

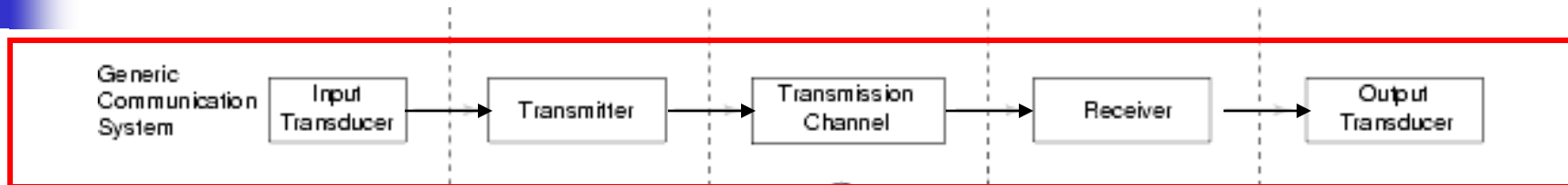
Modulation and Demodulation



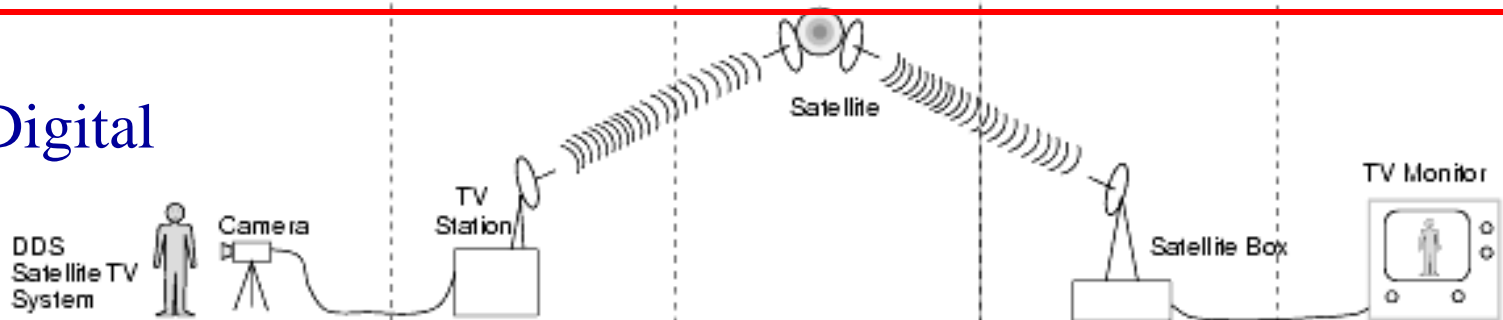
❖ Overview

- Communication systems
- Analog Modulation
 - AM
 - FM
- Digital Modulation
 - ASK
 - FSK
- Modems

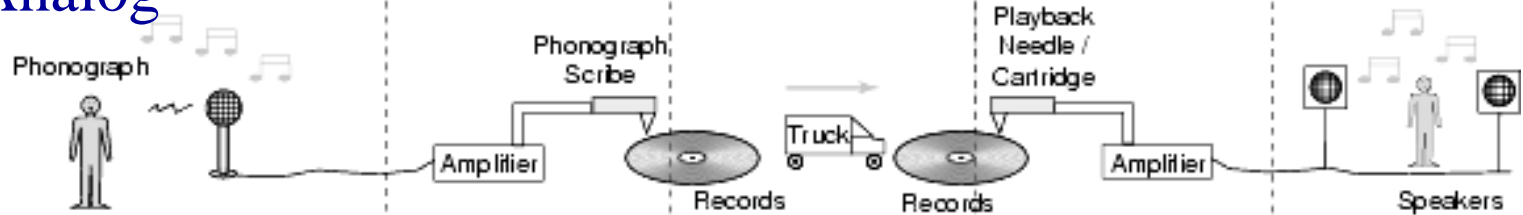
❖ Communication systems



Digital



Analog



- The block diagram on the top shows the blocks common to all communication systems

