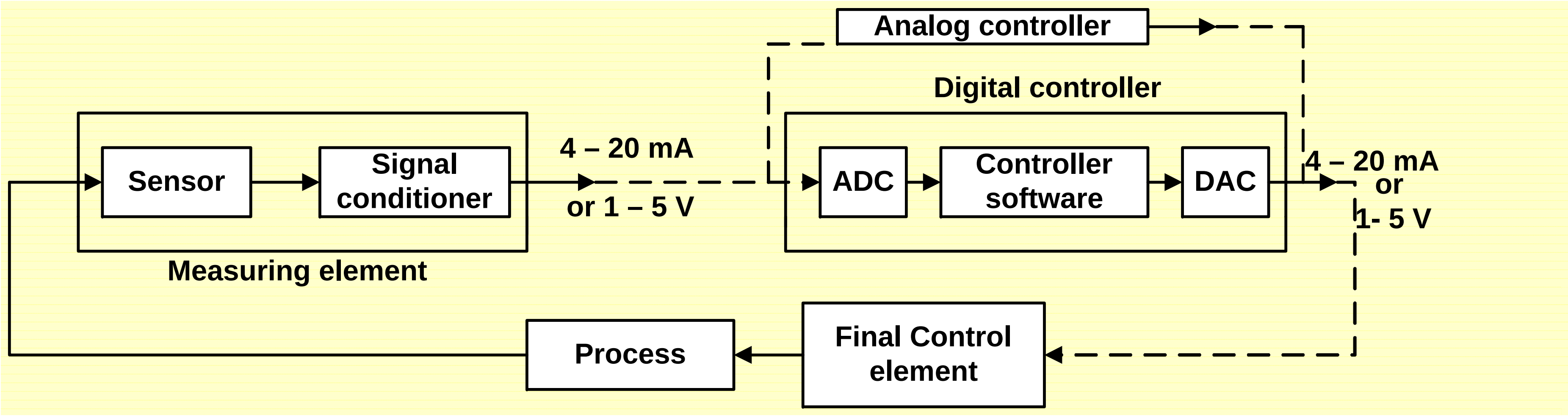
Electrical Signal Transmission Systems

Prof. Anjan Rakshit and Prof. Amitava Chatterjee
Electrical Measurement and Instrumentation Laboratory,
Electrical Engineering Department,
Jadavpur University, Kolkata, India.

Single-Loop Controllers



A single-loop controller

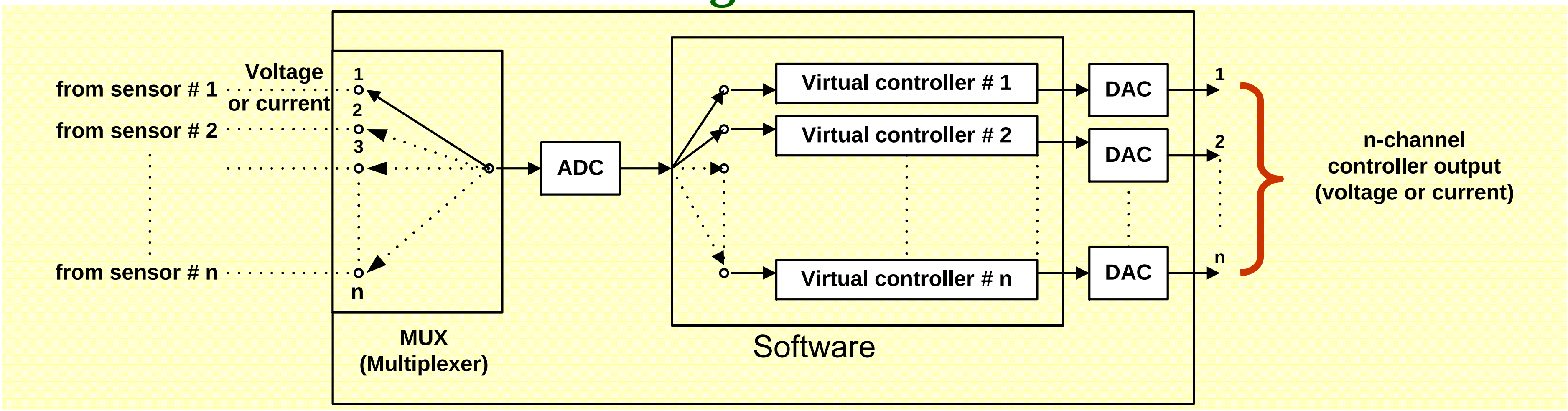
✓ Two popular modes of electrical signal transmission are:

- Voltage transmission ⇨ used for short distance
- Current transmission ⇨ used for long distance

Multi-Loop Controllers

✓ When the computer shares different control loops (for economic reasons), *multiplexers* are used for data collections.

Digital Controller

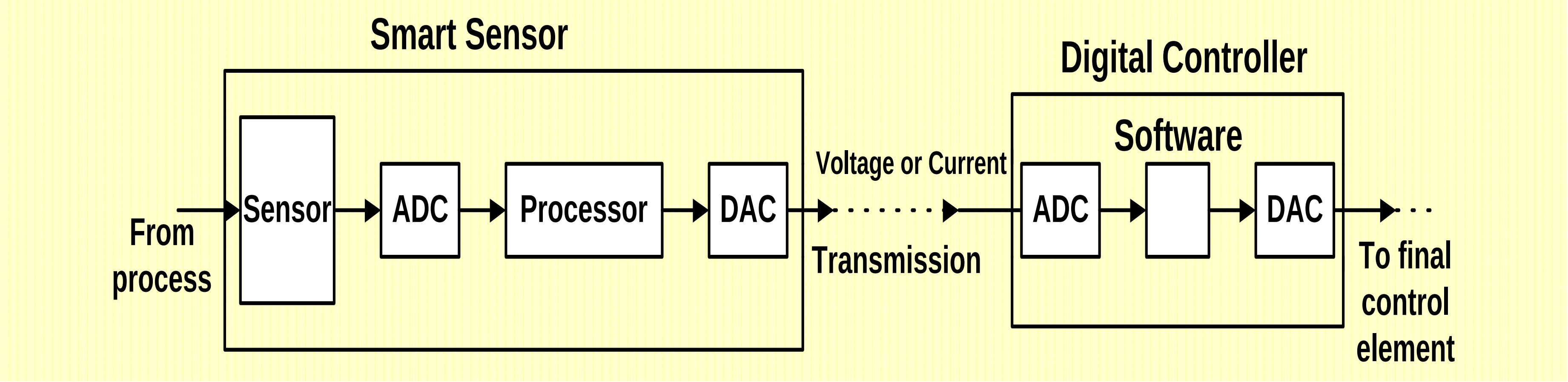


Problems:

- ➢ Sensor errors (e.g., offset, gain, non-linearity etc.) should be taken into account by the software.
- ➢ High cabling cost due to star connection/ junction at the controller.

Alternate Solution

✓ Utilize *smart sensors*, by incorporating a processor with requisite interface along with a traditional sensor.

