsory)

Pre-lab tasks:

1. Study BASK generation and detection from the textbook. Draw a block diagram representation of a system to generate a BASK waveform. Draw a block diagram representation of a system to recover the baseband line code from a BASK waveform using envelope detection. Can BASK be recovered using coherent demodulation? If so draw a block diagram representation of a system to coherently recover the baseband line code from the BASK waveform.

2. If the bit duration of the underlying transmitted bit sequence is T_b, what is the power spectrum of the BASK signal assuming that 0s and 1s occur on average $\frac{1}{2}$ of the time.

In lab tasks:

1. Let the bit sequence which needs to be transmitted be $\ldots 01010101 \ldots$ (alternating zeros and ones). Let the bit duration be 1 ms. Assume that the carrier frequency for BASK be 100 kHz. Using the systems you have drawn in the pre-lab assignment, implement a BASK generator and demodulator (baseband line code recovery). Record the spectrum of the BASK signal and the time domain representation of the input and output line codes.

3 Binary phase shift keying

3.1 Task 1 (Compulsory)

Pre-lab tasks:

1. Review BPSK generation and detection from the textbook. Draw a block diagram representation of a system to generate a BPSK waveform. Draw a block diagram representation of a BPSK coherent demodulator to recover the baseband line code.
2. If the bit duration of the underlying transmitted bit sequence is T_b, what is the power spectrum of the BPSK signal assuming that 0s and 1s occur on average $\frac{1}{2}$ of the time.

In lab tasks:

1. Let the bit sequence which needs to be transmitted be $\ldots 01010101 \ldots$ (alternating zeros and ones). Let the bit duration be 1 ms. Assume that the carrier frequency for BPSK be 100 kHz. Using the systems you have drawn in the pre-lab assignment, implement a BPSK generator and demodulator (baseband line code recovery). Record the spectrum of the BPSK signal and the time domain representation of the input and output line codes.

4 Binary frequency shift keying

4.1 Task 1 (Compulsory)

Pre-lab tasks:

1. Study BFSK generation and detection from the textbook. Draw a block diagram representation of a BFSK generator using a VCO. Draw a block diagram representation of a method to generate BFSK using two BASK generators. Draw a block diagram representation of a demodulator system to recover the baseband line code from a BFSK waveform using envelope detection.
2. If the bit duration of the underlying transmitted bit sequence is T_b, what is the (approximate) power spectrum of the BFSK signal assuming that 0s and 1s occur on average $\frac{1}{2}$ of the time.

In lab tasks:

1. Let the bit sequence which needs to be transmitted be $\ldots 01010101 \ldots$ (alternating zeros and ones). Let the bit duration be 1 ms. Assume that one of the frequencies f_1 for BFSK is 100 kHz. Let the other frequency f_2 be 110 kHz. Implement both BFSK generators that you have studied in the first pre-lab task.
2. Record the measured power spectrum of the BFSK signal. Comment on the differences between the measured power spectrum and what you have in the second pre-lab task as you vary the second carrier frequency f_2. Are there any differences? If so, why do they arise?
3. Implement the envelope detector based demodulator for BFSK. (Implement the demodulator for one of the carrier frequencies using the Emona kit.) Record the output signal in time domain and compare with the input.