UNIVERSIDAD TECNOLÓGICA NACIONAL

Project: Digital Modulator

- ASK (Amplitude Switch Modulation)
- FSK (Frequency Switch Modulation)
- BPSK (Phase Switch Modulation)
- QAM (Phase and Amplitude Combination Modulation) (and its variants)

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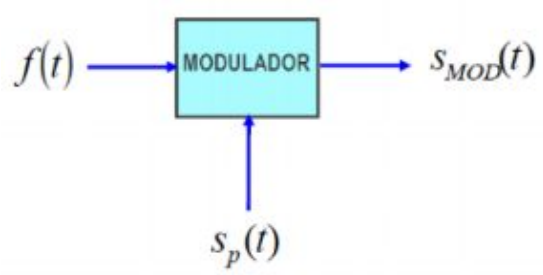
Theory

Modulation: Modulation is defined as the process by which the information contained in a signal f (t), called a modulating signal, is transferred to another signal, carrier signal Sp (t), the transmission of which is more appropriate for the transmission to use. The signal resulting from modulation is called a modulated signal, SMOD (t).

Analog Modulation:analog input and output as well.

Digital Modulation: Digital input signal and analog output.

The characteristics of the transmission channel: noise, attenuation and delay, within a certain bandwidth, implies that not any information signal can travel to through him. Sometimes it is required to transfer the information from the original signal to another whose characteristics are appropriate to be transmitted by the channel



Modulation Objectives:

● Overcome the limitations of the communication channel (restrictions such as noise, frequency, attenuation, bandwidth).

● Allows simultaneous transmission of multiple signals. Generally the width of the channel band is much higher than the signal so we can send several baseband signals.

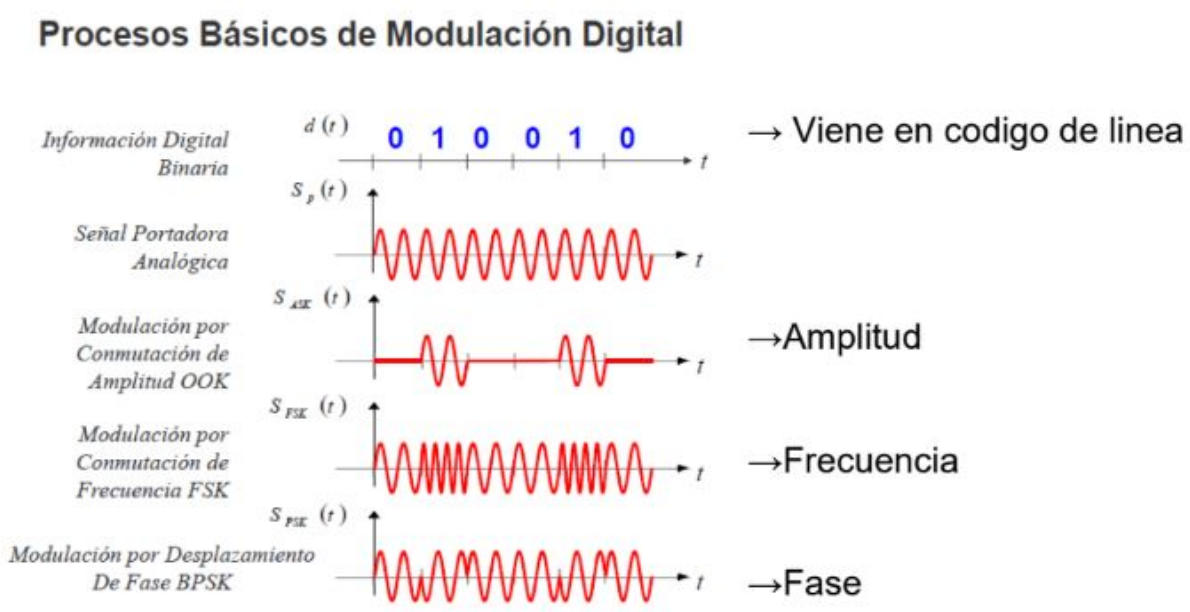
● Avoid the existence of noise and interference. We can avoid them in certain frequencies.

● Allow or enhance the radiation and propagation of electromagnetic waves in media unguided or wireless.

● Limitations of the communication channel.

