INF3190 - Data Communication

Physical Layer

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Overview

Basics

- Characteristics
- Bit Rate and Baud Rate
- Operating Modes

Analog and Digital Information Encoding and Transmission

- Binary Encoding
- Non-return-to-zero, inverted
- Manchester Encoding
- Differential Manchester Encoding

Multiplexing Techniques

- Frequency Multiplexing
- Time Division Multiplexing
- Multiplexer and Concentrator

Characteristics

ISO DEFINITION: the physical layer provides the following features:

- mechanical,
- electrical,
- functional and
- procedural

to initiate, maintain and terminate physical connections between

- Data Terminal Equipment (DTE) and
- Data Circuit Terminating Equipment (DCE, "postal socket")
- and/or data switching centers

Using **physical connections**, the physical layer ensures

- the transfer of a **transparent bitstream**
- between data link layer-entities

A physical connection permits transfer of a bitstream in the modes

- duplex or
- semi-duplex

Characteristics

MECHANICAL: size of plugs, allocation of pins, etc.

- e. g. ISO 4903:
- data transfer - 15 pin DTE/DCE connection and pin allocation

ELECTRICAL: voltage, etc.

- e. g. CCITT X.27/V.11:
- electrical features for the symmetric data transfer

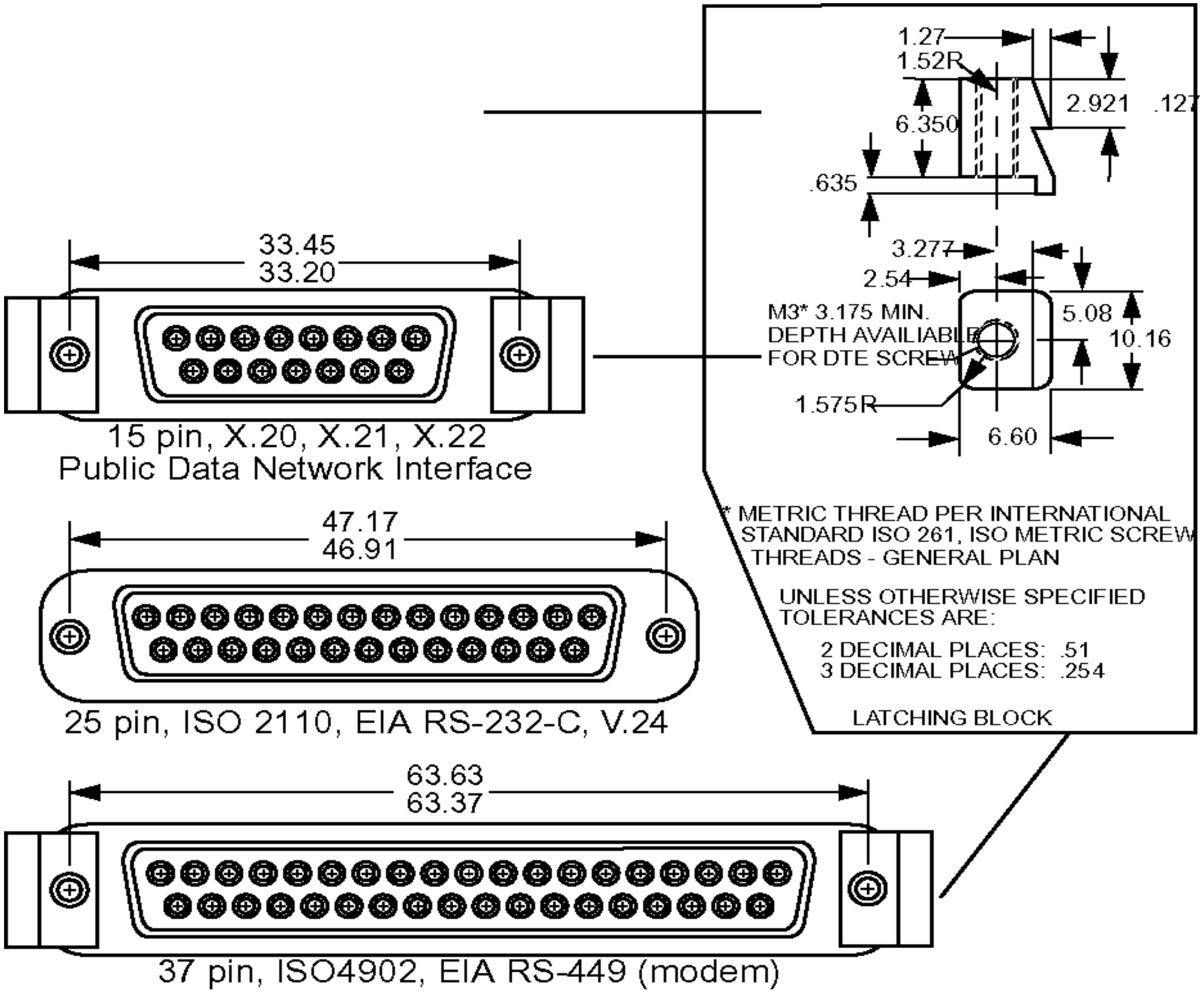
FUNCTIONAL: definition of switching functions; pin allocation (data, control, timing, ground)

- e. g. CCITT X.24:
- list of the switching functions between DTE und DCE in public data networks

