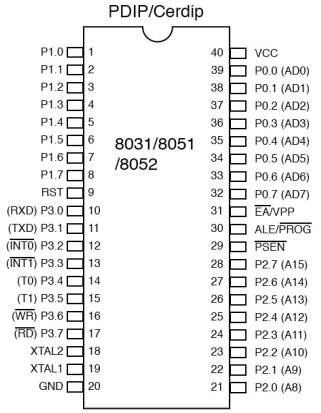
8051 Microcontroller:

Serial Communication



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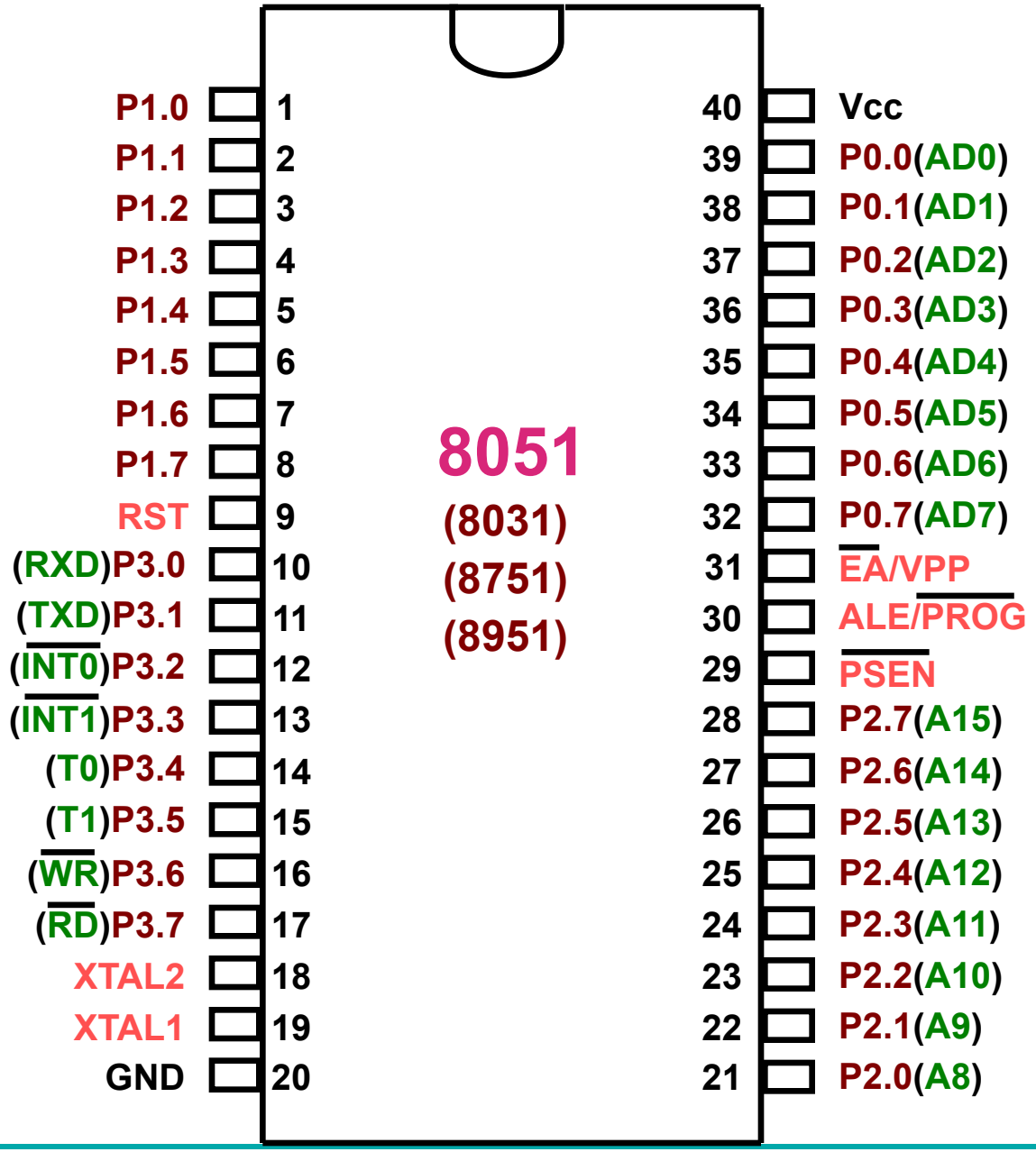
EE-309: Microprocessors

