DEFINITIONS AND FUNDAMENTAL PRINCIPLES

Data Communications

- Information is transmitted between two points in the form of data.
- Analog
  - » Varying amplitude, phase and frequency
- Digital
  - » In copper systems represented as a high and low voltage levels.
  - » In fibre systems represented as the presence or not of a light pulse.

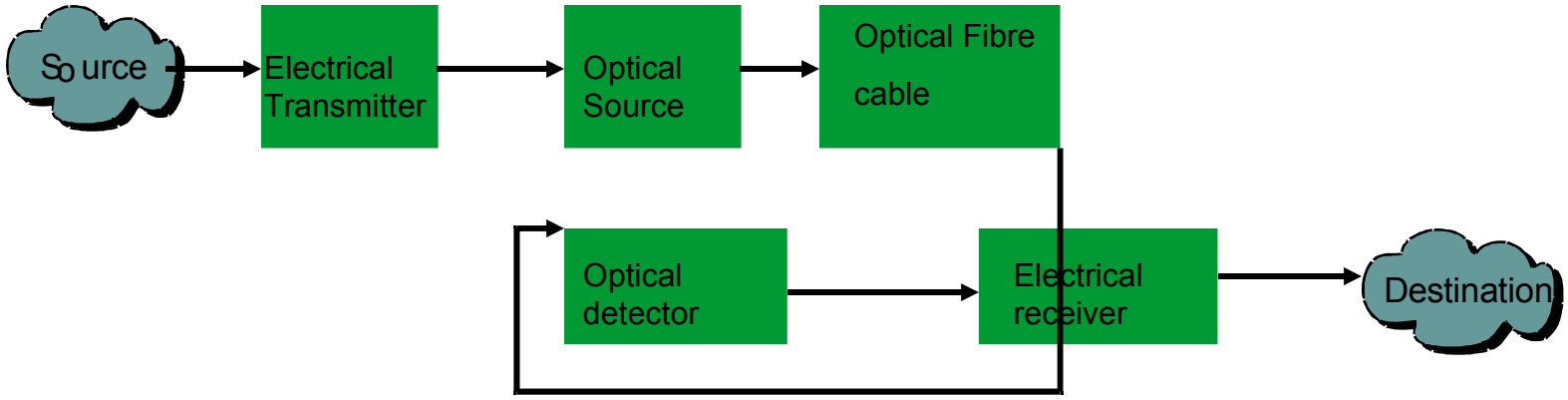
Transmitters, Receivers and Communications Channels

- A communications process requires
  - A source
  - A transmitter
  - A communications channel
  - A receiver
  - A destination

Communications Process

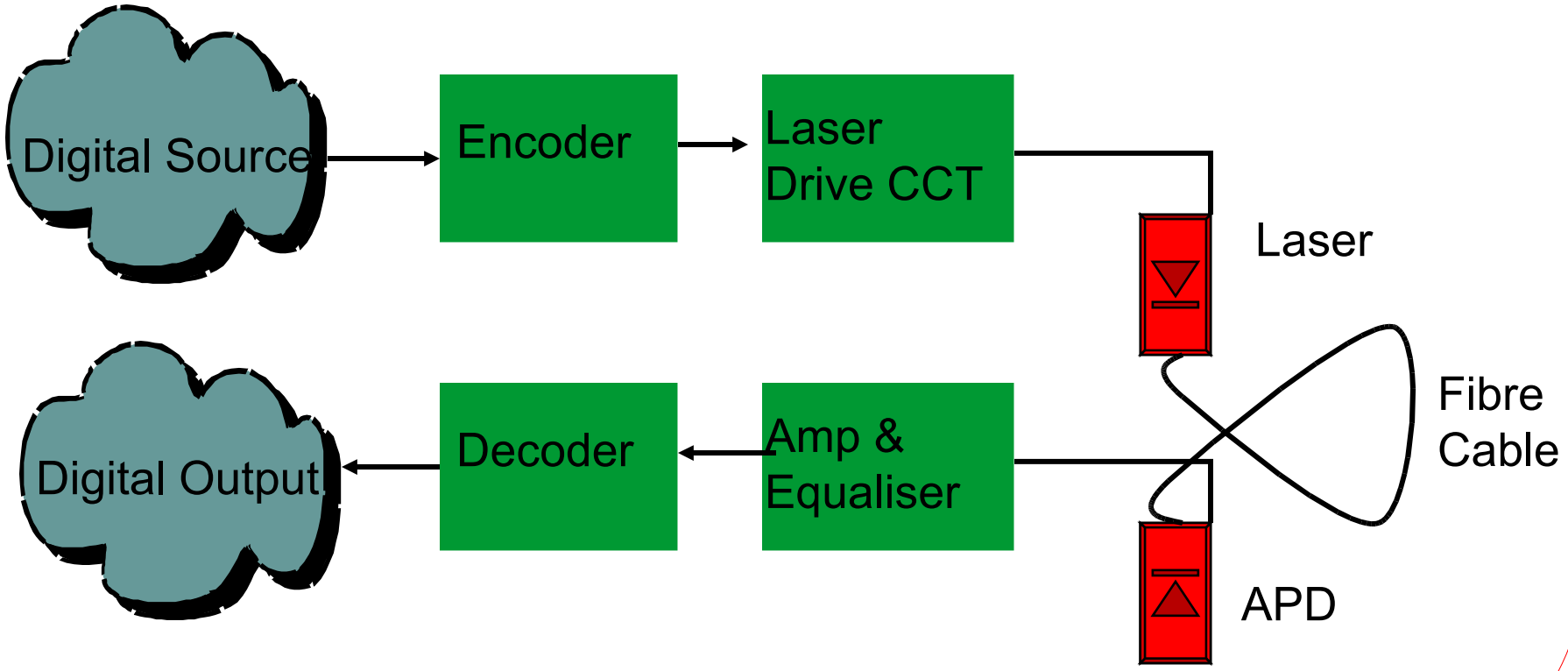
Generic Comms Process

Optical Fiber Communication System



Contd…….

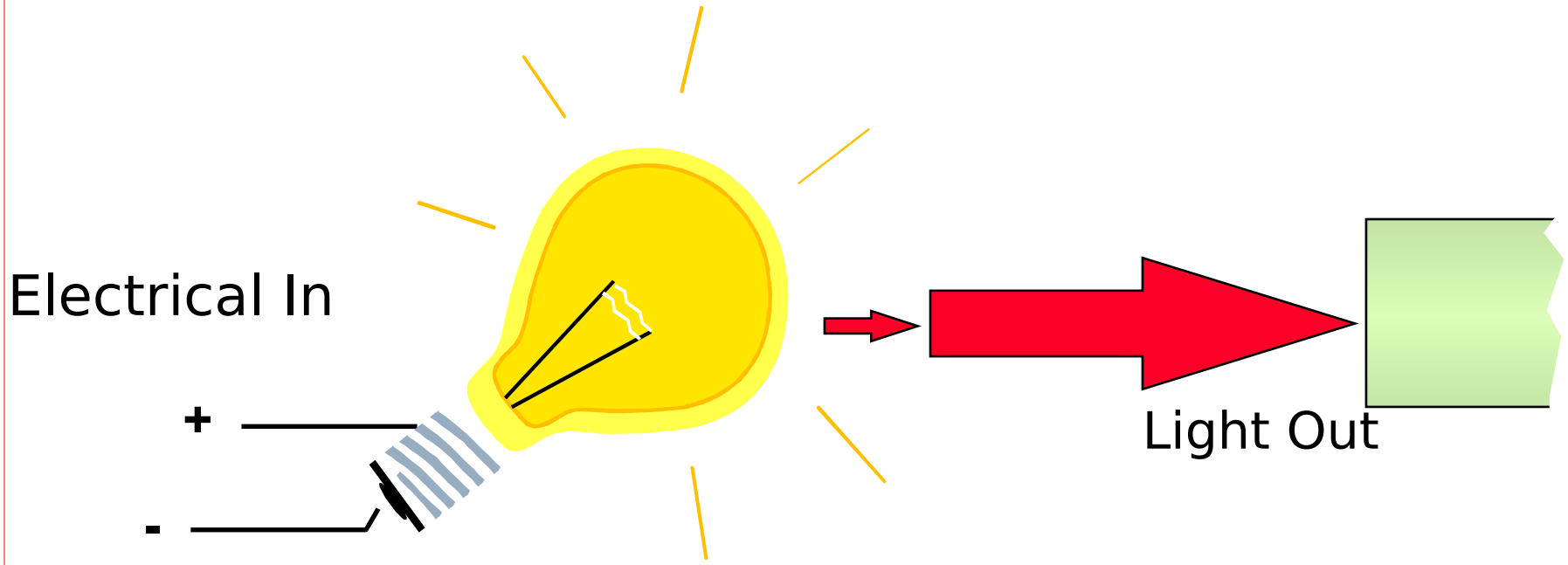
Optical Fibre Communications System Components



