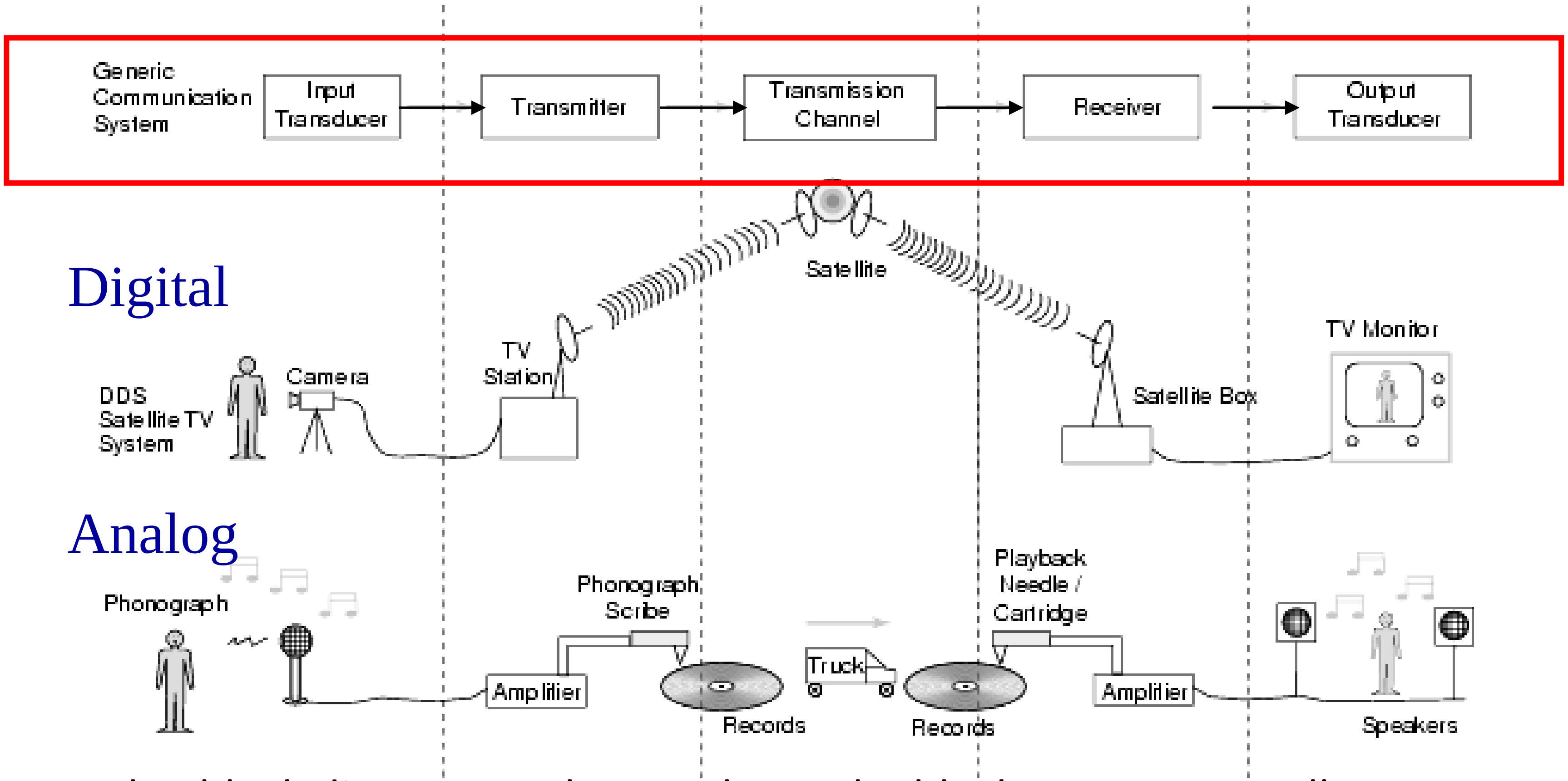
Communication Systems

Module 1

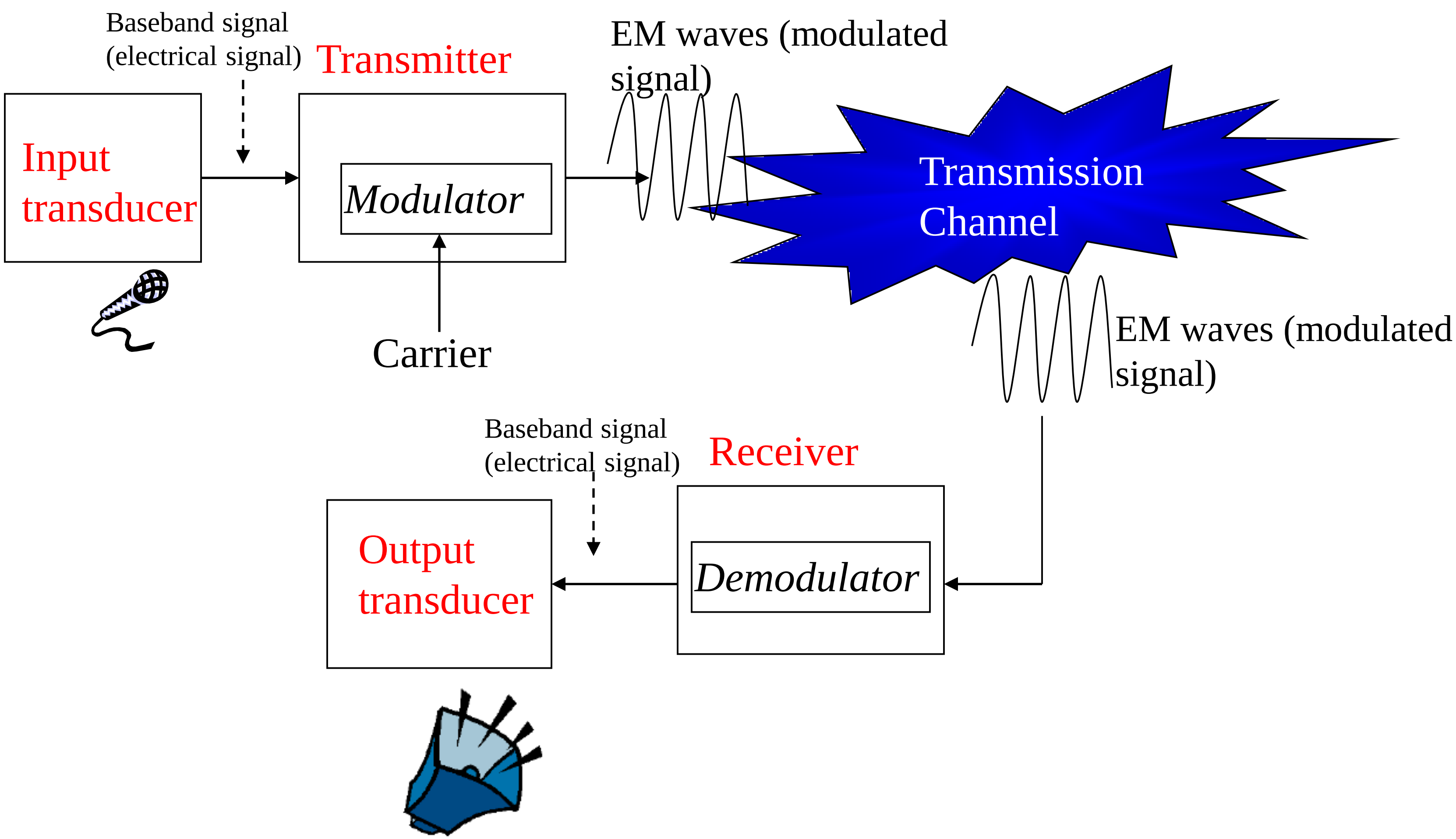
Analog Communication Systems

Communication System



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

Basic analog communications system



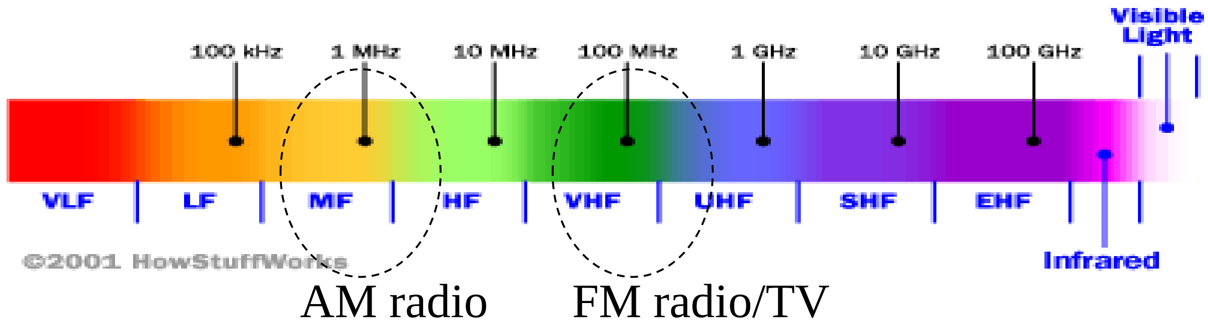
Components of a communications system:

- *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 can be wired or wireless.
- *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)

- 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

Some Definitions

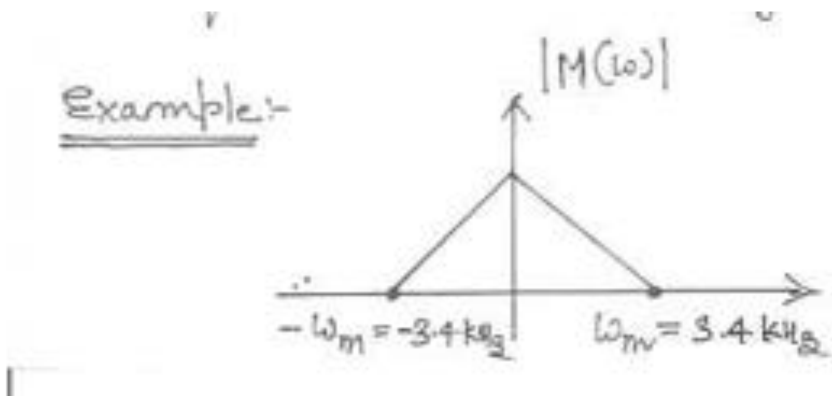
- Baseband Signal: A signal that has a very narrow frequency range and is used to designate the band of frequencies representing message signal. A *baseband signal* is also known as *lowpass signal* since it includes frequencies that are very near zero, by comparison with its highest frequency.

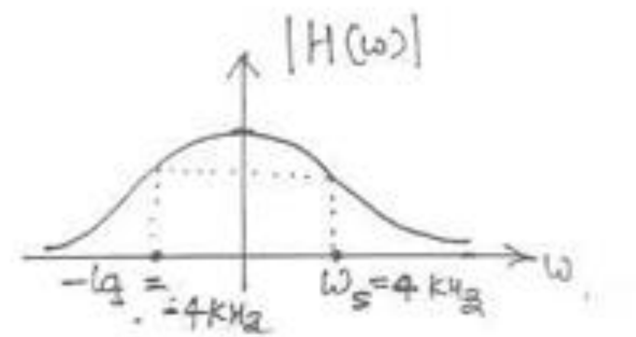
m(t): message signal

x(t): transmitted signal

Baseband Transmission:

