

SPI, I2C, Onewire, RS-232 / 422 / 485

By David Röbl, Sara Davila
Mendez, Daniel Öttl and
Roland Spindelbalker

Serial Peripheral Interface (SPI)





Introduction to SPI

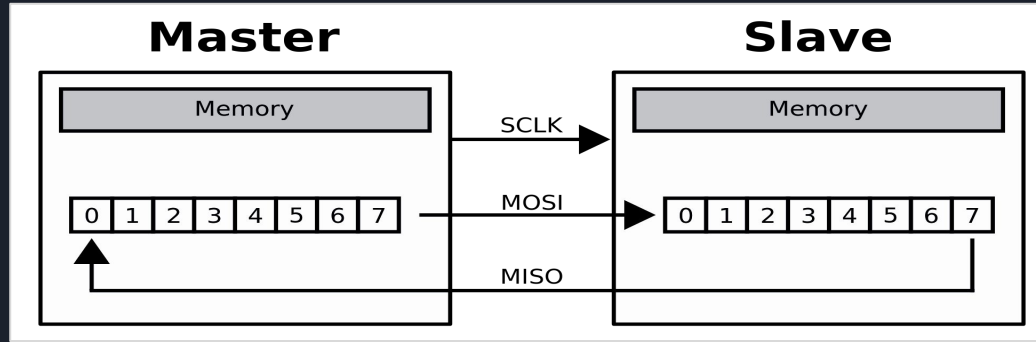
- Full-duplex synchronous data bus.
- Clock, data and a select lines.
- Used for data transmission between microcontrollers and small peripherals.
- Receiving hardware can be a simple shift register.
- Simpler and cheaper than the full-up Universal Asynchronous Receiver / Transmitter.



SPI-Specifications

Standard	SPI
Network Topology	Full-duplex synchronous bus
Maximum Devices	Protocol does not restrict it, your hardware does
Mode of Operation	Single master - slave(s)
Modes	<p>Depending on clock polarity (CPOL) and clock phase (CPHA) there are four unique modes</p> <ol style="list-style-type: none">1. (0, 0) -> data at leading rising edge of clk2. (1, 0) -> data at leading falling3. (0, 1) -> data on trailing falling edge4. (1, 1) -> data on trailing rising edge
Maximum Binary Rate	millions of bytes/s to much for some devices
Available Signals	<ol style="list-style-type: none">1. MOSI: Master Output Slave Input2. MISO: Master Input Slave Output3. SS: Slave Select (often active low, output from master)

SPI-Data transmission



1. Bus master configures the clock
2. Master selects slave with a logic level 0 on the select line
3. Master sends a bit on MOSI line and the slave sends a bit on the MISO line.
4. The master and slave have shift registers, they are connected in a virtual ring topology.

