# Analog Communication Systems
# EC-413-F

# Lecture No 2

# Topics covered

**Basic Concept of Modulation and Demodulation**

# What is Modulation?

In modulation, a message signal, which contains the information is used to control the parameters of a carrier signal, so as to impress the information onto the carrier.

**The Messages**

The message or modulating signal may be either:

analogue – denoted by *m*(*t*)

digital – denoted by *d*(*t*) – *i.e.* sequences of 1's and 0's

The message signal could also be a multilevel signal, rather than binary; this is not considered further at this stage.

**The Carrier**

The carrier could be a 'sine wave' or a 'pulse train'.

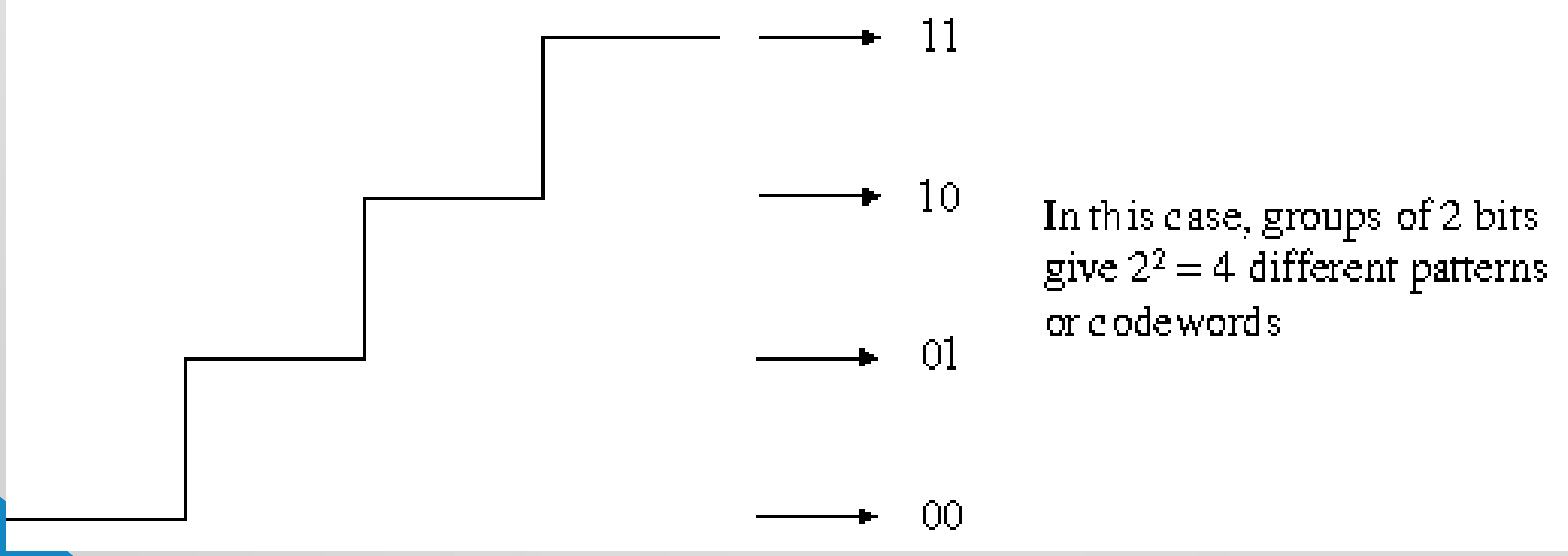
Consider a 'sine wave' carrier:

$$v_c(t) = V_c \cos(\omega_c t + \varphi_c)$$

- If the message signal *m*(*t*) controls amplitude – gives AMPLITUDE MODULATION AM
- If the message signal *m*(*t*) controls frequency – gives FREQUENCY MODULATION FM
- If the message signal *m*(*t*) controls phase- gives PHASE MODULATION PM or ϕM

# Multi-Level Message Signals

As has been noted, the message signal need not be either analogue (continuous) or binary, 2 level. A message signal could be multi-level or *m* levels where each level would represent a discrete pattern of 'information' bits. For example, *m* = 4 levels

