POLITEKNIK MALAYSIA KUALA TERENGGANU

KEMENTERIAN PENGAJIAN TINGGI

KOLEJ KOMUNITI MALAYSIA

DATA COMMUNICATION AND NETWORKING

ZUBAIDAH ABDUL RAHMAN

KEJURUTERAAN ELEKTRIK

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Diterbitkan oleh:
Politeknik Kuala Terengganu
20200 Jalan Sultan Ismail
Kuala Terengganu, Terengganu.
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BASIC CONCEPT OF DATA COMMUNICATION

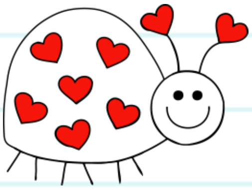
CHAPTER 1

PREFACE

DATA COMMUNICATION AND NETWORKING exposes the student to the principle of data communication and networking. This course covers basic concept of data communication and networking fundamental for a quality data transmission. Students are expose to Open Systems Interconnection (OSI) Model and Network Protocol. Students are also introduced to Local Area Network and public digital network.

ACKNOWLEDGEMENTS

Thanks to my family and colleague.



COURSE LEARNING OUTCOME

CLO1 : Evaluate the performance of data and computer networks while implementing the knowledge, concepts, technology and terms related to data communication and networking. (C5 , PLO 2)

CLO2 : Construct a simple LAN and WLAN in accordance to IEEE or TIA/EIA-568-A/B and the related data communication and networking equipment systematically in performing data transmission. (P4 , PLO 5)

CLO3 : Demonstrate awareness of data communication and networking standard during practical work sessions. (A3 , PLO 8)

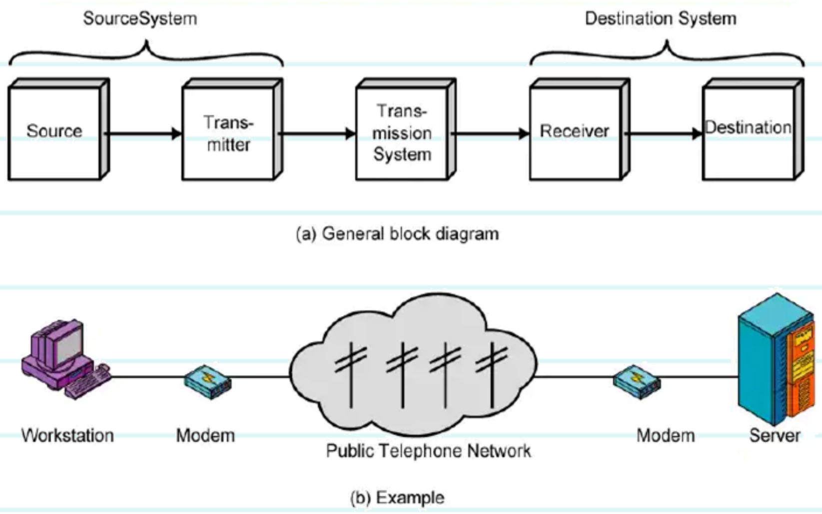
TABLE OF CONTENT

Basic Data Communication System

Definition of Data Communication

Defined as the transmission of digital information between two devices using electronic transmission systems.

Data will be represented either in the form of electrical signals, electromagnetic waves or light.



Data Communication Block Diagram

Source
- Voice
- Text
- Video
- Picture

Transmission Medium
- Cable
- Fiber Optic
- Free Space

Destination
- Computer
- Telephone

The source is the device that sends the data message.

The transmission medium is the physical path by which a message travels form sender to receiver.

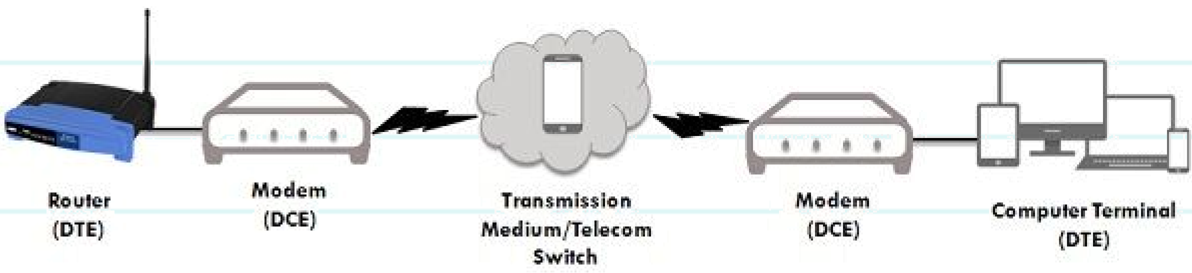
The receiver is the device that receives the massage.

SCAN ME

DTE-Data Terminal Equipment

DTE refers to the interface equipment used at the station (between the host and modem) to adapt the digital signals from the computer and terminals to a suitable form for transmission.

Examples for **DTE**: computer, visual monitor, logic controller unit and store buffer.

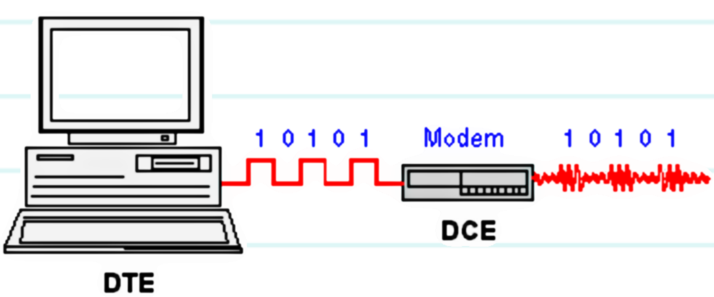


DTE and DCE in transmission system

DCE - Data Circuit Equipment

DCE means the equipment that converts digital signals to the analog signals and interfaces the data terminal equipment to the analog transmission medium.

DCE is a modem (modulator / demodulator). It converts binary digital signals to analog signals such as FSK, PSK, and QAM, and vice versa.



