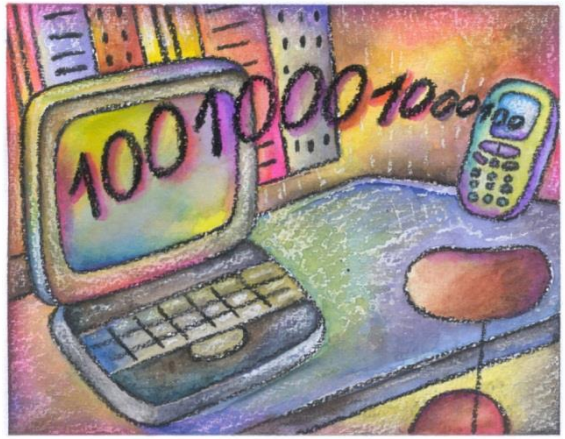
Wireless Technology Applications Understand the development of Wireless Technologies

Melvyn U Myint Oo
T16620
68970688
melvyn_oo@sp.edu.sg



Content

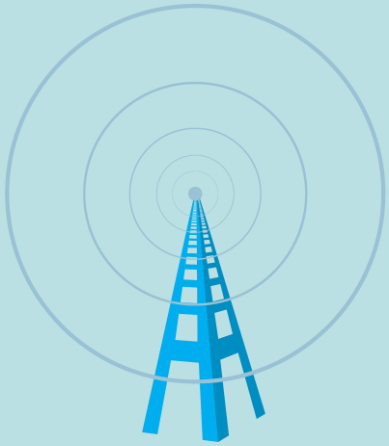
- What is wireless technology?
- Fundamentals
- Examples and applications
- Advantages and disadvantages
- Wireless Local Area Network (WLAN)
- Wireless Personal Area Network (WPAN)

What is wireless technology?

- In 1895, Guglielmo Marconi succeeded in sending wireless signals over a distance of 1½ miles.
- In 1896, he demonstrated it in London and obtained the first patent in wireless telegraphy.
- In 1909, he was awarded the Nobel Prize for Physics for his discovery of radio waves.
- With his discovery, a new industry emerged.

What is wireless technology?

- *Wireless technology* is a term used to describe telecommunications in which electromagnetic waves carry signal over part or all of the communication path.
- Due to different throughput requirements for different applications (voice, data, video) and different coverage (PAN, LAN, MAN, WAN), different wireless technologies are being used.



Fundamentals

- Fundamental requirement for wireless technology is the use of electromagnetic waves as data carriers.
- Radio Frequency is the portion of electromagnetic spectrum that can be generated by feeding AC to an antenna.
- Wireless technology uses RF as carriers for signal transmission.

Fundamentals

RF spectrum is divided into 11 bands with one logarithmic frequency per band

Band name	Frequency
ELF	3-30Hz
SLF	30-300Hz
ULF	300-3000Hz
VLF	3-30kHz
LF	30-300kHz
MF	300-3000kHz
HF	3-30MHz
VHF	30-300MHz
UHF	300-3000MHz
SHF	3-30GHz
EHF	30-300GHz

Fundamentals

Ground waves

Low signal attenuation and travels very far

Different RF bands have different characteristics

Sky waves

Can be refracted and reflected by upper atmosphere

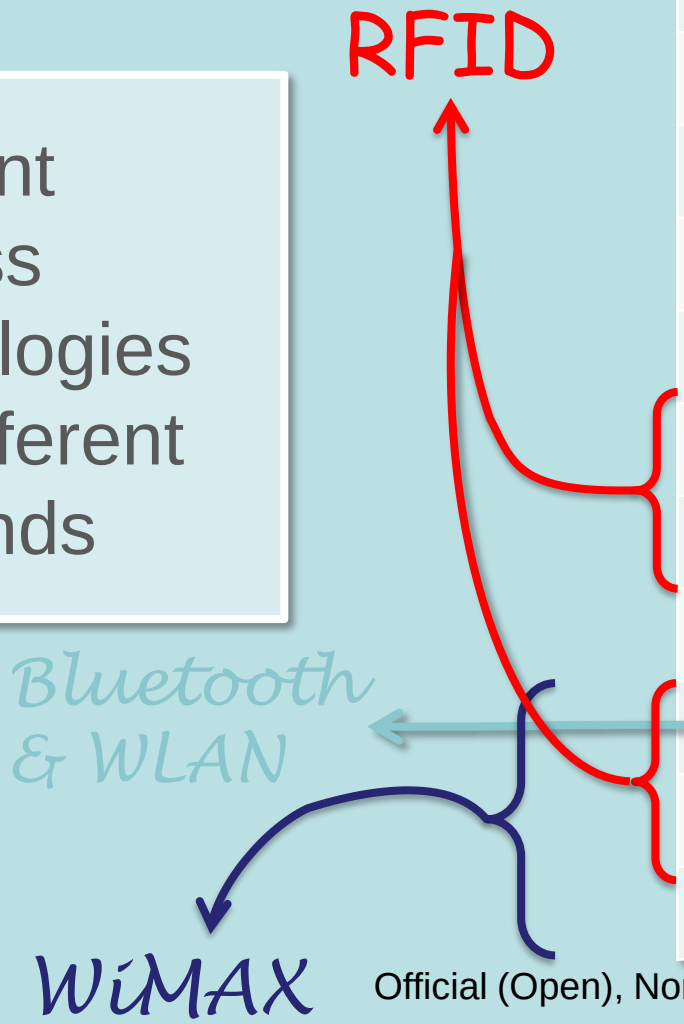
Space waves

Require line-of-sight propagation

Band name	Frequency
ELF	3-30Hz
SLF	30-300Hz
ULF	300-3000Hz
VLF	3-30kHz
LF	30-300kHz
MF	300-3000kHz
HF	3-30MHz
VHF	30-300MHz
UHF	300-3000MHz
SHF	3-30GHz
EHF	30-300GHz

