Network Physical Layer

Fundamentos de Redes

Mestrado Integrado em
Engenharia de Computadores e Telemática
DETI-UA

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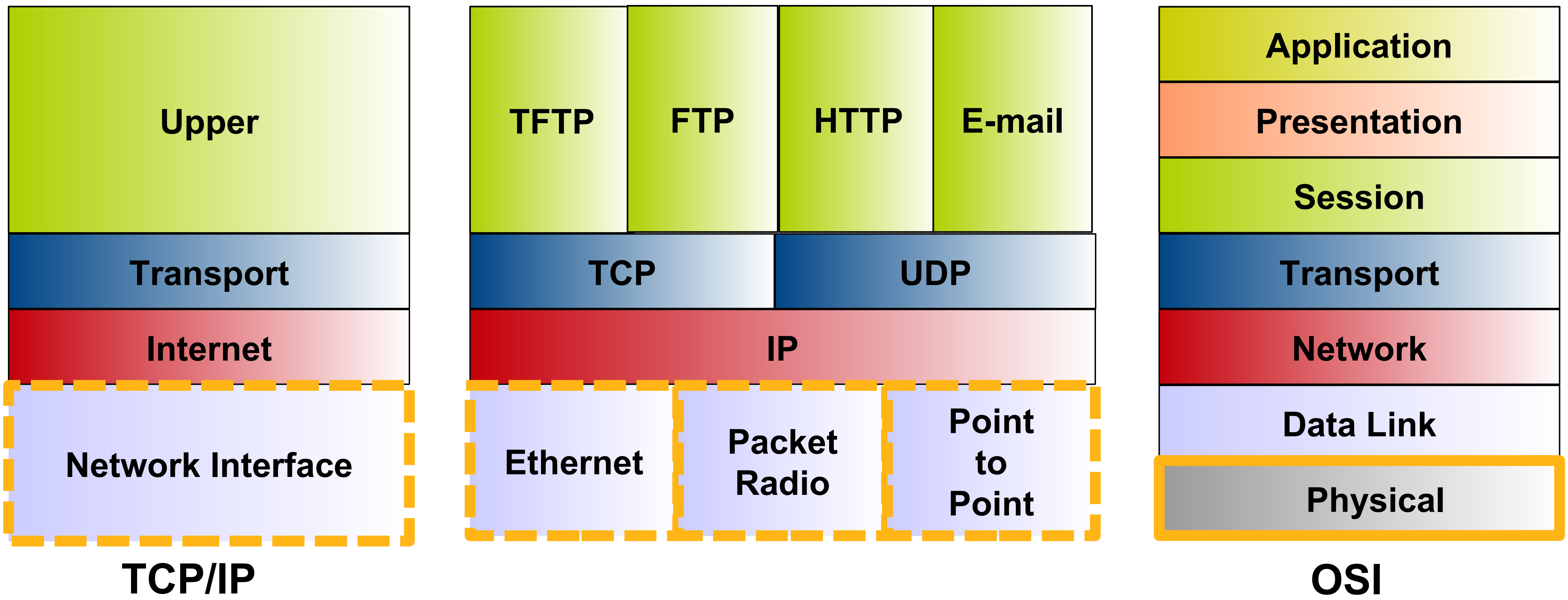
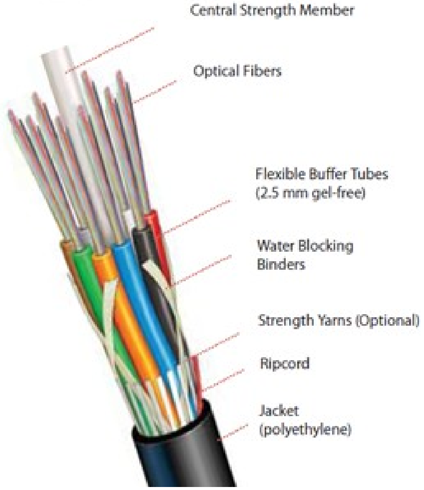
TCP/IP Reference Model



Guided/Unguided Transmission Systems



- A transmission system can be classified as **Guided** or **Unguided**.
- In **Guided** systems, a signal travels through a bounding physical medium.
  - Copper cable, Optical fibre, …
- In **Unguided** media, a signal travels through a boundless medium
  - Air, Water, Vacuum, …
  - Can be directional or omni-directional.
    - In directional configuration, the source emits a focused beam in a particular direction.
      - The receiver should be aligned for receiving the signals.
    - In omni-directional configuration, the source emits equally in all directions.