Lecture 14 (18 Aug 2015)

CADSL

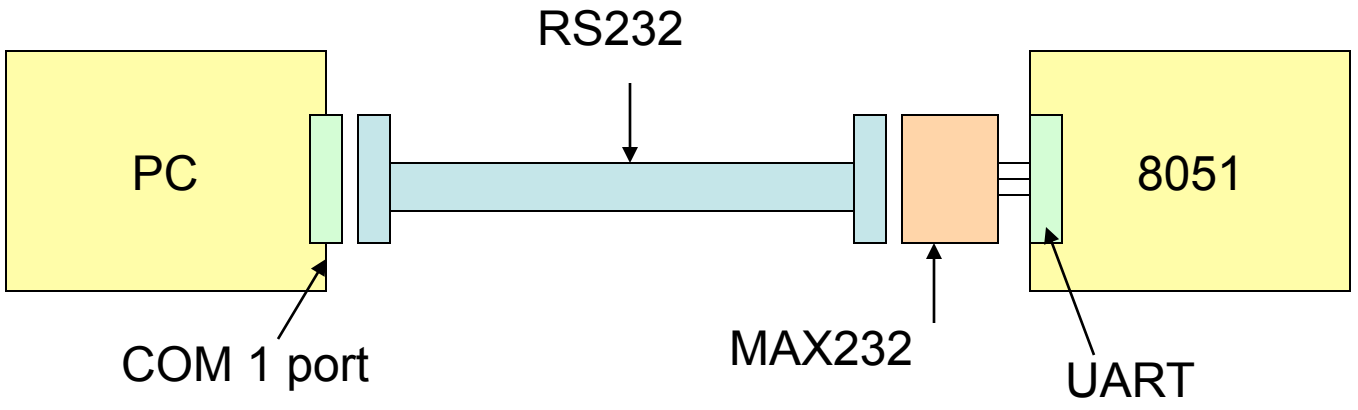
8051 Pin Diagram



Data Communication

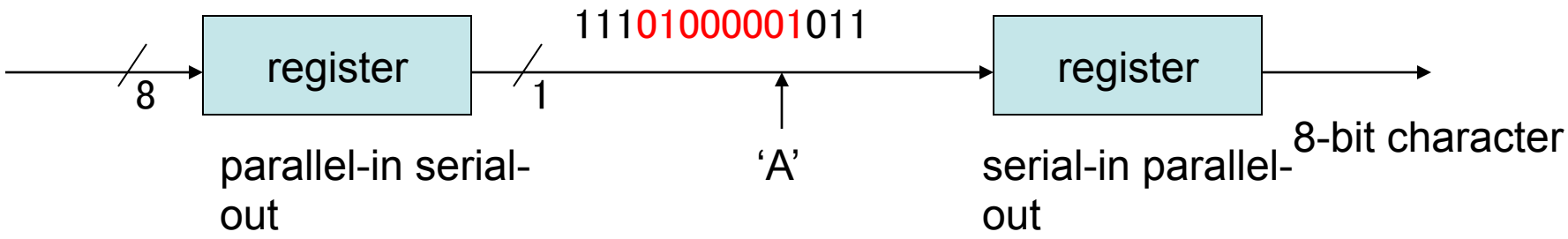
8051 and PC

- The 8051 module connects to PC by using RS232.
- RS232 is a protocol which supports half-duplex, synchronous/asynchronous, serial communication.