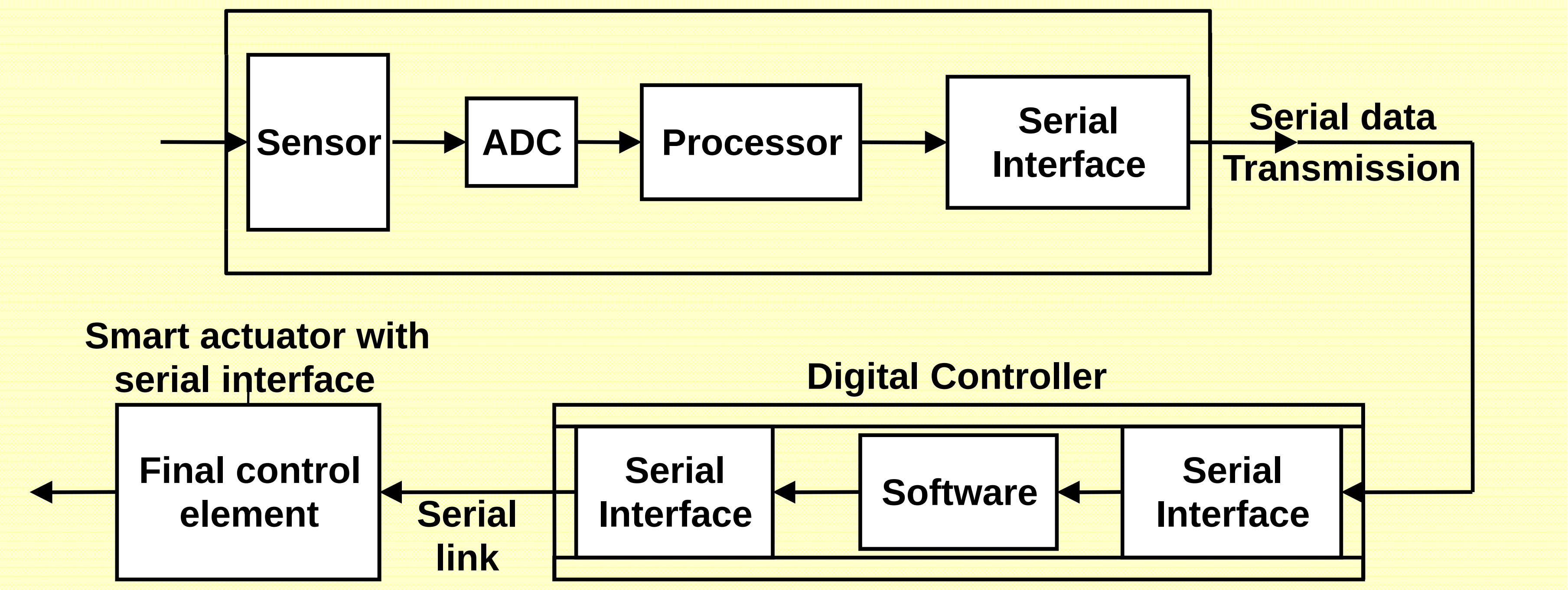


Problems:

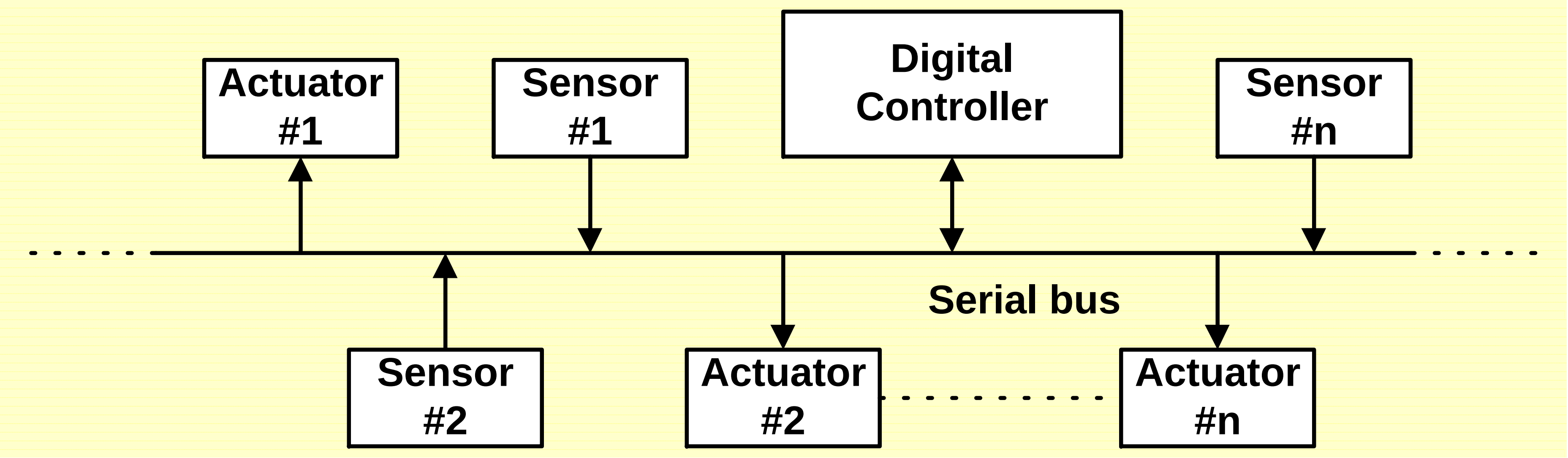
- Interface inaccuracies (e.g. ADC and DAC errors).

An Improved version of the Previous Solution

- ✓ Interface inaccuracies can be minimized with a serial digital transmission between a smart sensor and digital controller.



Adaptation for Multi-Loop Control



Features:

- ✓ A multiplexed serial data transmission system (bus) is used to minimize the cabling cost.
- ✓ Proper communication protocol is necessary for selective transmission of data from sensor-to-controller and controller-to-final control element .

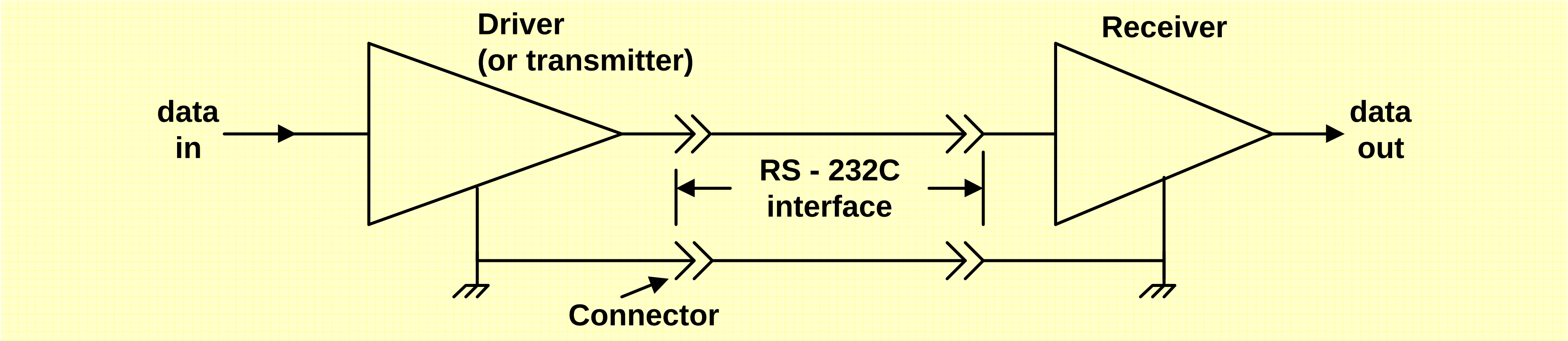
Serial Interface Standards

Standard	Origin	Type	Max. Length	Max. Data Rate	Number of Drivers and Receivers
RS – 232C (V24)	EIA (CCITT)	Single ended (unbalanced)	50 ft (at 20 kb/s)	20 kb/s	1 – driver 1 – receiver
RS – 423	EIA	Single ended (unbalanced)	4000 ft (< 1 kb/s)	100 kb/s (upto 30 ft)	1 – driver 10 – receivers
RS – 422	EIA	Differential (balanced)	4000 ft (< 100 kb/s)	10 Mb/s (upto 40 ft)	1 – driver 10 – receivers
RS – 485	EIA	Differential (balanced)	4000 ft (< 100 kb/s)	10 Mb/s (upto 40 ft)	32 – drivers 32 – receivers

EIA :	**Electronics Industries Association (USA)**
CCITT:	**International Telephone and Telegraph Consultative Committee**

