ASSIGNMENT 4  
NANDINI ROUT  
FET-BAML-2022-26-016  
  
  
How do UART, I²C, SPI, CAN, and USB communication protocols differ in terms of data transmission speed, complexity, pin usage, and device-to-device communication? What are the key features that make each protocol suitable for specific applications, and in what types of embedded systems would each be most commonly used ?

**1. Data Transmission Speed:**

* **UART**: Up to 115200 bps; higher speeds possible.
* **I²C**: Up to 3.4 Mbps in high-speed mode.
* **SPI**: Typically up to 10 Mbps; faster than I²C.
* **CAN**: Standard up to 1 Mbps; higher in CAN FD.
* **USB**: Up to 480 Mbps (USB 2.0); much higher in USB 3.x.

**2. Complexity:**

* **UART**: Simple and easy to implement.
* **I²C**: Moderate complexity; supports multiple devices.
* **SPI**: Moderate; requires chip select for multiple slaves.
* **CAN**: Moderate; includes error handling and message prioritization.
* **USB**: High complexity; extensive protocol stack.

**3. Pin Usage:**

* **UART**: 2 pins (TX, RX).
* **I²C**: 2 pins (SDA, SCL).
* **SPI**: 4-6 pins (MOSI, MISO, SCK, SS).
* **CAN**: 2 pins (CANH, CANL).
* **USB**: 4 pins (VCC, GND, D+, D-).

**4. Device Communication:**

* **UART**: Point-to-point only.
* **I²C**: Multi-master, multi-slave support.
* **SPI**: Point-to-point; supports multiple slaves.
* **CAN**: Multi-master, robust for many devices.
* **USB**: Master-slave (host-device) configuration.

**5. Key Features & Applications:**

* **UART**: Good for simple serial communication (e.g., GPS, Bluetooth).
* **I²C**: Ideal for sensors and EEPROMs; popular in microcontrollers.
* **SPI**: Best for high-speed applications (e.g., SD cards, displays).
* **CAN**: Reliable for automotive and industrial systems.
* **USB**: Used in consumer electronics and high-speed embedded devices.

**Common Applications:**

* **UART**: Debugging, sensor interfacing.
* **I²C**: Sensor communication, peripheral interfacing.
* **SPI**: Memory and display interfaces.
* **CAN**: Vehicle ECUs, industrial automation.
* **USB**: PC peripherals, high-speed embedded applications