

# Lecture (01)

## Introduction to Wireless Networking Concepts (I)

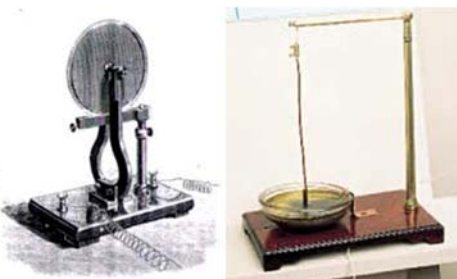
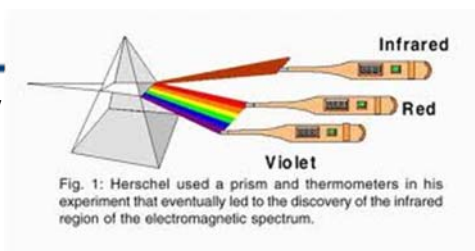
Dr. Ahmed ElShafee

## Agenda

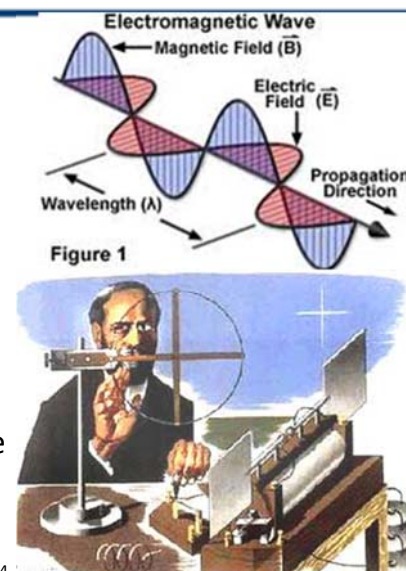
- **Foundation & History**
- How Bandwidth Is Achieved from RF Signals?
- Common WLAN bands
- Modulation & Encoding

## Foundation & History

- Infrared light was discovered by Sir William Herschel (1738 to 1822)
- The discovery of infrared light led the way to the electromagnetic wave theory
- Michael Faraday (1791 to 1867) and Andre-Marie Ampere (1775 to 1836), achieved some discoveries related to electromagnetism



- James Maxwell (1831 to 1879) electromagnetic wave theory
- Heinrich Hertz (1857 to 1894) built on the discoveries of Maxwell by proving that electromagnetic waves travel at the speed of light and that electricity can be carried on these waves.



## Foundation & History (cont,..)

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So what is the relation between hertz discovery and wireless LAN?

- In standard LANs, *data is propagated* over wires such as an Ethernet cable, in the form of electrical signals.
- The discovery that Hertz made opens the airways to transfer the same data, as electrical signals, without wires, which is the godfather of wireless LANs.
- And this technology exists because of the research and discoveries that Faraday , Maxwell, Ampere, and Hertz made.
- This is accomplished by way of Radio Frequencies (RF).

## Agenda

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- Foundation & History
- **How Bandwidth Is Achieved from RF Signals?**
- Common WLAN bands
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## How Bandwidth Is Achieved from RF Signals?

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- To send data over the airwaves, the IEEE has developed the 802.11 specification,
- which defines half-duplex operations using the same frequency for send and receive operations on a WLAN.
- No licensing is required to use the 802.11 standards; however, you must follow the rules that the FCC has set before.
- The FCC governs
  - the frequencies that can be used,
  - power levels at which WLAN devices can operate,
  - the transmission technologies that can be used,
  - the locations where certain WLAN devices can be deployed.

## How Bandwidth Is Achieved from RF Signals? (cont,..)

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- The FCC is the regulatory body that exists in the United States.
- The *European Telecommunications Standards Institute (ETSI)* is the European equivalent to the FCC.
- Other countries have different regulatory bodies.
  
- To place data on the RF signals, you use a modulation technique.
- Modulation is the addition of data to a carrier signal.
- To send music, news, or speech over the airwaves, you use *frequency modulation (FM)* or *amplitude modulation (AM)*.

## How Bandwidth Is Achieved from RF Signals? (cont,..)

- When you refer to bandwidth, In wireless networking, the word *bandwidth can mean two* different things.
  - In one sense of the word, it can refer to data rates.
  - In another sense of the word, it can refer to the width of an RF channel.
- The standard unit to measure bandwidth is the Hertz (Hz).
- A Hertz measures the number of cycles per second.
- One Hertz is one cycle per second.

