ज्ञानेन प्रकाशते जगत्
INDUS UNIVERSITY

Wireless Communication (EC0603)

Unit-III

B.Tech (Electronics and Communication)

Semester-VI

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Multiple Access Techniques for Wireless Communication

FDMA

TDMA

CDMA

SDMA

Introduction

1. many users at same time

Multiplexing is the process of combining multiple signals in one channel

It is used for multiple users in one channel known as multiple access

Multiple Access is nothing but the applications of multiplexing. (WiFi, hotspot etc….)

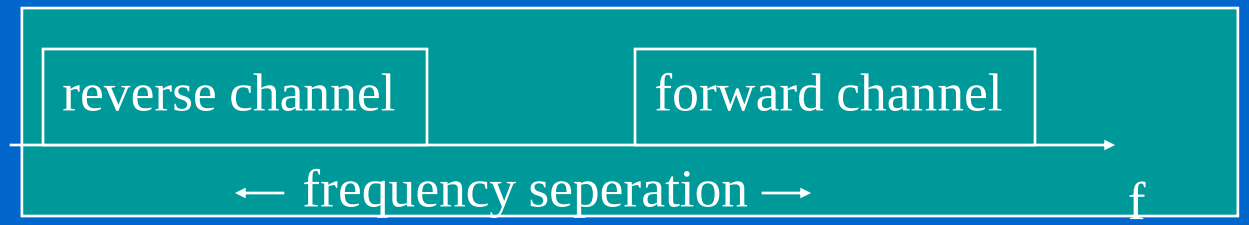
2. share a finite amount of radio spectrum
3. high performance
4. duplexing generally required
5. frequency domain
6. time domain

Cont..

- A **duplex** communication system is a point-to-point system composed of two connected parties or devices that can communicate with one another in both directions.
- In a **full duplex** system, both parties can communicate with each other simultaneously.
- In a **half-duplex** system, there are still two clearly defined paths/channels, and each party can communicate with the other but not simultaneously; the communication is one direction at a time.

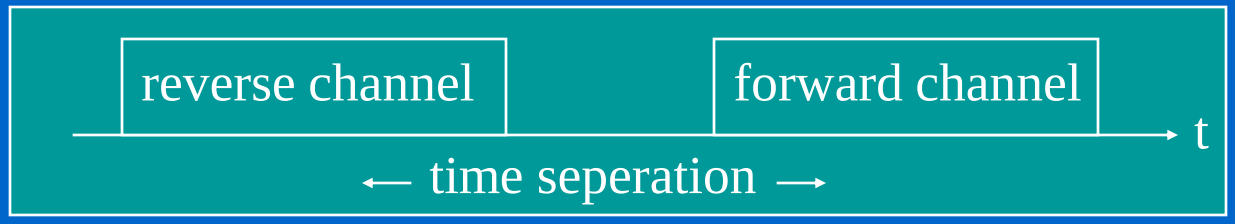
Frequency division duplexing (FDD)

- two bands of frequencies for every user
- forward band
- reverse band
- duplexer needed
- frequency separation between forward band and reverse band is constant

