Physical Layer

1 Bandwidth

Bandwidth is the physical property fo the transmission medium

Definition: Baseband

The signal that runs from 0 to a maximum frequency. Has very narrow and near-zero frequency range. Used in wires

Definition: Passband

Signals that occupy the higher range of frequency and pass through frequency filter(s). Used in wireless spectrum

1.1 Signal Bandwidth

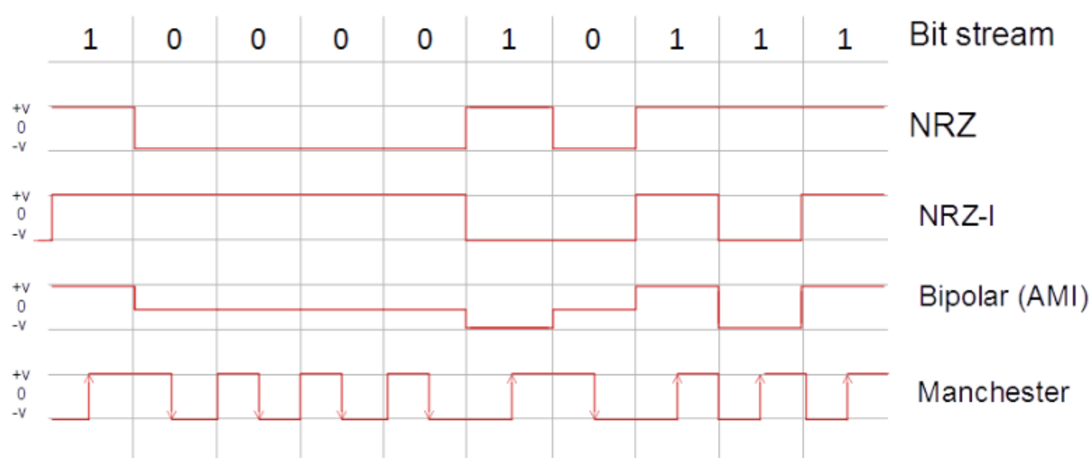
Bandwidth of analogue and digital signals are measured differently:

- Analogue signal bandwidth is measured in terms of its frequency (Hz)
- Digital signal bandwidth is measured in terms of bit rate (bps)

2 Digital Modulation

Digital signals (0,1) are encoded by low and high voltage

There are many digital encoding schemes



2.1 NRZ Encoding (Non-Return-to-Zero)

Definition: NRZ Encoding

- A high voltage represents a 1 and a low voltage represents a 0
- The voltage does not return to zero, it changes only when the bit value changes

- Problem: having long runs of consecutive bits with the same value (no changes in voltage) the constant signal values can't synchronize the communicating devices
- Especially with long runs of either 0 or 1, there is no change to resynchronise so it is likely that the clocks would get out of sync

2.2 NRZI Encoding

- NRZI attempts to alleviate the problem in NRZ scheme

Definition: NRZI Encoding

- 0 is encoded as no change in the level. 1 is encoded depending on the current state of the line
- 1 is encoded as an inverting of the current state

- This fixes the problem of sending consecutive 1s but not consecutive 0s

2.3 Bipolar Encoding

Definition: Bipolar Encoding

- 0 is represented by a zero voltage, neither high nor low
- 1 is represented by either positive voltage or negative voltage
  - It is inverted based on the last transmission of 1
  - It is represented by a negative voltage if it was represented by a positive voltage when it was last transmitted, and vice versa

For this, over a long enough message, the sum of the voltages is zero, this is called a ”balanced encoding” and is desirable in some applications

2.4 Manchester Encoding

Definition: Manchester Encoding

- A high to low voltage represents a 1 and a low to high voltage represents a 0
- Uses signal changes to transmit a bit and achieves synchronisation
- This is equivalent to an XOR of the clock signal and the NRZ encoding. The clock is at twice the frequency of the NRZ

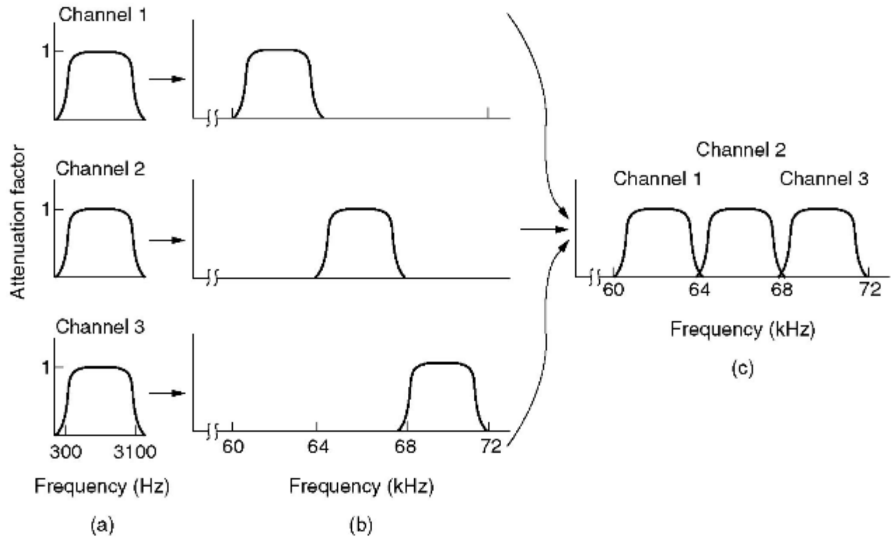
- Twice the bandwidth of NRZ is required

