Week 2 – Physical Layer Contd

COMP90007
Internet Technologies

Wireless Transmission

- Mobile users requires a **mobility enabled network** - contrast with the wired networks

- Wireless networks can provide advantages even in fixed location environments

- There are many types of wireless data transmission networks, but they all have a common basis – **electromagnetic wave propagation**

- Unlike previous mediums wireless signals are **broadcasted over a region**

- Potential signal collisions >> Need regulations

Electromagnetic Spectrum

Variety of sets of frequencies are for different things:

- Radio: wide-area broadcast;
- Infrared/Light: line-of-sight
- Microwave: LANs and 3G/4G;
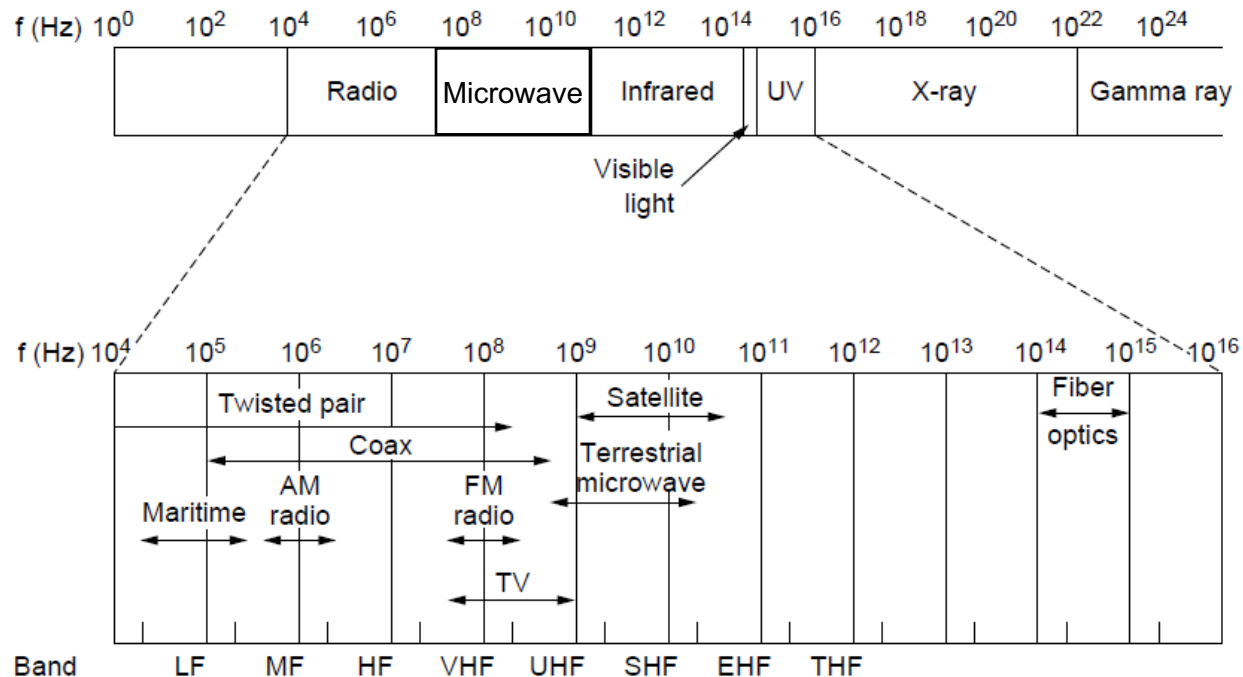
ElectroMagnetic (EM) Spectrum

- Number of oscillations per second of a wave is called frequency, measured in Hertz (Hz).

- Distance between two consecutive minima or maxima is called wavelength.

- All EM waves travel at same speed (speed of light)

- Fundamental relationship:
  - Wavelength x Frequency = Speed of Light
  - Units: (m) x (1/s) = (m/s)

1 Wavelength

1 Wavelength
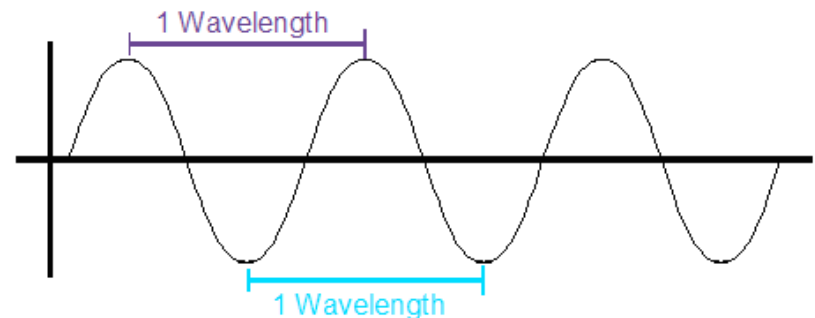
Wireless vs. Wires/Fiber

Wireless:

- + Easy and inexpensive to deploy
- + Naturally supports mobility
- + Naturally supports broadcast
- ■ Transmissions interfere and must be managed
- ■ Signal strengths hence data rates vary greatly

Wires/Fiber:

- + Easy to engineer a fixed data rate over point-to-point links
- ■ Can be expensive to deploy, esp. over distances
- ■ Doesn't readily support mobility or broadcast