APD = Avalanche Photodiode

Optical Fibre Communications System Components

Electrical to Optical (E-O) Converter

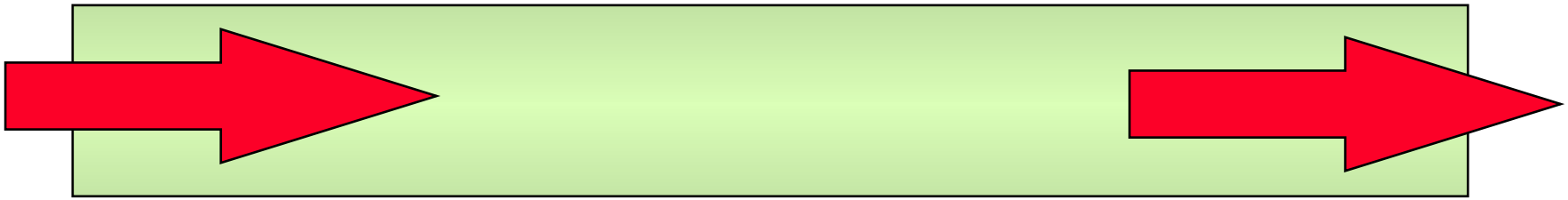


Variable Intensity = Analog
Blink On & Off = Digital

Optical Fibre Communications System Components

Optical Waveguide

Silica-Glass Optical Fiber



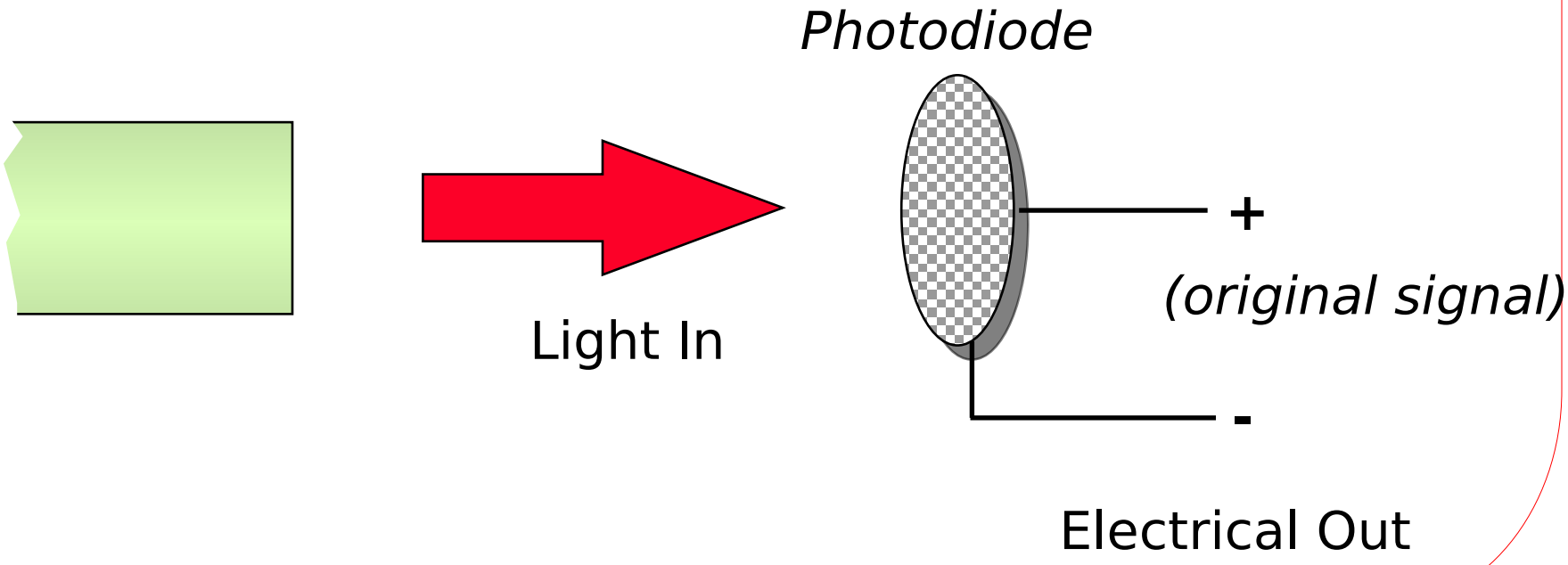
Light In

Light Out

Optical Fibre Communications System Components

Receiver

Optical to Electrical (O-E) Converter



- For successful communications between both ends of a communication link there must be mutual agreement on:
  - The form and magnitude of the signals used
  - The type of communications link
  - The coding of the signals
  - Data flow control
  - Error detection and correction

Important Concepts

- Interface standards (eg.RS232)
  - » Defines electrical and mechanical aspects of the interface to allow different manuafcturers equipment to work together
  - » 1. defines Electrical signal characteristics (voltage levels, grounding)
  - » 2. defines Mechanical characteristics (connectors and pin assignments)
  - » Functional characteristics (defines the function of data, timing and control signals)

  Does not cover how the data is transferred

  ›

Important Concepts

- Coding (describes the way the data is converted into symbols before transmission)
  - » Wide variety of codes eg. Morse code
  - » The more common code symbols used for transmission today are:
    - – Example : ASCII Code and EBCIDIC (see ASCII table) – letter D = 1000100