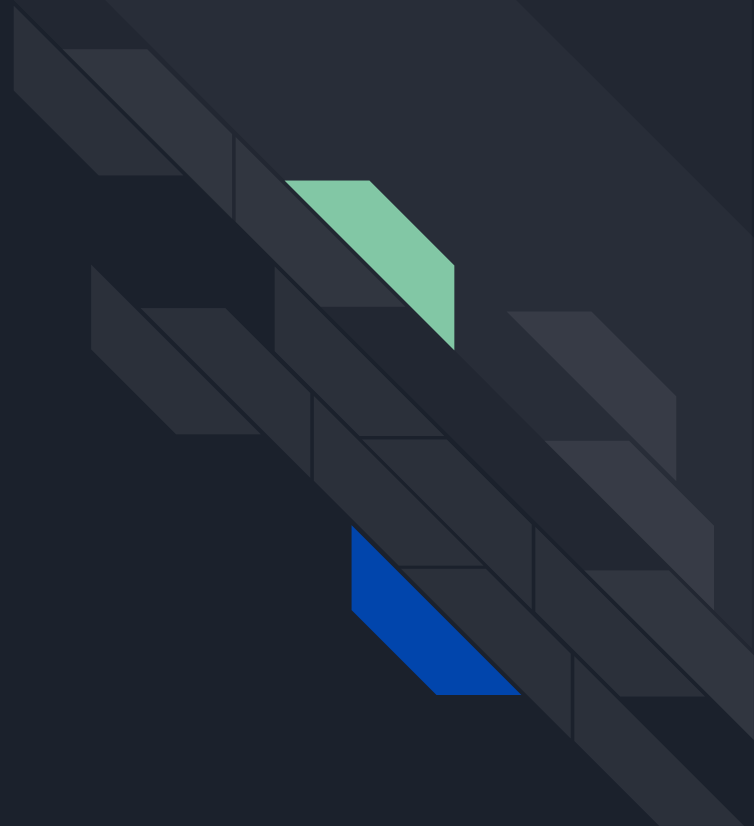


SPI-Applications

- Flash **memory**
- Multiple Media Card (MMC) or SD card
- **Sensors:** temperature, pressure, touchscreens
- **Real-time clocks** (RTCs)
- **Control devices:** audio codecs, digital potentiometers, Digital to Analog Converter
- **Communications:** Ethernet, USB, USART, CAN, IEEE 802.15.4, IEEE 802.11
- **Liquid-crystal displays** (LCD)

I²C

Inter-Integrated Circuit Bus

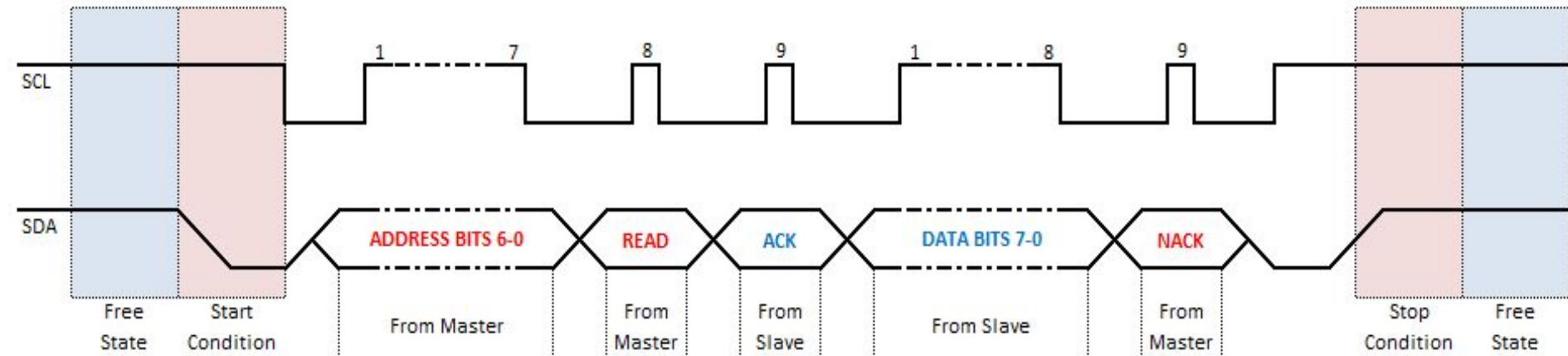




I²C-Specifications

Standard	i2c specification
Physical Media	two wires: SDA, SCL
Network Topology	bus
Maximum Devices	127 slaves to one master (7 bit address space)
Maximum Distance	less than 10 meters (limited by 400 pF cap.)
Mode of Operation	master - slave (allows multi master)
Maximum Binary Rate	<ul style="list-style-type: none">• 100 kbit / s standard mode• 400 kbit / s fast mode• + some new faster modes bus speed is determined by slowest node on bus
Voltage Levels	5V reference voltage (but allows also 2V) "0": less than 30% reference voltage "1": more than 70% reference voltage
Available Signals	0, 1, start, stop

I²C-Data transmission



<https://rheingoldheavy.com/wp-content/uploads/2015/01/Featured-30.png>



I²C-Applications

- developed for TV sets in the 80s
- between microcontrollers
- pretty much anywhere you need a simple & low-cost connection to a device