Communication Satellites

Satellites are effective for broadcast distribution and anywhere/anytime communications
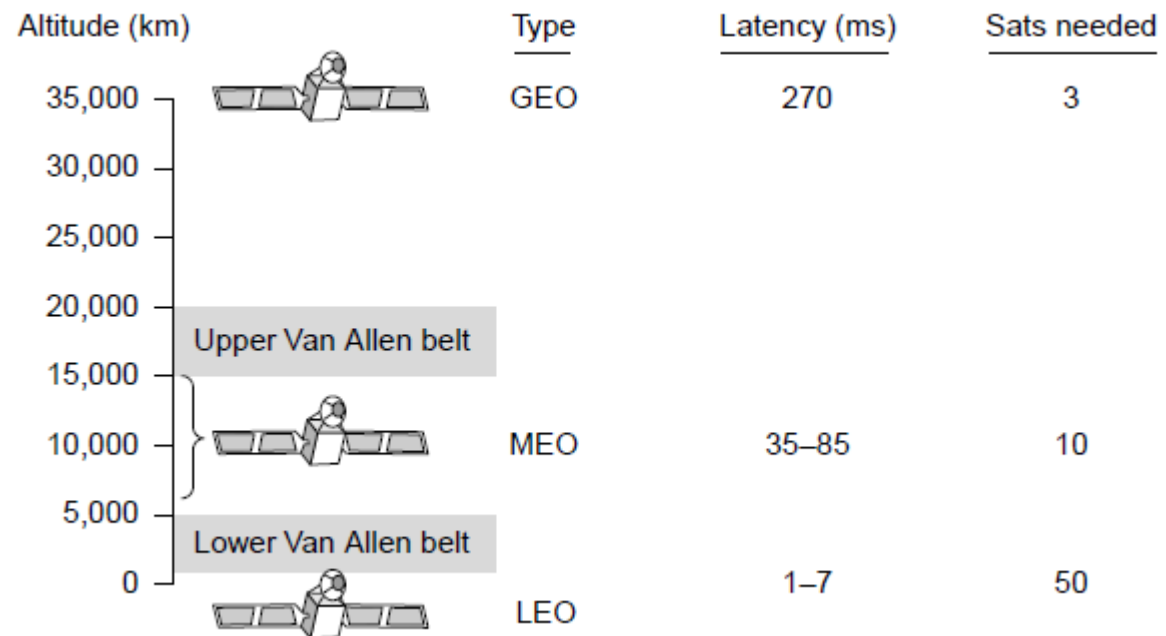
- ❑ Kinds of Satellites
    - ■ Geostationary (GEO) Satellites
    - ■ Medium-Earth Orbit (MEO) Satellites
    - ■ Low-Earth Orbit (LEO) Satellites

- ❑ Satellites vs. Fiber is a key comparison

Kinds of Satellites

Satellites and their properties vary by altitude: Geostationary (GEO), Medium-Earth Orbit, (MEO), and Low-Earth Orbit (LEO)

Sats needed for global coverage

Altitude (km)		Type	Latency (ms)	Sats needed
35,000		GEO	270	3
30,000				
25,000				
20,000				
	Upper Van Allen belt			
15,000				
10,000		MEO	35–85	10
5,000				
	Lower Van Allen belt			
0		LEO	1–7	50

Geostationary Satellites

GEO satellites orbit 35,000 km above a fixed location

- VSAT (computers) can communicate with the help of a hub
- Different bands (L, S, C, Ku, Ka) in the GHz are in use but may be crowded or susceptible to rain.
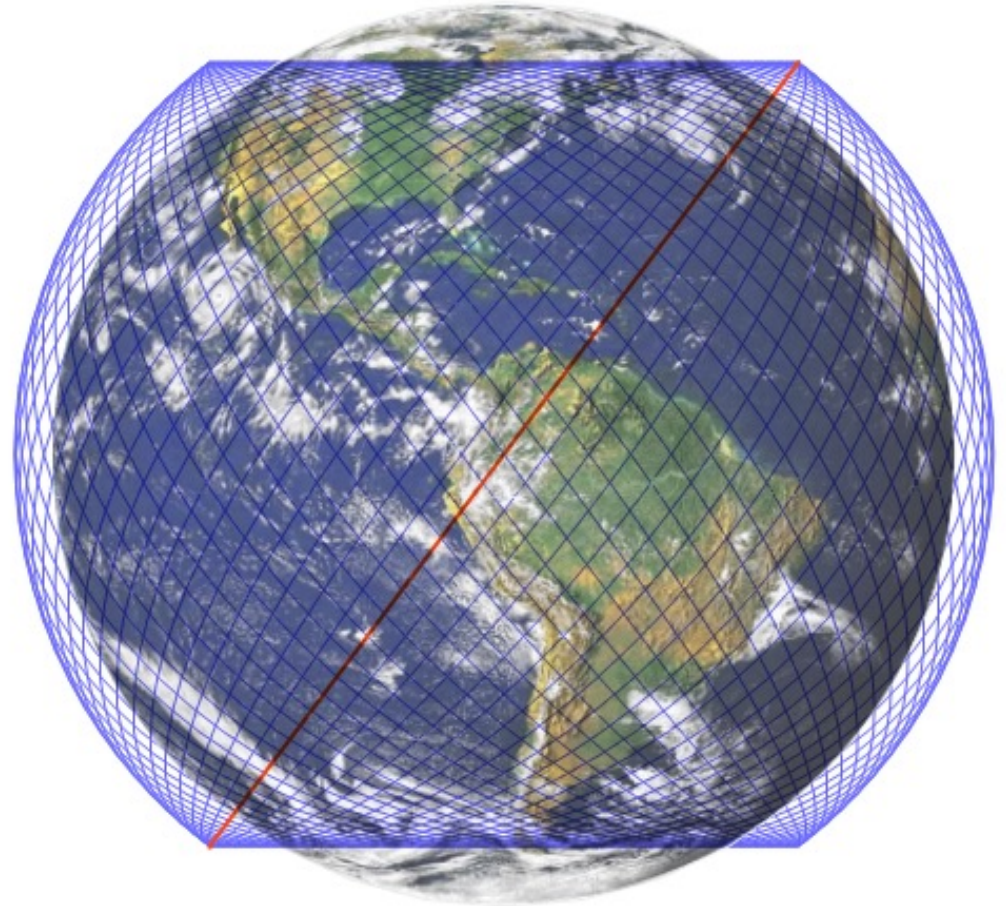
GEO satellite