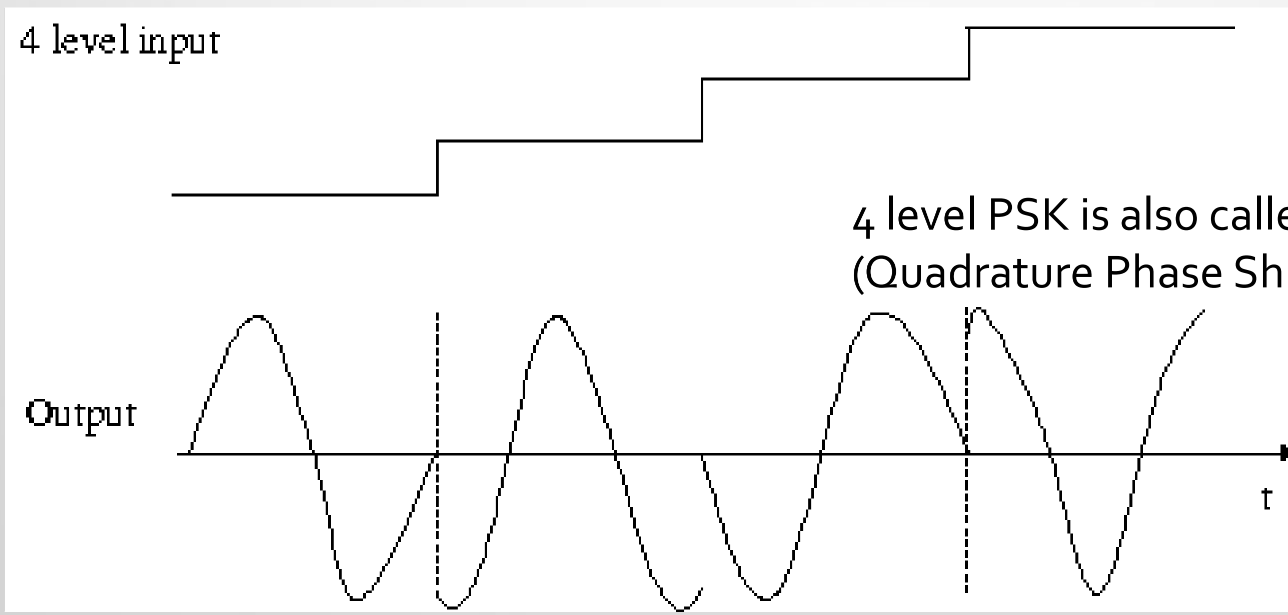


- In general $n$ bits per <u>codeword</u> will give $2^n = m$ different patterns or levels.
- Such signals are often called *m*-ary (compare with binary).
- Thus, with $m = 4$ levels applied to:

  Amplitude gives 4ASK or *m*-ary ASK

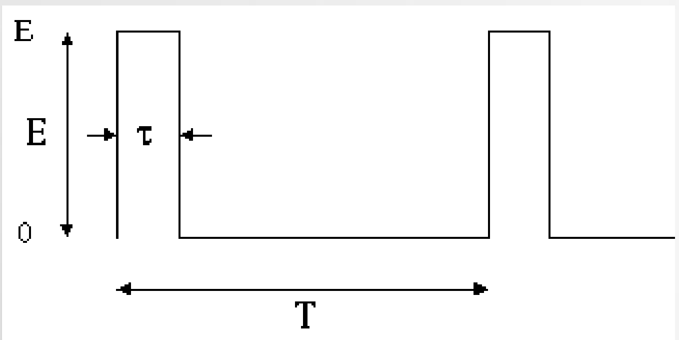
  Frequency gives 4FSK or *m*-ary FSK

  Phase gives 4PSK or *m*-ary PSK




4 level PSK is also called QPSK (Quadrature Phase Shift Keying).

