

CPE/EE 421/521  
Fall 2004  
Chapter 9 – The Serial  
Input/Output Interface

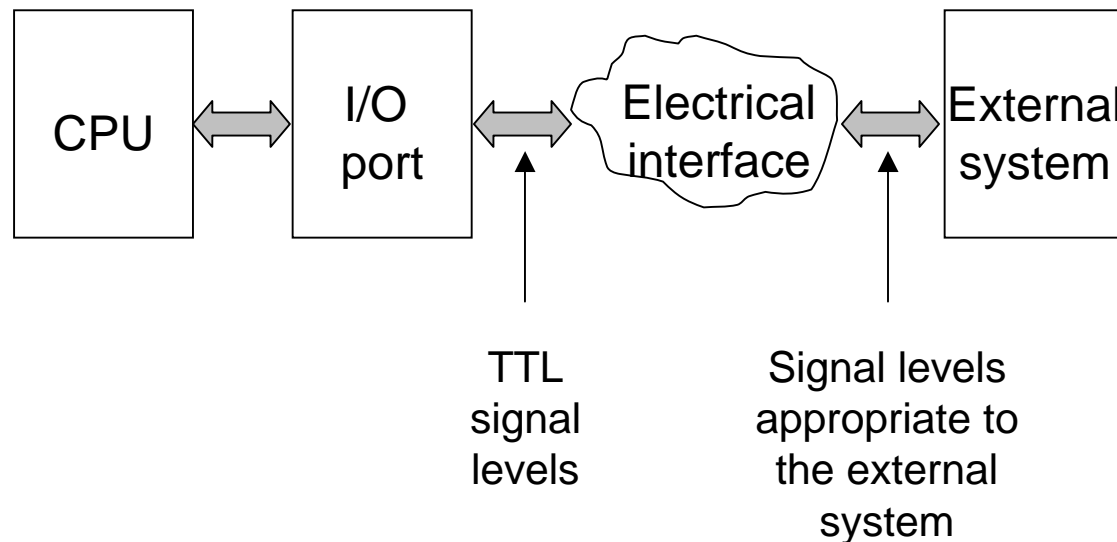
Dr. Rhonda Kay Gaede

**UAH**

## Background Material - Microprocessor Interfaces

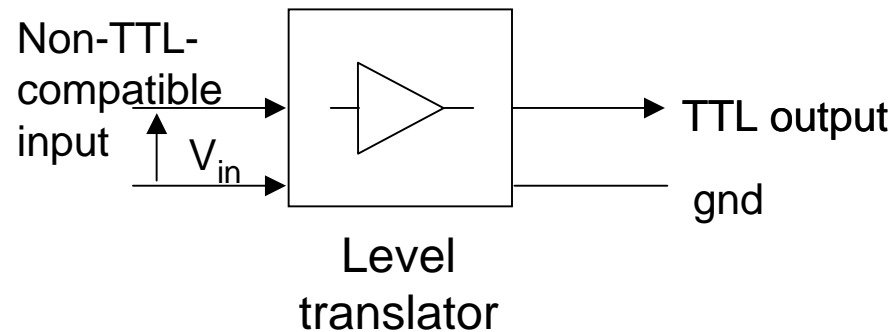
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- TTL levels within CPU
- All digital signals either below  $V_{OL}$  or above  $V_{OH}$
- Real-world signals
- Example: Serial interface  $-12V$  to  $+12V$

