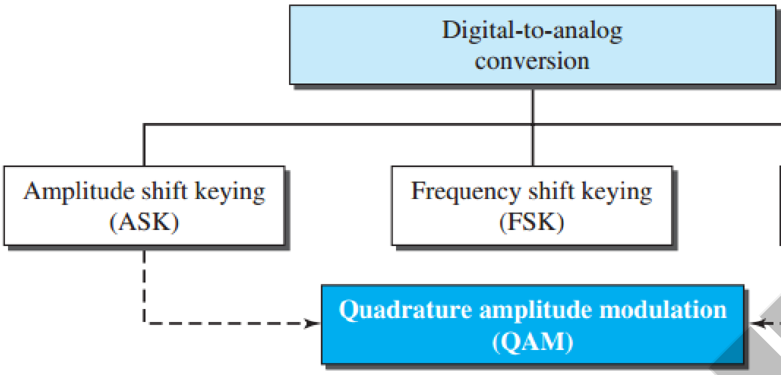
Digital to Analog Conversion

There are the following mechanisms to convert digital data to analog signals:

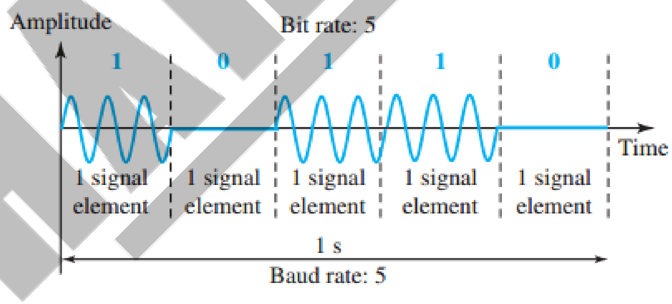
1. Amplitude Shift Keying (ASK)
2. Frequency Shift Keying (FSK)
3. Phase Shift Keying (PSK)

There is also a fourth mechanism that is a combination of amplitude and phase shift keying, called **Quadrature Amplitude Modulation (QAM)**. It is more efficient and better mechanism, mostly used today.



1. Amplitude Shift keying (ASK)

Amplitude Shift Keying is a technique in which carrier signal is analog and data to be modulated is digital. The amplitude of analog carrier signal is modified to reflect binary data. The binary signal when modulated gives a zero value when the binary data represents 0 while gives the carrier output when data is 1. The frequency and phase of the carrier signal remain constant.



Advantages of amplitude shift Keying

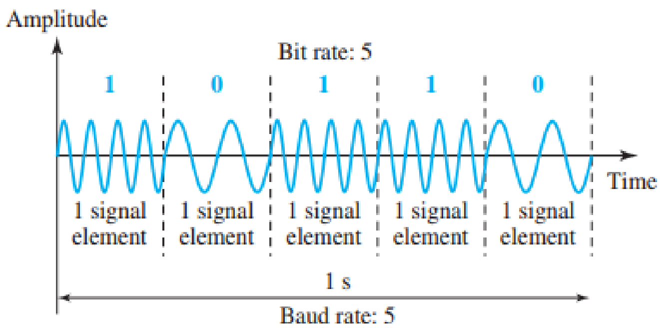
- ✓ It can be used to transmit digital data over optical fiber.
- ✓ The receiver and transmitter have a simple design which also makes it comparatively inexpensive.
- ✓ It uses lesser bandwidth as compared to FSK thus it offers high bandwidth efficiency.

Disadvantages of amplitude shift Keying

- ✓ It is susceptible to noise interference and entire transmissions could be lost due to this.
- ✓ It has lower power efficiency.

2. Frequency Shift keying (FSK)

In this modulation the frequency of analog carrier signal is modified to reflect binary data. The output of a frequency shift keying modulated wave is high in frequency for a binary high input and is low in frequency for a binary low input. The amplitude and phase of the carrier signal remain constant.



