Parallel and Serial Data

SERIAL I/O STANDARDS

The need for data movement

- One of the most common operations in a computer or digital system is sending data from one place to another. See Fig. 1.

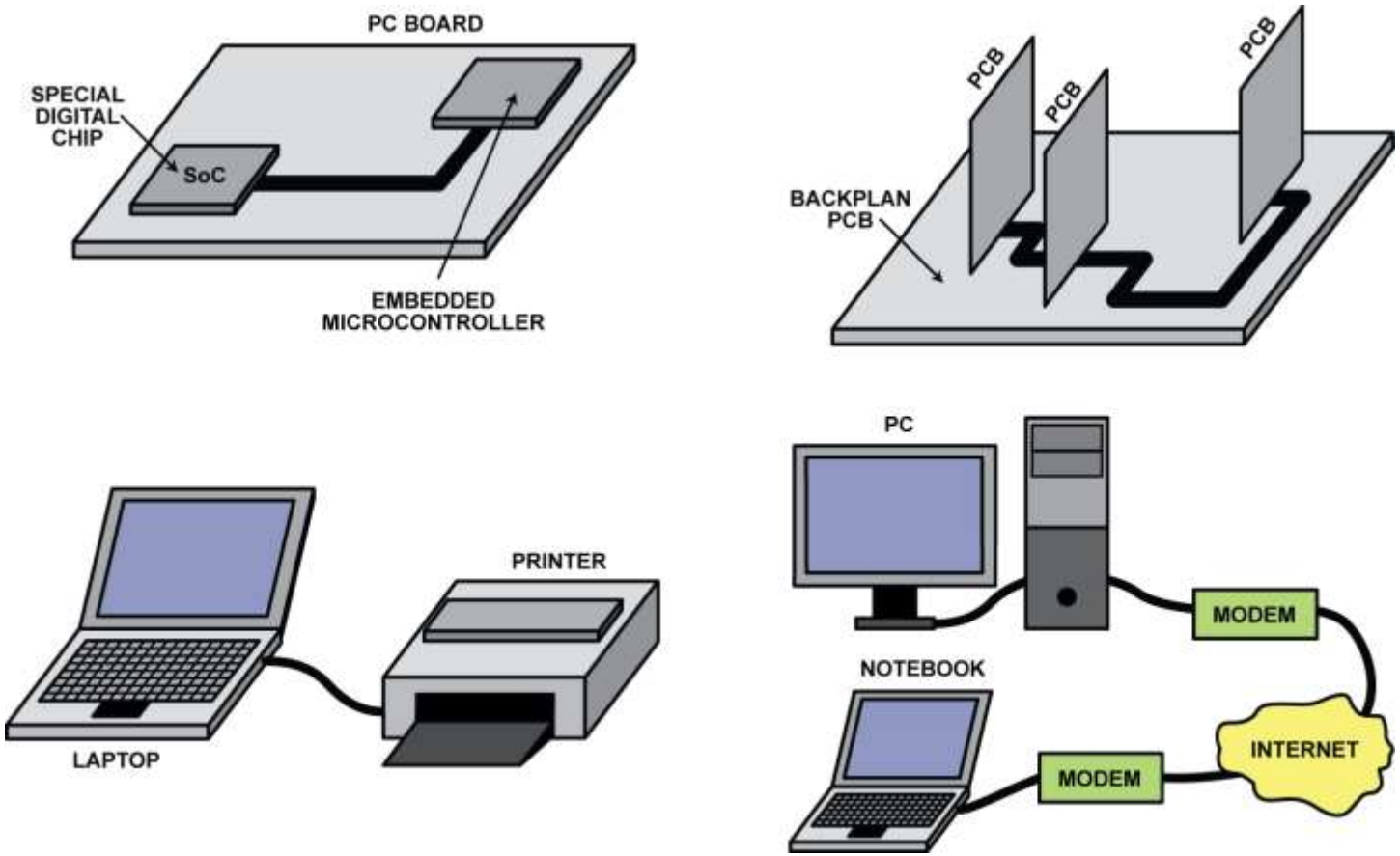

Figure 1

The need for data movement

- One of the most common operations in a computer or digital system is sending data from one place to another. See Fig. 1.
  - From chip to chip on a printed circuit board (PCB)
  - From one PCB to another in a system
  - From one piece of equipment to another (PC to printer)
  - From one computer to another distant computer over a network