Onewire
(1-Wire)





Intro to 1-Wire serial protocol

- Single data line plus ground reference for communication.
- voltage-based digital system
- Parasitically powered
- Slaves have unique ID from manufacturer
- Most economical way to add electronic functionality to nonelectronic objects



Onewire-Specifications

Standard	1-Wire
Network Topology	Bus
Maximum Devices	Up to 75 devices to one bus
Maximum Distance	Up to 300 meter
Mode of Operation	Single master - slave(s) communication
Maximum Binary Rate	16.3 kbit/s
Voltage Levels	2.8V (min) to 5.25V (max)
Available Signals	<ul style="list-style-type: none">• 1-wire output• 1-wire input

Onewire-Data transmission



1. Master starts a transmission with a reset pulse, the wire \rightarrow 0 volts
2. Slaves show existence with a "presence" pulse by pulling the line low
3. At this point all slave devices on the 1-Wire line are synchronized to a known state.



Onewire-Applications

- Identification and authentication
- Delivery of calibration data or manufacturing information
- Rack cards
- Computer accessories
- Protection of IP (e.g., cloning prevention)
- iButtons

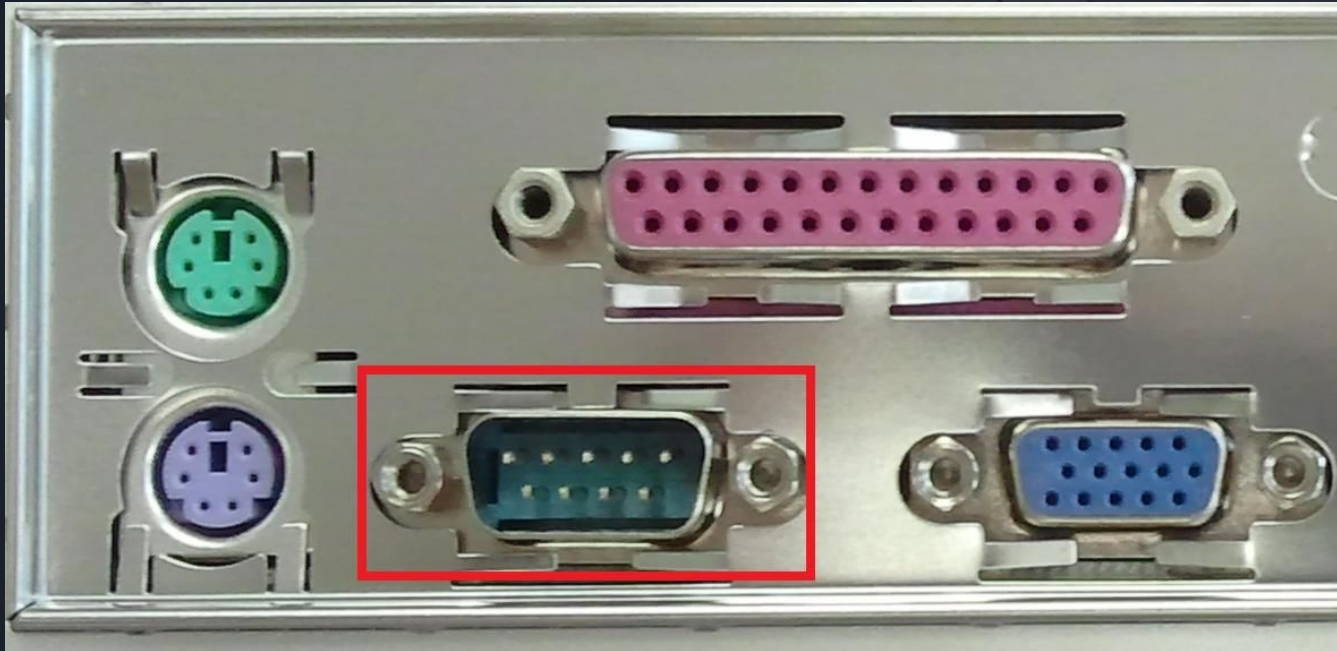
RS-232



Better known as Serial port



Better known as Serial port

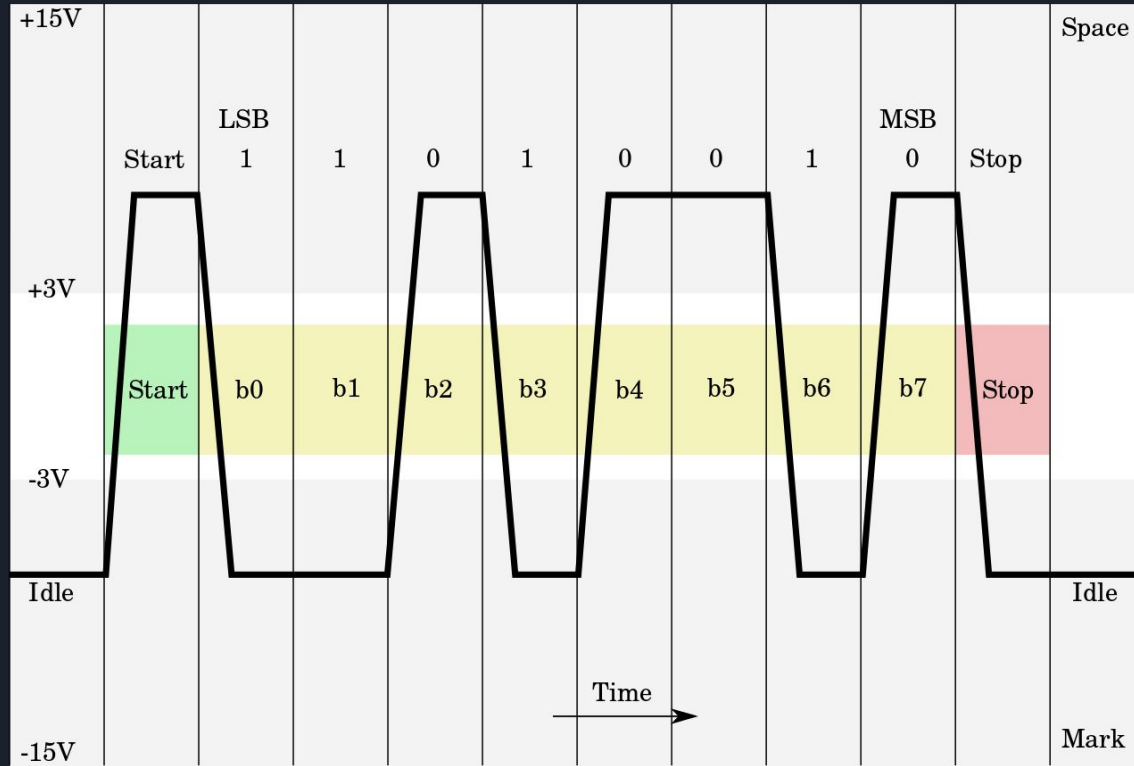




Specifications

Standard	RS-232
Physical Media	Straight or Twisted Pair
Network Topology	Point-to-point
Maximum Devices	2
Maximum Distance	15 - 30 m (absolute max 300 m)
Mode of Operation	Non-differential
Maximum Binary Rate	50 bit/s - 500.000 bit/s
Voltage Levels	-3V to -15V and +3V to +15V
Mark (1)	Negative Voltages
Space (0)	Positive Voltages
Available Signals	TxD, TX, TD RxD, RX, RD (Full Duplex)