# Consider Now A Pulse Train Carrier




where

$$p(t) = E, 0 < t < \tau$$

$$p(t) = 0, \tau < t < T$$

and

$$p(t) = \frac{E\tau}{T} + \frac{2E\tau}{T}\sum_{n=1}^{\infty} sinc\left(\frac{n\omega\omega}{2}\right)\cos(n\omega\omega)$$

- The 3 parameters in the case are:

  Pulse Amplitude E

  Pulse width vt

  Pulse position T

Hence:

- If *m*(*t*) controls E – gives PULSE AMPLITUDE MODULATION PAM
- If *m*(*t*) controls t - gives PULSE WIDTH MODULATION PWM
- If *m*(*t*) controls T - gives PULSE POSITION MODULATION PPM

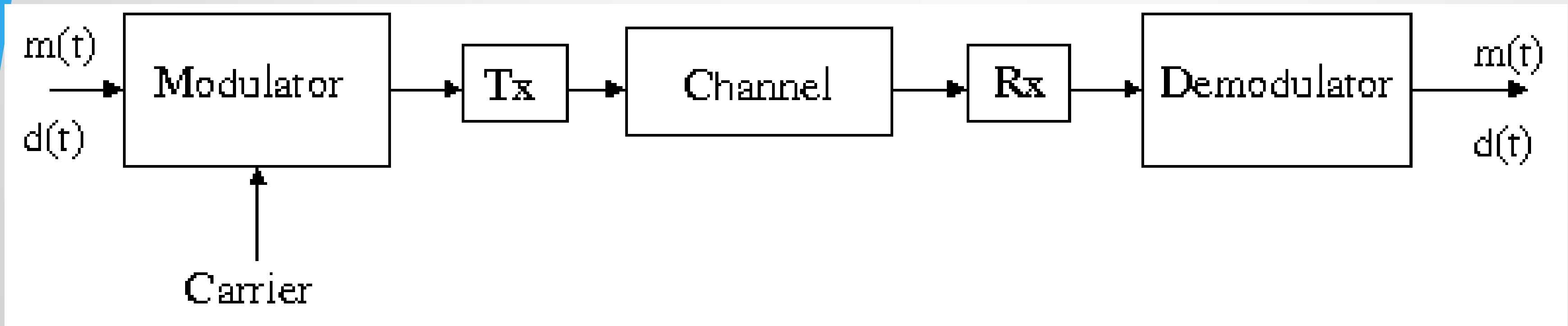
In principle, a digital message *d*(*t*) could be applied but this will not be considered further.