Data transmission is a Communications System

- Fig. 2 shows a generic example of a simple data transmission system.
- The source of data may be a computer, embedded controller, or other digital source.
- The data is usually organized as in bytes or larger words of 16, 32 or 64 bits.
- The receiver of the data may be a computer, embedded controller or some other digital circuit.

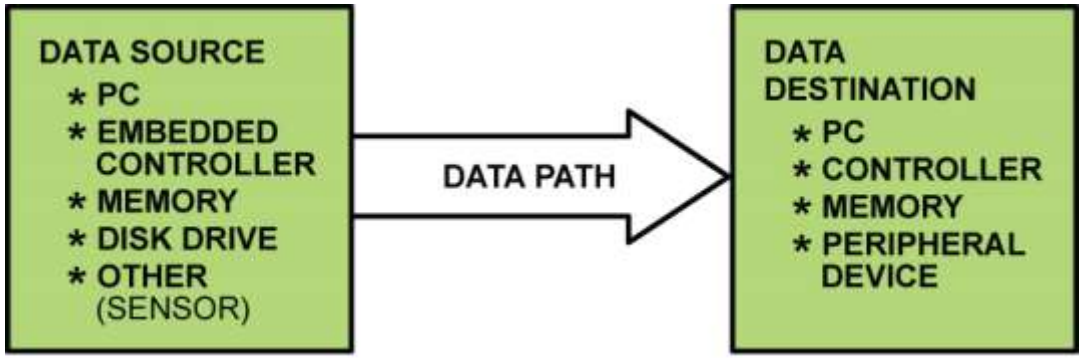

Figure 2

The Communications Medium

- The communications path for the data may be any one of many different connections. Examples:
  - Copper traces on a PC board.
  - Ribbon cable.
  - Cable such as coax or twisted pair.
  - Fiber optic cable.
  - Radio or wireless.

Parallel and Serial Data Transfers

- There are two ways to transfer digital data between two points: parallel and serial.
- Parallel data transfers cause all bits of a binary word or number to be transmitted simultaneously over multiple parallel connections, one wire or connection per bit.
- Serial data transfers transmit a binary word or number one bit at a time over a single data connection.

Parallel Transmission

- Parallel transmission is used primarily when very high speed is needed. All bits move together at the same time. See Figure 3.
- The transmission path or medium is usually referred to as a bus made up of one wire or conductor for each binary bit. referenced to ground.
- Very high speed buses use differential transmission requiring two wires per bit. Differential transmission is preferred for very high speeds and longer conductors where noise pickup is a problem.

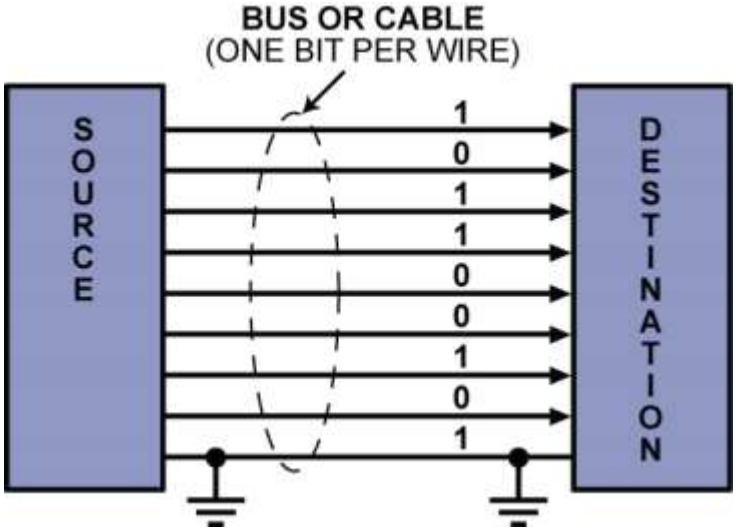

Figure 3

Single-Ended vs. Differential Transfers

- A single-ended transfer is made when the bit voltage appears on a single wire referenced to ground. See Fig 4A.
- Tx is the transmitting circuit or driver, Rx is the receiving circuit or receiver.

