Digital Communications
Unit IV

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Wireless Revolution

Yesterday - 2000

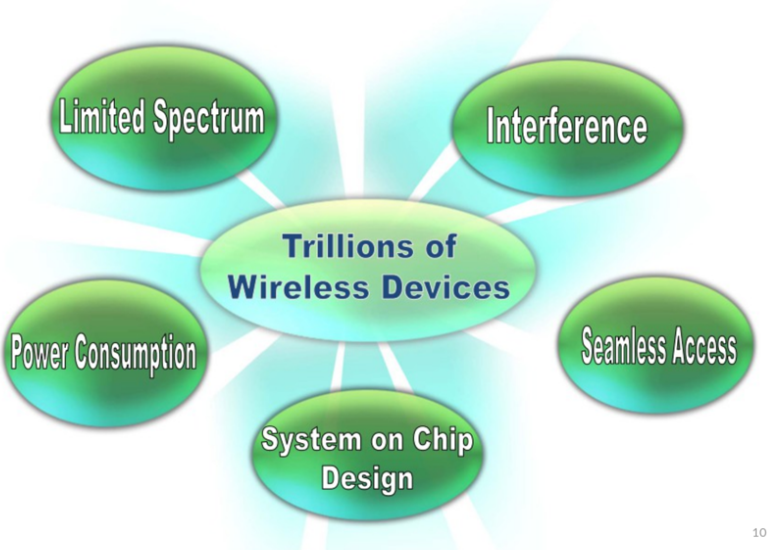
Millions of wireless devices

Today - 2016

Billions of wireless devices

Wireless Revolution

Challenges


Limited Spectrum
Interference
Trillions of Wireless Devices
Power Consumption
Seamless Access
System on Chip Design

Topics

Basic Theory:

1. Pulse Amplitude Modulation (PAM)
2. Pulse Width Modulation (PWM)
3. Pulse Position Modulation (PPM)
4. Pulse Code Modulation (PCM)

Communication Schemes:

1. Amplitude Shift Keying (ASK)
2. Phase Shift Keying (PSK)
3. Frequency Shift Keying (FSK) and
4. Differential Phase Shift Keying (DPSK).

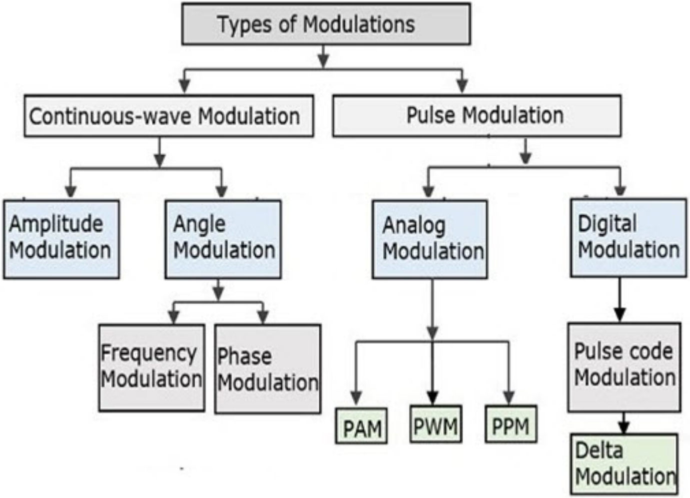
communication system

In a communication system, the modulation is an important step. Modulation is the process of transmitting a message signal (Baseband signal with low frequency) from transmitter to receiver without changing its characteristics (like amplitude, frequency, phase) by using a carrier signal (high frequency) which varies in accordance with the instantaneous values of the low frequency wave by keeping its frequency and phase constant.

Modulation Techniques

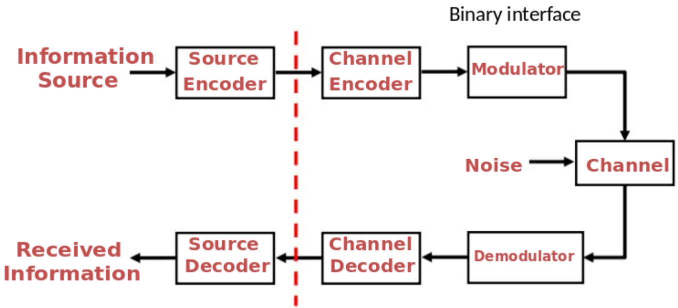
The modulation techniques are classified into two major types: analog and digital or pulse modulation. We have discussed previously the different types of modulation techniques, let us understand the basic difference between PAM, PWM, and PPM.