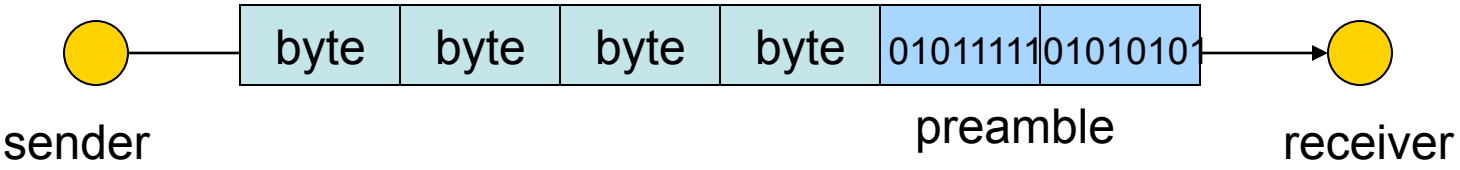
Serial Communication

- How to transfer data?
  - Sender:
    - The byte of data must be converted to serial bits using a parallel-in-serial-out shift register.
    - The bit is transmitted over a single data line.
  - Receiver
    - The receiver must be a serial-in-parallel-out shift register to receive the serial data and pack them into a byte.

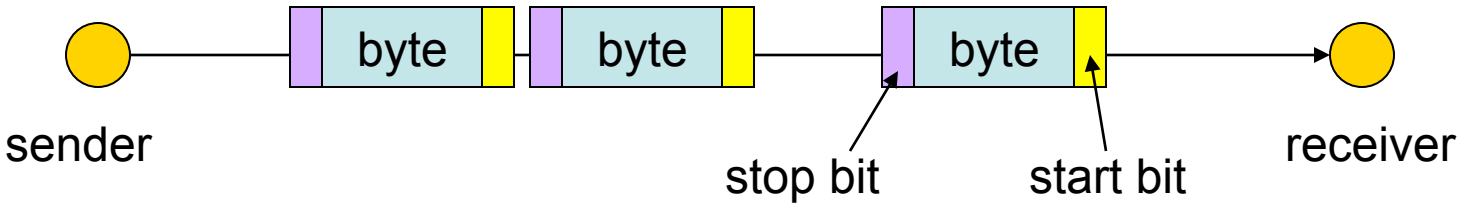


Asynchronous vs. Synchronous

- Serial communication uses two methods:
  - In synchronous communication, data is sent in blocks of bytes.



  - In asynchronous communication, data is sent in bytes.



UART and USART

- It is possible to write software to use both methods, but the programs can be tedious and long.
- Special IC chips are made for serial communication:
  - USART (universal synchronous-asynchronous receiver-transmitter)
  - UART (universal asynchronous receiver-transmitter)
- The 8051 chip has a built-in UART.