PROCEDURAL: rules for using switching functions

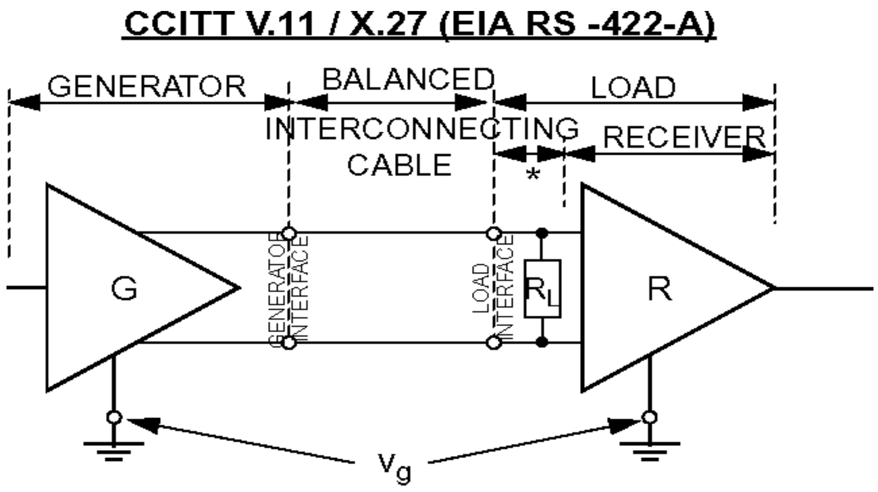
- e. g. CCITT X.21:
- protocol between DTE and DCE for synchronized data transfer in public data networks

Mechanical



33.45
33.20
15 pin, X.20, X.21, X.22
Public Data Network Interface
47.17
46.91
25 pin, ISO 2110, EIA RS-232-C, V.24
63.63
63.37
37 pin, ISO4902, EIA RS-449 (modem)
1.27
1.52R
6.350
2.921
.127
.635
3.277
2.54
M3* 3.175 MIN.
DEPTH AVAILIABLE
FOR DTE SCREW
5.08
10.16
1.575R
6.60
* METRIC THREAD PER INTERNATIONAL
STANDARD ISO 261, ISO METRIC SCREW
THREADS - GENERAL PLAN
UNLESS OTHERWISE SPECIFIED
TOLERANCES ARE:
2 DECIMAL PLACES: .51
3 DECIMAL PLACES: .254
LATCHING BLOCK

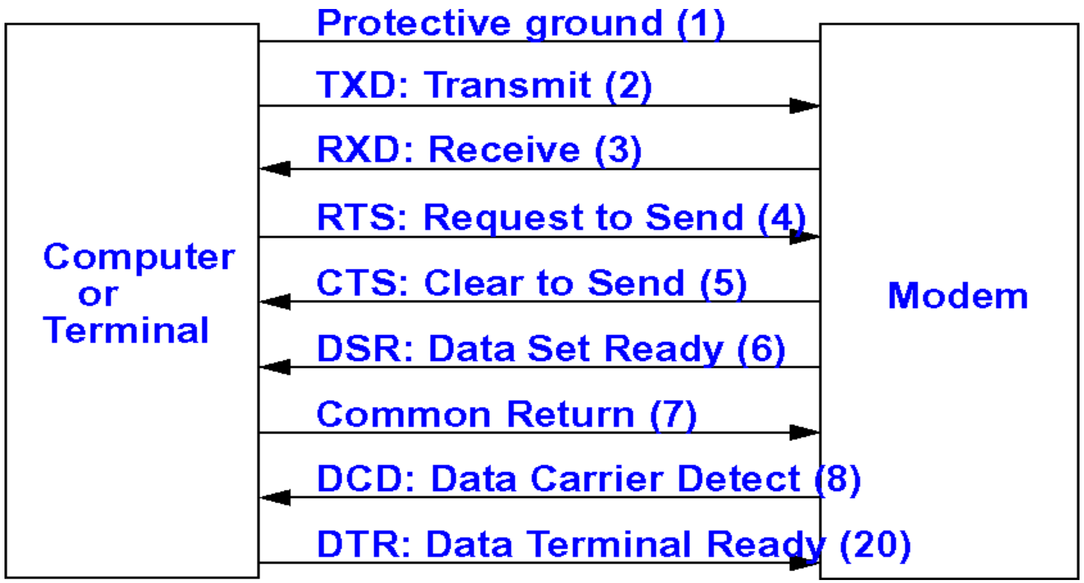
Electrical



e. g. .. "

- designed for IC Technology
- balanced generator
- differential receiver
- two conductors per circuit
- signal rate up to 10 Mbps
- distance: 1000m (at appr. 100 Kbps) to10m (at 10Mbps)
- considerably reduced crosstalk
- interoperable with V.10 / X.26 ..."