Types of Modulations Techniques



Types of Modulation Techniques

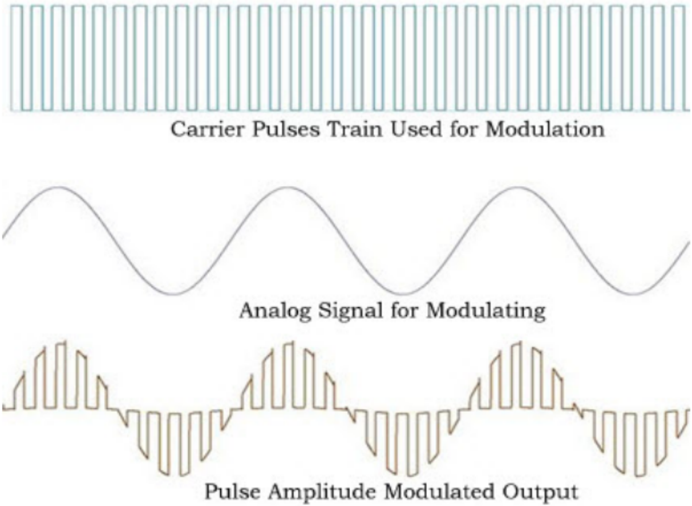
Simplified block diagram of a digital communication system



Pulse Amplitude Modulation

By varying the amplitude of the pulses (the carrier signal) in proportion to the instantaneous values of the analog signal (the message signal).

Pulse Amplitude Modulation



Pulse Amplitude Modulation (PAM) Signals

Pulse Amplitude Modulation

The above figure illustrates the time domain representation of the PAM technique which mentions analog message and PAM modulated signal as an output. content...

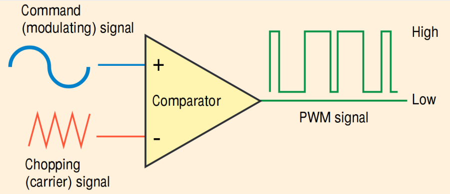
Pulse amplitude modulation is used in the popular Ethernet communication standard. The PAM modulator and demodulator circuits simple compared to other kinds of modulation and demodulation techniques.

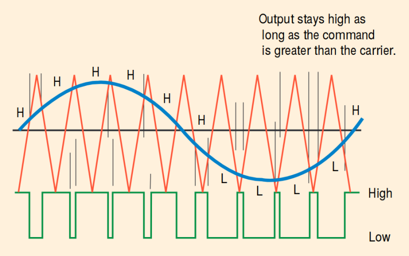
There are two categories of PAM techniques, one is the pulses have the same polarity and the other in which the pulses can have both positive and negative polarities according to the amplitude of the modulating signal.

Pulse Width Modulation

Pulse-width modulation (PWM) is a modulation process or technique used in most communication systems for encoding the amplitude of a signal right into a pulse width or duration of another signal, usually a carrier signal, for transmission.

Pulse Width Modulation





Pulse Width Modulation

A simple comparator with a sawtooth carrier can turn a sinusoidal command into a pulse-width modulated output. In general, larger the command signal, wider the pulse.

One of the advantages of PWM is that the signal remains digital all the way from the processor to the controlled system; no digital-to-analog conversion is necessary.

By keeping the signal digital, noise effects are minimized. Noise can only affect a digital signal if it is strong enough to change a logical 1 to a logical 0, or vice versa.

Pulse Width Modulation

Increased noise immunity is yet another benefit of choosing PWM over analog control, and is the principal reason PWM is sometimes used for communication.

Switching from an analog signal to PWM can increase the length of a communications channel dramatically. At the receiving end, a suitable RC (resistor-capacitor) or LC (inductor-capacitor) network can remove the modulating high frequency square wave and return the signal to analog form.

Pulse Position Modulation

Pulse position modulation (PPM) is a signal modulation used for both analog and digital signal transmissions. This method is widely used for optical communication systems such as optic fiber and IR remote controls, where efficiency is required and little or no external interference occurs.