SCAN ME

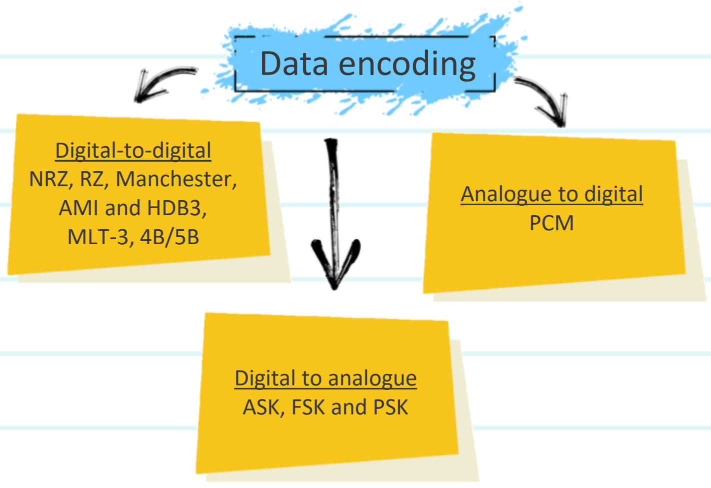
Data encoding

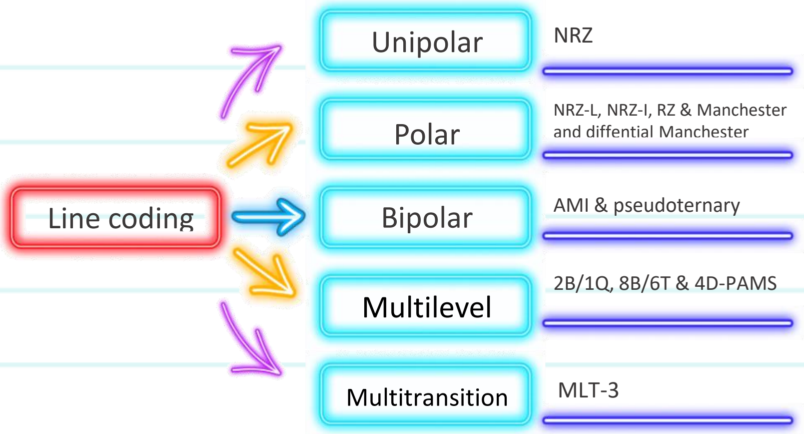
Encoding is the process of converting data into a format including:

- Program compiling and execution
- Data transmission, storage and compression/decompression
- Application data processing, such as file conversion

Encoding used to reduce the size of audio and video files.

Encoding is not encryption, which hides content



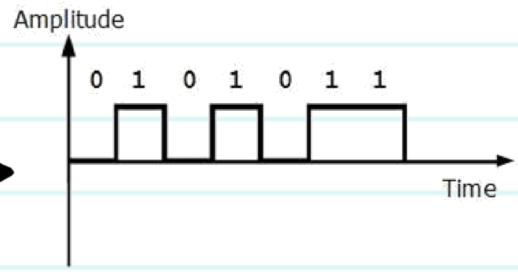


Digital-to-Digital Encoding

Unipolar NRZ

Non-Return-to-Zero (NRZ) encoding

Unipolar NRZ - the signal does not return to zero at the middle of the bit. Figure shows a unipolar NRZ scheme.



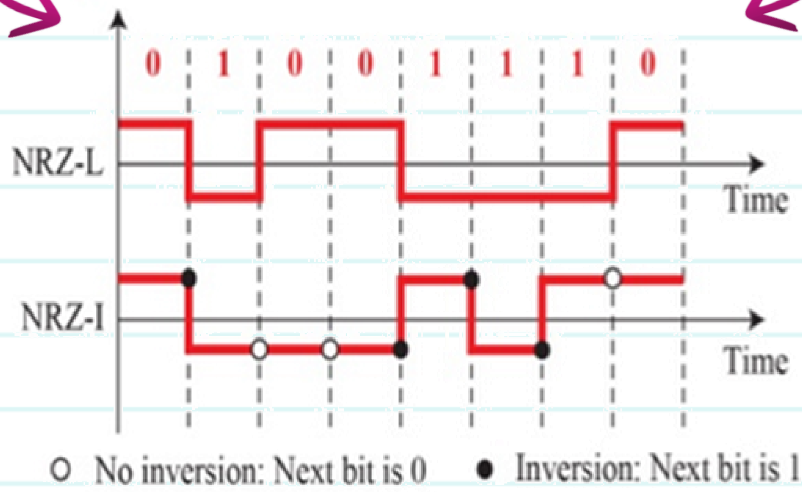
Polar NRZ

NRZ-L (NRZ-Level), the level of the voltage determines the value of the bit.

> 1 ⇔ negative voltage (low level)
>
> 0 ⇔ positive voltage (high level)

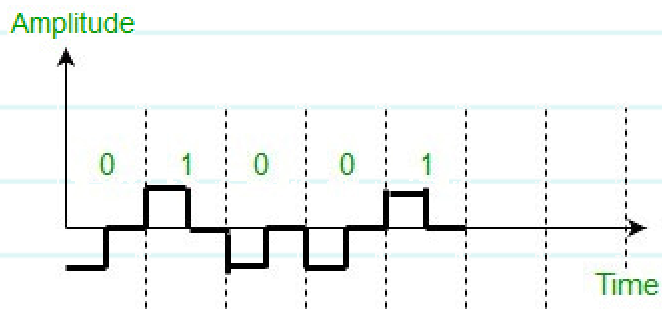
NRZ-I (NRZ-Invert), if there is no change, the bit is 0; if there is a change, the bit is 1.