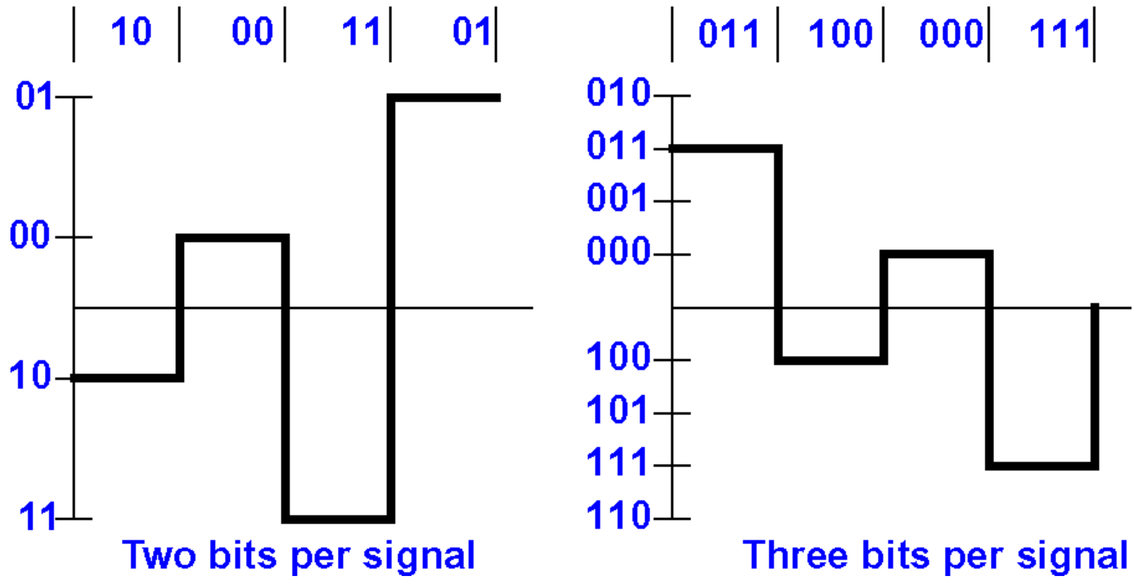
Functional, Procedural



Example RS-232-C, functional specification describes

- connection between pins
  - e.g. "zero modem" computer-computer-connection (Transmit(2) - Receive(3))
- meaning of the signals on the lines
  - DTR=1, when the computer is active, DSR=1, modem is active, ...
  - Action/reaction pairs specify the permitted sequence per event
  - e. g. when the computer sends an RTS, the modem responds with a CTS when it is ready to receive data

Bit Rate and Baud Rate



BAUD RATE

measure of number of symbols (characters) transmitted per unit of time

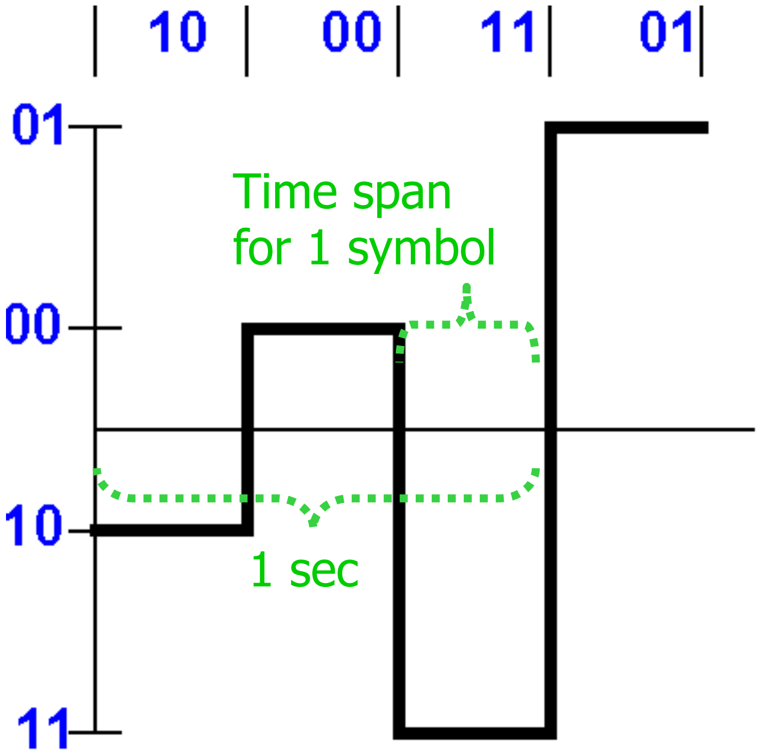
- signal speed, number of signal changes per second
  - changes in amplitude, frequency, phase
- each symbol normally consist of a number of bits
  - so the baud rate will only be the same as the bit rate when there is one bit per symbol

