BINARY PHASE-SHIFT KEYING (BPSK)

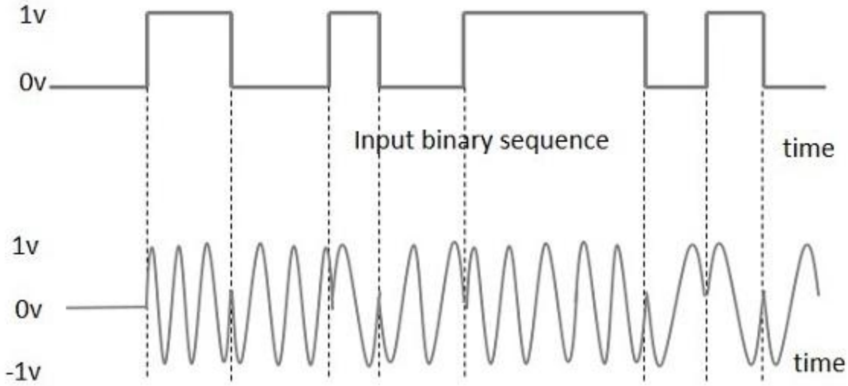
n the simplest form of phase-shift keying known as binary phase-shift keying (BPSK), the pair of signals s1(t) and s2(t) used to represent symbols 1 and 0, respectively, are defined by

$$s_i(t) = \begin{cases} \sqrt{\frac{2E_b}{T_b}}\cos(2\pi f_c t), & \text{for symbol 1 corresponding to } i = 1 \\ \sqrt{\frac{2E_b}{T_b}}\cos(2\pi f_c t + \pi) = -\sqrt{\frac{2E_b}{T_b}}\cos(2\pi f_c t), & \text{for symbol 0 corresponding to } i = 2 \end{cases}$$

Where with Tb denoting the bit duration Eb and denoting the transmitted signal energy per bit. This property, which follows directly from Eq. (7.12), has two important consequences:

**1.** The transmitted energy per bit,Eb is constant; equivalently, the average transmitted power is constant.

**2.** Demodulation of BPSK cannot be performed using envelope detection; rather, we have to look to coherent detection

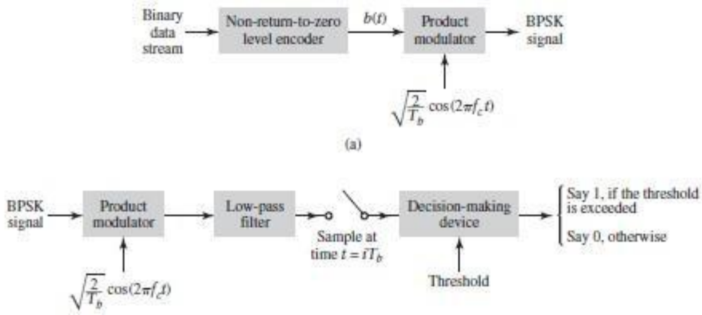



BPSK Modulated output wave

GENERATION OF BPSK SIGNALS

To generate the BPSK signal, we build on the fact that the BPSK signal is a special case of DSB-SC modulation. Specifically, we use a product modulator consisting of two components

**(i)** Non-return-to-zero level encoder, whereby the input binary data sequence is encoded in polar form with symbols 1 and 0 represented by the constant-amplitude levels: and , respectively.




Product modulator, which multiplies the level-encoded binary wave by the sinusoidal carrier c(t) of amplitude to produce the BPSK signal. The timing pulses used to generate the level-

encoded binary wave and the sinusoidal carrier wave are usually, but not necessarily, extracted from a common master clock.

COHERENT DETECTION OF BPSK SIGNALS

To detect the original binary sequence of 1s and 0s, the BPSK signal x(t) at the channel output is applied to a receiver that consists of four sections, as depicted in Fig. 3.1(b)

**(i)** Product modulator, which is also supplied with a locally generated reference signal that is a replica of the carrier wave c(t).

**(ii)** Low-pass filter, designed to remove the double-frequency components of the product modulator output and pass the zero-frequency components.

**(iii)** Sampler, which uniformly samples the output of the low-pass filter at t=iTb where i= the local clock governing the operation of the sampler is synchronized with the clock responsible for bit-timing in the transmitter.

**(iv)** Decision-making device, which compares the sampled value of the low-pass filter's output to an externally supplied threshold, every Tb seconds. If the threshold is exceeded, the device decides in favor of symbol 1; otherwise, it decides in favour of symbol 0.

The BPSK receiver described in Fig. 3.1 is said to be coherent in the sense that the sinusoidal reference signal applied to the product modulator in the demodulator is synchronous in phase (and, of course, frequency) with the carrier wave used in the modulator In addition to synchrony with respect to carrier phase, the receiver also has an accurate knowledge of the interval occupied by each binary symbol.

The operation of the coherent BPSK receiver in Fig. 3.4(b) follows a procedure similar to that described for the demodulation of a double-sideband suppressed-carrier (DSBSC) modulated wave with a couple of important additions: sampler and decision-making device. The rationale for this similarity builds on what we have already stated: BPSK is simply another form of DSB-SC modulation. However, an issue that needs particular attention is how to design the low-pass filter in Fig. 3.4(b)

**3.3 SPECTRAL ANALYSIS OF BPSK**

As with the experiment on BASK, consider a binary data stream that consists of a square wave, the amplitude of which alternates between every Tb seconds. The square wave is centered on the origin. The objectives of this second experiment are similar to those of

Computer Experiment I on BASK:

**(i)** To evaluate the effect of varying the carrier frequency on the power spectrum of the

BPSK signal, for a fixed square modulating wave.

**(ii)** To evaluate the effect of varying modulation frequency on the power spectrum of the BPSK signal for a fixed carrier frequency.

BASK and BPSK signals occupy the same transmission bandwidth—namely,2/Tb — which defines the width of the main lobe of the sinc-shaped power spectra. The BASK spectrum includes a carrier component, whereas this component is absent from the BPSK spectrum. With this observation we are merely restating the fact that BASK is an example of amplitude modulation, whereas BPSK is an example of double sideband-suppressed carrier modulation.