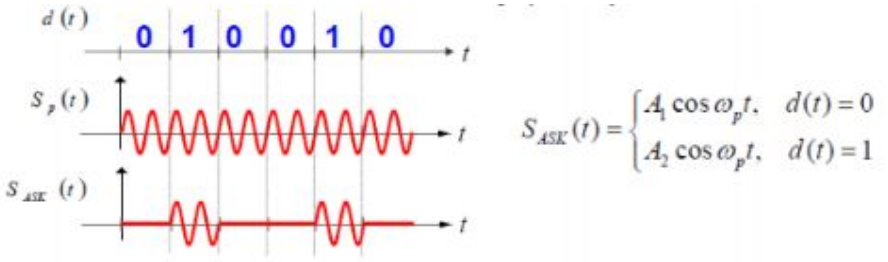
Modulation process: Modulation is obtained by varying some of the parameters of the carrier signal as a function of the information signal. Usually the carrier signal is a signal with the lowest possible information content, therefore any sinusoidal signal is suitable:

$s_p(t) = A_p \cos(\omega_p t + \theta_p)$ Being its **amplitude Ap**, its **frequency Wp** and **phase Θp** the parameters are prone to being varied.



Amplitude Switch Modulation (ASK) On Off Key (OOK): It is one of the modulation methods, in which digital data is represented through variations in the amplitude of the carrier wave.

The amplitude of an analog carrier signal varies according to the bit current (modulating the signal), keeping the frequency and phase constant. The level of amplitude can be used to represent the binary values 0 and 1. In the modulated signal, the logical value 0 is represented by the absence of the carrier.



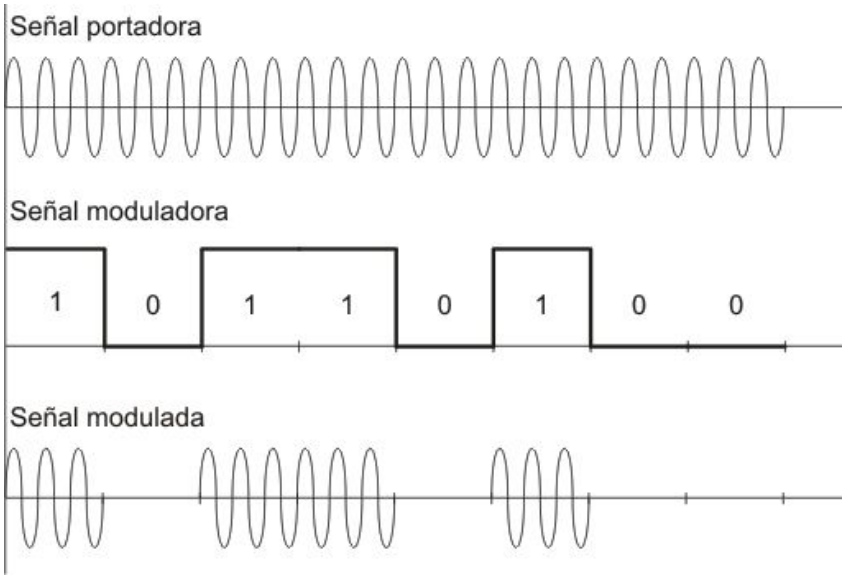
$$S_{ASK}(t) = \begin{cases} A_1 \cos \omega_p t, & d(t) = 0 \\ A_2 \cos \omega_p t, & d(t) = 1 \end{cases}$$

$$S_{OOK}(t) = \begin{cases} 0, & d(t) = 0 \\ A_1 \cos \omega_p t, & d(t) = 1 \end{cases}$$

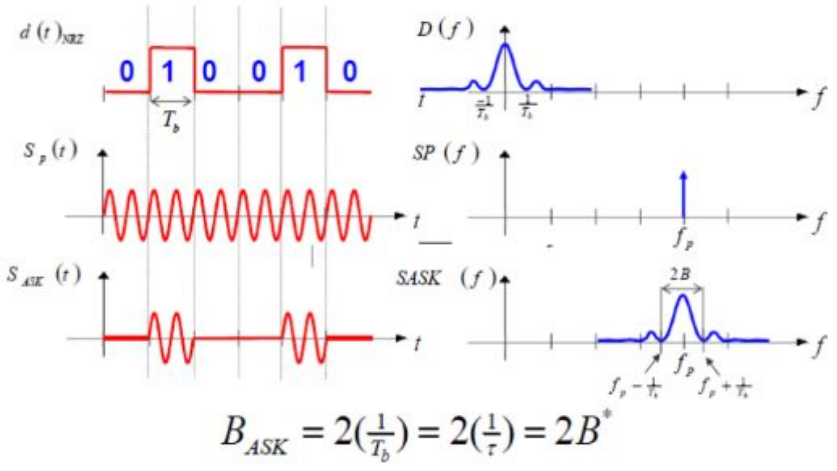
$$S_{ASK}(t) = d(t)\, Ap \cos \omega_p t$$

The modulated signal is the result of the product of the data signal by the sinusoidal carrier.