VSAT
(Very Small Aperture Terminals)
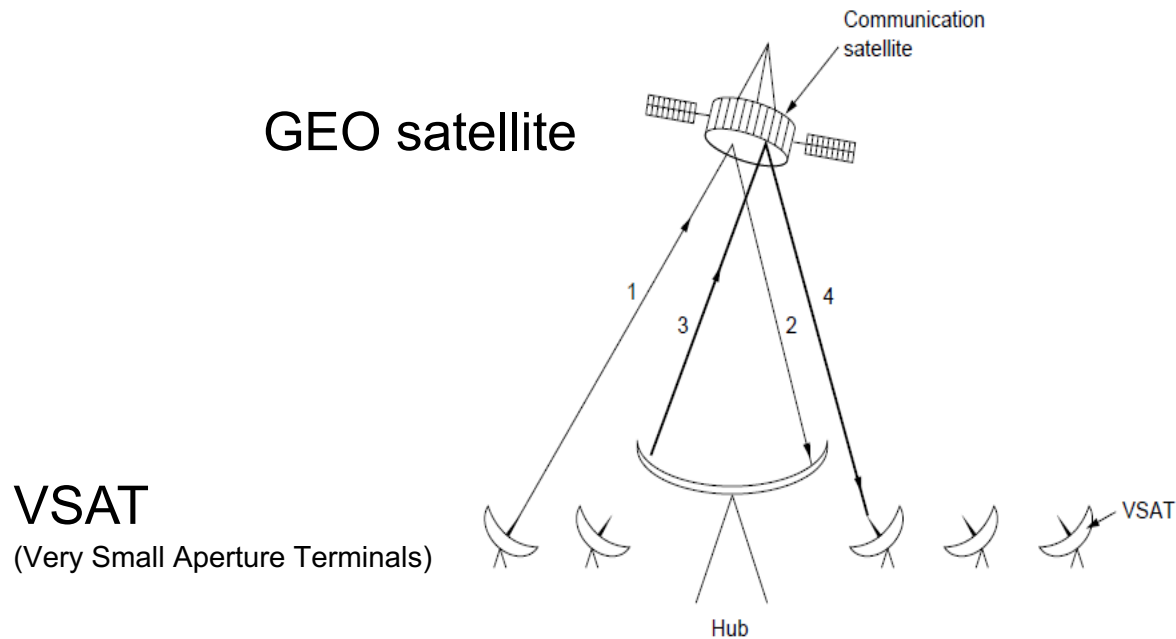
Low-Earth Orbit Satellites

Systems such as Iridium use many low-latency satellites for coverage and route communications via them

Each satellite has four neighbors

The Iridium satellites form six necklaces around the earth.
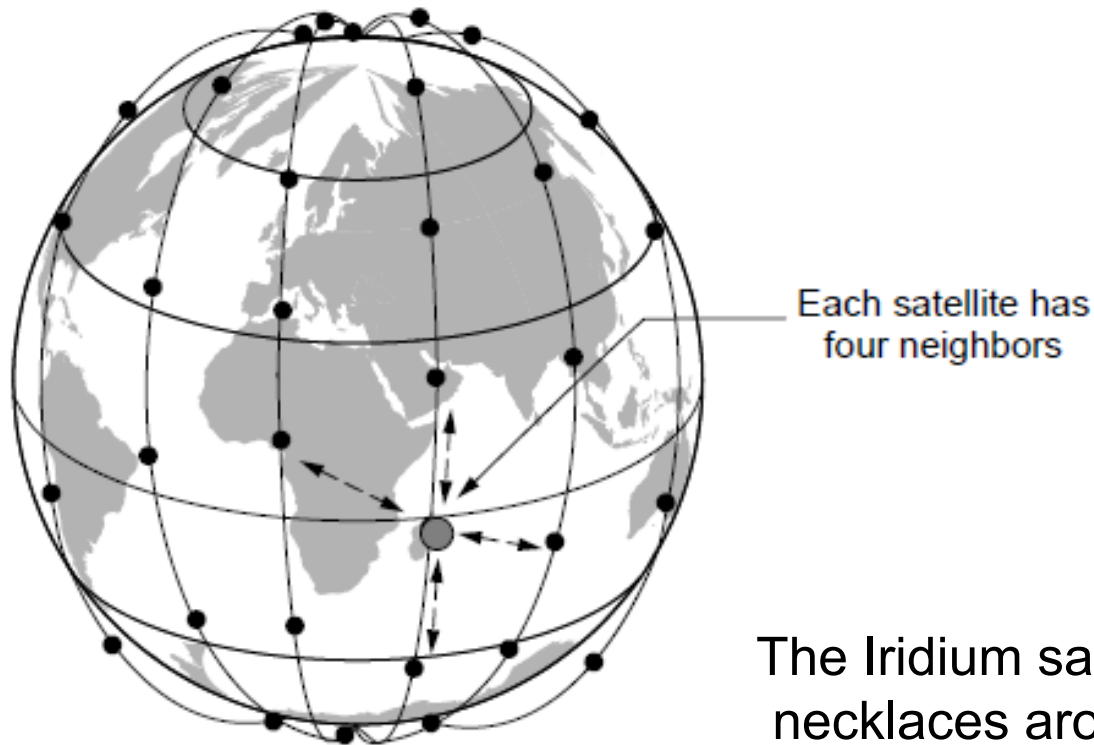
Starlink constellation phase 1

First orbital shell: 72 orbits with 22 each = 1584 sattelites.