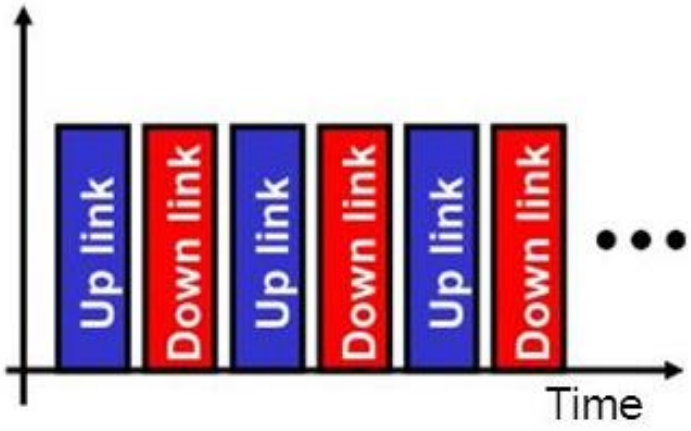


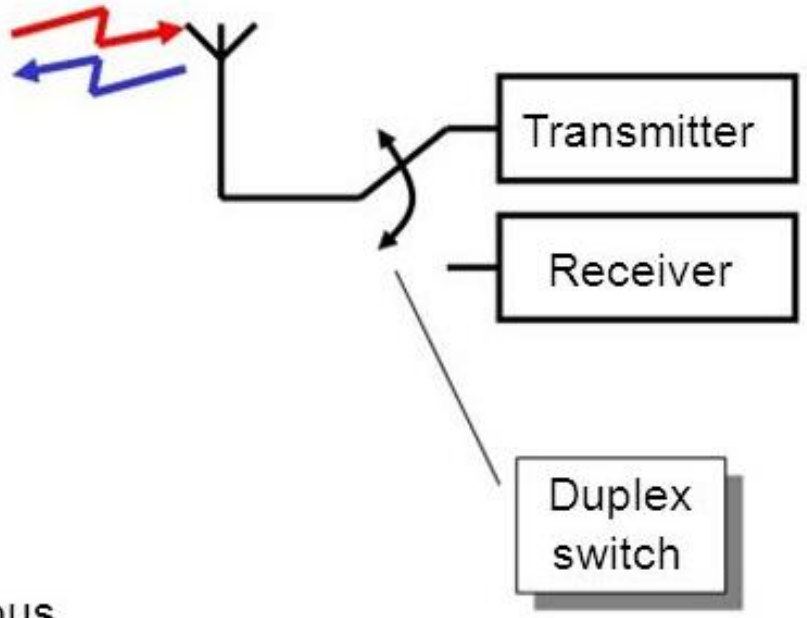
Time division duplexing (TDD)

- uses time for forward and reverse link
- multiple users share a single radio channel
- forward time slot
- reverse time slot
- no duplexer is required



Time division duplexing (TDD)

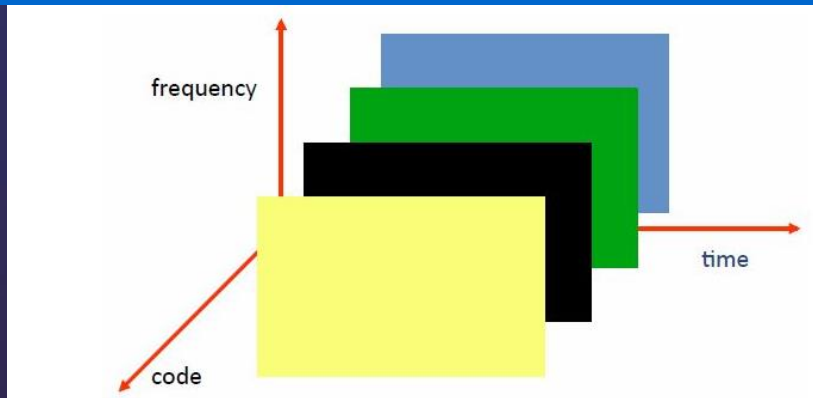




TDD gives a low complexity solution (the duplex switch).

Cannot be used for continuous transmission.

Multiple Access Schemes



3 orthogonal Schemes:

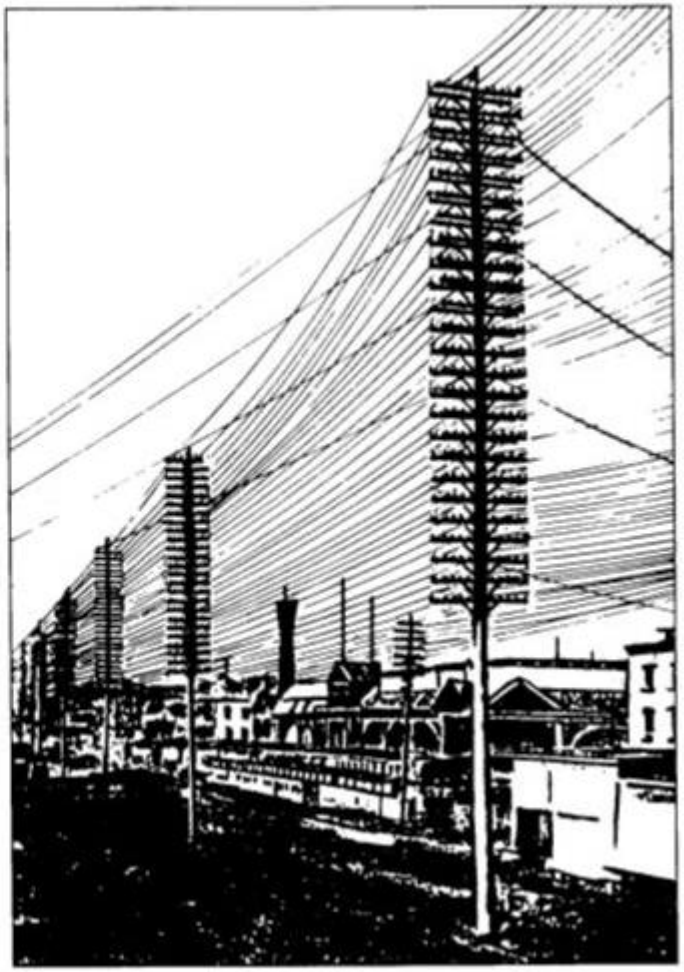
- Frequency Division Multiple Access (FDMA)
- Time Division Multiple Access (TDMA)
- Code Division Multiple Access (CDMA)