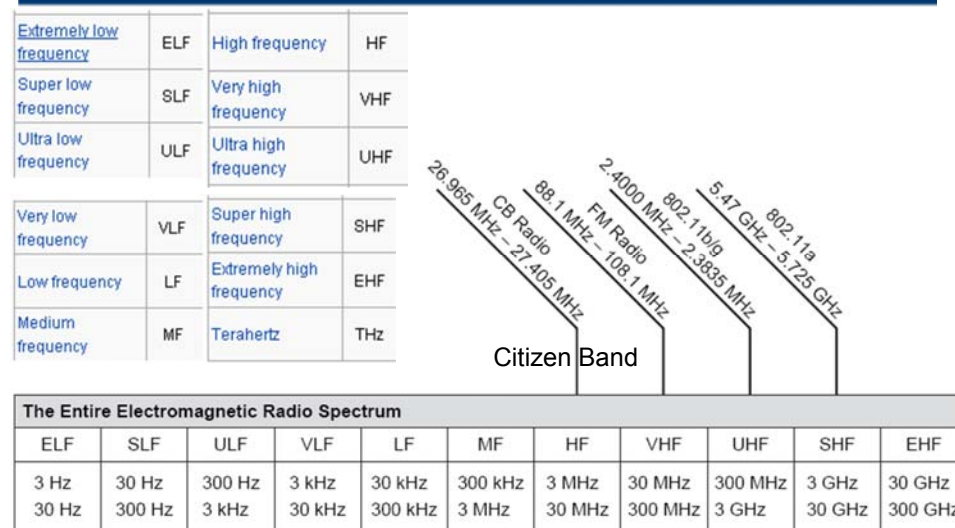
## How Bandwidth Is Achieved from RF Signals? (cont,..)

- In radio technology,
- *AM radio is pretty low quality. It uses about 3 kHz of bandwidth.*
- FM radio is generally a higher quality, using about 175 kHz of bandwidth.
- Compare that to a television signal, which sends both voice and video over the air.
- The TV signal you receive uses almost 4500 kHz of bandwidth.

## How Bandwidth Is Achieved from RF Signals? (cont,..)

- Most of the spectrum is governed by organizations like the FCC or ETSI
- This means that you cannot use the same frequencies that FM radio uses in your wireless networks.

## How Bandwidth Is Achieved from RF Signals? (cont,..)



## How Bandwidth Is Achieved from RF Signals? (cont,..)

*Usable Frequency Bands in Europe, the United States, and Japan*

Europe	USA	Japan	Frequency
	900 MHz		900 MHz
2.4 GHz	2.4 GHz ISM		2.0–2.4835 GHz
		2.4 GHz	2.0–2.495 GHz
CEPT A	UNII-1	5.15–5.25 GHz	5.15–5.25 GHz
CEPT A	UNII-2		5.25–5.35 GHz
CEPT B	UNII-2 Extended		5.47–5.7253 GHz
	ISM		5.725–5.850 GHz
		5.0 GHz	5.038–5.091 GHz
		4.9 GHz	4.9–5.0 GHz

Conference of European Post and Telecommunication (CEPT)  
Unlicensed National Information Infrastructure (UNII)  
Industrial scientific Medical (ISM)

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- Foundation & History
- How Bandwidth Is Achieved from RF Signals?
- **Common WLAN bands**
- Modulation & Encoding

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## Common WLAN bands

### 900 MHz

- The 900-MHz band starts at 902 MHz and goes to 928 MHz.
- Most cordless phone that operates in this range.
- You might have picked up your cordless phone only to hear a lot of static or even a neighbor on his cordless phone.
- If this happened, you could press the Channel button to switch to a channel that did not have as much interference. When you found a clear channel, you could make your call.

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## Common WLAN bands (cont,..)

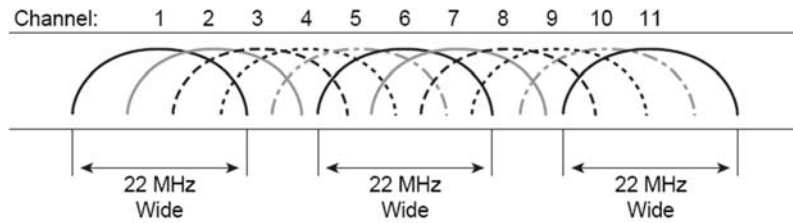
### 2.4 GHz

- The 2.4-GHz range is most widely used frequency range in WLANs.
- It is used by the 802.11, 802.11b, 802.11g, and 802.11n IEEE standards.
- Subdivided into channels that range from 2.4000 to 2.4835 GHz.
- The United States has 11 channels, and each channel is 20-MHz wide.