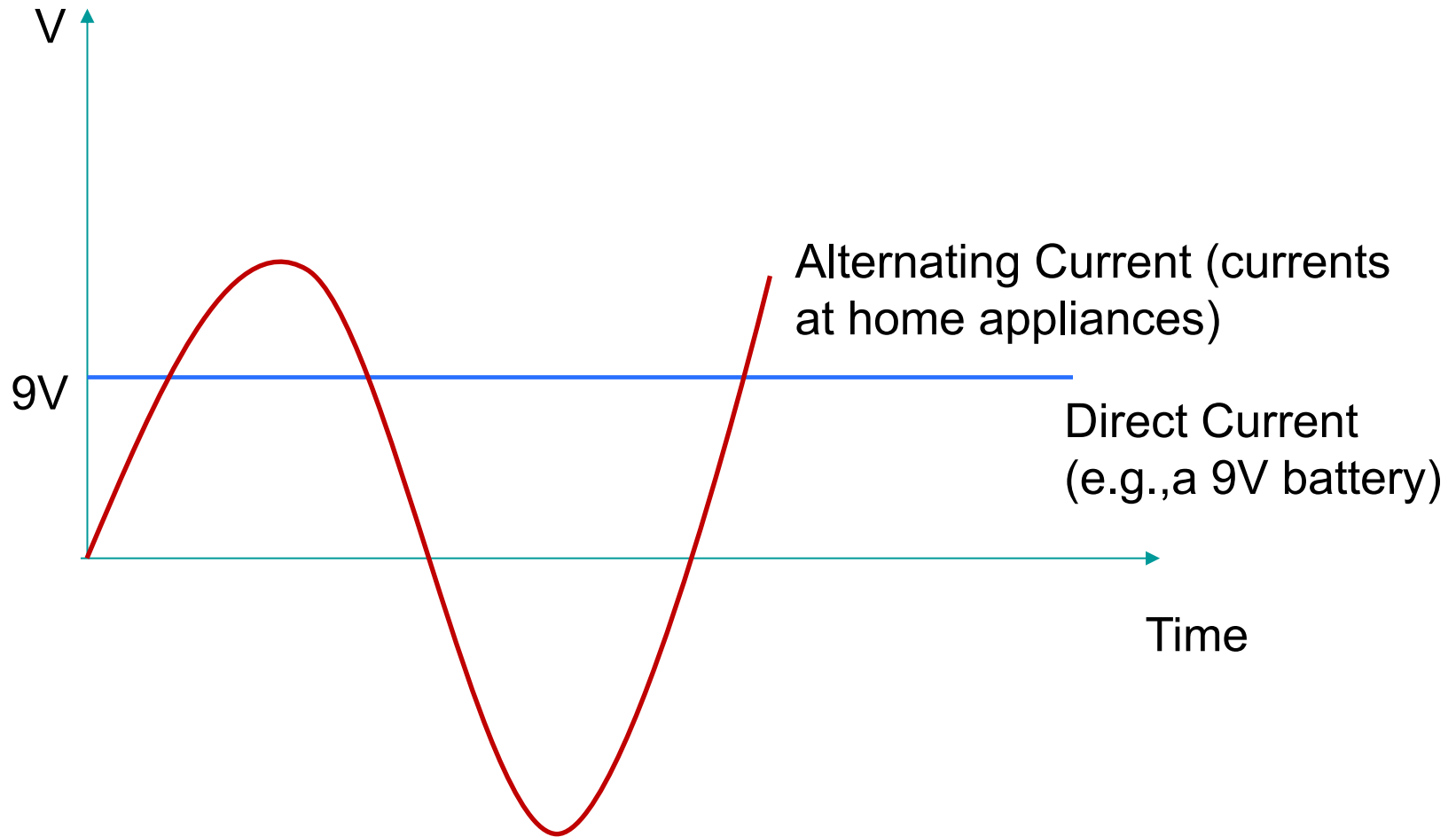3 more shells active in phase 1 also!

Satellite vs. Fiber

Satellite:

- + Can rapidly set up anywhere/anytime communications (after satellites have been launched)
- + Can broadcast to large regions
- ■ Limited bandwidth and interference to manage

Fiber:

- + Enormous bandwidth over long distances
- ■ Installation can be more expensive/difficult

# Lets Look at Further Details: Putting Signals on a Copper Wire

V

9V

Alternating Current (currents at home appliances)

Direct Current (e.g.,a 9V battery)

Time

Who found out Electromagnetic Waves?