Multiple Access Techniques

- Multiple access schemes are used to allow many mobile users to share simultaneously a finite amount of radio spectrum.
- **The sharing of spectrum is required to achieve high capacity** by simultaneously allocating the available bandwidth (or the available amount of channels) to multiple users.
- **For high quality communications**, this must be done without severe degradation in the performance of the system.

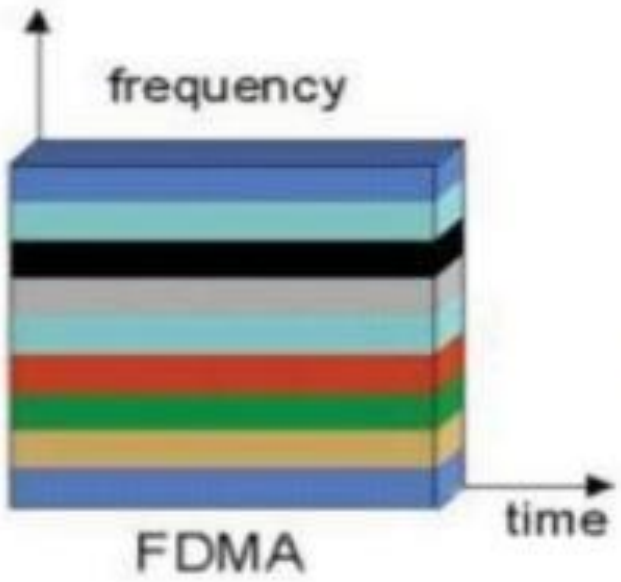
Need of Multiple Access Schemes

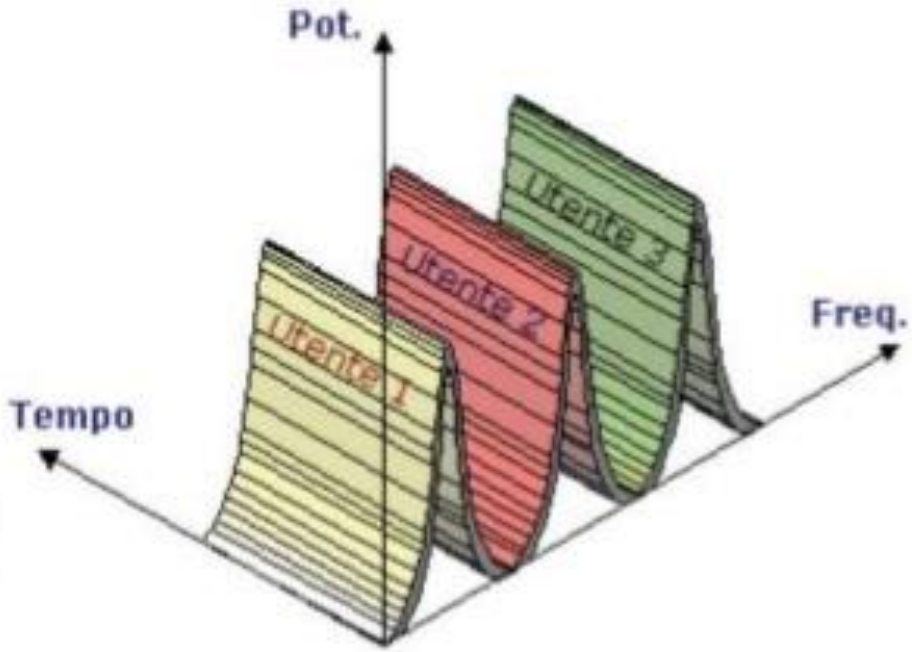
- This picture shows the technique adopted to transport phone signals at the beginning of 1900: different wires for different users.
- The introduction of **multiplexing** and **multiple access** allows that a transmission resource is shared among different users.



