# Introduction to Data Communication

**Course Code:** 01078,S:A **Course Title:** Data Communication

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# Lecture Outline


1. Characteristics of Data Communication
2. Key Elements of Data Communication
3. A Data Communications Model
4. Data Representation
5. Data Transmission
6. Mode of Serial transmission
7. Bit Rate
8. Types of Networks

# Characteristics of Data Communication

- Data communications are the exchange of data between two devices via some form of transmission medium such as a wire cable.

- For data communications to occur, the communicating devices must be part of a communication system made up of a combination of hardware (physical equipment) and software (programs).

- The effectiveness of a data communications system depends on four fundamental characteristics:

✓ **Delivery:** System must deliver data to the correct destination.
✓ **Accuracy:** System must deliver the data accurately.
✓ **Timeliness (latency/delay):** System must deliver data in a timely manner.
✓ **Jitter:** Refers to the variation in the packet arrival time.

# Key Elements of Data Communication


**Source**: Generates (binary) data to be transmitted. examples are telephones and personal computers.

**Transmitter**: Converts data into transmittable electromagnetic signals. For example, a modem takes a digital bit stream from an attached device such as a personal computer and transforms that bit stream into an analog signal that can be handled by the telephone network.

**Transmission system**: This can be a single transmission line or a complex network connecting source and destination.

**Receiver**: Converts received signal into data. For example, a modem will accept an analog signal coming from a network or transmission line and convert it into a digital bit stream.