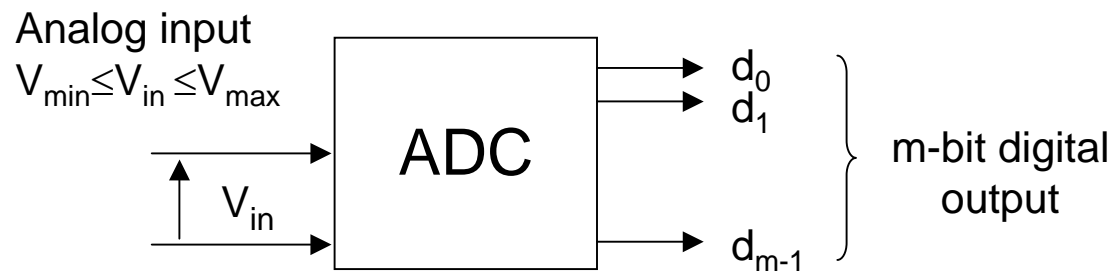


## Background Material - Level Translation and Type Conversion

- Electrical interface between two-level non-TTL signal and CPU input port



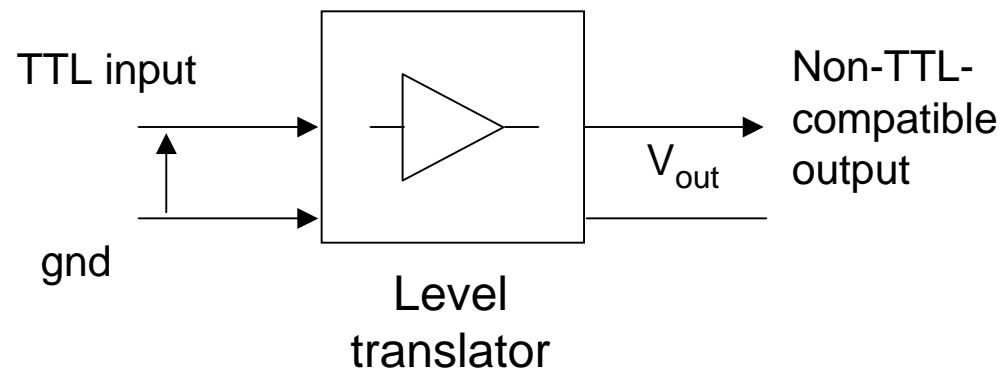
- Electrical interface between analog input and a quantized  $2^m$ -level output



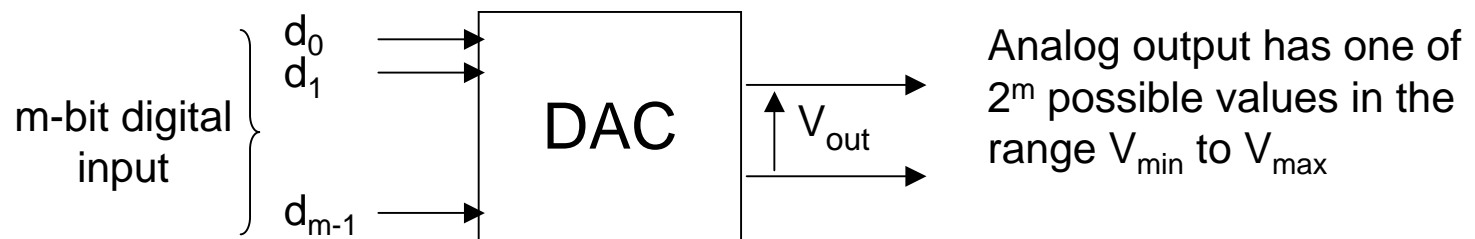
## Background Material - Level Translation and Type Conversion