The most popular application of ASK is fiber optic transmission as it is very easy to "turn on" and "turn off" the light beam; In addition, fiber bears the disadvantages of amplitude modulation methods as it has little attenuation.



ASK Modulation Frequency Spectrum:

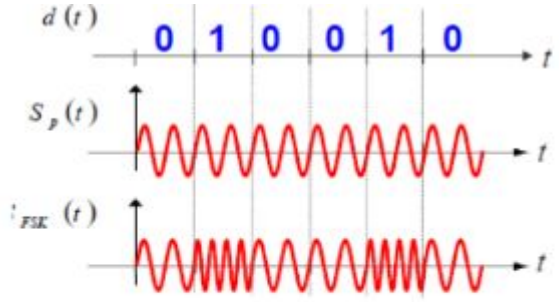


For the example, a signal encoded in NRZ is considered (frequencies shown positive). The bandwidth is 2B because the part that was previously the domain of the complexes now exist.

Frequency Switching Modulation: It is one of the modulation techniques for the digital transmission of information using two or more different frequencies for each symbol. The modulating signal varies the frequency of the carrier, so that the resulting modulated signal encodes the information associating it with frequency values different This FSK signal is a sinusoid of constant amplitude A, which "jumps" between two different frequencies f0 and f1.

In digital modulation, the rate of change at the modulator input is called bit-rate and its unit is the bit per second (bps). The exchange ratio at the exit of the modulator is called baud-rate. In essence the baud-rate is the speed or amount of symbols per second.

In FSK, the bit rate = baud rate. So, for example, a binary 0 can be represented by a frequency f1, and the binary 1 is represented with a different frequency f2.

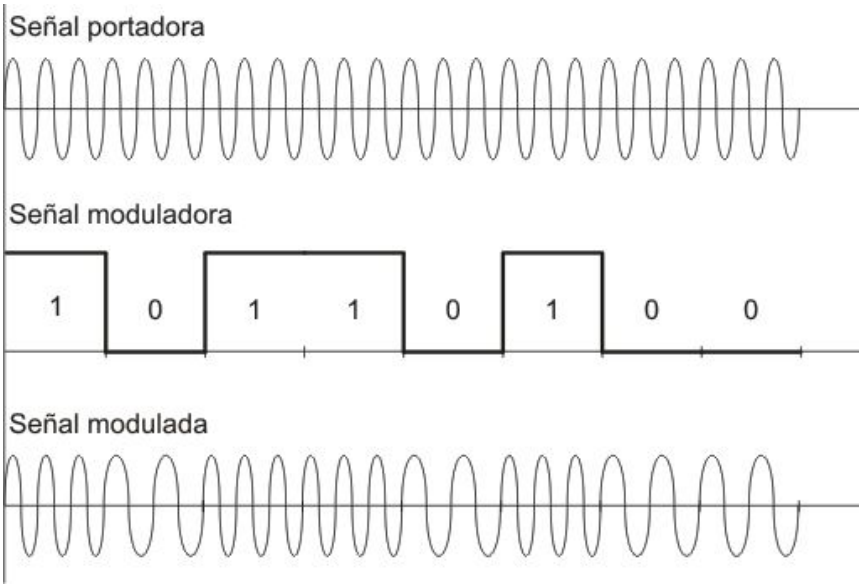


$$S_{FSK}(t) = \begin{cases} Ap\cos\omega_1 t, & d(t)=0 \\ Ap\cos\omega_2 t, & d(t)=1 \end{cases}$$

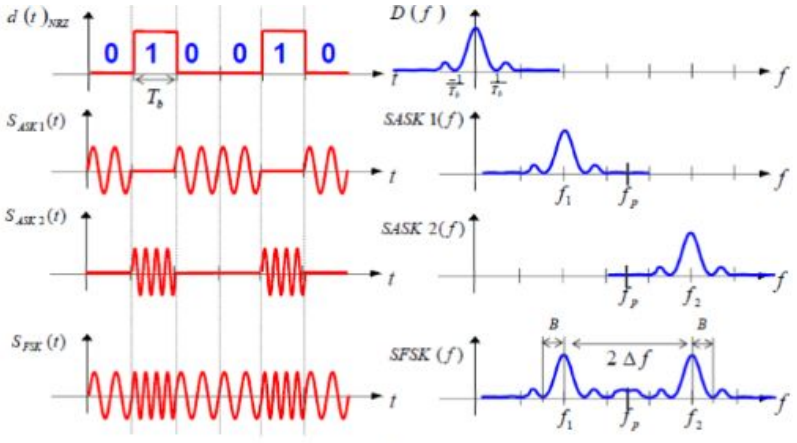
$$con \quad \omega_1(t) = \omega_p - \Delta\omega$$

$$y \quad \omega_2(t) = \omega_p + \Delta\omega$$

$$\Delta\omega = \frac{\omega_1 - \omega_2}{2} \qquad Desplazamiento \ de \ frecuencia$$