**Destination**: Takes incoming data from the receiver.

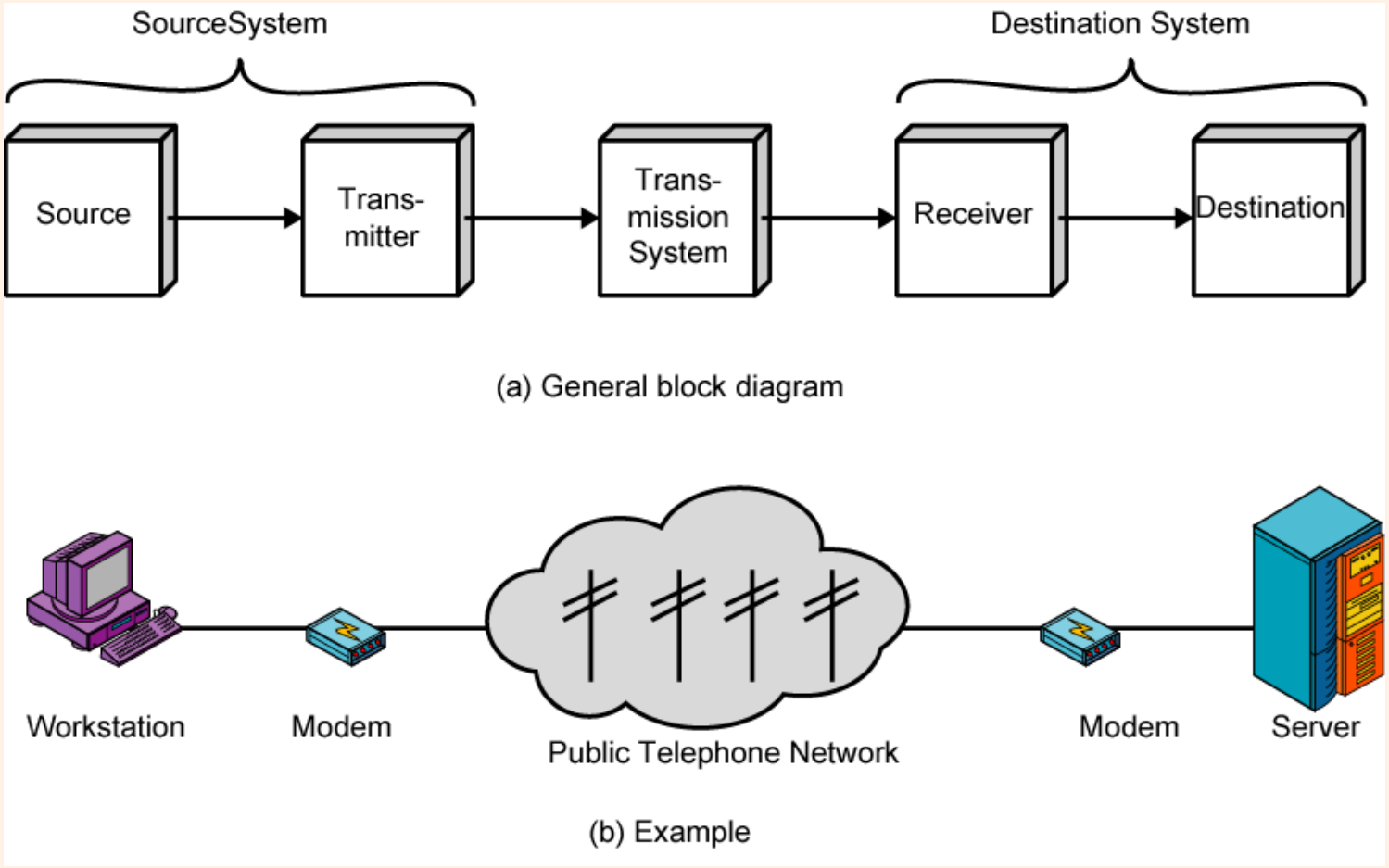



Figure: Key Elements of Data Communication

# A Data Communications Model

Suppose that the input device and transmitter are components of a personal computer. The user of the PC wishes to send a message ***m*** to another user.

1. The user activates the electronic mail package on the PC and enters the message via the keyboard (input device).
2. The character string is briefly buffered in main memory, which can be view as a sequence of bits (g) in memory.
3. The personal computer is connected to some transmission medium, such as a local network or a telephone line, by an I/O device (transmitter), such as a local network transceiver or a modem.
4. The input data are transferred to the transmitter as a sequence of voltage shifts [g(t)].
5. The transmitter is connected directly to the medium and converts the incoming stream [g(t)] into a signal [s(t)] suitable for transmission.

6. The transmitted signal s(t) presented to the medium is subject to a number of impairments, before it reaches the receiver.

7. Thus, the received signal r(t) may differ from s(t).

8. The receiver will attempt to estimate the original s(t), based on r(t) and its knowledge of the medium, producing a sequence of bits g'(t).

9. These bits are sent to the output personal computer (as a block of bits)

10. The destination system will attempt to determine if an error has occurred and, if so, cooperate with the source system to eventually obtain a complete, error-free block of data.

11. These data are then presented to the user via an output device, such as a printer or screen. The message (m') as viewed by the user will usually be an exact copy of the original message (m)