# Need of Modulation

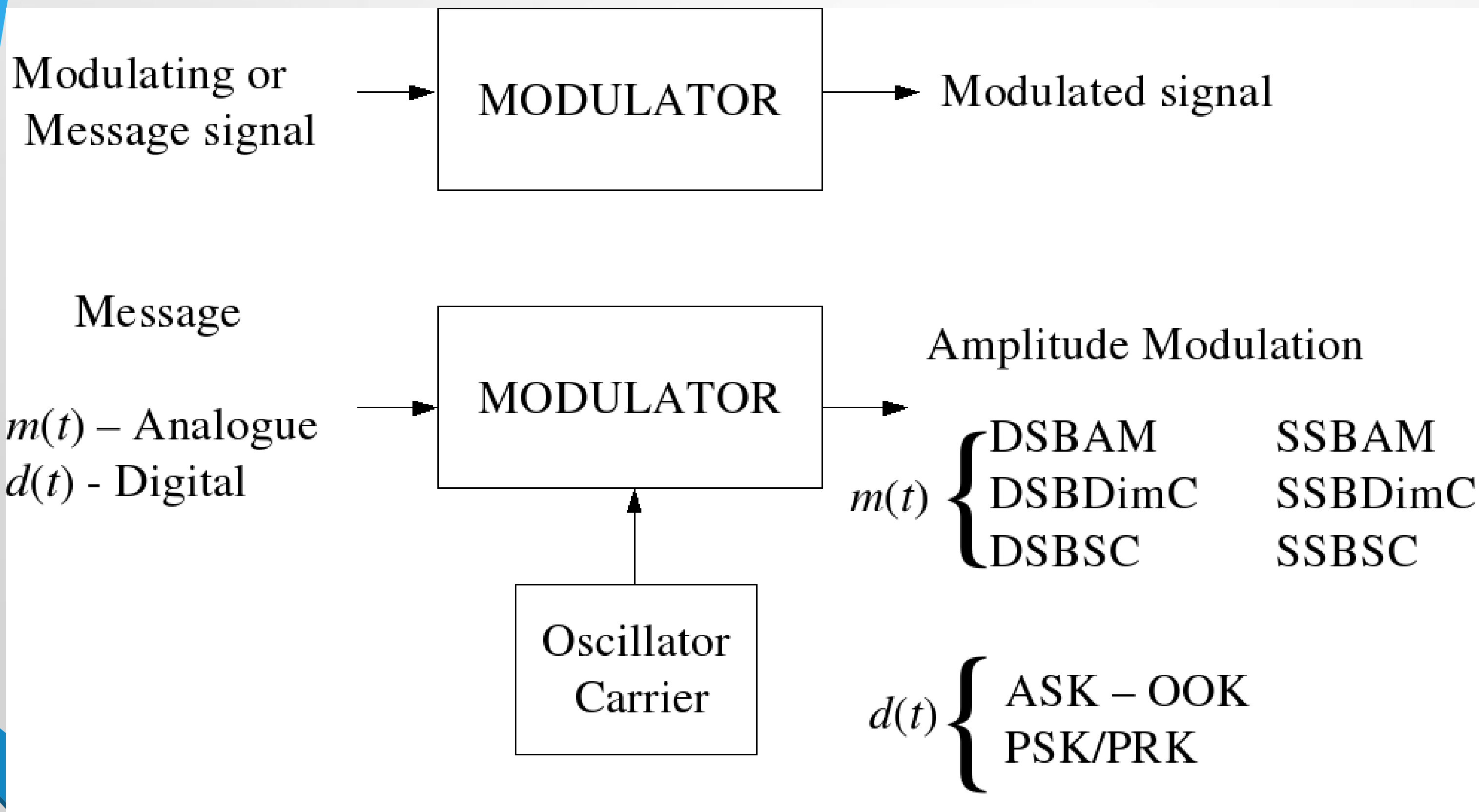
- Practicality of Antenna
- Multiplexing
- To remove interference
- Common Processing
- Effect of Noise is reduced.