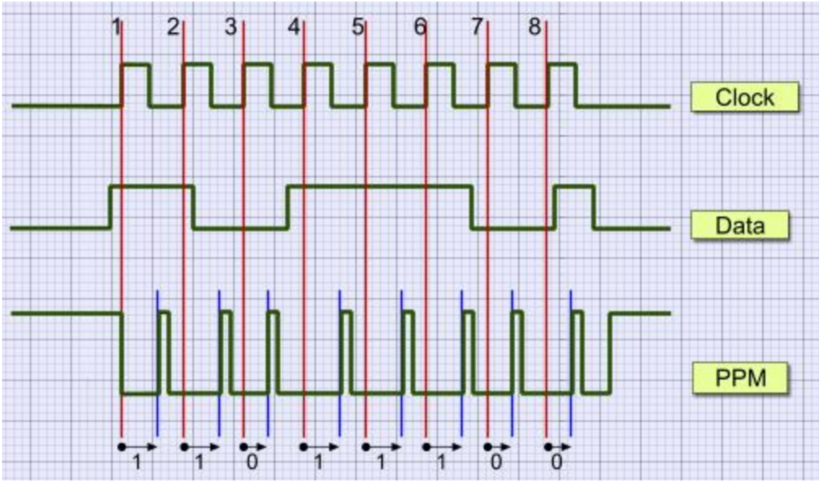
Pulse Position Modulation

Modulating a digital signal to Pulse Position is pretty much straight forward. The duration between the pulses will represent a digital 0 or 1.

A small duration represents digital 0, and a large duration represents digital 1. The duration is not standard and varies according to the system requirements.

An example is the IR TV remote control. The Sony IR protocol for example uses PPM transmission. A delay of 1.2mSec represents digital 0, and a delay of 1.8mSec represents digital 1. Here is an 8-bit data transmission example:

Pulse Position Modulation

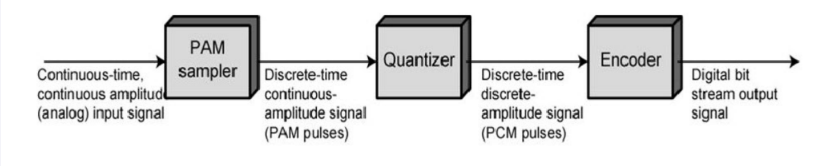


The byte '11011100' is encoded with PPM so that it can be transmitted with infrared light. For the first bit (1), the transmitter will send a pulse 1.8 mSec after the rising edge of the clock. For the second bit (1), the transmitter will send a pulse 1.8 mSec after the second rising edge of the clock. But for the third bit which is 0, the transmitter will send a pulse after 1.2 mSec from the third rising edge of the clock. Same algorithm applies for all other bits.

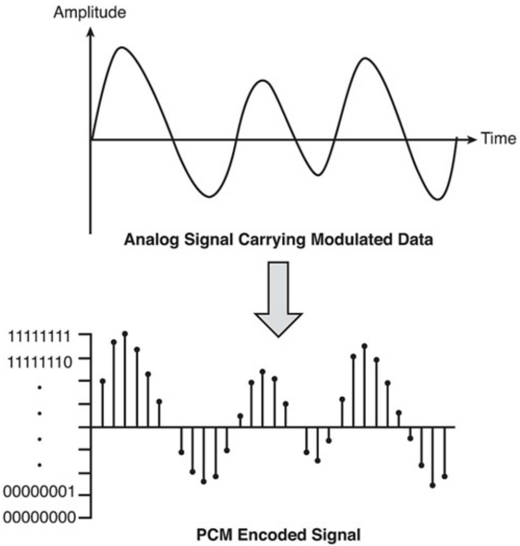
Pulse Code Modulation

Pulse code modulation is a method that is used to convert an analog signal into a digital signal, so that modified analog signal can be transmitted through the digital communication network. PCM is in binary form ,so there will be only two possible states high and low(0 and 1). We can also get back our analog signal by demodulation. The Pulse Code Modulation process is done in three steps Sampling, Quantization, and Coding.

Pulse Code Modulation



Pulse Code Modulation



Pulse Code Modulation

Sampling

Sampling is a process of measuring the amplitude of a continuous-time signal at discrete instants, converts the continuous signal into a discrete signal.

Quantization

An analog sample with an amplitude that converted into a digital sample with an amplitude that takes one of a specific defined set of quantization values. Quantization is done by dividing the range of possible values of the analog samples into some different levels, and assigning the center value of each level to any sample in quantization interval. Quantization approximates the analog sample values with the nearest quantization values. So almost all the quantized samples will differ from the original samples by a small amount.

Quantization

The encoder encodes the quantized samples. Each quantized sample is encoded into an 8-bit code word by using A-law in the encoding process.
Bit 1 is the most significant bit (MSB), it represents the polarity of the sample. "1" represents positive polarity and "0" represents negative polarity. Bit 2,3 and 4 will defines the location of sample value. These three bits together form linear curve for low level negative or positive samples. Bit 5,6,7 and 8 are the least significant bits (LSB) it represents one of the segments quantized value. Each segment is divided into 16 quantum levels.