> 1 ⇔ existence of a ***signal transition*** at the beginning of the bit time
>
> 0 ⇔ **no *signal transition*** at the beginning of the bit time



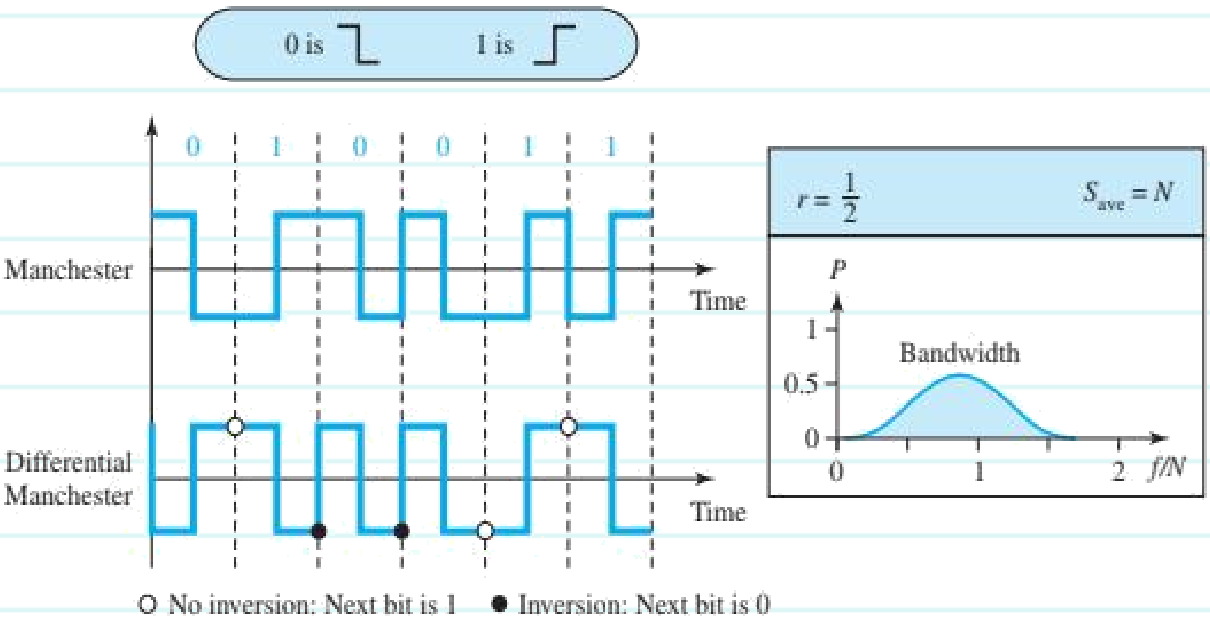
Return-to-Zero (RZ) encoding

The signal state is determined by the voltage during the first half of each data binary digit . The signal returns to a resting state (called zero) during the second half of each bit. The resting state is usually zero volts, although it does not have to be.



Manchester Encoding

There is **always** a mid-bit transition {which is used as a clocking mechanism}.
The **direction** of the mid-bit transition represents the digital data.

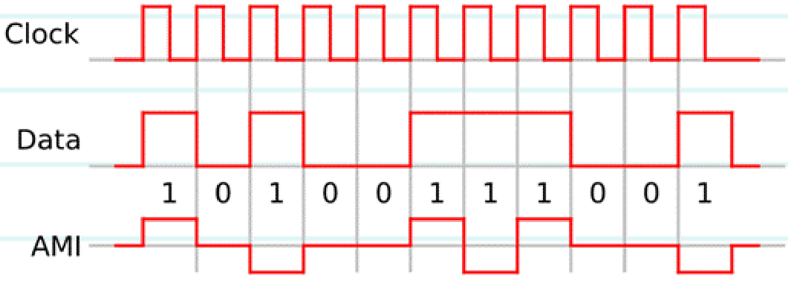


1 ⇔ **low-to-high** transition
0 ⇔ **high-to-low** transition

Used in 802.3 baseband coaxial cable and CSMA/CD twisted pair.

Alternate Mark Inversion (AMI)

AMI scheme, a binary 0 is represented by no line signal.
A binary 1 is represented by a positive or negative pulse.
The binary 1pulses must alternate in polarity.

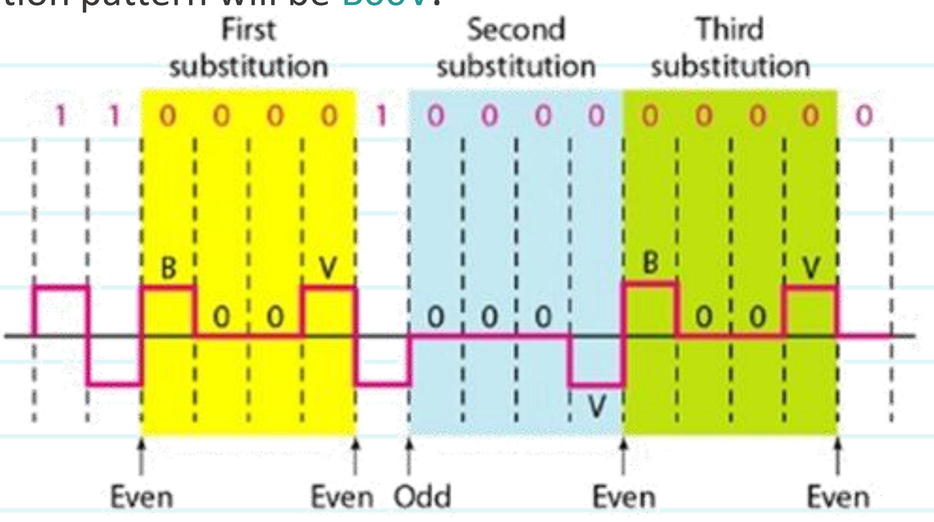


With this line encoding it is the alternating voltages that determine the binary 1s

High Density Bipolar 3-zero (HDB3)

Based on AMI code, but extends this by inserting violation codes whenever there is a run of 4 or more 0's
Four consecutive zero-level voltages are replaced with a sequence of 000V or B00V.
The reason for two different substitutions is to maintain the even number of nonzero pulses after each substitution.

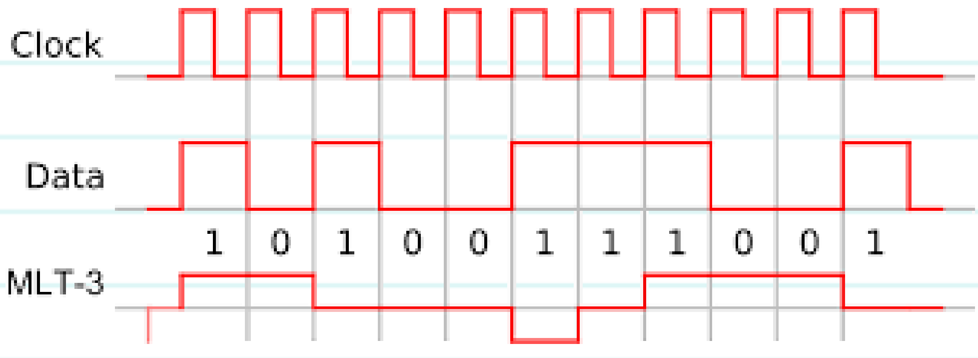
The two rules can be stated as follows:
If the number of bit '1' before the four consecutive '0' is **odd**, the substitution pattern will be 000V.
If the number of bit '1' before the four consecutive '0' is **even**, the substitution pattern will be B00V.