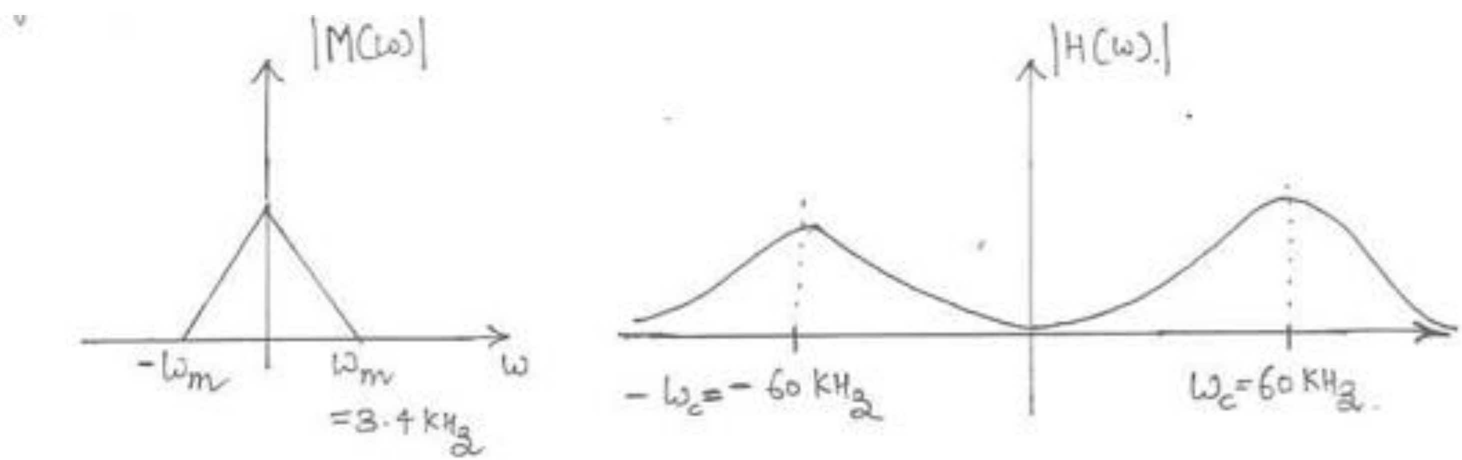
- In Baseband Transmission, the band of transmission frequencies supported by the channel closely matches with the band of frequencies occupied by the message signal.





Passband Transmission

- In Passband Transmission, the transmission band of channel is centered at the frequency much higher than the highest frequency component of message signal.

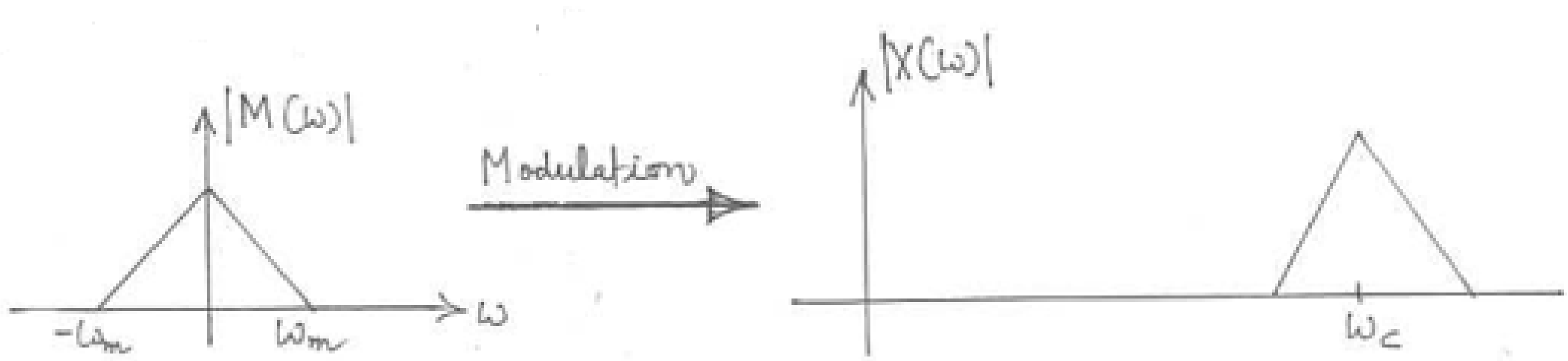


Passband Signal

- Baseband transmission sends the information signal as it is without modulation (without frequency shifting) while **passband transmission** shifts the signal to be transmitted in frequency to a higher frequency and then transmits it, where at the receiver the signal is shifted back to its original frequency.

