Indian Institute of Technology, Kharagpur

Department of Electronics & Electrical Communication Engineering

Subject: Digital Communication Laboratory (EC 39001)
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Experiment 3: Binary Phase Shift Keying (BPSK) Modulation

Objective: To implement BPSK modulation for a random bit sequence.

Major Components: IC 741 op-amp, IC M4016 switch, resistors, breadboard, oscilloscope, function generator, supply voltage, connecting wires.

Brief Theory:

Phase Shift Keying (PSK)

PSK is the digital modulation technique in which the phase of the carrier signal is changed by choosing either the sine and cosine signals at a particular time. PSK technique is widely used for wireless LANs, bio-metric, contactless operations, along with RFID and Bluetooth communications.

Binary Phase Shift Keying (BPSK)

Binary Phase Shift Keying (BPSK) is a two phase modulation scheme, where the 0's and 1's in a binary message are represented by two different phase states in the carrier signal: $\theta = 0^\circ$ for binary 1 and $\theta = 180^\circ$ for binary 0.

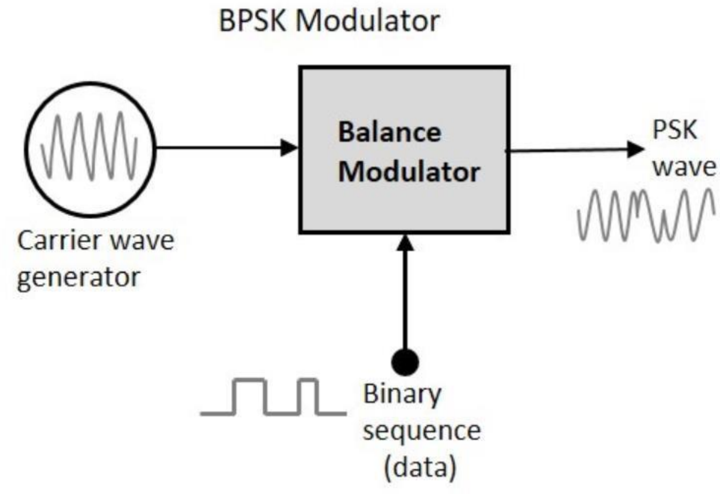
In digital modulation techniques, a set of basis functions are chosen for a particular modulation scheme. Generally, the basis functions are orthogonal to each other. Basis functions can be derived using Gram Schmidt orthogonalization procedure. Once the basis functions are chosen, any vector in the signal space can be represented as a linear combination of them. In BPSK, there is only one basis function which is a sinusoid. Modulation is achieved by varying the phase of the sinusoid depending on the message bits. Therefore, within a bit duration T_b, the two different phase states of the carrier signal are represented as,

$$
\begin{aligned}
s_1(t) &= A_c\, cos(2\pi f_c t), \qquad 0 \leq t \leq T_b \quad \text{for binary 1} \\
s_0(t) &= A_c\, cos(2\pi f_c t + \pi), \quad 0 \leq t \leq T_b \quad \text{for binary 0}
\end{aligned}
$$

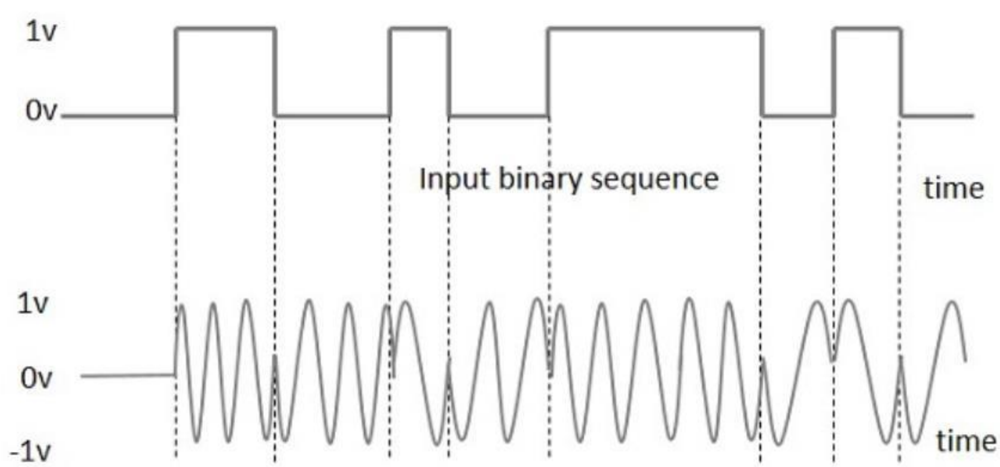
where, A_c is the amplitude of the sinusoidal signal, f_c is the carrier frequency (Hz), t being the instantaneous time in seconds, T_b is the bit period in seconds. The signal $s_0(t)$ stands for the carrier signal when information bit $a_k = 0$ was transmitted and the signal $s_1(t)$ denotes the carrier signal when information bit $a_k = 1$ was transmitted.

BPSK Modulator

The block diagram of Binary Phase Shift Keying consists of the balance modulator which has the carrier sine wave as one input and the binary sequence as the other input. Following is the diagrammatic representation.



The modulation of BPSK is done using a balance modulator, which multiplies the two signals applied at the input. For a zero binary input, the phase will be 0° and for a high input, the phase reversal is of 180°. Following is the diagrammatic representation of BPSK Modulated output wave along with its given input.



The output sine wave of the modulator will be the direct input carrier or the inverted 180° phase shifted input carrier, which is a function of the data signal.

We can intuitively recognize that the system will be more robust if there is greater separation between these two phases. We only have 360° of phase to work with, so the maximum difference between the logic-high and logic-low phases is 180°. But we know that shifting a sinusoid by 180° is the same as inverting it; thus, we can think of BPSK as simply inverting the carrier in response to one logic state and leaving it alone in response to the other logic state.

Expected Outcome: Using the PN sequence generated in the previous lab as input data, design a circuit to generate a BPSK signal and observe in the oscilloscope

References:

1. Proakis, John G., and Masoud Salehi. *Digital communications*.