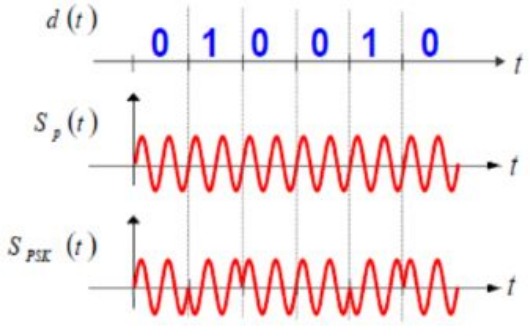
FSK Modulation Frequency Spectrum



$$B_{FSK} = 2(\Delta f + B)$$

It is a non-linear modulation where F is the frequency shift (separation between carriers). This requires more bandwidth; when using two frequencies for a 0, 1 carrier is sent, and for a 1, a different one is sent. If the two spectra are added, they produce what is seen in the last figure.

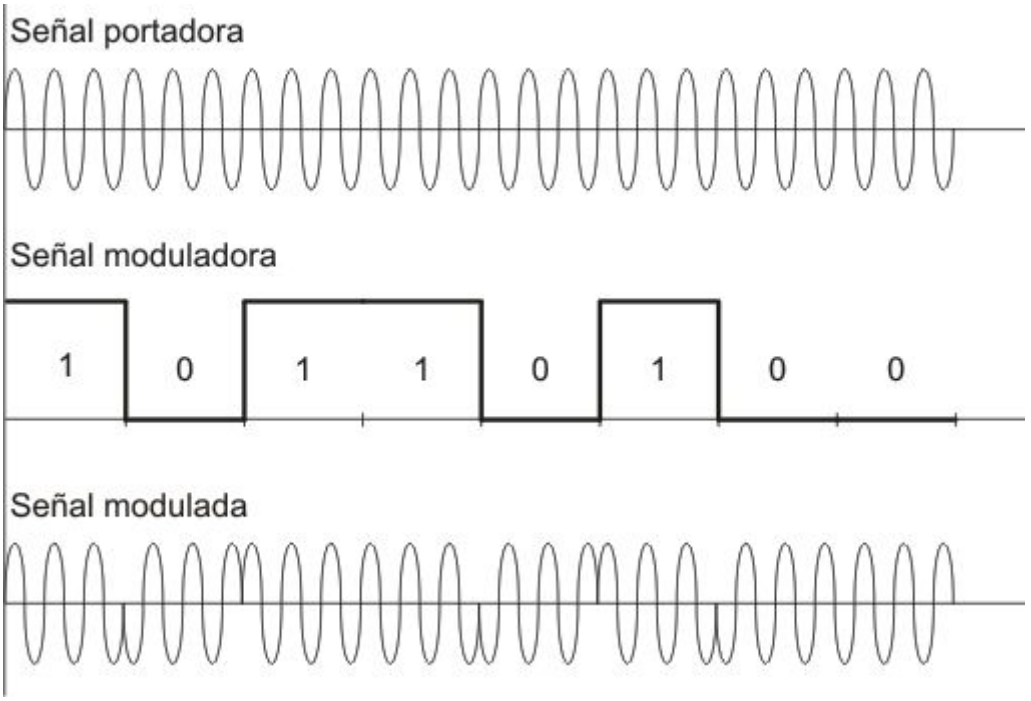
Phase Switching Modulation (BPSK): It is one of the modulation techniques which consists of varying the phase of the carrier between a certain number of discrete values. It uses 2 symbols, with 1 bit of information each. It is also the one that presents greater immunity to noise, since the difference between symbols is maximum (180º). These symbols usually have a phase jump value of 0º for the 1 and 180º for the 0, as shown in a constellation diagram. Instead, its speed of transmission is the lowest of the phase modulations.