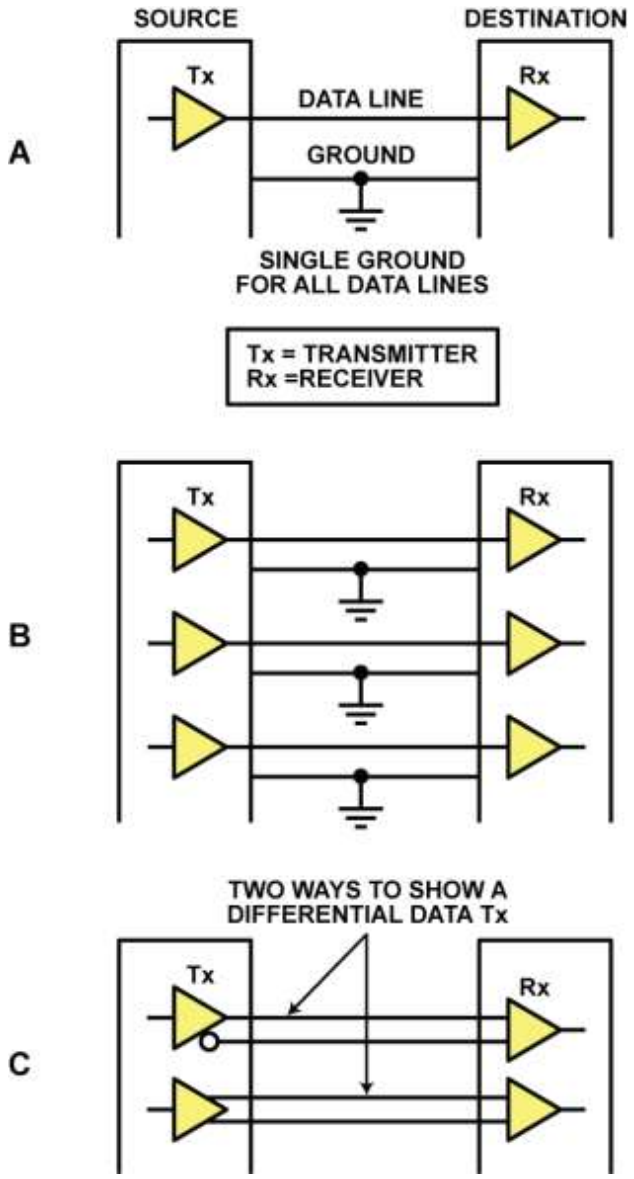

Figure 4A-C

Single-Ended vs. Differential Transfers

- Some transfers use a single ground connection for all parallel lines. Others use a separate ground wire for each bit line. See Fig. 4B.