FDMA

- Each user transmits with no limitations in time, but using only a portion of the whole available frequency bandwidth.
- Different users are separated in the frequency domain.

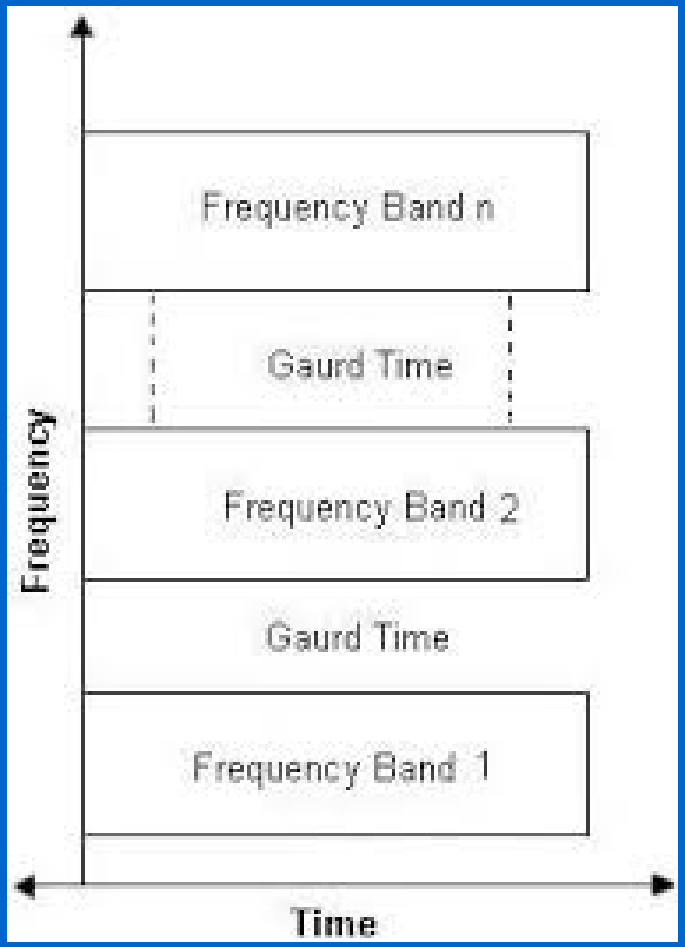




Frequency division multiple access FDMA

- one phone circuit per channel
- idle time causes wasting of resources
- simultaneously and continuously transmitting
- usually implemented in narrowband systems
- for example: in AMPS is a FDMA bandwidth of 30 kHz implemented

FDMA



In FDMA, each user is allocated a unique frequency band or channel. During the period of the call, no other user can share the same frequency band.

FDMA

- 20-120MHz BW & 5 users (20MHz/user)
- Example of FM

Nonlinear Effects in FDMA

- In FDMA system many channels share the same antenna at the base station.
- near saturation power amplifiers are nonlinear
- nonlinearities causes signal spreading
- intermodulation frequencies
- *(**Intermodulation** is a source of interference that arises from the combination of two or more signals at different frequencies in some kind of non-linear system.)*

Nonlinear Effects in FDMA

- IM are undesired harmonics
- interference with other channels in the FDMA system
- decreases user C/I - decreases performance
- interference outside the mobile radio band: adjacent-channel interference
- RF filters needed - higher costs

- An **RF Filter**, or radio frequency **filter**, is an electronic **filter** which is designed to operate on signals in medium to extremely high frequencies.

- These ranges are **used** in radio, television and wireless communications. Therefore most **RF** devices include some kind of **filtering** on the signals transmitted or received.