# What is Demodulation?

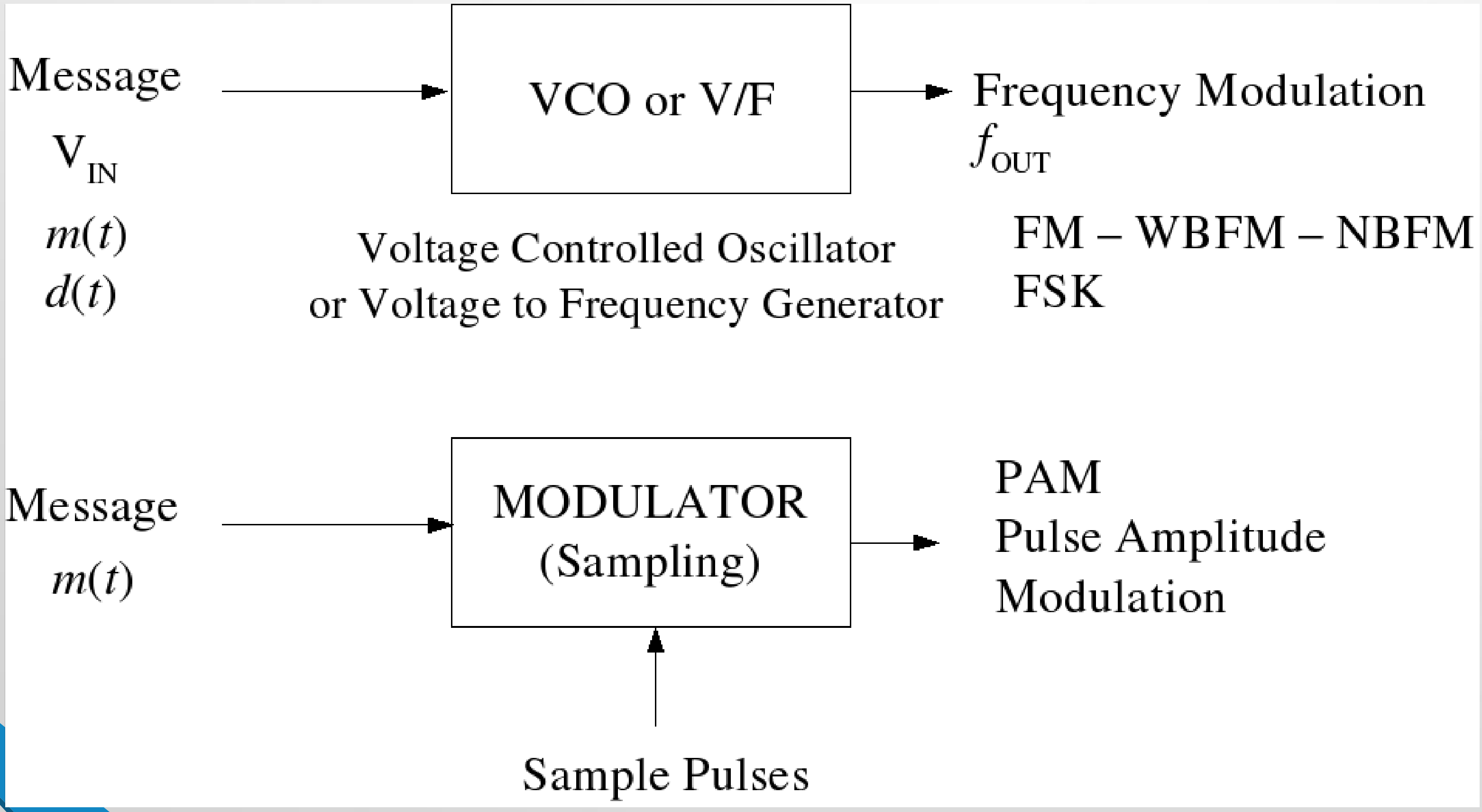
Demodulation is the reverse process (to modulation) to recover the message signal *m*(*t*) or *d*(*t*) at the receiver.



