Universal Asynchronous Receiver Transmitter

Networks and Embedded Systems

Second Grade Level

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UART (1)

- Design
    - Serial Communication Protocol
    - Point-to-Point Communication
    - Unidirectional Transmission Lines
        - RxD: Received Data
        - TxD: Transmitted Data
    - Hardware flow control (optional)
        - RTS: Request To Send
        - CTS: Clear To Send

UART (2)

- Quite a lot of configuration
    - Baud rate (bps: bits per second)
    - Number of data bits (Baudot: 5 bit, ASCII: 7 bit)
    - Parity mode (even, odd, none)
    - Number of stop bits (one, two)
    - Example: 9600/8N1
        - 9600 bits per second (104 µs per bit)
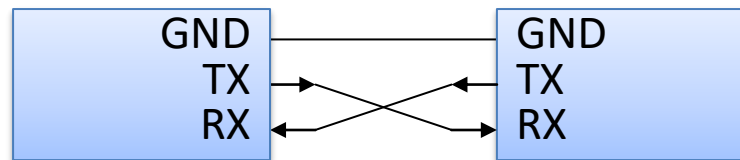   - 8 data bits, no parity bit, 1 stop bit

UART (3)

- What is the parity bit?
  - Simplest form of an error detecting code
  - Two variants of parity bit: even (E) or odd (O)
  - Number of 1s including parity bit must be E or O

Data Bits	Even Parity	Odd Parity
0000000	+ 0 = E	+ 1 = O
1010001	+ 1 = E	+ 0 = O
1101001	+ 0 = E	+ 1 = O
1111111	+ 1 = E	+ 0 = O

UART (4)

- UART means asynchronous transmission
  - Three line connection

  - Bit transmission
    - Example: 8N1, G = 47_{hex} = 01000111

standby	sync	data bits								sync	standby
	start	0	1	2	3	4	5	6	7	stop	

RS-232 (1)

- ## How is it designed?
  - ### Based on UART

  - ### Additional control lines
    - RI: Ring Indicator
    - DTR: Data Terminal Ready

  - ### Flow Control
    - No handshaking
    - Hardware handshaking (RTS and CTS)
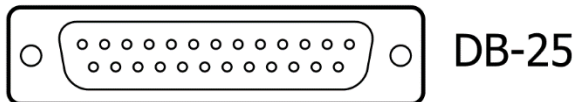   - Software handshaking (XON and XOFF control characters)

RS-232 (2)

- ## How is it designed? (continued)
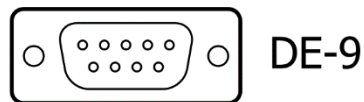 - ### Voltage Levels
    - 0: +3 … +15 V (space), UART: GND (0 V)
    - 1: -15 … -3 V (mark), UART: VCC (5.0 V, 3.3 V)
  - ### Connectors
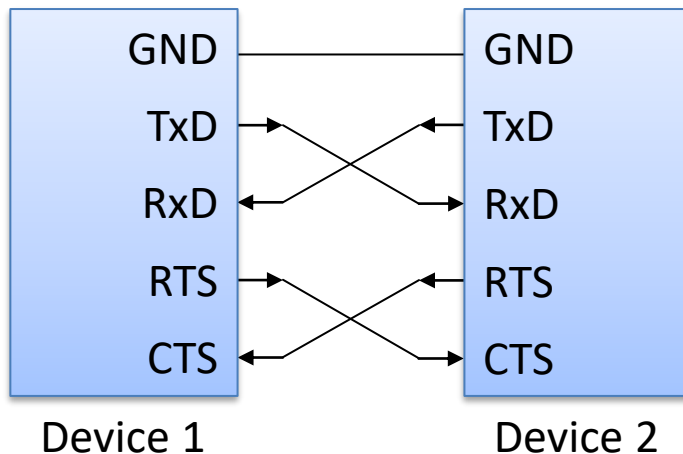   - 25-pin D-subminiature connector (standard recommendation)