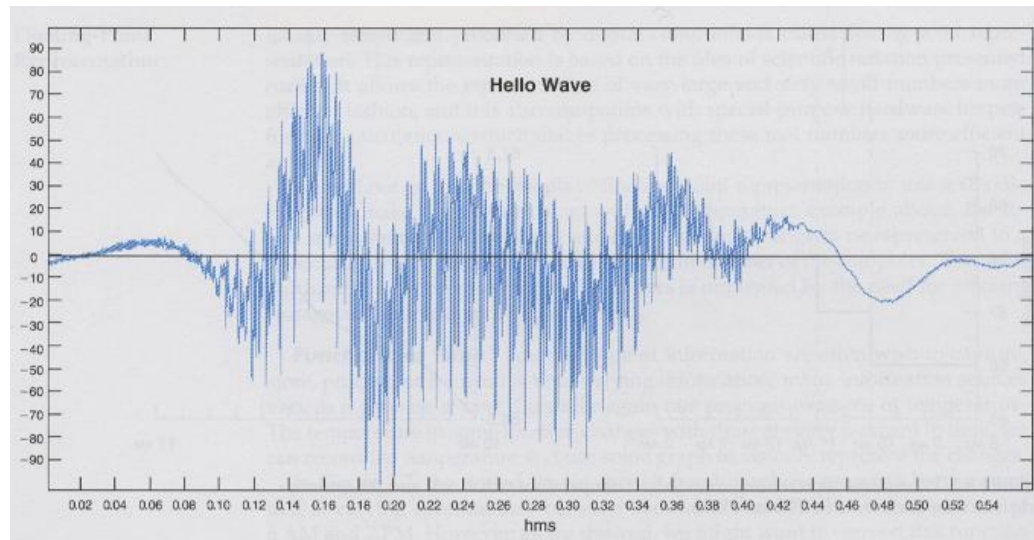


Remember the components of a communications system:

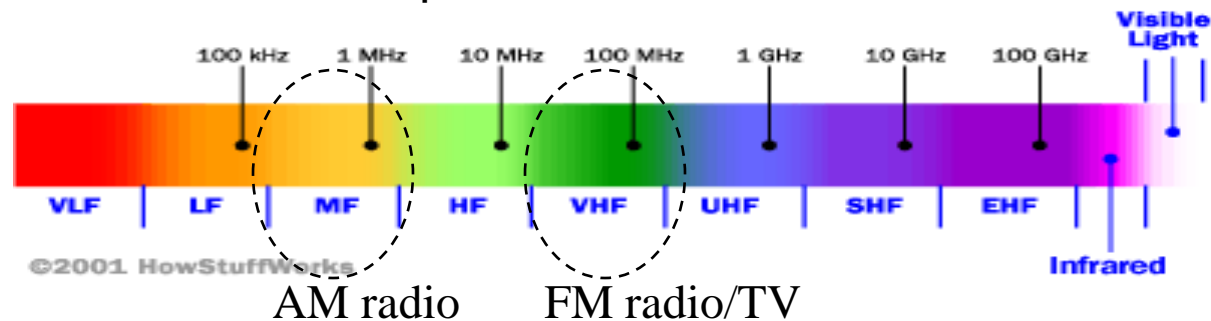
- Input transducer: The device that converts a physical signal from source to an electrical, mechanical or electromagnetic signal more suitable for communicating
- Transmitter: The device that sends the transduced signal
- Transmission channel: The physical medium on which the signal is carried
- Receiver: The device that recovers the transmitted signal from the channel
- Output transducer: The device that converts the received signal back into a useful quantity

❖ Analog Modulation

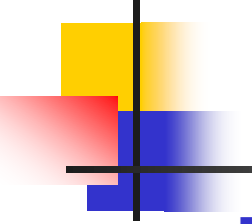
- The purpose of a communication system is to transmit information signals (baseband signals) through a communication channel
- The term *baseband* is used to designate the band of frequencies representing the original signal as delivered by the input transducer
 - For example, the voice signal from a microphone is a baseband signal, and contains frequencies in the range of 0-3000 Hz
 - The "hello" wave is a baseband signal:



- Since this baseband signal must be transmitted through a communication channel such as air using electromagnetic waves, an appropriate procedure is needed to shift the range of baseband frequencies to other frequency ranges suitable for transmission, and a corresponding shift back to the original frequency range after reception. This is called the process of *modulation* and *demodulation*
- Remember the radio spectrum:



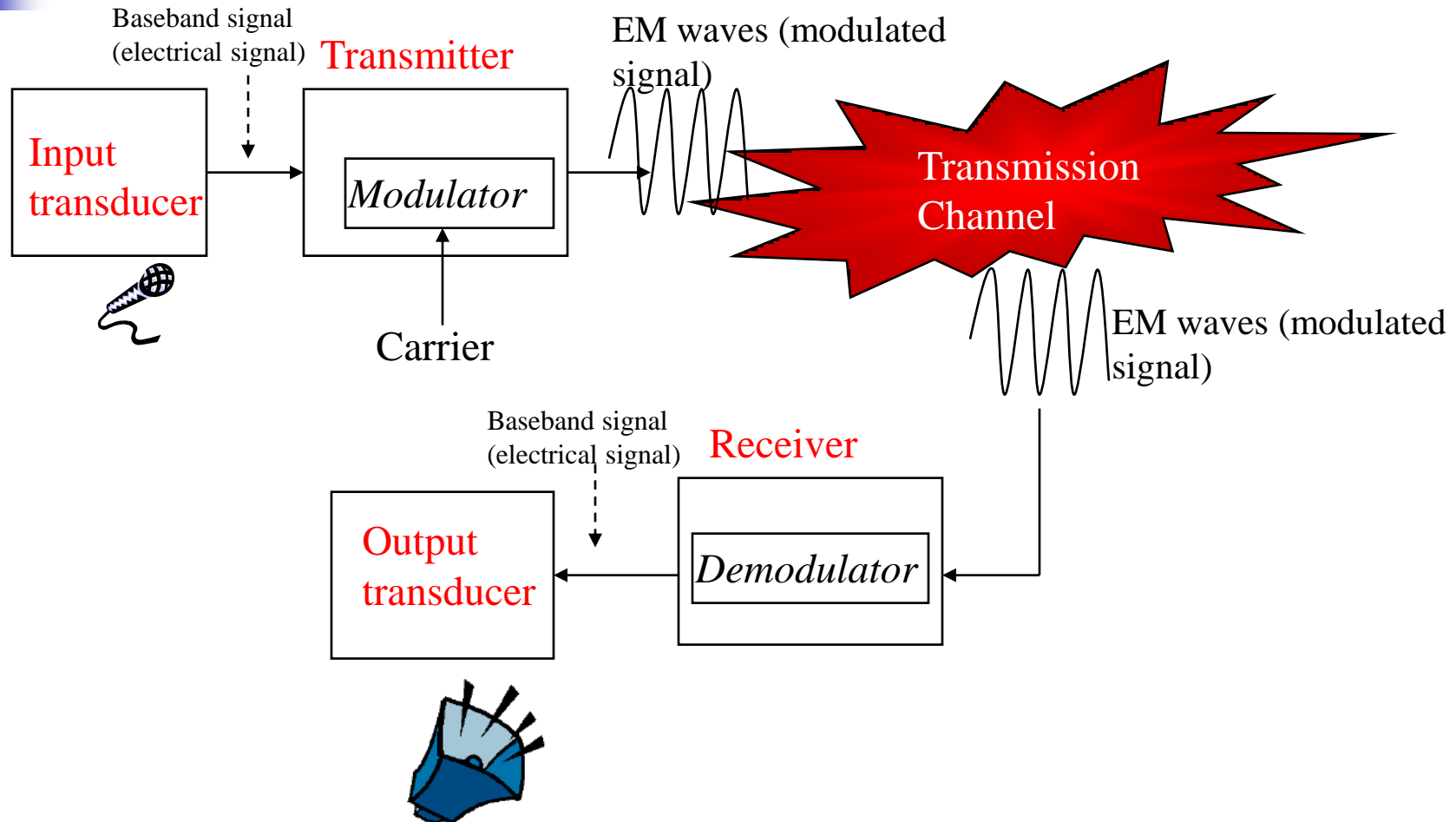
- For example, an AM radio system transmits electromagnetic waves with frequencies of around a few hundred kHz (MF band)
- The FM radio system must operate with frequencies in the range of 88-108 MHz (VHF band)

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- Since the baseband signal contains frequencies in the audio frequency range (3 kHz), some form of frequency-band shifting must be employed for the radio system to operate satisfactorily
 - This process is accomplished by a device called a *modulator*
 - The **transmitter** block in any communications system contains the modulator device
 - The **receiver** block in any communications system contains the demodulator device
 - The modulator **modulates** a *carrier wave* (the electromagnetic wave) which has a frequency that is selected from an appropriate band in the radio spectrum
 - For example, the frequency of a carrier wave for FM can be chosen from the VHF band of the radio spectrum
 - For AM, the frequency of the carrier wave may be chosen to be around a few hundred kHz (from the MF band of the radio spectrum)
 - The demodulator extracts the original baseband signal from the received modulated signal

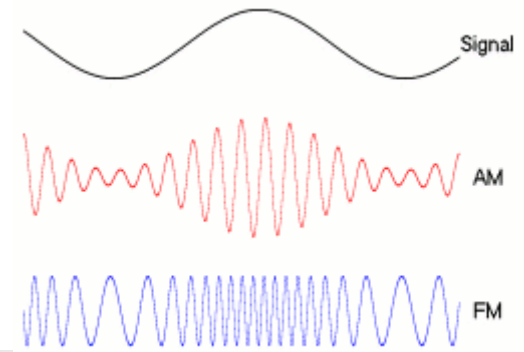
To Summarize:

- Modulation is the process of impressing a low-frequency information signal (baseband signal) onto a higher frequency carrier signal
- Modulation is done to bring information signals up to the Radio Frequency (or higher) signal

Basic analog communications system

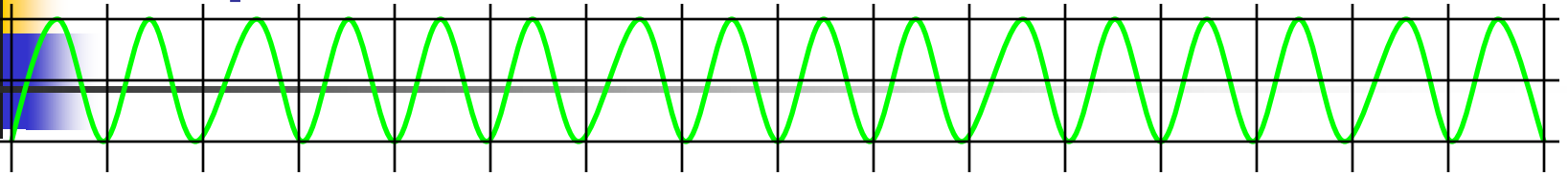


Types of Analog Modulation

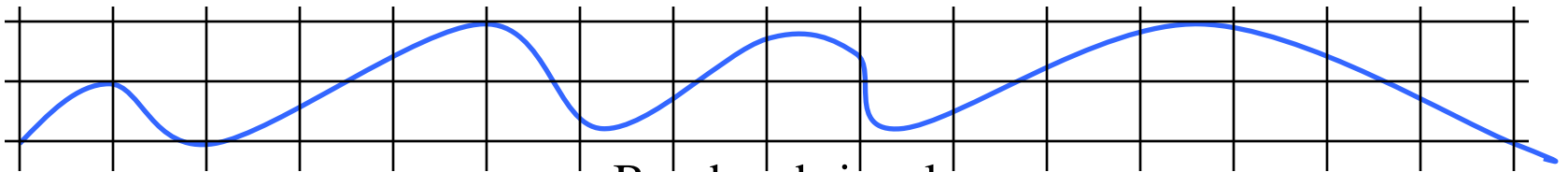


- **Amplitude Modulation (AM)**
 - Amplitude modulation is the process of ***varying the amplitude of a carrier wave in proportion to the amplitude of a baseband signal.*** The frequency of the carrier remains constant
- **Frequency Modulation (FM)**
 - Frequency modulation is the process of ***varying the frequency of a carrier wave in proportion to the amplitude of a baseband signal.*** The amplitude of the carrier remains constant
- **Phase Modulation (PM)**
 - Another form of analog modulation technique which we will not discuss

