Session - 26

I2C, SPI communication protocol

SPI and I2C are both widely used synchronous serial communication protocols in embedded systems. SPI (Serial Peripheral Interface) is a high-speed, full-duplex protocol that uses four wires (or more) for communication, while I2C (Inter-Integrated Circuit) is a slower, half-duplex protocol that uses just two wires.

SPI (Serial Peripheral Interface):

- **Full-duplex:** Data can be transmitted and received simultaneously, making it faster than I2C.
- **Four-wire:** Uses SCLK (Serial Clock), MOSI (Master Out Slave In), MISO (Master In Slave Out), and SS (Slave Select) lines.
- **Master-slave:** Typically involves one master device controlling one or more slave devices.
- **High speed:** Operates at higher speeds than I2C, suitable for applications requiring fast data transfer.
- **Simple protocol:** Relatively simple to implement, with minimal overhead.
- **Applications:** Interfacing with sensors, memory devices, and display interfaces.

I2C (Inter-Integrated Circuit):

- **Half-duplex:** Data can only be transmitted or received at a time.
- **Two-wire:** Uses SCL (Serial Clock) and SDA (Serial Data) lines.
- **Multi-master and multi-slave:** Supports multiple master and slave devices on the same bus.
- **Slower speed:** Generally slower than SPI, suitable for low to moderate-speed applications.

- **Addressing:** Uses a 7-bit (or 10-bit) addressing scheme to identify devices on the bus.
- **Applications:** Connecting microcontrollers, I/O interfaces, A/D and D/A converters, and EEPROMs.

Key Differences Summarized:

Feature	**SPI**	**I2C**
Data Transfer	Full-duplex	Half-duplex
Number of Wires	4+ (SCLK, MOSI, MISO, SS)	2 (SCL, SDA)
Speed	Faster	Slower
Addressing	Slave Select lines for each slave	7-bit or 10-bit address per device
Multi-master	Not supported	Supported
Clocking	Master generated clock	Master generated clock
Overhead	Minimal	More overhead (start/stop bits, ACK)

I²C (Inter-Integrated Circuit) and **SPI (Serial Peripheral Interface)** communication protocols — both widely used in **embedded systems** for communication between microcontrollers and peripherals (sensors, displays, memory, etc.).

🔌 I²C vs SPI – Summary Table

Feature	I²C	SPI
Full Name	Inter-Integrated Circuit	Serial Peripheral Interface
Bus Type	Multi-master, multi-slave	Single-master, multi-slave
Wires Required	2 (SDA, SCL)	4 (MISO, MOSI, SCLK, SS/CS)
Speed	Up to 3.4 Mbps (standard: 100–400 kbps)	Up to 50+ Mbps (device dependent)
Data Direction	Bi-directional (on SDA)	Full-duplex
Addressing	7-bit or 10-bit slave address	No addressing, uses SS line
Complexity	Moderate (protocol-managed addressing and ack)	Simple (no addressing protocol)
Data Integrity	Uses ACK/NACK	No built-in error checking
Distance	Short (<1 meter typical)	Short (<1–2 meters typical)
Use Case	Low-speed sensors, RTCs, EEPROM	High-speed ADCs, LCDs, memory

🔷 I²C (Inter-Integrated Circuit)

🪢 Wires Used:

- **SDA** (Serial Data)
- **SCL** (Serial Clock)

🔁 **How It Works:**

- **Master** sends clock and initiates communication.
- **Each device** has a unique **7-bit or 10-bit address**.
- Devices acknowledge communication with **ACK/NACK** bits.
- Supports **multiple masters** and **multiple slaves**.

📚 **Protocol Format:**

START → [ADDRESS + R/W] → ACK → [DATA] → ACK → ... → STOP

✅ **Pros:**

- Only 2 wires for multiple devices
- Simple wiring
- Supports multiple masters

❌ **Cons:**

- Slower than SPI
- Requires pull-up resistors
- Limited cable length and speed

🔷 **SPI (Serial Peripheral Interface)**

🪢 **Wires Used:**

- **MOSI** (Master Out Slave In)
- **MISO** (Master In Slave Out)
- **SCLK** (Clock)
- **SS/CS** (Slave Select / Chip Select) — one per slave

🔁 How It Works:

- Master sends clock pulses on **SCLK**.
- Master sends data to slave via **MOSI**.
- Slave sends data back via **MISO**.
- **SS/CS** line selects which slave to talk to.

✅ Pros:

- Very fast (high throughput)
- Full-duplex communication
- Simple protocol logic

❌ Cons:

- Needs more wires (extra SS lines for each slave)
- No formal addressing scheme
- No error detection by default

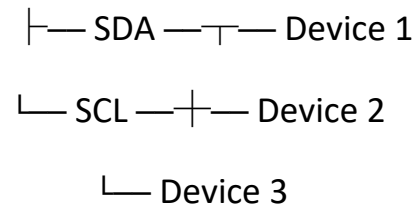
📌 When to Use

Use Case	Best Protocol
Communicating with multiple sensors slowly	I²C
Fast memory or display interface	SPI
Long-distance or complex topologies	Neither (use UART or CAN)

📷 Diagram Comparison

I²C:

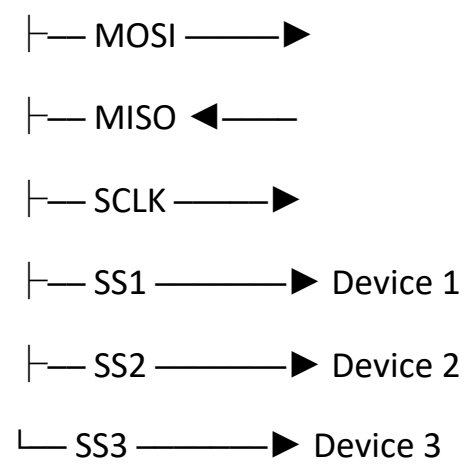
Master



(2 wires shared, each device has an address)

SPI:

Master



(4 wires + 1 SS wire per slave)