Sairam INSTITUTIONS

Sri SAI RAM ENGINEERING COLLEGE

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West Tambaram, Chennai - 44

| YEAR | SEM |
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| II | III |

COURSE CODE: EC 8394

# ANALOG AND DIGITAL COMMUNICATION

UNIT No. II PULSE AND DATA COMMUNICATION

## 2.5 DATA COMMUNICATION CIRCUITS AND CODE

# DATA COMMUNICATION HARDWARES

## DATA MODEMS

- The primary purpose of a data modem is to interface computers, computer networks and other digital terminal equipment to analog communication lines and radio channels.
- The word modem is a contraction derived from the words modulator and demodulator.
- In a modem transmitter, digital signals modulate an analog carrier and in a receiving modem, analog signals are demodulated and converted into digital signals.
- A modem is sometimes called as DCE(Data communication equipment), a data set, a dataphone.
- Modems are generally classified as either asynchronous or synchronous.
- Modems use one of the following modulation

  techniques: (1). Amplitude Shift Keying (ASK)

  (2). Frequency Shift Keying

  (FSK) (3). Phase Shift Keying

  (PSK)

  (4). Quadrature Amplitude Modulation (QAM)

### Difference between Synchronous and Asynchronous Modems

| **Synchronous Modems** | **Asynchronous Modems** |
|---|---|
| In these type of Modems, clocking information is recovered in the receiver. | In these type of Modems, clocking information is not recovered at receiver and may not require. |
| These Modems uses the modulation techniques like PSK and QAM. | These Modems uses the modulation techniques like ASK and FSK. |
| It can be used for Medium and High Speed applications up to 57.6 Kbps. | It can be used for Low Speed applications below<br>2.4 Kbps. |

### Low-Speed Modems

- Low speed modems are generally asynchronous.
- It uses Non-coherenr FSK.
- The transmit carrier and clock frequencies need not be recovered by the receive modem.
- Therefore, they don't need scrambler and descrambler circuits.
- Speed 1200 to 1800 baud.

### Medium and High-Speed Modems

- Medium and High speed Modems are used where transmission rates of 2400 bps or baud are required.
- PSK or QAM modulation techniques are used.
- These Modems are synchronous.
- Because these Modems are synchronous, clock timing recovery and carrier recovery must be

required.

- These Modems contain scrambler and descrambler circuits and adaptive equalizers.
- Example: the 208 Modem is a synchronous, 4800 baud rate, 8-DPSK modulation technique. Each symbol represents three bits and is 0.625 milliseconds duration.

## Modem Control

The smart Modems are controlled by other larger computers through a system of commands. The most common system of modem commands is the AT command set which is also known as the Hayes command set. Hayes Microcomputer Products originally developed the AT command set for its own line of modems.

| **Characters** | **Command** |
|---|---|
| AT | **Attention** |
| A | **Answer an incoming call** |
| DT | **Dial using DTMF tones** |
| DP | **Dial using Pulse dialing** |
| E0 | **Do not echo transmitted data to terminal screen** |
| E1 | **Echo transmitted data to terminal screen** |
| F0 | **Half-duplex communications** |
| F1 | **Full-duplex communications** |
| H | **Go on-hook (Hang up)** |
| O | **Switch from command to on-line mode** |
| Z | **Reset Modem** |
| +++ | **Escape code; switch from on-line mode to command mode** |

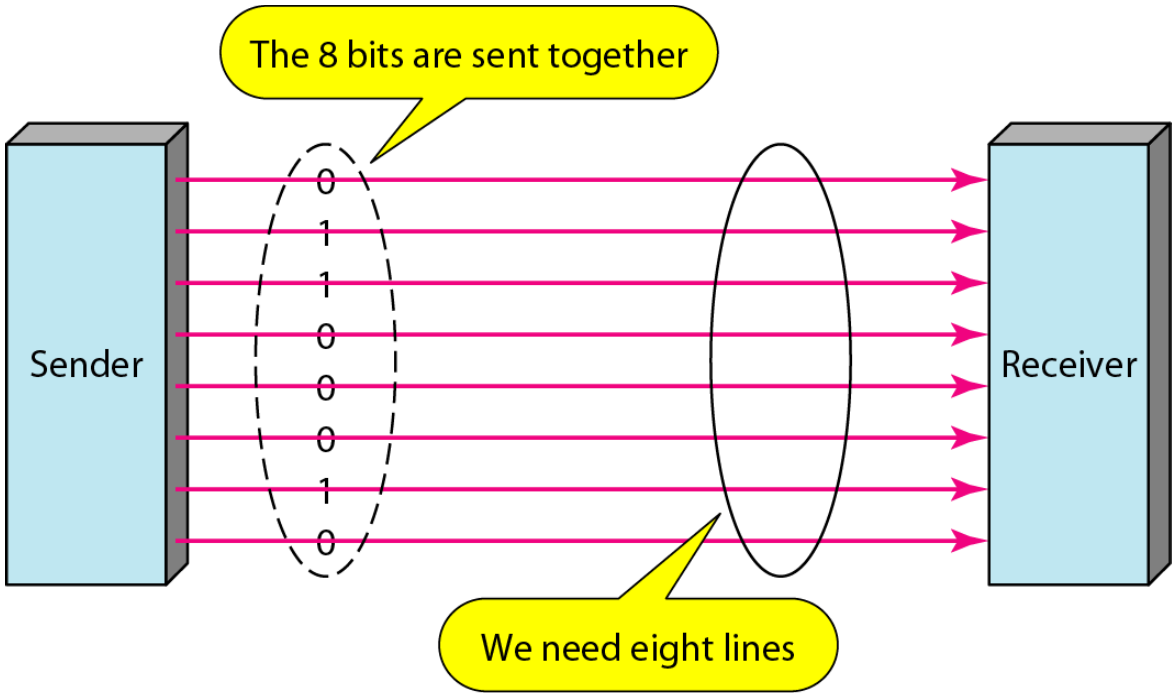
### AT command mode

- All modem commands in the AT command set begin with the ASCII characters AT (Attention).
- In the command mode, the modem monitors the information sent to it through the DTE(Data Terminal Equipment-Computer system)[Modem called as DCE-Data Communication Equipment] by the local terminal looking for the ASCII characters AT.
- ASCII character 'T' is the command to use tones rather than pulses and the character 'D' is the command to dial.
- For example to dial the telephone number 91-424-2533279, the character sequence would be ATDT914242533279.