Microwave link

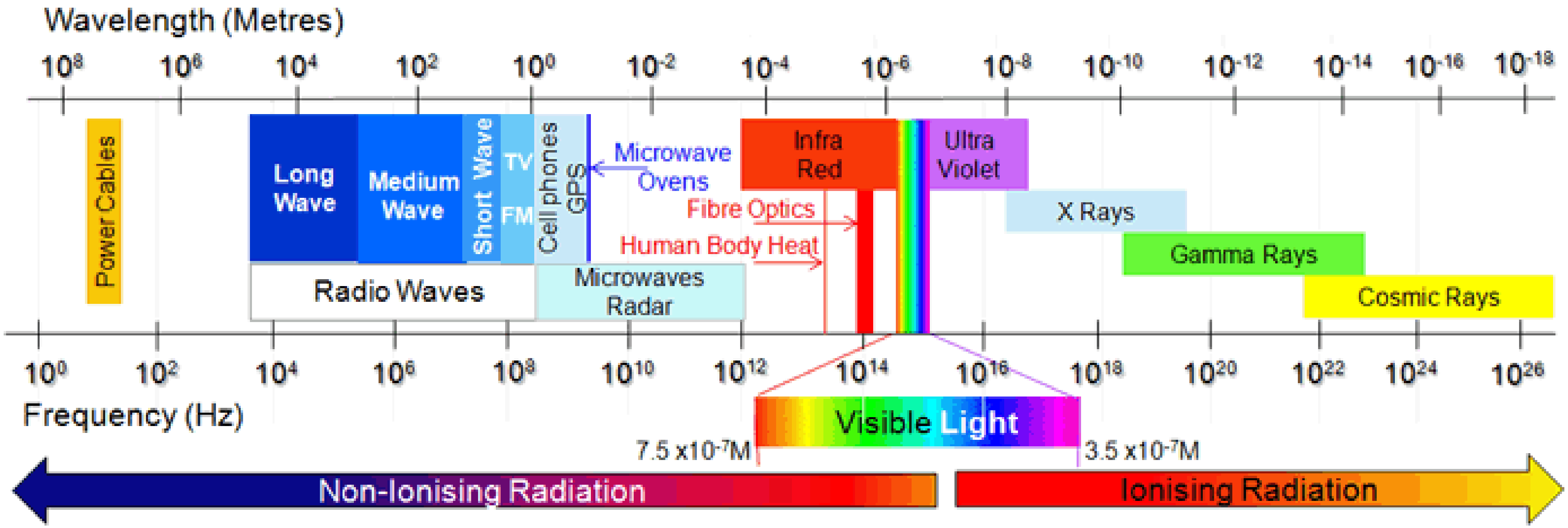
Free Space Optics (FSO)