Fundamentals

Different wireless technologies use different RF bands

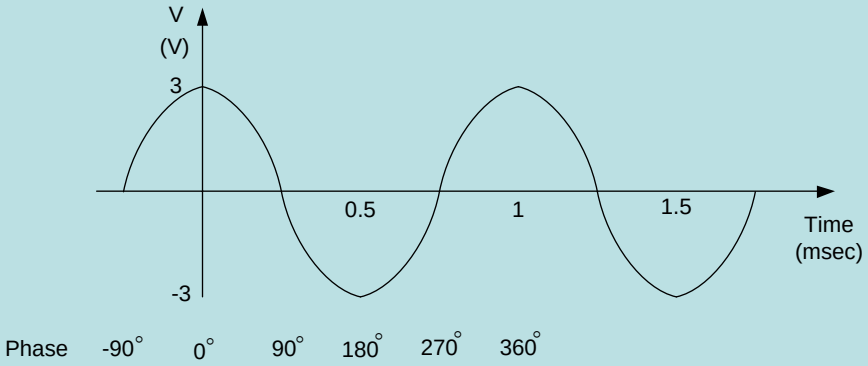


Band name	Frequency
ELF	3-30Hz
SLF	30-300Hz
ULF	300-3000Hz
VLF	3-30kHz
LF	30-300kHz
MF	300-3000kHz
HF	3-30MHz
VHF	30-300MHz
UHF	300-3000MHz
SHF	3-30GHz
EHF	30-300GHz

Fundamentals

Frequency

- **Frequency** is the number of occurrences of a repeating event per unit time.
- The frequency is usually denoted as *f.*
- In SI units, the unit of frequency is hertz (Hz), named after the German physicist Heinrich Hertz.



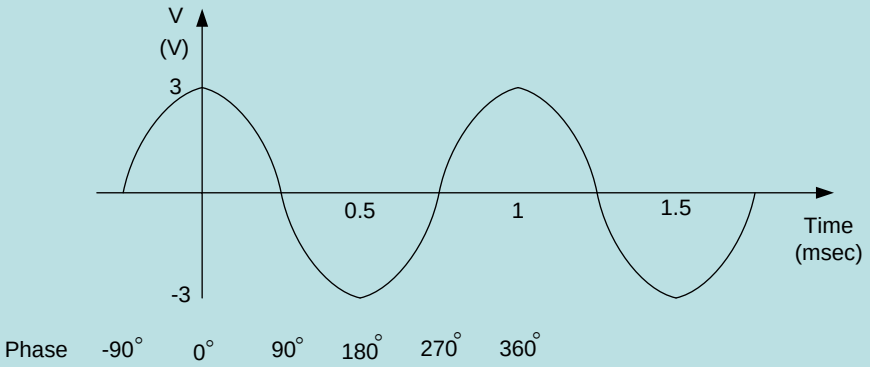
Fundamentals

Period

- The **period** is the duration of one cycle in a repeating event, so the period is the reciprocal of the frequency.
- The period is usually denoted as *T*, and is the reciprocal of the frequency *f*:
- The SI unit for period is the second.

$$T = \frac{1}{f}$$

where T = period in second
f = frequency in Hz

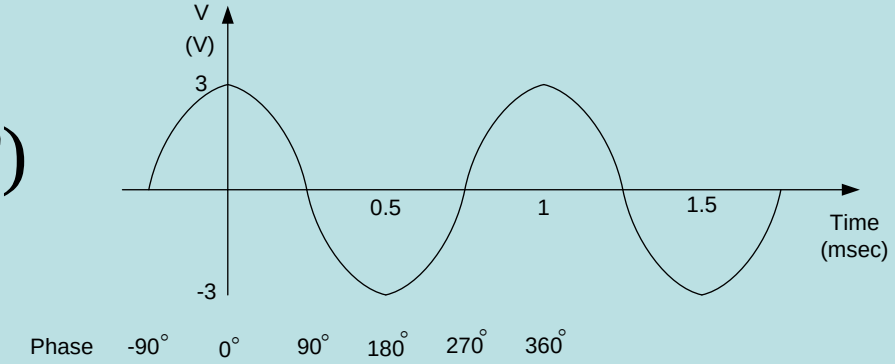


Fundamentals

Phase

- The phase describes the point in time which the signal has advance in its cycle. The phase is identified at the beginning of the cycle.
- For an example, a sine wave can be represented as:

$$v(t) = V_p \sin(2\pi f t + \theta)$$



where v(t) = instantaneous voltage amplitude
V_p = peak voltage amplitude
f = frequency
θ = phase