Advantages of frequency shift Keying

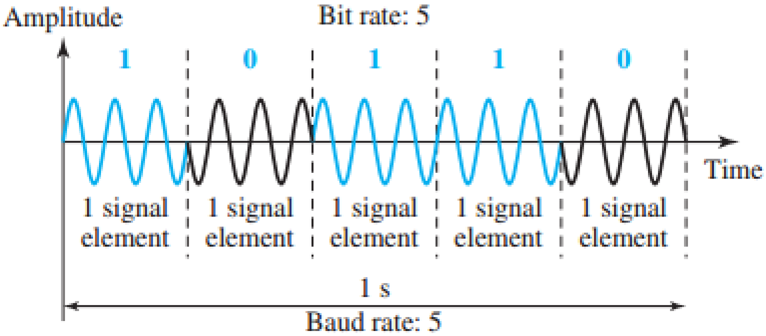
- ✓ It has lower chances of an error.
- ✓ It provides high signal to noise ratio.
- ✓ The transmitter and receiver implementations are simple for low data rate application.
- ✓ Frequency shift keying modulated signal can help avoid the noise problems beset by ASK.

Disadvantages of frequency shift Keying

- ✓ It uses larger bandwidth as compared to ASK thus it offers less bandwidth efficiency.
- ✓ It has lower power efficiency.

3. Phase Shift keying (PSK)

In this modulation the phase of the analog carrier signal is modified to reflect binary data. The amplitude and frequency of the carrier signal remains constant.



It is further categorized as follows:

I. **Binary Phase Shift Keying (BPSK):**
BPSK also known as phase reversal keying or 2PSK is the simplest form of phase shift keying. The Phase of the carrier wave is changed according to the two binary inputs. In Binary Phase shift keying, difference of 180 phase shift is used between binary 1 and binary 0. This is regarded as the most robust digital modulation technique and is used for long distance wireless communication.

II. **Quadrature phase shift keying:**
This technique is used to increase the bit rate i.e. we can code two bits onto one single element. It uses four phases to encode two bits per symbol. QPSK uses phase shifts of multiples of 90 degrees. It has double data rate carrying capacity compare to BPSK as two bits are mapped on each constellation points.

Advantages of phase shift Keying

- ✓ It is a more power efficient modulation technique as compared to ASK and FSK.
- ✓ It has lower chances of an error.
- ✓ It allows data to be carried along a communication signal much more efficiently as compared to FSK.

Disadvantages of phase shift Keying

- ✓ It offers low bandwidth efficiency.
- ✓ The detection and recovery algorithms of binary data is very complex.
- ✓ It is a non-coherent reference signal.

4. Quadrature Amplitude Modulation (QAM)

Quadrature amplitude modulation (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. This allows multiple analog signals to be placed on a single carrier, for example, in television signals, which contain both color signals and sound. The two channels required for stereo sound signals can be carried by a single QAM. Digital QAM or quantized QAM is often used for radio communication systems from regular cellular to LTE including WiMAX and Wi-Fi.

"Quadrature amplitude modulation is a combination of ASK and PSK."

Advantages of QAM

- ✓ It increases the efficiency of transmission for radio
- ✓ It can sends multiple analog signals of single carrier wave
- ✓ Efficient use of bandwidth

Disadvantages of QAM

- ✓ QAM modulation is more susceptible to the noise.
- ✓ It takes more power.

Analog to Analog Conversion

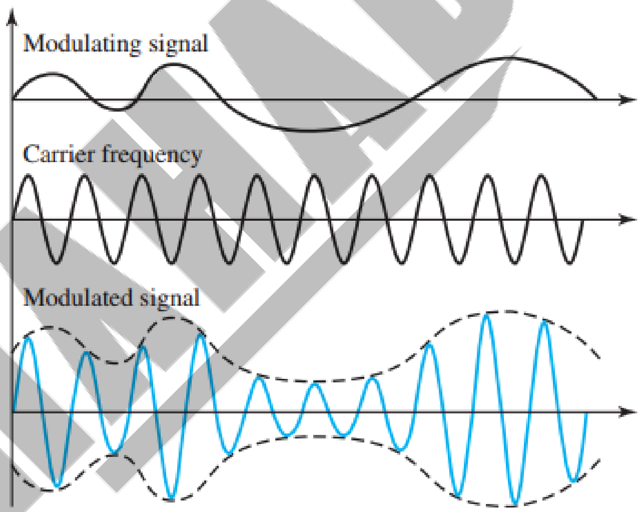
Analog-to-analog conversion, or modulation, is the representation of analog information by an analog signal. It is a process by virtue of which a characteristic of carrier wave is varied according to the instantaneous amplitude of the modulating signal. This modulation is generally needed when a bandpass channel is required. Bandpass is a range of frequencies which are transmitted through a bandpass filter which is a filter, allowing specific frequencies to pass preventing signals at unwanted frequencies.