Serial Communication

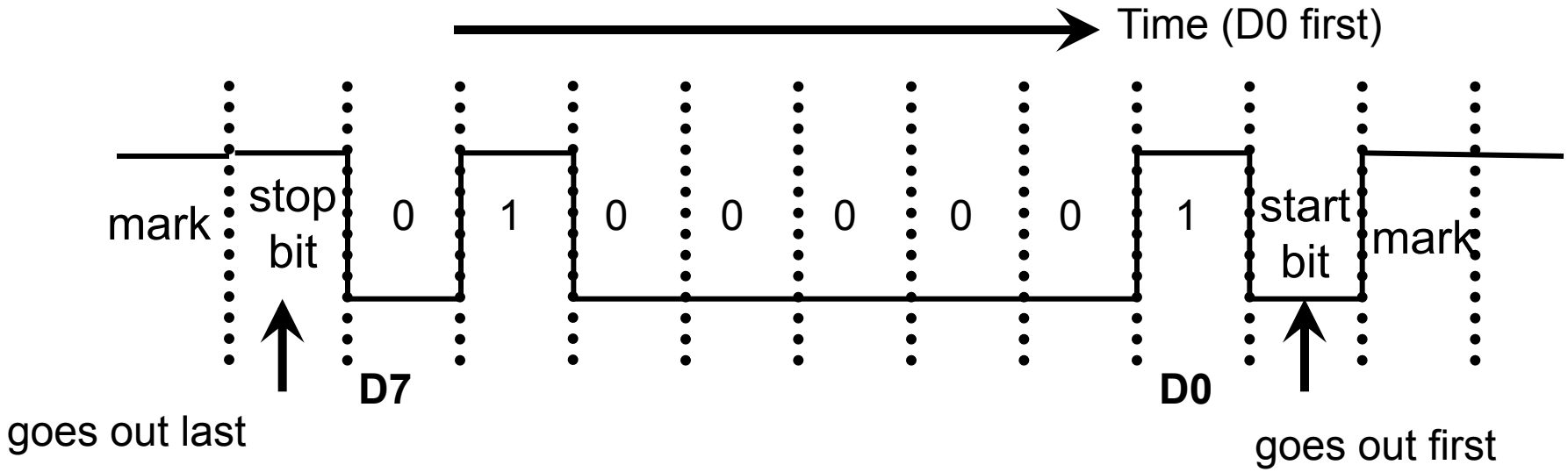
8051 Serial Communication

- The 8051 has serial communication capability built into it.
  - Asynchronous mode only.

- How to detect that a character is sent via the line in the asynchronous mode?
  - Answer: Data framing!

Framing

- Framing: Each character is placed in between start and stop bits
  - Framing ASCII “A” (41H)



Framing

- We have a total of 10 bits for each character:
  - 8-bits for the ASCII code
  - 2-bits for the start and stop bits
  - 25% overhead
- In some systems in order to maintain data integrity, the parity bit is included in the data frame.
  - In an odd-parity bit system the total number of bits, including the parity bit, is odd.
  - UART chips allow programming of the parity bit for odd-, even-, and no-parity options.

Data Transfer Rate

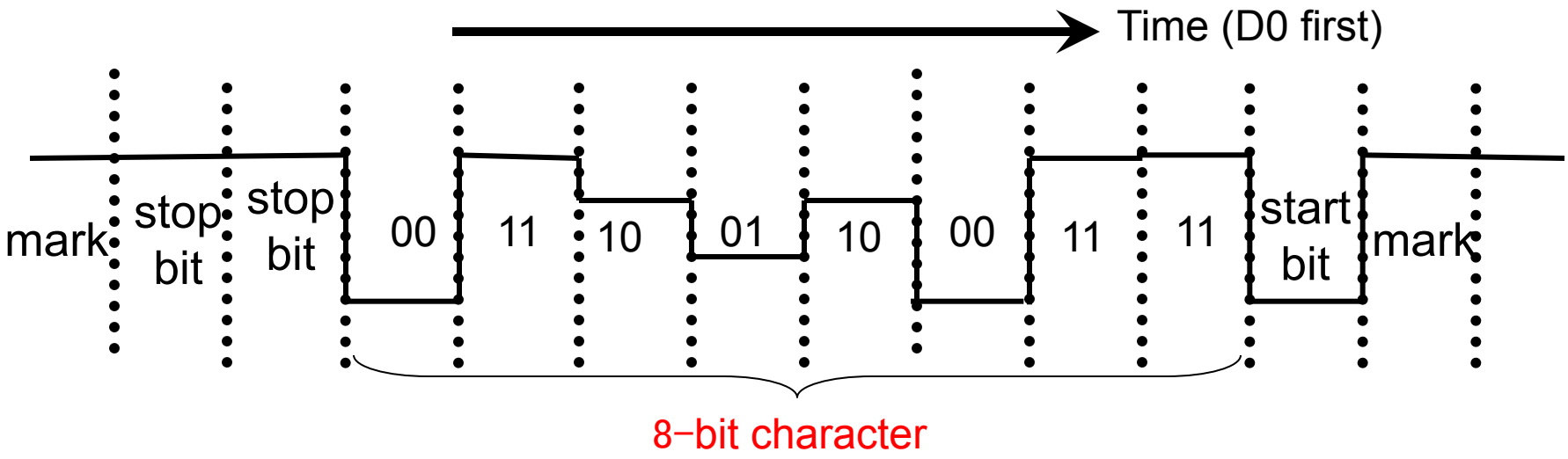
- How fast is the data transferred?
- Three methods to describe the speed:
  - Baud rate is defined as the number of signal changes per sec.
    - The rate of data transfer is stated in *Hz* (used in modem).
  - Data rate is defined as the number of bits transferred per sec.
    - Each signal has several voltage levels.
    - The rate of data transfer is stated in *bps* (bits per second).
  - Effective data rate is defined as the number of actual data bits transferred per second.
    - Redundant bits must be removed