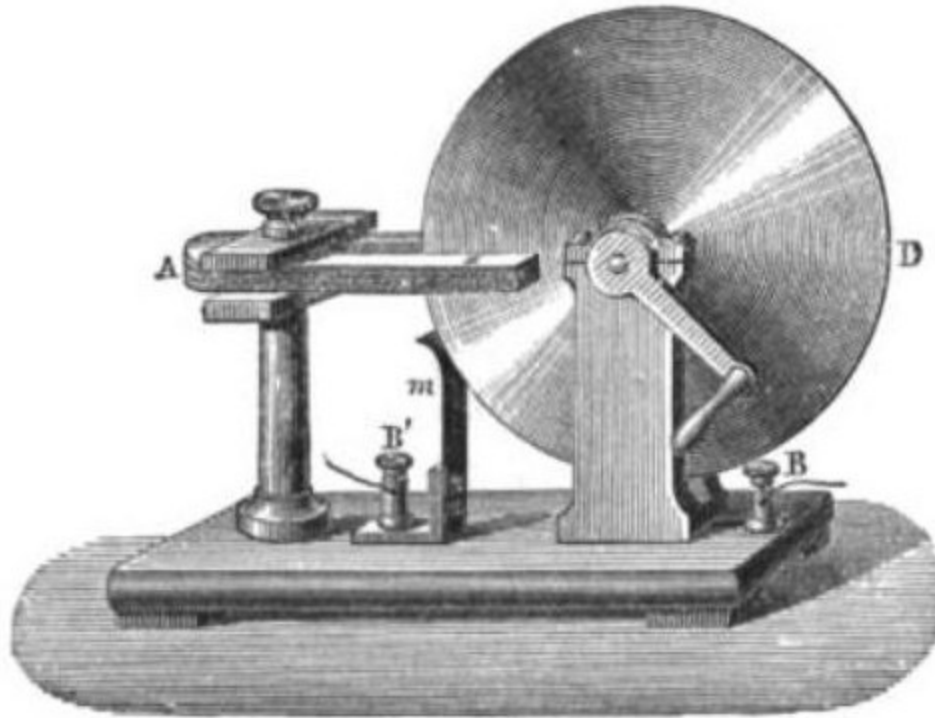- Electromagnetism was first predicted by Maxwell

- Later ***Hertz*** has proved they exist
- His name is used as a unit of frequency now