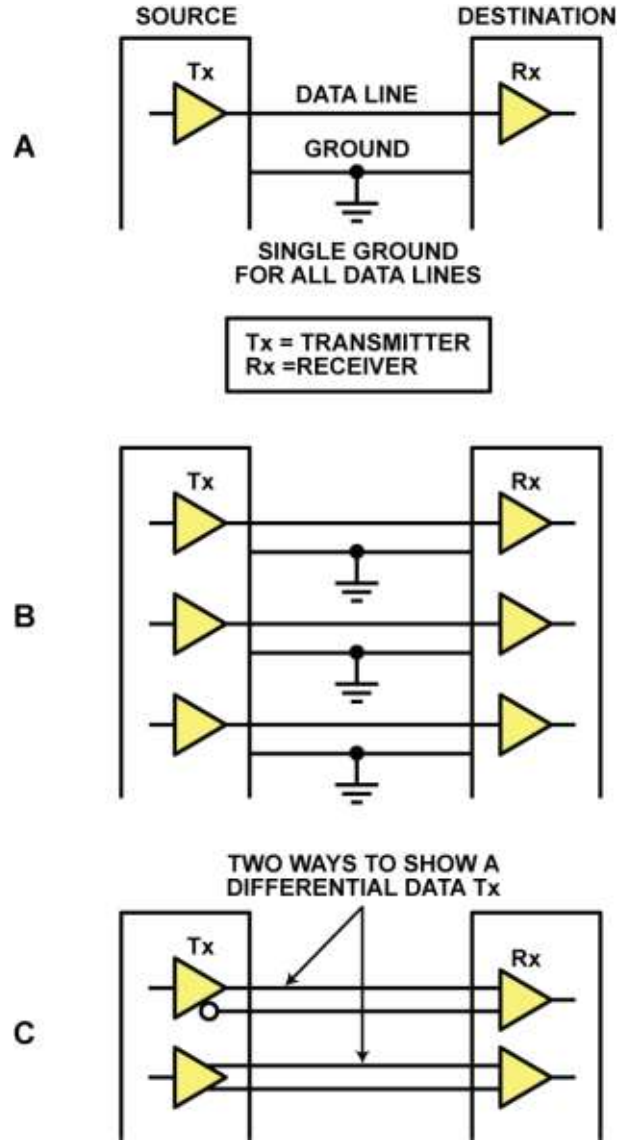

Figure 4A-C

Single-Ended vs. Differential Transfers

- In differential transfers, two lines are used. No ground reference is used. Fig 4C.
- Differential transfers are more immune to noise than single-ended transfers over longer distances.

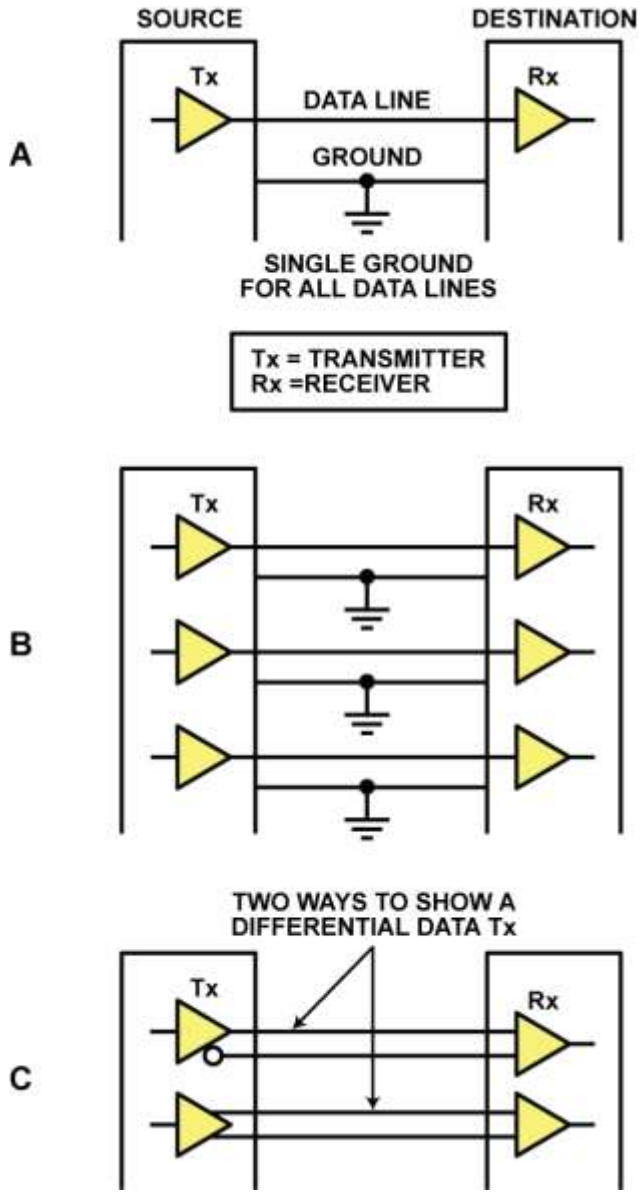

Figure 4A-C

Parallel Transfer Advantages

- Parallel data transfers are extremely fast since all bits are transmitted simultaneously.
- Transfer rates of hundreds of MHz are possible.