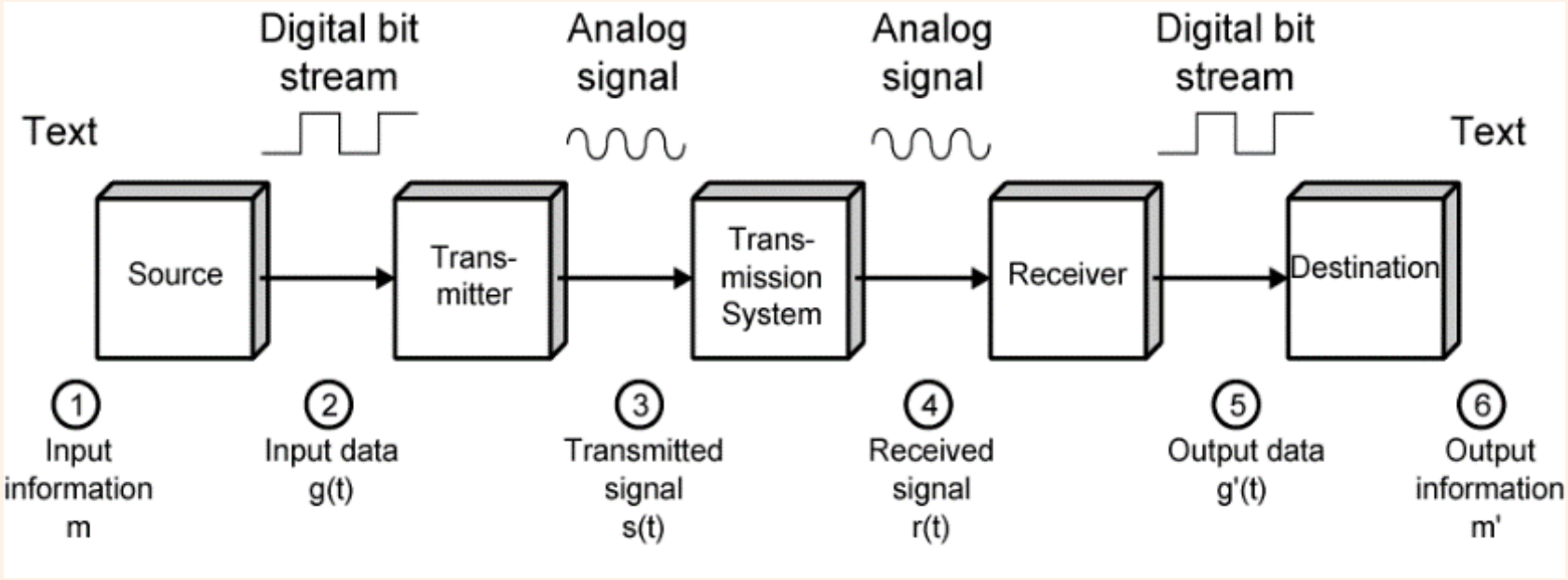



Figure: A Data Communications Model

# Data Representation

A binary digit or bit has only two states, “0" and "I" and can represent only two symbols, but even the simplest form of communication between computers requires a much larger set of symbols, e.g.

1. 52 capital and small letters,
2. 10 numerals from 0 to 9
3. punctuation marks and other special symbols, and
4. terminal control characters-Carriage Return (CR), Lane Feed (Lr).

- Therefore, a group of bits is used as a code to represent a symbol. The code is usually *5 to 8* bits long. . 5-bit code can have $2^5 = 32$ combinations and can, therefore, represent 32 symbols.

- Similarly an 8-bit code can represent $2^8 = 256$ symbols.

- A code set is the set of these codes representing the symbols.

- There are several code sets, some arc used for specific applications white others are the proprietary code sets of computer manufacturers. The following two code sets arc very common:

I. ANSI's 7-bit American Standard Code for Information Interchange (ASCII)

2. IBM's 8-bit Extended Binary-Coded-Decimal Interchange Code (EBCDIC).

- **American Standard Code for Information Interchange (ASCII)**
- ASCII is the most common code set and is used worldwide.
- It is, 7 bit code and all the possible 128 codes have defined meaning. The code set consists of following symbols:

1. 96 graphic symbols (columns 2 to 7), comprising 94 printable characters, SPACE. And Delete characters
2. 32 control symbols (columns 0 and I).

| 7-Bit ASCII (American Standard Code for Information Interchange) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 000... | 001... | 010... | 011... | 100... | 101... | 110... | 111... |
| ..0000 | *NUL* | *DLE* | *SP* | 0 | @ | P | ‘ | p |
| ..0001 | *SOH* | *DC1* | ! | 1 | A | Q | a | q |
| ..0010 | *STX* | *DC2* | " | 2 | B | R | b | r |
| ..0011 | *ETX* | *DC3* | # | 3 | C | S | c | s |
| ..0100 | *EOT* | *DC4* | $ | 4 | D | T | d | t |
| ..0101 | *ENQ* | *NAK* | % | 5 | E | U | e | u |
| ..0110 | *ACK* | *SYN* | & | 6 | F | V | f | v |
| ..0111 | *BEL* | *ETB* | ’ | 7 | G | W | g | w |
| ..1000 | *BS* | *CAN* | ( | 8 | H | X | h | x |
| ..1001 | *HT* | *EM* | ) | 9 | I | Y | i | y |
| ..1010 | *LF* | *SUB* | * | : | J | Z | j | z |
| ..1011 | *VT* | *ESC* | + | ; | K | [ | k | { |
| ..1100 | *FF* | *FS* | , | < | L | \ | l | \| |
| ..1101 | *CR* | *GS* | - | = | M | ] | m | } |
| ..1110 | *SO* | *RS* | . | > | N | ^ | n | ~ |
| ..1111 | *SI* | *US* | / | ? | O | _ | o | *DEL* |

- The binary representation of a particular character can be easily determined from its hexadecimal coordinate. For example, the coordinate of character "K" are (4B) and, therefore, it's binary code is 100 1011.

- EXAMPLE 1:

https://www.freecodecamp.org/news/ascii-table-hex-to-ascii-value-character-code-chart-2/

Represent the message "3P.bat" in ASCH code. The eighth bit may be kept as "0".