Data transmission

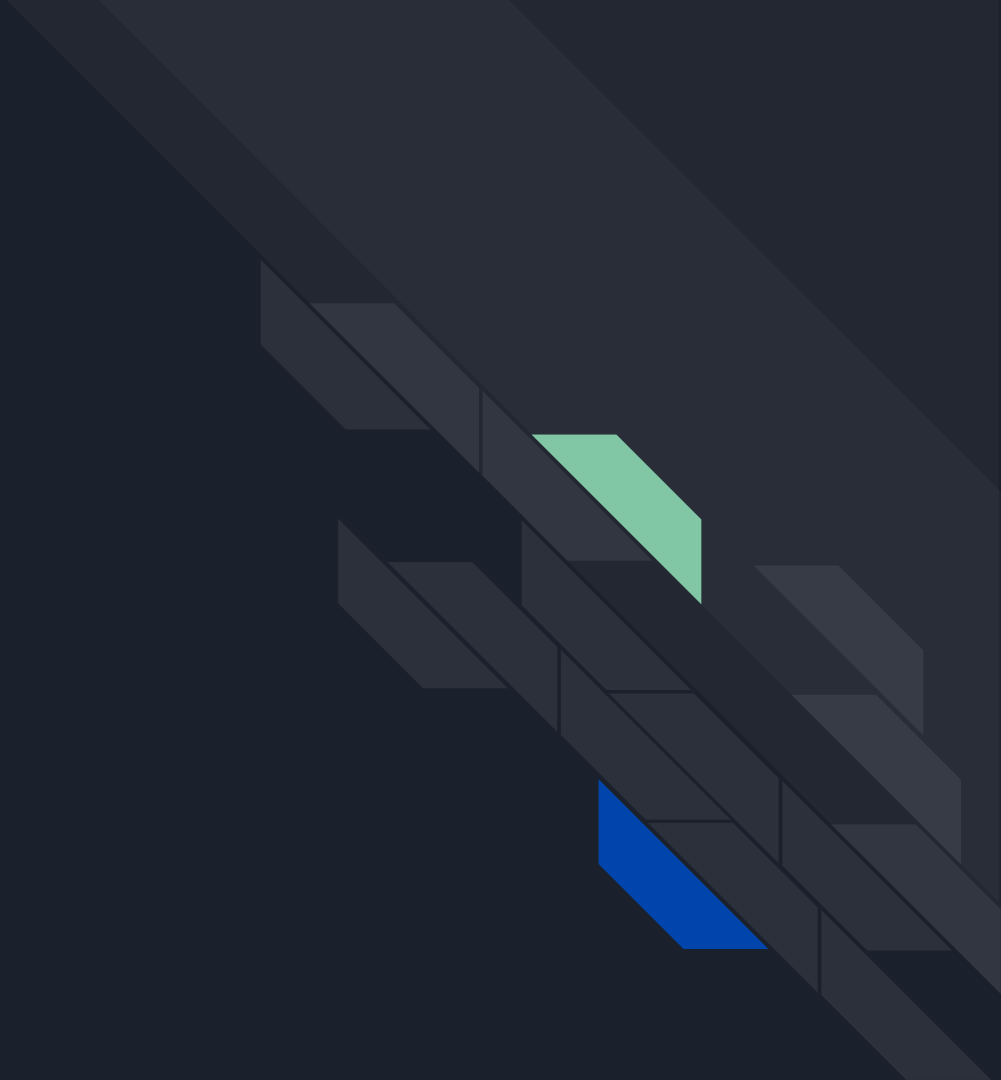




Applications

- Automation
- Receipt Printer, POS
- Sensor Data Communication

RS-422





Differences to RS-232

- Symmetrical, unidirectional Data Transmission
- Using differential signals
- On a shared bus for up to 10 receivers



