School of Engineering Science, Simon Fraser University
ENSC-327
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Lab #4 — Binary Phase Shift Keying

Report format: A "formal report" is required for this lab: single column, 12-point font.

1. OBJECTIVES

To gain practical experience about BPSK modulation and demodulation and investigate the effect of noisy channel on digital transmission.

(CEAB indicators: 1.4: Discipline-specific Knowledge)

2. LIST OF EQUIPMENT

- TIMS AUDIO OSCILLATOR
- TIMS MULTIPLIER
- TIMS ADDER
- TIMS SEQUENCE GENERATOR
- TIMS LINE CODE ENCODER
- TIMS LINE CODE DECODER
- TIMS NOISE GENERATOR
- TIMS DECISION MAKER
- TIMS LPF
- Oscilloscope
- Spectrum Analyzer

IMPORTANT NOTATIONS

T_b denotes bit interval and is 1/bit rate.

NRZ is Non-Return-to-Zero encoding scheme. Using NRZ, a logic 1 bit is sent as a high value (+V volts) and a logic 0 bit is sent as a low value (-V volts).

EXPERIMENT:

BASEBAND BPSK:

a) **Overview:** The generation of binary signals requires a clock. Here, we can generate the clock by using the AUDIO OSCILLATOR. Use the AUDIO OSCILLATOR to generate an 8 kHz signal. The TTL output of the AUDIO OSCILLATOR is then connected to the Line Code Encoder (Fig. 1). The Encoder can divide the input clock signal by different factors. Use the division by 4 output of the Encoder as a 2 kHz clock pulse which is connected to the Sequence Generator. The LINE CODE ENCODER is used to change the data stream to NRZ-L format (0/V volts to -V/+V volts). The LINE CODE ENCODER is driven by a master clock of 8 kHz.

b) **Circuit Assembly:** Make sure that both on-board switches on the SEQUENCE GENERATOR Module are at the Up position. This will generate a 32-bit random sequence which will keep repeating. A new sequence would be generated each time you press RESET. Sequence Generator generates two different sequences marked as X and Y. Connect the SEQUENCE GENERATOR's TTL X output (digital output marked in red on the module), as shown in Figure 2, to the LINE CODE ENCODER's Data In. View the resulting BPSK waveform by connecting NRZ-L output of the Encoder to the oscilloscope. Don't forget to connect the SYNC signal from the Sequence Generator to the oscilloscope's external trigger *. Since this is a repeating sequence, the SYNC will send a pulse at the beginning of every 32-bit sequence to the oscilloscope in order for us to have a steady oscilloscope display. This is your baseband signal. You may not be able to view all 32 bits on the Oscilloscope, but you should be able to view the first 16 bits. Include a screen shot in your report and indicate what the first 16-bits of your sequence are (0s and 1s)?

(*) You might need to change the oscilloscope trigger source settings to external trigger.

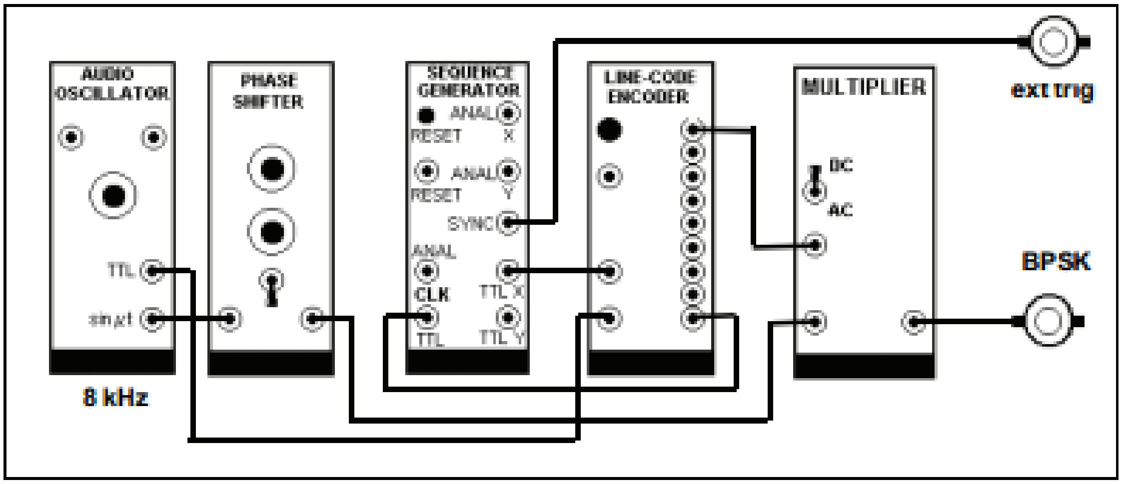

Figure 1

MODULATION:

c) In order to modulate the baseband BPSK signal, we will use an 8KHz sinusoidal carrier generated by the Audio Oscillator. Note that the PHASE SHIFTER is optional, it is used to achieve phase difference values range between -180 - 180 degrees. The modulated signal is generated by multiplying the sinusoidal output of the Audio Oscillator and the baseband BPSK.