Solution:

| Bit Positions | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 |
|---|---|---|---|---|---|---|---|---|
| 3 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 |
| P | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| . | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 0 |
| b | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 0 |
| a | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 |
| t | 0 | 1 | 1 | 1 | 0 | 1 | 0 | 0 |

# Data Transmission

Bytes: Byte is a group or bits which is considered as a single unit during processing. It is usually eight bits long though its length may be different . A character code, e.g., 1001011 of ASCII, is a byte having a defined meaning "K", but it should be noted that there may be bytes which are not elements of any standard code set.

There is always need to exchange data, commands and other control information between a computer and its terminals or between two computers. This information is in the form of bits.

Data transmission refers to movement of the bits over some physical medium connecting two or more digital devices. There are two options of transmitting the bits, namely,

1. Parallel transmission
2. Serial transmission.

- **Parallel transmission:** Here all the bits of a byte are transmitted simultaneously on separate wires and multiple circuits interconnecting the two devices are, therefore, required. It is practical only if the two devices, e.g., a computer and its associated printer are close to each other.

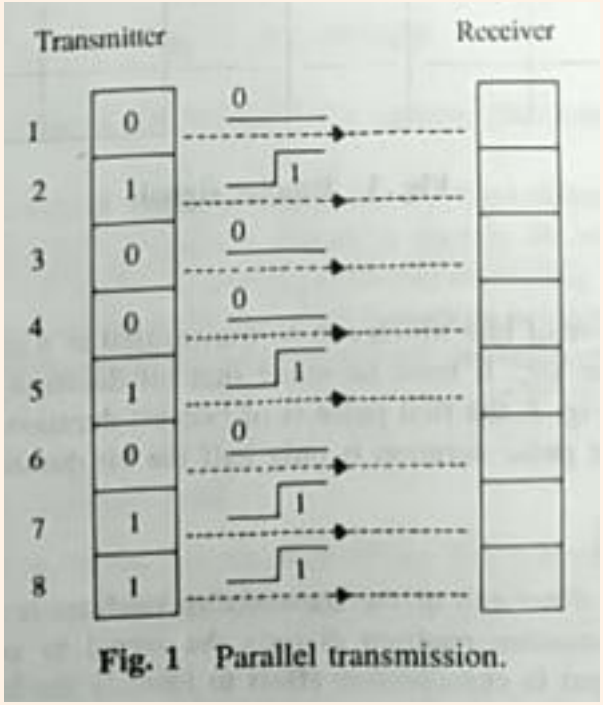


Fig. 1 Parallel transmission.

- **Serial transmission**: Here bits are transmitted serially one after the other . The least significant bit (LSB) is usually transmitted first. Note that as compared to parallel transmission, serial transmission requires only one circuit interconnecting the two devices. Therefore. Serial transmission is suitable for transmission over long distance.

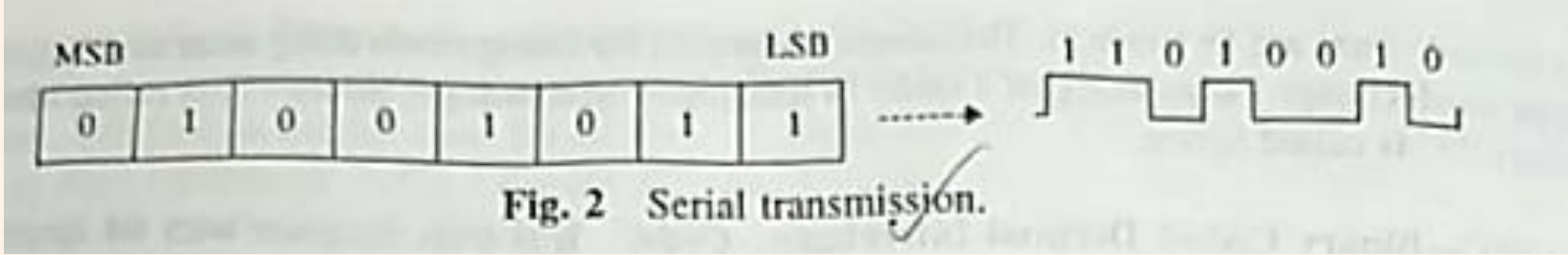



Fig. 2 Serial transmission.