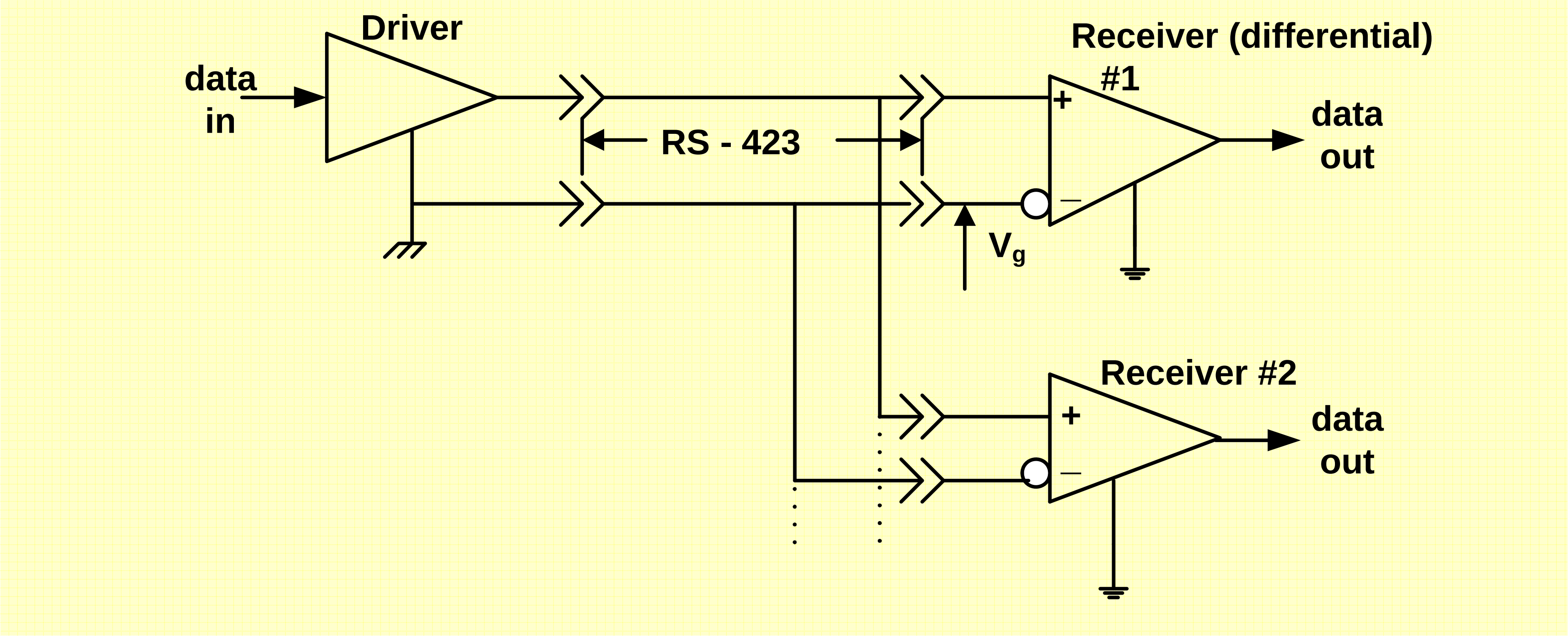
Serial Interface Standards

RS-232C



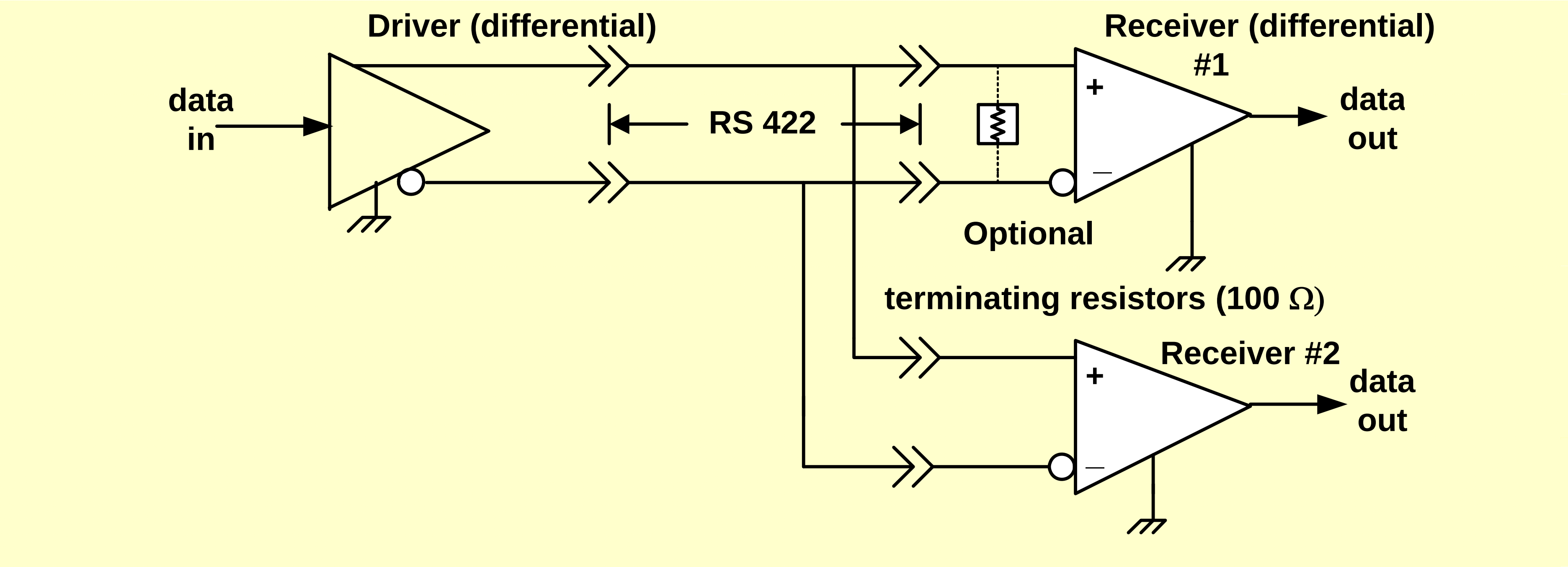
Serial Interface Standards

RS-423



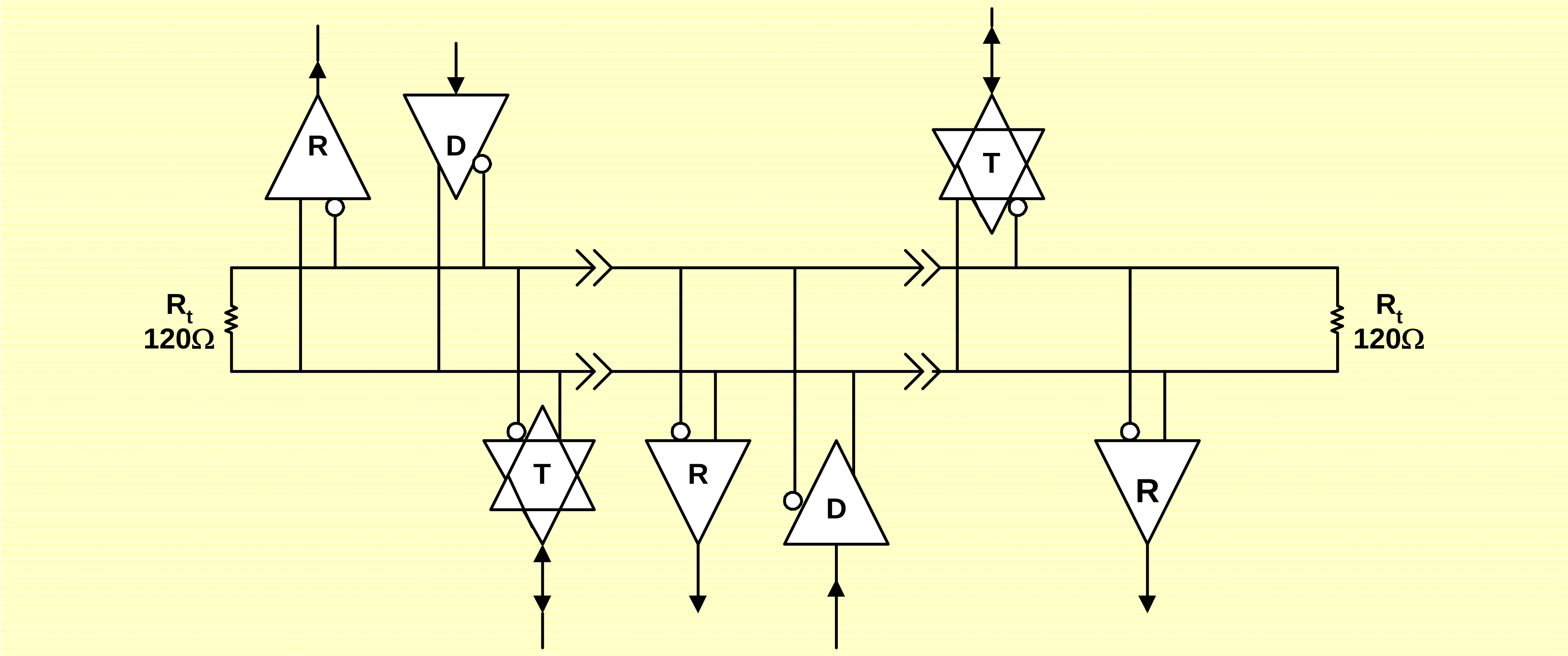
Serial Interface Standards

RS-422



Serial Interface Standards

RS-485



R_t : terminating resistor; R: receiver; D: driver; T: transceiver [Transmitter(driver) + receiver]

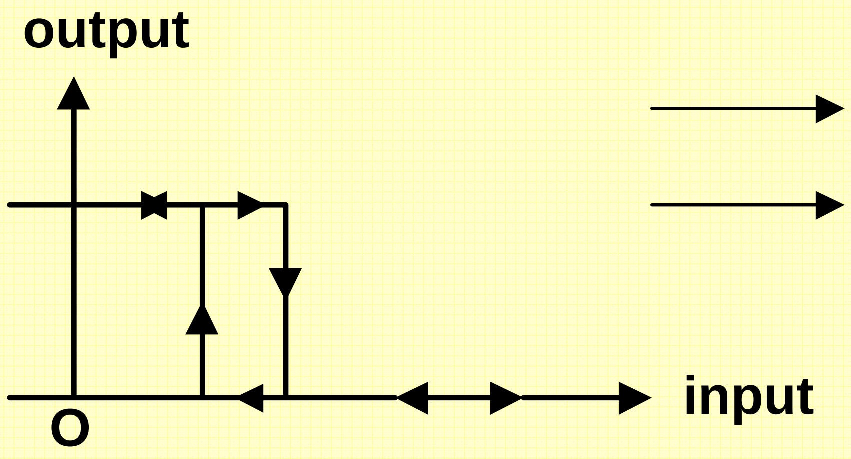
- ✓ In RS – 485, drivers can withstand bus faults and bus contention

Serial Data Transmission in presence of Noise

✓ In *differential or balanced* data transmission systems, common mode noise voltages (with respect to ground) are nullified.