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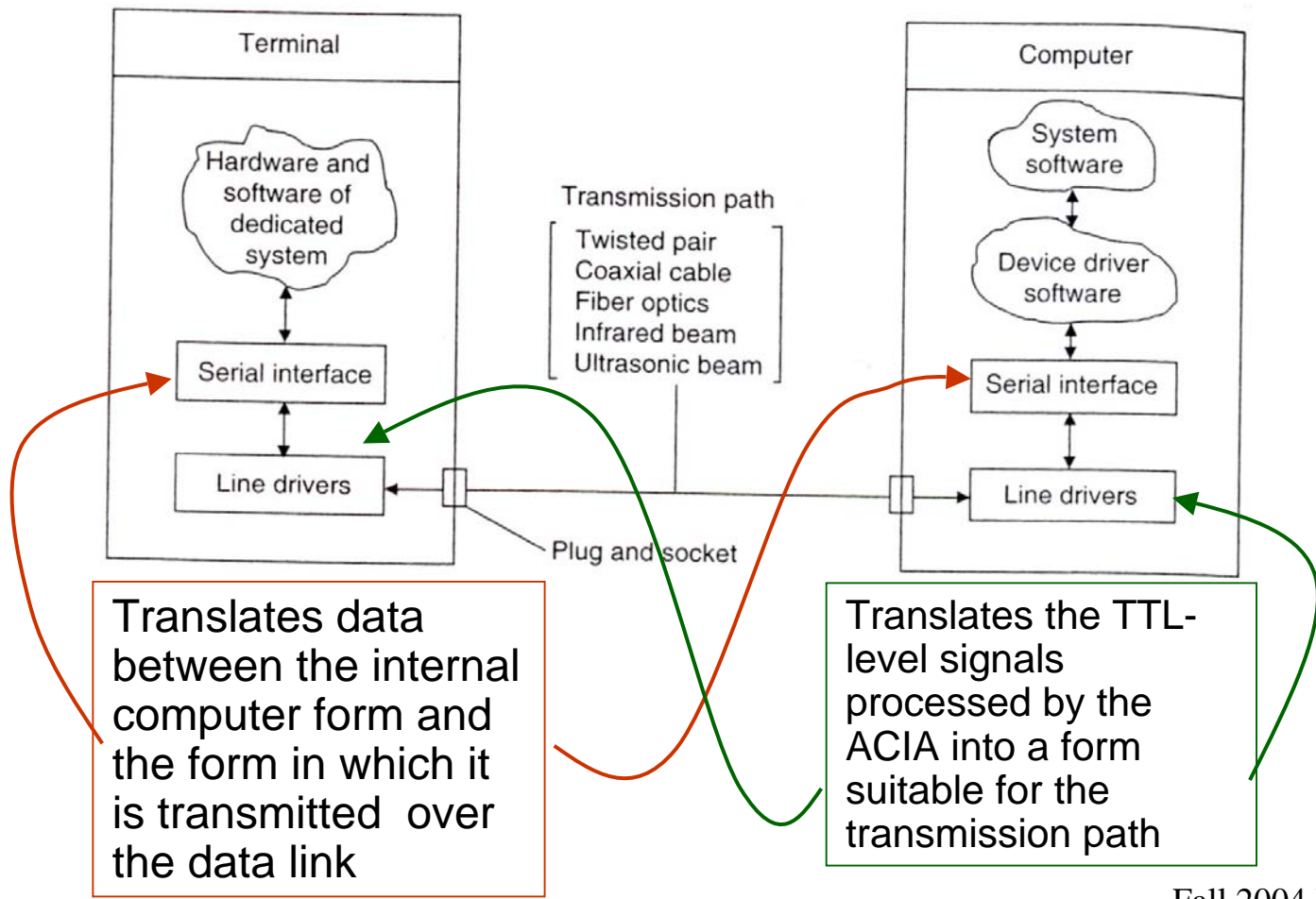
- Electrical interface between CPU input port and two-level non-TTL signal



- Electrical interface between a quantized  $2^m$ -level input and an analog output



# Introduction - Serial I/O Interface Functional Units



## 9.1 Asynchronous Serial Data Transmission

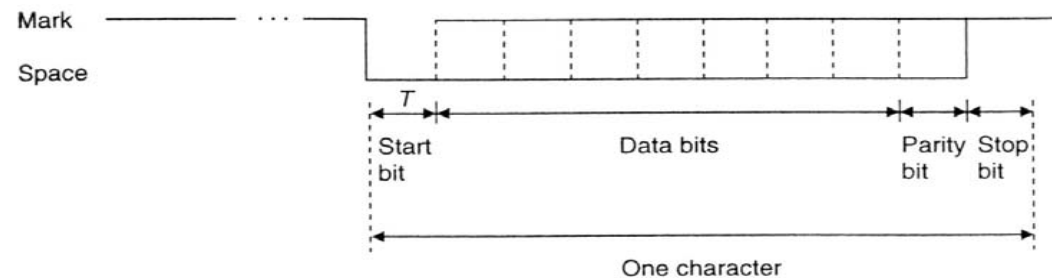
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- Asynchronous
  - Transmitted and received data are not synchronized over any extended period
  - No synchronization between receiver and transmitter clocks
- Serial
  - Usually character oriented
  - Data stream divided into individual bits at the transmitter side
  - Individual bits are grouped into characters at the receiving side
- Information is usually transmitted as ASCII-encoded characters
  - 7 or 8 bits of information plus control bits