      DB-25

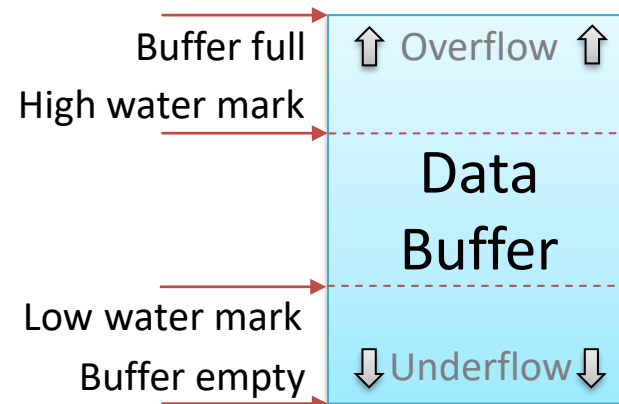   - 9-pin D-subminiature connector (widely used)

      DE-9

RS-232 (3)

- ## How does flow control work?

Hardware handshake

GND	GND
TxD	TxD
RxD	RxD
RTS	RTS
CTS	CTS

Device 1   Device 2

RTS: ready to receive data
CTS: request to send data

Software handshake

Buffer full
High water mark

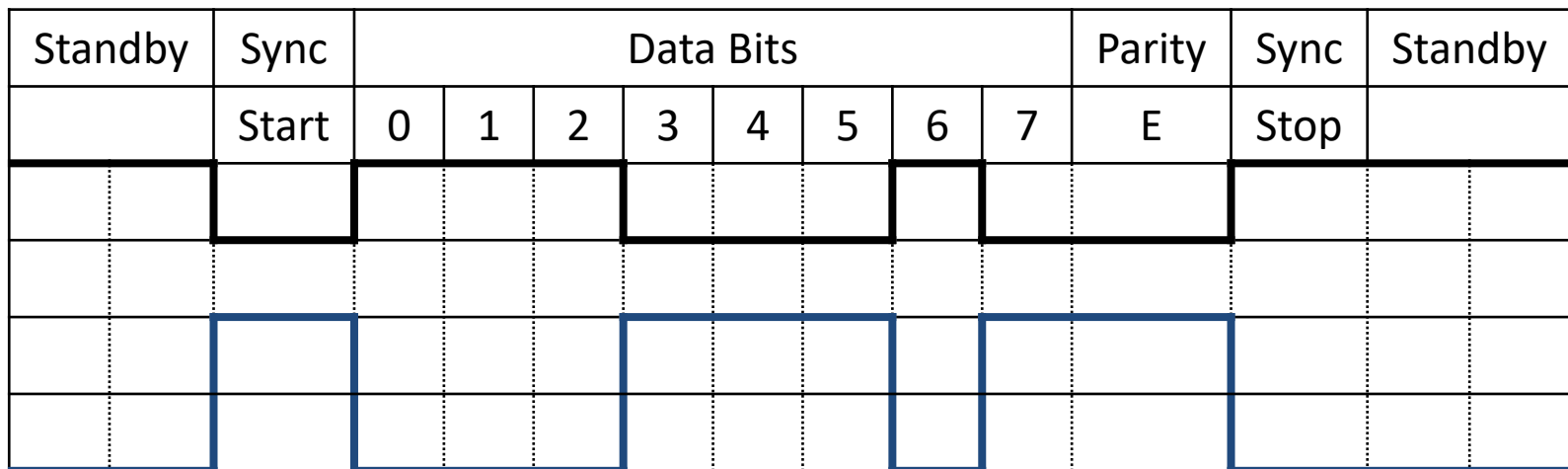⇧ Overflow ⇧

Data Buffer

Low water mark
Buffer empty

⇩ Underflow ⇩

XON: sent if below low water mark
XOFF: sent if above high water mark

RS-232 (4)