Data Transfer Rate

- The data transfer rate depends on communication ports incorporated into that system.
  - Ex: 100-9600 bps in the early IBM PC/XT
  - Ex: 56 kbps in Pentium-based PC
  - The baud rate is generally limited to 100kHz.

Example of Data Transfer Rate

- Data is sent in the following asynchronous mode:
  - 2400 baud rate
  - each signal has 4 voltage levels (-5V, -3V, 3V, 5V)
  - one start bit, 8-bit data, 2 stop bits



Example of Data Transfer Rate

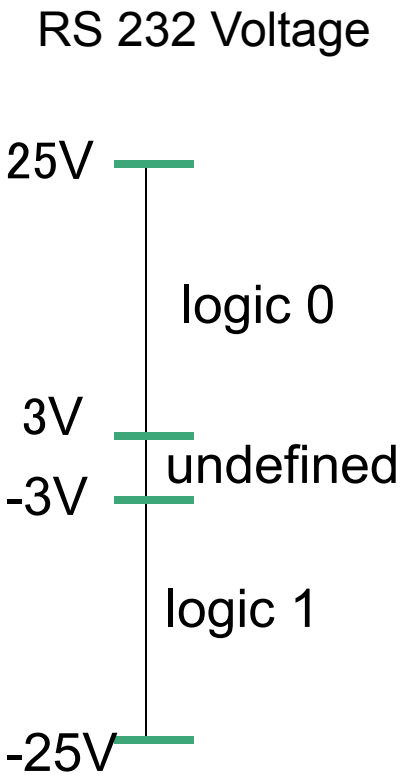
- 2400 baud = 2400 signals per second =2400 Hz
- 4 voltage level: $Log_2 4=2$
  - 2 bits is sent in every signal change
- Data rate = 2 * 2400 Hz = 4800 bps
- Effective ratio = 8 / (1+8+2) =8/11
- Effective data rate = data rate * effective ratio = 4800 * 8 /11=3490.9

RS232 Standard

- RS232 is an interfacing standard which is set by the Electronics Industries Association (EIA) in 1960.
  - RS232 is the most widely used serial I/O interfacing standard.
  - RS232A (1963), RS232B (1965) and RS232C (1969), now is RS232E
- Define the voltage level, pin functionality, baud rate, signal meaning, communication distance.