Origins of Electrical Signals

- Electromagnetic induction is at the origins of putting signals on to a wire

- Michael Faraday is the father of this
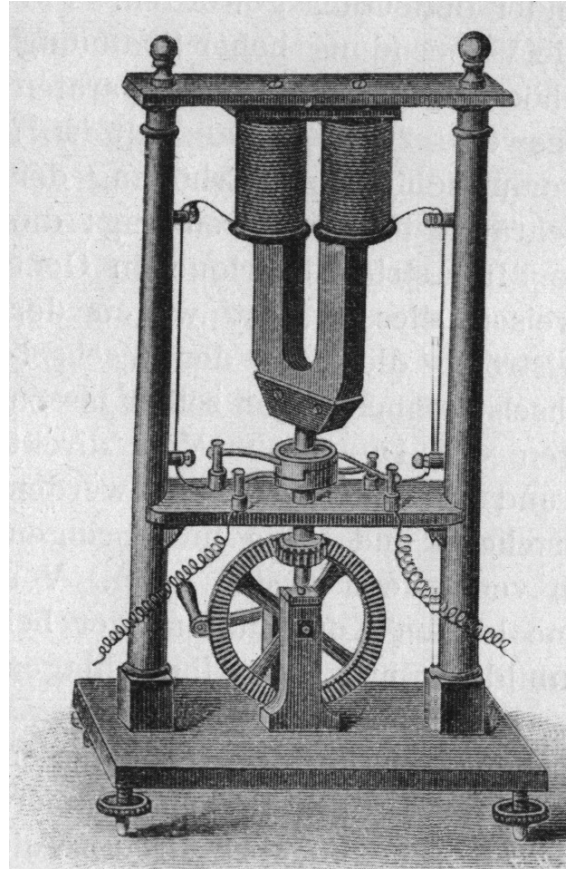
- All these famous scientists lived in 19th century
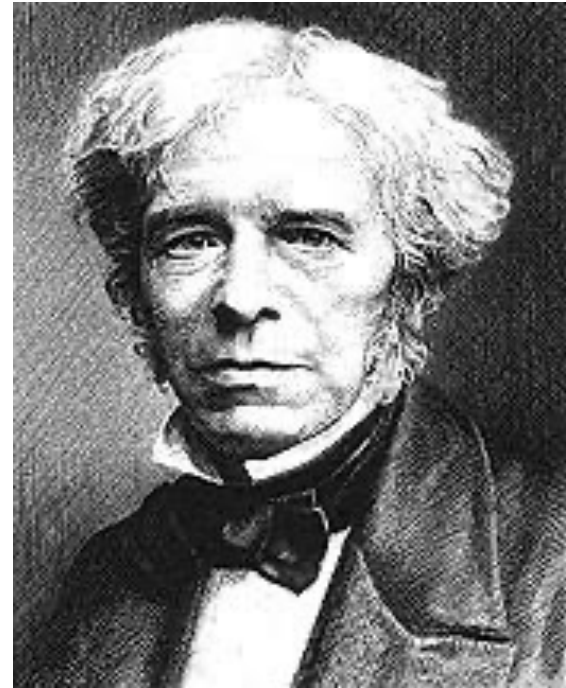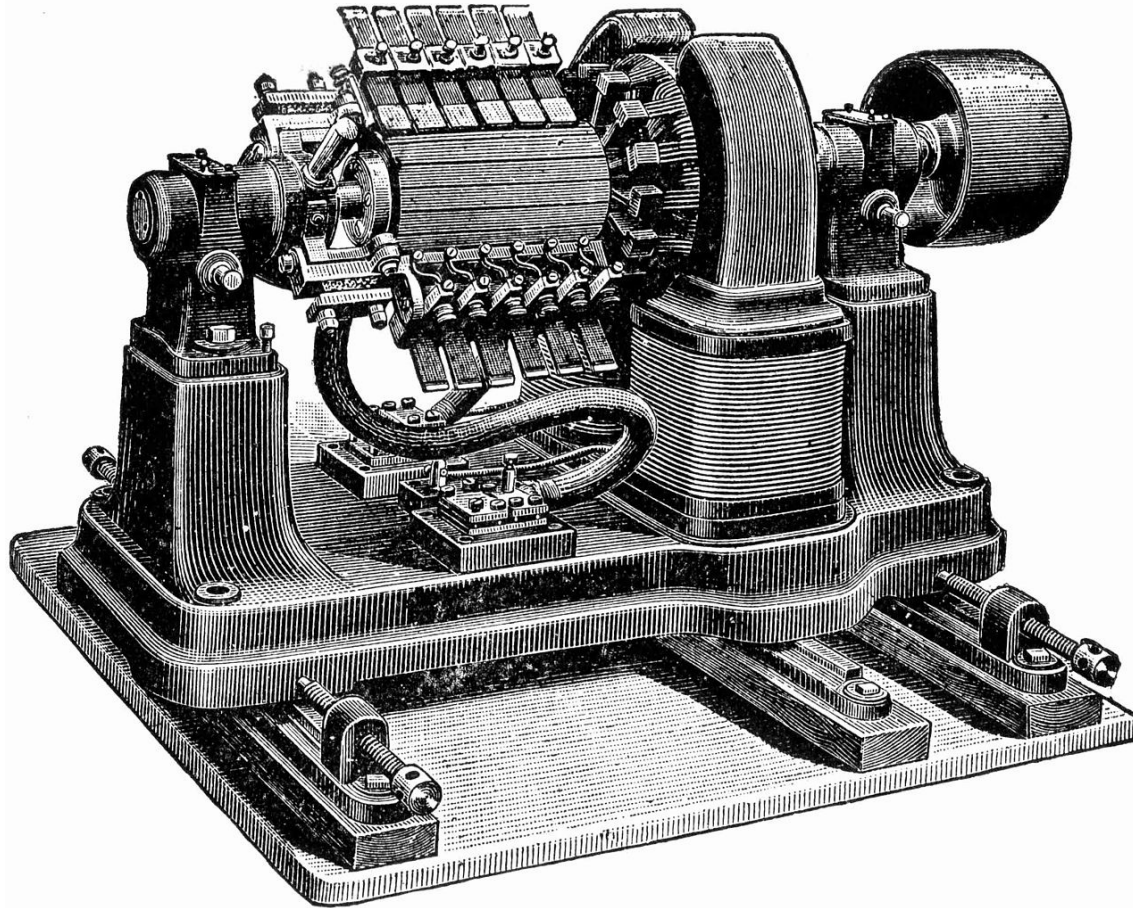
Faraday Disk as An Electric Generator
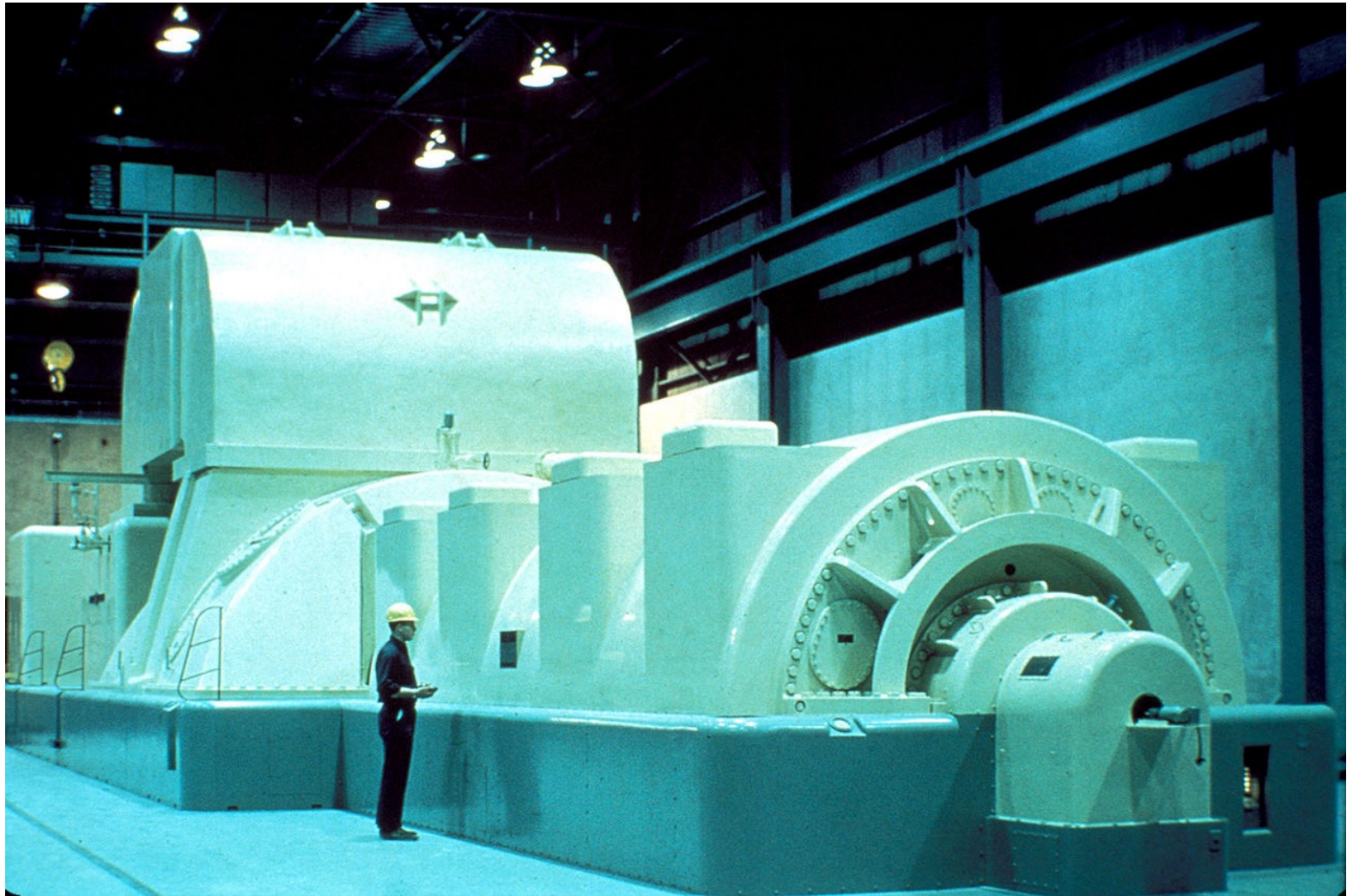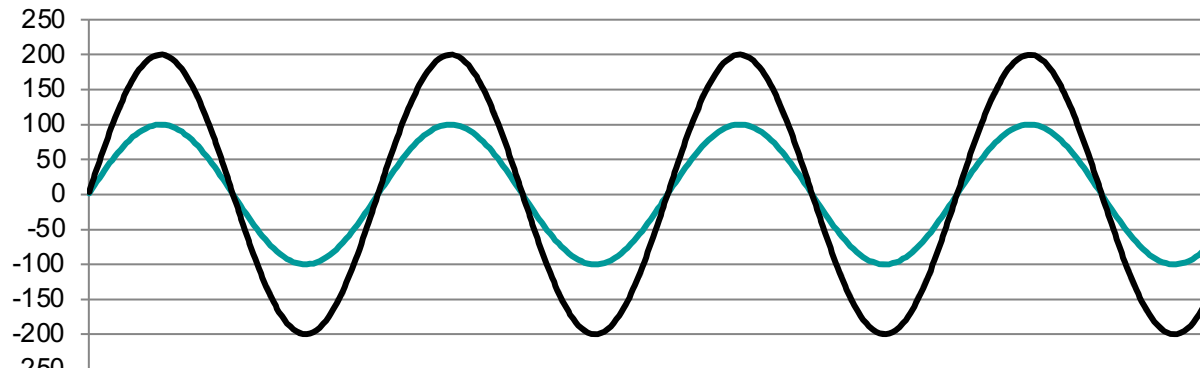
An Early Dynamo
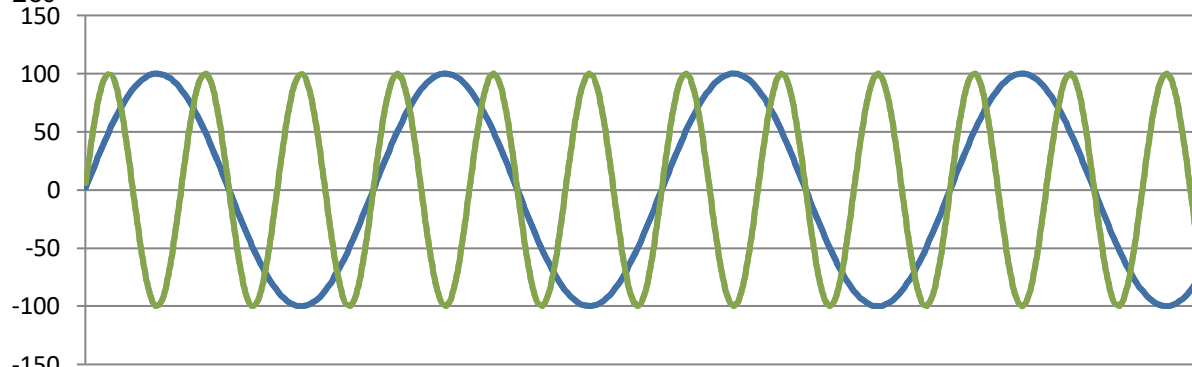
Another Example