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## Common WLAN bands (cont,..)



2.4-GHz Channels

- Some channels overlap with others and cause interference.
- For this reason, channels 1, 6, and 11 are most commonly used because they do not overlap.
- In fact, many wireless devices are hard set so you can choose only one of the three channels.

## Common WLAN bands (cont,..)

- In 802.11b and 802.11g, the energy is spread out over a wide area of the band 20MHz
- The 2.4-GHz range uses *direct sequence spread spectrum (DSSS) or modulation or Orthogonal Frequency Division Multiplexing (OFDM)*.
- Data rates of 1 Mbps, 2 Mbps, 5.5 Mbps, and 11 Mbps are defined for this range (DSSS), and 54MHz for OFDM.

## Common WLAN bands (cont,..)

### 5 GHz

- The 5-GHz range is used by the 802.11a standard and the new 802.11n
- The 5-GHz range is also subdivided into channels, each being 20-MHz wide.
- A total of 23 non overlapping channels exist in the 5-GHz range.
- Uses *Orthogonal Frequency Division Multiplexing (OFDM) modulation technique*.
- The 802.11a standard, data rates can range from 6 Mbps to 54 Mbps.
- And 802.11n supports data rate up to 75Mbps (for 20MHz Band width) or 150Mbps (for dual band width 40MHz) MIMO

## Agenda

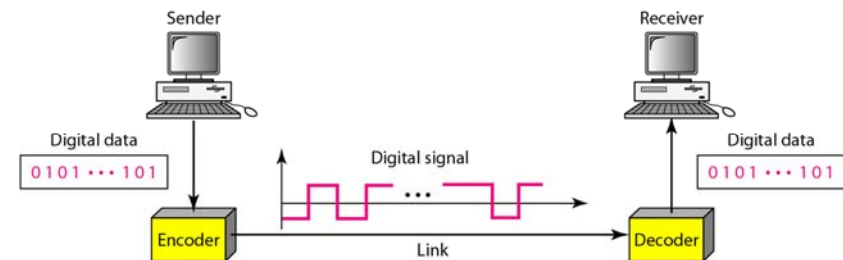
- Foundation & History
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- **Modulation & Encoding**

# Modulation & Encoding

- Imagine that you are singing a song.
- Words are written on a sheet of music.
- If you just read the words, your tone is soft and does not travel far.
- To convey the words to a large group, you use your vocal chords and modulation to send the words farther.
- While you are singing the song, you encode the written words into a waveform and let your vocal cords modulate it.
- People hear you singing and decode the words to understand the meaning of the song.

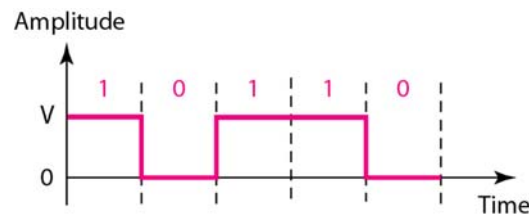
# Modulation & Encoding (cont,..)

- **Coding:**  
Is transform data form to another form, which means how to resent 0s and 1s in digital format.  
Ex: 0s can be presented as 0volt, or falling edge  
1s can be presented as 5volts, or rising edge, or inverting the signal itself.

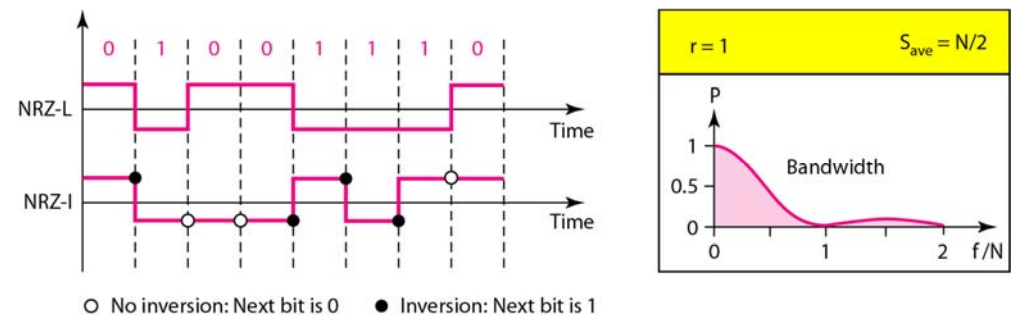


some coding types:

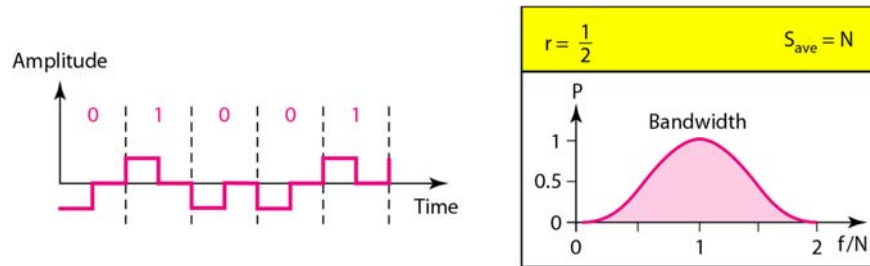
## Unipolar coding



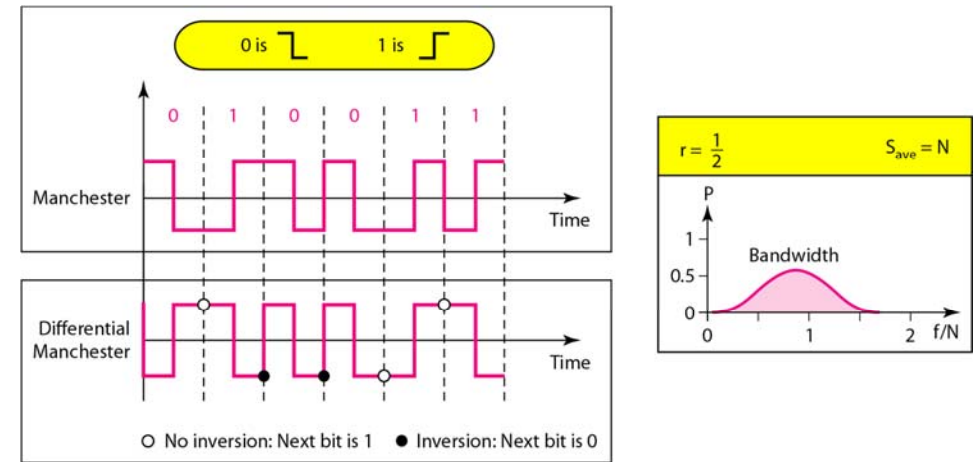
## • Polar NRZ-L and NRZ-I schemes



- **Polar RZ scheme**



- **Polar biphas: Manchester and differential Manchester schemes**



- **Modulation:**

Is changing the nature of signals (which presents the data 0,1) from digital format to analog format.

As analog wave form can be easily transmitted over RF unlike the digital signals.

## Modulation & Encoding (cont,..)

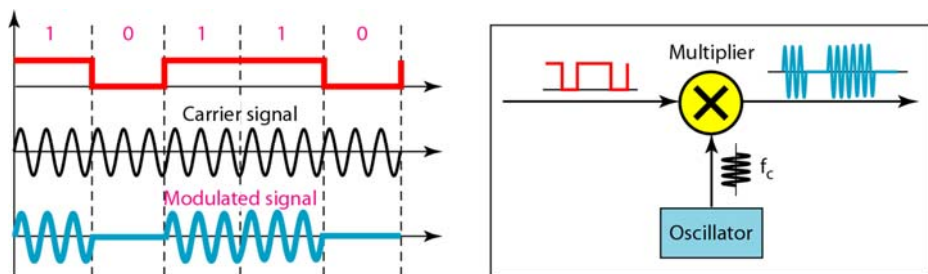
### Examples of Modulation techniques

- *Amplitude: The volume of the signal*
- *Phase: The timing of the signal between peaks*
- *Frequency: The pitch of the signal*

Wireless networks use a few different modulation techniques, including these:

- *DSSS*
- *OFDM*

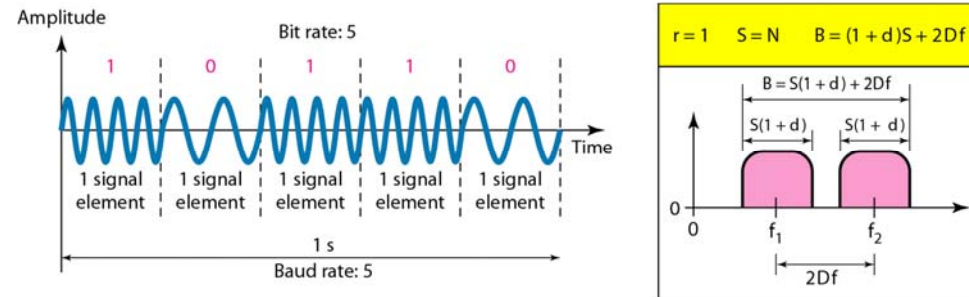
- Binary ASK



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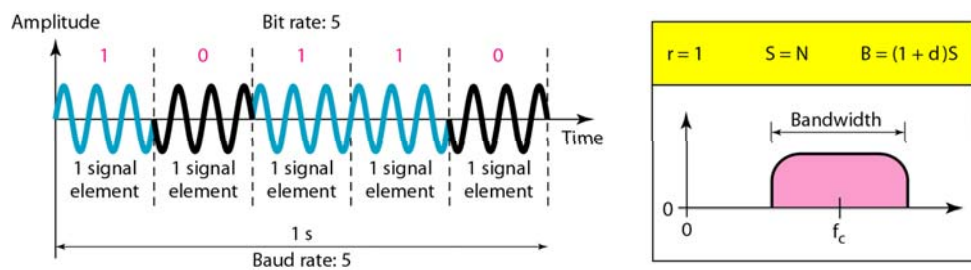
- Binary FSK



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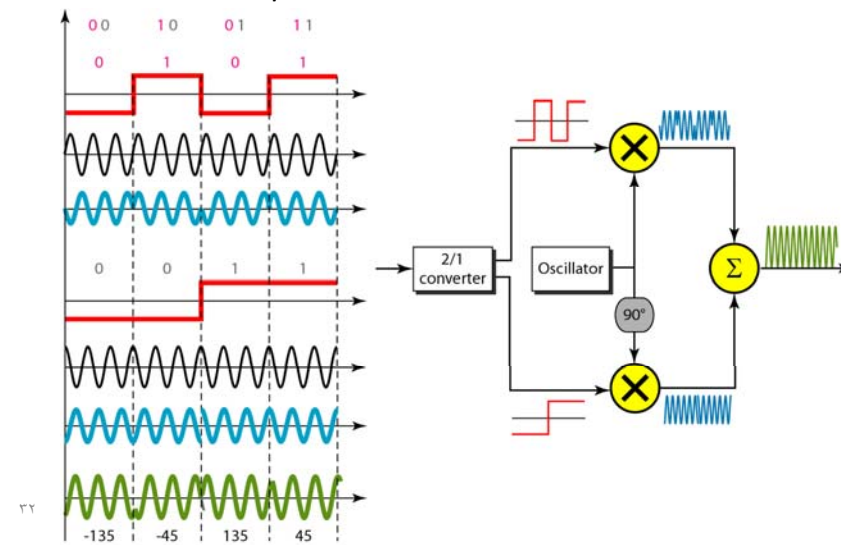
- Binary phase shift keying



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- QPSK and its implementation