Directional LTE

Omnidirectional LTE

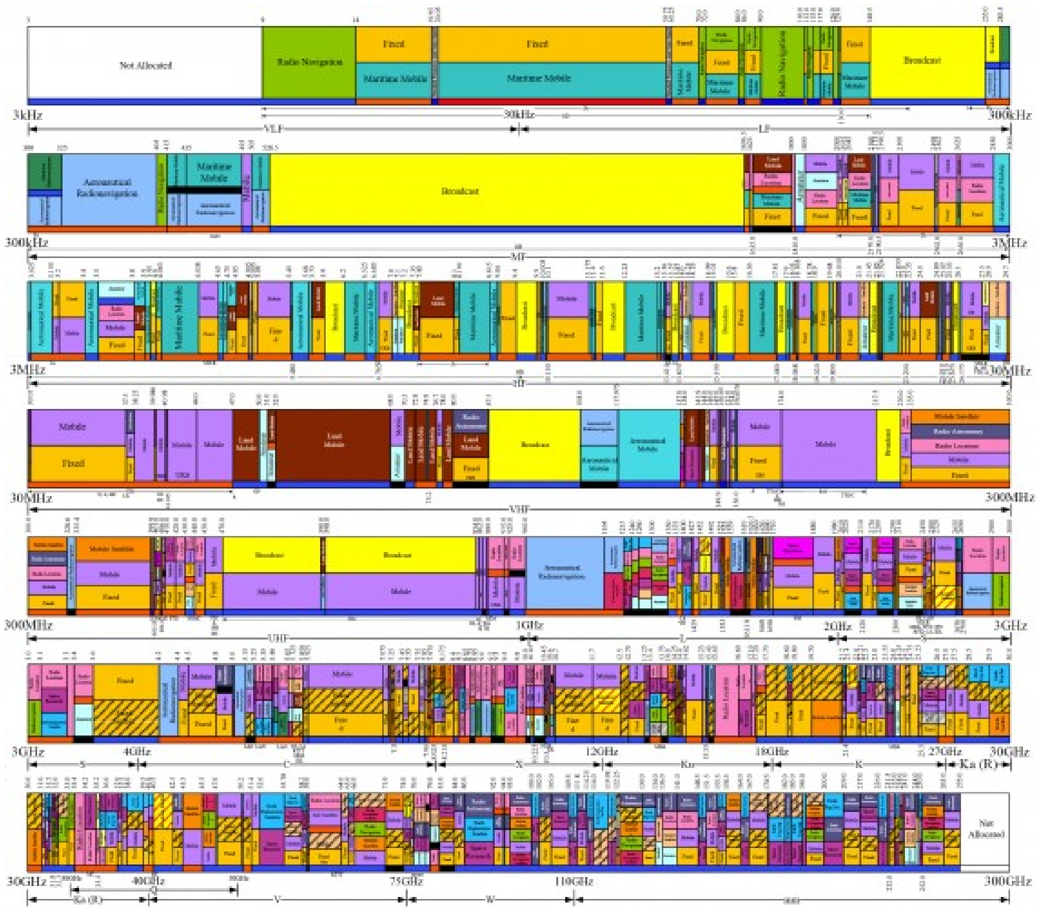
802.11 Omnidirectional

Electromagnetic Spectrum



- For radio signals the antenna transmits a sinusoidal signal ("carrier") that radiates in air/space.

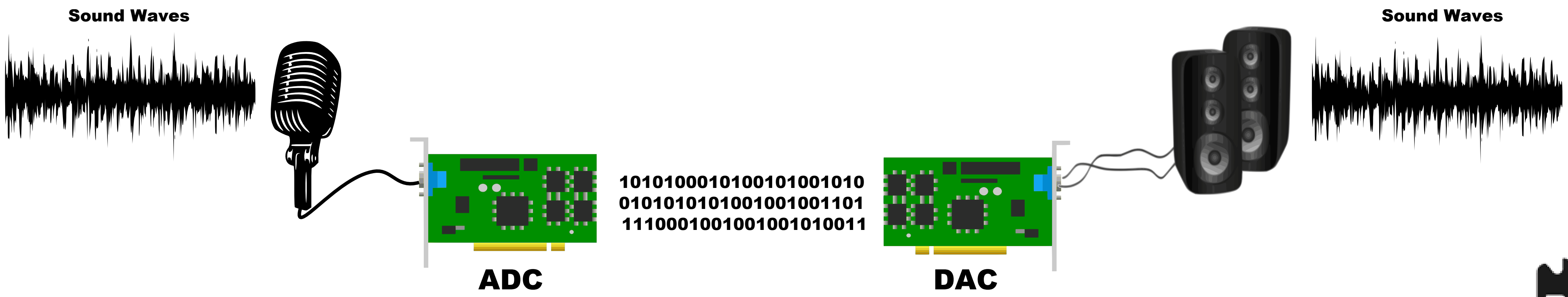
Radio/Microwave Spectrum (3KHz-300GHZ)



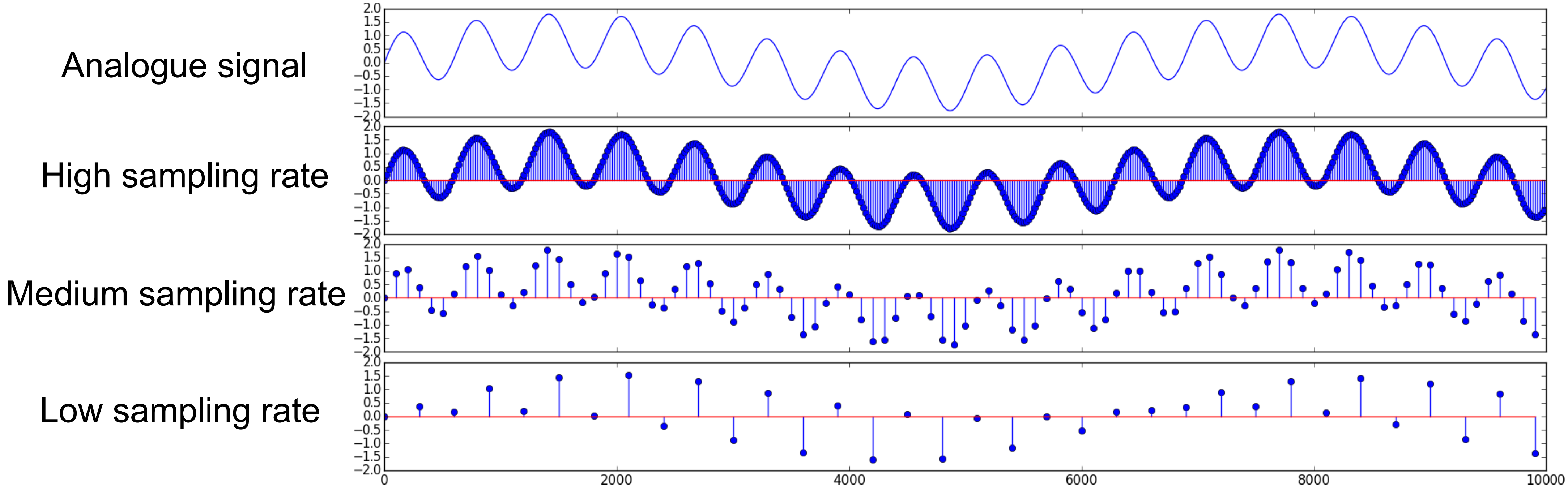
- Portugal (ANACOM)
  - https://www.anacom.pt/render.jsp?categoryId=150422
- UK (OFCOM)
  - https://www.ofcom.org.uk/spectrum/information/uk-fat
- USA (FCC)
  - https://www.fcc.gov/engineering-technology/policy-and-rules-division/general/radio-spectrum-allocation
- ...