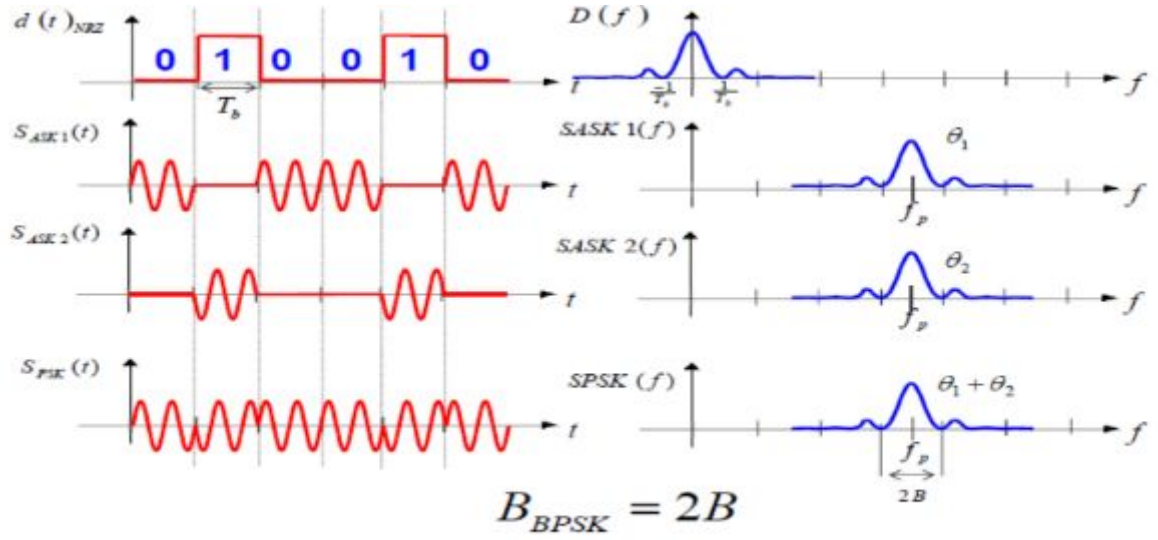
$$S_{PSK}(t) = \begin{cases} Ap\cos(\omega_p t + \theta_1), & d(t) = 0 \\ Ap\cos(\omega_p t + \theta_2), & d(t) = 1 \end{cases}$$

$$Si \quad \theta_1 = 0 \quad y \quad \theta_2 = \pi \quad entonces:$$

$$S_{BPSK}(t) = \begin{cases} Ap\cos(\omega_p t + 0), & d(t) = 0 \\ Ap\cos(\omega_p t + \pi), & d(t) = 1 \end{cases}$$



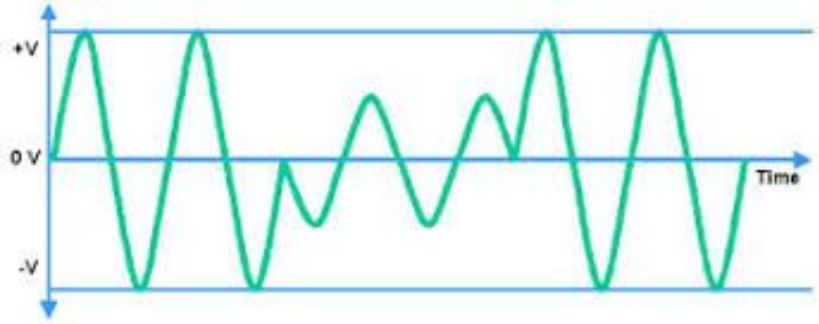
BPSK Modulation Frequency Spectrum



$$B_{BPSK} = 2B$$

Donde B es el ancho de banda de la señal de banda base o 2B el ancho de banda de nulo a nulo.

Quadrature Amplitude Modulation (QAM): QAM is a technique that combines modulation phase and amplitude. With this you can fit four bits per baud, achieving quadruple the bit rate compared to other modulation techniques. This is achieved by modulating the same carrier wave, out of phase by 90°. The modulated signal in QAM is composed of the linear sum of two previously modulated signals in double band side with suppressed carrier. The vast majority of 9600 bps modems adhere to the ITU V.29 standard. This standard uses a 1700 Hz carrier over which both the amplitude and the phase are varied, resulting in 16 possible combinations of eight phase angles and four amplitudes.



There exist more divisions QAM modulations such as **8QAM**, **16QAM** and **32QAM** that aim to maximize the bitrate transmitted simultaneously, this does not come without the disadvantage of being exponentially more susceptible to noise so they must be used carefully.