Modulation Schemes in Satellite Communication

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ELECTRONICS & TELECOMMUNICATION ENGINEERING

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MODULATION

- A process of varying one or more properties of carrier signals with message/modulation signal.
- Properties can be amplitude, frequency and phase.

WHY MODULATION?

- Enables the adjustment of antenna in terms of size.
- Enables long distance communication
- Reduces the effect of noise on the signal.
- Need of digital modulation because digital modulation provides flexibility.
- Flexibility indicates ruggedity, compression, encryption, and possibility of error correction.

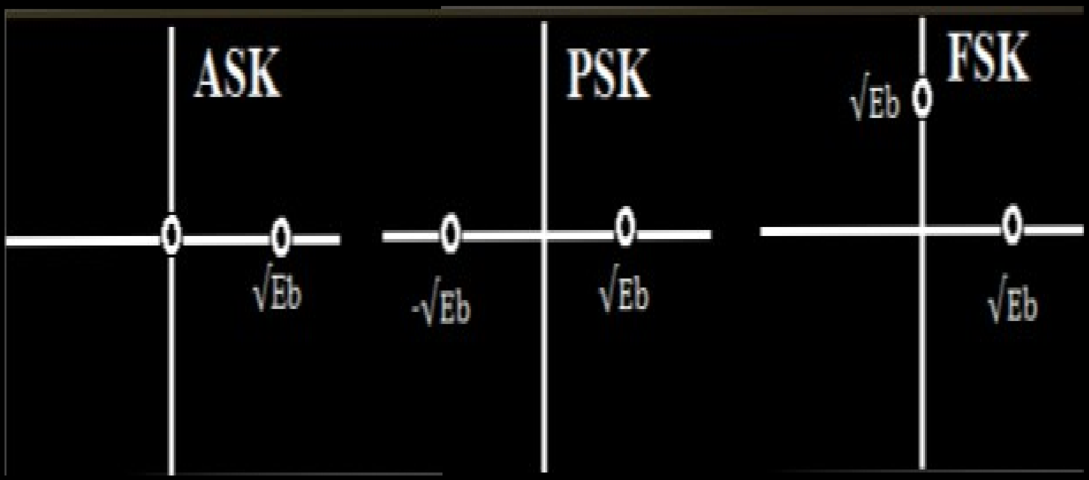
WHY MODULATION?(Cont.)

$C=B*\log_2(1+S/N)$

Here, C: channel capacity in bits/second
B:bandwidth of the channel in Hz
S: Signal power in watts
N:Noise power in watts

Keeping the bandwidth constant, does it mean that infinite bits can be transmitted over a channel by varying the signal to noise ratio?

WHY MODULATION?(Cont.)



Analog Modulation

- A procedure of transmitting low-frequency baseband signals along with a high-frequency carrier signal
- A bandpass channel is required where it corresponds to the specific range of frequencies
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- The carrier signal is represented as:

$$A_c \cdot \cos(2\Pi f_c t + \Phi)$$

Where; Ac- amplitude, fc - frequency and Φ - phase of the carrier signal

Amplitude Modulation

- In amplitude modulation ,the amplitude of the carrier signal is varied in accordance with the amplitude of the modulating signal by maintaining frequency and phase at constant.
- The modulating (input signal) represented as : $i(t) = A_i\cos(2\prod fit)$
- The carrier signal is represented as: $c(t) = A_c\cos(2\prod fct)$
- In the expressions, A_i and A_c represent the amplitudes of two waves while f_i and f_c are the frequencies of the two waves correspondingly.
- Solving the two expressions, a modulated wave is represented as:

$$M(t) = A_i + A_c\cos(2\prod (f_i + f_c)t)$$

- The modulating signal is twice the band-width of the message signal.

Frequency Modulation

- In frequency modulation, the frequency of the carrier signal is varied in correspondence

  with the amplitude of the modulating signal by maintaining amplitude and phase

  at constant.
- When the modulating (input signal) is represented as i(t) and the carrier signal is

  represented as $c(t) = A_c \cos(2\prod f_c t)$, then the frequency- modulated

  wave is $M(t) = A \cos (2\prod f_c + ks(t)t + \Phi)$
- The bandwidth of the FM modulated wave is cosidered in two cases:
  - In narrowband FM, the bandwidth is two times the maximum frequency of the FM.
  - In wideband FM, the bandwidth is very large of the FM spectrum.