# Summary of Modulation Techniques 1



# Summary of Modulation Techniques 2

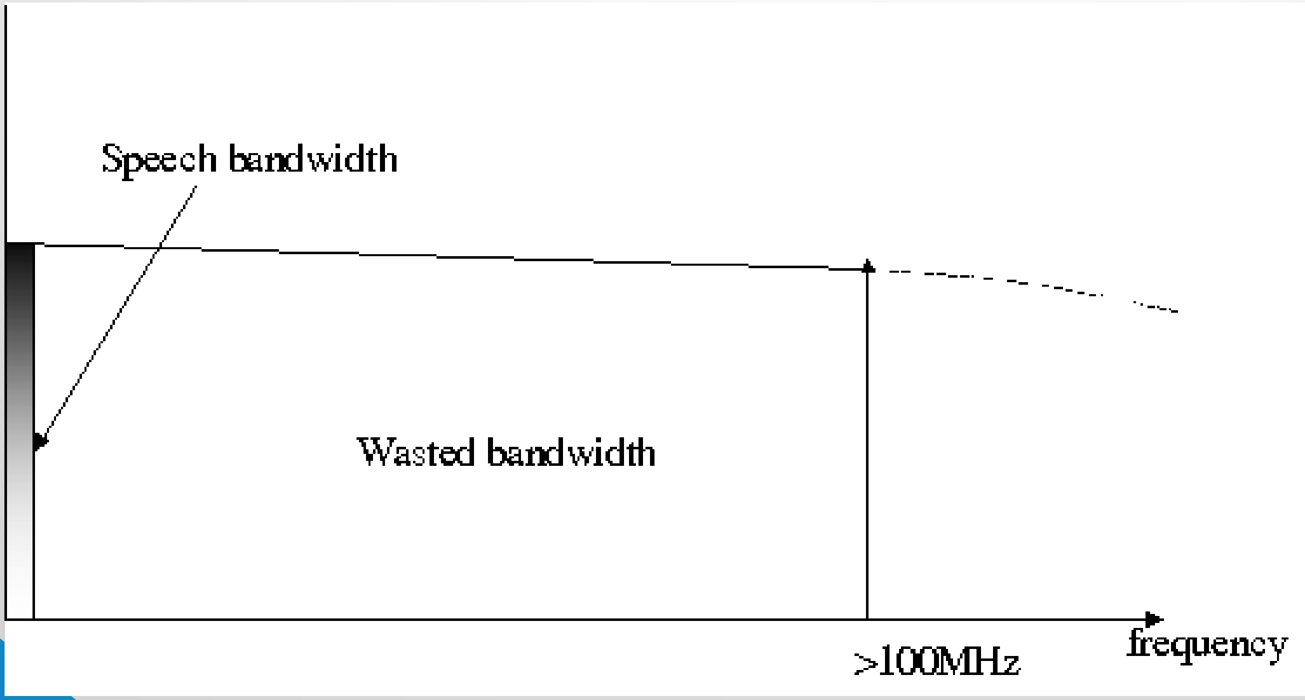


# Channels

- Band-limited (e.g. Telephone Channel)
- Power-limited (e.g. Satellite Channel )

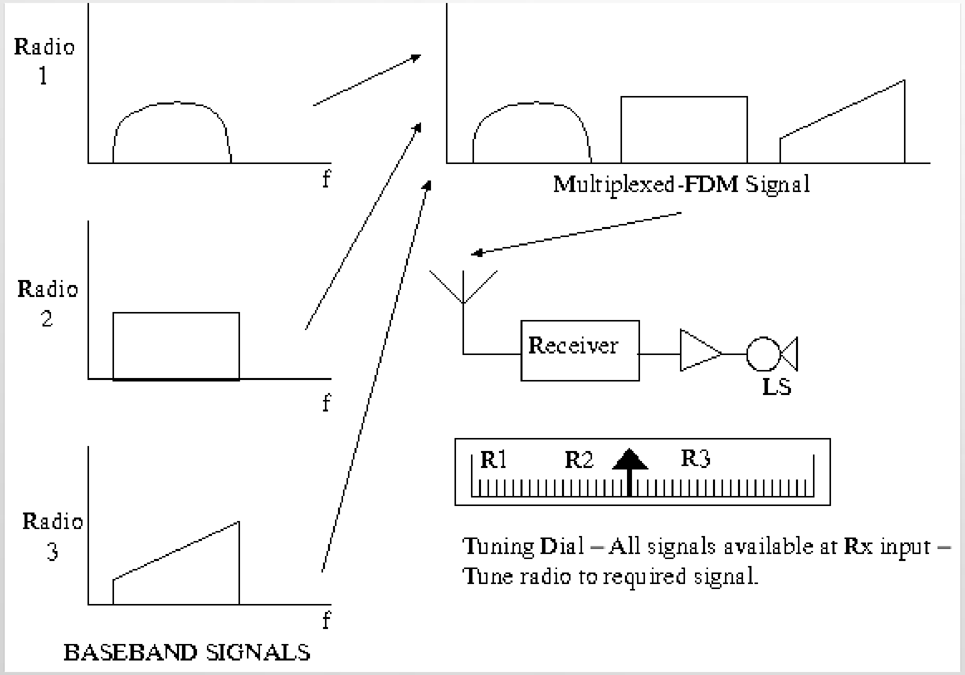
# Multiplexing

Multiplexing is a modulation method which improves channel bandwidth utilisation. For example, a co-axial cable has a bandwidth of 100's of Mhz. Baseband speech is a only a few kHz