## 9.1 Asynchronous Serial Data Transmission – Data Format

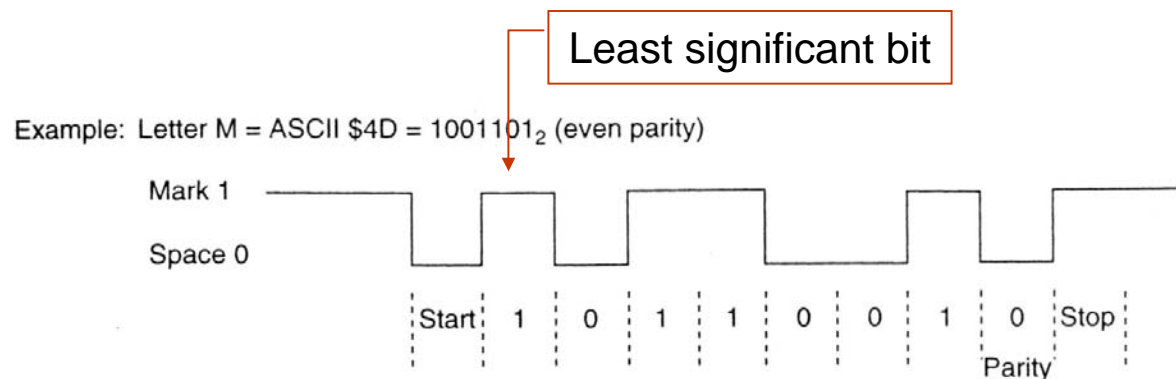
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- MARK level (or OFF, or 1-state, or 1-level)
  - This is also the idle state (before the transfer begins)
- SPACE level (or ON, or 0-state, or 0-level)
- One character:
  - Start bit: space level
  - Data bits
  - Optional parity bit
  - Optional stop bit

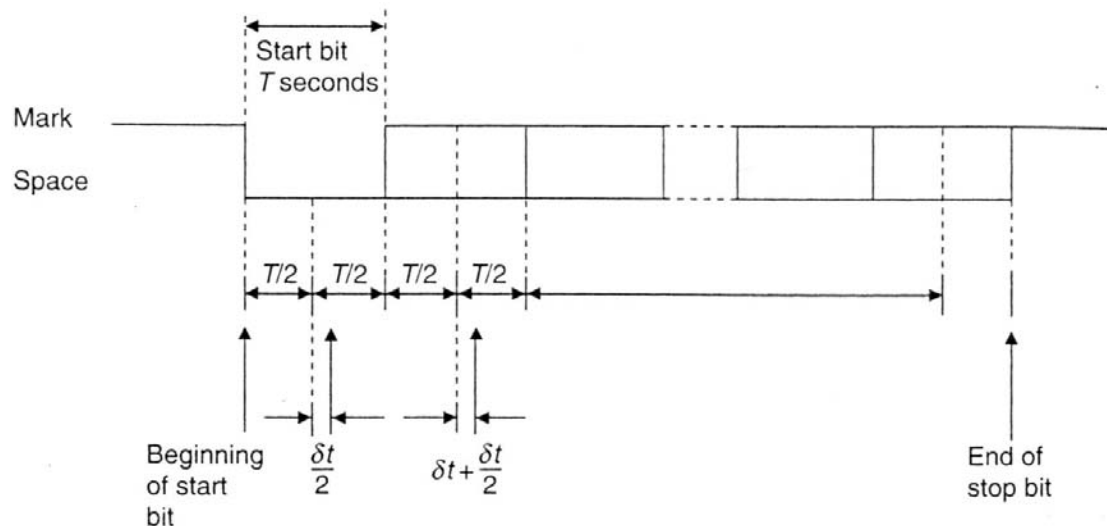


## 9.1 Asynchronous Serial Data Transmission – Data Format Example

- 12 possible basic formats:
  - 7 or 8 bits of data
  - Odd, even, or no parity
  - 1 or 2 stop bits
  - Others exist also: no stop bits, 4/5/6 data bits, 1.5 stop bits, etc.