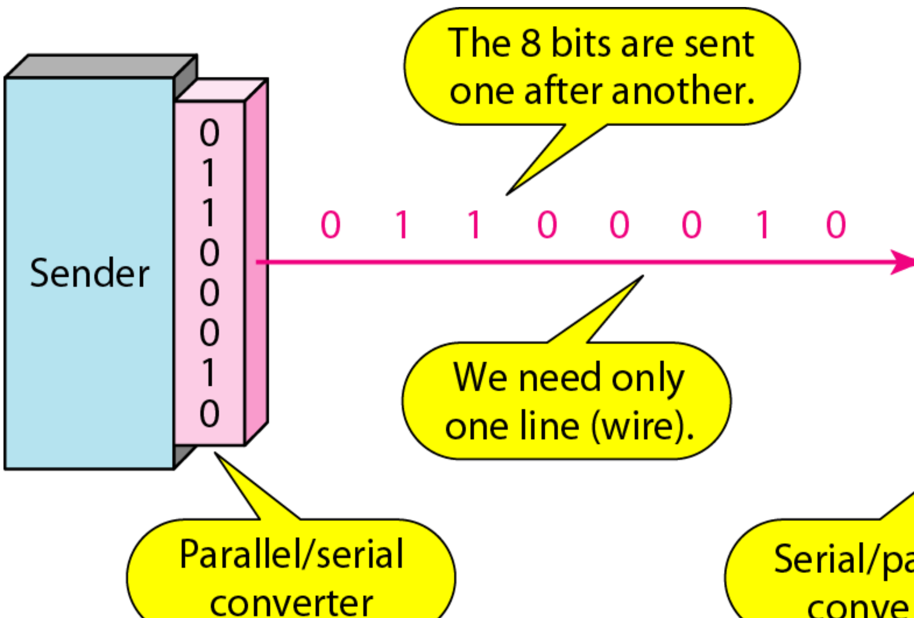
### AT on-line mode

- Once communications have been established with a remote modem, the local modem switches to the on-line mode.
- The local modem simply accepts the characters and allows them to modulate its carrier before sending them to a remote location.
- The local terminal (computer system) can switch the modem from the on-line mode to the command mode by sending three consecutive plus signs (+ + +). This sequence is called as escape code.
- In response to the escape code, the modem switches to the command mode and begins monitoring data for the ASCII AT command code.