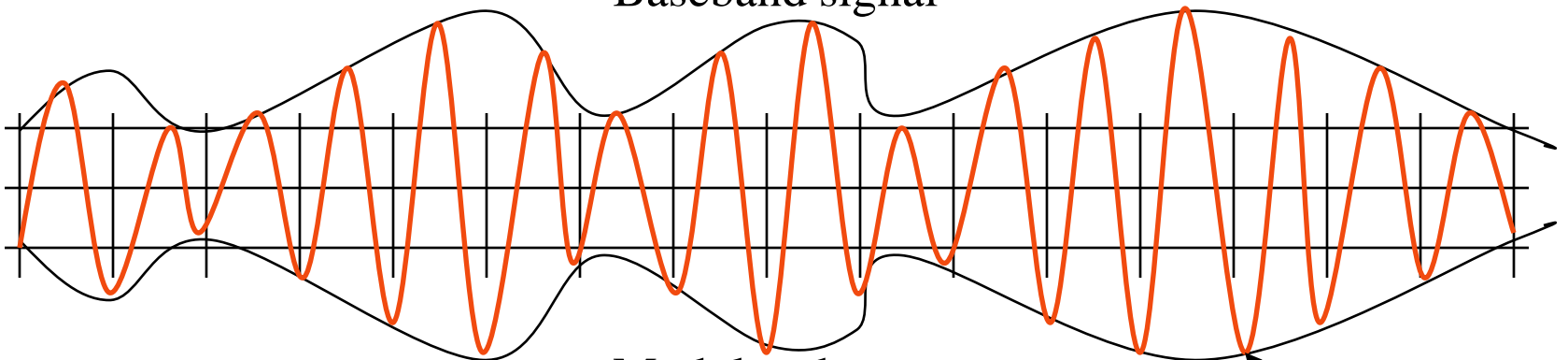
Amplitude Modulation



Carrier wave



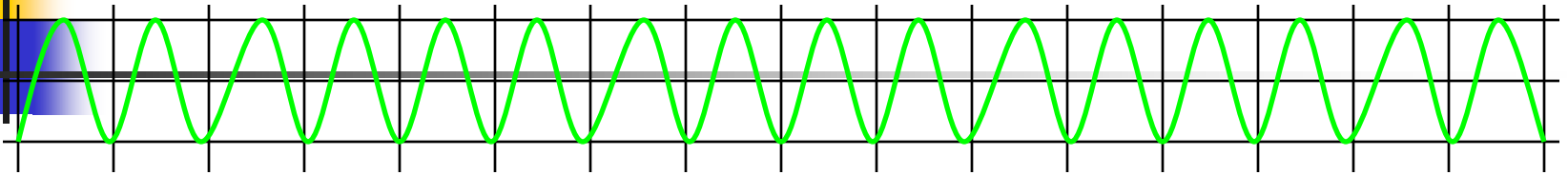
Baseband signal



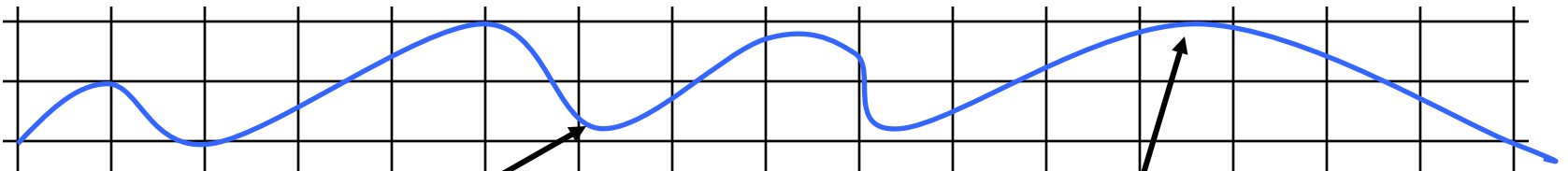
Modulated wave

Amplitude varying-
frequency constant

Frequency Modulation



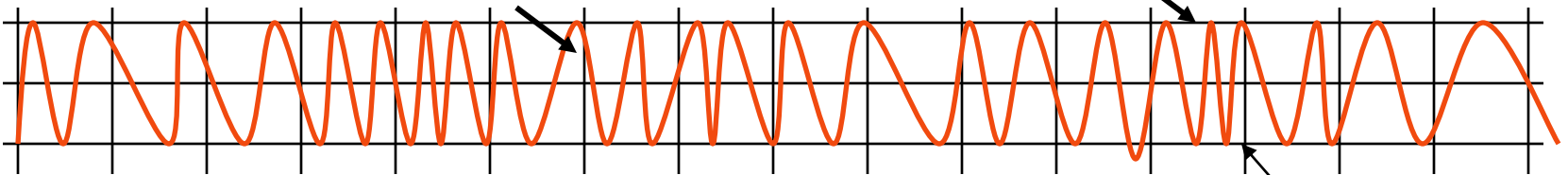
Carrier wave



Baseband signal

*Small amplitude:
low frequency*

*Large amplitude:
high frequency*



Modulated wave

Frequency varying-
amplitude constant



AM vs. FM

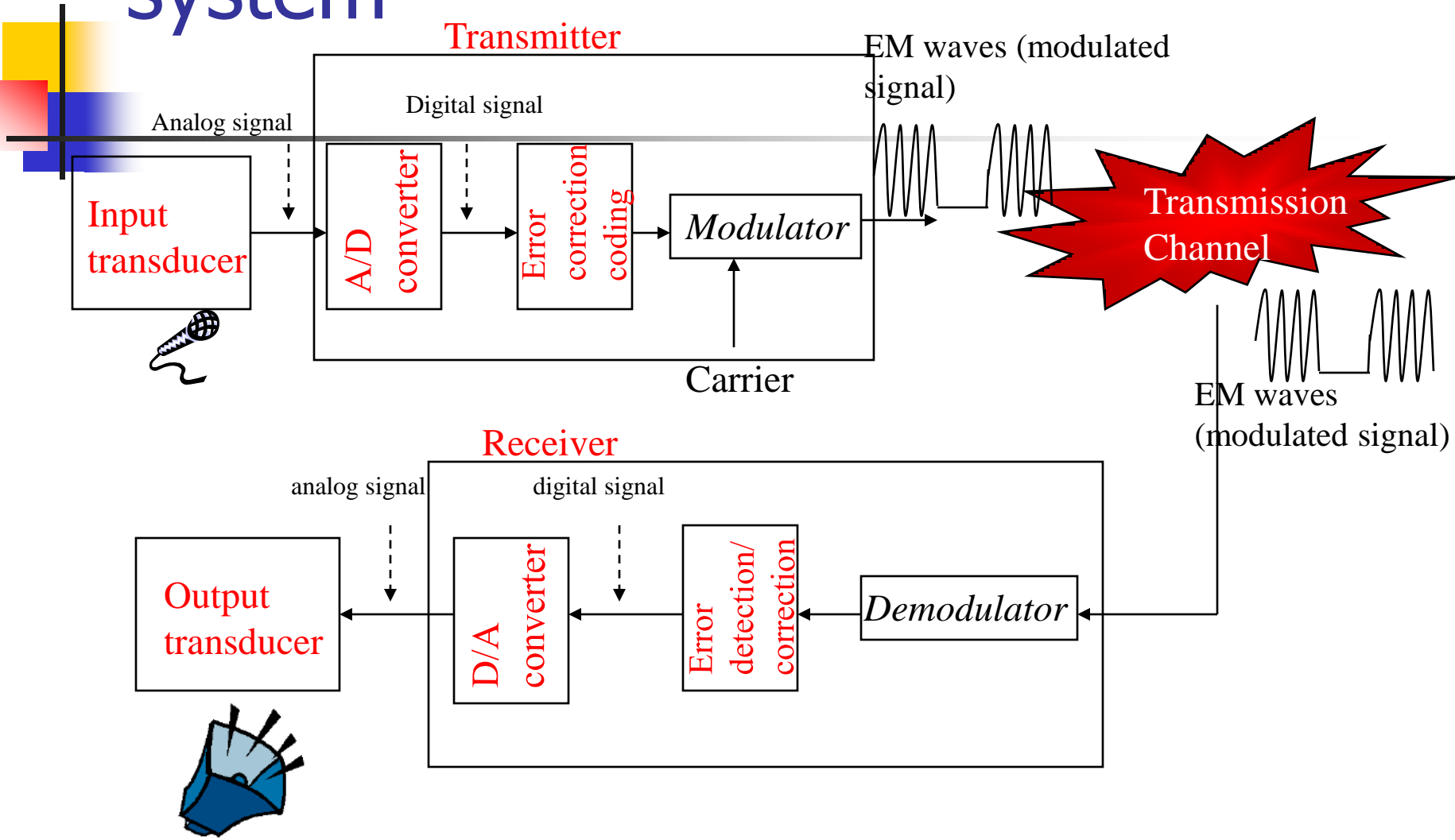
- AM requires a simple circuit, and is very easy to generate.
- It is simple to tune, and is used in almost all short wave broadcasting.
- The area of coverage of AM is greater than FM (longer wavelengths (lower frequencies) are utilized-remember property of HF waves?)
- However, it is quite inefficient, and is susceptible to static and other forms of electrical noise.
- The main advantage of FM is its audio quality and immunity to noise. Most forms of static and electrical noise are naturally AM, and an FM receiver will not respond to AM signals.
- The audio quality of a FM signal increases as the frequency deviation increases (deviation from the center frequency), which is why FM broadcast stations use such large deviation.
- The main disadvantage of FM is the larger bandwidth it requires



❖ Digital Modulation

- The previous section presented analog communication systems that transmit information in analog form using Amplitude or Frequency modulation
- Digital communication systems also employ modulation techniques, some of which include:
 - Amplitude Shift Keying
 - Frequency Shift Keying
 - Phase Shift Keying