3 Multiplexing

- Channels are often shared by multiple signals
- Different ways to accomplish multiplexing:

3.1 Frequency Division Multiplexing

- Refactor the signals to start at different frequencies
- Sit them side by side on the frequency spectrum on the same channel, so they don’t interfere with each other
- Put a small region in-between adjacent frequency bands to avoid interference



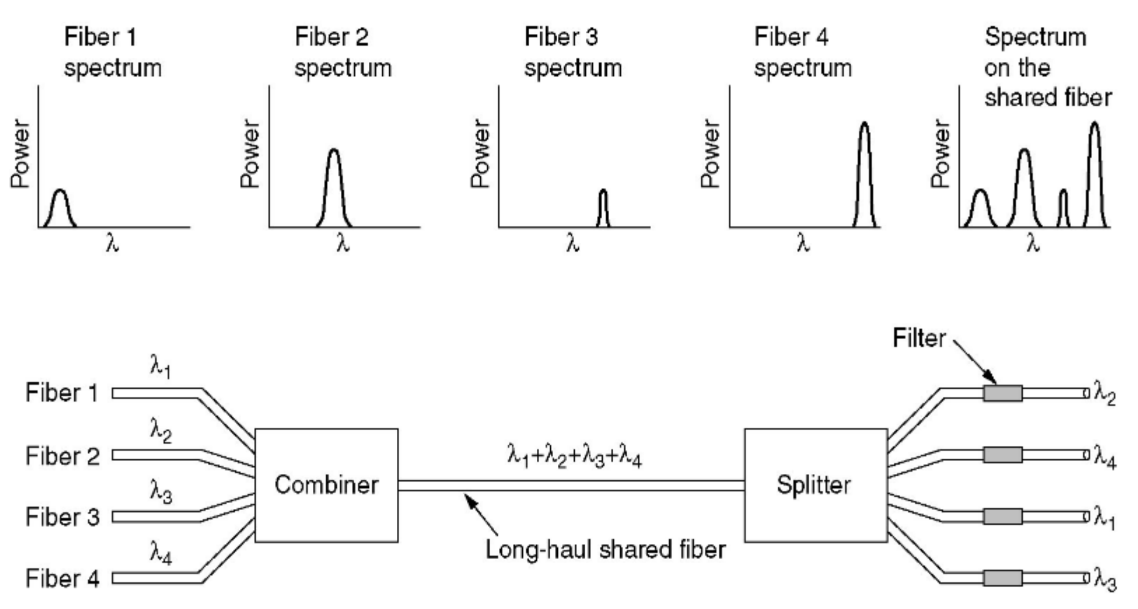
a The original bandwidths

b The bandwidths raised in frequency

c The multiplexed channel

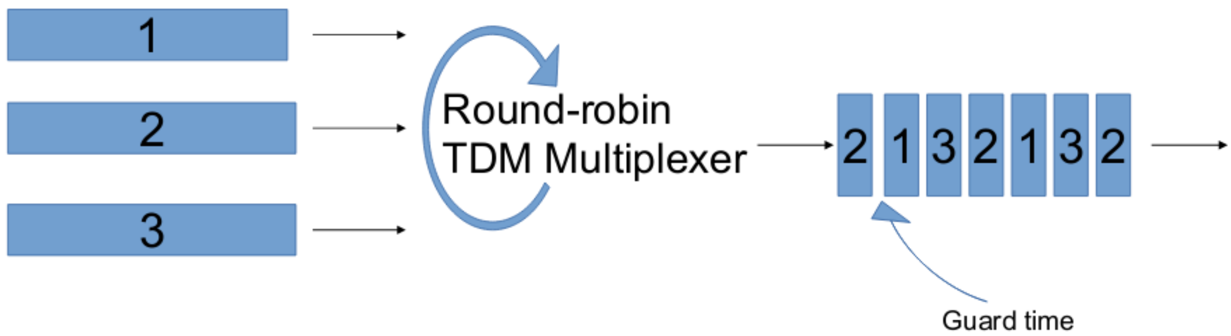
3.2 Wavelength Division Multiplexing

- The same as FDM but for optical fibres instead of wireless signals



3.3 Time division multiplexing

- Intersperse the channels in some sequence, leave a guard time to be able to separate out information



3.4 Code Division Multiple Access

- Nice and clean mathematical method allows every transmitter to use the entire channel all the time
- The individual transmissions are blended (or extracted by a receiver) using coding theory
- Imagine that we have four transmitters called, from now on, stations
- Each station has a chip (i.e. a code), which is a four bit vector
- These codes are chosen so that the dot product of any of these codes with any other of the codes is 0 i.e. they are orthogonal to each other
- Transmitting the stations chip sequence a 1
- Transmitting the negation of a stations chip sequence is a 0