✓ For *both balanced and unbalanced* transmission systems, receivers are provided with adequate *hysteresis to reject interference*.

Provision of Hysterisis with Asymmetry

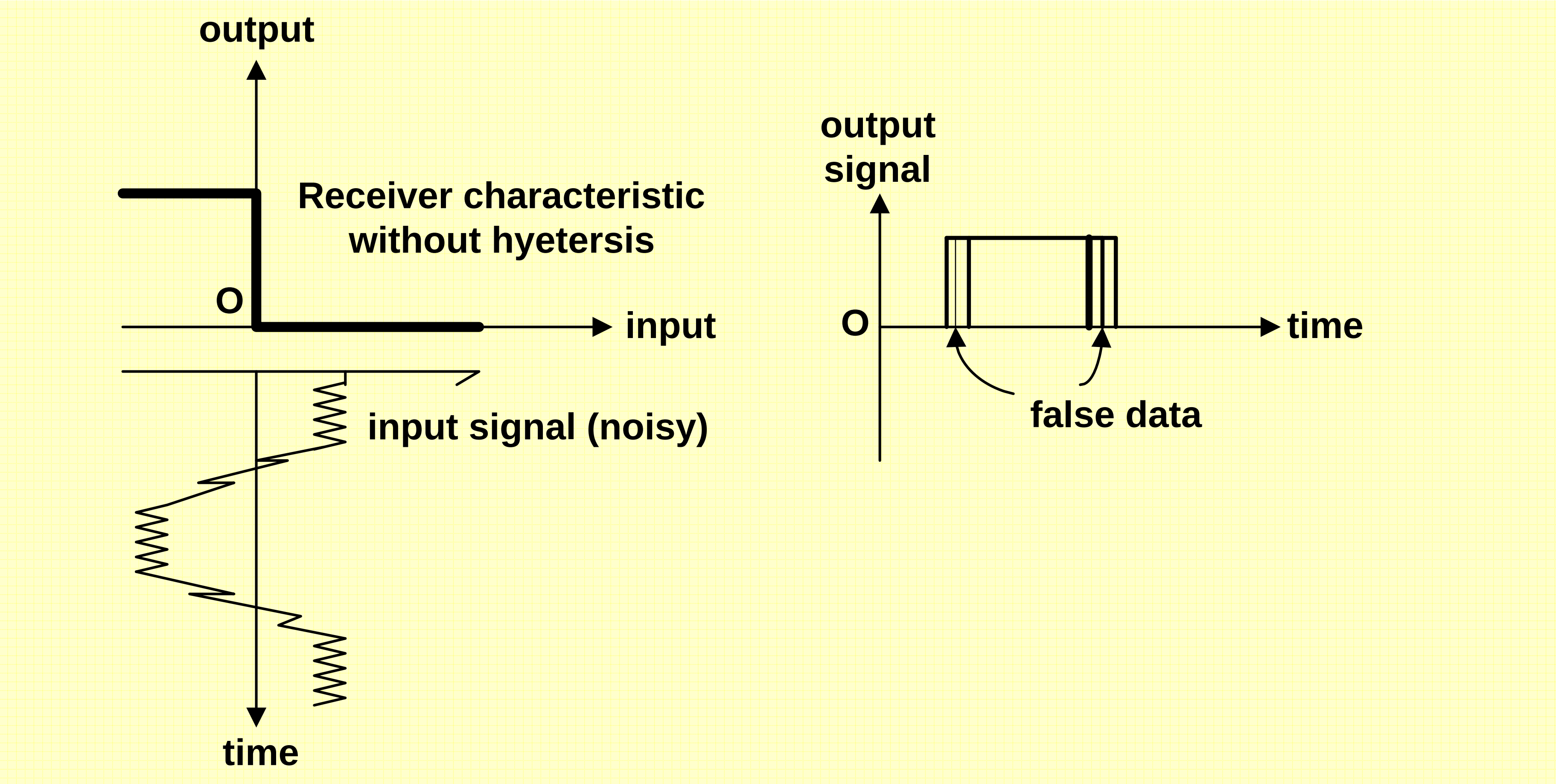


A failsafe feature

here output will be in high state under open input condition

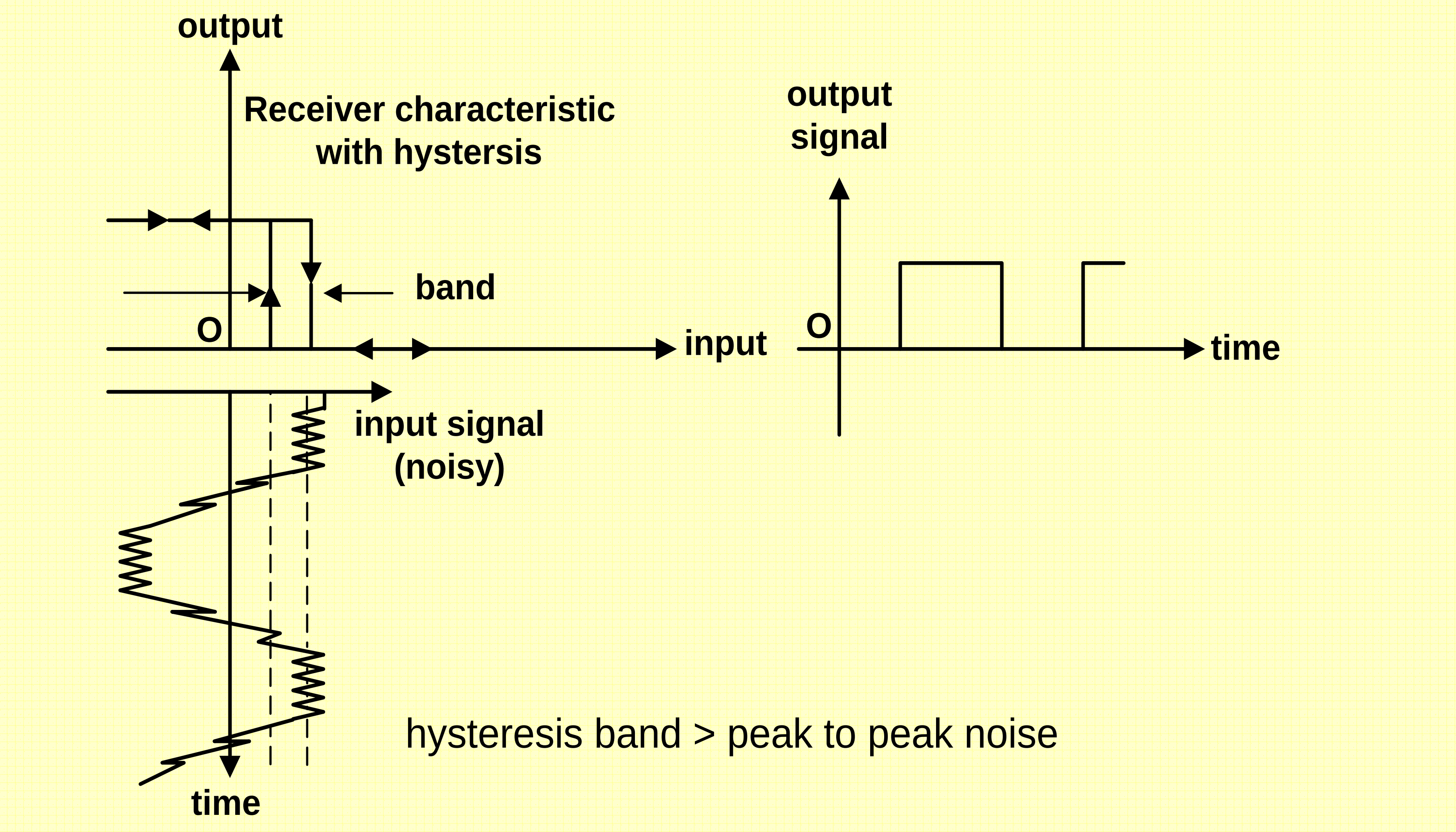
Serial Data Transmission in presence of Noise