- Serial Transmission Example- Write the bit transmission sequence of the message “**3p.bat**”.
- Solution:

| **3** | **p** | **.** | **b** | **a** | **t** |
|---|---|---|---|---|---|
| 11001100 | 00001010 | 01110100 | 01000110 | 10000110 | 00101110 |

- **Bipolar Signal** - Bits are transmitted as electrical signals over the interconnecting wires. The two binary states “1” and “0” are represented by two voltage levels. If one of these states is assigned 0 volt level, the transmission is termed unipolar and if we choose to represent a binary "1" by , say, a positive voltage +V volts and n binary “o'' by a negative voltage -V volts, the transmission is said to be bipolar.

- The following figure shows the bipolar waveform of the character "K". Bipolar transmission is preferred because the signal does not have any DC component. The transmission media usually do not allow the DC signals to pass through.

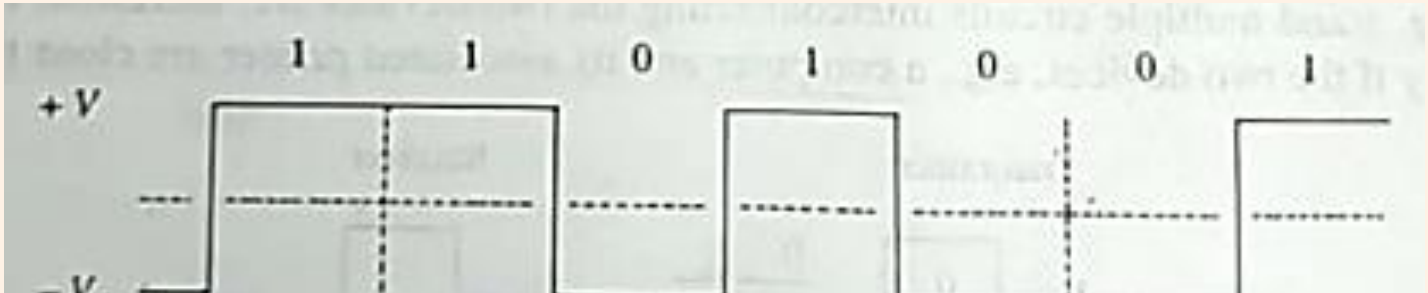



Fig. 3 Bipolar signal.

# Mode of Serial transmission

Serial transmission can be two types:

1. Synchronous Transmission
2. Asynchronous Transmission

- In synchronous transmission, bits are sent one after another without start or stop bits or gaps. It is the responsibility of the receiver to group the bits.

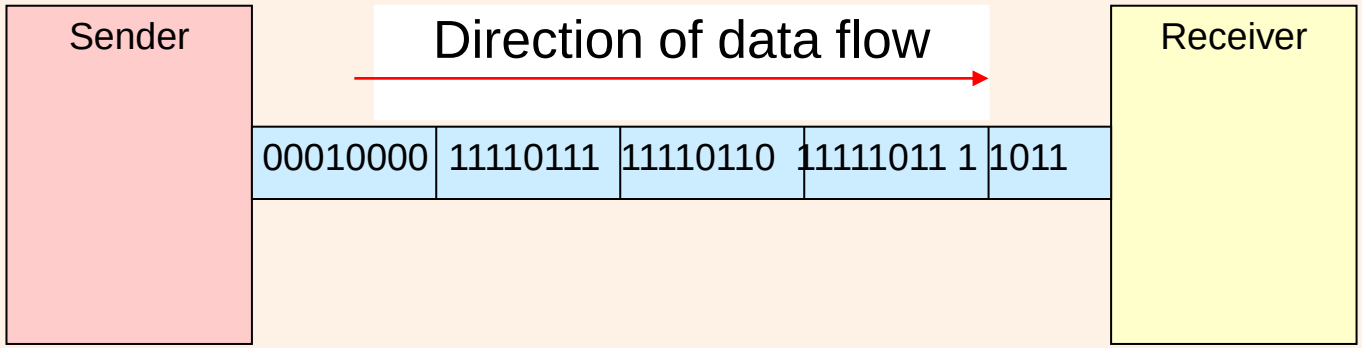



Figure: Synchronous transmission

- In synchronous transmission, one start bit (0) at the beginning, followed by a byte and one or two stop bits (1) at the end of each byte. There may be a gap between each byte. This is also known as framing.

1. Generally use in low speed data transmission.
2. Send one start bit (0) at beginning of the byte and one or two stop bits (1) at end of each byte.
3. There are variable–length gaps between each byte.