Phase Modulation

- In phase modulation, the phase of the carrier signal is varied in correspondence with the amplitude of the modulating signal by maintaining amplitude and frequency at constant.
- $P(t) = A_c \cos[W_c t + k_p m(t)]$

  Here A_c represents the amplitude of the carrier signal

  W_c represents the carrier signal's angular frequency $2\prod f_c$

  And m(t) represents the modulating signal

Digital Modulation

- parameter of analog carrier is varied between two or more discrete states.
- Historically known as “Shift Keying”
- Power of digital signal processing makes digital modulation a natural choice.
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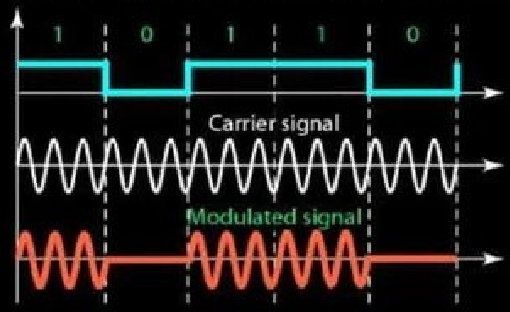
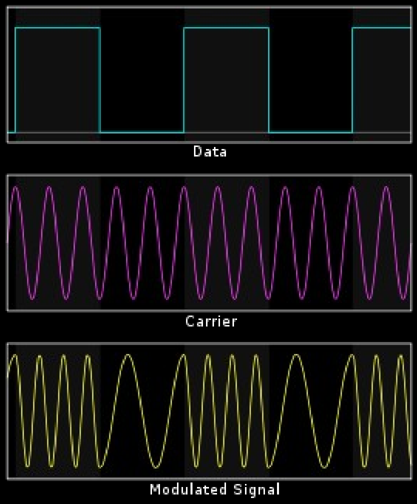
Amplitude Shift Keying

- In ASK, the amplitude of the signal is changed in response to information and all else is kept fixed
- Bit 1 is transmitted by a signal of one particular amplitude. To transmit 0,we change the amplitude keeping the frequency constant



Frequency Shift Keying

- In FSK, frequency of the carrier wave is changed according to the discrete baseband signal
- One particular frequency is used for a ‘1’ and another frequency for a ‘0’



Phase Shift Keying

- A digital modulation scheme that conveys data by changing the phase of carrier signal
- Universally used for satellite links
- Phase of carrier is set into one of m states according to the value of a modulating voltage
- phase state of the transmitted signal represents a symbol, which can convey more than one bit.

Binary Phase Shift Keying

- Digital modulation technique that conveys data by modulating two different phases of carrier wave(reference) separated by 180^0.
- Also known as 2-PSK
- Use different phased signals to represent binary values.
  - 0 = In phase with reference
  - 1= Out of phase with reference

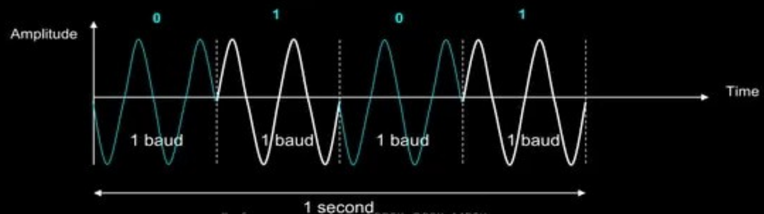
BPSK (Cont.)

General expressions for BPSK:

$$s_0(t) = -\sqrt{\frac{E_b}{T_b}}\cos 2\pi f_c t \text{ ; for binary 0}$$

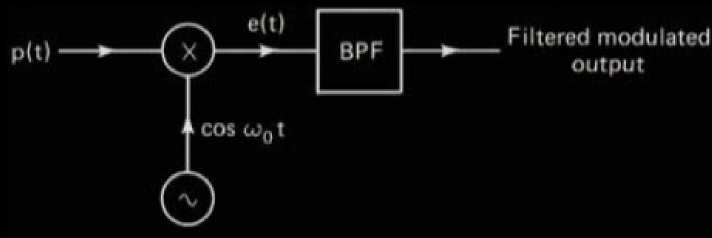
$$s_1(t) = \sqrt{\frac{E_b}{T_b}}\cos 2\pi f_c t \text{ ; for binary 1}$$

