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**Comparing Embedded System Interfaces: GPIO, PWM, and UART**

Embedded systems rely heavily on peripheral interfaces to communicate with the physical world. Selecting the appropriate interface is essential for ensuring the correct operation of sensors, actuators, and other external components. Among the most commonly used interfaces in embedded development are GPIO (General Purpose Input/Output), PWM (Pulse Width Modulation), and UART (Universal Asynchronous Receiver/Transmitter). Each offers distinct features and is suited to specific application scenarios.

GPIO is a fundamental digital interface used to control or read the binary state (high or low) of a pin. It does not support structured data communication but is ideal for simple tasks such as turning an LED on or off or reading a switch's state. Because of its simplicity and low overhead, GPIO is often used when a direct, binary signal is sufficient.

PWM, on the other hand, builds upon the digital nature of GPIO by offering a way to simulate analog signals. It achieves this by rapidly switching a digital pin on and off at a defined frequency and duty cycle. This allows developers to control devices such as servo motors, dim LEDs, or adjust the speed of fans by varying the average power delivered to the device. Although PWM still uses digital output, its ability to vary the output signal makes it highly useful in applications requiring fine control.

UART is a serial communication protocol that facilitates the exchange of data between devices using dedicated transmit (TX) and receive (RX) lines. Unlike GPIO and PWM, which are mostly used for control purposes, UART supports bi-directional, asynchronous communication, making it suitable for transmitting text or binary data. UART is often used to connect microcontrollers to modules like GPS receivers, Bluetooth chips, or other microcontrollers.

Each interface has advantages depending on the task at hand. GPIO is chosen for binary signal control due to its simplicity. PWM is preferred when variable control of an output is needed. UART is essential when structured data needs to be exchanged between devices. Understanding these differences allows embedded system designers to select the most effective communication method for their application.