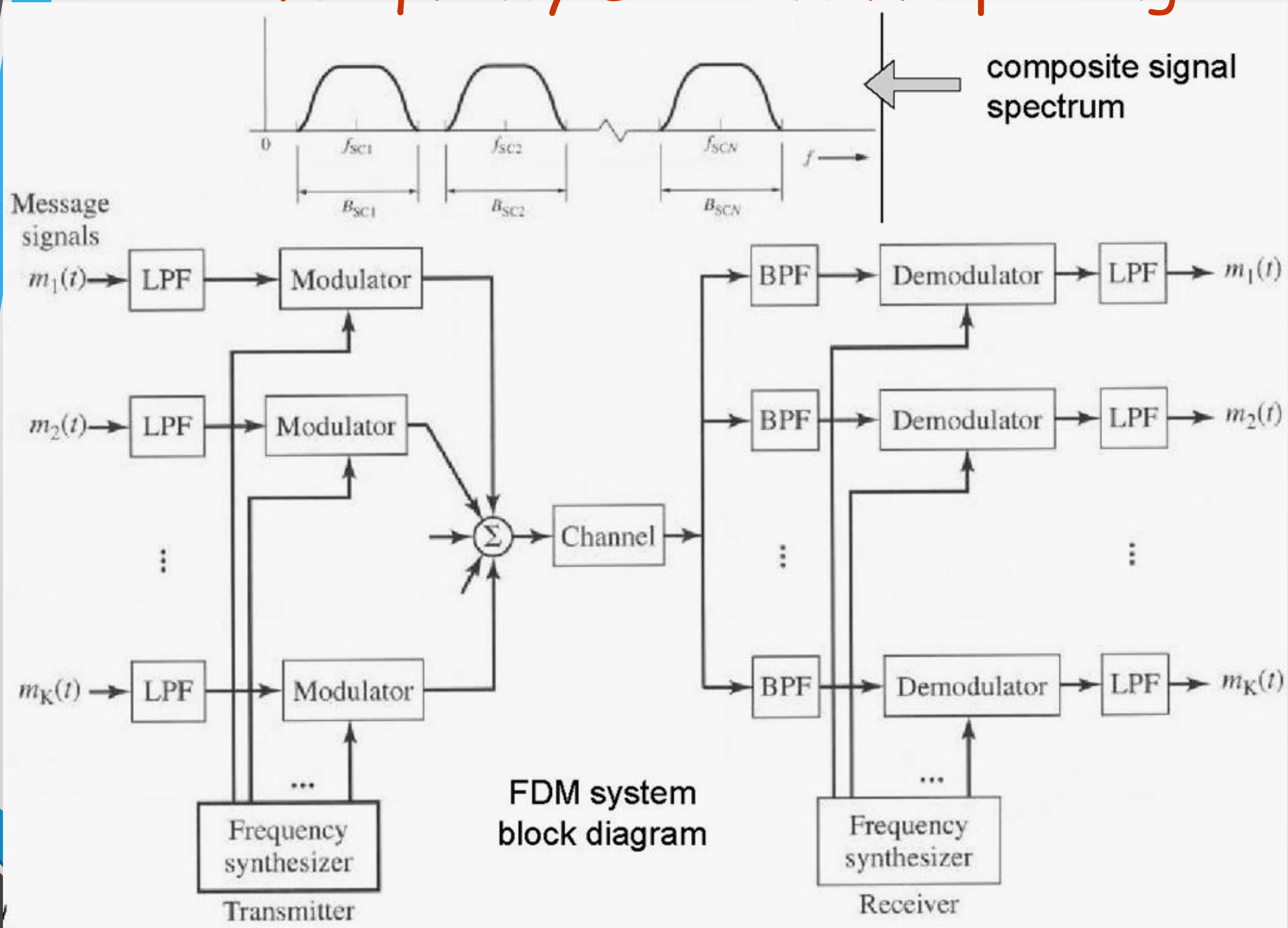


# 1) Frequency Division Multiplexing FDM

This allows several 'messages' to be translated from baseband, where they are all in the same frequency band, to adjacent but non overlapping parts of the spectrum. An example of FDM is broadcast radio (long wave LW, medium wave MW, *etc.*)



# Frequency Divison Multiplexing



# Limitations of Communication System

- Noise Limitations
- BW Limitations
- Equipment Limitations