Communication Schemes

Amplitude Shift Keying (ASK)

Phase Shift Keying (PSK)

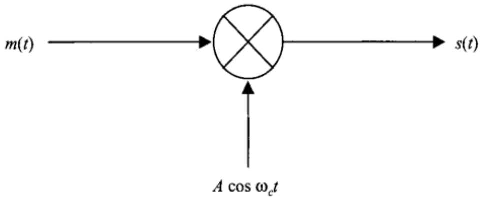
Frequency Shift Keying (FSK)

Differential Phase Shift Keying (DPSK)

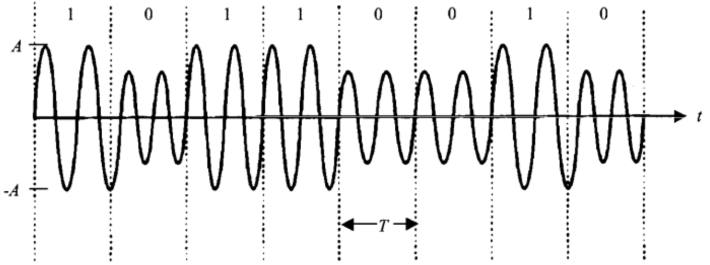
Amplitude Shift Keying (ASK)

The most basic (binary) form of ASK involves the process of switching the carrier either on or off, in correspondence to a sequence of digital pulses that constitute the information signal. One binary digit is represented by the presence of a carrier, the other binary digit is represented by the absence of a carrier, Frequency remains fixed .
Amplitude-shift keying (ASK) the amplitude of the carrier is varied inaccordance with the binary source, In its simplest form, the carrier is turned on and off every T seconds to represent 1's and O's, and this form of ASK is known as on-off keying.

Amplitude Shift Keying (ASK)



(a) Amplitude modulation



(b) Amplitude-shift keying (ASK) signal

Amplitude Shift Keying (ASK)

$$s(t) = \frac{A}{2}[1 + m(t)]cos\ \omega_c t \tag{1}$$

where $m(t)$ is the modulating signal and ω_c is the carrier frequency
Since the carrier conveys no information, power efficiency is improved by suppressing the carrier and transmitting only the sidebands

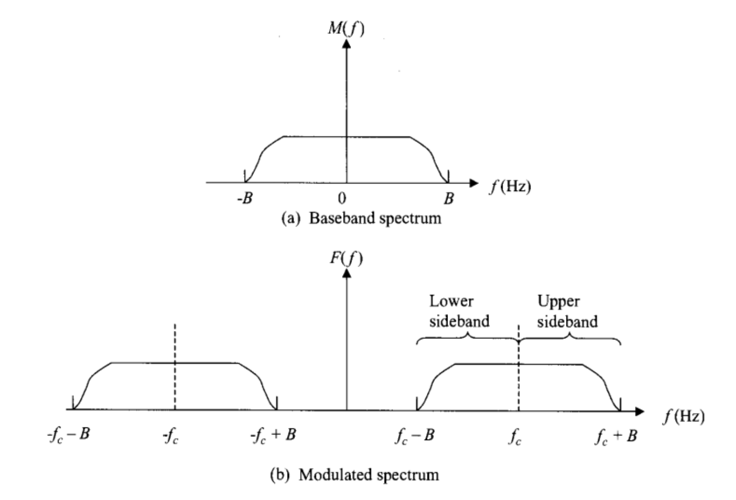
Amplitude Shift Keying (ASK)

The general form of the double sideb and-suppressed carrier (DSB-SC) signal is

$$s(t) = Am(t)cos\ \omega_c t \tag{2}$$

Double sideband signals contain an upper and lower sideband that are symmetrically distributed about the carrier frequency.
For applications in which spectral efficiency is important, the required bandwidth may be halved by use of single sideband (SSB) modulation.
The unwanted sideband is removed by a bandpass filter. The sharp cutoff required for the bandpass filter has led to vestigial sideband (VSB) in which a portion of theunwanted sideband is transmitted along with the complete other sideband.