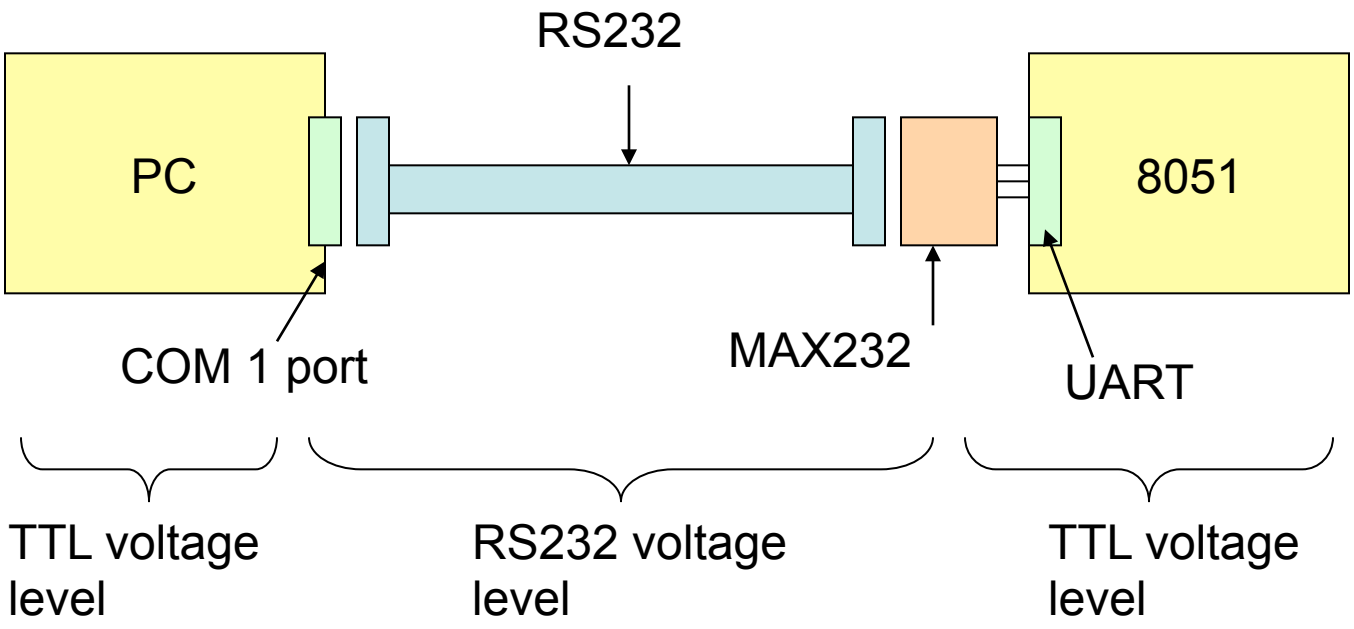
RS232 Voltage Level

- The input and output voltage of RS232 is not of the TTL compatible.
  - RS232 is older than TTL.
- We must use voltage converter (also referred to as line driver) such as MAX232 to convert the TTL logic levels to the RS232 voltage level, and vice versa.
  - MAX232, TSC232, ICL232

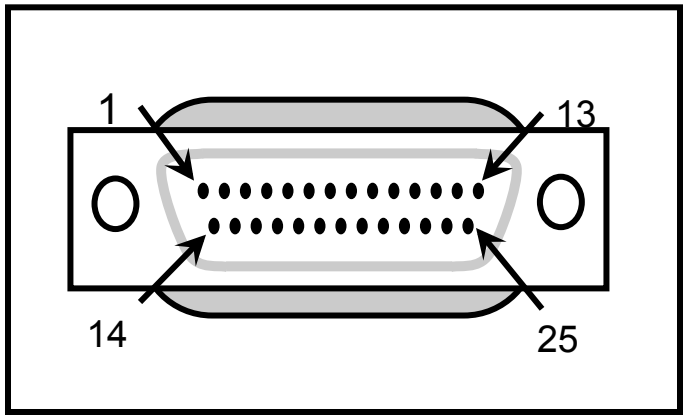


MAX232

- MAX232 IC chips are commonly referred to as line drivers.