Parallel Transmission

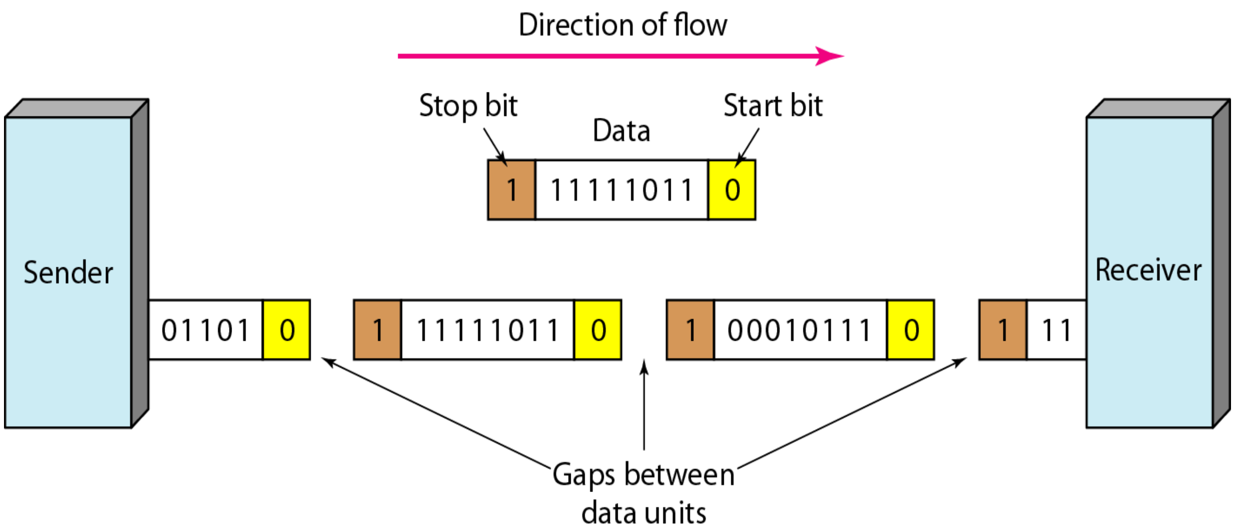



**Serial Transmission**



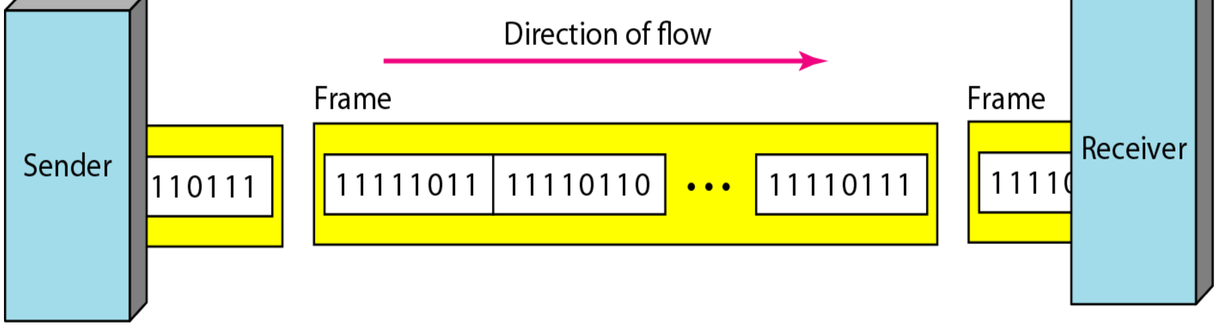
## ASynchronous Transmission

- In asynchronous transmission, send 1 start bit (0) at the beginning and 1 or more stop bits (1s) at the end of each byte. There may be a gap between each byte.
- **Asynchronous here means "asynchronous at the byte level," but the bits are still synchronized; their durations are the same.**

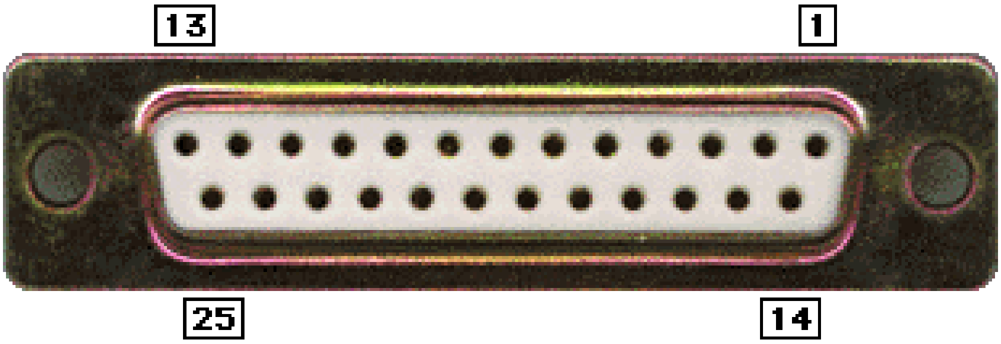



## Synchronous Transmission

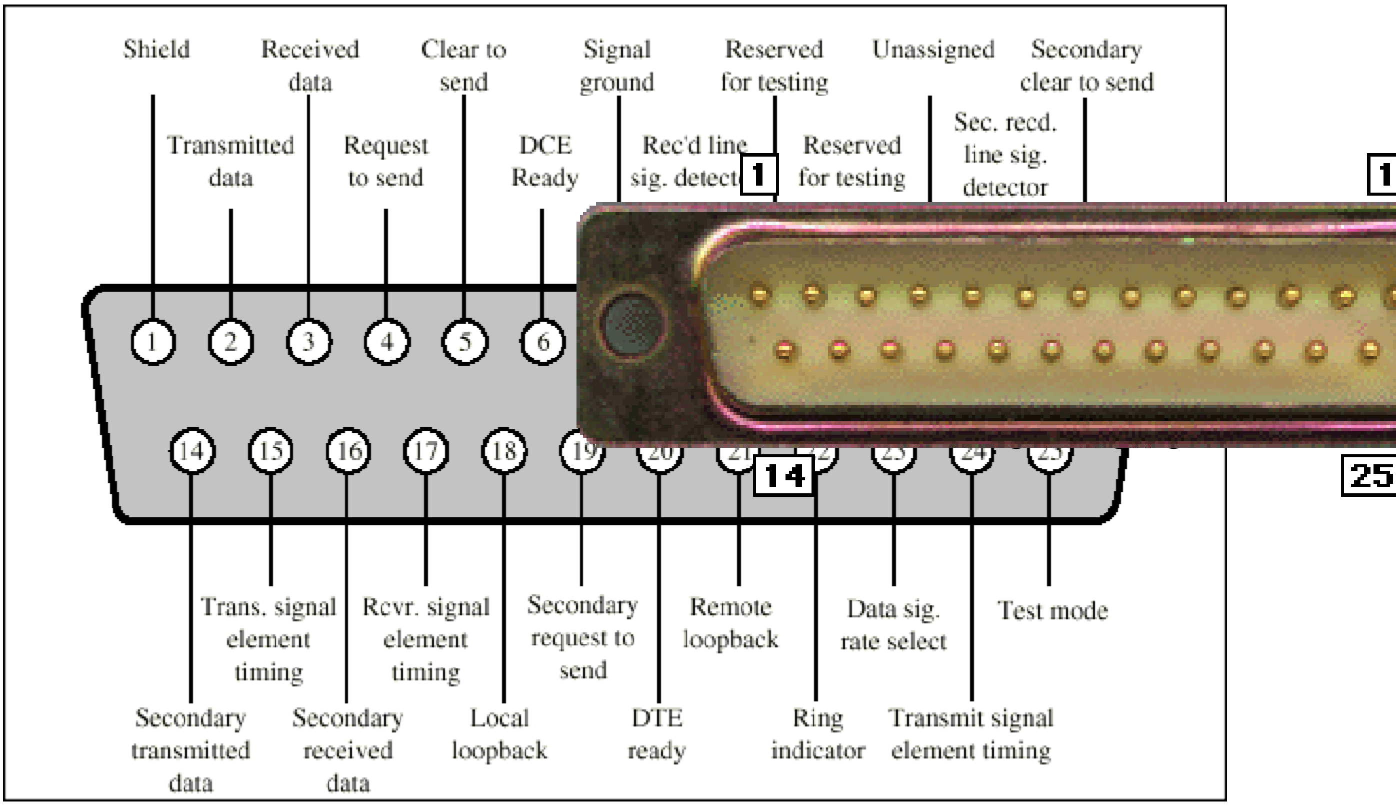
- **In synchronous transmission, we send bits one after another without start or stop bits or gaps. It is the responsibility of the receiver to group the bits. The bits are usually sent as bytes and many bytes are grouped in a frame. A frame is identified with a start and an end byte.**