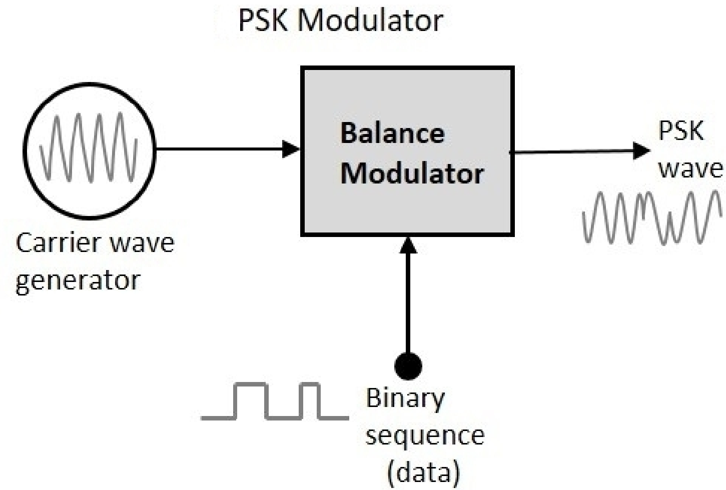
Amplitude Shift Keying (ASK)



Phase Shift Keying (PSK)

Phase Shift Keying (PSK) is the digital modulation technique in which the phase of the carrier signal is changed by varying the sine and cosine inputs at a particular time. PSK technique is widely used for wireless LANs, bio-metric, contactless operations, along with RFID and Bluetooth communications.

Phase Shift Keying (PSK)

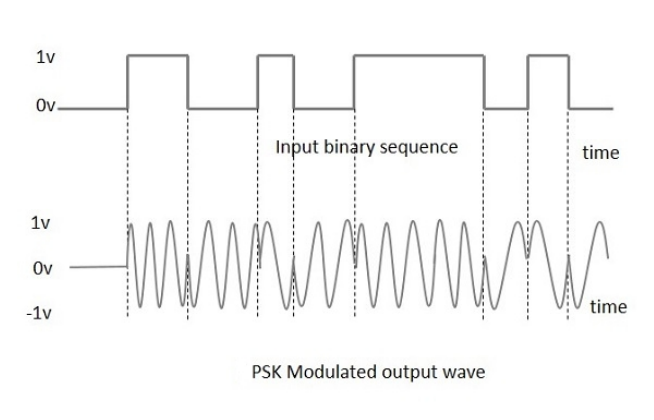


Phase Shift Keying (PSK)

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.

The modulation of PSK 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^o and for a high input, the phase reversal is of 180^o.

Phase Shift Keying (PSK)

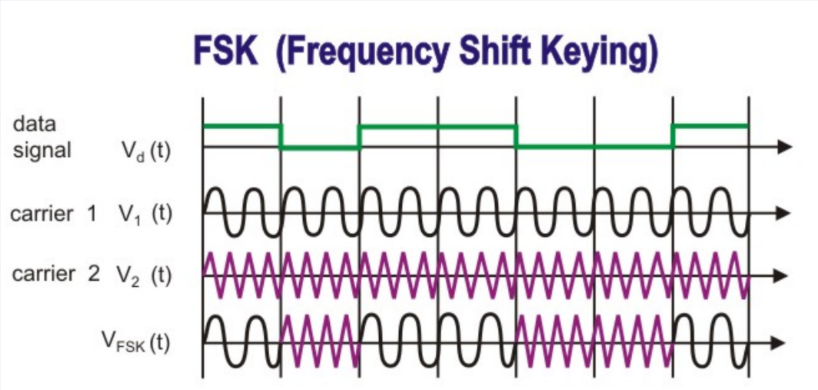


The output sine wave of the modulator will be the direct input carrier or the inverted (180^o phase shifted) input carrier, which is a function of the data signal.

Frequency Shift Keying (FSK)

The most basic form of FSK involves the process of varying the frequency of a carrier wave by choosing one of two frequencies (FSK) in correspondence to a sequence of digital pulses that is the information signal. Two binary digits are represented by two frequencies around the carrier frequency, Amplitude remains fixed.

