Lecture 1: Introduction

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Wireless Communication Principle Courses

EEE202 Analogue and Digital Communications (I)
EEE301 Analogue and Digital Communications (II)

EE326 Wireless Communication Systems

Content of this module

- Introduction
- Signal and systems
- Modulation / Demodulation: **analogue signal**
- **Digitisation** : sampling, quantisation
- **Baseband transmission/reception** of digital signal
- Random Processes
- Noise

Prerequisites

- EEE203 Continuous and Discrete Time Signals and System
- EEE204 Continuous and Discrete Time Signals and System
- MTH013 Calculus (Science and Engineering)
- MTH008 Multivariable Calculus (Science & Engineering)
- MTH007 Linear Algebra
- MTH101 Engineering Mathematics I
- **MTH102 Engineering Mathematics II (Probability Statistics and Random Process)**
- MTH201 Engineering Mathematics III

Recommended Texts

- Simon Haykin, Michael Moher, "Introduction to analogue and digital communications”,, John Wiley &Sons, 2nd edition 2007.

- Simon Haykin, Michael Moher , “Communication systems”, 5th edition, international student version, John Wiley &Sons, 2010.

Structure

Classes 2nd Semester

20 hours of lectures

6 hours tutorial classes

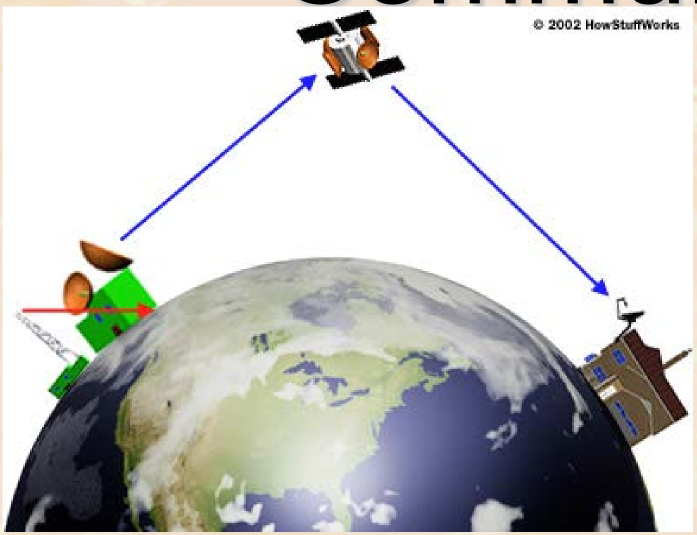
6 hours lab

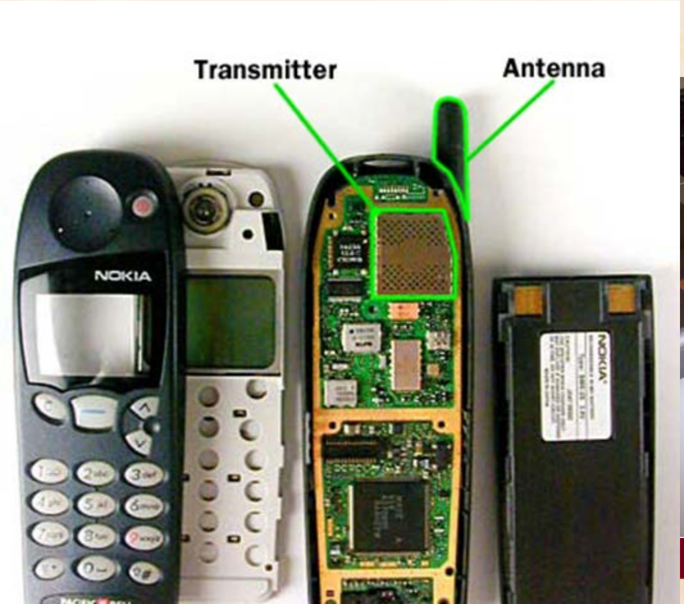
Assessment

20% Experiment- Simulink

80% Final exam

Examples of Modern Communication Systems





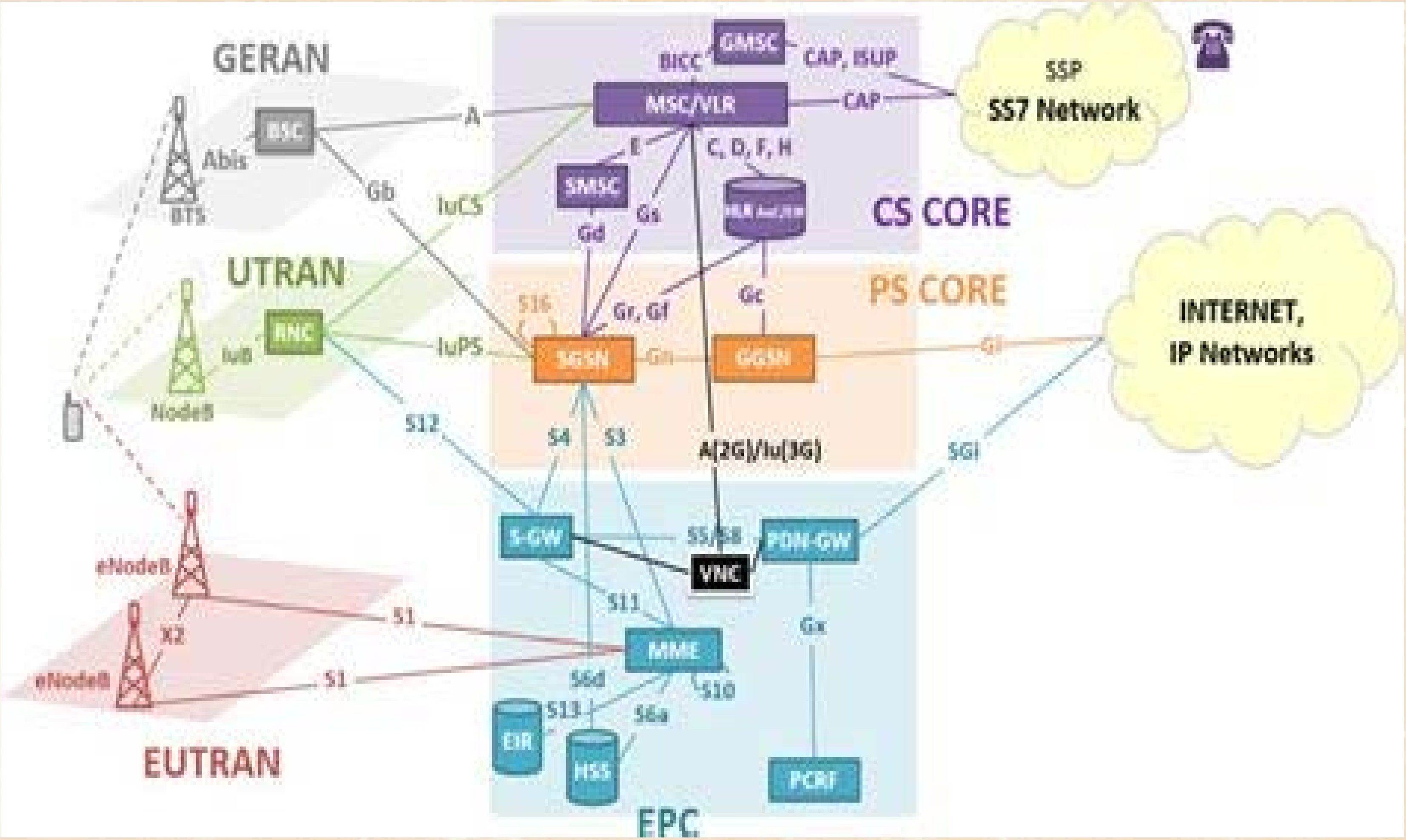
Communications System

- **Information Source**
  - Information may take many forms: data, image, voice, video
- **Transmittter**
  - Processes information into a form suitable for transmission
  - Modulates information onto waveform which will propagate
- **Channel**
  - Relays information between locations (possibly corrupts it)
- **Receiver**
  - Must reconstruct transmitted information from received waveform as accurately as possible