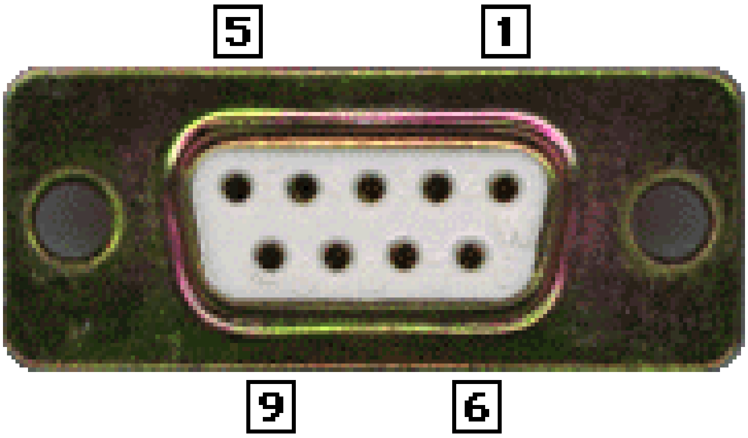
## Serial Interfaces- RS 232




DB-25 Female

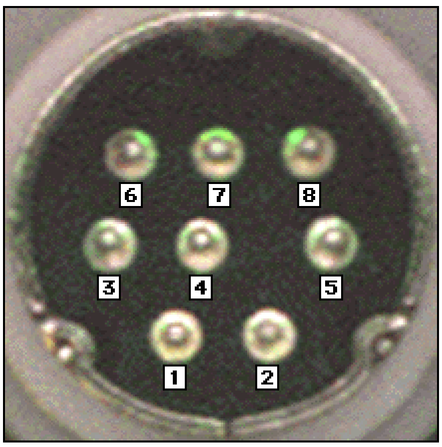



RS-232 DB-25 Pinouts

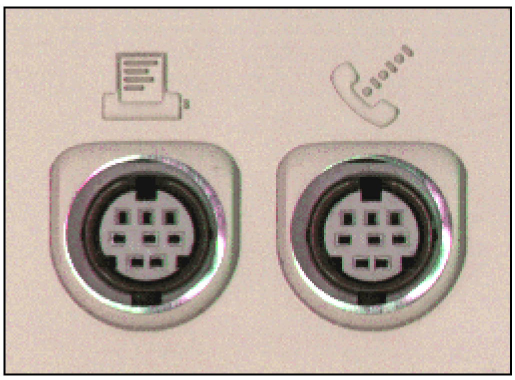




**RS-232 DB-9 Connectors**




**DIN-8 Male**



**DIN-8 Female**

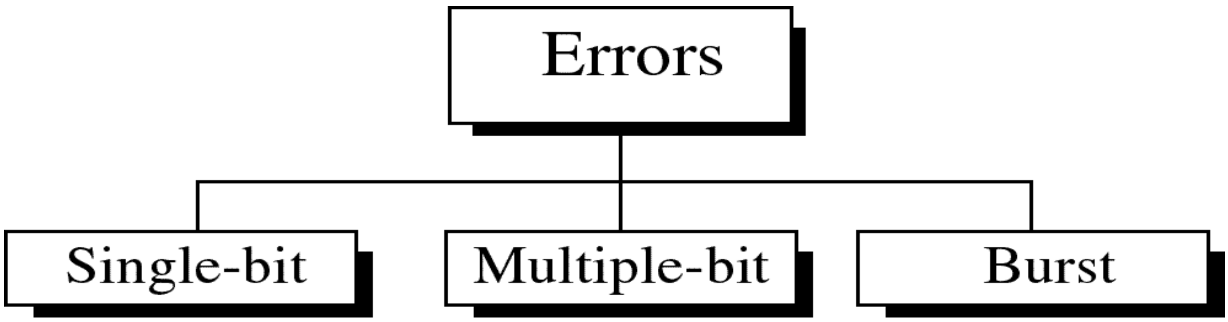
## Error Control

Networks must be able to transfer data from one device to another with complete accuracy. Data can be corrupted during transmission. For reliable communication, errors must be detected and corrected. Error control can be divided into two general categories:

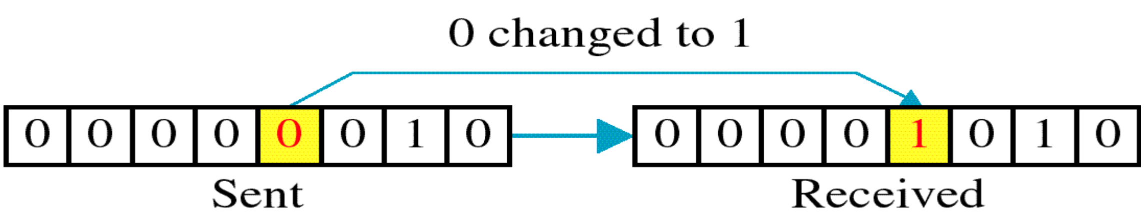
[1]. Error Detection
[2]. Error Correction

**Error detection and Error correction** are implemented either at the **data link layer** or the **transport layer** of the OSI model.