A System Without Hysterisis



Serial Data Transmission in presence of Noise

A System With Hysterisis



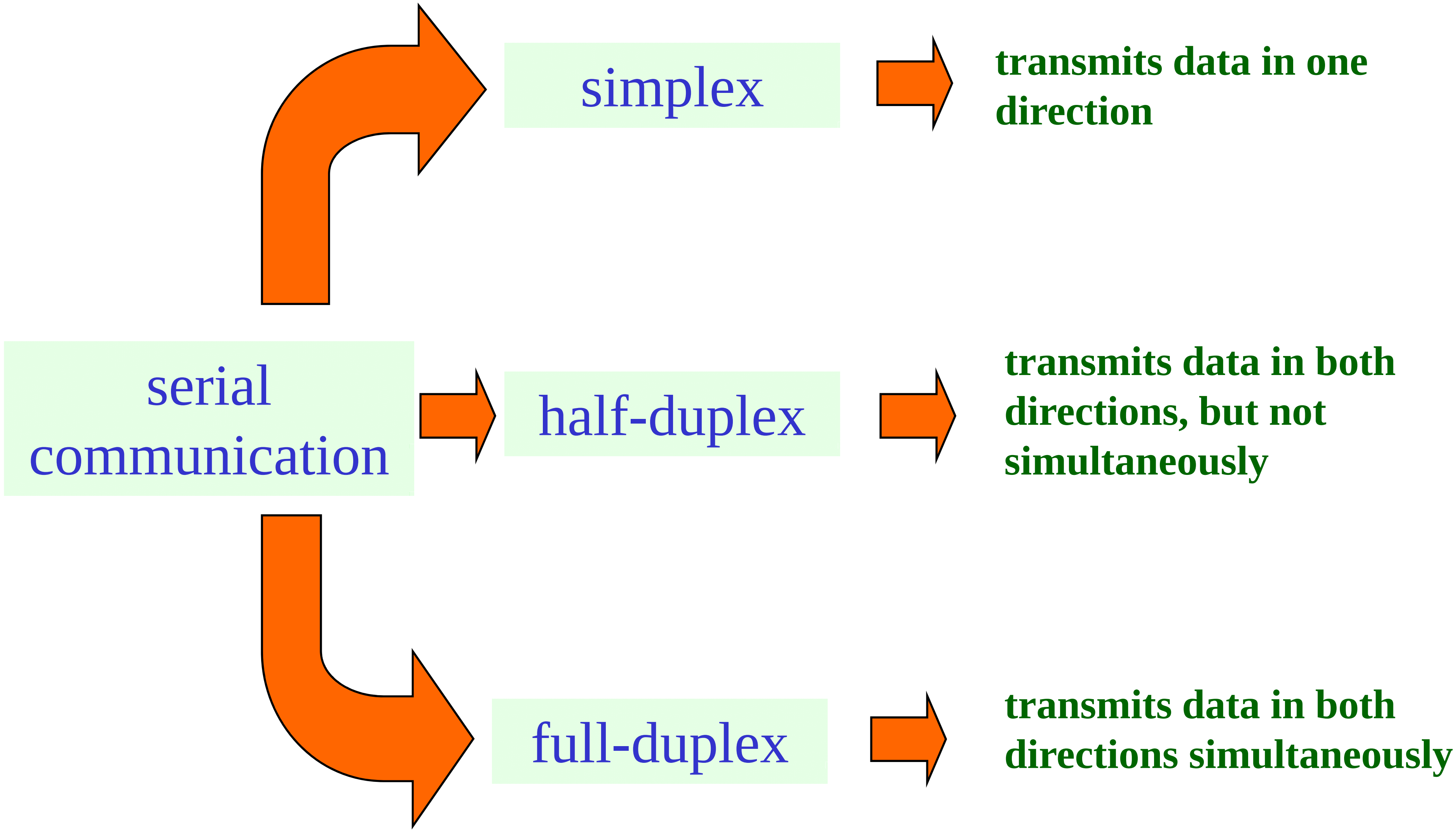
hysteresis band > peak to peak noise

Electrical Specifications of Serial Interface Standards

	RS – 232C	RS – 423	RS – 422	RS – 485
Driver output maximum voltage	± 25V	± 6V	- 0.25V to + 6V	- 7V to + 12V
Driver output loaded Signal level unloaded	± 5V ± 15V	± 3.6V ± 6V	± 2V ± 5V	± 1.5V ± 5V
Driver load impedance	3K to 7K	450Ω min	100 Ω	54 Ω
Slew rate	30V/μS*			
Receiver input voltage range	± 15V	± 12V	± 7V	– 7V to + 12V
Receiver input sensitivity (min voltage)	± 3V	± 200 mV	± 200 mV	± 200 mV
Receiver input resistance	3K to 7K	4K min	4K min	12K min

*As the line is open ended, effects of line reflections are minimized with limited slew rate

Asynchronous Serial Data Communication



serial communication

simplex

transmits data in one direction

half-duplex

transmits data in both directions, but not simultaneously

full-duplex

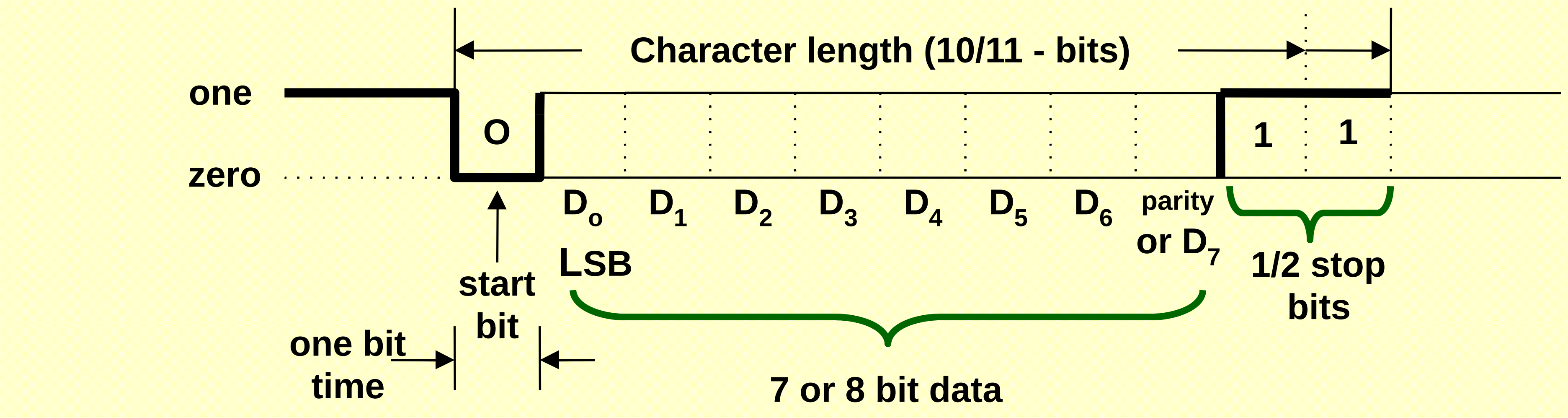
transmits data in both directions simultaneously

Asynchronous Serial Data Communication

✓ In *asynchronous transmission*, inter character spacing is not fixed. Each data character starts with *a start bit* with *one or two stop bits* at the end. Each character is identified by its start and stop bits – thus *it can be sent at any time* (i.e. in an asynchronous manner).