Fundamentals

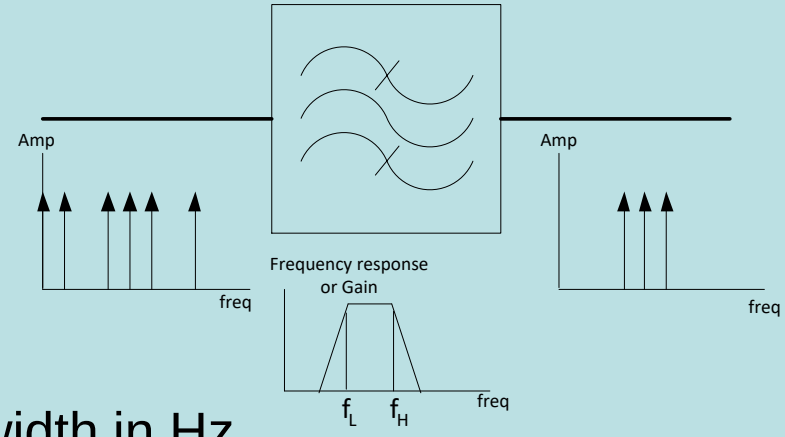
- Bandwidth
  - **Bandwidth** is typically measured in hertz, and may sometimes refer to *passband bandwidth*, sometimes to *baseband bandwidth*, depending on context.
  - **Passband bandwidth** is the difference between the upper and lower cutoff frequencies of, for example, an electronic filter, a communication channel, or a signal spectrum

Fundamentals

For example

- If the lowest frequency a channel can transmit is f_L and the highest is f_H then the bandwidth is the difference between the highest and lowest fre
- quencies:

$$BW = f_H - f_L$$



where

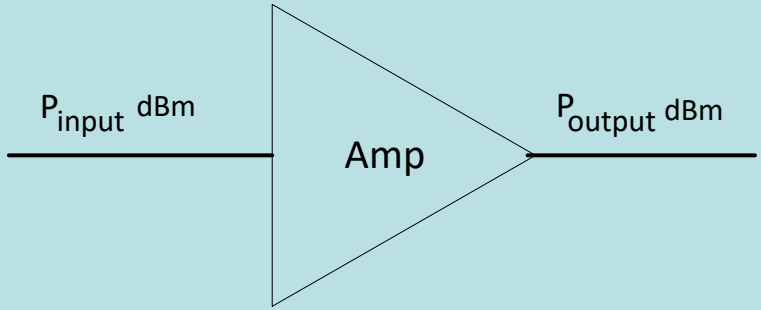
BW ➔ the channel bandwidth in Hz
f_L ➔ the lowest frequency in Hz,
f_H ➔ the highest frequency in Hz.

Fundamentals

Decibel (dB)

- The **decibel** (**dB**) is a logarithmic unit of measurement that expresses the magnitude of a physical quantity (usually power or intensity) relative to a specified or implied *reference level*. Since it expresses a ratio of two quantities with the same unit, it is a dimensionless unit.

$$\text{Gain(or loss)dB} = 10\log_{10}\left(\frac{P_{output}}{P_{input}}\right)$$



where

Pinput ➔ Power at the input

Poutput ➔ Power at the output

Gain ➔ Power at the output > Power at input

Loss ➔ Power at the output < Power at input

Fundamentals

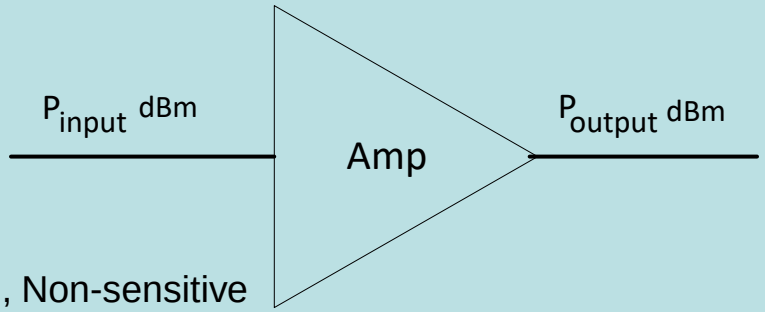
Examples

- It input power is 1 watt and output power is doubled, then

$$\text{Power Gain} = \frac{2}{1} = 2 \quad \text{OR} \quad G_{dB} = 10\log_{10} 2 = 3.01\text{dB}$$

i.e. a gain of 2 times in power is equivalent to 3 dB.

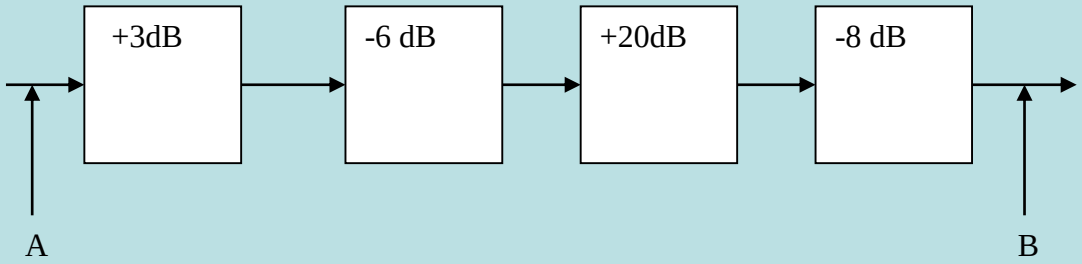
Similarly, a power gain of 100 is equivalent to 20 dB.