### Types of Errors

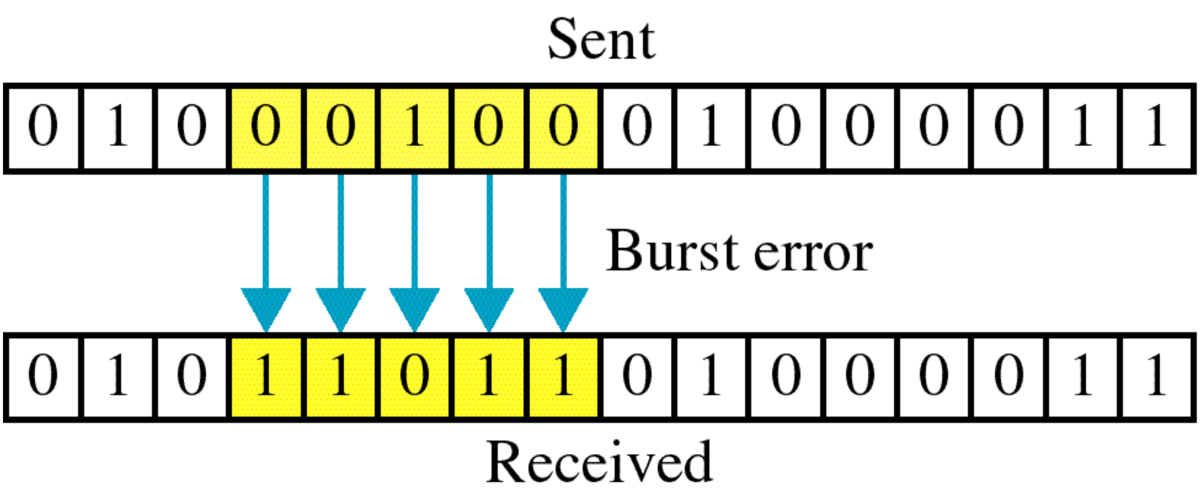


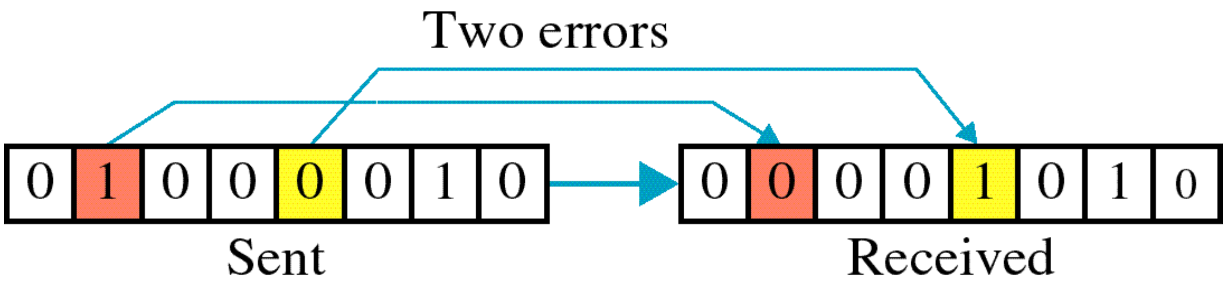

### [1]. Single-bit error




**Single bit errors** are the **least likely** type of errors in serial data transmission because the noise must have a very short duration which is very rare. However this kind of errors can happen in parallel transmission.

### [2]. Burst error






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

**Burst errors does not** necessarily **mean that the errors occur in consecutive bits**, the length of the burst is measured from the first corrupted bit to the last corrupted bit. Some bits in between may not have been corrupted.

**Burst error is most likely to happen in serial transmission** since the duration of noise is normally longer than the duration of a bit. The number of bits affected depends on the data rate and duration of noise.

## [1]. Error detection

Error detection means to decide whether the received data is correct or not without having a copy of the original message. Error detection **uses the concept of redundancy**, **which means** adding extra bits for detecting errors at the destination.

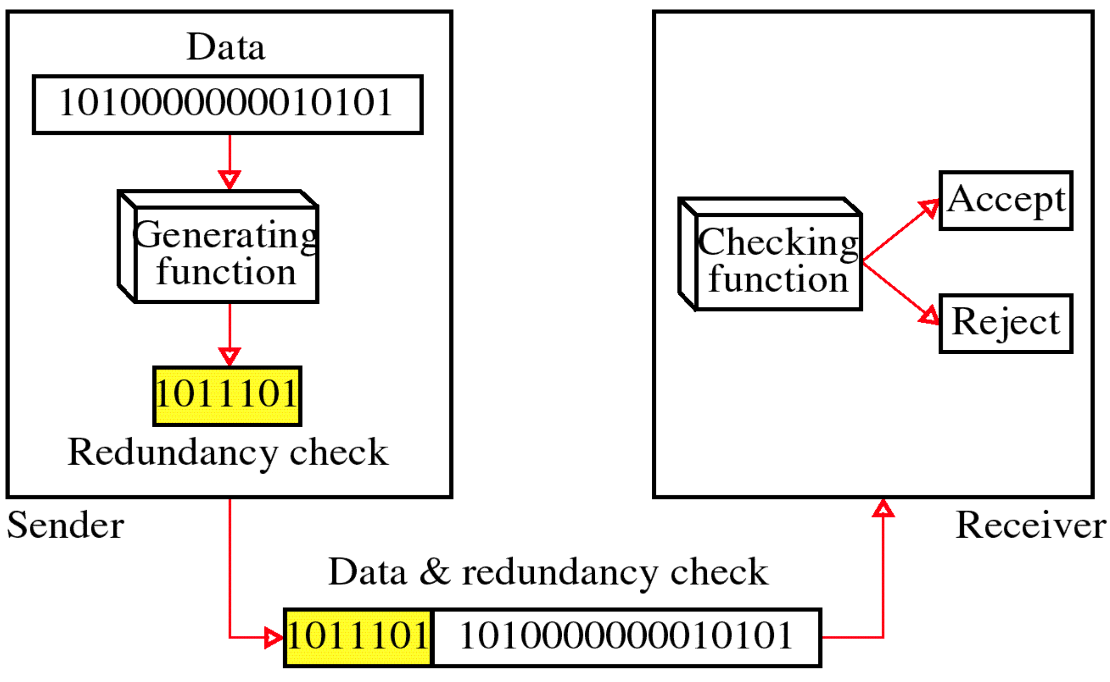
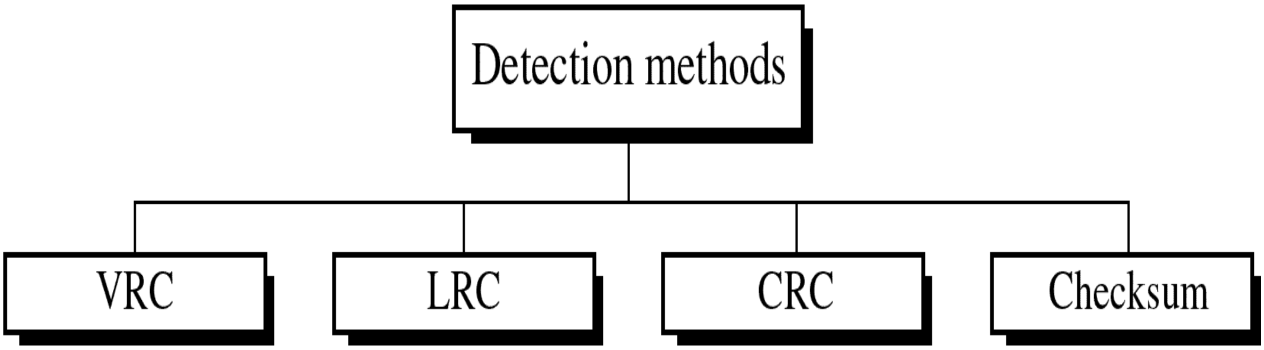