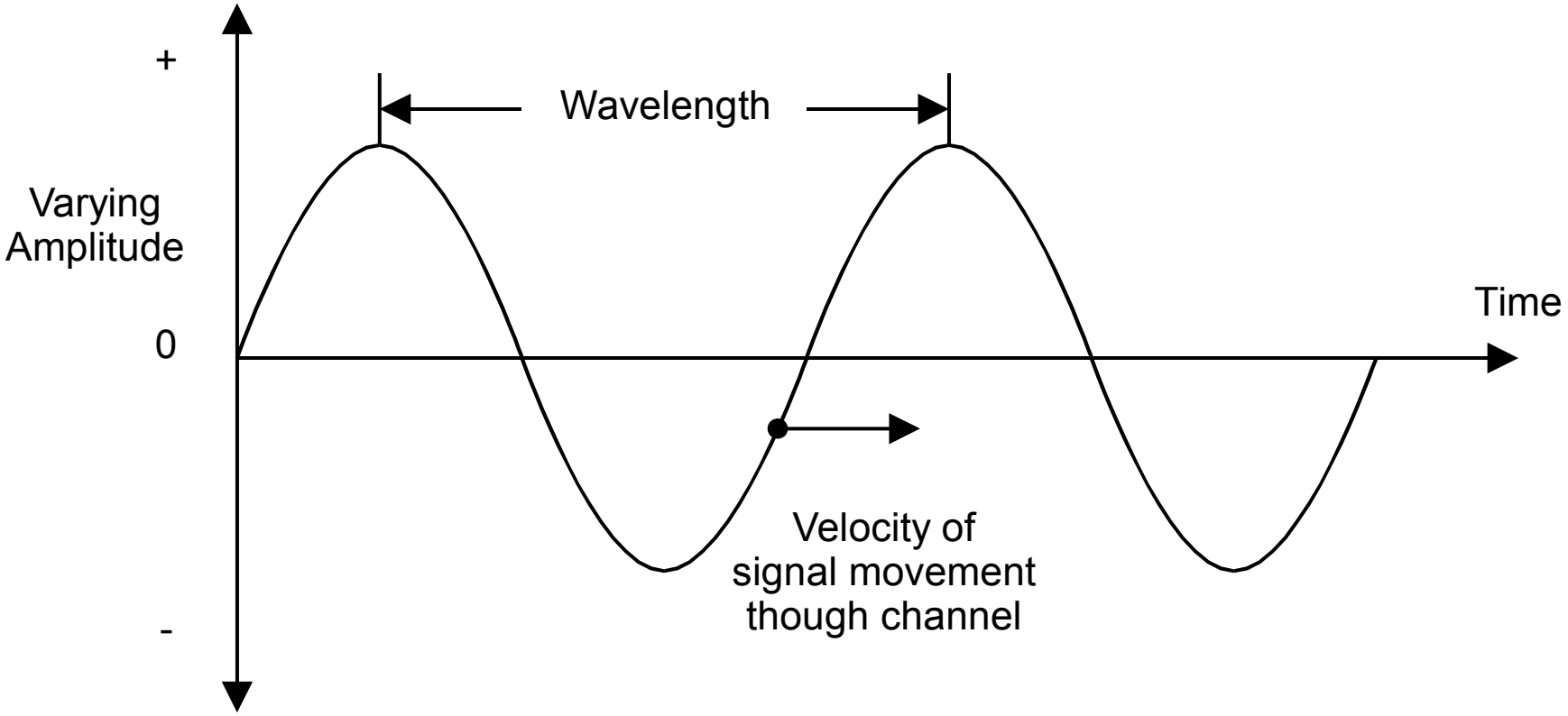
- **Protocols** (Oxford dic: rules or formalities of a procedure)
  - » Initialisation – initiates the protocol parameters (sets the rules for data transmission)
  - » Framing and synchronisation – defines the start and end of the frame and gives synchronisation information to receiver
  - » Flow control – manages the flow (speeds up and down) of data

- Protocols contd…
  - Line control – Used with half duplex links to switch tramsitter and receiver
  - Error control – techniques used to check the accuracy of the data and identify errors
  - Time out control – “retry or abort” procedures
  - Examples:
    - XMODEM, KERMIT, BSC, SDLC, HDLC, TCP/IP, MAP, TOP, MODBUS, DH+, HART,

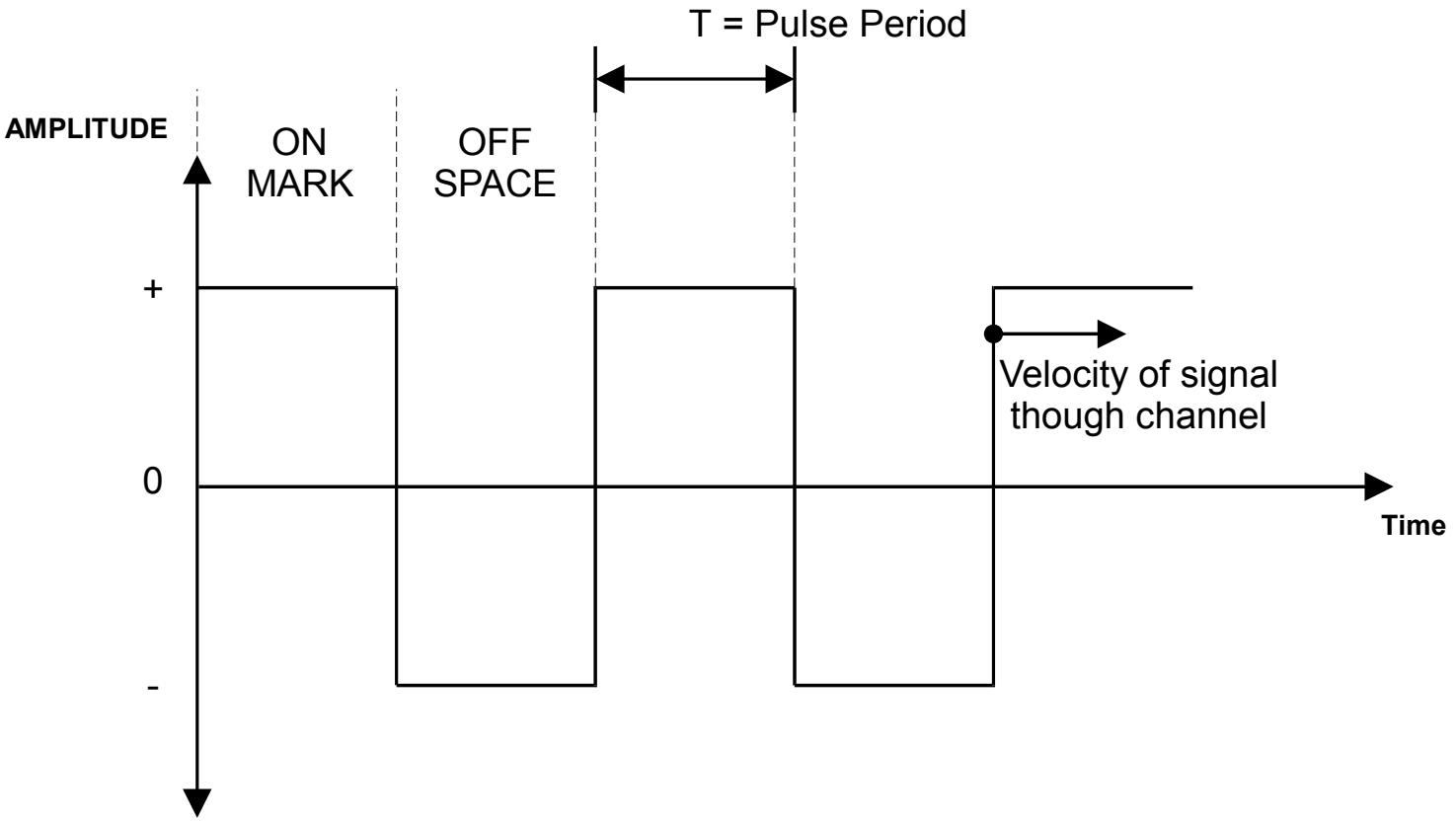
Communication Channels

- Analog
  - » Varying amplitude, phase and frequency
- Digital
  - » High - low voltages levels; on - off signals.