Analogue-Digital Conversion

- The digital transmission of analogue signals requires:
  - An ADC in the source, and
  - A DAC in the destination.
- ADC (Analogue to Digital Conversion)
  - Sampling
  - Quantization and Encoding
- DAC (Digital to Analogue Conversion)
  - Signal reconstruction



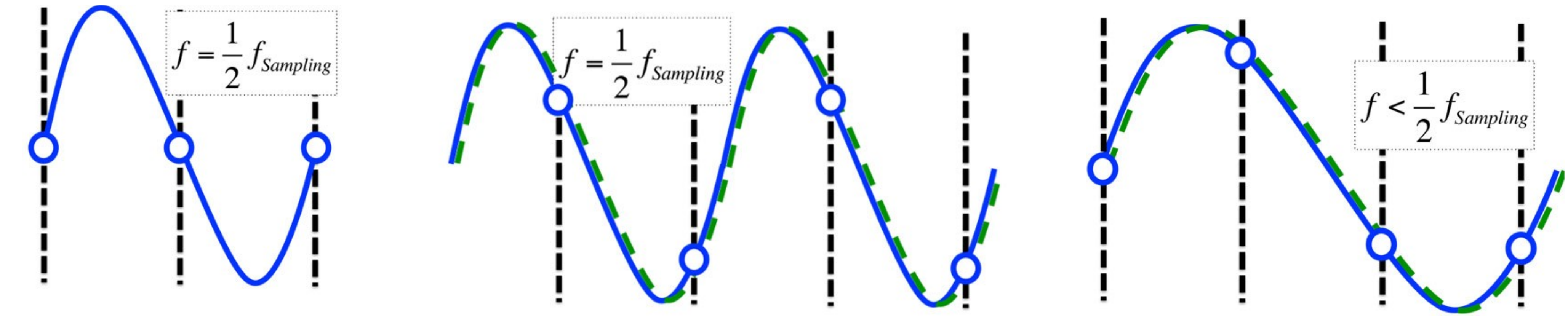
Sampling



- The sampling process, measures and quantifies the analogue signal at equally space time intervals.
- The sampling process must be able to capture the main characteristics of the original analogue signal.
- The sampling rate determines the amount of information that its transferred to the digital signal.

Sampling Theorem

- To reconstruct a signal from the samples, the sampling frequency must be high enough to capture the relevant signal information (frequency components).
  - Sampling frequency is the number of samples per second (f_s).
- For a signal where the highest (relevant) frequency is f_m, the sampling frequency (f_s) must be higher than two times f_m
  - $f_s > 2 * f_m <=> f_m < f_s / 2$
  - $f_s / 2$ is called the **Nyquist frequency**.
  - $2 * f_m$ is called the **Nyquist rate**.