Fig. Redundancy

## Redundancy Checks Types:




**(1).** VRC - **Vertical Redundancy Check**

**(2).** LRC - **Longitudinal Redundancy Check**

**(3).** CRC - **Cyclic Redundancy Check**

(4). Checksum

### (1). VRC - Vertical Redundancy Check

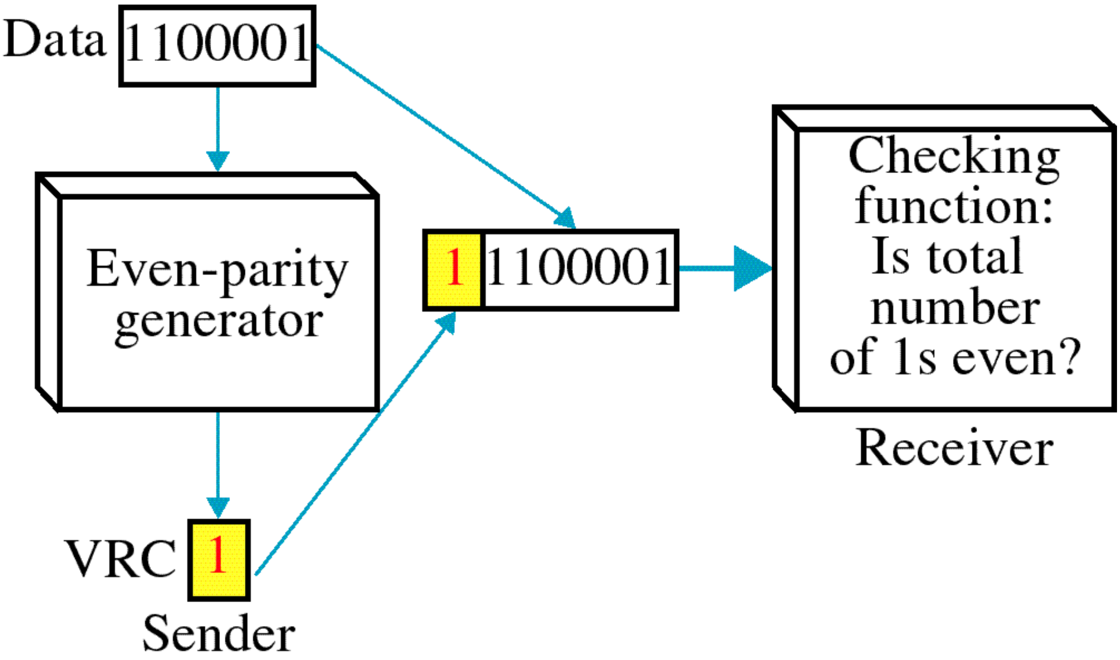



**Fig. VRC-Vertical Redundancy Check**

VRC is also referred to as character parity. With character parity, each character has its own error-detection bit called the parity bit. The parity bit is considered as a redundant bit. An n-character message would have 'n' redundant parity bits.

- It can detect single bit error.
- It can detect burst errors only if the total number of errors is odd.

## (2). LRC - Longitudinal Redundancy Check

LRC is also referred to as message parity since it is used to check error occurred within a message. With LRC each bit position has a parity bit. LRC is the result of XORing the bits present in all the characters present in a message whereas VRC is the result of XORing the bits within a single character.

- In LRC even parity is generally used, whereas with VRC odd parity is generally used.
- LCR increases the likelihood of detecting burst errors.
- If two bits in one data units are damaged and two bits in exactly the same positions in another data unit are also damaged, the LRC checker will not detect an error.