Specifications

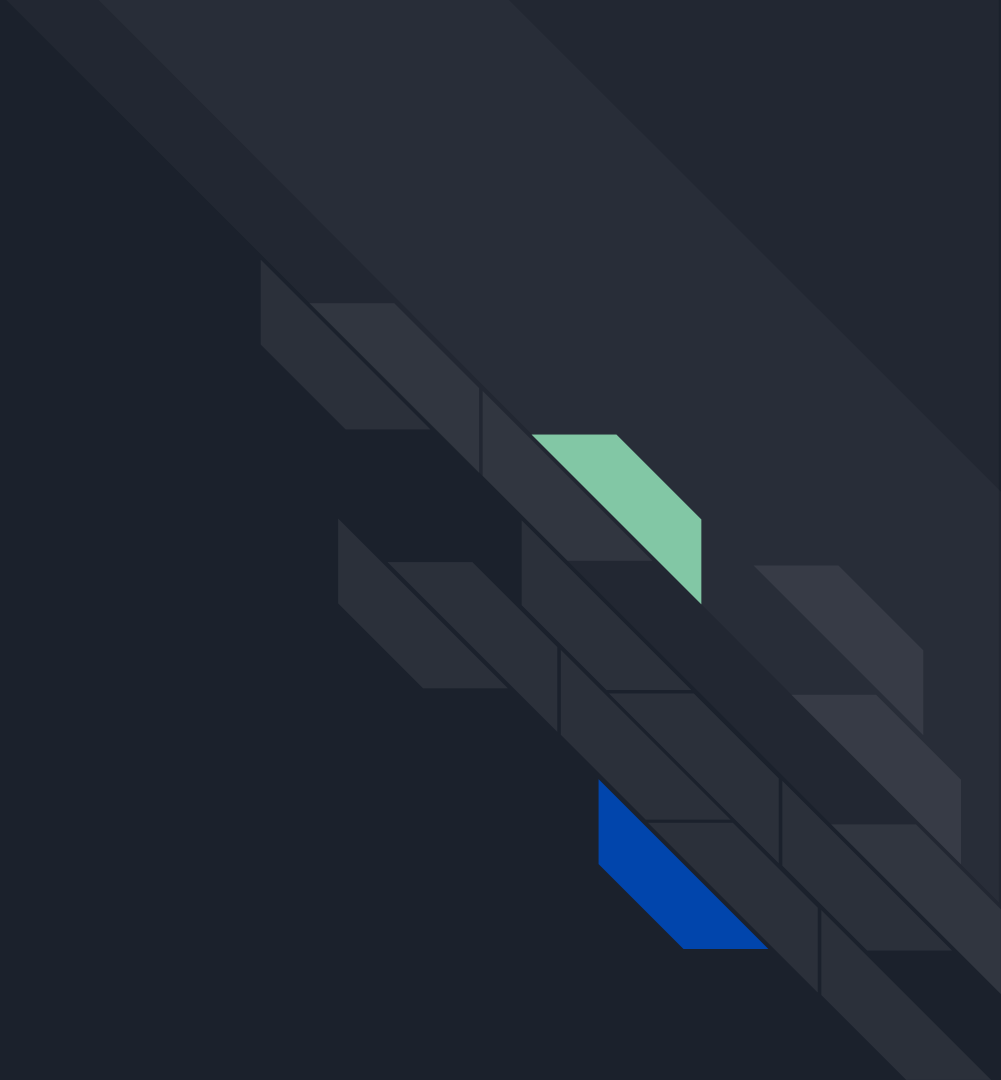
Standard	TIA/EIA-422
Physical Media	Twisted Pair
Network Topology	Point-to-point, Multi-dropped
Maximum Devices	10 (1 driver & 10 receivers)
Maximum Distance	1500 metres
Mode of Operation	Differential
Maximum Binary Rate	100 kbit/s - 10 Mbit/s
Voltage Levels	-6V to +6V (maximum differential Voltage)
Mark (1)	Negative Voltages
Space (0)	Positive voltages
Available Signals	Tx+, Tx-, Rx+, Rx- (Full Duplex)



Applications

- Early Macintosh computers
 - Both RS-422 and RS-232 mode available
 - Used to connect peripherals
- Common transport mechanism for RS-232 extenders