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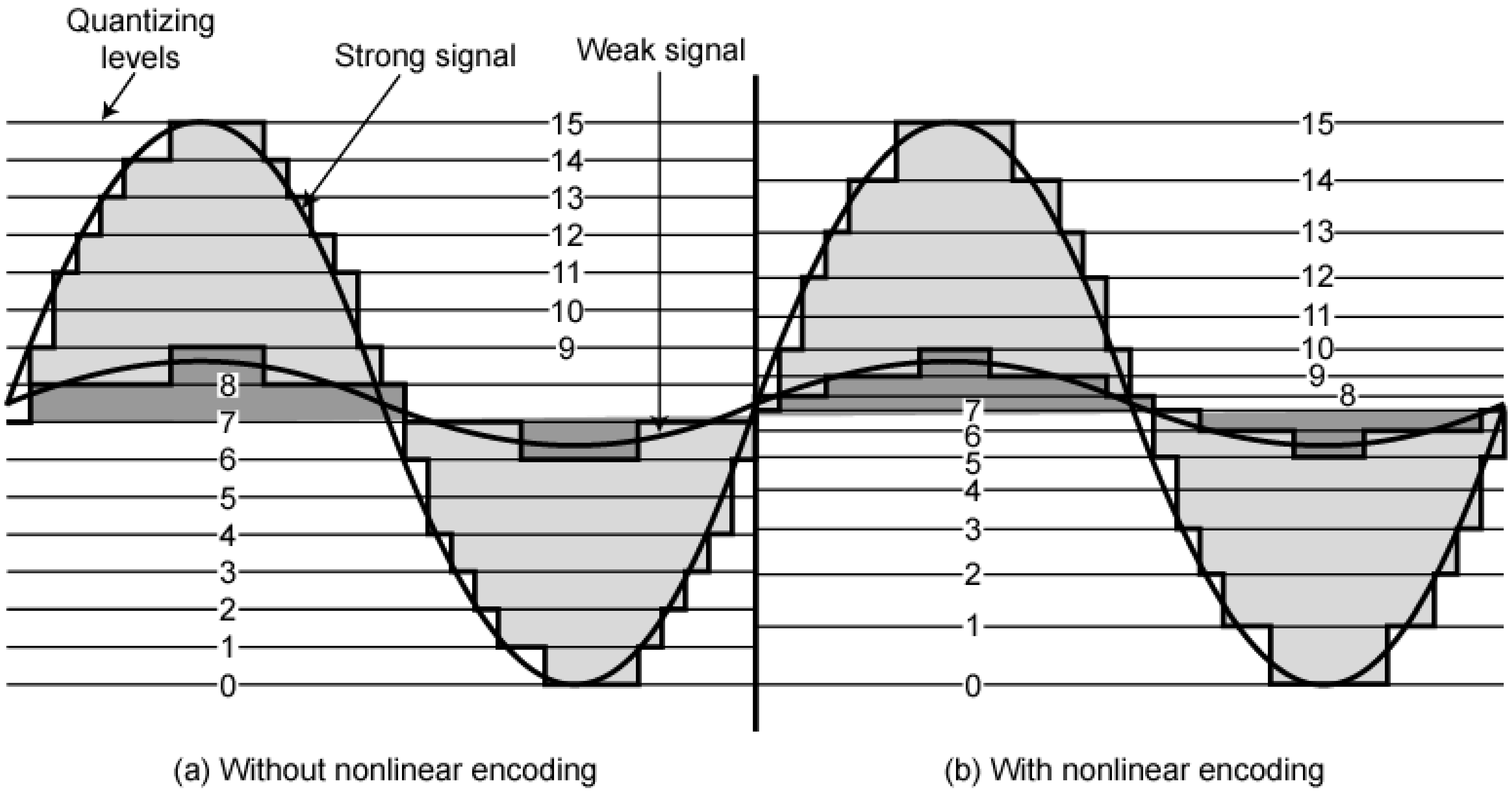
Signal Quantization and Encoding

- Each sampled value must be “rounded” to the nearest member of a set of discrete values.
- The resulting value is then encoded into a binary format.