Number of channels in a FDMA system

$$N = \frac{B_t - 2 * B_{guard}}{B_c}$$

- N … number of channels
- B_t … total spectrum allocation
- B_{guard} … guard band
- B_c … channel bandwidth

Example: Advanced Mobile Phone System

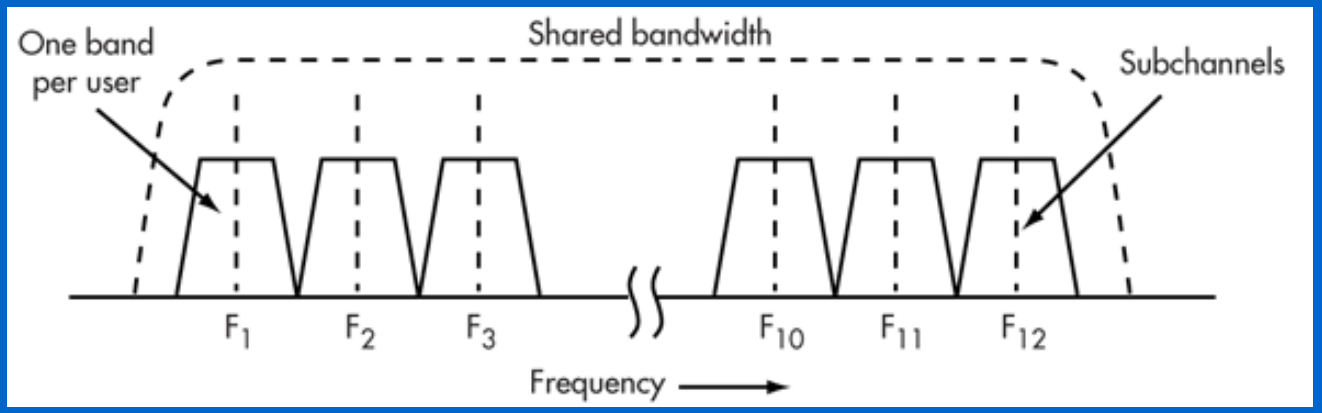
- AMPS
- FDMA/FDD
- analog cellular system
- 12.5 MHz per simplex band - B_t
- B_{guard} = 10 kHz ; B_c = 30 kHz

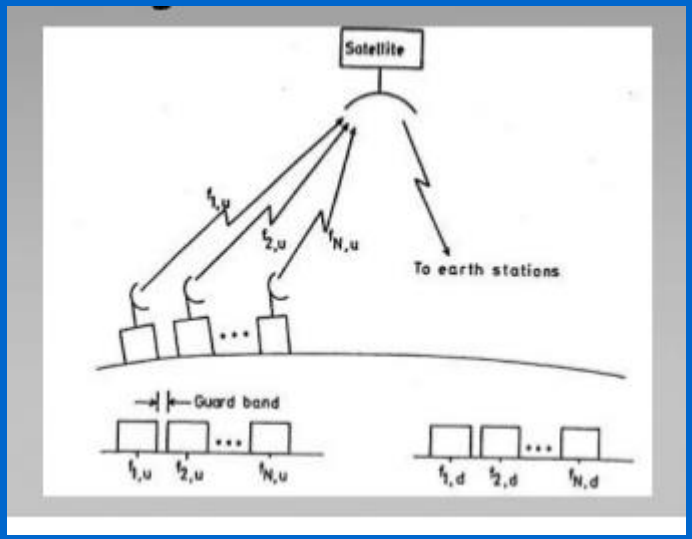
$$N = \frac{12.5E6 - 2*(10E3)}{30E3} = 416 \text{ channels}$$

Example

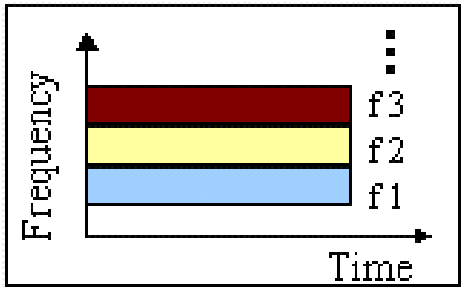
- In US AMPS, 416 channels are allocated to various cellular operators. The channel between them is 30 KHz with the guard band of 10 KHz. Calculate the spectrum allocation given to each operator.

- ANS: 12.5MHz is allocated for each band.