## 9.1 Asynchronous Serial Data Transmission – Receiver Clock Timing



- For  $N=9$  bits (7 data + parity + stop) maximum tolerable error is 5%

$$T/2 > (2N+1)\delta t/2$$

$$\delta t/2 < 1/(2N+1)$$

$$\delta t/T < 100/(2N+1) \text{ as a percentage}$$

## 9.5 Serial Interface Standards – RS232

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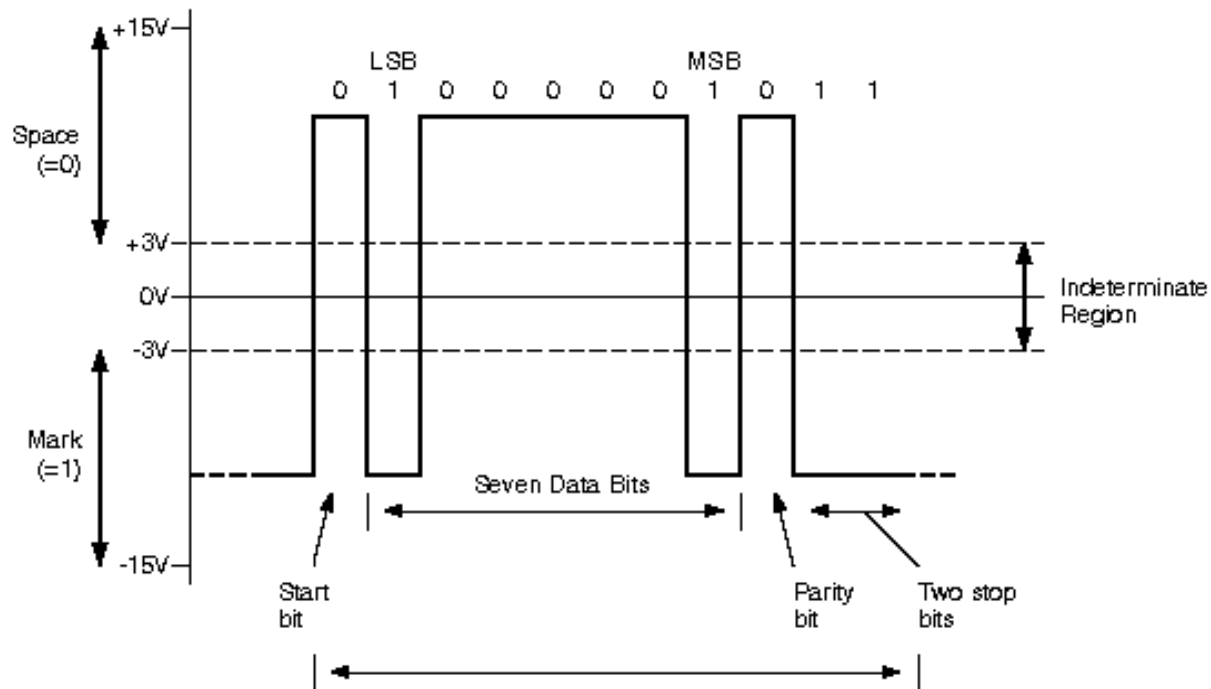
- Bi-polar:
  - +3 to +12V (ON, 0-state, or SPACE condition)
  - -3 to -12V (OFF, 1-state, or MARK condition)
- Modern computers accept 0V as MARK
- “Dead area” between -3V and 3V is designed to absorb line noise
- Originally developed as a standard for communication between computer equipment and modems
- From the point of view of this standard:
  - MODEM: *data communications equipment (DCE)*
  - Computer equipment: *data terminal equipment (DTE)*
- Therefore, RS-232C was intended for DTE-DCE links (not for DTE-DTE links, as it is frequently used now)