What were they doing

A modern switching center

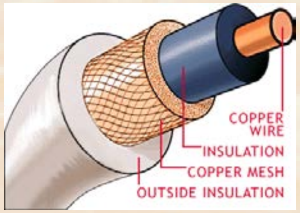
From 2G to 4G cellular systems



Two Types of Medium

- **Guided Electromagnetic Wave Channel**

  eg. Twisted pairs, coaxial cable, optical fiber etc





- **Electromagnetic Wave Propagation Channel**

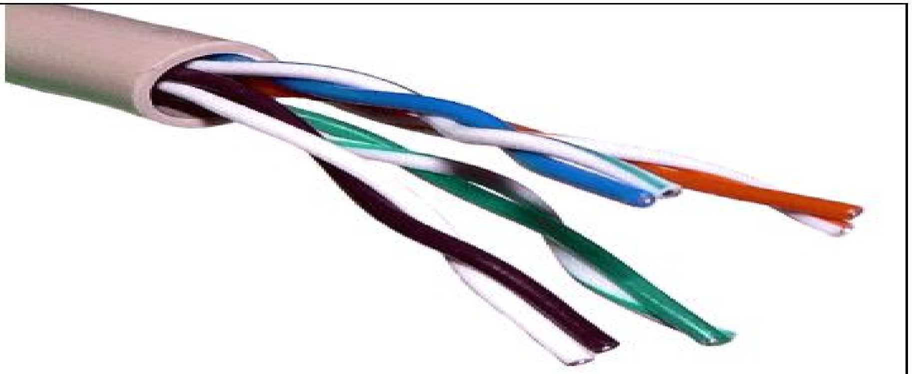
  eg. wireless broadcast channels, mobile radio channel, satellite etc



Guided Media

- Twisted pair: -

It's a cable that is consisted by pairs of copper wire twisted. These copper wires are enclosed with the outer sheath. The most common twisted pair is the unsheathed twisted pair (UTP). UTP is common in both LAN and telephone connections.



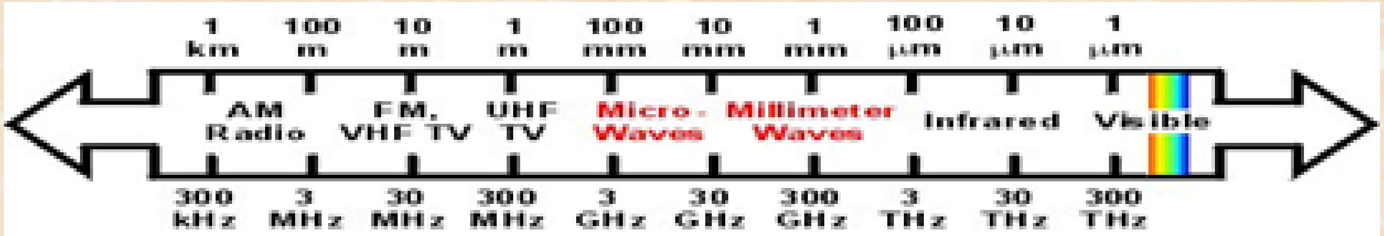
- Coaxial cable:-

This cable is moderately immune to outside electromagnetic interference compared to twisted pair. It was first invented to be used for an analogue TV, to transmit on frequencies range from 30MHZ to 3GHZ. It is also well suited for broadband applications. It is expensive and takes more space and is inflexible.