Asynchronous Serial Data Communication

Data Format for Asynchronous Transmission

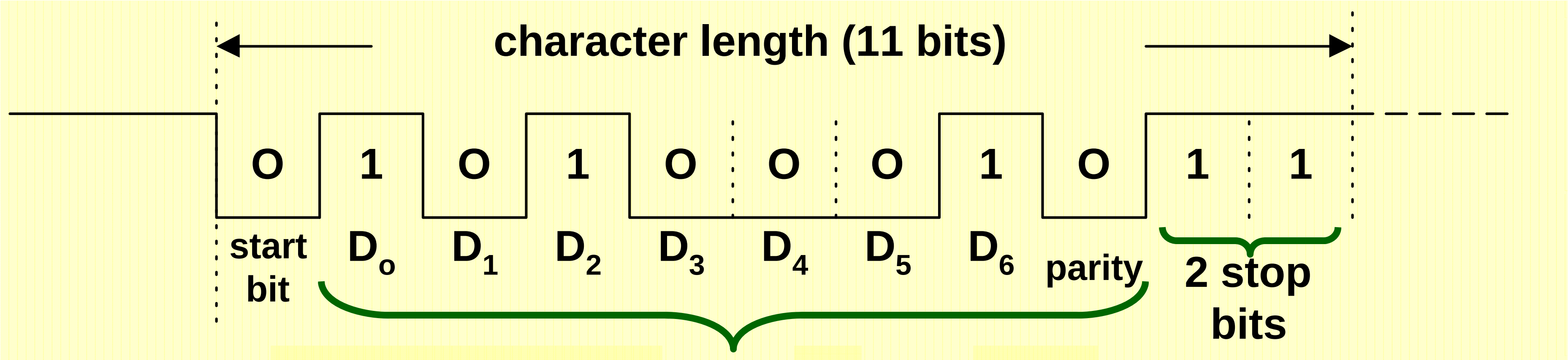


✓*Parity Bit* - set as odd or even – to identify one-bit error per character during transmission.

Asynchronous Serial Data Communication

Data Format for Asynchronous Transmission

An Example:



number of ‘1’s → 3 → odd

7 bit ASCII character ‘E’ with odd parity and two stop bits

‘E’: 69 d = 45 h

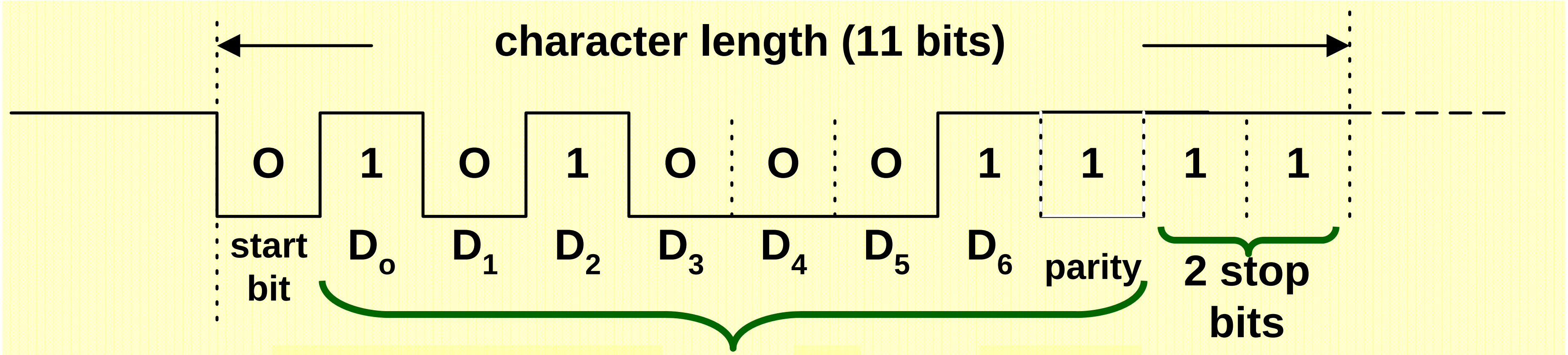
✓**overall parity of 7-bit character ‘E’**

= total number of ones including parity bit = 3 → odd.

Asynchronous Serial Data Communication

Data Format for Asynchronous Transmission

Another Example:



number of ‘1’s → 4 → even

7 bit ASCII character ‘E’ with even parity and two stop bits

‘E’: 69 d = 45 h

✓**overall parity of 7-bit character ‘E’**

= total number of ones including parity bit = 4 → even.

RS-232C based Data Transmission Systems

Data Transmission Using MODEMs

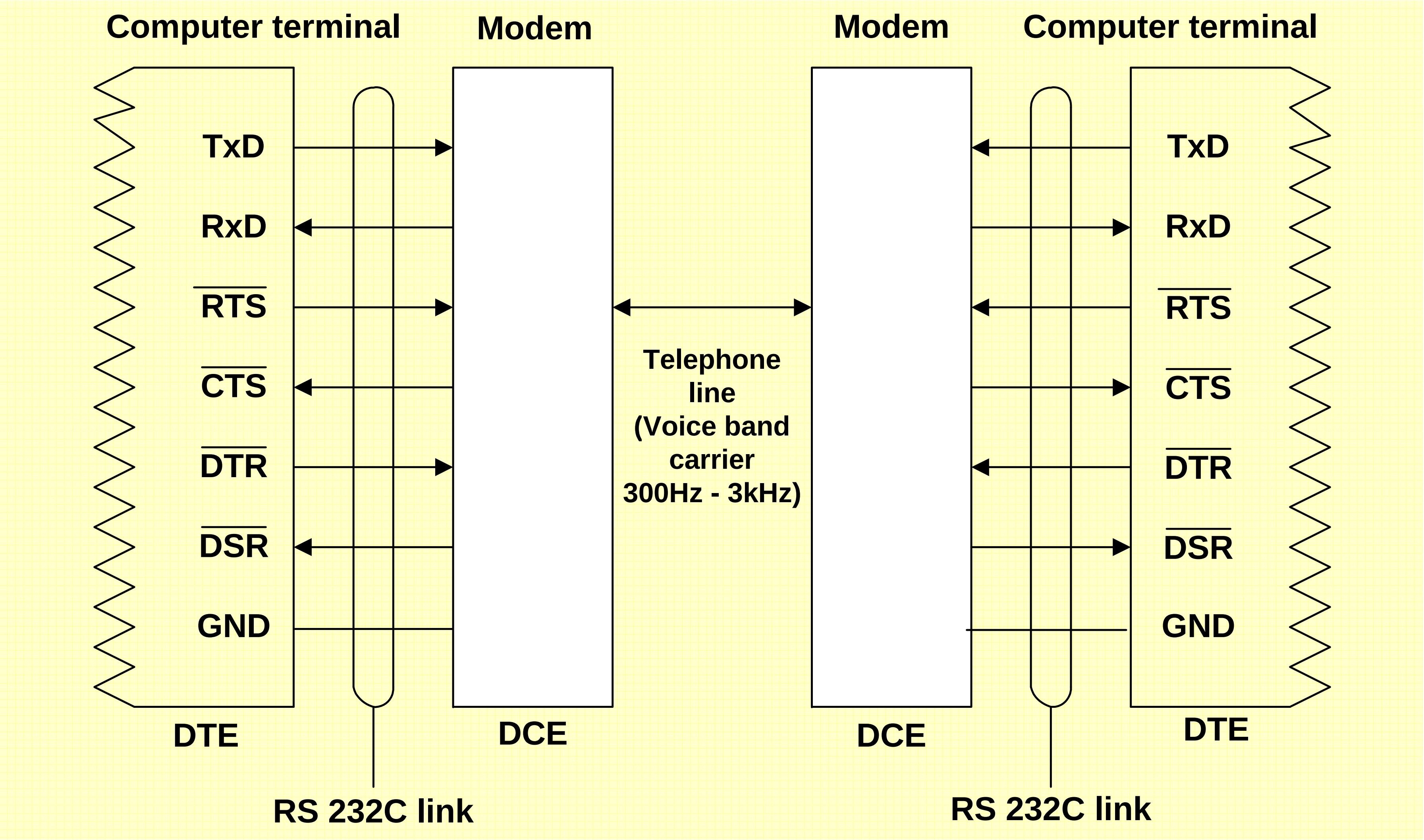
✓MODEM stands for (Modulator + Demodulator)

✓Modulation Techniques:

- AM (Amplitude Modulation)
- FSK (Frequency Shift Keying)
- PSK (Phase Shift Keying)
- ….