Basic digital communications system





Some Types of Digital Modulation

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

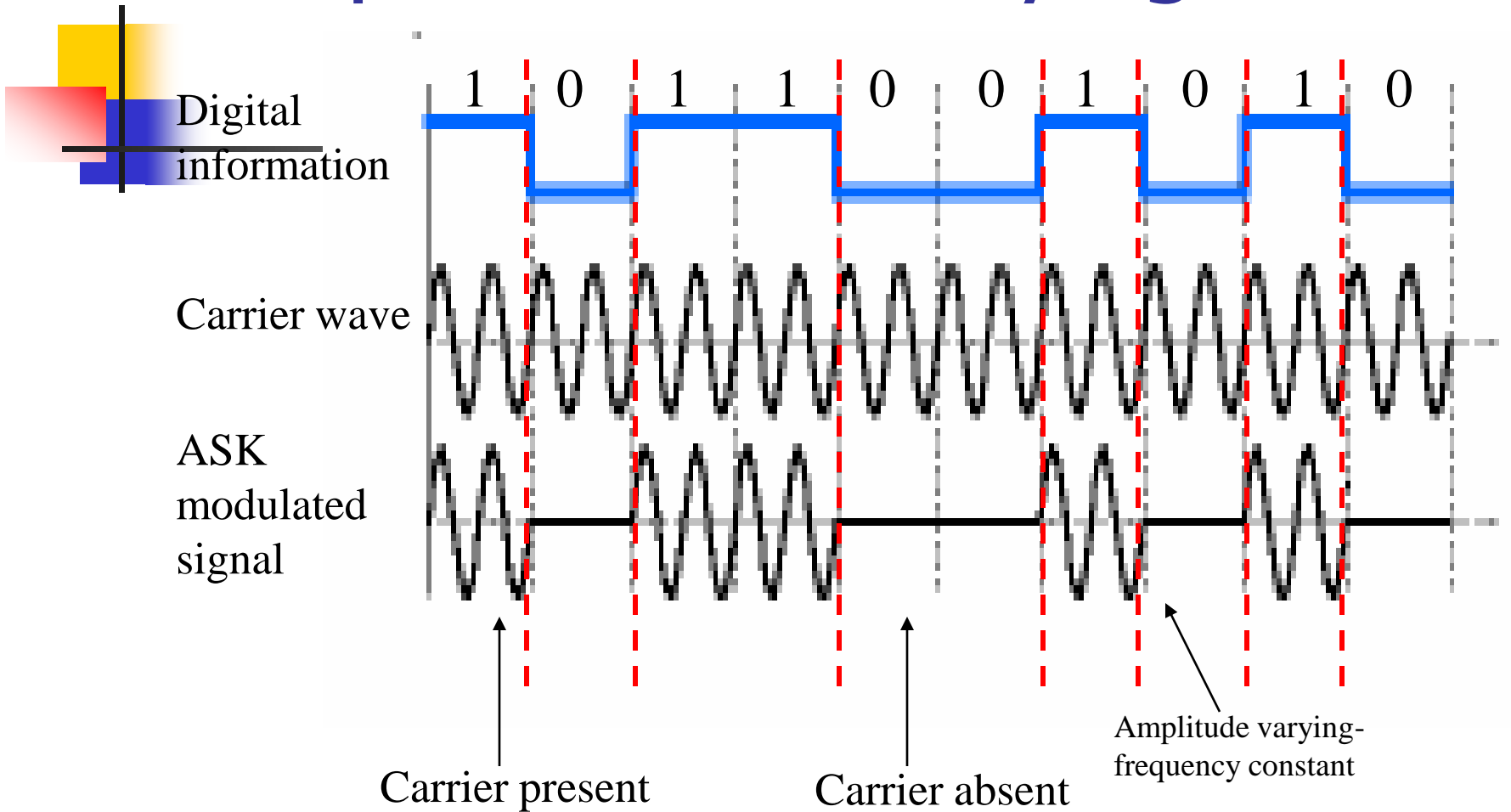
■ Frequency Shift Keying (FSK)