Multiline Transmission-3 Level (MLT-3)

MLT-3 encoding (Multi-Level Transmit) is a line code (a signalling method used in a telecommunication system for transmission purposes) that uses three voltage levels (+V, 0, -V) and three transmission rules to move between the levels.

- If the next bit is 0, there is no transition.
- If the next bit is 1 and the current level is not 0, the next level is 0.
- If the next bit is 1 and the current level is 0, the next level is the opposite of the last nonzero level.



Block Coding : 4B/5B

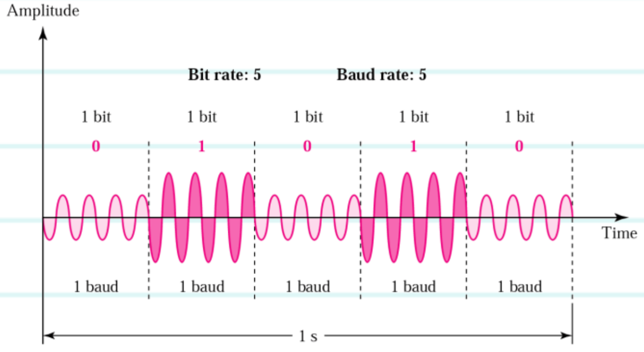
4B5B maps groups of 4 bits onto groups of 5 bits, with a minimum density of 1 bits in the output.

4B binary data	5B code symbol
0000	11110
0001	01001
0010	10100
0011	10101
0100	01010
0101	01011
0110	01110
0111	01111
1000	10010
1001	10011
1010	10100
1011	10110
1100	11010
1101	11011
1110	11100
1111	11101

Digital-to-analogue modulation

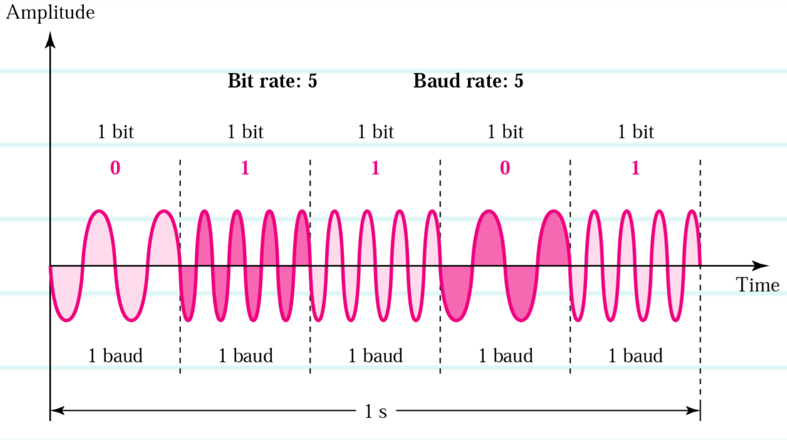
Amplitude Shift Keying (ASK)

- The strength of the carrier signal is varied to represent binary 1 and 0.
- Frequency and phase remains the same.
- Highly susceptible to noise interference.
- Used up to 1200 bps on voice grade lines, and on optical fiber.



Frequency Shift Keying (FSK)

- Frequency of the carrier is varied to represent digital data (binary 0/1)
- Peak amplitude and phase remain constant.
- Avoid noise interference by looking at frequencies (change of a signal) and ignoring amplitudes.
- Limitations of FSK is the physical capabilities of the carrier.
- f1 and f2 equally offset by equal opposite amounts to the carrier freq.
- In MFSK more than 2 freq are used, each signal element represents more than one bit



Digital-to-analogue modulation

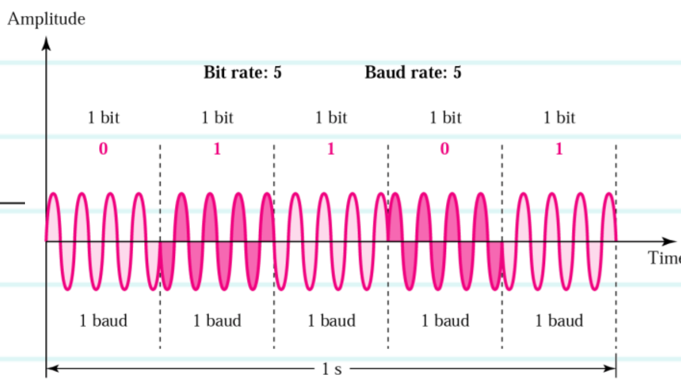
Phase Shift Keying (PSK)

- Phase of the carrier is varied to represent digital data (binary 0 or 1)
- Amplitude and frequency remains constant.
- If phase 0 deg to represent 0, 180 deg to represent 1. (2-PSK)
- PSK is not susceptible to noise degradation that affects ASK or bandwidth limitations of FSK

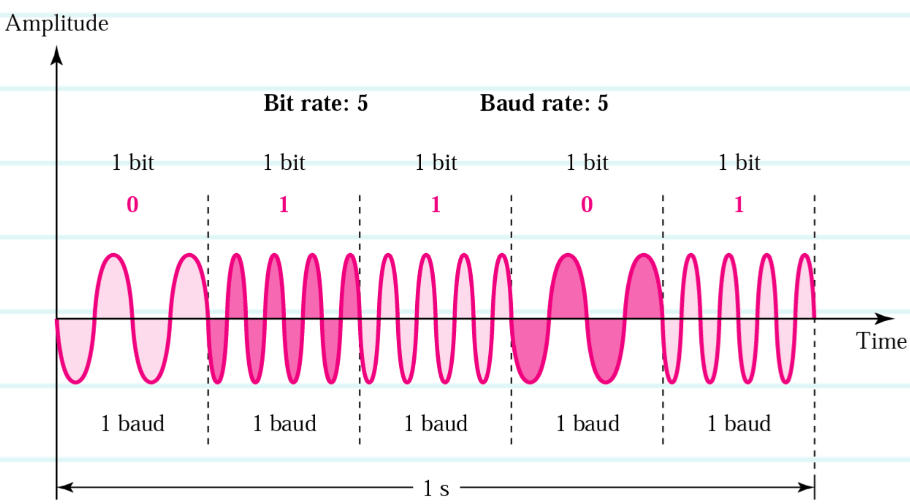
Bit	Phase
0	0
1	180

Bits

Constellation diagram



QPSK – Quadrature Phase Shift Keying



M-ary Encoding

- *M-ary* is a term derived from the word *binary.*

- *M* simply represents a digit that corresponds to the number of conditions, levels, or combinations possible for a given number of binary variables.

