Universal Asynchronous Receiver Transmitter

Embedded Software

Wolfgang Neff

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

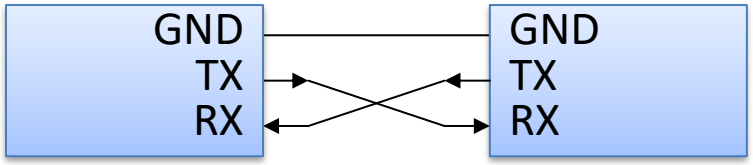
UART (3)

- 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

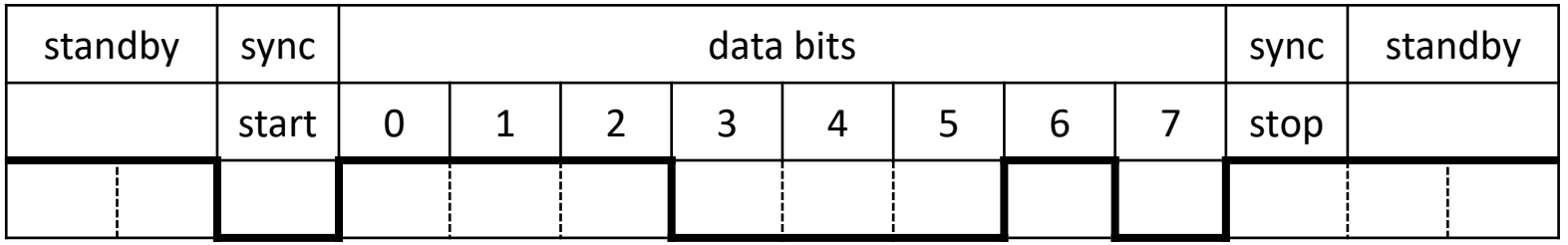
Data Bits	Even Parity	Odd Parity
0000000	+ 0 = E	+ 1 = O
1010001	+ 1 = E	+ 0 = O
1101001	+ 0 = E	+ 1 = O
1111111	+ 1 = E	+ 0 = O

UART (4)

- UART means asynchronous transmission
  - Three line connection



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

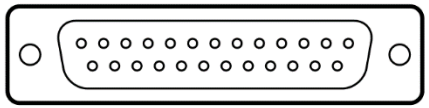


RS-232 (1)

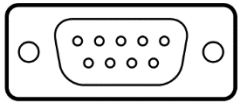
- How is it designed?
  - Based on UART
  - Additional control lines
    - RI: Ring Indicator
    - DTR: Data Terminal Ready
  - Flow Control
    - No handshaking
    - Hardware handshaking (RTS and CTS)
    - Software handshaking (XON and XOFF control characters)

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

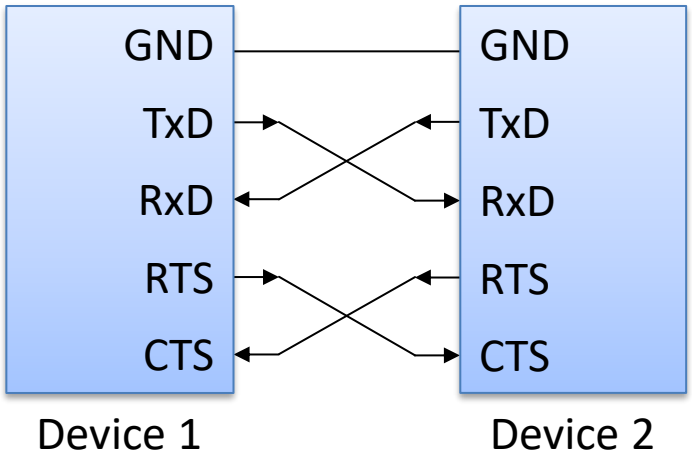
    - 9-pin D-subminiature connector (widely used)


DE-9

RS-232 (3)

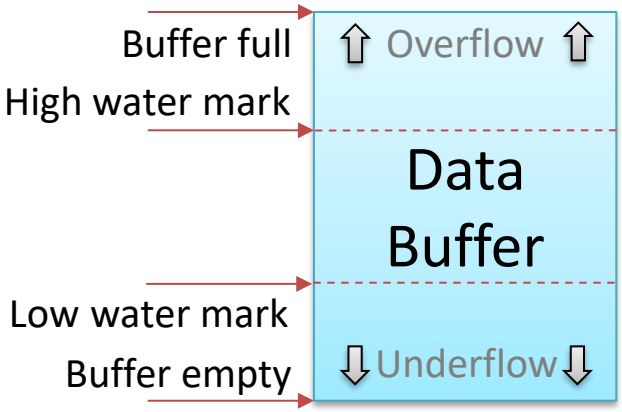
- How does flow control work?