Fundamentals

Example

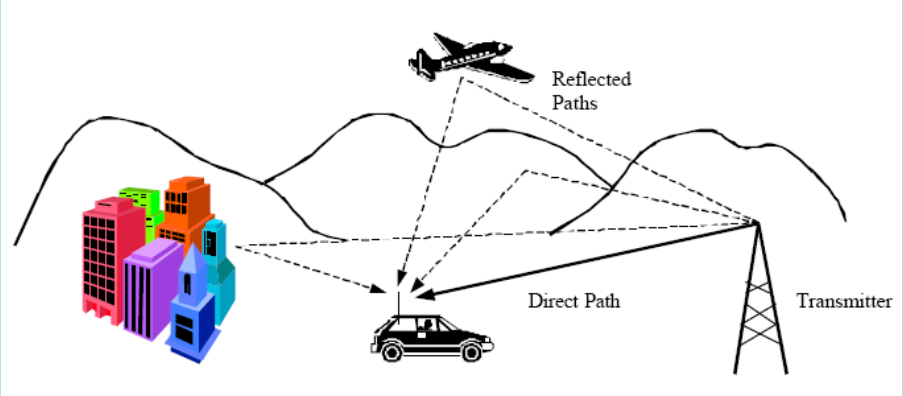
– The overall system gain from A to B of the system shown is:

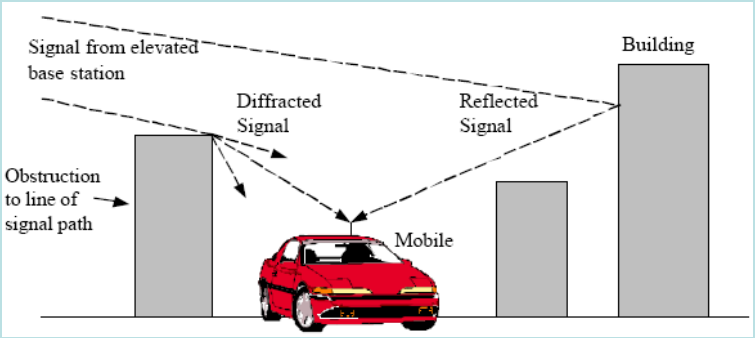


G_{Total} = +3dB + (-6dB) + (20dB) + (-8dB) = 9 dB

Fundamentals

- **Effect of radio wave propagation**
  - Reflection
  - Diffraction
  - Attenuation
  - Multi-path effects





Fundamentals

Noise

- The thermal noise depends on the bandwidth of the system and its temperature. It can be calculated by using the following equation.

$$P_n = kT_O B \quad \text{Watts}$$

where T_O, temperature of the system at 290°K
B, bandwidth of the system in Hz
k, Boltzmann constant in J/°K (=1.38×10^{-23})

Fundamentals

Signal to Noise Ratio (SNR)

- SNR defines the ratio of the signal power to the noise power at a specific point in a data communication system.

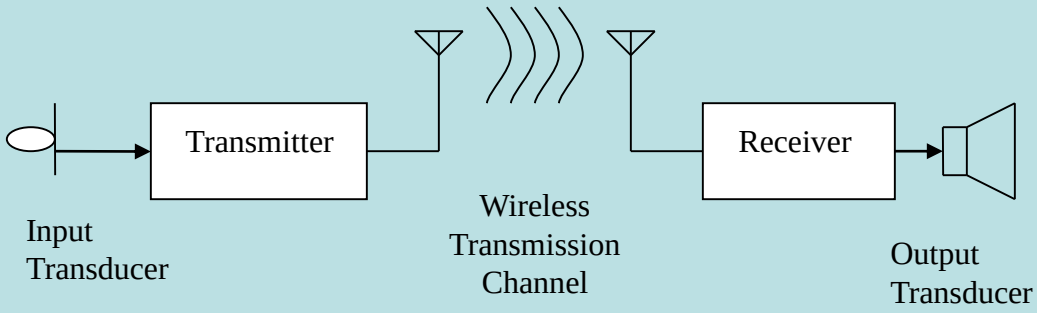
$$\text{SNR} = \frac{\text{Signal Power, } P_S \text{ at a point in a communication system}}{\text{Noise Power, } P_n \text{ at a point in a communication system}}$$

$$\text{SNR(dB)} = 10\log_{10}\text{SNR} = 10\log_{10}\left(\frac{P_s\,(\text{in Watts})}{P_n\,(\text{in Watts})}\right)$$

- A high SNR means that the signal power relative to the noise interference is high and will result in a good quality signal received.
- It can also be used to compare noise performance between different systems.