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

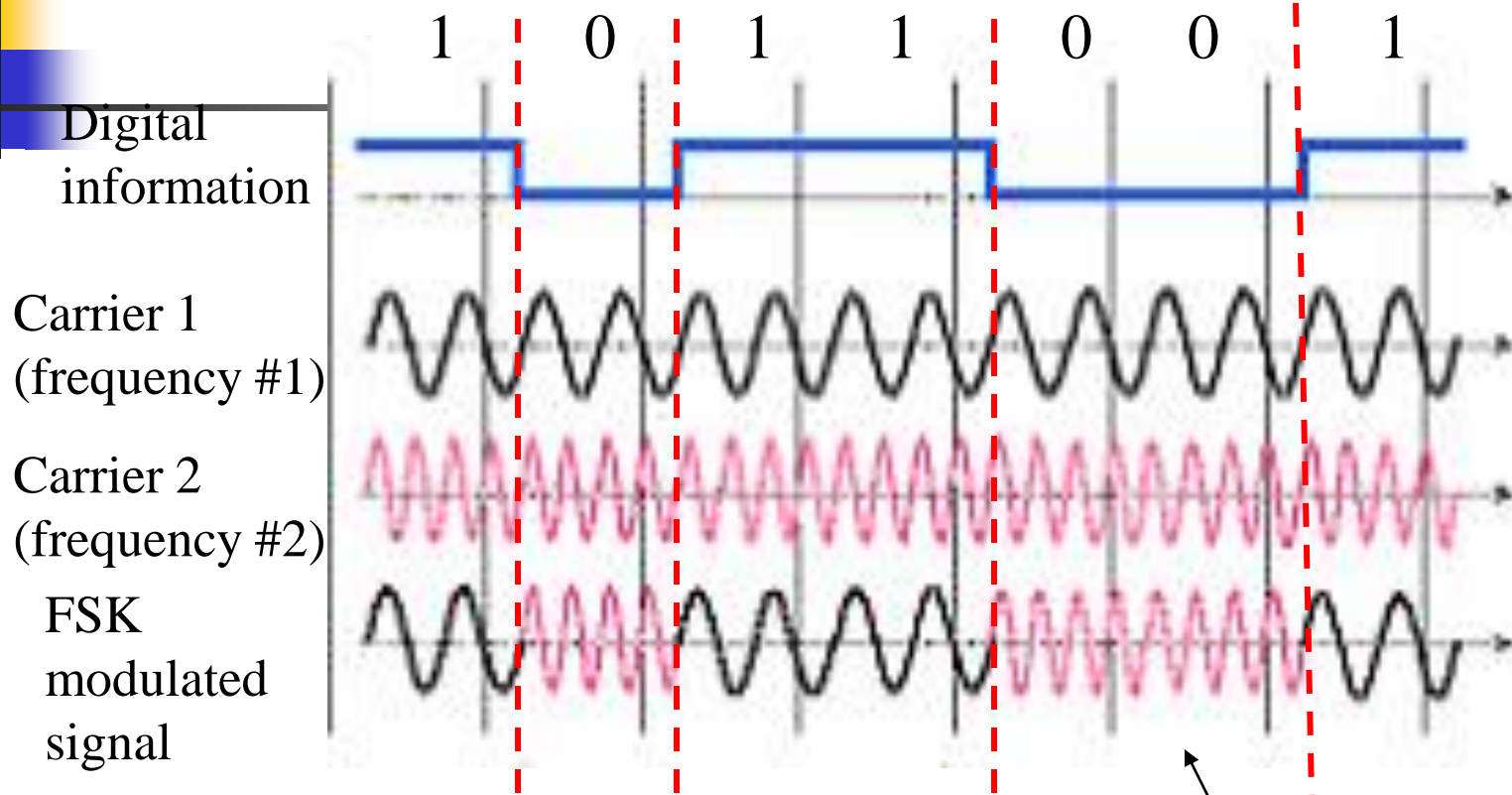
■ Phase Shift Keying (PSK)

- Another form of digital modulation technique which we will not discuss

Amplitude Shift Keying



Frequency Shift Keying

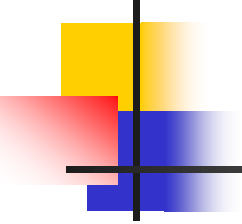


Frequency varying-
amplitude constant



❖ Modems

- *Modems are devices used to enable the transfer of data over the public switched telephone network (PSTN)*
- The name modem comes from the name MOulator- DEModulator which describes the function the modem performs to transfer digital information over an analog network
- The goal is to produce a signal that can be transmitted easily and decoded to reproduce the original digital data. Primarily used to communicate via telephone lines, modems can be used over any means of transmitting analog signals
- There are many kinds of modems available today:
 - Internal modem:
 - A modem card in your computer that is integrated within the system
 - Less expensive than external modems
 - Disadvantage is that you need to access inside the computer to replace the modem
 - External modem
 - A device that connects externally to your computer through a serial port
 - External power supply does not drain power from the computer
 - Modem activity can easily be observed
 - More expensive than an internal modem

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- DSL (Digital Subscriber Line)
 - A high-speed data service that works over conventional telephone lines and is typically offered by telephone companies
 - It does not occupy the phone line-you can still talk on the phone
 - Speed is much higher than regular modem

 - Cable modem
 - A device that connects to the existing cable feed and to an Ethernet network card in the PC (also called a NIC for Network Interface Card)
 - Is different than a common dial up modem
 - Supports higher speeds
 - Typically offered by cable companies

 - Modems are the most popular means of Internet access, UCLA 2001 study of American Internet users shows that 81.3% of them use telephone modem, and 11.5% cable modem