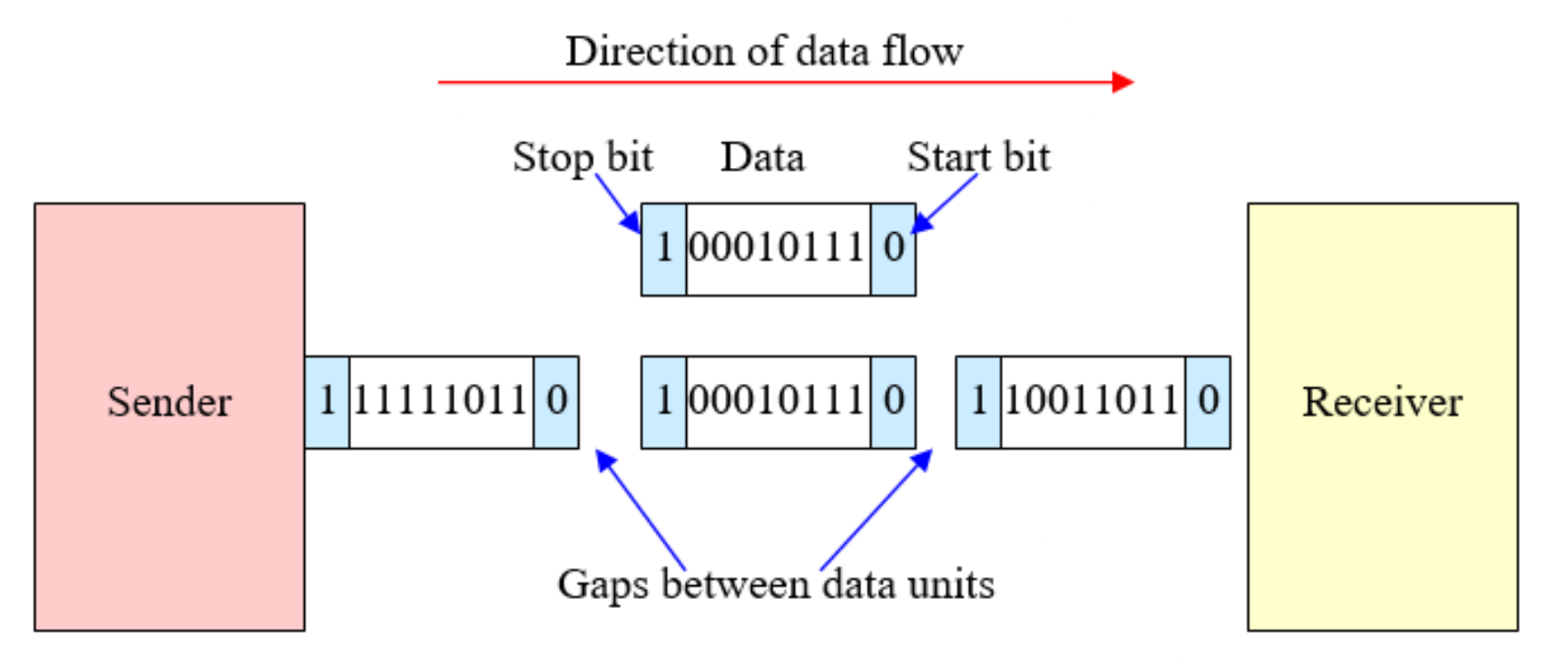



Figure: Asynchronous transmission

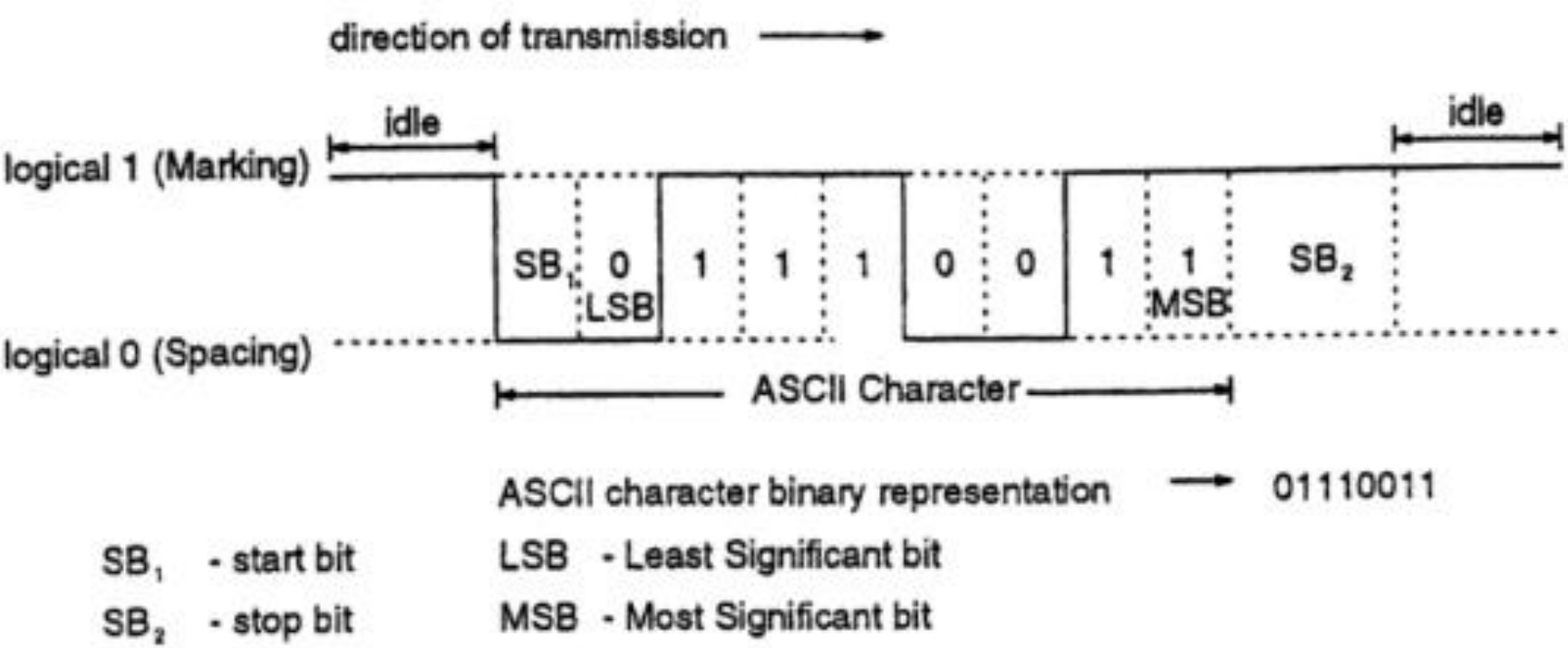



Figure: Asynchronous Transmission Details

# Bit Rate

- Bit rate is simply the number of bits which can be transmitted in a second. If $t_p$ is the duration of a bit, the bit rate R will be $1/ t_p$. It must be noted that bit duration is not necessarily the pulse duration. For example, the first pulse is of two-bit duration . Later, we will come across signal format in which the pulse duration is only half the bit duration.

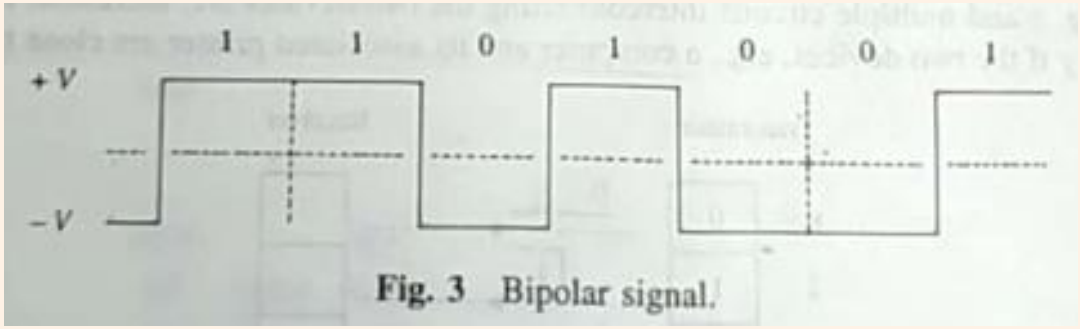
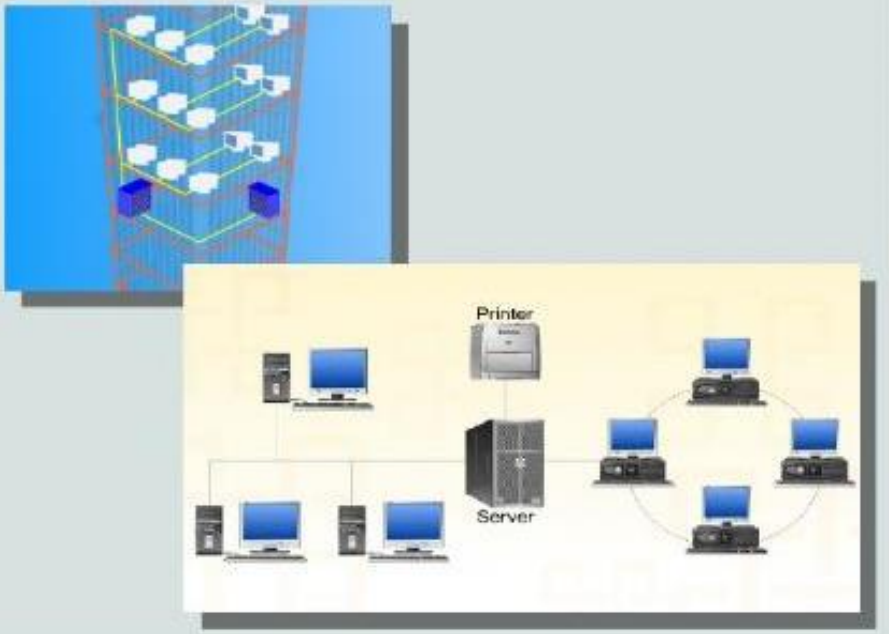