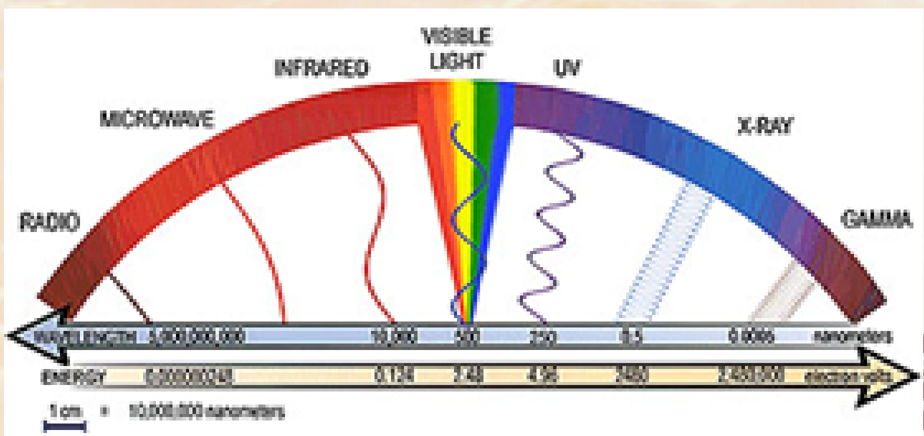
- Optic fibre cable:-

This cable has much greater data transmission rates than coaxial cable and twisted pair. It is also immune to outside electrical interference. Commonly it is used in the higher rate communication places such as major cities. The wires in optic fibre cable hard thick and they can send down 50 billion telephone conversions at a time.

Electromagnetic Spectrum

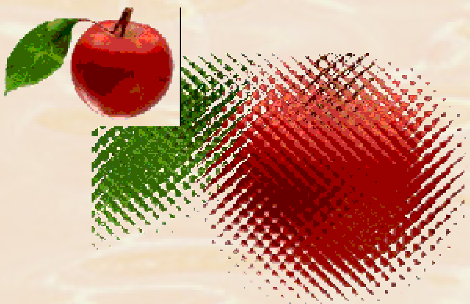


If a speech signal containing frequency components up to 3kHz were to be transmitted at baseband (i.e. without modulation) calculate the wavelength and hence the approximate **antenna size** required to transmit and receive such radiation.



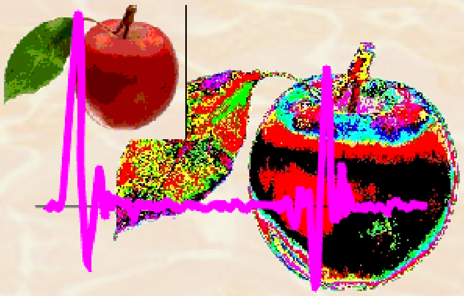
Electromagnetic radiation interacts with matter in different ways in different parts of the spectrum .

Channel Degradation



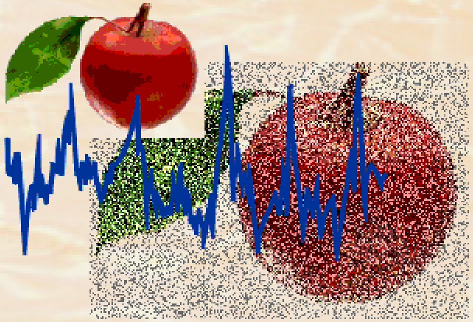
Interference

contamination of the channel by extraneous signals



Distortion

Correlated with the signal and disappears when the signal is turned off.



Noise

Random, unpredictable and undesireable electrical signals from natural sources.

What Makes a Good Communication System?

- Good Signal Fidelity
  - Analogue System: high Signal to Noise Ratio (SNR)
  - Digital System: low Bit Error Rate (BER)
- Low Signal Power
- Transmits a large amount of information
- Occupies a small bandwidth
- Low cost (complexity?)
  - Complex digital operations have steadily grown cheaper
- Comms engineers must trade off all of these

Channel Bandwidth

- Bandwidth (B) of a channel is the range of frequencies that it can transmit with reasonable fidelity.
- Bandwidth of an information signal is the difference between the highest and lowest frequencies contained in the information.
- **Data rate proportional to bandwidth**

Trade-off in Communications : energy efficiency vs bandwidth efficiency

- Satellite and Deep Space Communications
  - Power is expensive to generate in space and transmission distances are enormous – Must energy efficient
- Microwave Relay Towers
  - Power maybe cheap, but available bandwidth is restricted by regulation - Must be bandwidth efficient
- Cellular Phones
  - Power is costly (impacts battery life and size) but bandwidth is also limited - Must be both bandwidth and power efficient

Classification of Signals

- **Analogue** : infinite set of values
- **Digital** : finite set of values
- **Deterministic** : no uncertainty, explicit
- **Random** : uncertain, defined statistically
- **Continuous** : defined for all time
- **Discrete** : defined at discrete times
- **Power** : infinite energy, finite power
- **Energy** : finite energy, zero average power

Analogue vs Digital

•An **analogue** signal is defined as a physical time varying quantity and is usually smooth and continuous, e.g. acoustic pressure variation when speaking. The performance of an analogue communications system is often specified in terms of its fidelity or quality, hence the term HIFI – HIgh Fidelity, measured by Signal to Noise Ratio.