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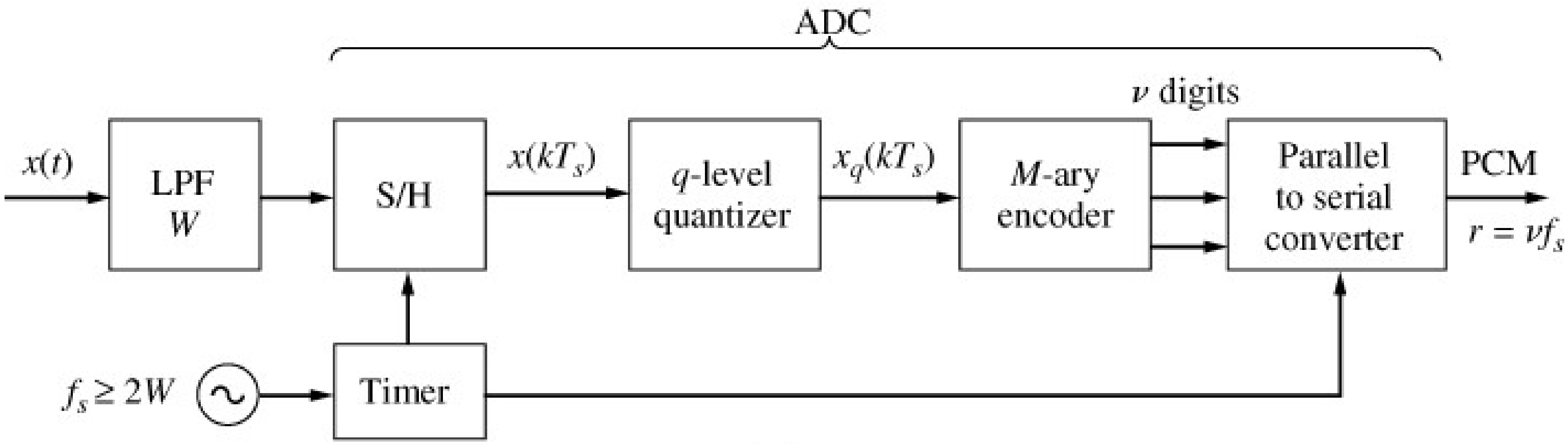
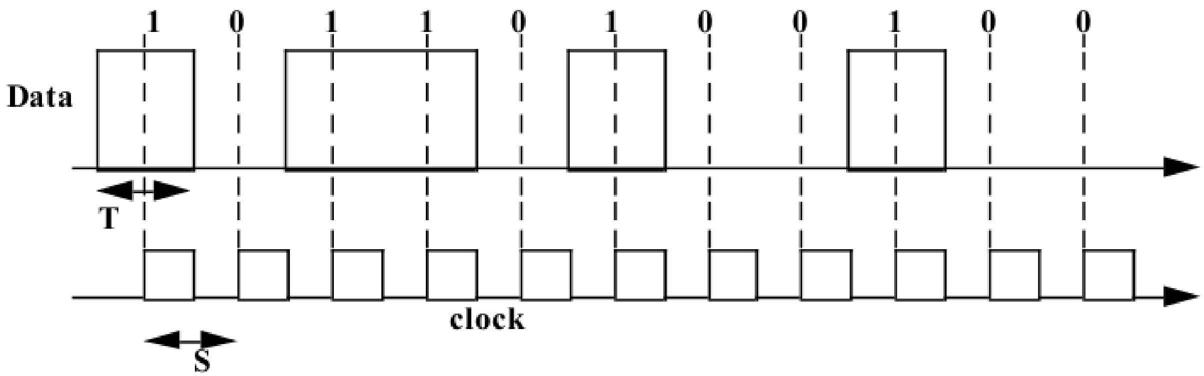
Pulse Code Modulation (PCM)

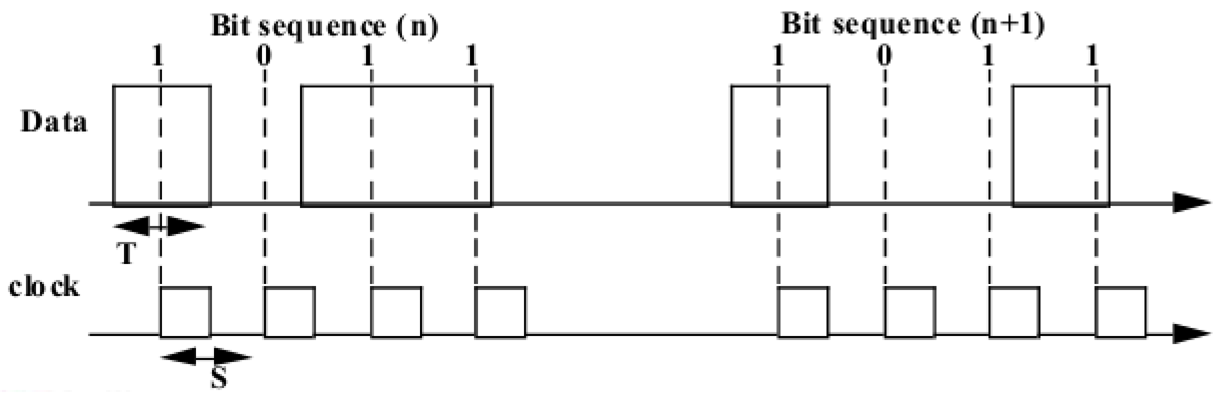
- All mechanisms of an ADC can be implemented using a PCM encoder.