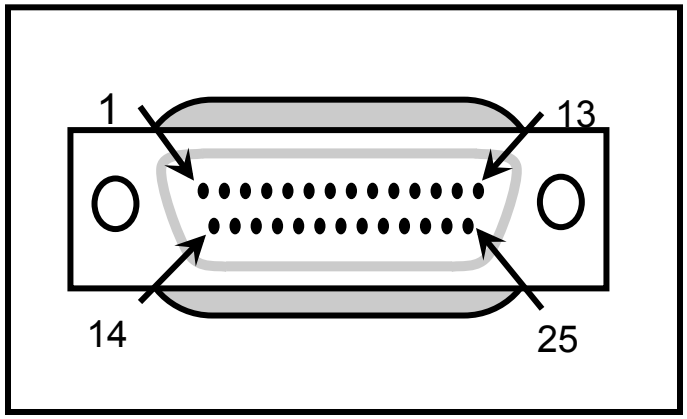


RS232 Pins for DTE



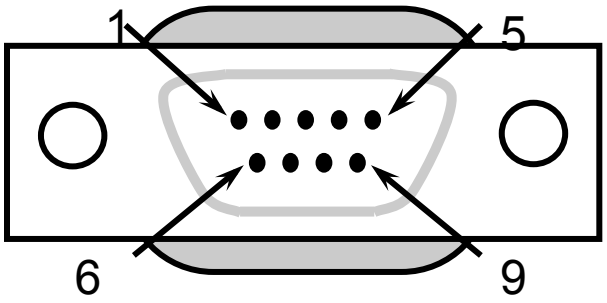
Pin	Description
1	Protective ground
2	Transmitted data (TxD)
3	Received data (RxD)
4	Request to send (RTS)
5	Clear to send (CTS)
6	Data set ready (DSR)
7	Signal ground (GND)
8	Data carrier detect (DCD)
9/10	Reserved for data testing
11	Unassigned
12	Secondary data carrier detect
13	Secondary clear to send

RS232 Pins for DTE



Pin	Description
14	Secondary transmitted data
15	Transmit signal element timing
16	Secondary received data
17	Receive signal element timing
18	Unassigned
19	Secondary request to sent
20	Data terminal ready (DTR)
21	Signal quality detector
22	Ring indicator
23	Data signal rate select
24	Transmit signal element timing
25	Unassigned

DB-9 Signals for DTE

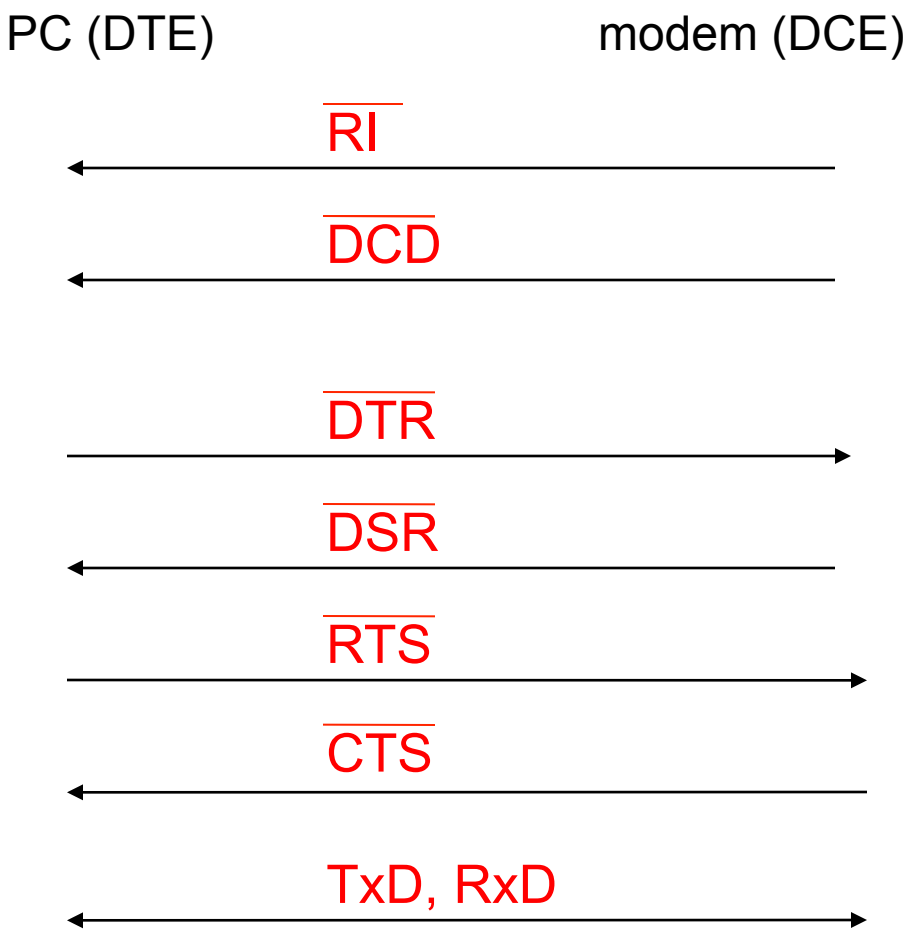


Pin	Description
1	Data carrier detect (DCD)
2	Received data (RxD)
3	Transmitted data (TxD)
4	Data terminal ready (DTR)
5	Signal ground (GND)
6	Data set ready (DSR)
7	Request to send (RTS)
8	Clear to send (CTS)
9	Ring indicator (RI)

