Zephyr: Serial Communication

Medical Electrical Equipment (BME590L)

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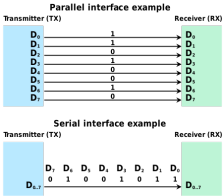
What is Serial Communication?

- Send data one bit at a time, sequentially, over a communication channel (in contrast to parallel communication).
- Common examples:
  - RS-232
  - USB
  - SATA/SCSI
  - PS/2
  - Ethernet
  - HDMI/DVI
  - PCIe (not PCI!)



https://en.wikipedia.org/wiki/Serial_communication

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Serial vs. Parallel Communication

- Parallel can communicate more bits / clock cycle, but serial links can be clocked much faster:
  - No clock skew issues.
  - Fewer cables / connections, allowing better isolation from noise / interference / crosstalk.
- Cheaper (fewer pins / data lanes)

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Universal Asynchronous Receiver/Transmitter (UART)

- Sensors
- USB-to-UART Controllers
- **Asynchronous**, peer-to-peer communication protocol

UART Timing Diagram

- `Start bit` is usually `LOW`, followed by 8 bits.
- A `parity` bit, conveying even or off data stream, can be added at the end to help confirm data validity.

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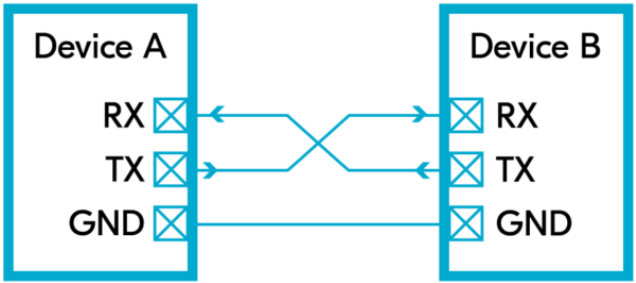
Tx/Rx without Flow Control



- `RX` senses the start bit and then stores the subsequent data in a "word".
- The data baud rate between `TX:RX` needs to be established before data exchange (typically 115200 or 9600 bits/s).

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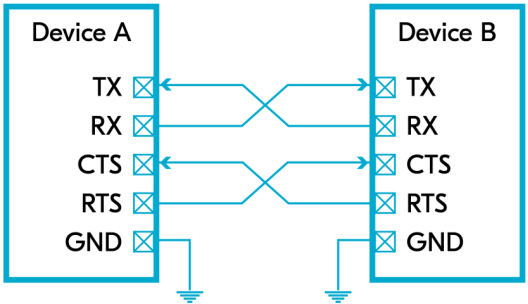
Tx/Rx with Flow Control



- `RTS`: Ready To Send
- `CTS`: Clear To Send

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UART Firmware API Events

Event	Description
`UART_TX_DONE`	The whole TX buffer was transmitted
`UART_TX_ABORTED`	Transmitting aborted due to timeout or `uart_tx_abort` call
`UART_RX_RDY`	Some data was received and receive timeout occurred (if RX timeout is enabled) or when the receive buffer is full
`UART_RX_BUF_REQUEST`	Driver requests next buffer for continuous reception
`UART_RX_BUF_RELEASED`	Buffer is no longer used by UART driver
`UART_RX_DISABLED`	This event is generated whenever receiver has been stopped, disabled or finished its operation (receive buffer filled) and can be enabled again using `uart_rx_enable()`
`UART_RX_STOPPED`	RX has stopped due to external event

Types of events passed to callback in `UART_ASYNC_API`
Type `uart_event_type`

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UART ISRs

- `RTS` / `CTS` can be used to initiate an ISR in firmware.
- High-priority event to avoid missing data, but could "stall" the device.
- Can motivate using an RTOS instead of a single "super-loop" / bare-metal embedded architecture.

Inter-Integrated Circuit (I2C)

- Widely used 2-wire synchronous serial communication protocol over short distances.
  - `SCL`: serial clock
  - `SDA`: serial data
- Common data communication rates: 100, 400 & 1000 kbps.[1]
- Access data using simple `read()` and `write()` commands.
- Multiple devices can communicate through an I2C interface, identified by a unique address (7- or 10-bits).

[1] Note the "kb"!

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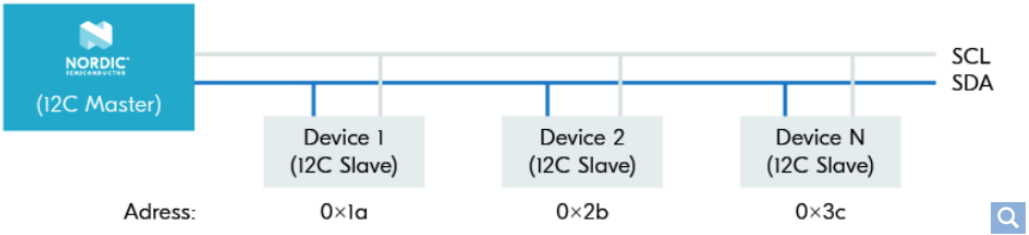
I2C Protocol



https://www.allaboutcircuits.com/news/how-master-slave-terminology-reexamined-in-electrical-engineering/

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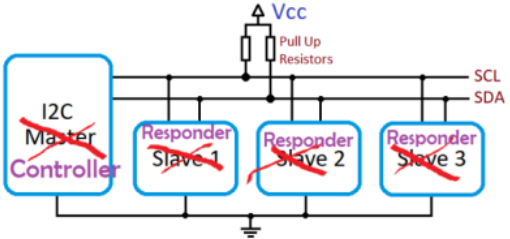
Alternative I2C Terminology

- Primary/Secondary
- Controller/Responder
- Parent/Child



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Example I2C Datasheet

https://gitlab.oit.duke.edu/mhealthtympanometer/mhealth-tymp-ecad/-/blob/main/datasheets/sps-siot-mpr-series-datasheet-32332628-ciid-172626.pdf

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UART vs. I2C

- Both are "slow", but I2C is faster.
- UART can do 2-way communication concurrently; I2C is 1-way at a time (half duplex).
- I2C allows for multiple peripherals to be connected, but at the expense of higher complexity and needing a `CLK` signal.

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Serial Passing Interface (SPI)

- Like I2C, but allows for full duplex (concurrent send and receive of data).
- Needs 4 wires (`SCK`, `MOSI`, `MISO`, `SS`) instead of 2:
  - `SCK`: clock signal
  - `MOSI`: Master Out Slave In
  - `MISO`: Master In Slave Out
  - `CS/SS`: Chip Select (active low, indicates data transfer in progress); used instead of a device address
- Higher speed than I2C (e.g., SD card)
- More complicated connectivity to multiple peripherals.

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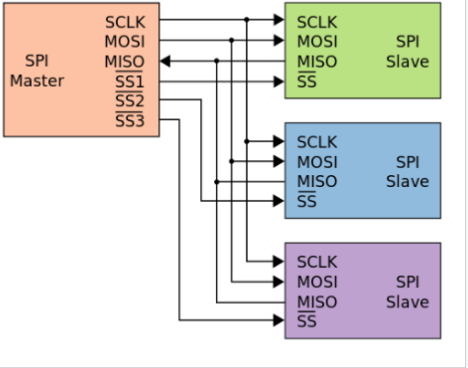
SPI Block Diagram



Typical SPI bus: master and three independent slaves

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SenseWire (I3C)

- 2-pin superset of I2C
- Lower power and space requirements
- Much faster
- Dynamic address assignment
- "Hot" peripheral connection

References

- DevAcademy: UART
- DevAcademy: I2C