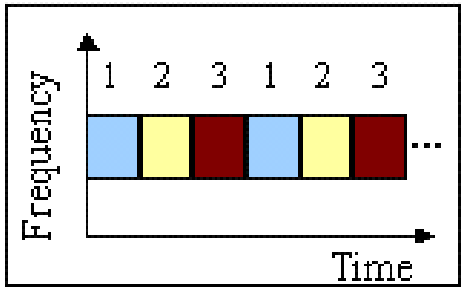

One band
per user
Shared bandwidth
Subchannels
F1
F2
F3
F10
F11
F12
Frequency


Satellite
To earth stations
Guard band

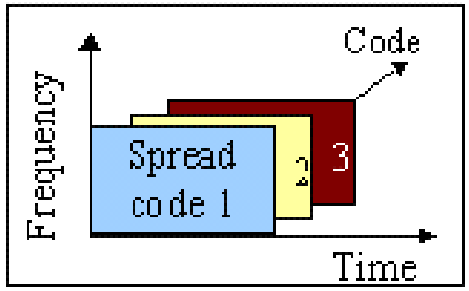
FDMA
(Frequency Division Multiple Access)

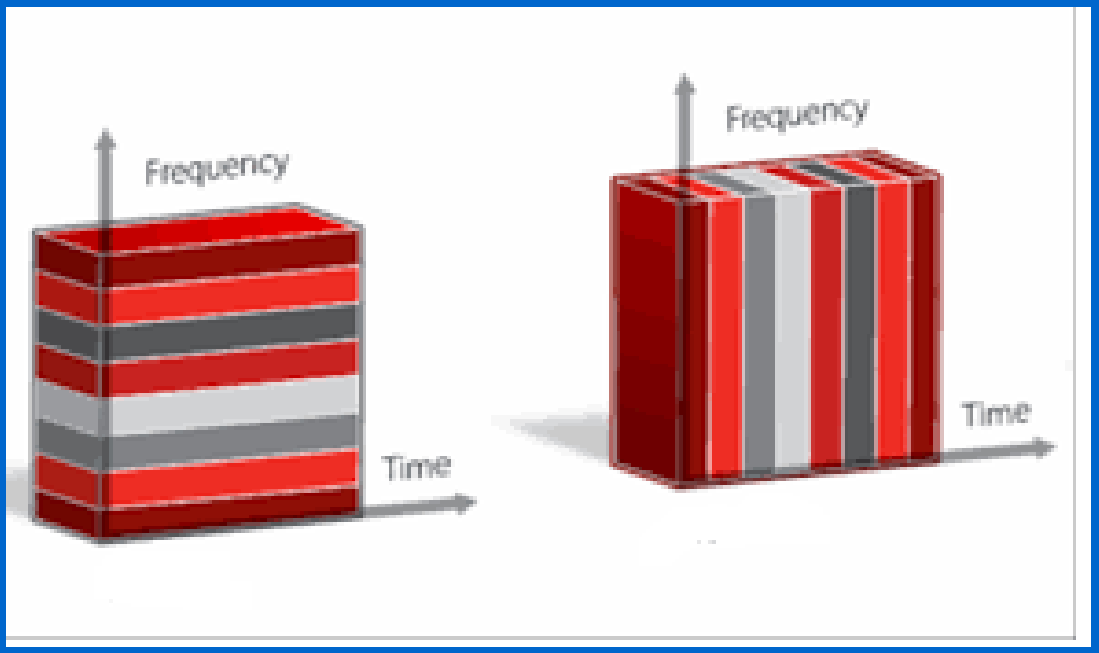


TDMA
(Time Division Multiple Access)



CDMA
(Code Division Multiple Access)




Frequency
Time
Frequency
Time

OFDM

Unit- III

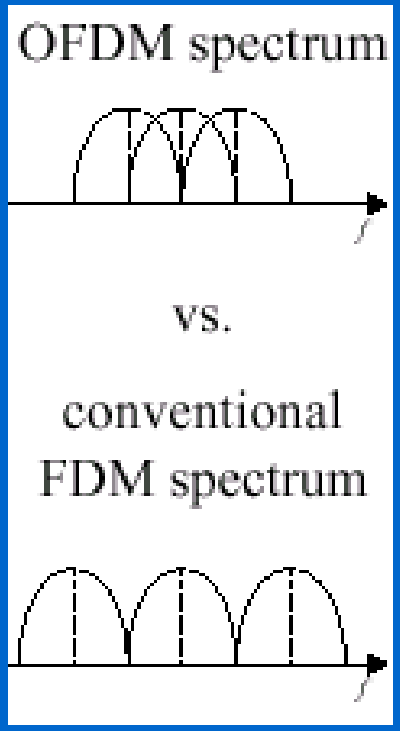
OFDM

- OFDM-Orthogonal frequency division multiplexing

- In **flat fading**, the coherence bandwidth of the channel is larger than the bandwidth of the signal. Therefore, all frequency components of the signal will experience the same magnitude of fading.
- In **frequency-selective fading**, the coherence bandwidth of the channel is smaller than the bandwidth of the signal. Different frequency components of the signal therefore experience uncorrelated fading.