## 9.5 Serial Interface Standards – RS232 Interface Standard

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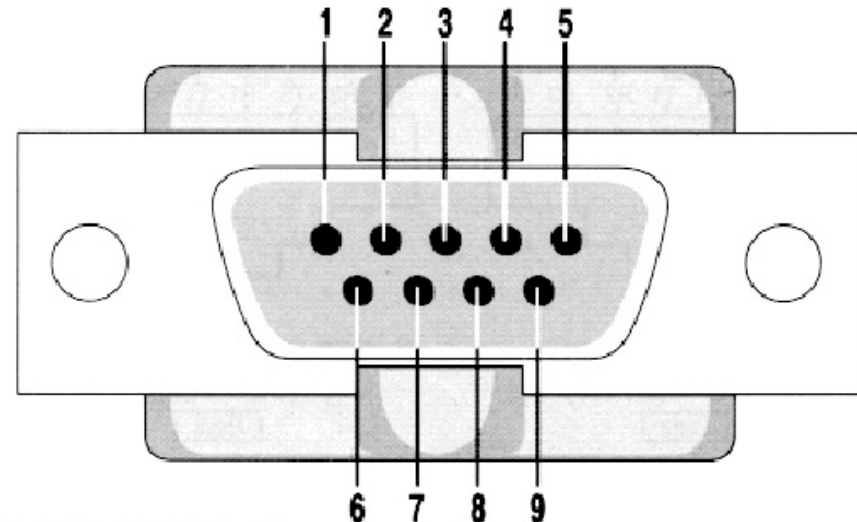
- Each manufacturer may choose to implement only a subset of functions defined by this standard
- Two widely used connectors: DB-9 and DB-25
- Three types of links
  - Simplex
  - Half-duplex
  - Full-duplex
- Basic control signals
  - RTS (Request to send):  
DTE indicates to the DCE that it wants to send data
  - CTS (Clear to send):  
DCE indicates that it is ready to receive data
  - DSR (Data set ready):  
indication from the DCE (i.e., the modem) that it is on
  - DTR (Data terminal ready):  
indication from the DTE that it is on