RS-485





Differences to RS-422

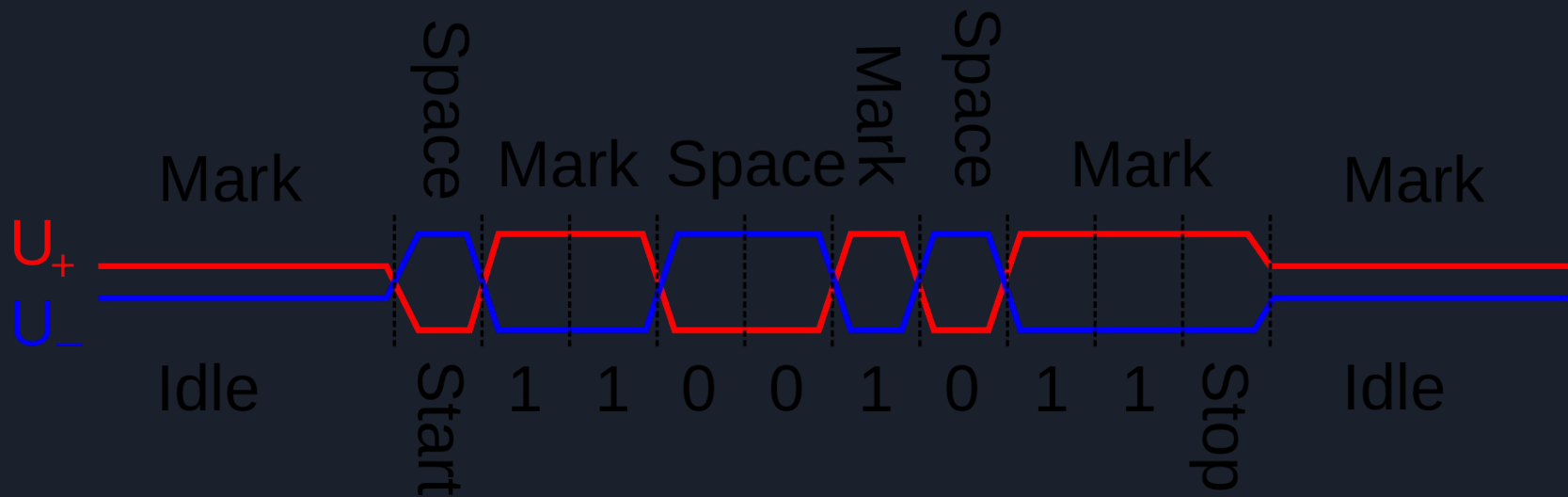
- Three-state-logic
 - Individual transmitters can be deactivated
 - Implements linear bus topology on two wires
- Master-Slave configuration
 - Master centrally located
 - Slaves provide termination



Specifications

Standard	ANSI/TIA/EIA-485-A-1998
Physical Media	Balanced interconnecting cable
Network Topology	Point-to-point, multi-dropped, multi-point
Maximum Devices	At least 32 unit loads
Maximum Distance	Not specified
Mode of Operation	Different receiver levels: binary 1 (OFF) ($V_{oa}-V_{ob} < -200 \text{ mV}$) binary 0 (ON) ($V_{oa}-V_{ob} > +200 \text{ mV}$)
Maximum Binary Rate	up to 10 Mbit/s
Available Signals	A, B, C

Example transmission





Applications

- SCSI-2 and -3 as physical layer
- Programmable logic controllers
- Factory floors
- Physical layer in many automation protocols (Modbus, Profibus)
- Lighting controllers in theaters
- Building automation
 - Video surveillance system
 - Security control panel interconnection
 - Access control card readers

Thank you for your
attention!





Online-Sources

<https://learn.sparkfun.com/tutorials/serial-peripheral-interface-spi/all>

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

<https://www.corelis.com/education/tutorials/spi-tutorial/>

<https://home.roboticlab.eu/en/examples/sensor/1-wire>

<https://www.maximintegrated.com/en/app-notes/index.mvp/id/1796>

<https://en.wikipedia.org/wiki/1-Wire>

<https://www.picotech.com/library/oscilloscopes/1-wire-serial-protocol-decoding>