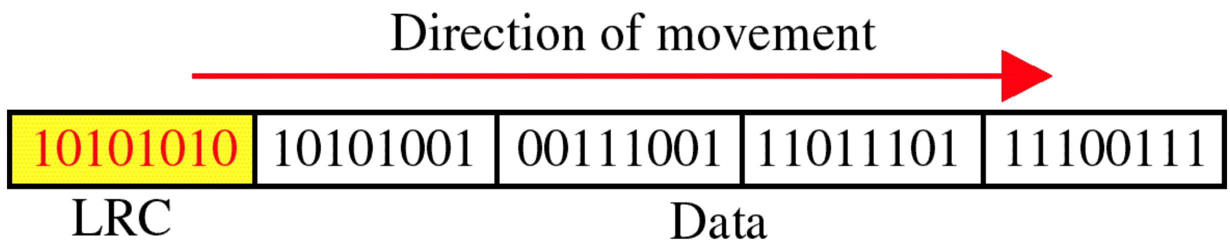



Fig.LRC - Longitudinal Redundancy Check

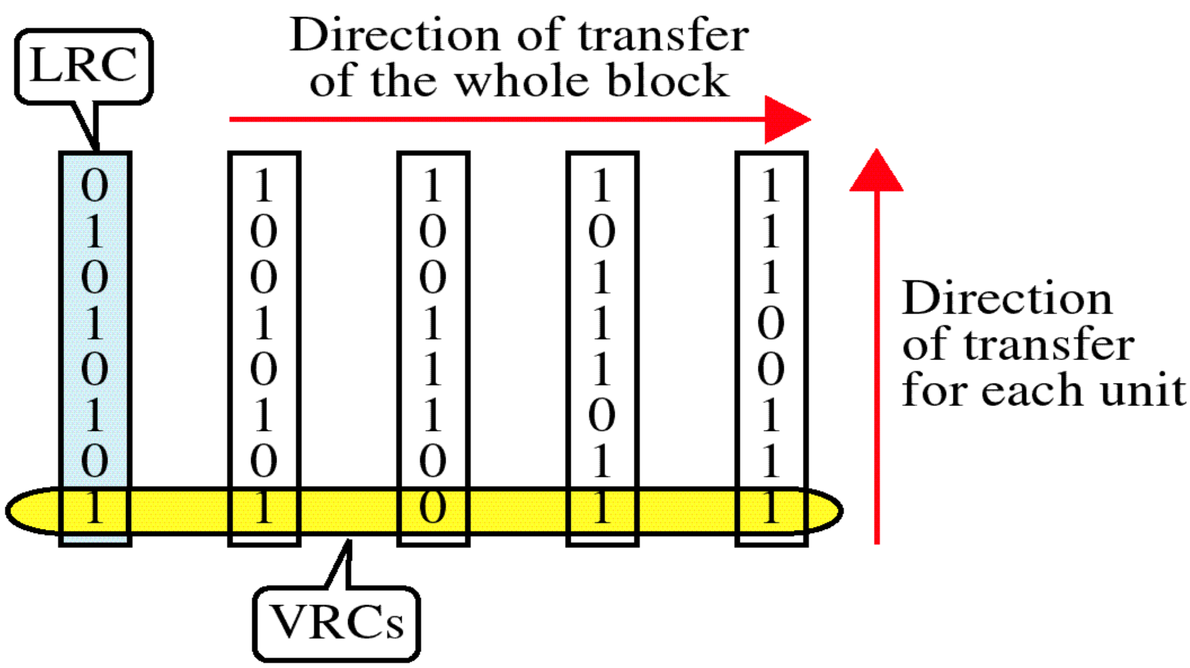



**Fig. VRC and LRC**

## (3). Checksum

The characters within a message are combined together to produce an error-checking character called as checksum, which can be as simlple as the arithmetic sum of the numerical values of all the characters in the message. The checksum is appended to the end of the message.

The receiver replicates the combining operation and determines its own checksum. The receivers checksum is compared with transmitter checksum appended with the message, and if they are the same, it is assumed that no transmission errrors have occurred.