# 9.5 Serial Interface Standards – RS232 Data Format Example



## 9.5 Serial Interface Standards – RS232 Interface Standard

- DB-25 connector is described in the book; let's take a look at DB-9

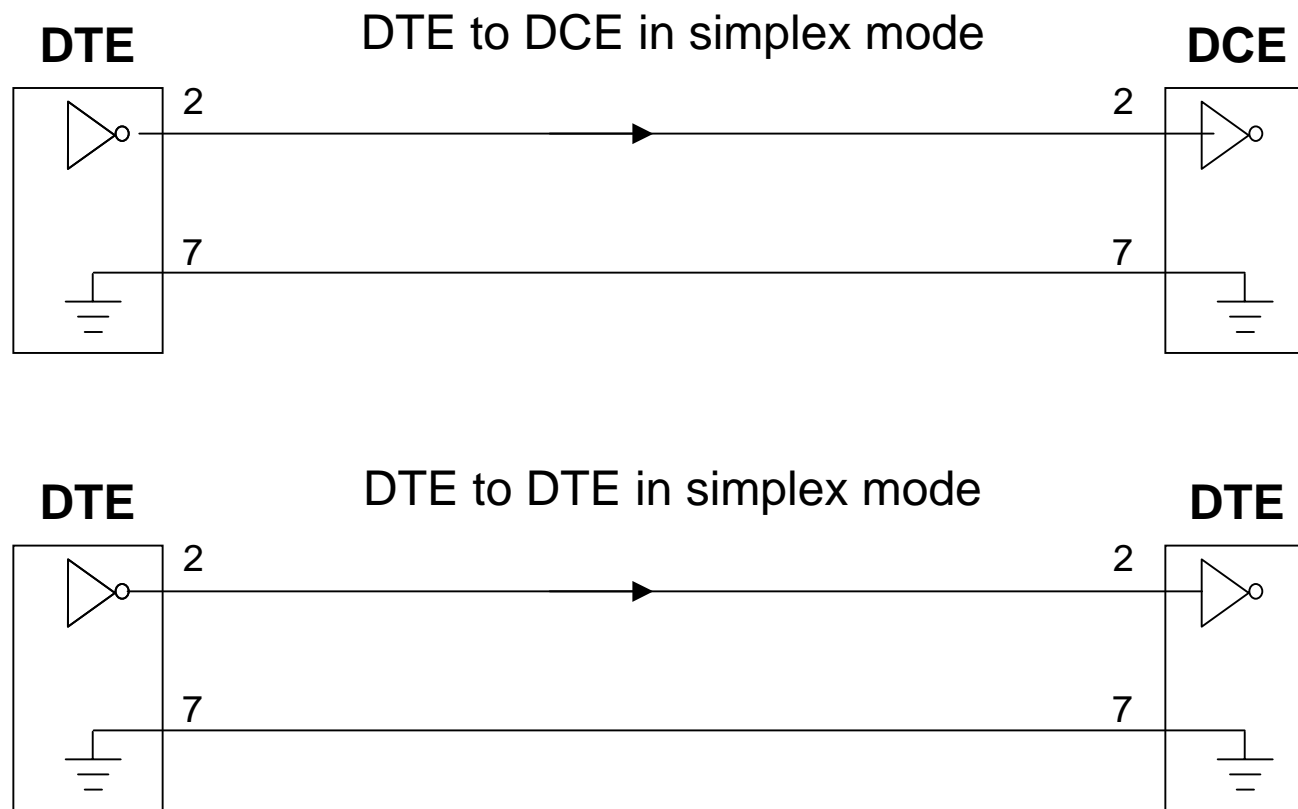


Pin	Signal	Pin	Signal
1	Data Carrier Detect	6	Data Set Ready
2	Received Data	7	Request to Send
3	Transmitted Data	8	Clear to Send
4	Data Terminal Ready	9	Ring Indicator
5	Signal Ground		

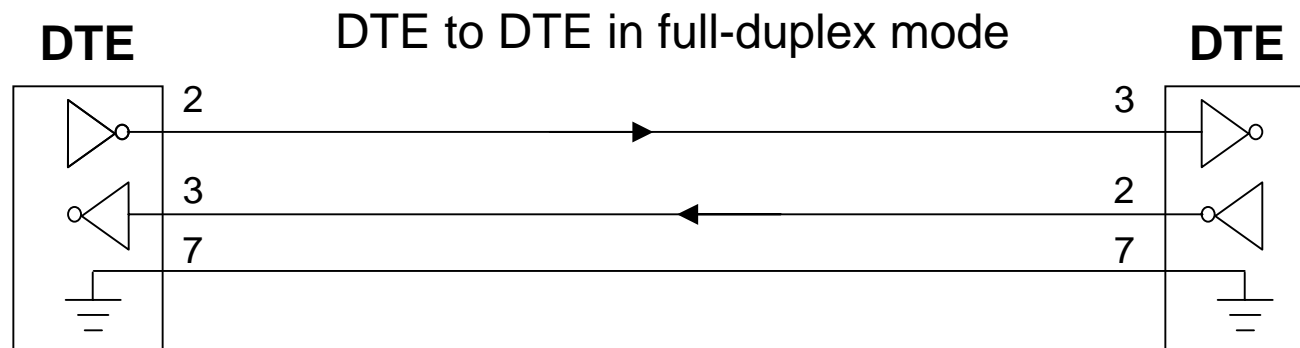
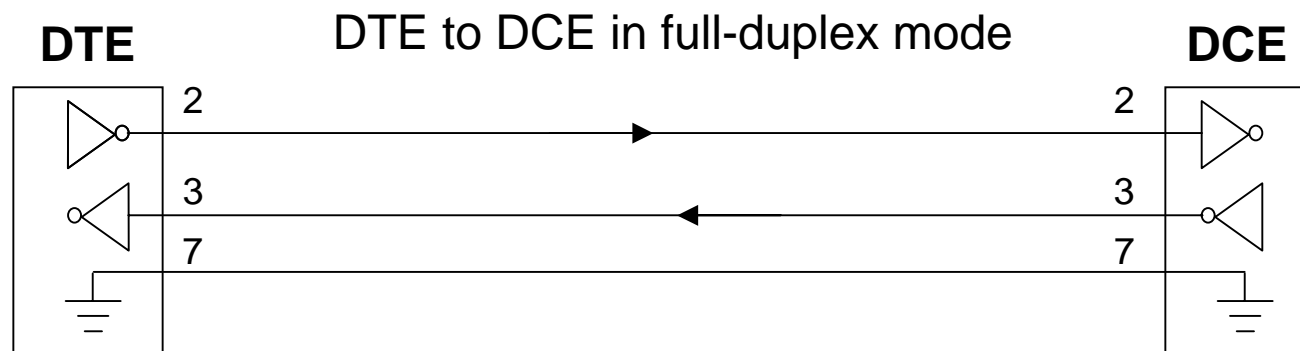
## 9.5 Serial Interface Standards – RS232 Interface Standard