- For example, a digital signal with four possible conditions

- (voltage levels, frequencies, phases, and so on) is an M-ary system where M = 4. If there are eight possible conditions, M = 8 and so forth.

- The number of bits necessary to produce a given number of conditions is expressed mathematically as

$$N = \log_2 M$$

where *N* = number of bits necessary

M = number of conditions, levels, or combinations possible with *N* bits

Equation can be simplified and rearranged to express the number of conditions possible with *N* bits as

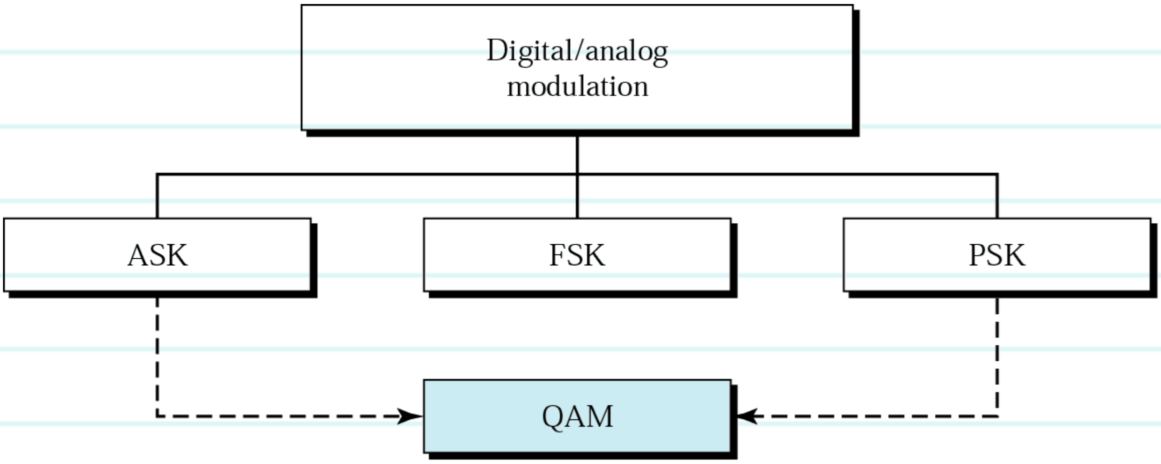
$$2^N = M$$

For example, with one bit, only $2^1 = 2$ conditions are possible. With two bits, 22 = 4 conditions are possible, with three bits, $2^3 = 8$ conditions are possible, and so on.

Advantages Of M-ary Encoding

- Bandwidth efficiency increases with M
- Send more information at a time
- More information is packed into a symbol so data rates can be increased
- Generally, higher data rates require more power (shorter distances, better SNR) to get good results

QAM – Quadrature Amplitude Modulation



Quadrature amplitude modulation is a combination of ASK and PSK so that a maximum contrast between each signal unit (bit, dibit, tribit, and so on) is achieved.

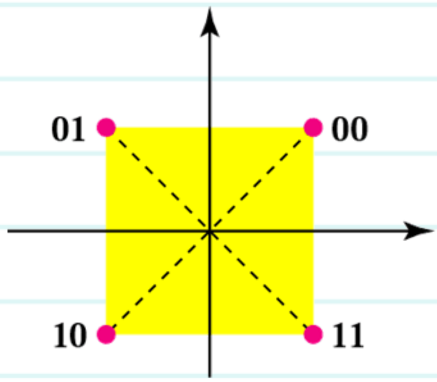
PSK is limited by the ability of the equipment to distinguish between small differences in phases.

Limits the potential data rate.

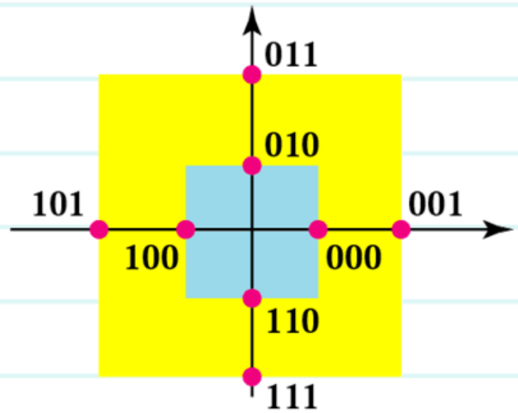
Quadrature amplitude modulation is a combination of ASK and PSK so that a maximum contrast between each signal unit (bit, dibit, tribit, and so on) is achieved.

We can have x variations in phase and y variations of amplitude

x • y possible variation (greater data rates)