RS232 Handshaking Signals

- Many of the pins of the RS232 connector are used for handshaking signals.
  - DTR (data terminal ready)
  - DSR (data set ready)
  - RTS (request to send)
  - CTS (clear to send)
  - RTS and CTS are hardware control flow signals.
  - DCD (carrier detect, or data carrier detect)
  - RI (ring indicator)
- They are not supported by the 8051 UART chips.

Communication Flow

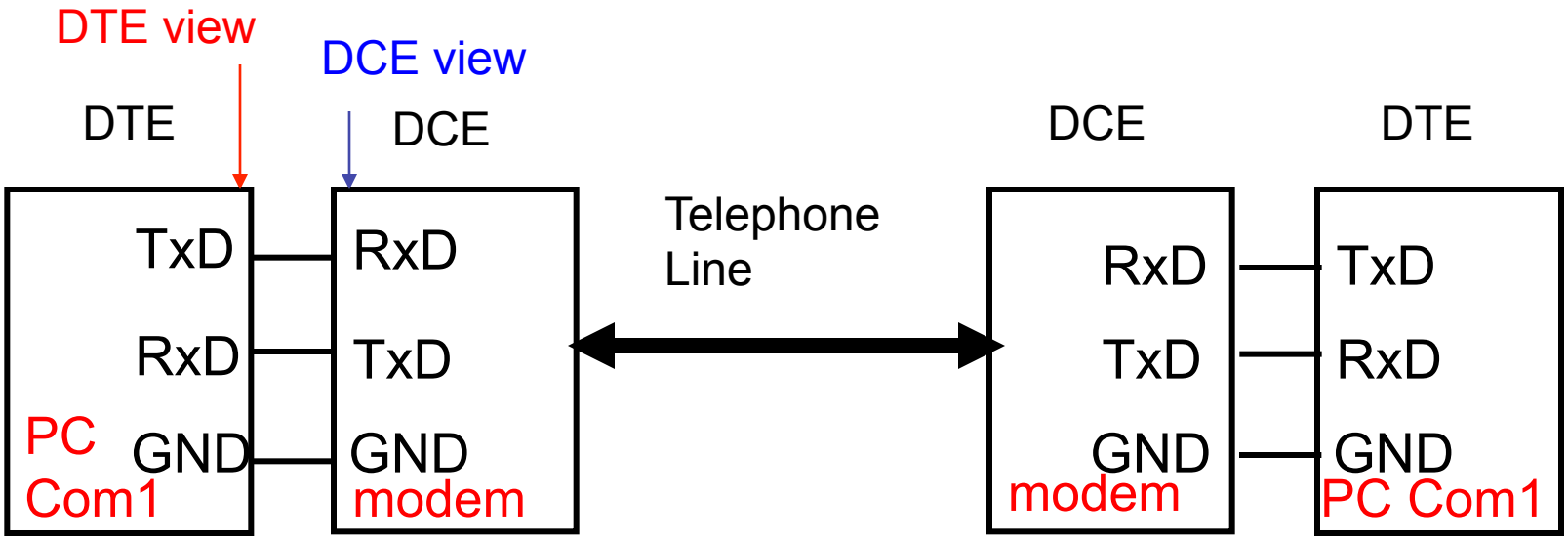


Communication Flow

- While signals DTR and DSR are used by the PC and modem, respectively, to indicate that they are alive and well.
- TRS and CTS control the flow of data.
- When the PC wants to send data, it asserts RTS.
- If the modem is ready (has room) to accept the data, it sends back CTS.
- If, for lack of room, the modem does not activate CTS, and PC will deassert DTR and try again.

DTE and DCE

- Communication Equipments are classified as
  - DTE (data terminal equipment)
    - Terminals and computers that send and receive data
  - DCE (data communication equipment)
    - Communication equipment (only for transfer data), modem



Thank You