Analog Signals



Digital Signals



Channel Properties

- Physical properties of the communications medium limit the effective transmission of data
- Measurement of gain and loss in circuits is carried out using decibels
  - Decibels are a relative measure

GAIN = 10 LOG (Pb/Pa) dB

- Absolute Gain Measurement ?
  - » Can also be measured with respect to 1 milliwatt

    GAIN = 10 LOG (P/10^{-3}w) dB_m

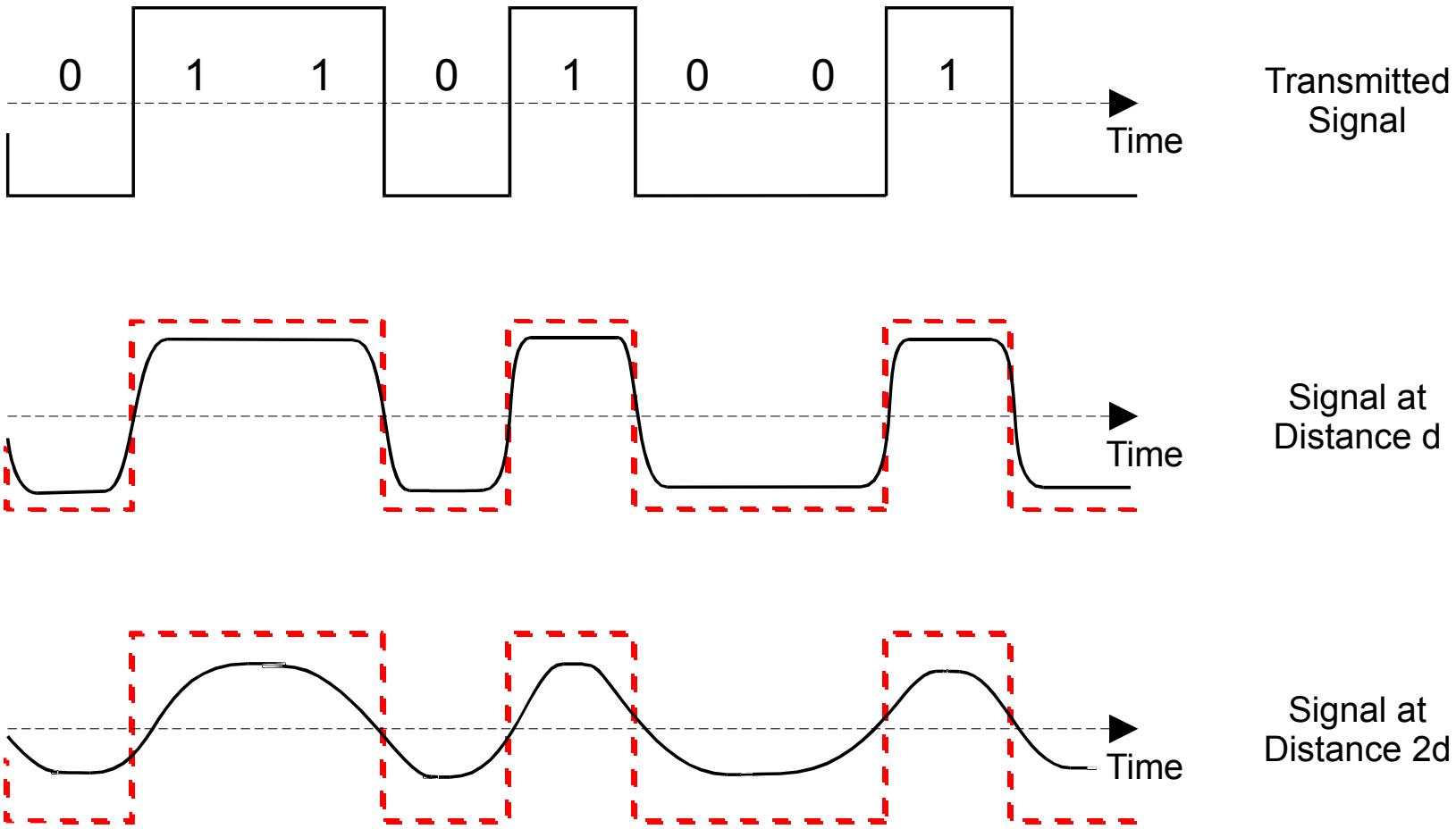
  - » Or can be measured with respect to 1 watt

    GAIN = 10 LOG (P/1w) dB_w

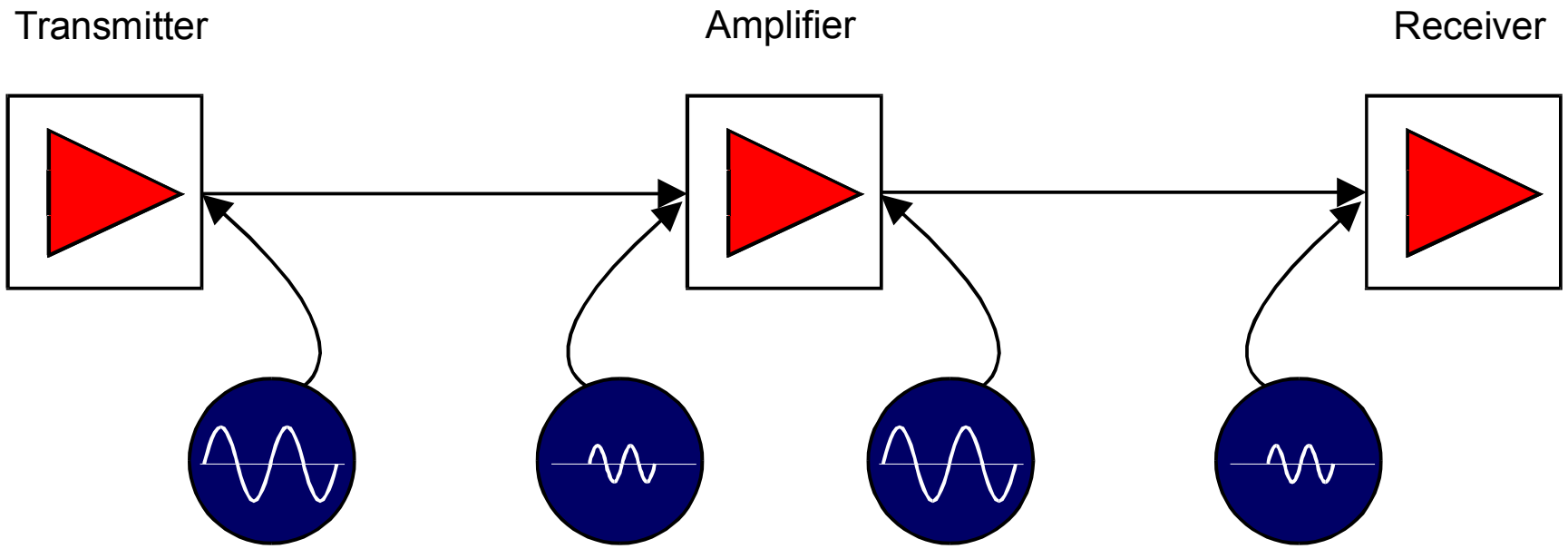
SIGNAL ATTENUATION

- Natural resistive cable properties absorb the electrical energy and turn it into heat
- Limits the length of the communications channel
- Digital signals have fast rising edges which represent high frequency components. Signal attenuation increases with increasing frequency.
- Use repeater, amplifiers and equalisers
- Natural resistive properties of glass absorb electromagnetic energy