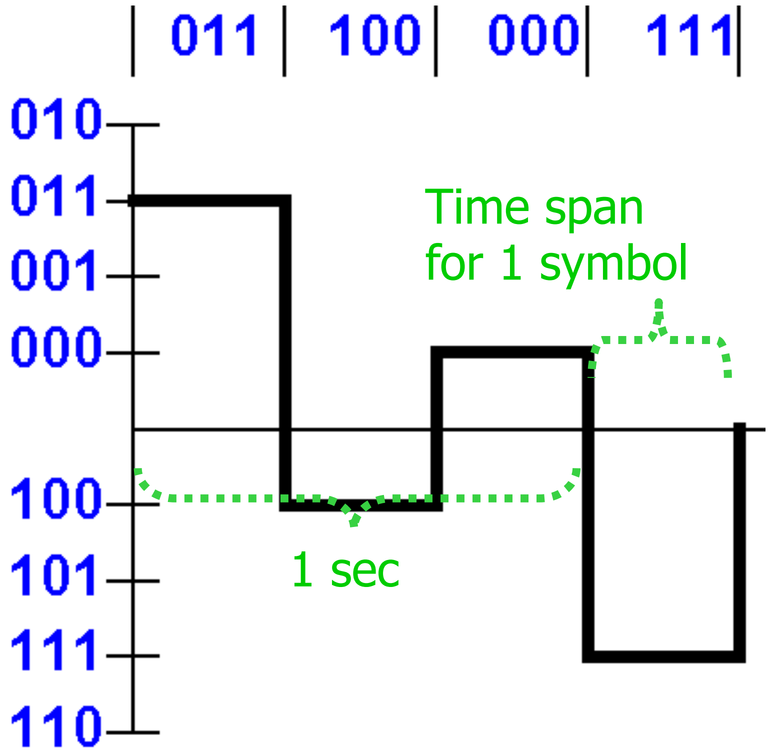
BIT RATE

number of bits transferred per second (bps)

- bit rate may be higher than baud rate ("signal speed")
  - because one signal value may transfer several bits
  - e.g. above same baud rate, different bit rate (if x axis have same dimension)

Bit Rate and Baud Rate: Example





We encounter

- 4 possible values per symbol
- i.e each value encoded with 2 bits (per symbol)
- 3 symbols per sec.

Baud Rate: (symbols per time span) 3 Bd

Bit Rate: 3 Bd * 2 bit/symbol = 6 bit per sec

We encounter

- 8 possible values per symbol
- i.e. each value encoded with 3 bits (per symbol)
- 3 symbols per sec.

Baud Rate: 3 Bd

Bit Rate: 9 bit per sec

Operating Modes

Transfer directions (temporal parallelism)

- simplex communication
  - data is always transferred into one direction only
- (half-duplex) semi-duplex communication
  - data is transferred into both directions
  - but never simultaneously
- full-duplex communication
  - data may flow simultaneously in both directions

Serial and parallel transmission

- parallel
  - signals are transmitted simultaneously over several channels
- serial
  - signals are transmitted sequentially over one channel

Operating Modes: Synchronous Transmission

Definition

- the point in time at which the bit exchange occurs
  is pre-defined by a regular clock pulse (requires synchronization)
- whereby the clock pulse lasts as long as the transmission of a series of multiple characters takes

Implementation

- receiving clock pulse
  - on a separate line (e.g. X.21) or
  - gained from the signal
- bit synchronous or frame synchronous
  (frames in fact on data link level)
  - special characters

    e. g.

    ```
    SOH   Start of Header
    STX   Start of Text
    ETX   End of Text
    ```

Operating Modes: Asynchronous Transmission

Definition

- clock pulse fixed for the duration of a signal
- termination marked by
  - Stop signal (bit) or
  - number of bits per signal

Implementation

- simple
  - sender and receiver generate the clock pulse independently from each other
- frame size usually approx. 9 bit
  (of this approx. 70% reference data)

Example:

```
7 Bit ASCII reference data
1 Parity Bit (odd, even, or unused)
1 Start-Bit
1 Stop-Bit
```

- example: RS-232-C
  - UART (universal asynchronous receiver and transmitter) IC module
  - often between
    - computer and printer or
    - computer and modem

Analog and Digital Information Encoding and Transmission

Variants and examples

		Transmission: analog	Transmission: digital
Information Coding	analog (voice, music)	"old" telephone system (POTS) ➔ AM, FM	ISDN (voice service) Internet Audio ➔ PCM, DM, …
	digital (texts, images)	modem (modulator demodulator) at analog telephone connection Radio Data System RDS ➔PAM, PPM, PFM, … and V.21, V.22 bis, …, V.32 bis, V. 34.	traditional computer networks and applications ISDN (data service) ➔ Manchester Encoding, …

Digital Information – Digital Transmission

Digital information at end system

- usually TTL-Logic ("1" : 3V, "0" : 0V)

Digital transmission

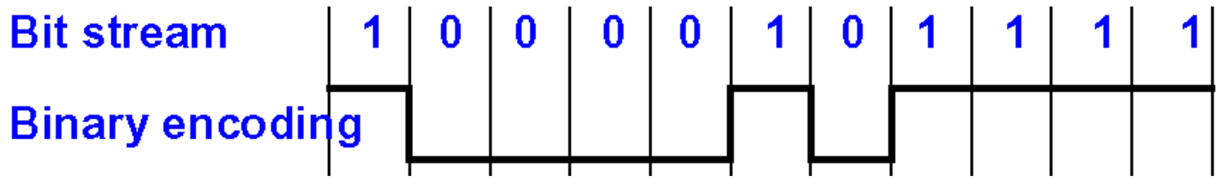
- sender/receiver synchronization
- signal levels around 0V (lower power)

→ Conversion

Coding techniques

- binary encoding, non-return to zero-level (NRZ-L)
  - 1: high level
  - 0: low level
- return to zero (RZ)
  - 1: clock pulse (double frequency) during interval
  - 0: low level
- Non-return-to-zero, inverted
- Manchester Encoding
- Differential Manchester Encoding
- ...