Fig. 3 Bipolar signal.

# Types of Networks

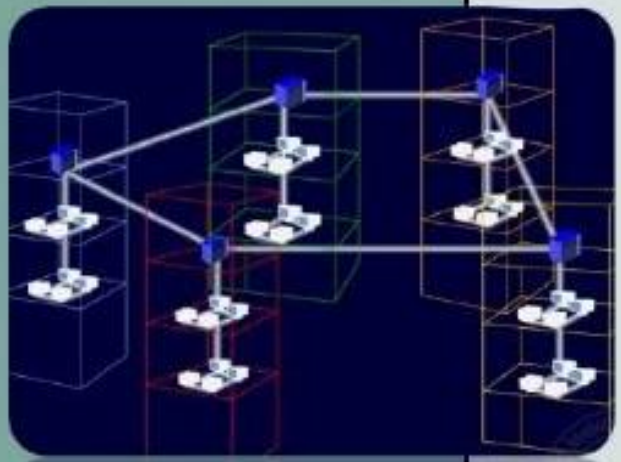
| Local Area Network (LAN) | A local area network is a network that connects computers and device in **a limited geographical area** such as a **home,** school **computer laboratory,** office building |
|---|---|



## Metropolitan Area Network (MAN)

A metropolitan area network (MAN) is a high speed network that connects local area networks **in a metropolitan area** such as **city or town** and handles bulk of communication activity across the region

A MAN typically includes one or more LAN but covers a smaller geographic area than a WAN

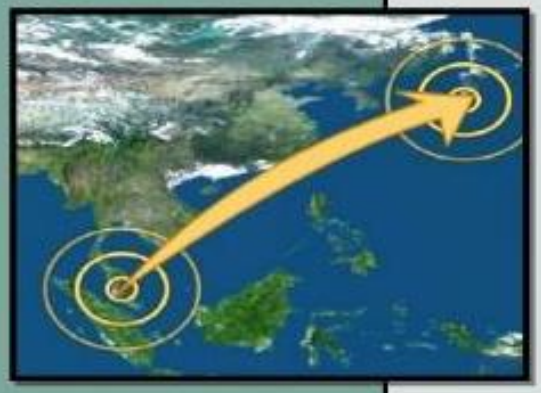


## Wide Area Network (WAN)

A wide area network is a network that **covers a large geographical area** such **country or the world**

WAN combines many types of media such as telephone lines, cables and radio wave. A WAN can be one large network or can consist of two or more LANs connected together

The internet is the worlds largest WAN



# Books


1. Forouzan, B. A. "Data Communication and Networking. Tata McGraw." (2005).
2. Prakash C. Gupta, “Data communications”, Prentice Hall India Pvt.

# References


1. Prakash C. Gupta, “Data communications”, Prentice Hall India Pvt.
2. William Stallings, "Data and Computer Communications”, Pearson
3. Forouzan, B. A. "Data Communication and Networking. Tata McGraw." (2005).