Signal Attenuation

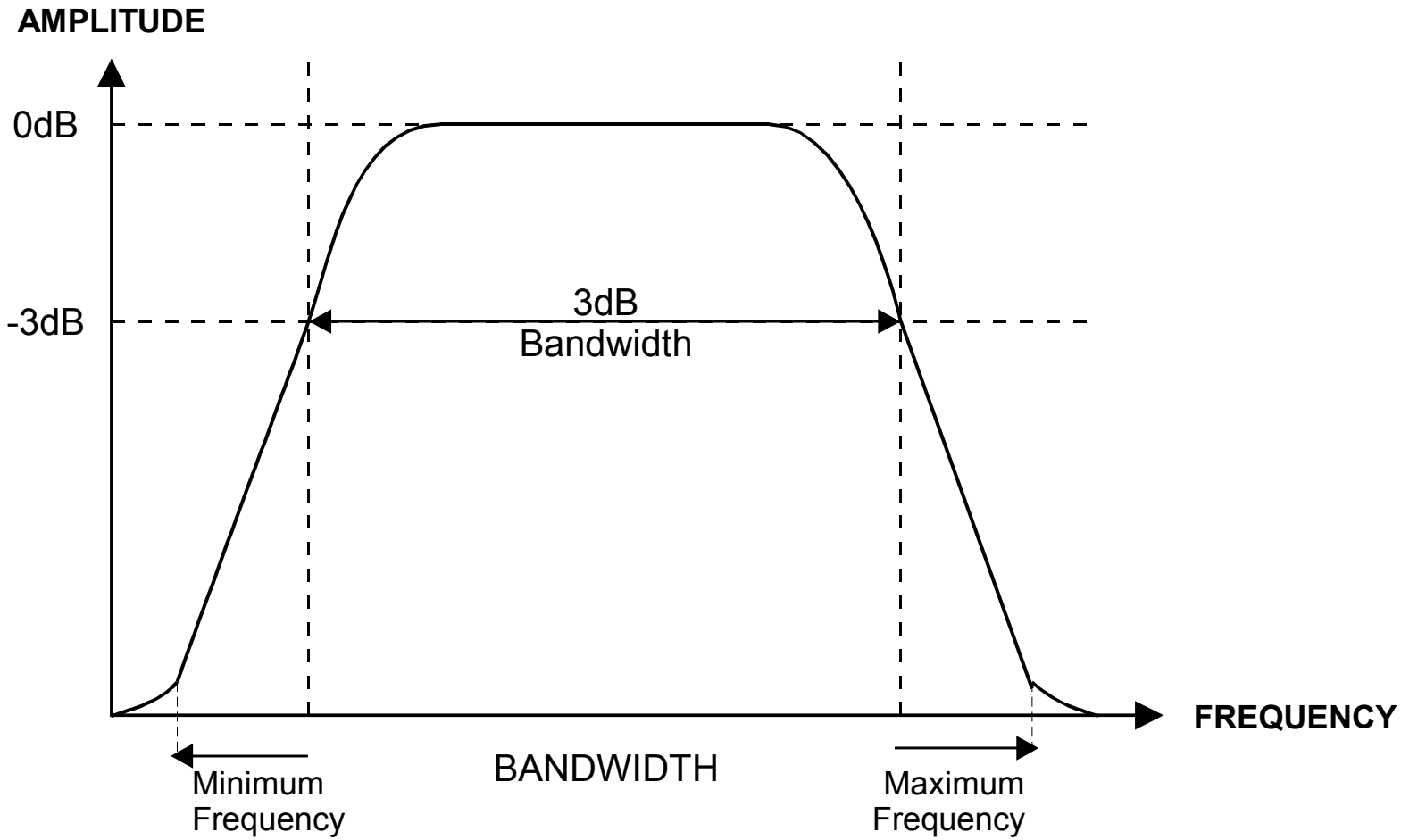


Signal Repeaters

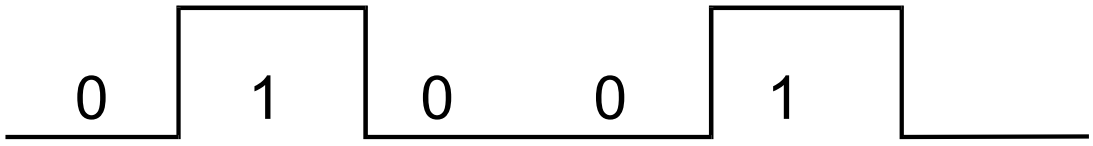


- CHANNEL BANDWIDTH (the way the channel affects data throughput)
  - The difference between the highest and the lowest frequencies that can pass though a channel.
  - Where the highest and lowest frequencies have dropped to half power i.e. 3 dB drop in power.
  - Digital signals are constructed of many frequencies but their transmission is limited by the channel analog bandwidth.
  - The higher the bandwidth the higher the frequency that can be transmitted.

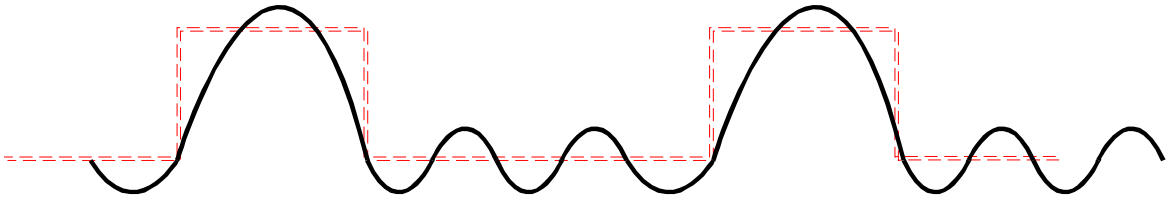
Channel Bandwidth



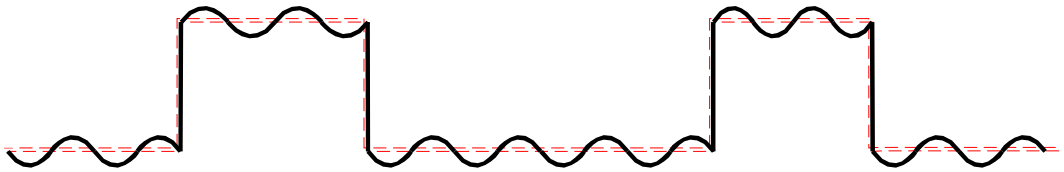
Effect Of Channel Bandwidth On A Digital Signal



Original Digital Data



1200 Hz Bandwidth Signal



4000 Hz Bandwidth Signal

» The maximum data rate is given by Shannons Law:

$$C = 2 B \log_2 M \quad bps$$

– Where B = bandwidth in Hertz
and M = levels of signalling element

- Noise
  - Vibration of molecules emit random electromagnetic radiation - noise
  - Natural low level EMR limits the transmit signal level.
  - Measure of useful signal power is the SIGNAL to NOISE Ratio:

$$\mathbf{S/N = 10\ LOG_{10}\ (Signal/Noise)\ \ dB}$$

Signal = Signal power in WATTS

Noise = Noise power in WATTS

Shannon Hartley law relates signal to noise ratio to the maximum data rate:

$$C = B \log_2 (1 + S/N) \text{ in bps}$$

Where: B = Bandwidth in HERTZ

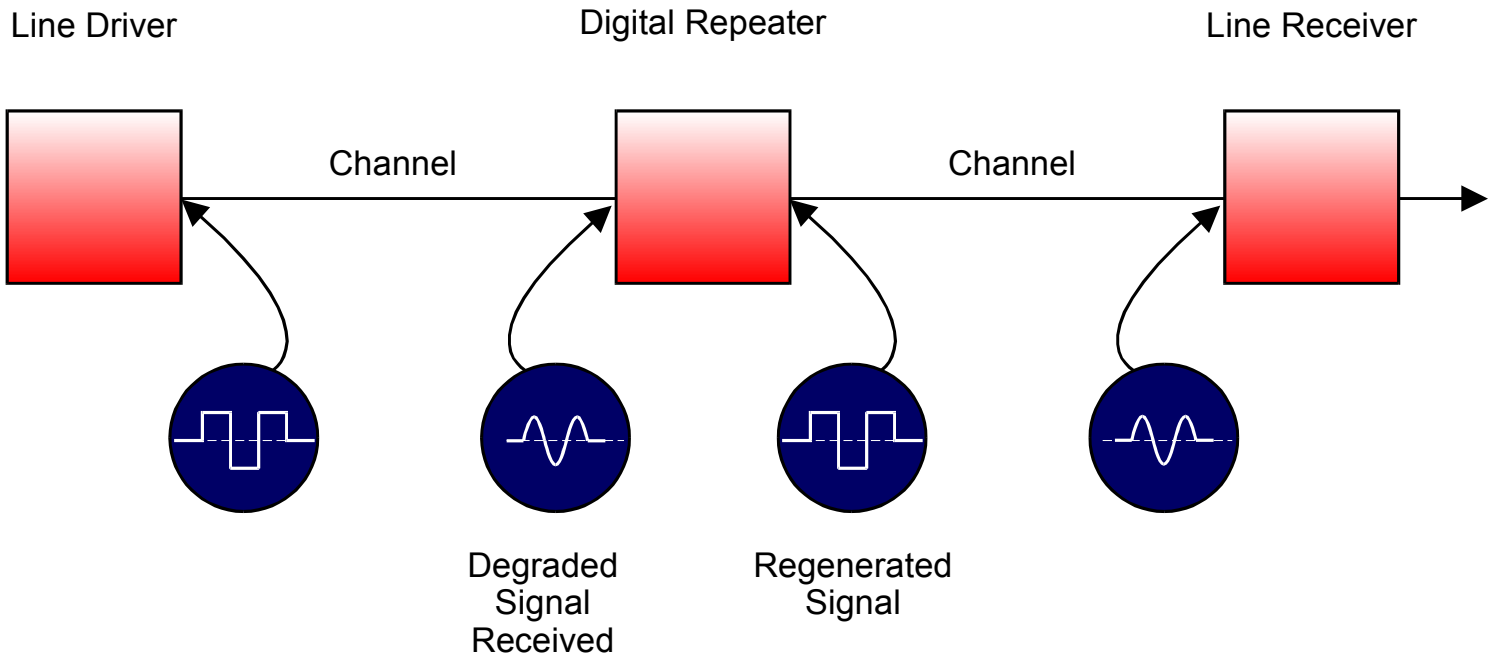
S = Signal power in WATTS

N = Noise power in WATTS

- An increase in B or S/N increases data rate capability
- An increase in B is more effective than an equivalent increase in S/N

» Digital regenerators provide transmission distances of 1000s km.