Analog to Analog conversion can be done in three ways:

1. Amplitude Modulation
2. Frequency Modulation
3. Phase Modulation

1. Amplitude Modulation

The modulation in which the amplitude of the carrier wave is varied according to the instantaneous amplitude of the modulating signal keeping phase and frequency as constant. The figure below shows the concept of amplitude modulation. AM is normally implemented by using a simple multiplier because the amplitude of the carrier signal needs to be changed according to the amplitude of the modulating signal.



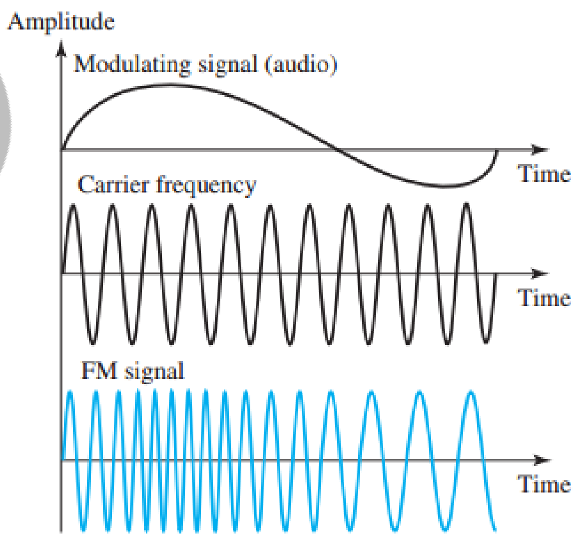
AM bandwidth

The modulation creates a bandwidth that is twice the bandwidth of the modulating signal and covers a range centered on the carrier frequency.

Bandwidth= 2fm

2. Frequency Modulation

The modulation in which the frequency of the carrier wave is varied according to the instantaneous amplitude of the modulating signal keeping phase and amplitude as constant. The figure below shows the concept of frequency modulation. FM is normally implemented by using a voltage-controlled oscillator as with FSK. The frequency of the oscillator changes according to the input voltage which is the amplitude of the modulating signal.

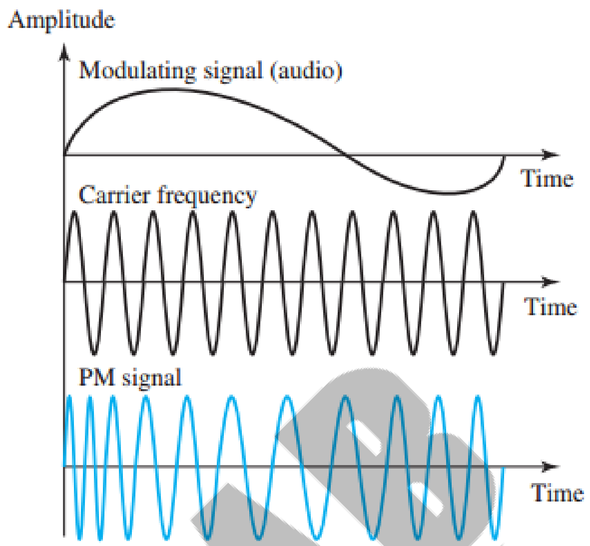


FM bandwidth

I. The bandwidth of a frequency modulated signal varies with both deviation and modulating frequency. If modulating frequency (Mf) 0.5, wide band FM signal.
II. For a narrow band FM signal, bandwidth required is twice the maximum frequency of the modulation, however for a wide band FM signal the required bandwidth can be very much larger, with detectable sidebands spreading out over large amounts of the frequency spectrum.

3. Phase Modulation

The modulation in which the phase of the carrier wave is varied according to the instantaneous amplitude of the modulating signal keeping amplitude and frequency as constant. The figure below shows the concept of frequency modulation.



Phase modulation is practically similar to Frequency Modulation, but in Phase modulation frequency of the carrier signal is not increased. It is normally implemented by using a voltage-controlled oscillator along with a derivative. The frequency of the oscillator changes according to the derivative of the input voltage which is the amplitude of the modulating signal.

PM bandwidth

1. For small amplitude signals, PM is similar to amplitude modulation (AM) and exhibits its unfortunate doubling of baseband bandwidth and poor efficiency.
2. For a single large sinusoidal signal, PM is similar to FM, and its bandwidth is approximately, 2(h+1)FM where h= modulation index.

Thus, Modulation allows us to send a signal over a bandpass frequency range. If every signal gets its own frequency range, then we can transmit multiple signals simultaneously over a single channel, all using different frequency ranges.