What is an OFDM System ?

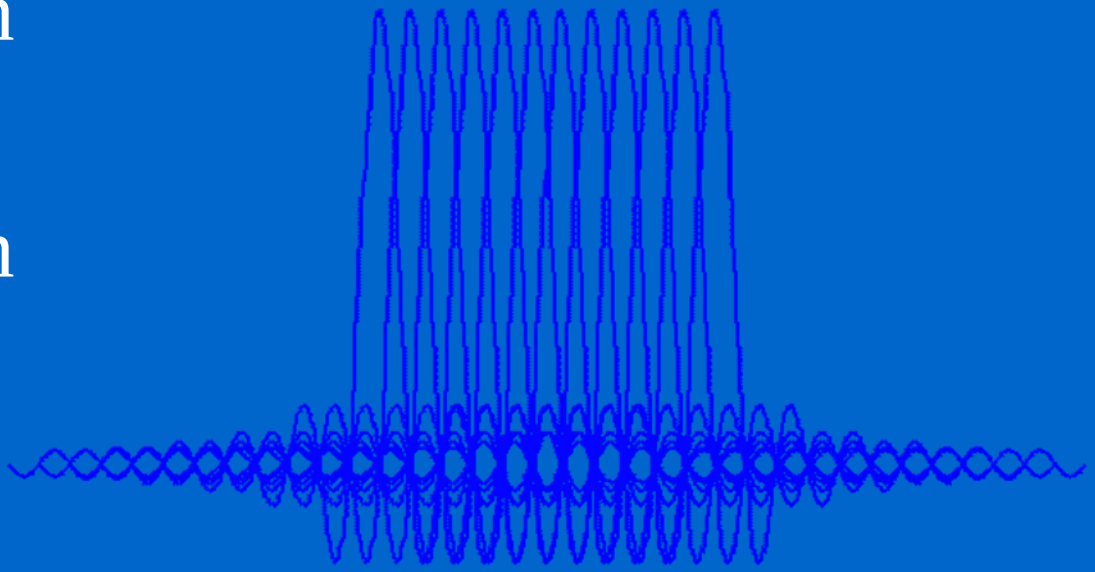
- Data is transmitted in parallel on multiple carriers that overlap in frequency



- Multicarrier communications
- Synchronization

Issues

- Synchronization
- Sidelobes



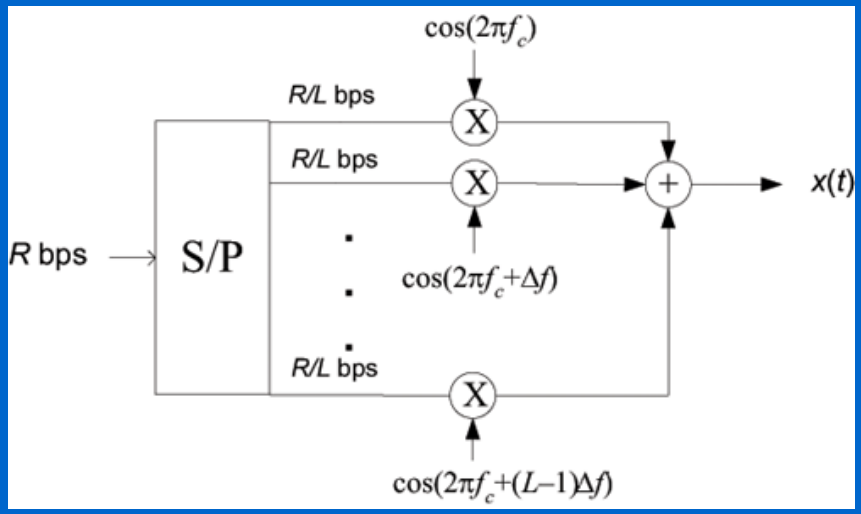
- OFDMA

Intersymbol Interference

- Occurs when symbol period (T_s) is less than channel delay spread, τ
- ISI introduces an error floor to BER
  - Limits maximum throughput (**throughput** is the rate of successful message delivery over a communication channel.)
- Solutions:
  - Equalization (high complexity)-- is the process of adjusting the balance between **frequency** components within an electronic signal.
  - Longer symbol periods (generally means lower data rate)