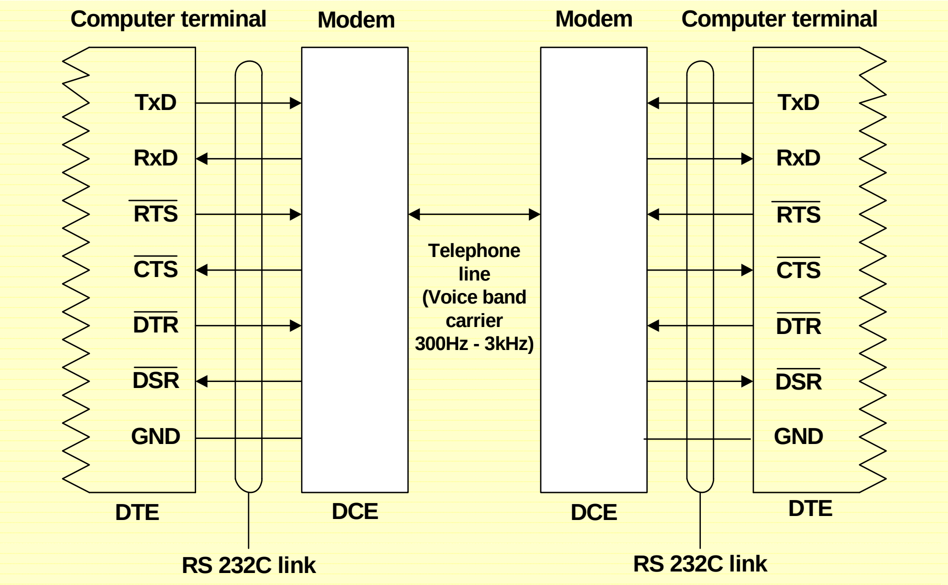
RS-232C based Data Transmission Systems

Data Transmission Using MODEMs



RS-232C based Data Transmission Systems

Data Transmission Using MODEMs



RS 232C – Pin Connections (DTE) (Male)

Name	DB 25 pin no.	DB9 pin no.
TxD	2	3
RxD	3	2
GND	4	7
$\overline{\text{RTS}}$	5	8
$\overline{\text{CTS}}$	6	6
$\overline{\text{DSR}}$	20	4
$\overline{\text{DTR}}$	7	5

DTE connector : 25 pin Male

DCE connector : 25 pin Female

DTE: Data Terminal Equipment; DCE: Data Communication Equipment

TxD: Transmitter data [zero : + 12V, one : – 12V (typical value)] → for all signal lines

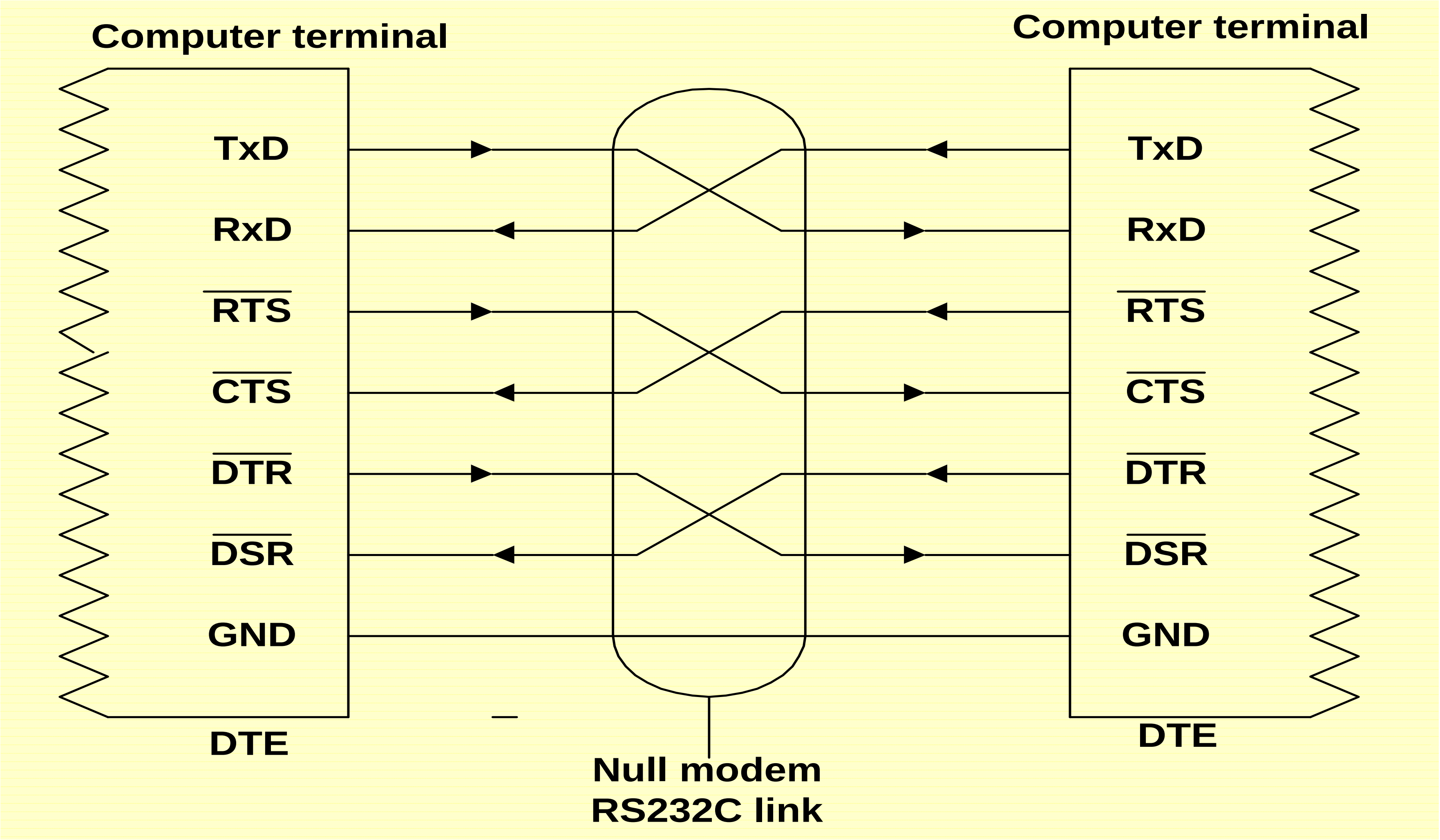
RxD: Receiver data [--do--] $\overline{\text{RTS}}$ **:Request to send [--do--]**

$\overline{\text{CTS}}$ **:Clear-to-send [--do--]** $\overline{\text{DTR}}$ **:Data terminal ready [--do--]**

$\overline{\text{DSR}}$ **:Data-set-ready [--do--]**

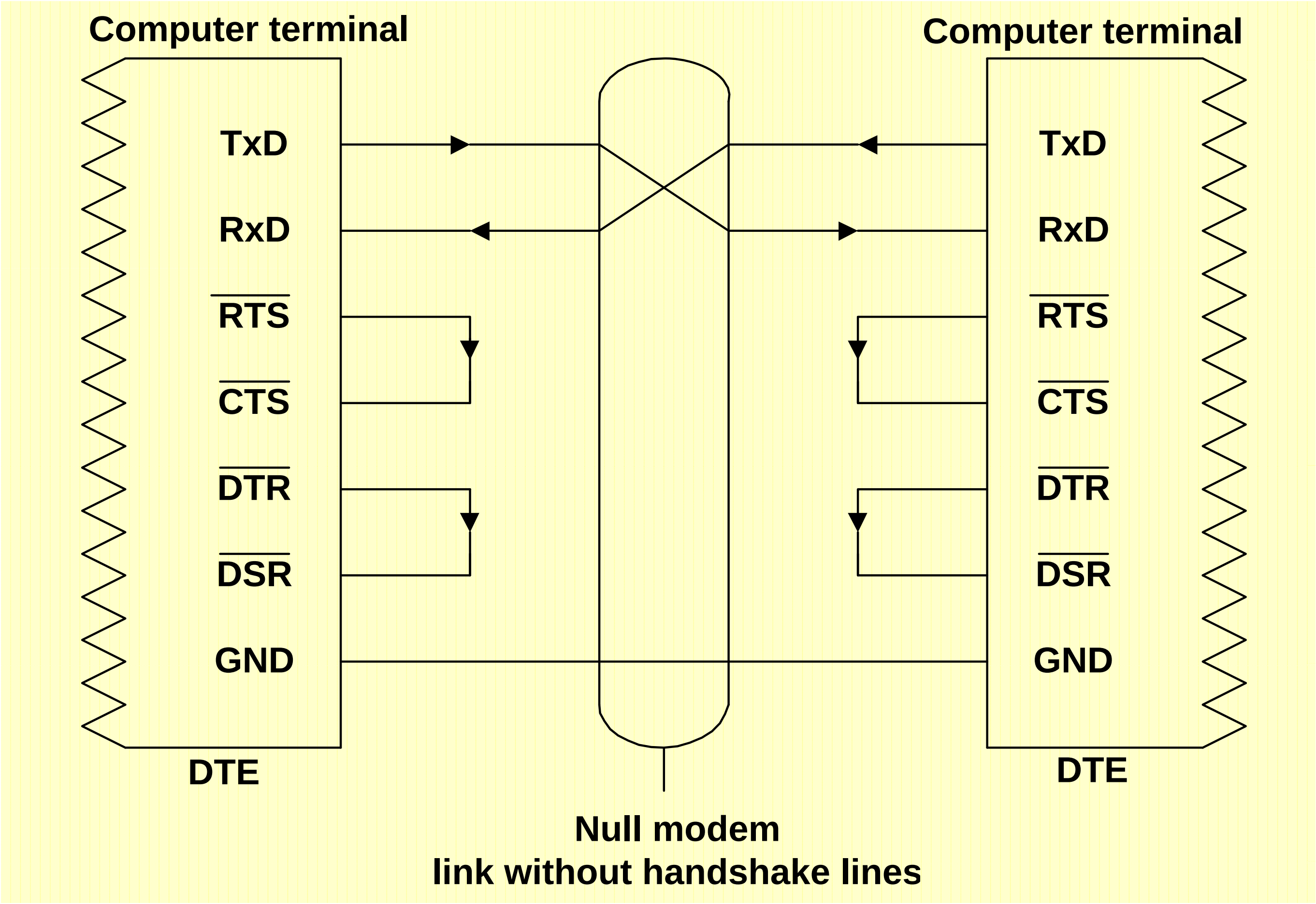
RS-232C based Data Transmission Systems

- Data Transmission Without MODEMs (Null Modem)



RS-232C based Data Transmission Systems

Data Transmission Without MODEMs and Without Handshaking



✓ If hardware handshaking is not available, software based handshaking is normally used through a suitable half-duplex communication protocol.