A Turbine

But How Bits Look as a Signal

- Information on wire transmitted by **varying a physical property** e.g., voltage, current etc

- Generating a periodic function is needed, imagine a simple Sine function for example

- E.g., the sine function: c*sin(ax+b):
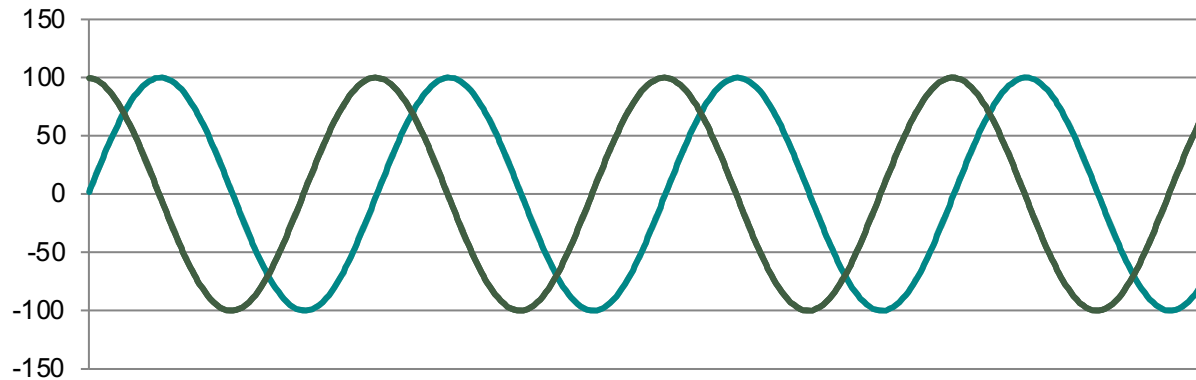 - Three things can change the behaviour of this function: c: Amplitude, a:Frequency and b:Phase