Modulation

- The process of shifting the spectrum of message signal or baseband signal to a higher frequency is modulation. It is performed at the transmitter.



Need for Modulation

1. Modulation for ease of radiation

2. Modulation for efficient transmission

3. **Modulation for multiplexing**

4. **Modulation for frequency assignment**

5. **Modulation to improve the signal-to- noise ratio**

Modulation for ease of radiation

For efficient radiation, the size of the antenna should be λ/10 or more (preferably around λ/4), where λ is the wavelength of the signal to be radiated.

Modulation for efficient transmission

- Quite a few wireless channels have their own appropriate passbands. For efficient transmission, it would be necessary to shift the message spectrum into the passband of the channel intended.
- Ground wave propagation (from the lower atmosphere) is possible only up to about 2 MHz. Long distance ionospheric propagation is possible for frequencies in the range 2 to 30 MHz. Beyond 30 MHz, the propagation is line of sight. Preferred frequencies for satellite communication are around 3 to 6 GHz.
- By choosing an appropriate carrier frequency and modulation technique, it is possible for us to translate the baseband message spectrum into a suitable slot in the passband of the channel intended. That is, **modulation results in frequency translation.**

Modulation for multiplexing

- Several message signals can be transmitted on a given channel, by assigning to each message signal an appropriate slot in the passband of the channel.

- Example - AM broadcast, used for voice and medium quality music broadcast. The passband of the channel used to 550 kHz to 1650 kHz. If the required transmission bandwidth is taken as 10 kHz, then it is possible for us to multiplex, atleast theoretically, 110 distinct message signals on the channel.

Modulation for frequency assignment

- Continuing on the broadcast situation, let us assume that each one of the message signals is being broadcast by a different station. Each station can be assigned a suitable carrier so that the corresponding program material can be received by tuning to the station desired.

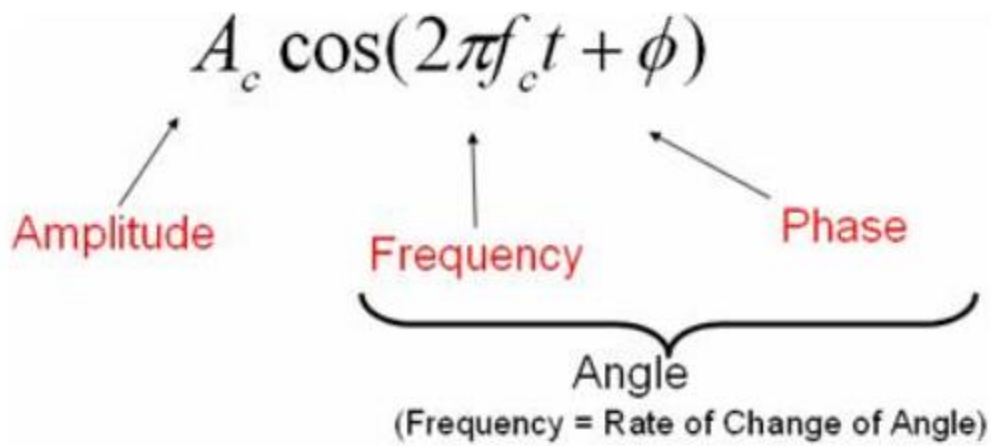
Modulation to improve the signal-to-noise ratio

- Signal-to-noise ratio (abbreviated SNR or S/N) is defined as the ratio of signal power to the noise power, often expressed in decibels in electrical signals.

- Certain modulation schemes (notably frequency modulation and phase modulation) have the feature that they will permit improved signal-to-noise ratio at the receiver output, provided we are willing to pay the price in terms of increased transmission bandwidth (Note that the transmitted power need not be increased). This feature can be taken advantage of when the quality of the receiver output is very important.

Types of Modulation

Signal modulation changes a sine wave to encode information. The equation representing a sine wave is as follows:



Analog Modulation Techniques

Carrier Wave c(t)

Message Signal m(t)

Analog Modulation (AM)

Frequency Modulation (FM)

Phase Modulation (PM)

Transmitted signal x(t)