Frequency Shift Keying (ASK)



Frequency Shift Keying (FSK)

$$s_1(t) = A \cos \omega_1 t \qquad \textit{for Binary } 1 \tag{3}$$

$$s_0(t) = A \cos \omega_0 t \qquad \textit{for Binary } 0 \tag{4}$$

An alternative representation of the FSK waveform is obtained by letting $f_1 = f_c - \Delta f$ and $f_0 = f_c - \Delta f$, so that

$$s_1(t) = A \cos (\omega_c - \Delta\omega)t \tag{5}$$

$$s_0(t) = A \cos (\omega_c + \Delta\omega)t \tag{6}$$

where Δf is called the **frequency deviation**.

transmission bandwidth (B_T) requirements can be estimated for two cases of special interest:

$$f(x) = \begin{cases} 2\Delta f, & \Delta f \gg B \\ B, & \Delta f \ll B \end{cases}$$

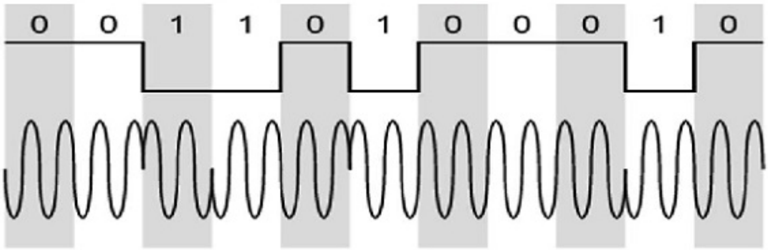
where B is the bandwidth of the baseband modulation signal. The ratio of the frequency deviation Δf to the baseband bandwidth B is called the **modulation index** m, defined as A general relationship defining FM transmission bandwidth was established

$$m = \frac{\Delta f}{B} \tag{7}$$

Differential Phase Shift Keying (DPSK)

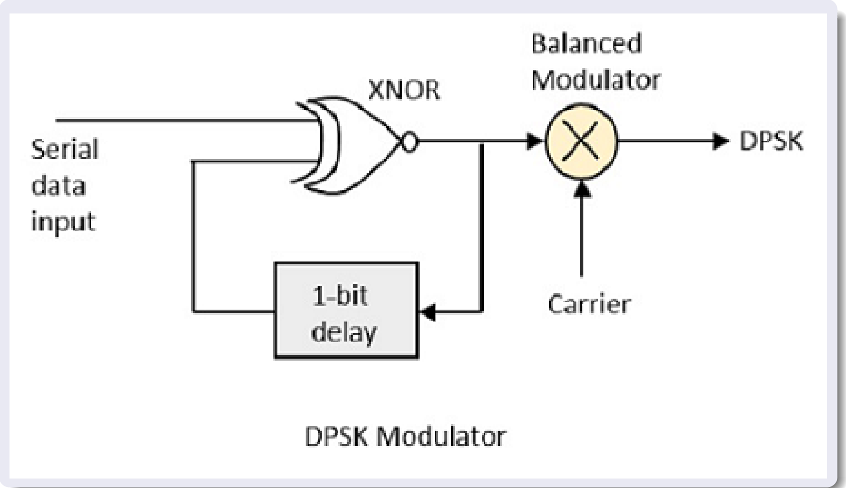
Differential phase-shift keying (DPSK) is an alternative form of digital modulation where the binary input information is contained in the difference between two successive signaling elements rather than the absolute phase.

Frequency Shift Keying (ASK)



if the data bit is Low i.e., 0, then the phase of the signal is not reversed, but continued as it is. If the data is a High i.e., 1, then the phase of the signal is reversed.

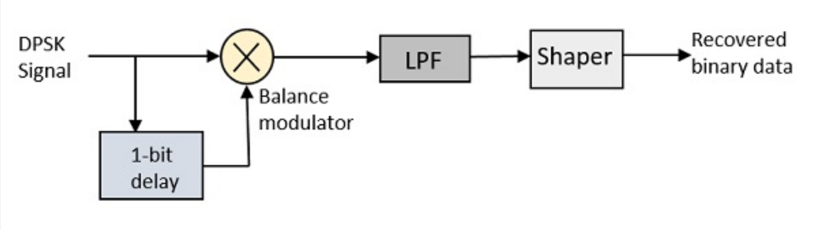
Differential Phase Shift Keying (DPSK)



DPSK is a technique of BPSK, in which there is no reference phase signal. Here, the transmitted signal itself can be used as a reference signal.

Differential Phase Shift Keying (DPSK)

DPSK encodes two distinct signals, i.e., the carrier and the modulating signal with 180^o phase shift each. The serial data input is given to the XNOR gate and the output is again fed back to the other input through 1-bit delay. The output of the XNOR gate along with the carrier signal is given to the balance modulator, to produce the DPSK modulated signal.



The phase of the reversed bit is compared with the phase of the previous bit. Following is the block diagram of DPSK demodulator. That signal is made to confine to lower frequencies with LPF. Then it is passed to a shaper circuit, to recover the original binary data as the output.


Thank you