03.1 Digital communication

Digital signals convey information via a communication channel: a wired or wireless means of transmitting and receiving electromagnetic signals over some distance. In embedded computing, most digital communication channels are wires and buses. An example of a bus is the familiar "slot" on a PC motherboard, as shown in Fig. 03.1.

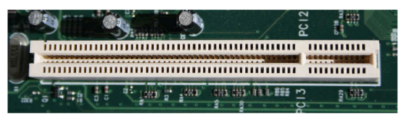
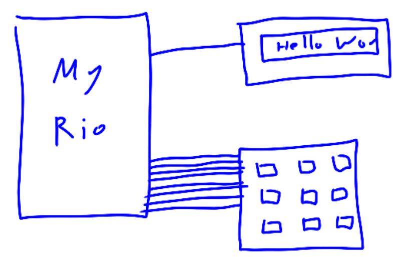


Figure 03.1: a 32-bit PCI bus (Jonathan Zander).



There are two primary divisions of digital communication: serial/parallel and synchronous/asynchronous. These divisions are explored in the following sections. Afterward, common communication protocols are described.

Serial and parallel communication

Communication can be in serial or parallel, with the former taking place sequentially over a single channel and the latter over multiple channels, as shown in Fig. 03.2. Serial communication transfers each bit of information at a time and has significant advantages for "long-haul" communication, since only a single channel is required to span the distance. Parallel communication transfers several bits in parallel, which can be faster than serial communication, but has the disadvantages of clock skew (in synchronous parallel communication, arrival of supposedly simultaneous bits can be "skewed" in time) and serialization/deserialization (converting parallel-to-series and vice versa). However, recently improved serial communication speed has given it the advantage, even over short distances; for instance, the parallel PCI bus of Fig. 03.1 has been largely replaced by the serial PCI Express bus.

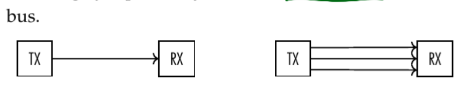


Figure 03.2: (left) serial communication and (right) parallel communication.

Synchronous and asynchronous communication

Synchronos communication is that for which a common, external "clock" times both TX output and RX input. The clock (usually a digital signal itself) signifies when the signal at the RX is valid and should therefore be read.

Asynchronous communication encodes the starting and stopping information in the bitstream itself: the RX detects a "start bit"; waits a predetermined amount of time; reads the next (often seven or eight) bits as "data" at a predetermined constant rate called the bitrate or baud rate; often reads the parity bit; and finally the "stop bit."

The parity bit is used for error checking, for which there are two general forms: even and odd parity. In even parity, the TX sends a parity bit of 0 if the number of ones in the data is even, and a 1 when it is odd. Even parity takes the opposite approach, with evens getting 1 and odds getting 0. This lets the RX check the parity of the received data. Of course, if an even number of bits are incorrect, checking the parity bit will not be sufficient for error detection.

Standards

Communication standards define signal, electrical, connector, cable, and other characteristics that can be adopted across an entire industry. For instance, USB, Ethernet (IEEE 802.3), and RS-232 are such standards for serial communications. The Institute of Electrical and Electronics Engineers (IEEE) defines communication protocols for many wired communications and the International Organization for Standardization (ISO) defines several others.