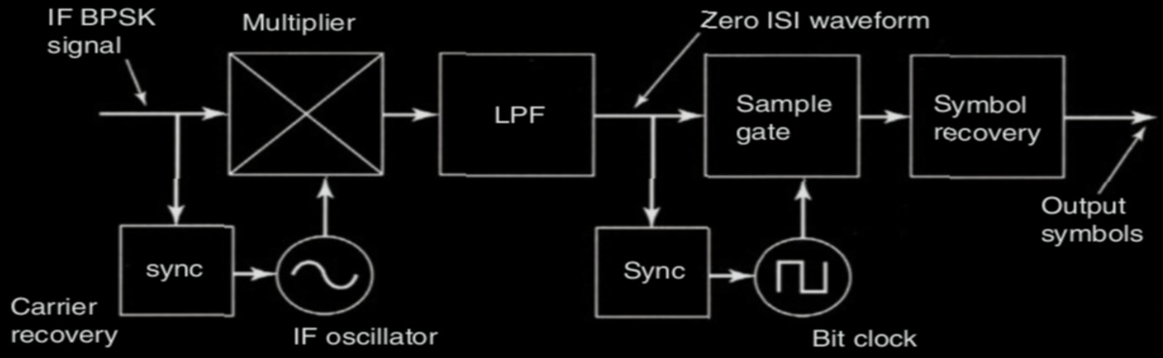
Waveform of BPSK:



7/11/2019 Performance analysis of BPSK, QPSK, MPSK and DPSK 5

BPSK Modulator and Demodulator





QUADRATURE PHASE SHIFT KEYING

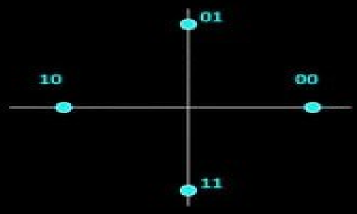
- In QPSK, two bits are grouped together to form signals, and one of the four possible cases are: 00,01,10 and 11 is transmitted.
- PSK that uses phase shifts of $90^{o}=\pi/2$rad.
- 4 different signals are generated, each representing two bits.
- Higher data rate than BPSK, while bandwidth occupancy remains the same.

QPSK(Cont.)

- General expressions for QPSK:

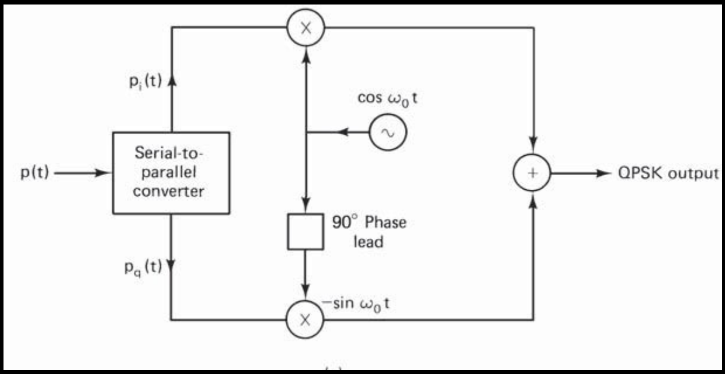
$$S_{QPSK}(t)= \sqrt{\frac{2E_b}{T_b}}\cos[2\pi f_c t+(i-1)\frac{\pi}{2}]$$

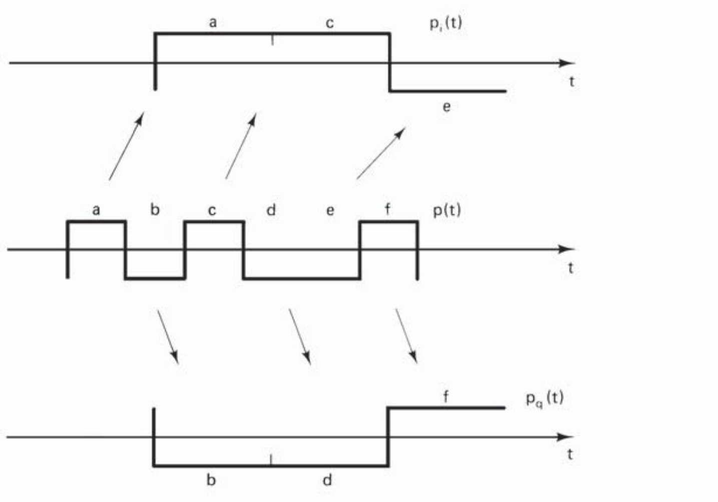
- QPSK Constellation:



4-PSK (Q-PSK)

QPSK Modulator





(b)

QPSK Demodulator