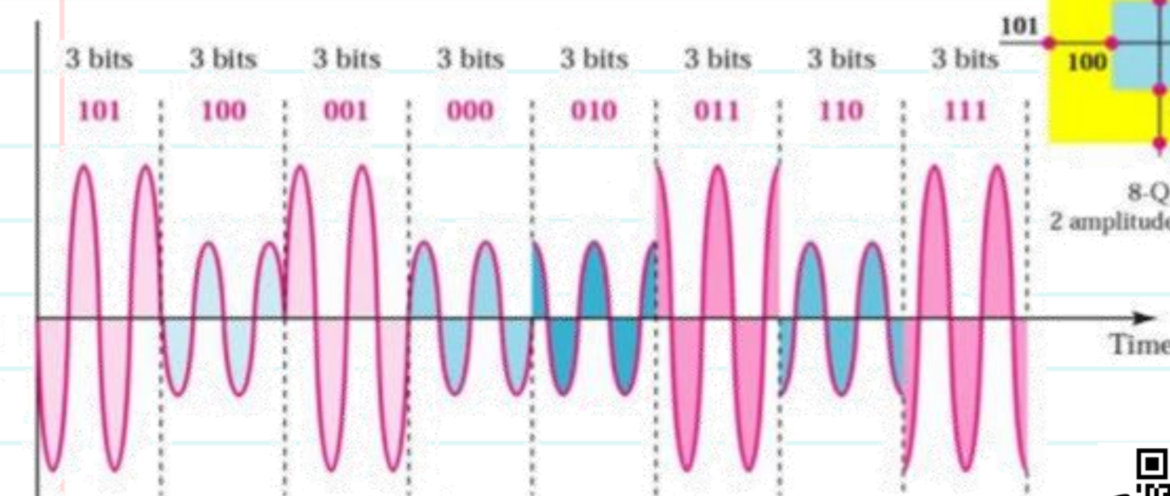
4-QAM
1 amplitude, 4 phases

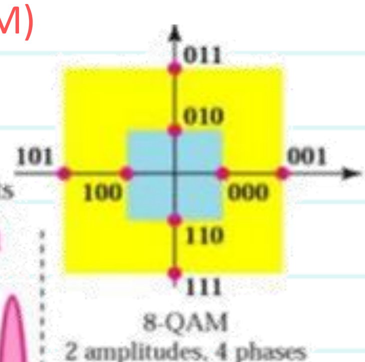


8-QAM
2 amplitudes, 4 phases

Numerous variations (4-QAM, 8-QAM)

8-QAM : 2 Amplitudes, 4 Phases





Error detection in data transmission

- Networks must be able to transfer data from one device to another with acceptable accuracy

- A system must guarantee that the data received are identical to the data transmitted.

- Data can be corrupted during transmission. Some applications require that errors be detected and corrected.

Importance Of Error Coding

- Extra bits are added to the data at the transmitter (redundancy) to permit error detection or correction at the receiver

- Done to prevent the output of erroneous bits despite noise and other imperfections in the channel

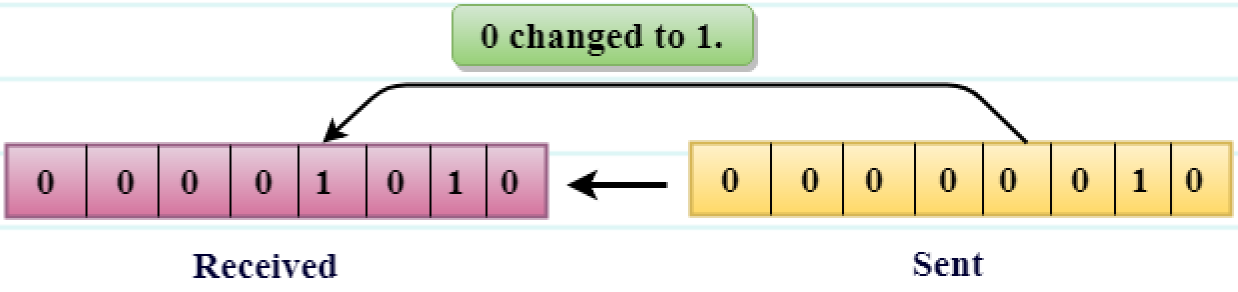
- Popular error control methods include:
  - Parity bits
  - Cyclic Redundancy Checking (CRC)

Types Of Error

Single-bit error

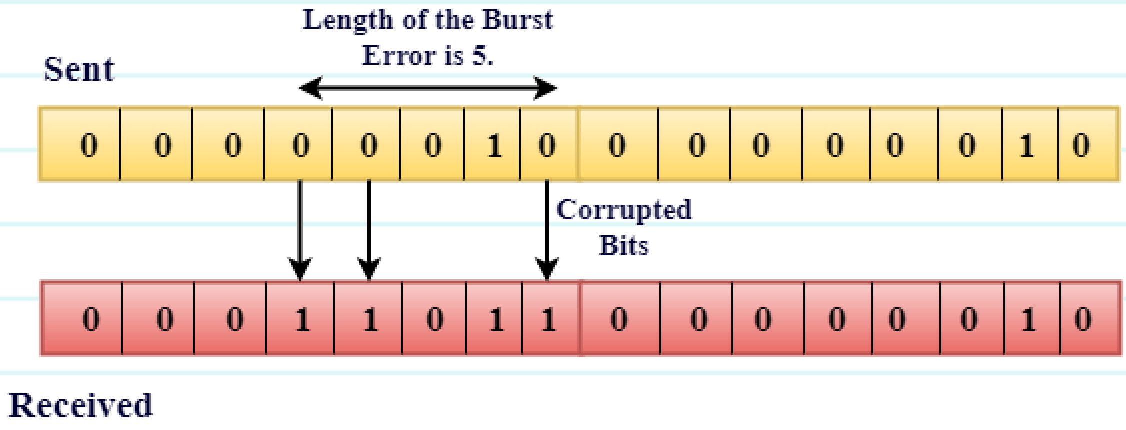
The term single-bit error means that only 1 bit of a given data unit (such as a byte, character, or packet) is changed from 1 to 0 or from 0 to 1

In a single-bit error, only 1 bit in the data unit has changed



Burst error (Multiple-bit error)

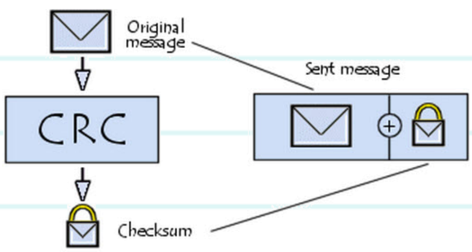
The term burst error means that 2 or more bits in the data unit have changed from 1 to 0 or from 0 to 1.



Cyclic Redundancy Check (CRC)

A cyclic redundancy check or CRC, is a form of data verification used by computer software and networking protocols to ensure there has been no corruption to the data being checked.

CRCs are employed mainly by networking protocols such as TCP/IP to ensure that any data sent across a network has not accidentally changed while in transit to its destination.