Fundamentals

Components of wireless communication system



The block diagram of a Wireless Communication System

Input transducers

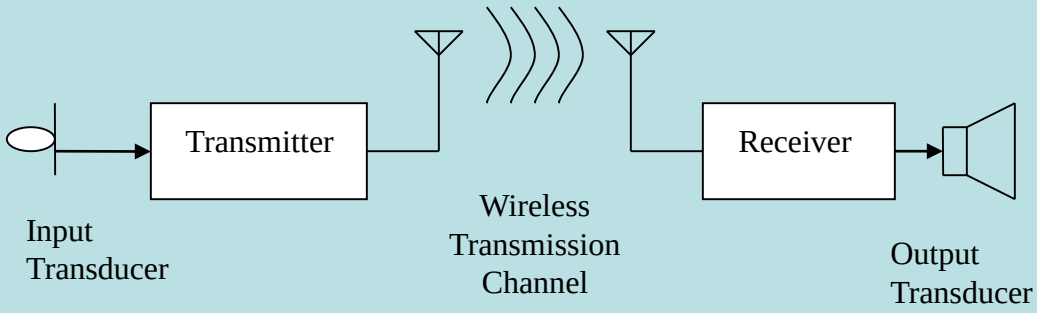
- a microphone
- a video camera

Transmitter

- modulation and amplification of the signal from the transducer

Fundamentals

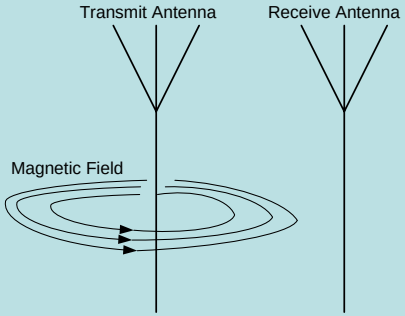
Components of wireless communication system



The block diagram of a Wireless Communication System

Antennas

- Tx Antenna
- Rx Antenna

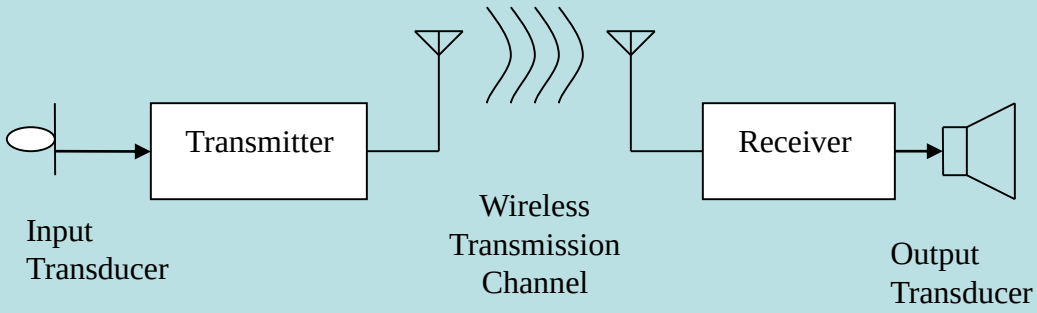


Transmission Channel

- the path or connection between transmitter and receiver

Fundamentals

Components of wireless communication system



The block diagram of a Wireless Communication System

Receiver

- perform functions like tuning, amplification and demodulation
- Output transducer

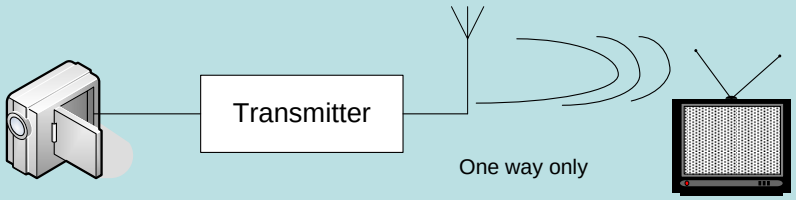
Two examples of output transducers are

- a speaker
- a cathode ray tube (CRT), LDC or Plasma Screen

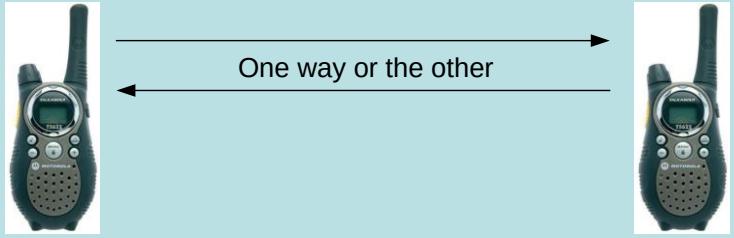
Fundamentals

Mode of Transmission

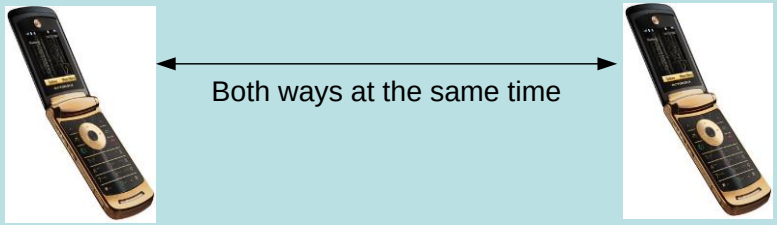
- There are three types of data flow: simplex, half-duplex and full-duplex.