Observe the baseband and the modulated signal on the oscilloscope simultaneously. Include a screenshot in your report .Answer the following questions:

What is the length of each bit interval?

What type of modulation is used?

How many periods of the carrier are included within each bit interval?

By observing the modulated signal only, explain briefly how you can tell when the information bit is changed from 0 to 1 or vice versa.

How is the information content of the data stream conveyed by the BPSK waveform?

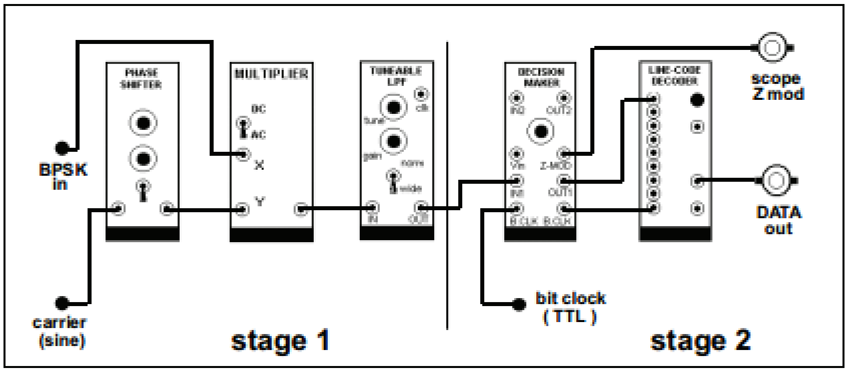

Figure 2

DEMODULATION:

d) To demodulate the BPSK waveform, we will use synchronous demodulation. Connect the modulated BPSK signal and sinusoidal carrier from the AUDIO OSCILLATOR to the MULTIPLIER inputs as shown in Figure 2. Again, you can skip the phase shifter module connection as it is optional. The output of multiplier then needs to be connected to the TUNEABLE LPF module to get the baseband BPSK. The DECISION MAKER module will be used for coherent data recovery. Set the onboard switch SW1 of the Decision Maker to accept NRZ-L coding (You can rotate the switch until you see NRZ-L). Use the 8KHz clock signal from the AUDIO OSCILLATOR in step (a) to connect to DECISION MAKER Bit Clock input. This instructs the decision maker to take 4 samples within each bit duration. Adjust the bandwidth of the TUNEABLE LPF until you get a signal as close as possible to the original baseband BPSK signal. Now adjust the gain of the filter to get 2V peak to peak signal. Connect the output of the LPF Module to IN-1 of the Decision Maker module. Connect the Z-MOD output of the DECISION MAKER module to the oscilloscope on channel 2 and the modulated signal obtained in step (c) on channel 1. You will see the sampling instants in the form of parallel vertical lines. Rotate the Decision Point knob slowly (clockwise) and observe that these lines will move forward. Adjust the Decision Point Knob so that the falling edge of the baseband signal coincides with the sampling instant. The DECISION MAKER will try to re-generate the original bit sequence. Observe the the output of the DECISION MAKER is still in the form of +V and -V volts. Now we will change it to our original binary sequence using the LINE CODE DECODER Module. Connect the OUT1 of the DECISION MAKER to NRZ-L input of the LINE CODE DECODER. The clock of the LINE CODE DECODER comes from the output B CLOCK of the DECISION MAKER. Connect the output of the decoder to oscilloscope and compare with that of the original data stream transmitted in step (b). What is the delay between the input and the output? Include a screenshot of your original bit stream and demodulated bit stream (use both channels in oscilloscope) in your lab report.

EFFECT OF NOISY CHANNEL:

e) To analyze the effects of a noisy channel, we will use the baseband BPSK in (a) and we will skip the modulation and demodulation segments. Connect the BPSK waveform to the input A and output of the NOISE GENERATOR module to input B of the ADDER module. Initially set the gain (g) of the noise input to zero by rotating it fully counter clockwise. Now connect the output of the ADDER module to the DECISION MAKER module and adjust the decision point as previously explained and finally to decode the signal connect to LINE CODE DECODER as previously explained. Set the noise level to +10 db. Now, gradually increase the gain (g) of the noise input. By viewing the output of the Decoder module on channel 2 and the original transmitted sequence on channel on channel 1, you will observe that the noisy input begins to produce errors in the output bit stream. When the decoded bits start to flip due to large noise power, it may not be possible to view a stable display on the oscilloscope. However, you can take one screen shot and include in your report.

Briefly explain what you observe as you increase the noise power.

Now decrease the noise power using the gain g, until the decoder is again error free? What other parameter in the system can you change to increase the BER?

Repeat the experiment for 18 and 20 dB for the noise level and explain you observations.