Description	Signal	9-pin DTE	25-pin DCE	Source DTE or DEC
Carrier Detect	CD	1	8	from Modem
Receive Data	RD	2	3	from Modem
Transmit Data	TD	3	2	from Terminal/Computer
Data Terminal Ready	DTR	4	20	from Terminal/Computer
Signal Ground	SG	5	7	from Modem
Data Set Ready	DSR	6	6	from Modem
Request to Send	RTS	7	4	from Terminal/Computer
Clear to Send	CTS	8	5	from Modem
Ring Indicator	RI	9	22	from Modem

# 9.5 Serial Interface Standards – Minimal RS232 Function: Simplex Mode

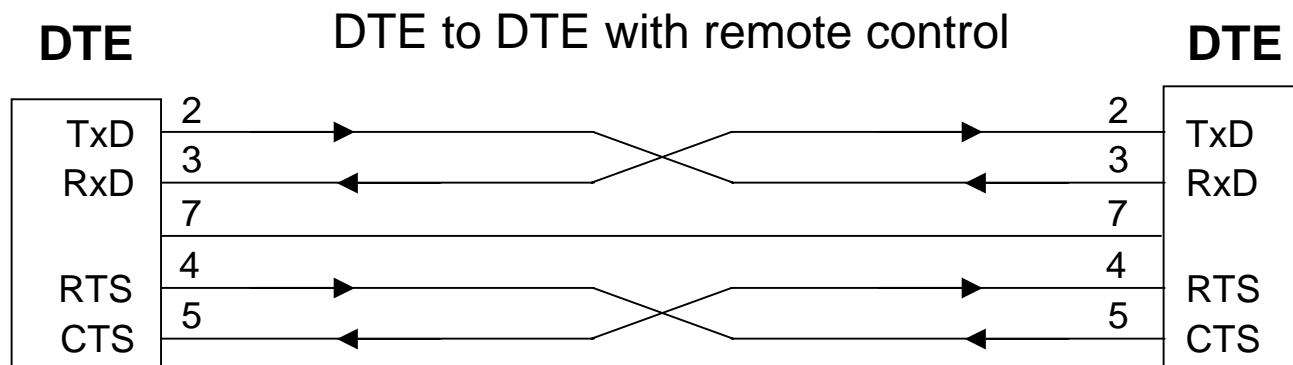
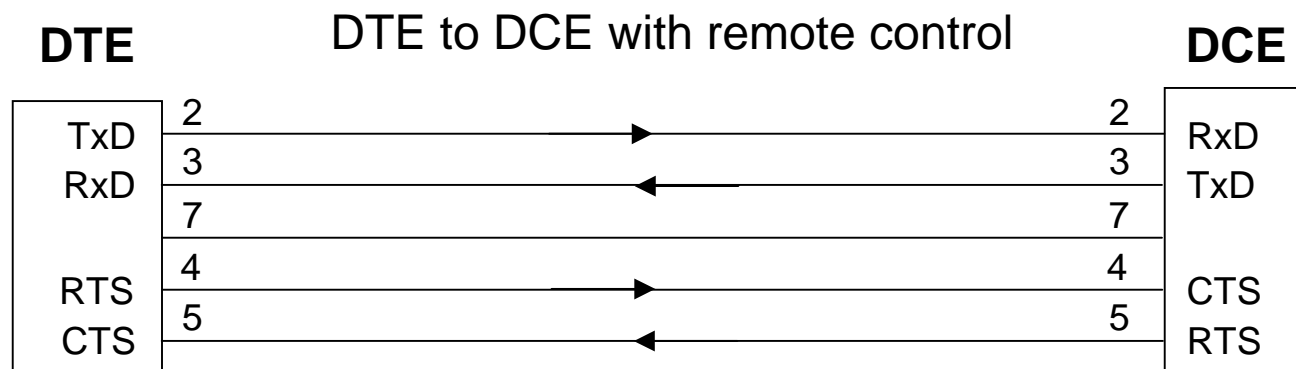


# 9.5 Serial Interface Standards – Minimal RS232 Function: Duplex Mode



# 9.5 Serial Interface Standards - Types of Transmissions

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# 9.5 Serial Interface Standards – Handshaking Between RTS and CTS