simplex



half-duplex

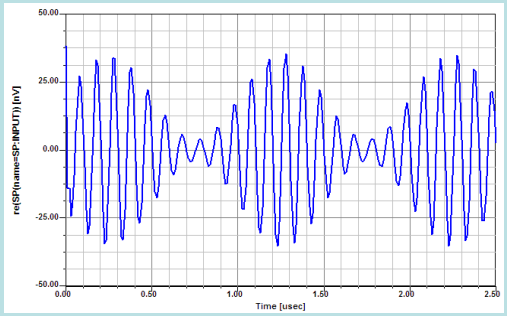


full-duplex

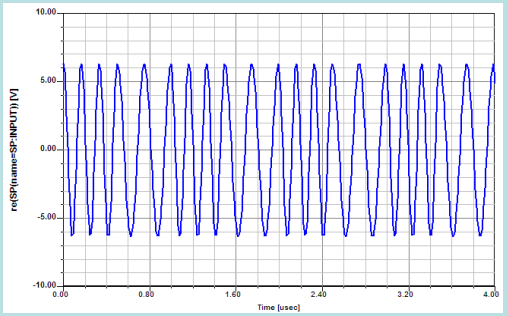
Fundamentals

Modulation

- Analog modulation is the representation of analog information by an analog signal.
  - Amplitude Modulation (AM)
  - Frequency Modulation (FM)
  - Phase Modulation (PM)



AM

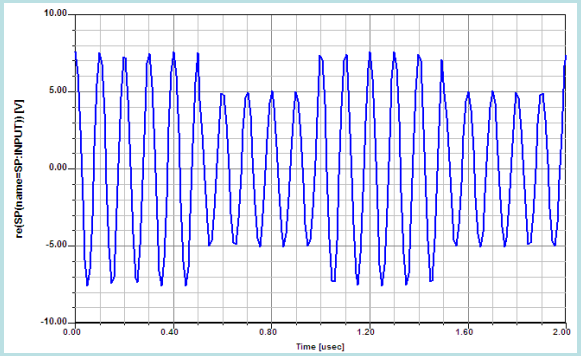


FM

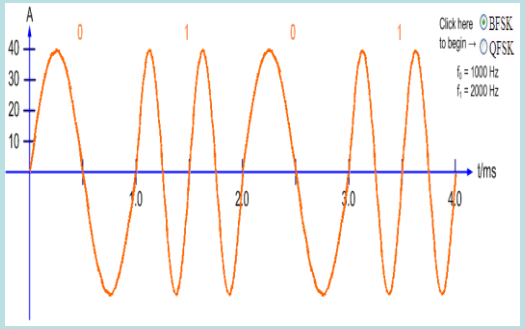
Fundamentals

Modulation

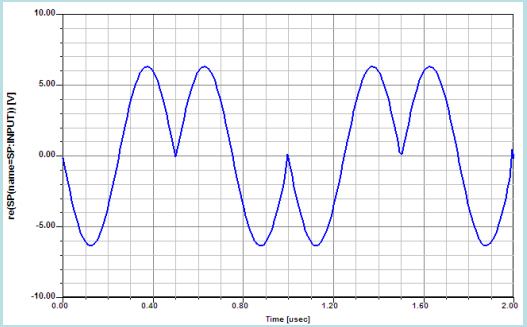
- Digital Modulation is the method of encoding a digital signal onto an analog wave for transmission over a medium that does not support digital signals.
  - Amplitude Shift Keying (ASK)
  - Frequency Shift Keying (FSK)
  - Phase Shift Keying (PSK)