•A **digital** signal is made up of discrete symbols selected from a finite set, e.g. letters from the alphabet or binary data. The performance of a digital system is specified in terms of accuracy of transmission e.g. Bit Error Rate (BER) and Symbol Error Rate (SER).

An analogue information source can be converted into a digital source by: Sampling the signal in time Quantizing the signal amplitude to a finite number of levels, and Encoding the a finite number of levels using binary.

Analogue and Digital

- **Analogue** (eg speech)
- Signal-to-noise ratio (SNR)
- Continuous range : infinite no. of values

- **Digital** (eg binary data)
- Probability of error (P_e)
- Transmitted in analogue waveforms

Possible advantages of digital systems

High fidelity (noise immunity)

☺ DSP may be applied

☺signal maybe coded and encrypted

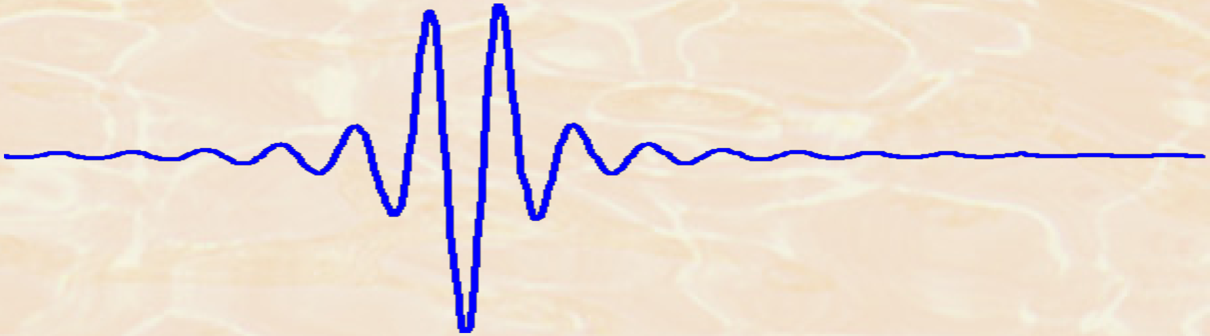
Deterministic vs random signals

– If the signal can be described by a mathematical equation, it is a *deterministic signal*,

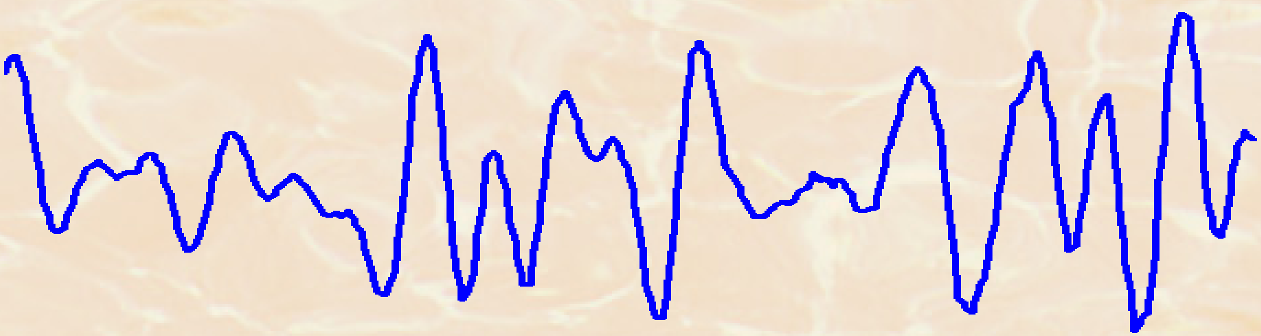
– otherwise it is called a *random signal*

Energy vs Power Signals

Energy signal



Power signal



Time and Frequency

A grasp of the **frequency content** of various types of time domain signals is the key for understanding various issues in a system design.

The mathematical tools used to map between the time and frequency domain are most commonly the **Fourier Series** representation (for periodic signals) and the **Fourier transform** (for general periodic and non-periodic signals).