Binary Encoding



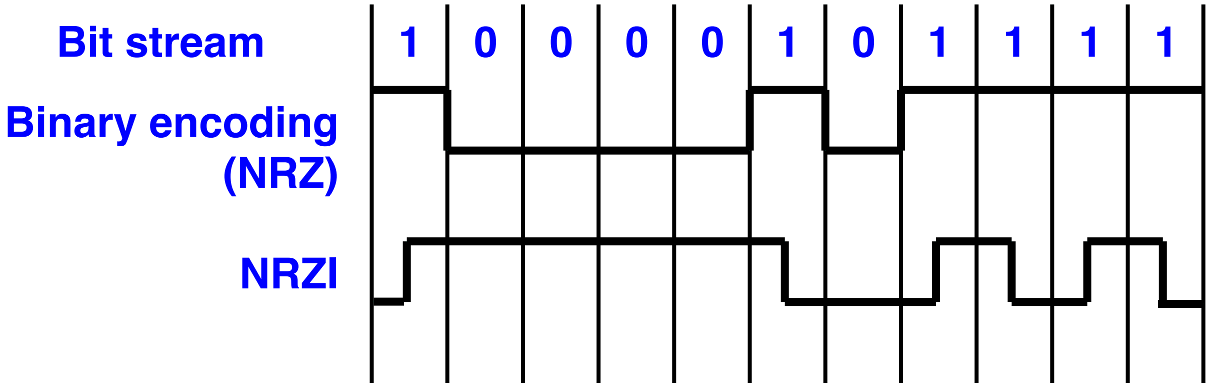
Binary encoding (NRZ, Non-return-to-zero):

- "1": voltage on high
- "0": voltage on low

i.e.

+ simple, cheap
+ good utilization of the bandwidth (1 bit per Baud)
- no "self-clocking" feature

Non-return-to-zero, inverted



Non-return-to-zero, inverted:

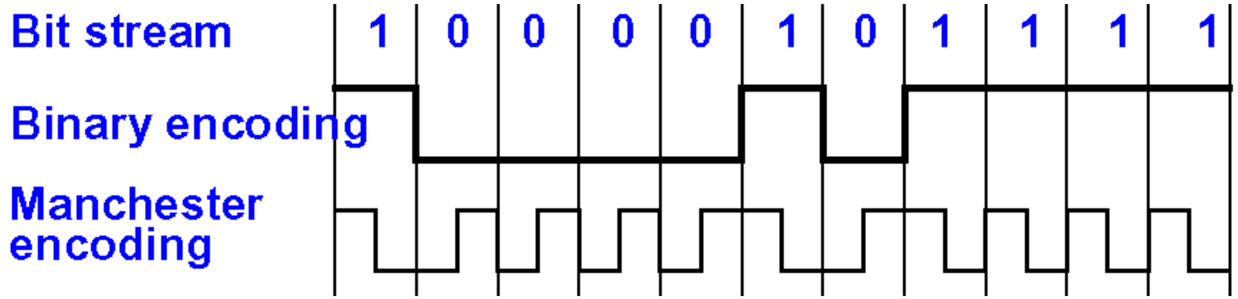
- "1": change in the level
- "0": no change in the level

USB uses opposite convention

- change on 0, no change on 1

\+ simple
\+ 1 bit per Baud
– no "self-clocking"
– clock must be ensured by bit stuffing

Manchester Encoding



Bit interval is divided into two partial intervals: I1, I2

- "1”:
  I1: high, I2: low 

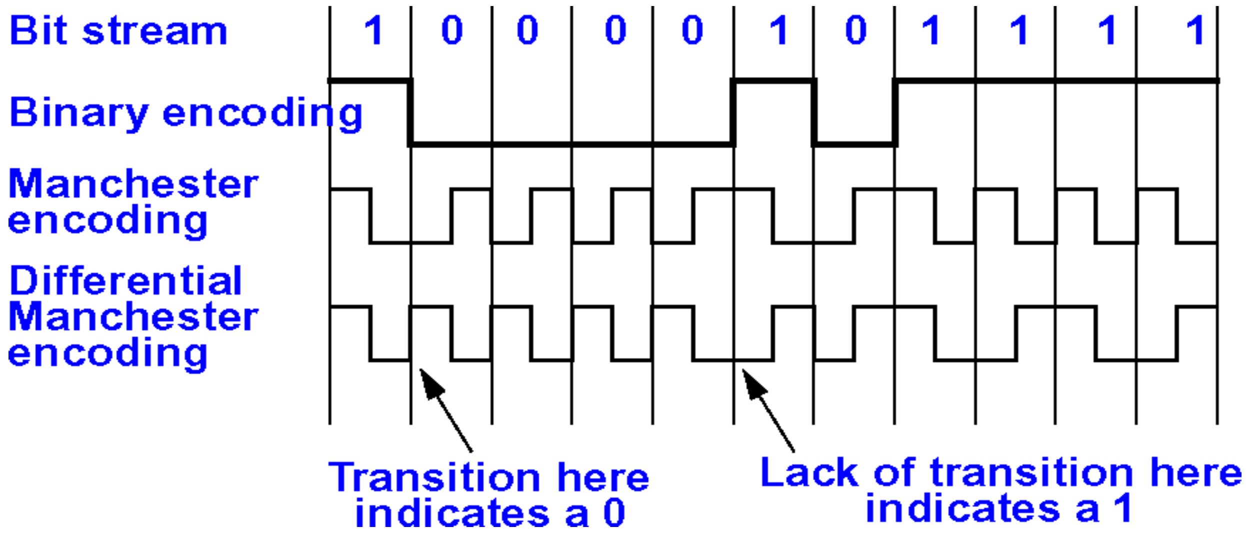
- "0”:
  I1: low, I2: high 

+ good "self-clocking" feature

– 0,5 bit per Baud

Application: 802.3 (CSMA/CD)

Differential Manchester Encoding



Differential Manchester Encoding:

- bit interval divided into two partial intervals:
  - "1": no change in the level at the beginning of the interval
  - "0": change in the level

\+ good "self-clocking" feature

\+ low susceptibility to noise because only the signal's polarity is recorded. Absolute values are irrelevant.