ASK



FSK

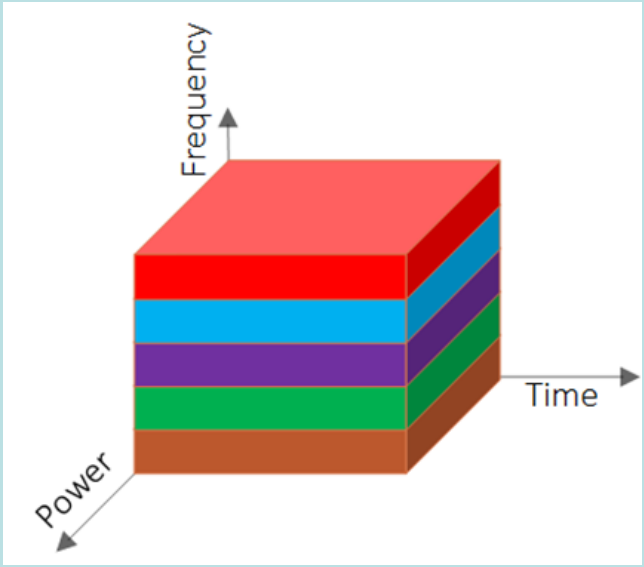


PSK

Fundamentals

Multiple access techniques

- Frequency Division Multiple Access (FDMA),



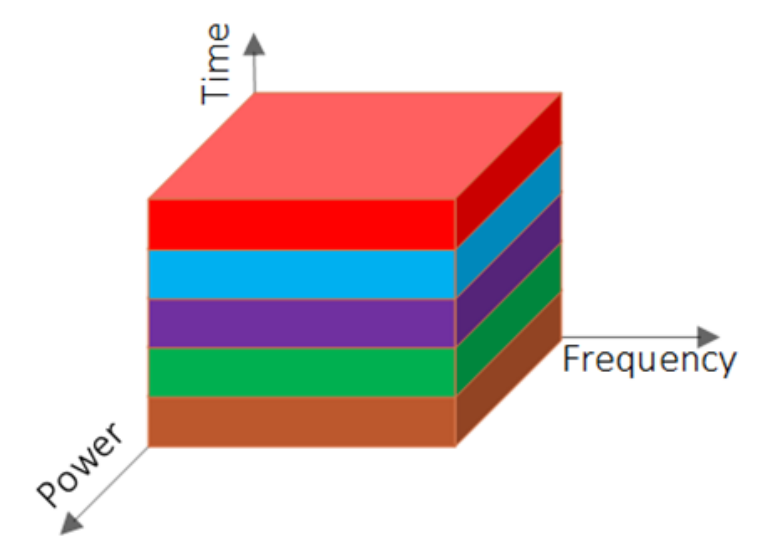
FDMA

- Most often used with analog transmissions interference one user to another
- Use guard band to prevent interference
- Drawbacks
  - Crosstalk (interference)
  - Not bandwidth efficient
  - Only single user can use a given frequency

Fundamentals

Multiple access techniques

- Time Division Multiple Access (TDMA)



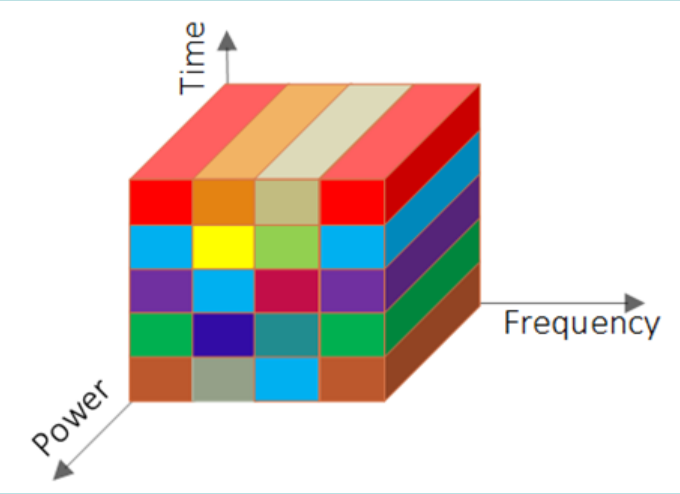
TDMA

- Most often used with digital transmissions
- Use guard time to prevent interference
- Advantages
  - Bandwidth efficient
  - Allow both data and voice transmissions to be mixed using the same frequency.

Fundamentals

Multiple access techniques

- TDMA/FDMA



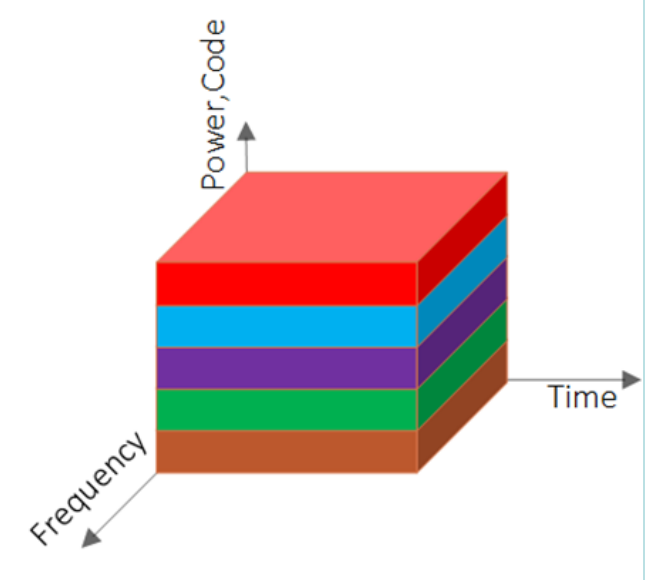
TDMA/FDMA

- Most often used with digital transmissions
- Advantages
  - Bandwidth efficient
  - Allow both data and voice transmissions to be mixed using the same frequency.

Fundamentals

Multiple access techniques

Code Division Multiple Access



CDMA

- Use direct sequence spread spectrum (DSSS) to differentiate the multiple transmission between the same frequency range.
- Use primarily for cellular communication
- the most efficient multiple access technique compared to FDMA and TDMA.

Wireless Technologies for IoT and SMART Mobility

- Providing low data rate and multi-kilometre coverage where WiFi can't reach.

