Modulation and demodulation

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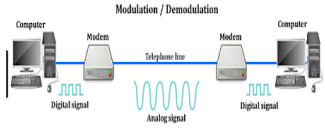
Modulation and Demodulation

- ***Modulation*** refers to the process of encoding information in a signal, while *demodulation* refers to the process of extracting information from a transmitted signal.



Modulation and Demodulation

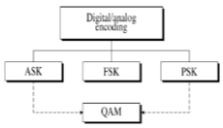
Digital Modulation

- The analog signals were used for long distance communication.
- This analog form of communication has many problems in transmission such as interference, security problems etc.
- In order to make communication more safer and reliable digital signals are used.
- The basic digital modulation techniques are
  - Amplitude-Shift Keying (ASK)
  - Phase-Shift Keying (PSK)
  - Frequency-Shift Keying (FSK)
  - Quadrature Amplitude Modulation (QAM)

Modulation and Demodulation

Digital Modulation

- Digital modulation is ideally suited to a multitude of communication applications including both **cable** and **wireless** systems.
- Applications includes
  - relatively low-speed voice-band data communications systems
  - high-speed data transmission systems
  - digital satellite communication systems
  - personal communication systems



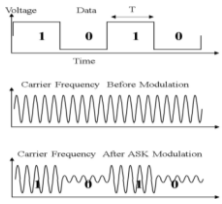
Modulation and Demodulation

Amplitude-Shift Keying (ASK)

- In this method signal level is represented by variations in the amplitude of the signal.
- In ASK only the amplitude is varied keeping **phase** and **frequency** constant.
- ASK is sometimes called as ***digital amplitude modulation*** (DAM).

Modulation and Demodulation

Amplitude-Shift Keying (ASK)



Modulation and Demodulation

Amplitude-Shift Keying (ASK)

- Amplitude shift keying is given in mathematical terms as:

$v_{ask}(t) = [\ 1 + v_m(t)\ ][\ A/2 \cos(\omega_c t)]$

Where

$v_{ask}(t)$ is amplitude-shift keying wave

$v_m(t)$ is digital modulation (modulating) signal in volts

A/2 is unmodulated carrier amplitude in volts and

ω_c is analog carrier radian frequency in radians per second.

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Amplitude-Shift Keying (ASK)

- In the above equation, for the modulating signal $v_m(t)$, logic 1 is represented by **+1V** and logic 0 is represented by **-1V**.
- So the modulated wave $v_{ask}(t)$ is either $A\cos(\omega_c t)$ or **0** i.e., the carrier is either ***on*** or ***off***.
- ASK is sometimes referred as **on-off keying (OOK)**.
- The rate of change of the ASK waveform (baud) is the same as the rate of change of the binary input making bit rate equal to baud.

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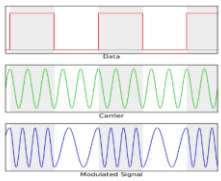
Frequency Shift Keying (FSK)

- In this method also signal level is represented by variations in the frequency of the signal.
- In FSK only the frequency is varied keeping ***amplitude*** and ***phase*** constant.
- We then use different frequency levels to show the signal levels 0 and 1.
- This binary data is converted by a modem into an FSK signal, which can be transmitted via telephone lines, fibre optics or wireless media.
- FSK is commonly used for caller ID and remote metering applications.

Modulation and Demodulation

Frequency Shift Keying (FSK)

- The binary **1s** and **0s** are called **Mark** and **Space frequencies**.
- Frequency deviation can be expressed as $f = |f_m - f_s| / 2$



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Phase-Shift Keying

- Phase-shift keying (PSK) is a method of **modulating digital signals onto an analog carrier wave** in which the **phase of the carrier wave is shifted between two or more values**, depending upon the logic state of the input bit stream.
- The simplest method uses two phases - 0 degrees and 180 degrees.
- The logic state of each bit is examined with respect to the logic state of the preceding bit.
- If the logic state changes (i.e. from logic high to logic low) the phase of the carrier is shifted by 180 degrees.
- If the logic state does not change, the phase of the carrier remains the same.

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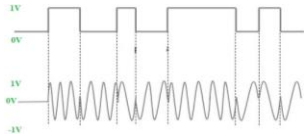
Phase-Shift Keying



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- **Binary phase-shift keying**:
- The simplest PSK technique is called **binary phase-shift** keying (BPSK), where N = 1 and M = 2.
- Therefore, with **BPSK** two phases are possible for the carrier.
- It uses two opposite signal phases (0 and 180 degrees).
- The digital signal is broken up time wise into individual bits (binary digits).
- The state of each bit is determined according to the state of the preceding bit.

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Binary phase-shift keying:

- If the phase of the wave does not change, then the signal state stays the same (0 or 1).
- If the phase of the wave changes by 180 degrees -- that is, if the phase reverses -- then the signal state changes (from 0 to 1 or from 1 to 0).
- Because there are two possible wave phases, BPSK is sometimes called ***biphase modulation or phase-reversal keying (PRK).***

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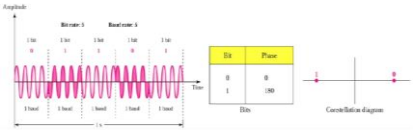
Binary phase-shift keying:

- A ***constellation diagram*** is a two-dimensional method of looking at the signal.



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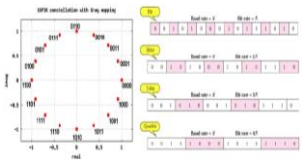
M-ary encoding scheme where N = 4, M = 16

- Phase modulation is widely used for **transmitting radio waves** and is an integral part of many digital transmission coding schemes that underlie a wide range of technologies like Wi-Fi, GSM and satellite television.



Modulation and Demodulation

Quadrature Amplitude Modulation (QAM)

- Quadrature amplitude modulation is a combination of ASK and PSK so that a maximum contrast between each signal unit (bit, dibit, tribit, and so on) is achieved.
- QAM is based on the application of ASK and PSK to two sinusoidal waves of the same frequency but with a phase difference of 90°.
- Sinusoidal waves 90° apart are said to be in a quadrature phase relationship.
- It is customary to refer to one of these waves as the **I wave**, or in-phase wave or component, and the other as the **Q wave**, or quadrature wave or component

Modulation and Demodulation

Quadrature Amplitude Modulation (QAM)

- QAM is a modulation scheme used for both digital and analog signals.
- QAM doubles the effective bandwidth by combining two amplitude-modulated signals into a single channel.
- Allows multiple analog signals to be placed on a single carrier,
- Example: television signals, which contain both color signals and sound.
- The two channels required for stereo sound signals can be carried by a single QAM.

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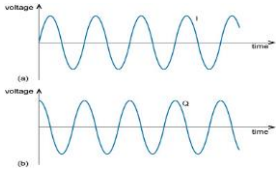
Quadrature Amplitude Modulation (QAM)



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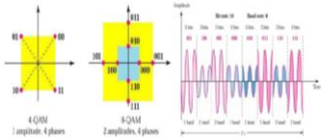
Quadrature Amplitude Modulation (QAM)

4-QAM and 8-QAM



Thank you!