– 0,5 bit per Baud

– complex

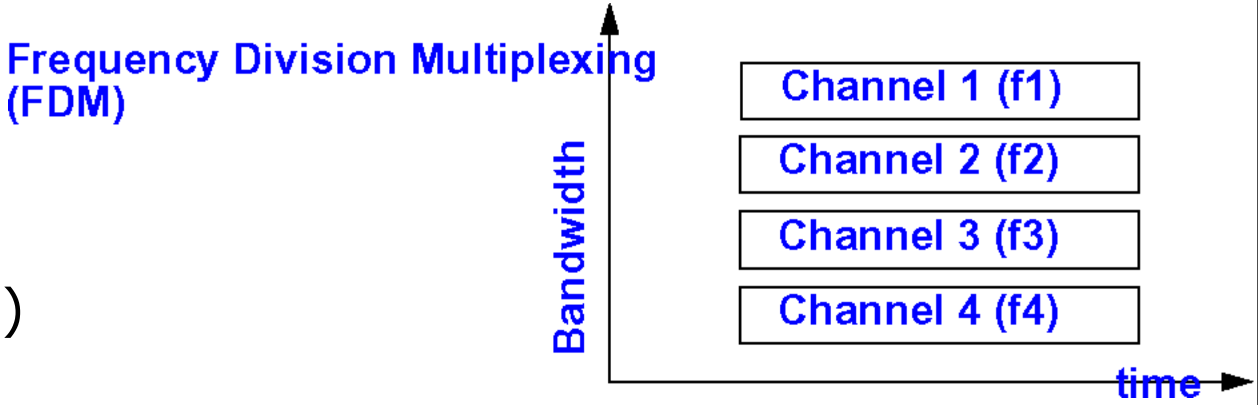
Multiplexing Techniques

Cost for implementing and maintaining either a narrowband or a wideband cable are almost the same

Multiplexing many conversations onto one channel

Two types

- FDM
  (Frequency Division Multiplexing)



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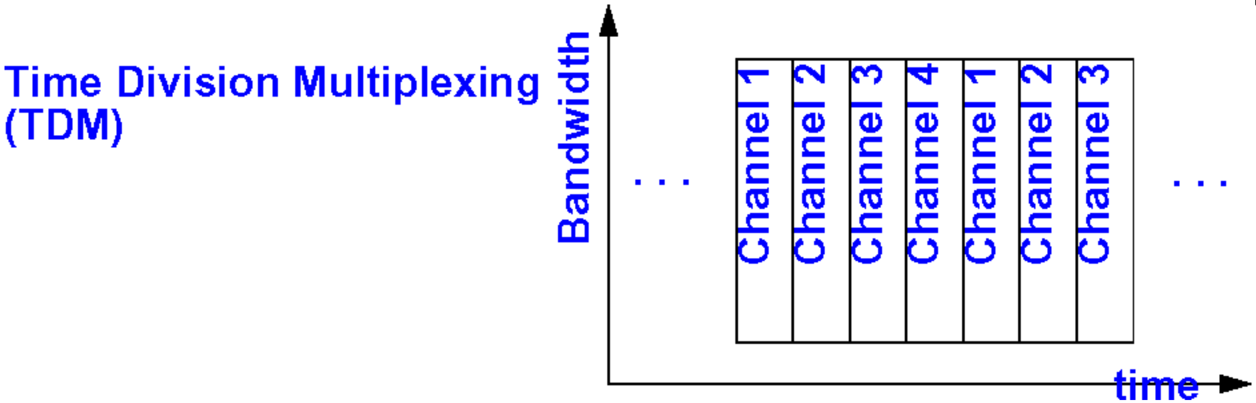
- TDM
  (Time Division Multiplexing)