Standard	Promoter
LoRaWAN	LoRa Alliance
Sigfox	Sigfox
LTE MTC Cat M1 (BW 1.4MHz) : [LPWAN (Cellular)]	3GPP
LTE NB-IoT (BW 200 kHz): [LPWAN (Cellular)}	

DSRC (Dedicated Short Range Communication),

- Short to medium-range wireless communications
- Capability permits very high data rate
- Use in vehicular communication to enable the communications-based safety road applications

Examples and applications

Wireless technologies under PAN/LAN

- Bluetooth
- ZigBee
- RFID
- Wireless LAN (IEEE 802.11a/b/g)
- Wireless LAN (IEEE 802.11n – upcoming)
- UWB
- NFC
- Wireless technology user MAN

  WiMAX (IEEE 802.16 - upcoming)

Examples and applications

Bluetooth

- Transfer voice between a mobile handphone and a headset
- Transfer stereo music between MP3 player and a headset

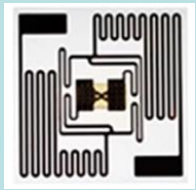
Wireless LAN

- Internet access from laptops/PDAs
- VoIP for voice applications

Examples and applications

RFID (Radio Frequency IDentification)

- For data acquisition and in supply chain management



WiMAX

(Worldwide Interoperability for Microwave Access)

- Last mile connectivity from users to backbone network

Examples and applications

NFC (Near Field Communication)

- A short-range HF wireless communication technology which enables the exchange of data between devices over about a 10 centimetre distance

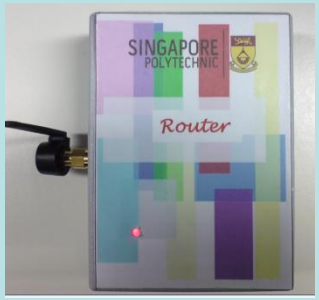
UWB (Ultra-Wide Band)

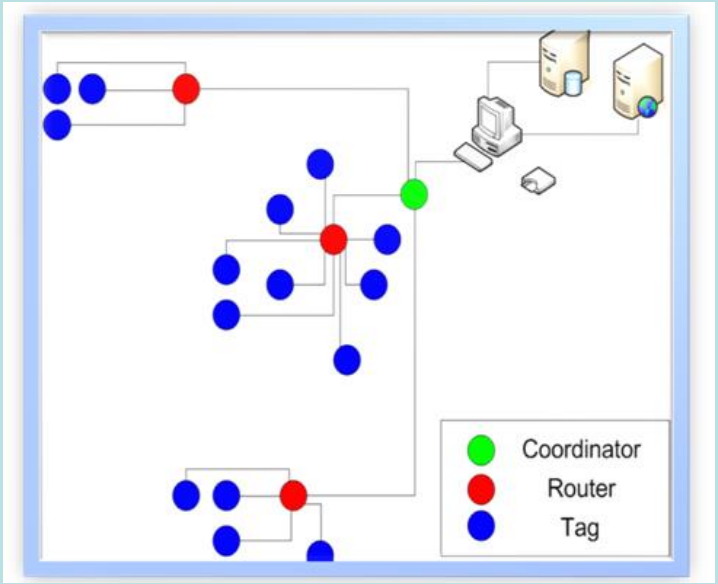
- For short-range high-bandwidth communications with high data rate

Examples and applications

ZigBee

- A low-power digital radios based on the IEEE 802.15.4 standard for wireless sensor networks





Wireless Local Area Network

- WLAN refers to wireless technologies that are used to enable mobile users to be connected to an existing local area network.

IEEE Standard	Multiple Access Technique	Frequency	Maximum Bit Rate
IEEE 802.11a	OFDM	5.2 GHz UNII	54 Mbps
IEEE 802.11b	DSSS	2.4 GHz ISM	11 Mbps
IEEE 802.11g	OFDM	2.4 GHz ISM	54 Mbps

- A new standard, IEEE 802.11n is ready and was published in October 2009.

Wireless Personal Area Network

- WPAN is a small network for interconnecting devices centered around an individual person's workspace. The RF range is typically 10 m.

IEEE Standard	Standard	Promoter	Specification
IEEE 802.15.1	Bluetooth	Bluetooth SIG	Version 2.1
IEEE 802.15.3a	MB-OFDM	WiMedia Alliance	
	DS-UWB	UWB Forum	
IEEE 802.15.4	ZigBee	ZigBee Alliance	Version 1.0

- RFID standard is maintained by ISO. There are three different types: passive, semi-active and active.

Advantages & disadvantages

- Six advantages of wireless technologies
  (1) Mobility
  (2) Installation
  (3) Flexibility
  (4) Cost
  (5) Scalability
  (6) Reach

Advantages & disadvantages

- Three disadvantages of wireless technologies
  (1) Security
  (2) Interference
  (3) Limited bandwidth

Abbreviation

- WPAN - Wireless Personal Area Network
- WLAN - Wireless Local Area Network
- WAN – Wide Area Network
- RFID – Radio Frequency Identification
- NFC – Near Field Communication
- UWB – Ultra Wide Band
- WiMAX – Worldwide Interoperability for Microwave Access
- MAN – Metropolitan Area Network
- PDA – Personal Digital Assistant
- VoIP – Voice over Internet Protocol
- PSTN – Public Switch Telephone Network

Abbreviation

- SIG – Special Interest Group
- MB-OFDM – MultiBand Orthogonal Frequency Division Multiplexing
- DS-UWB – Direct Sequence UWB
- DSSS – Direct Sequence Spread Spectrum
- FHSS – Frequency Hopping Spread Spectrum