- ## How data is transmitted
  - – Example: 8N1, G = 47_{hex} = 01000111

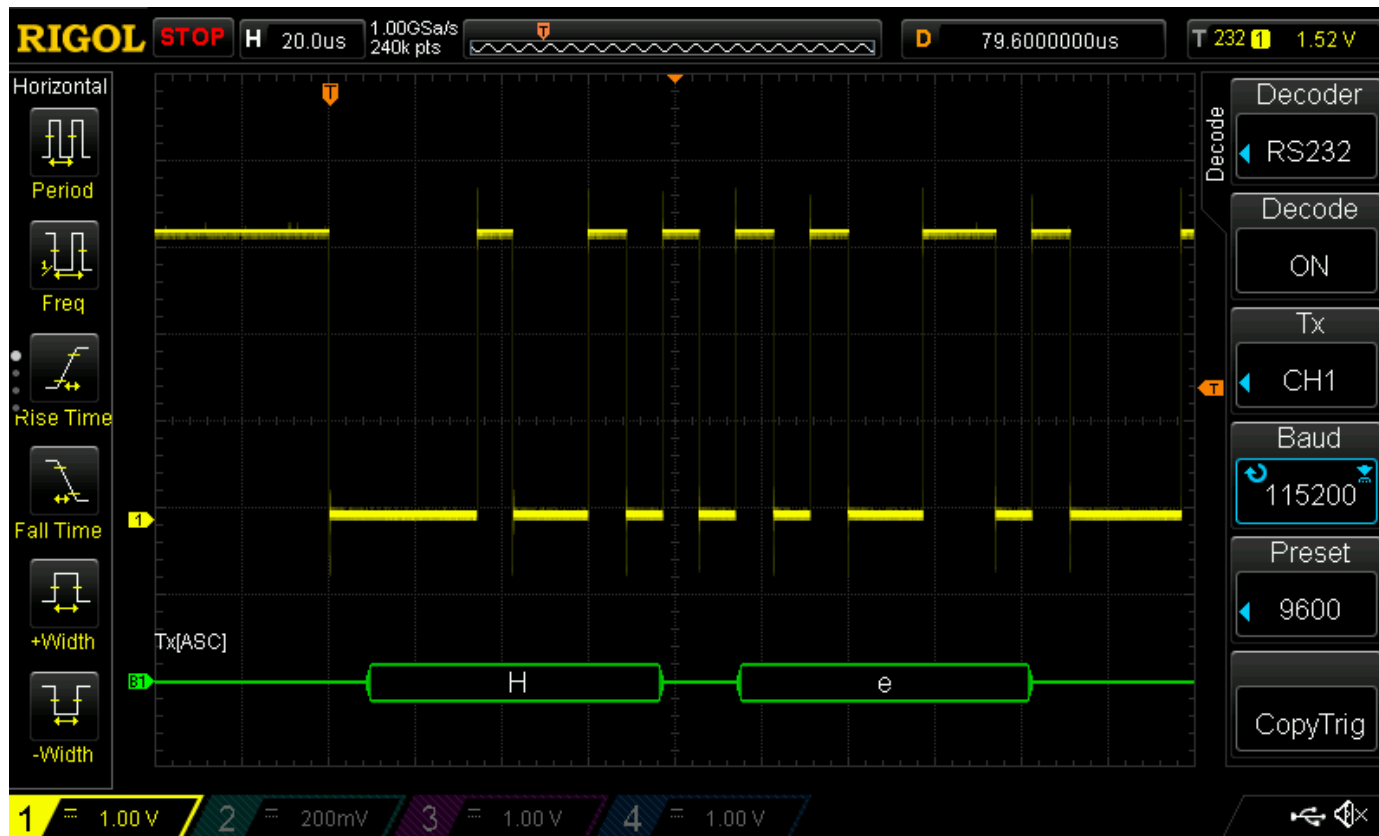| Standby	Sync	Data Bits								Parity	Sync	Standby
	Start	0	1	2	3	4	5	6	7	E	Stop	

——— Logical: 0, 1   ——— Signal: -15 V … +15 V

RS-232 (5)

- Real-Life Example (3.3 V positive logic levels)

RS-232 (6)

- Advantages
  - Simplicity
  - Low cost
  - Easy to implement
  - Widely used
  - Converters and adaptors available

RS-232 (7)

- Disadvantages
  - Point-to-point
  - No automatic configuration
  - Many configuration settings
  - Requires transceiver chip
    - MAX233 level shifter