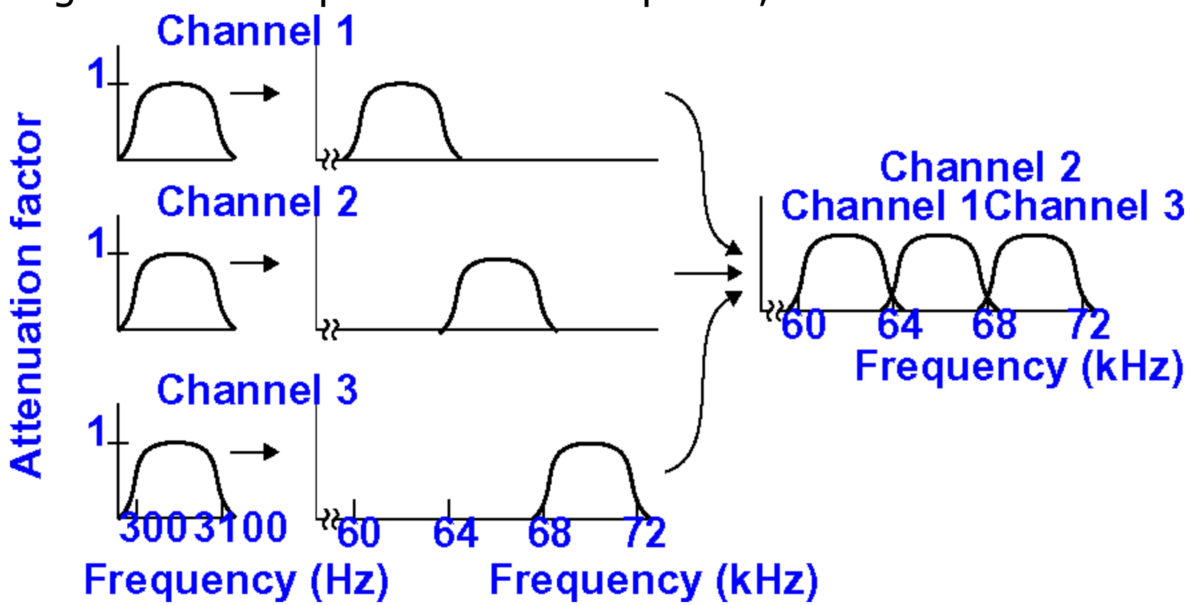
Frequency Multiplexing

Principle

- frequency band is split between the users
- each user is allocated one frequency band

Application

- example: multiplexing of voice telephone channels: phone, cable-tv



- filters limit voice channel to 3 000 Hz bandwidth
- each voice channel receives 4 000 Hz bandwidth
  - 3 000 Hz voice channel
  - 2 x 500 Hz gap (guard band)