Digital Transmission

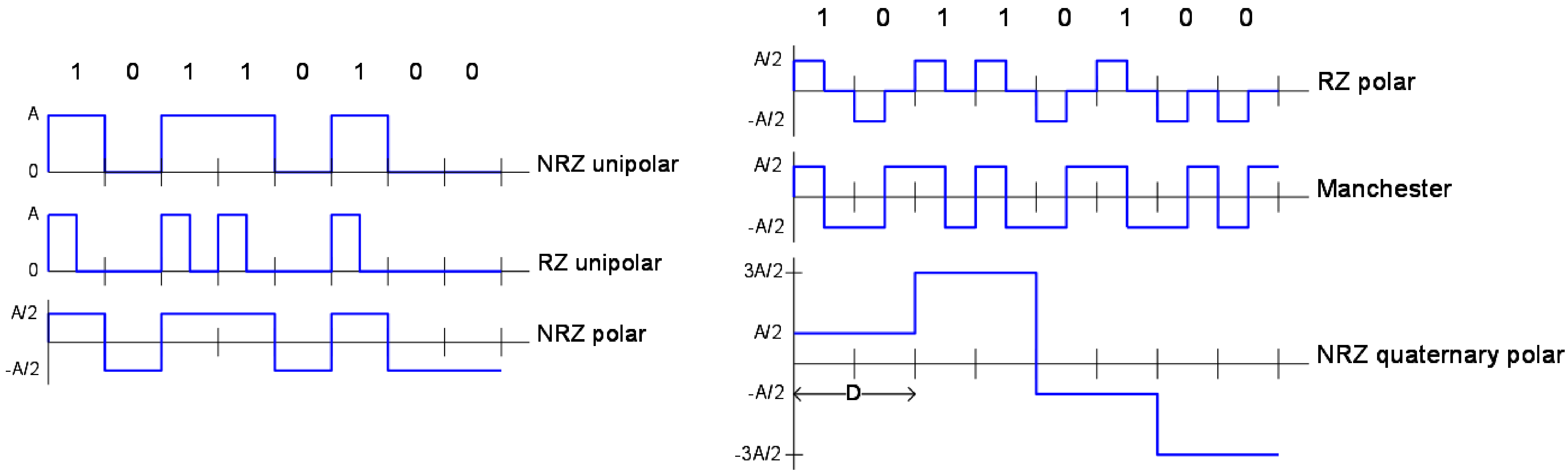
- Can be synchronous or asynchronous.
  - Synchronous Transmission data is transferred in the form of frames.
  - Asynchronous Transmission data is transmitted 1 bit or byte at a time.
- Synchronous Transmission requires a clock signal between the sender and receiver.
- Asynchronous Transmission sender and receiver does not require a clock signal, but data blocks must have a parity bit attached to it which indicates the start (start bit) of the new byte.
  - And, an optional stop bit.





Line Coding (1)

- Line Coding converts a binary sequence into a digital signal
- Sender then uses the digital signal to modulate transmitting signal in a way that the receiver can recognize.
- Line Coding can be done bit a bit, or in block of several bits (symbol).
- There are several (bit a bit) Line Codes:



Line Coding (2)

- mB/nB Encoding
  - Symbols of m bits are coded as line symbols of n bits.
  - Each valid line symbols has at least two 1s.

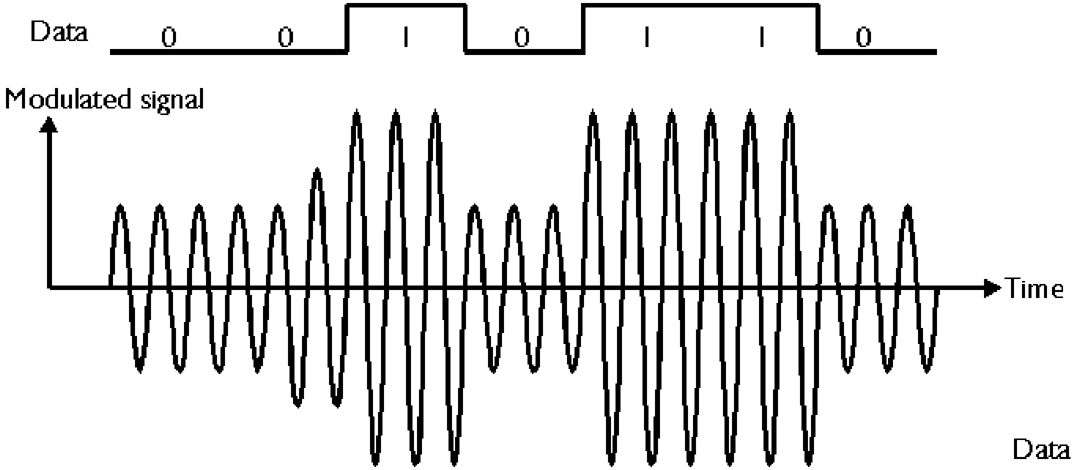
4B/5B Code

Bits	Symbol
0000	11110
0001	01001
0010	10100
0011	10101
0100	01010
0101	01011
0110	01110
0111	01111
1000	10010
1001	10011
1010	10110
1011	10111
1100	11010
1101	11011
1110	11100
1111	11101