Change in Amplitude, Frequency, & Phase
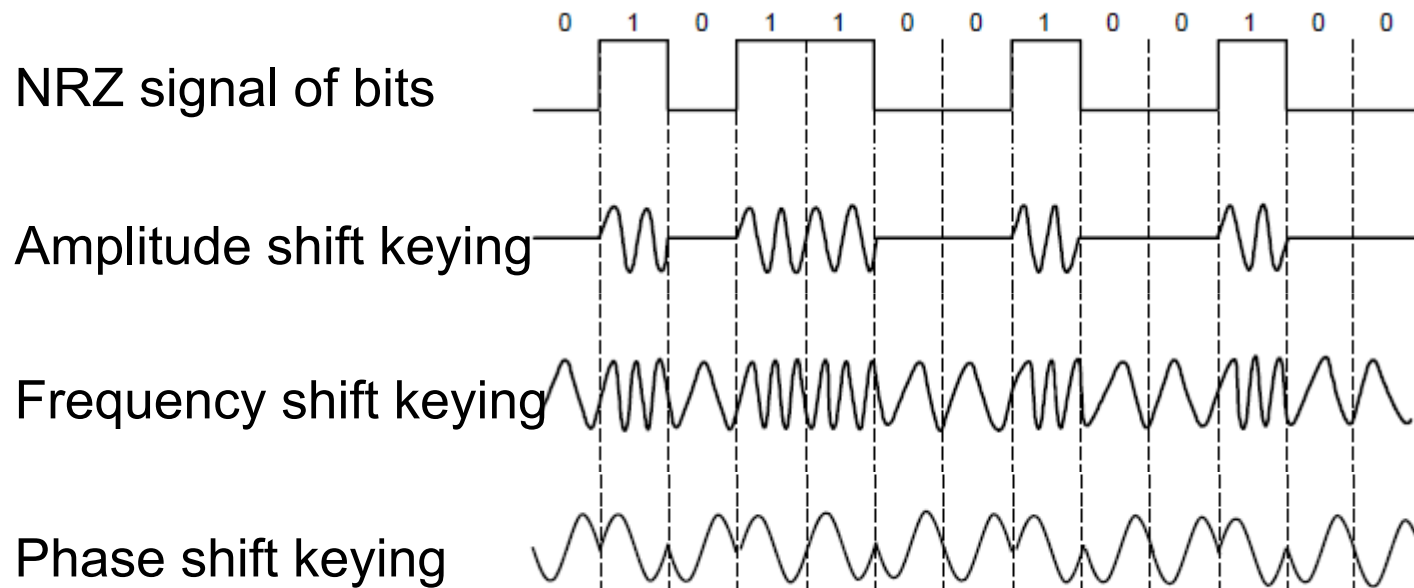
Modulation is the term used

Modulating the amplitude, frequency/phase of a carrier signal sends bits in a (non-zero) frequency range

NRZ signal of bits

Amplitude shift keying

Frequency shift keying

Phase shift keying

What Kind of Links We Can Have

<u>Full-duplex</u> link

- ❑ Used for transmission in both directions at once
- ❑ e.g., use different twisted pairs for each direction

<u>Half-duplex</u> link

- ❑ Both directions, but not at the same time
- ❑ e.g., senders take turns on a channel

<u>Simplex</u> link

- ❑ Only one fixed direction at all times; not common in communications

Multiplexing is used for sharing

- When multiple sources want to put things on to a medium
  - Time Division Multiplexing
  - Frequency Division Multiplexing

  - Statistical Multiplexing (for curious readers)
  - Code Division Multiple Access (we will mention later)

Time Division Multiplexing

- Users can send according to a fixed schedule
- Slotted access to the full speed of the media
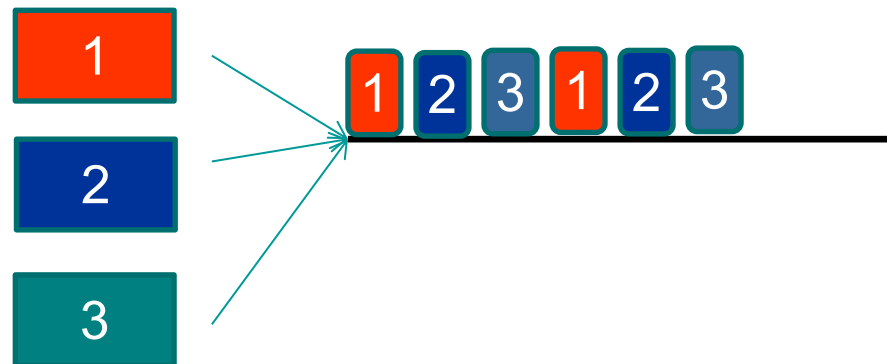
Frequency Division Multiplexing

- Users can only use specific frequencies to send their data