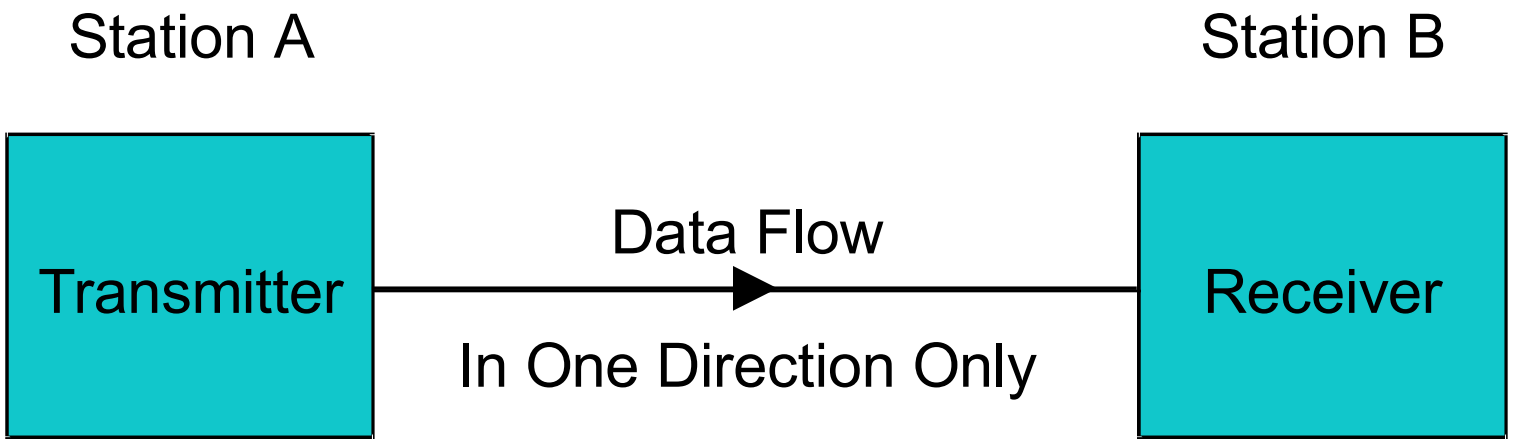
Digital Regenerator



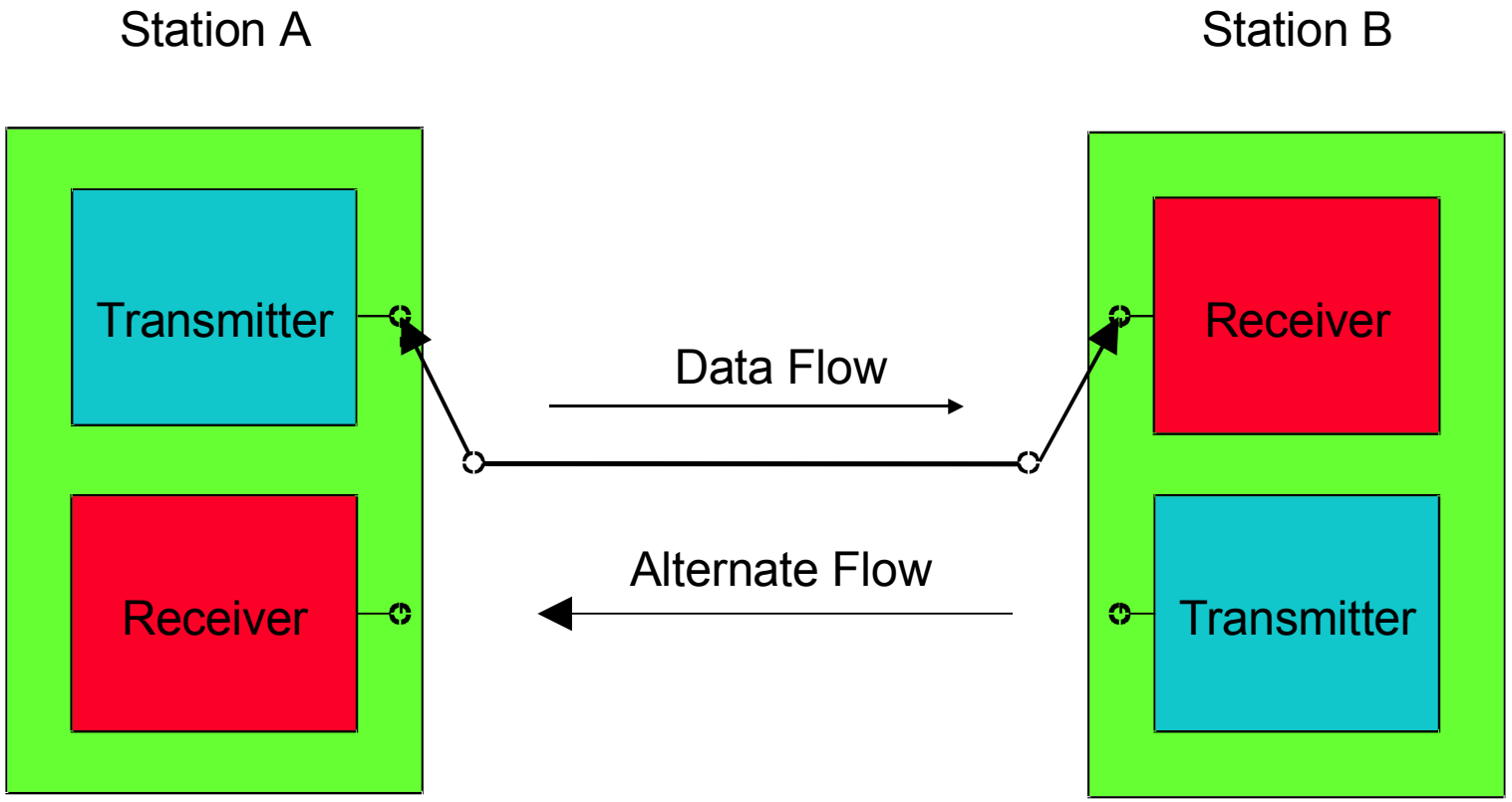
TRANSMISSION MODES

- Simplex
- Half duplex
- Full duplex

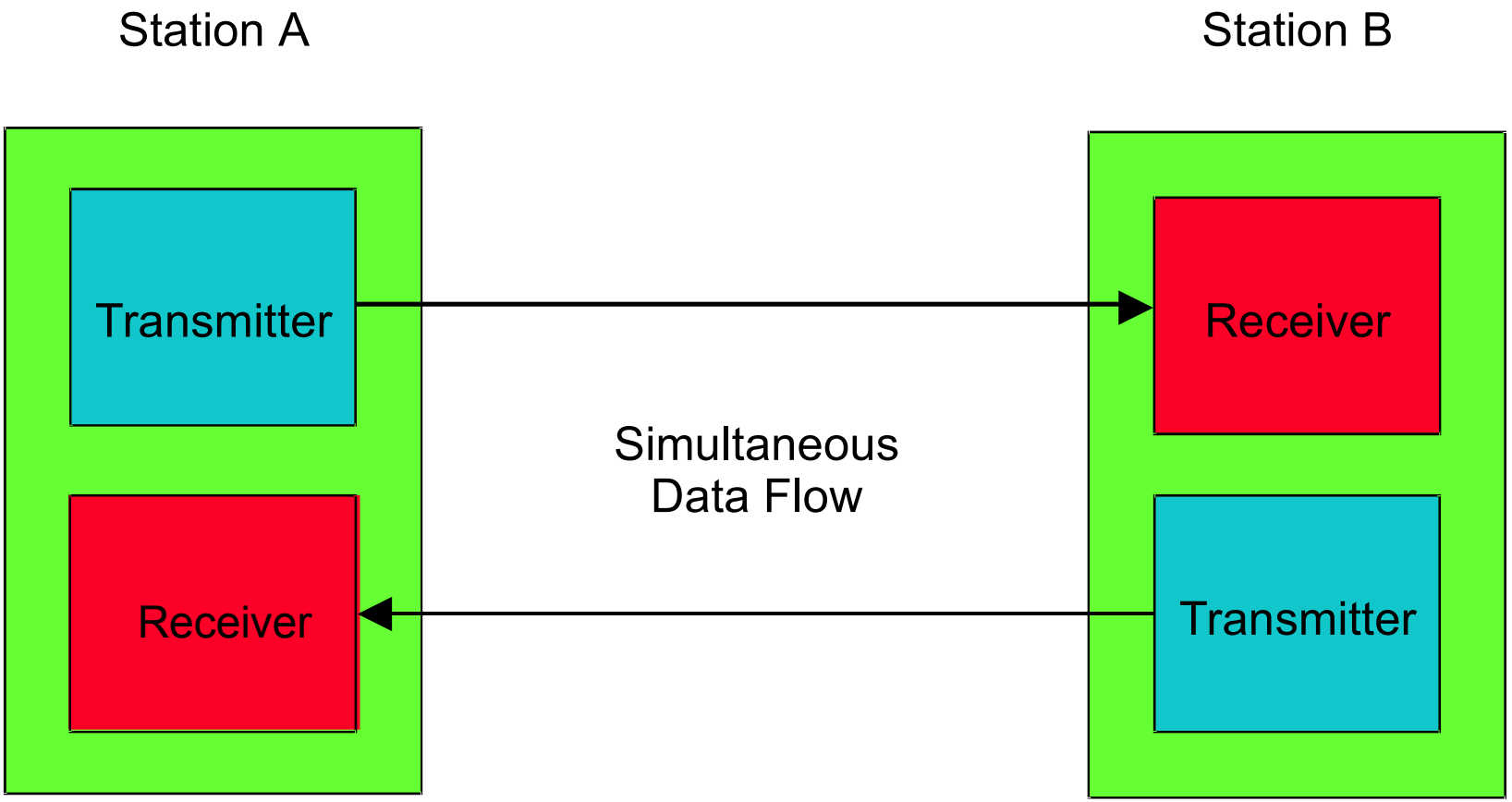
Simplex


Station A
Station B
Transmitter
Data Flow
In One Direction Only
Receiver

Half Duplex (2-Wire)

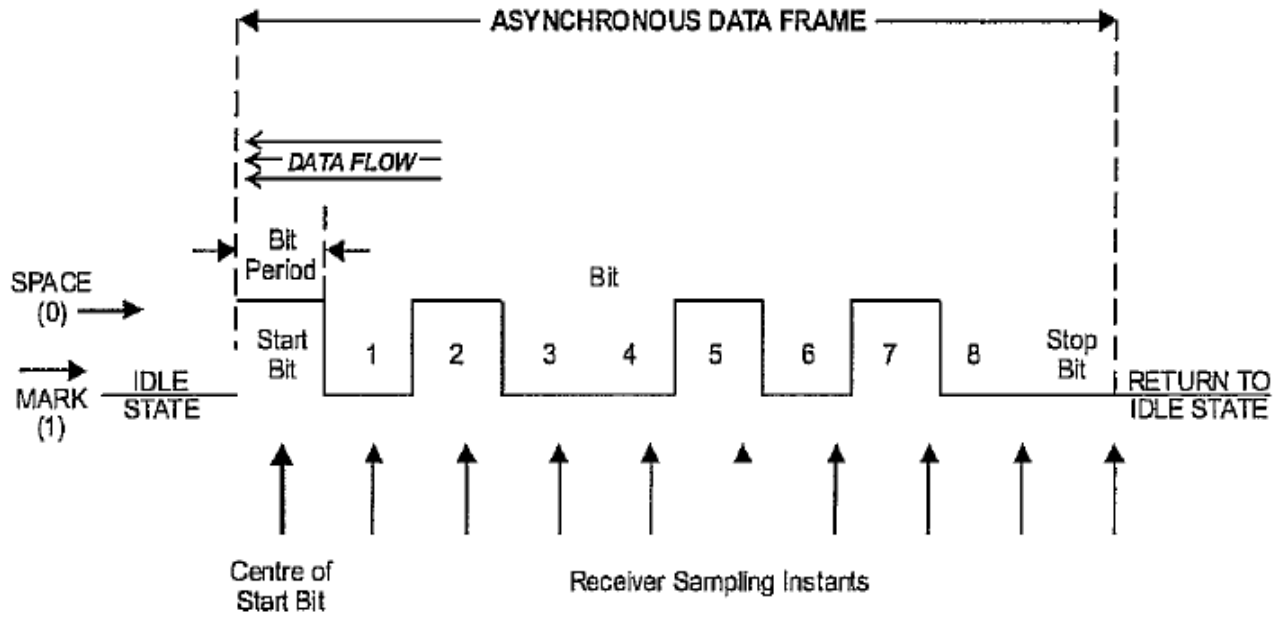


Full Duplex (4-wire)