Multicarrier communications: Longer period, same data rate

- Concept:
  - Divide original data stream at rate *R* into *L* lower rate (*R*/*L*) streams on different carriers to increase symbol time



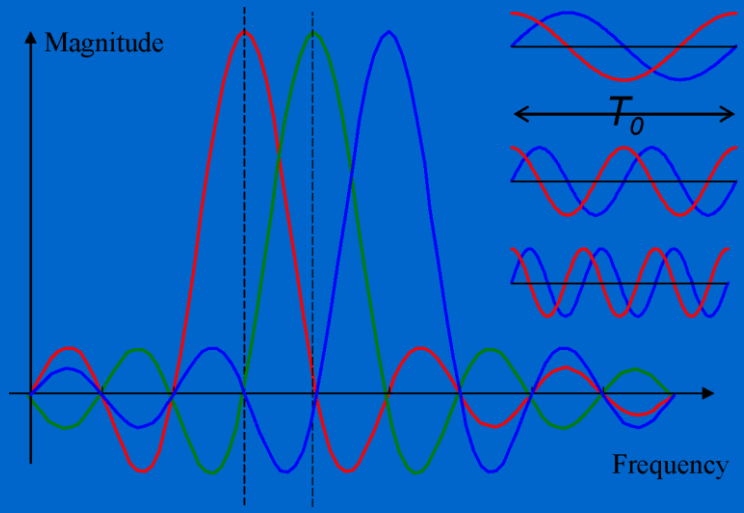
J. Andrews, A. Ghosh, R. Muhamed, **Fundamentals of WiMAX**, Prentice Hall, 2007

- Effects
  - High receiver complexity
    - separate receiver chain per carrier
  - Bandwidth due to sidebands
  - Each subcarrier experiences flat fading

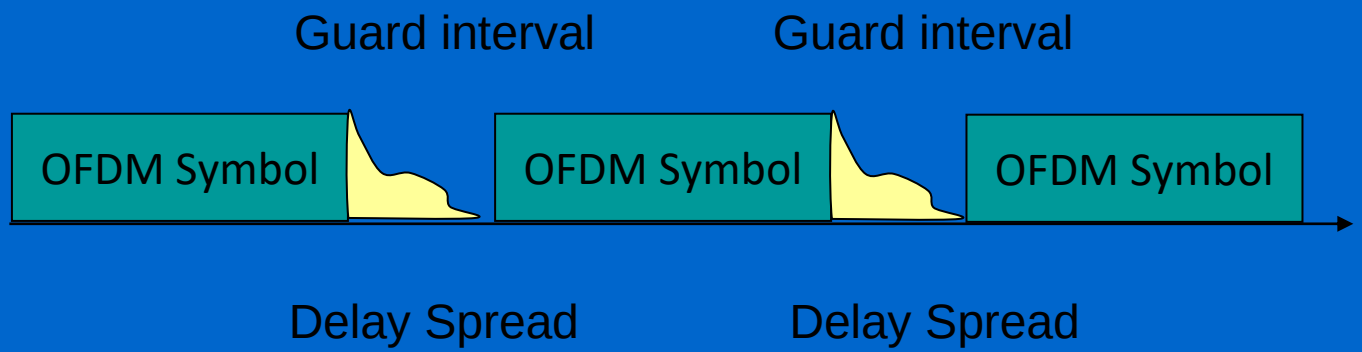
OFDM

- Much simpler to create multicarrier transmission using iFFT
  - Information carried in magnitude and phase of each bin
  - Then can be recovered by using FFT at receiver

- Inverse Fourier transform would be an infinite duration sine wave
  - Cut at Symbol duration T_s
  - Rectangular windowing causes sinc spectrum in frequency domain with zeros at $1/T_s$
  - Orthogonal subcarriers



Guard intervals and intersymbol interference



- If we space OFDM symbols by gaps at least as long as the delay spread, then there will be no intersymbol interference
- However, there will still be interference within the symbol