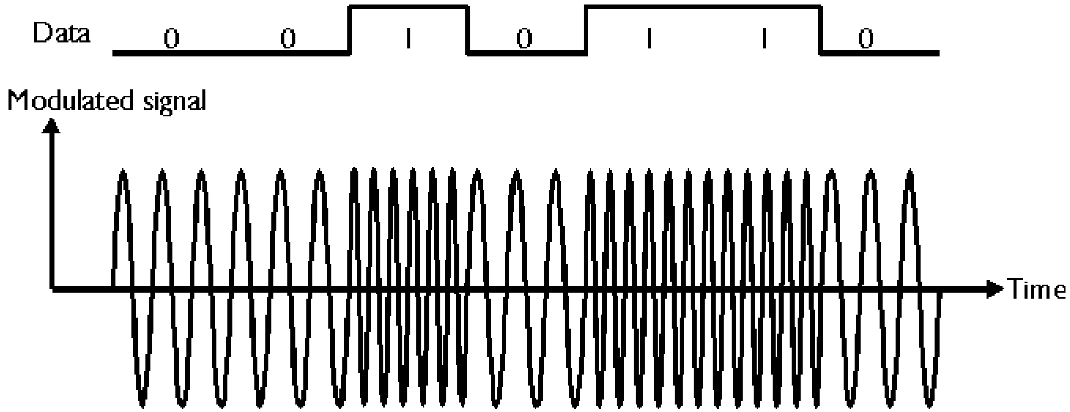
Bits	Symbol
IDLE	11111
J	11000
K	10001
T	01101
R	00111
S	11001
QUIET	00000
HALT	00100

Modulation (1)

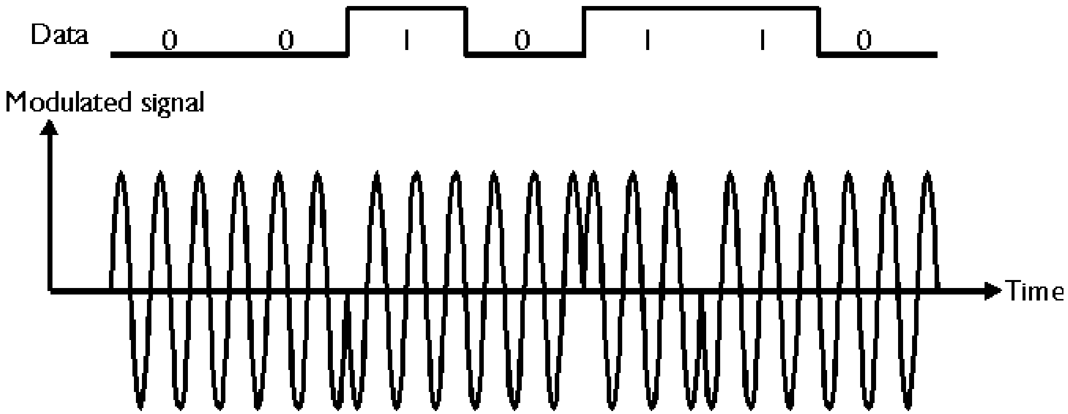
- Amplitude



- Frequency

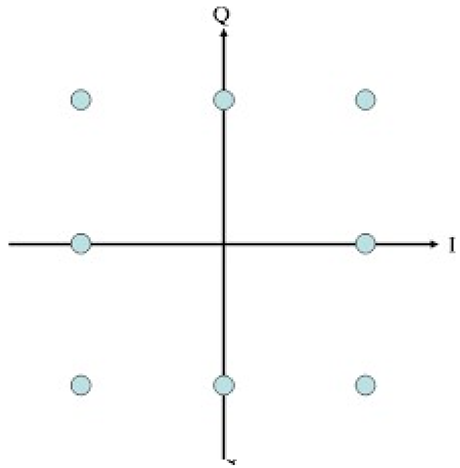


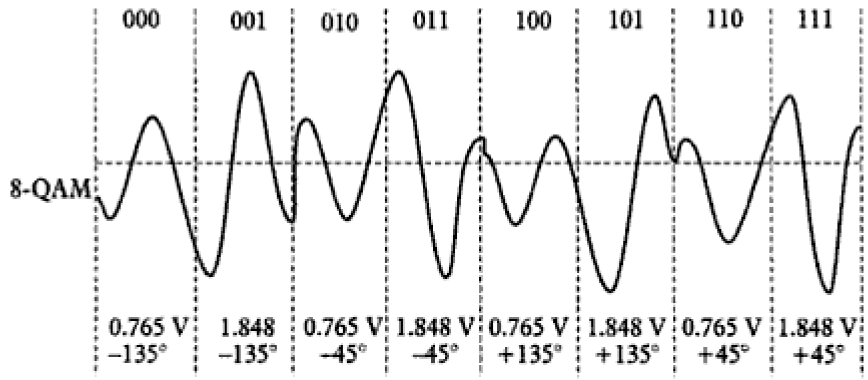
- Phase



Modulation (2)

- Quadrature Amplitude Modulation (QAM)
  - Uses 2-Dimensional signalling
    - Quadrature ← Sine wave + Cosine wave
  - $s(t) = I(t)cos(2\pi f_0 t) - Q(t)sin(2\pi f_0 t)$
- 8-QAM





- 16-QAM