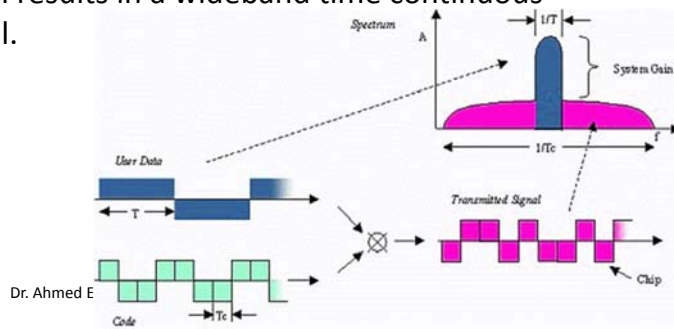


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- **DSSS**

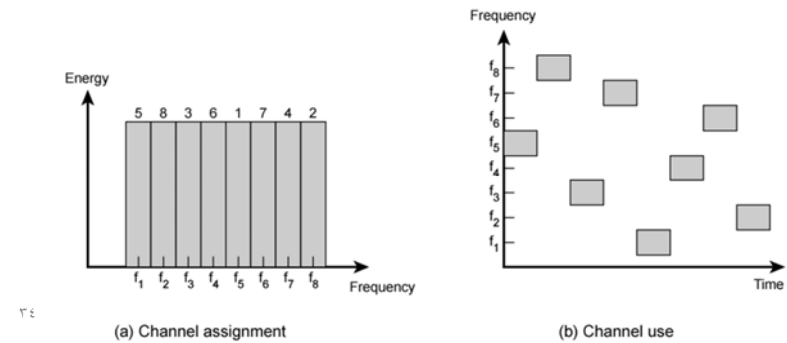
- Direct Sequence Spread Spectrum (DSSS) is a spread spectrum technique whereby the original data signal is multiplied with a pseudo random noise spreading code.
- This spreading code has a higher chip rate (this the bitrate of the code), which results in a wideband time continuous scrambled signal.



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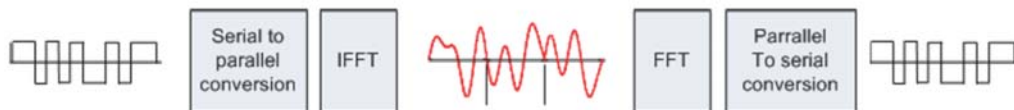
- DSSS significantly improves protection against interfering (or jamming) signals, especially narrowband and makes the signal less noticeable.
- It also provides security of transmission if the code is not known to the public.



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- **OFDM**

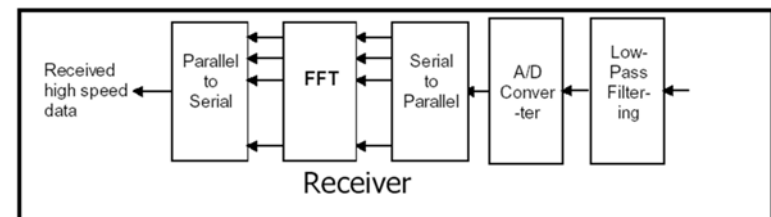
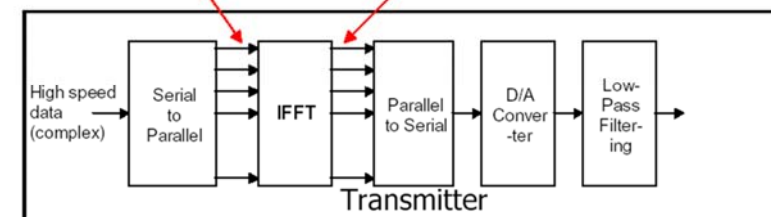
- OFDM stands for Orthogonal Frequency Division Multiplexing, and is a modulation technique for transmitting large amounts of digital data over a radio wave.



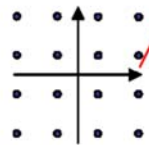
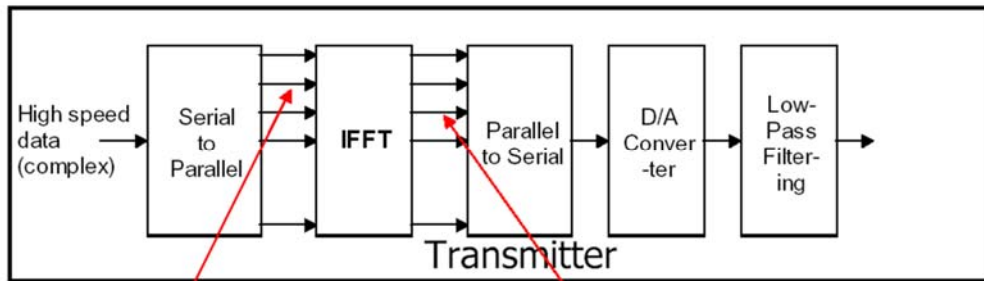
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- Discrete frequency domain: Each input controls signal at one frequency
- Discrete Time Domain: Samples of modulated and multiplexed signals



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Complex value representing data is input to IFFT

IFFT output gives samples of modulated multiplexed signal



Thanks,  
See you next Week, isA