Time Division Multiplexing

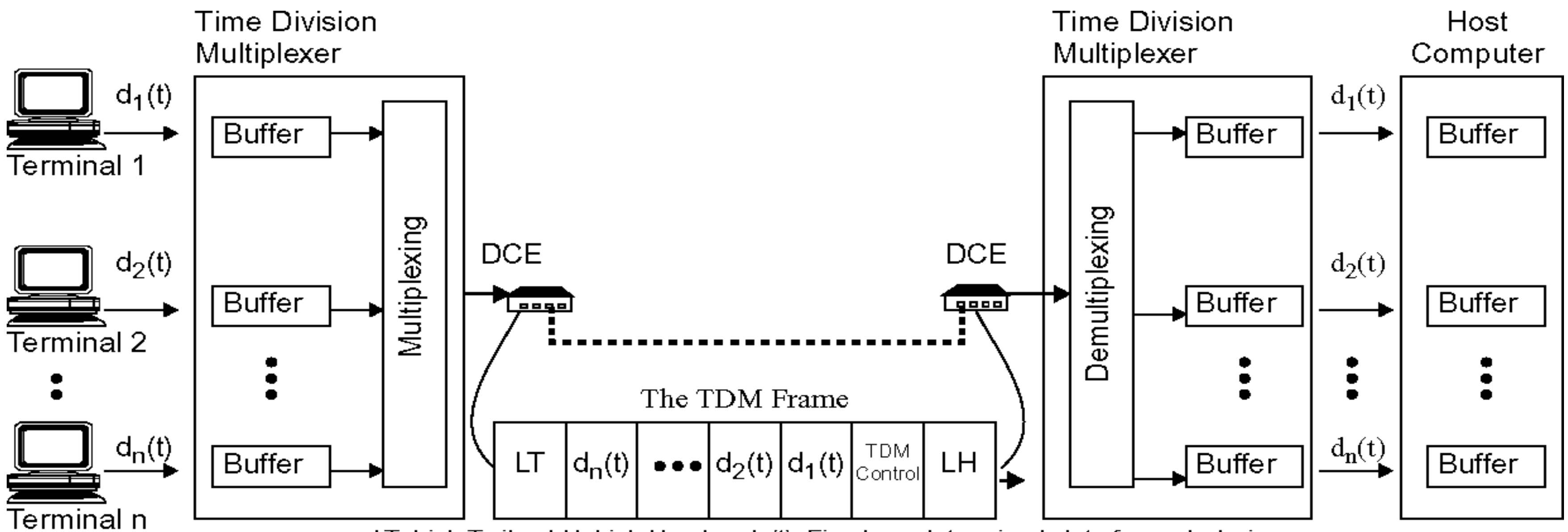
Principle

- user receives a time slot
- during this time slot he has the full bandwidth

$$\sum_{i=1}^{n} d_i(t) = d_0(t)$$

Application

- multiplexing of end systems, but also
- in transmission systems



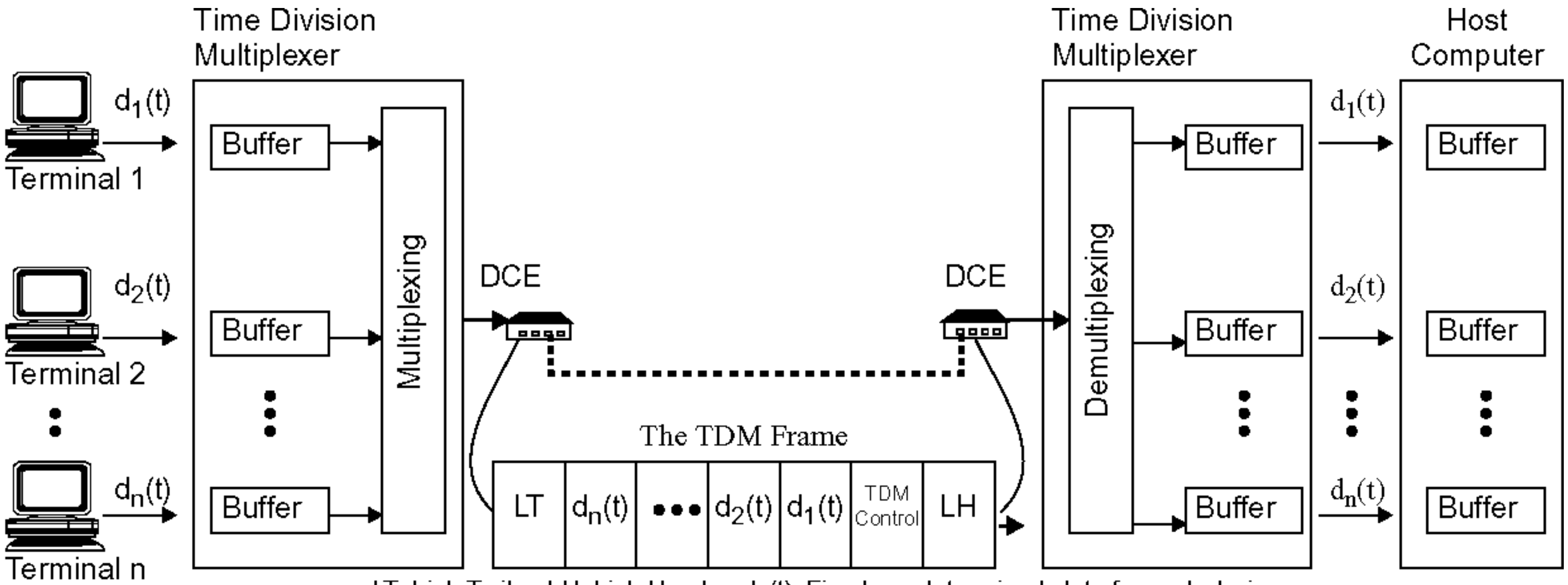
LT: Link Trailer, LH: Link Header, $d_n(t)$: Fixed, predetermined slots for each device,
TDM Control: Identification of specific TDM controls (may not exist on some TDMs)

Multiplexer and Concentrator

MULTIPLEXER

- INPUT from various links in predefined order
- OUTPUT at one single link in the same order

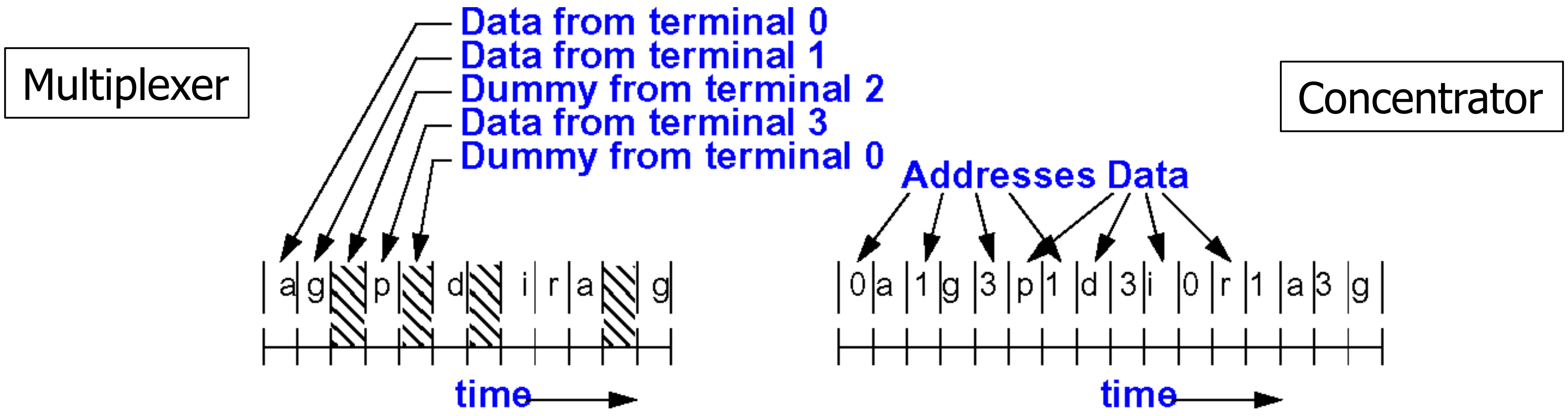
$$\sum_{i=1}^{n} c_i^{IN} = c^{OUT}$$



LT: Link Trailer, LH: Link Header, $d_n(t)$: Fixed, predetermined slots for each device,
TDM Control: Identification of specific TDM controls (may not exist on some TDMs)

Disadvantage: waste of time slots if station is not sending

Multiplexer and Concentrator



Concentrator

- INPUT from several links
- OUTPUT at one single link
- no fixed slot allocation,
  instead sending of (station addresses, data)

$$\sum_{i=1}^{n} C_i^{IN} > C^{OUT}$$

PROBLEM: All stations use maximum speed for sending

- "Solution": internal buffers

Recap

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