- Synchronisation of digital data signals
  - » Asynchronous transmission
    - – Rx and TX independent
    - – No clock signal
  - » Synchronous transmission
    - – Rx and TX synchronised to a system clock signal
    - – Higher overhead than Asynch

ASYNCHRONOUS DATA FRAME

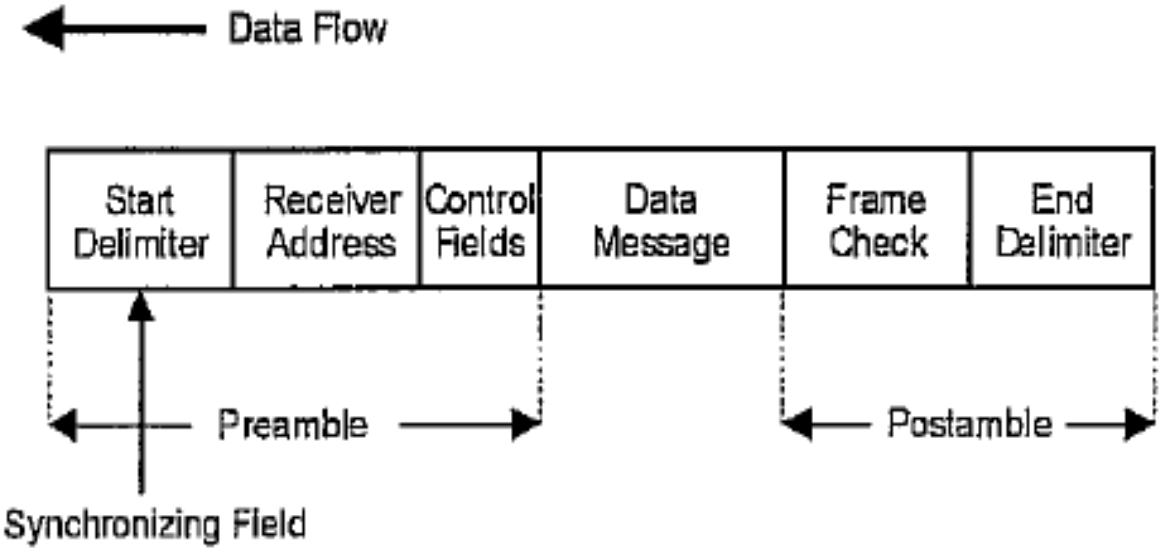


Data Bit	1 2 3 4 5 6 7 8
Received Data	1 0 1 1 0 1 0 1

IDC

SYNCHRONOUS TRANSMISSION

The transmitter and receiver here establish an initial synchronization then continuously transmit data maintaining their synchronization throughout the transmission. This is achieved by special data coding schemes, such as Manchester Encoding, which ensure continuous encoding of the transmitted clock into the transmitted data stream. This



IDC

LIGHT

- Is represented by
  - » Electromagnetic waves
  - » Photons (particles)

- Travels at a speed of 3×10^{8} m/s
- Reflect, refract and diffract off optical surfaces.

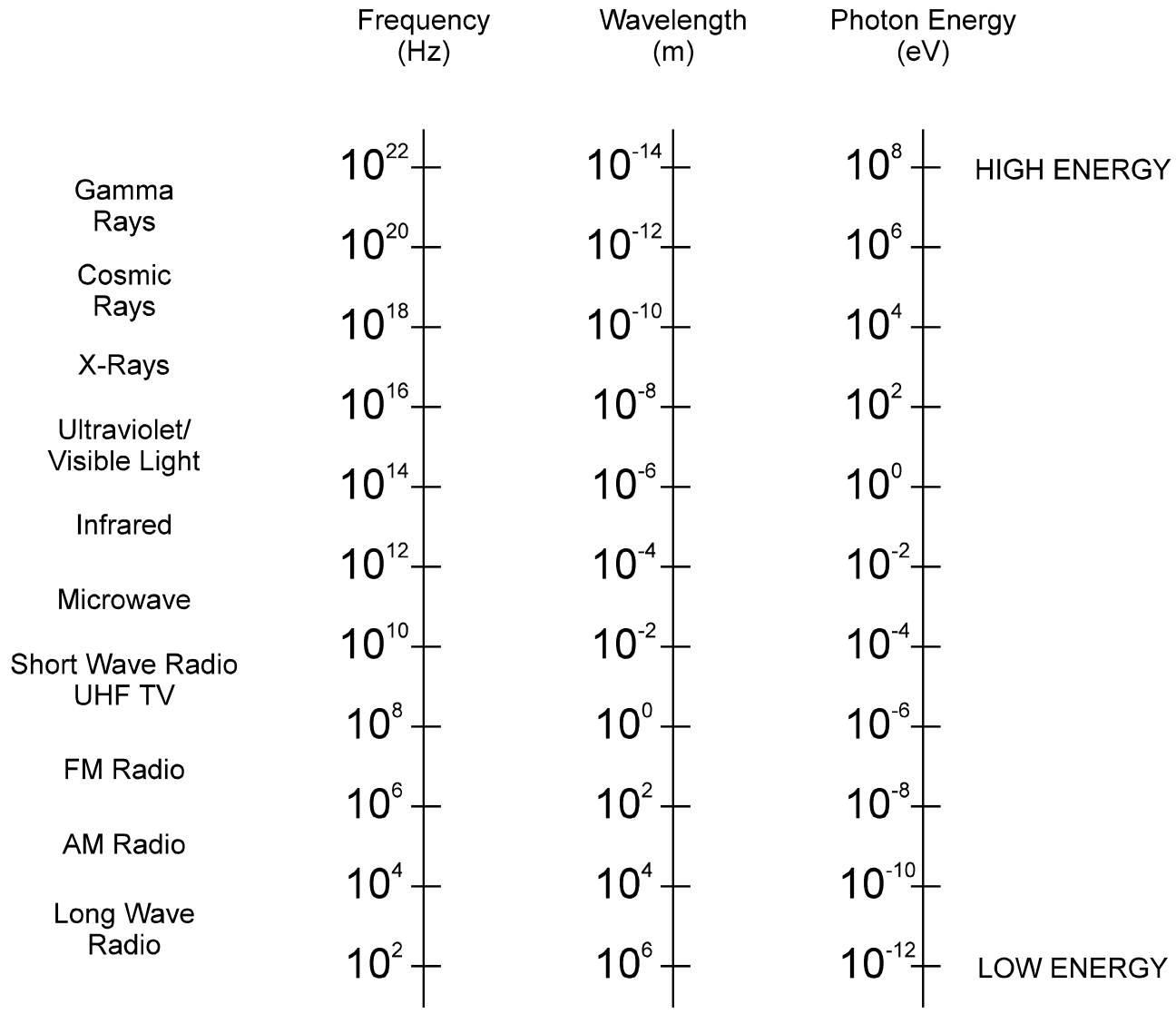
- Electromagnetic spectrum
  - » Represented by frequency and wavelength

$$\text{frequency} = \frac{\text{velocity}}{\text{wavelength}}$$

  - » Represented by photon energy

$$\text{energy (eV)} = \frac{1.2406}{\text{wavelength}(\mu m)}$$

Electromagnetic Spectrum



- Optical region of the spectrum used for fibre optics is:
  - **0.2 micrometers to 20 micrometres**
  - **or 200 nm to 20000 nm**

- Includes
  - Visible light (plastic) (650nm)
  - Infrared (silica) (850nm)
  - Ultraviolet (special silica)