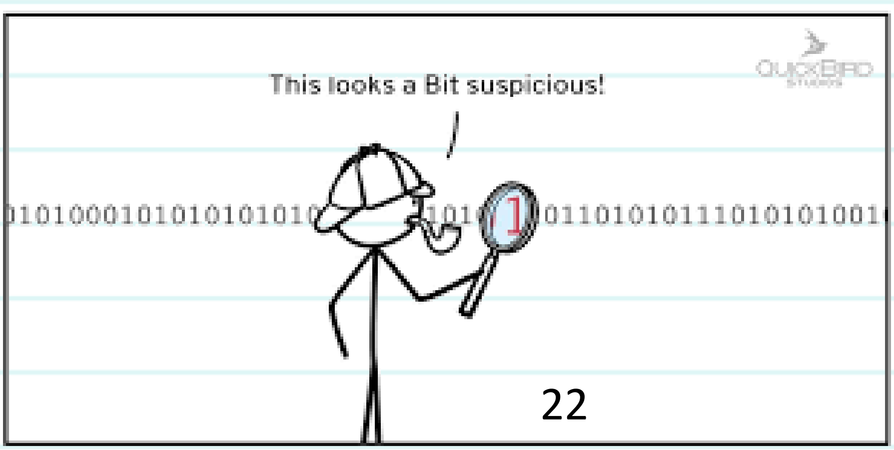


SCAN ME

k bit block of bits, or message, the transmitter generates an n-bit sequence, known as a frame check sequence (FCS), so that the resulting frame, consisting of k + n bits, is exactly divisible by some predetermined number.

The receiver then divides the incoming frame by that number and, if there is no remainder, assumes there was no error.

To clarify this, we present the procedure in three ways: ***modulo 2 arithmetic***, polynomials, and digital logic.



MODULO 2 ARITHMETIC

Modulo 2 arithmetic uses binary addition with no carries, which is just the exclusive or operation. For example:

$$\begin{array}{r} 1\ 1\ 1\ 1 \\ +\ \underline{1\ 0\ 1\ 0} \\ \underline{0\ 1\ 0\ 1} \end{array}$$

<u>EXAMPLE :</u>

1. Given

- Message M = 1010001101 (10 bits)
- Pattern *P = 110101 (6 bits)*
- FCS R = to be calculated *(5 bits)*

2. The message M is multiplied by *25, yielding 101000110100000.*

3. This product is divided by P:

```
                          1 1 0 1 0 1 0 1 1 0  <- Q

P -> 1 1 0 1 0 1  /  1 0 1 0 0 0 1 1 0 1 0 0 0 0 0  <- 2^n M
                     1 1 0 1 0 1
                     -----------
                       1 1 1 0 1 1
                       1 1 0 1 0 1
                       -----------
                           1 1 1 0 1 0
                           1 1 0 1 0 1
                           -----------
                               1 1 1 1 1 0
                               1 1 0 1 0 1
                               -----------
                                   1 0 1 1 0 0
                                   1 1 0 1 0 1
                                   -----------
                                     1 1 0 0 1 0
                                     1 1 0 1 0 1
                                     -----------
                                         0 1 1 1 0  <- R
```

4. **The remainder (R = 01110)** **is added to 2"M to give *T = 101000110101110,*** which is transmitted.

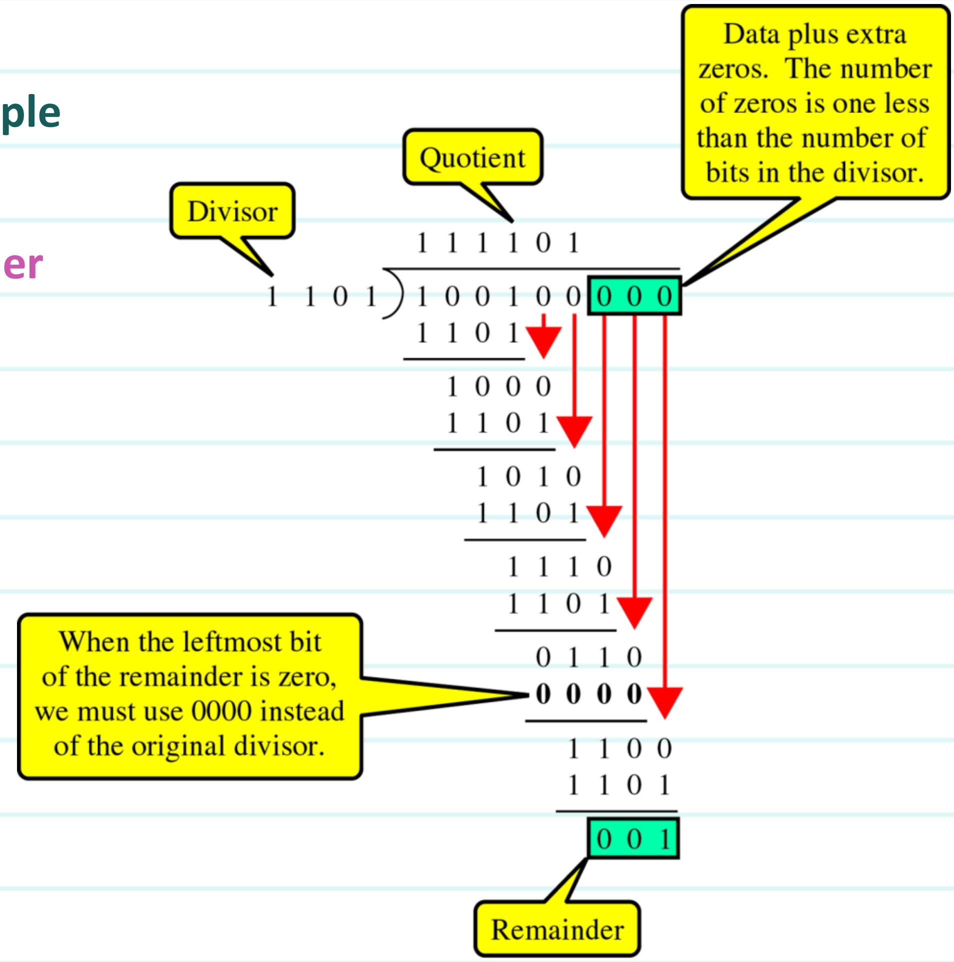
5. If there are no errors, the receiver receives T intact. The received frame is divided by P:

```
                     1 1 0 1 0 1 0 1 1 0  ⇐ Q
P ⇒ 1 1 0 1 0 1 / 1 0 1 0 0 0 1 1 0 1 0 1 1 1 0  ⇐ T
                  1 1 0 1 0 1
                    1 1 1 0 1 1
                    1 1 0 1 0 1
                        1 1 1 0 1 0
                        1 1 0 1 0 1
                            1 1 1 1 1 0
                            1 1 0 1 0 1
                                1 0 1 1 1 1
                                1 1 0 1 0 1
                                  1 1 0 1 0 1
                                  1 1 0 1 0 1
                                    0 0 0 0 0  ⇐ R
```