Hardware handshake



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

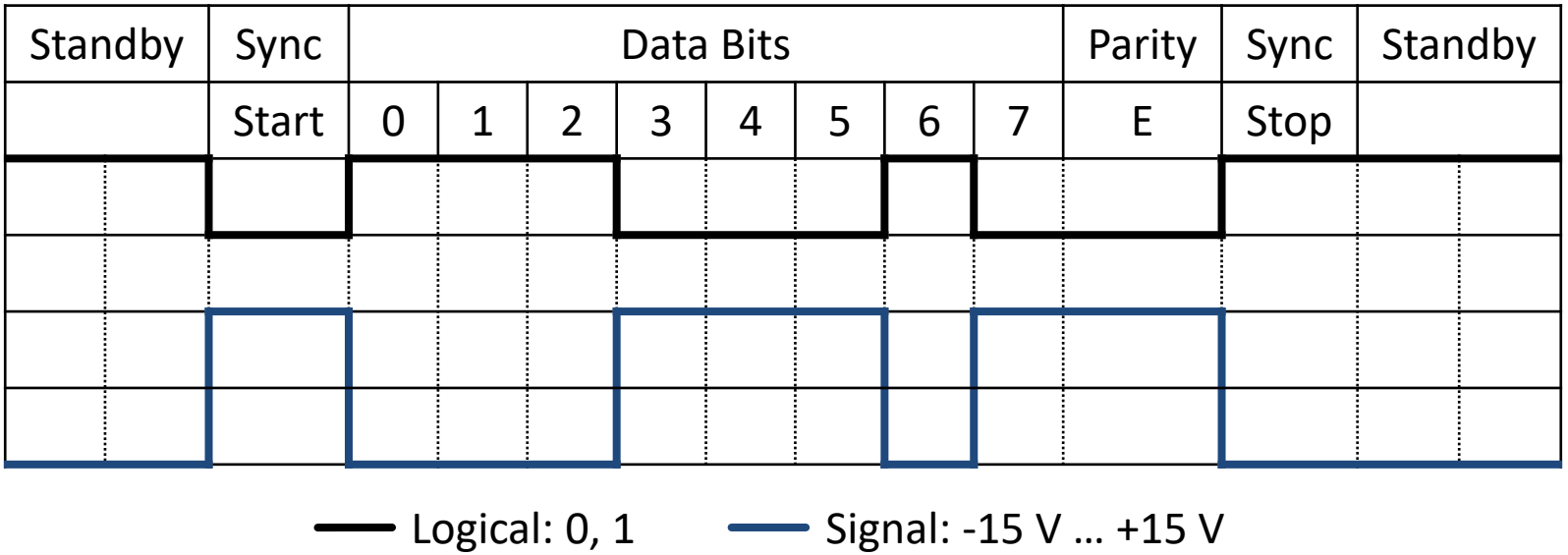
Software handshake



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

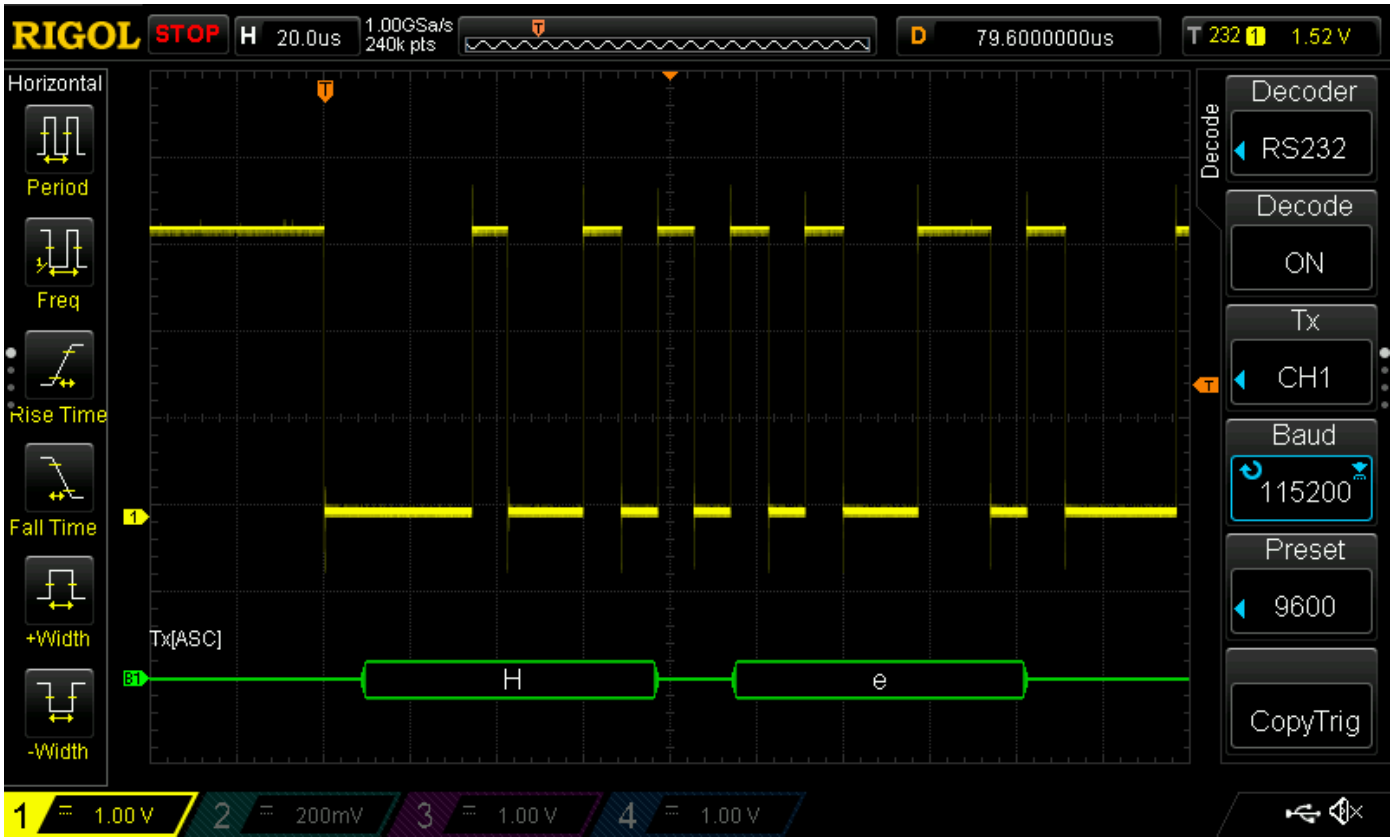
RS-232 (4)

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



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