(4). CRC - Cyclic Redundancy Check

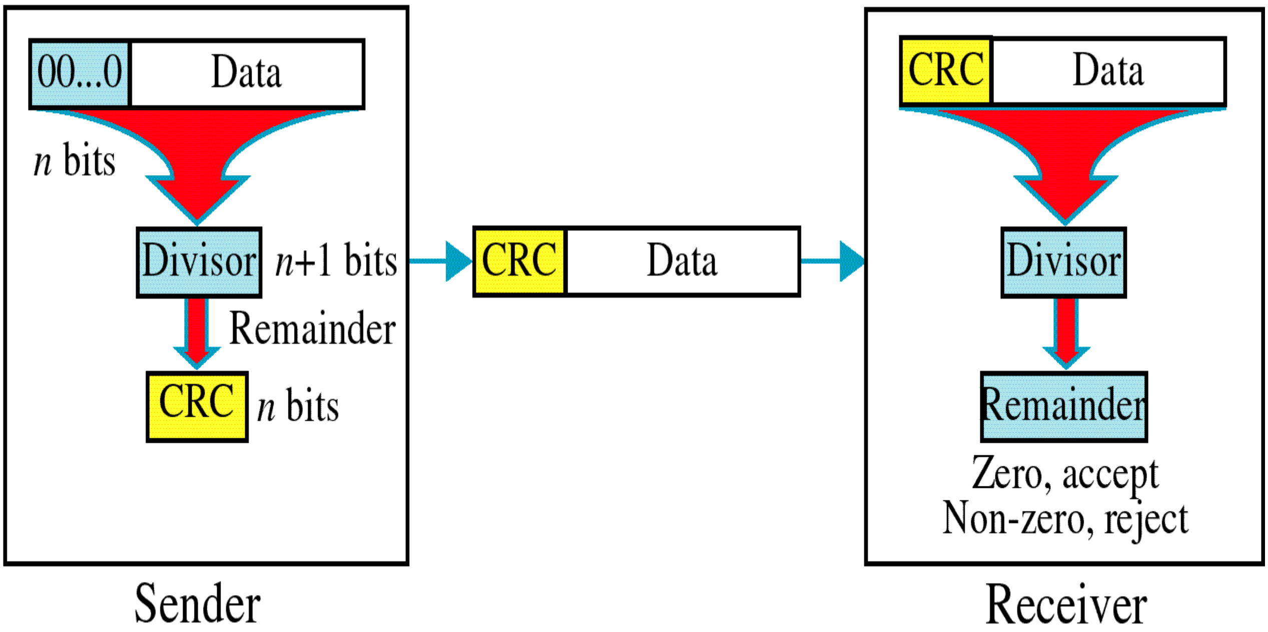
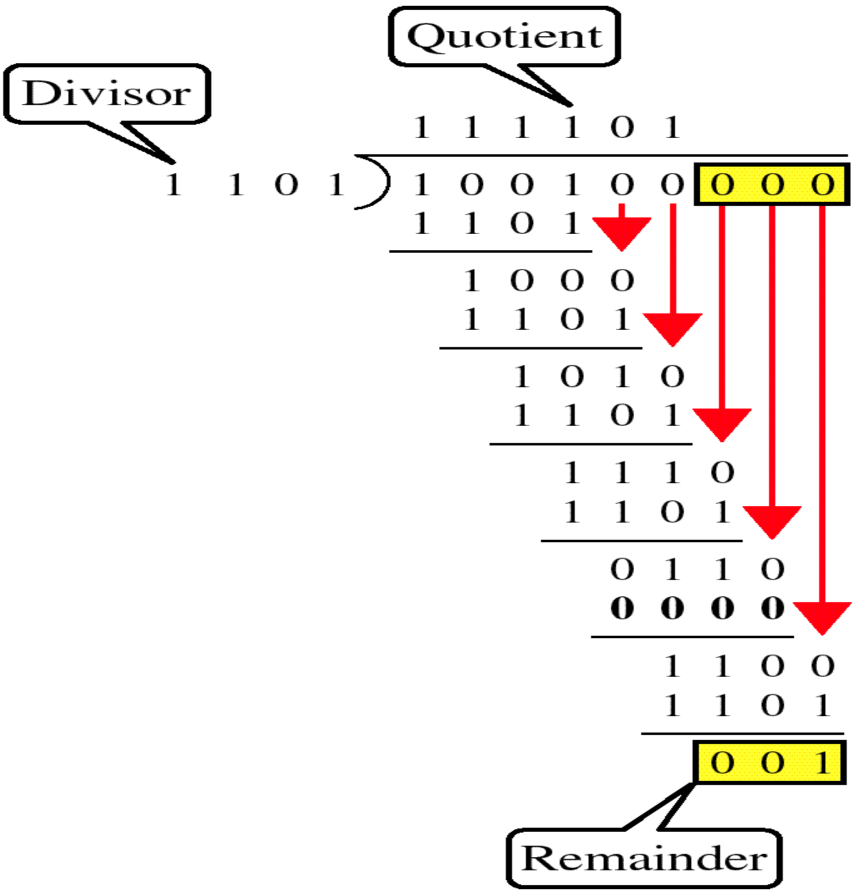



**Fig. Cyclic Redundancy Check**

It's a most reliable redundancy checking technique for errror detection is a convolutional coding scheme called **Cyclic Redundancy Check(CRC).** Given a k-bit frame or message, the transmitter generates an (n-k) bit sequence, known as a ***frame check sequence (FCS)(or) Block Check Code(BCS)***, so that the resulting frame, consisting of 'n' bits, is exactly divisible by some predetermined number. The receiver then divides the incoming frame by the same number and, if there is no remainder, assumes that there was no error.



$$\frac{G(x)}{P(x)} = Q(x) + R(x)$$

G(x) = Message Polynomial (message or Data) P(x) = Generator Polynomial

Q(x) = Quotient

R(x) = Remainder (CRC bits)

For this example

$$G(x) = x^5 + x^2$$

$$P(x) = x^3 + x^2 + x^0$$

$$G(x) = \{1,0,0,1,0,0\}$$

$$P(x) = \{1,1,0,1\}$$

Here in this example CRC bits are {0,0,1}

x

## [2]. Error Correction

*Error correction* is the detection of errors and reconstruction of the original, error-free data.

Error correction may generally be realized in two different ways:

- ***Automatic repeat request*** *(ARQ)* [Retransmission method] (sometimes also referred to as *backward error correction*): This is an error control technique whereby an error detection scheme is combined with requests for retransmission of erroneous data. Every block of data received is checked using the error detection code used, and if the check fails, retransmission of the data is requested – this may be done repeatedly, until the data can be verified.
- ***Forward error correction*** *(FEC)*: The sender encodes the data using an *error-correcting code (ECC)* prior to transmission. The additional information (**redundancy**) added by the code is used by the receiver to recover the original data. In general, the reconstructed data is what is deemed the "most likely" original data.

ARQ and FEC may be combined, such that minor errors are corrected without retransmission, and major errors are corrected via a request for retransmission: this is called ***hybrid automatic repeat-request*** *(HARQ)*.

## Forward Error Correction- Example

## Hamming Code. Hamming Code.

Hamming code is an error-correcting code used for correcting transmission errors in synchronous data streams. The Hamming code will correct only single-bit errors. It cannot correct mulitple-bit errors. Hamming bits also sometimes called as error bits are inserted in to a character at random manner.

The combination of data bits (m bits) and Hamming bits(n bits) called as Hamming code (m+n bits).

To correct an error, the receiver reverses the value of the altered bit. To do so, it must know which bit is in error.

Number of redundancy bits (Hamming bits) 'n' needed: Let data bits = *m*

Redundancy bits = *n*

Total message sent = *m*+*n*

The value of 'n' must satisfy the following relation:

$$2^n \geq m+n+1$$