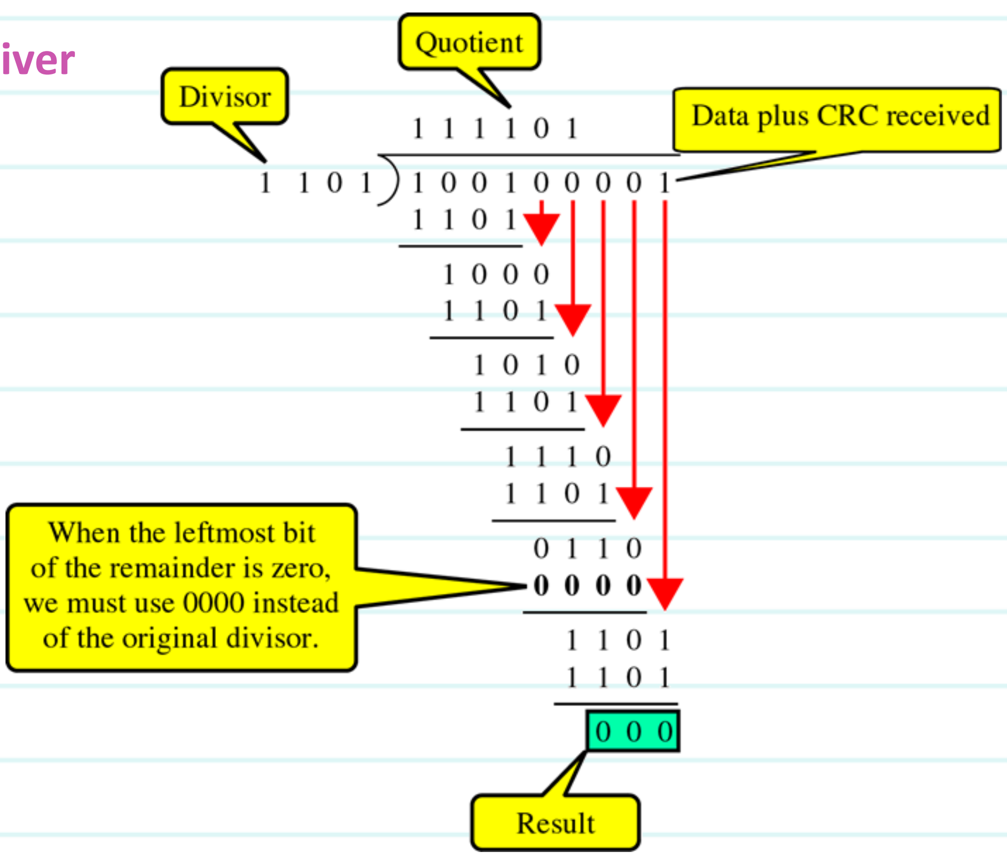
Because there is no remainder, it is assumed that there have been no errors

Example

Sender



Receiver



TUTORIAL

TUTORIAL

Question 1

	1	0	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	0
NRZ																			
NRZI																			
RZ																			
Manchester																			
AMI																			
HDB3																			
MLT-3																			

Question 2

a. Suppose you are using an odd parity. What should the binary word "1010" look like after you add the parity bit?

b. Suppose you are using an even parity. What should the binary word "1010" look like after you add a parity bit?

c. Assuming even parity, find the parity bit for each of the following data units.

   i. 1001011

   ii. 0001100

   iii. 1000000

   iv. 1110111

TUTORIAL

Question 3

Encode the bit-pattern 1010000101 using the following encoding schemes :

1. ASK
2. FSK
3. PSK
4. 4 QAM (use 2 amplitudes and 2 phases (0^o and 180^o)

Question 4

Data to be sent is 1010001101 and the generator is 110101. Using Cyclic Redundancy Check (CRC) technique, obtain data to be sent from transmitter to receiver. Meanwhile at the receiver, proved there is no error during the transmission process.

Question 5

Given data m(x) =101010, g(x)=1001 and 3 remainder bit = 100.

Apply the CRC (Cyclic Redundancy Check) technique to detect the error at the receiver.

Question 6

List five line coding schemes discussed in this book.

Question 7

List three different techniques in serial transmission and explain the differences.

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ACRONYMS

2B1Q	Two-binary, one-quaternary
4B/5B	Four binary, five binary
ANSI	American National Standards Institute
ASK	Amplitude shift keying
CSMA/CA	Carrier sense multiple access / collision avoidance
CSMA/CD	Carrier sense multiple access / collision detection
DCE	Data communications equipment
DNS	Domain Name System
DTE	Data Terminal Equipment
ESS	Extended service set (Wi-Fi group)
FTP	File Transfer Protocol
HTTP	HyperText Transfer Protocol
HTTPS	HyperText Transfer Protocol Secure
IEEE	Institute for Electrical and Electronic Engineers
IP	Internet Protocol
ISP	Internet service provider
ITU-T	International Telecommunications Union
LAN	Local area network
LLC	Logical link control
MAC	Media access control

ACRONYMS

MAN	Metropolitan area network
NIC	Network Interface Card
NRZ	Non-return-to-zero
NRZI	Non-return to zero inverted
OSI	Open System Interconnect (joint ISO and ITU standard)
PCM	Pulse-code modulation
PDU	Protocol data unit (such as segment, packet, frame, etc.)
POP3	Post Office Protocol, version 3
PPP	Point-to-point Protocol
RTP	Real-time Transport Protocol
SMTP	Simple Mail Transfer Protocol
SSID	Service set identifier (Wi-Fi)
TCP/IP	Transmission Control Protocol/Internet Protocol
UTP	Unshielded twisted pair
VPN	Virtual private network
WAN	Wide-area network
WEP	Wired Equivalent Privacy
Wi-Fi	Wireless Fidelity
WPA	Wi-Fi Protected Access
www	World Wide Web


Thank You!

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