Transmission Rate

Baud Rate → **It indicates the rate at which serial data is being transferred. It is defined as the *number of unit time intervals per second* in the transmission.**

An Example:

✓**If a maximum of ten characters with a data format using 7 bits per character, parity bit and 2 stop bits (i.e. 11 bit-times per character, considering the start bit) are transmitted each second, then *baud rate*:**

11 bit-times per character × 10 characters per second

= 110 baud

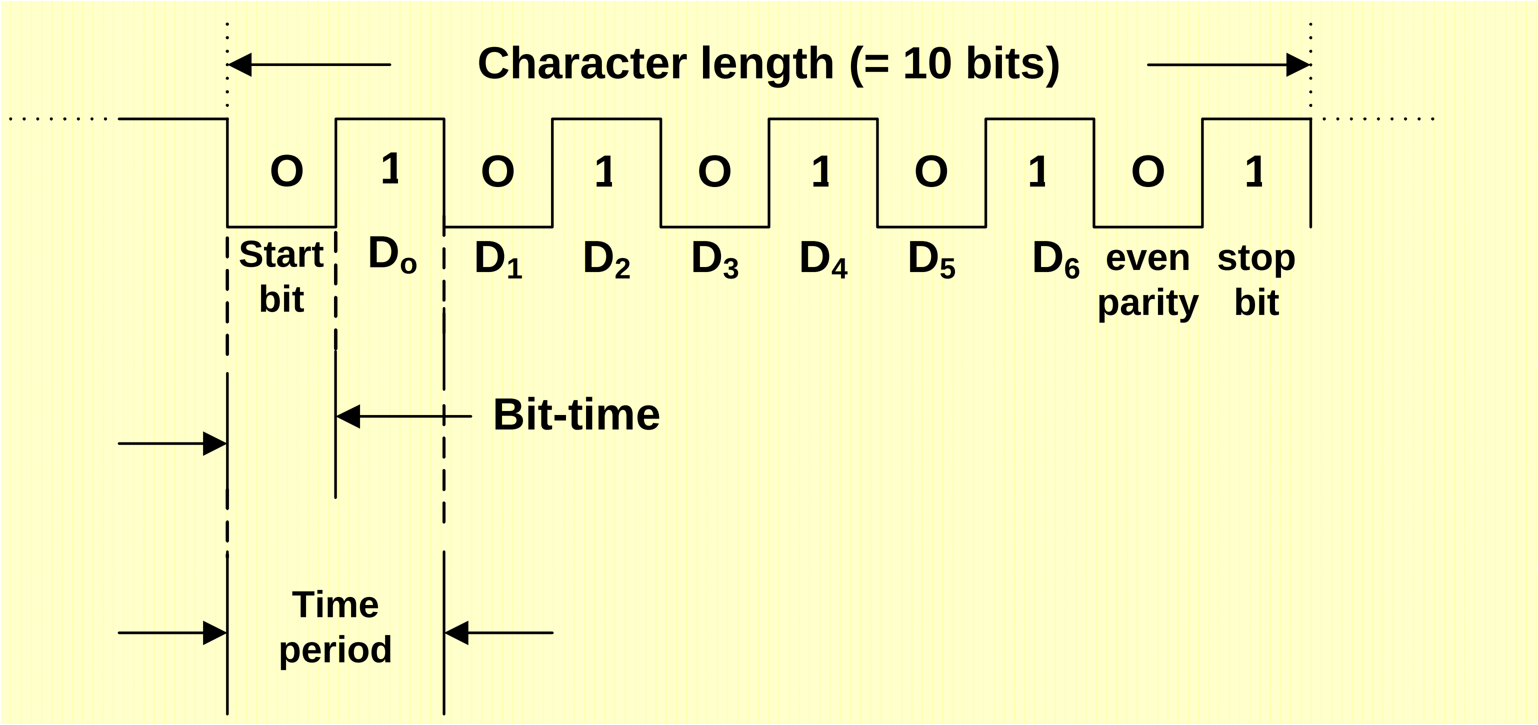
i.e. baud rate = 1/ bit-time

✓**Note: Baud rate and Bit rate (i.e. frequency) are not same.**

Transmission Rate

An Example:

Consider the following character with even parity and one stop bit



Baud Rate = 1/bit-time

Bit Rate (frequency)

= (1/Time Period)

Here, Time Period = 2 × bit-time,

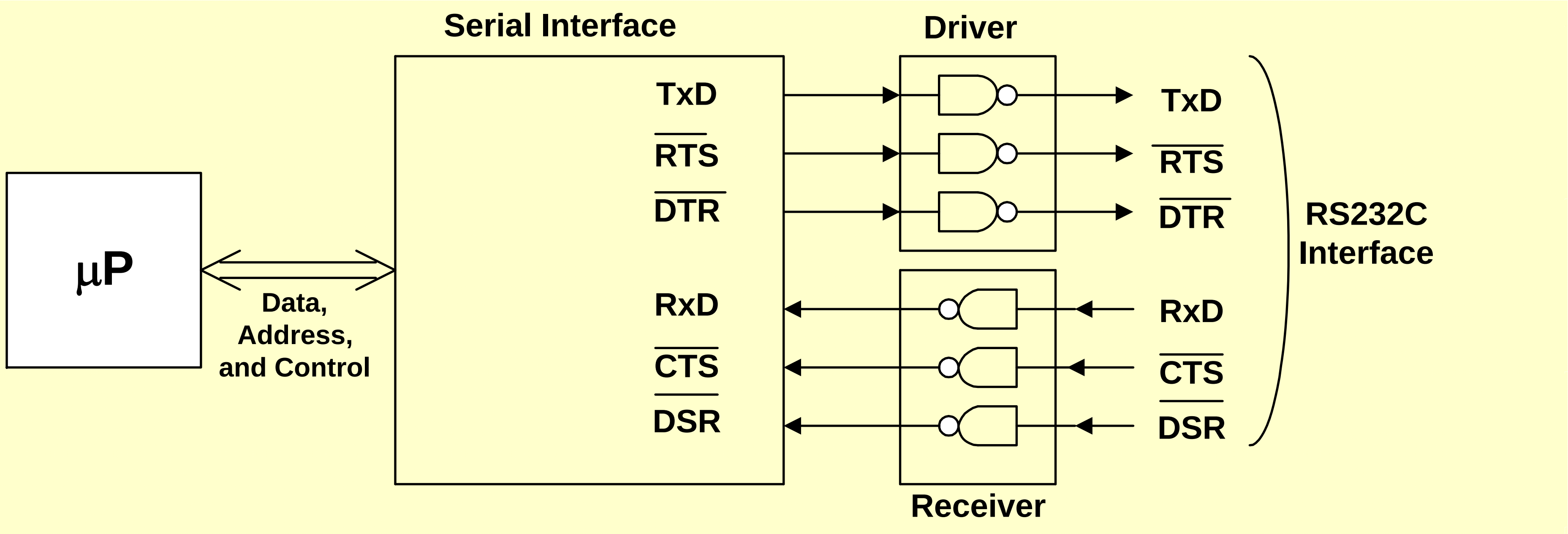
Hence, Bit Rate = ½ × Baud Rate

Transmission Rate

Standard Baud Rates

- ✓ 110 Baud
- ✓ 300 Baud
- ✓ 600 Baud
- ✓ 1200 Baud
- ✓ 2400 Baud
- ✓ 4800 Baud
- ✓ 9600 Baud
- ✓ 19.2 K baud
- ✓ ……

Microprocessor Interface



Thank You