Parallel Limitations

- Parallel transmissions are subject to high levels of signal distortion from the path capacitance and inductance if the distance of transmission is great.
- Transmission distances are limited to several inches if data rates exceed several hundred megahertz (MHz). For this reason, fast parallel transfers are usually limited to bus connections on a PC board, very short cables, or register transfers inside an IC.
- Parallel connections require more wires in a cable or more pins on an IC, take up more space on a PCB or require a larger connector.
- Parallel connections are more expensive than serial connections because of the multiple paths (copper lines, wires, etc.) and the multiple digital circuits needed to transmit and receive the data. (One transmitter and one receiver per bit.)

Parallel Applications

- Parallel buses are widely used in computers (PCI bus) for connecting chips together like microprocessor to memory or I/O chips on a PCB. Chips on a PC motherboard are an example.
- Parallel buses in the form of short ribbon cables are used to connect disk drives to mother boards in a PC.
- In the past, longer parallel cables were the most common way to connect a PC to a printer. At low data transfer rates longer cables (many feet) can be used.

Serial is the answer.

- In serial data transfers, a binary word is transmitted one bit at a time over a single connection. See Figure 5.

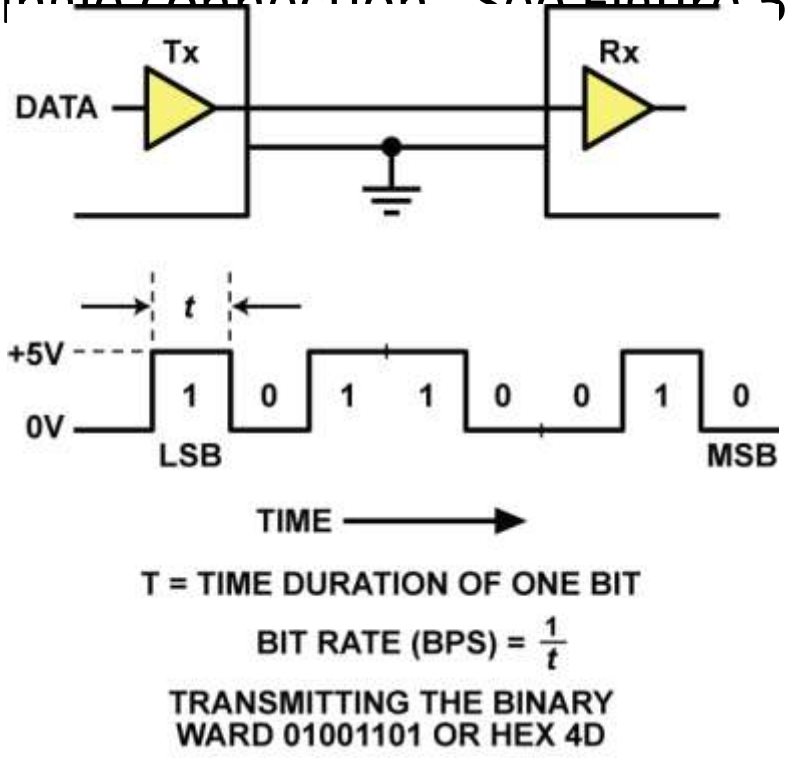

Figure 5

Serial is the answer.

- Either the LSB or MSB can occur first. In Fig. 5 LSB is first.
- Each bit is sent during a fixed time interval (t) one bit after the other.
- Serial transfers are simpler and less expensive. Only one transmitter and one receiver is needed. Only 2 wires are needed in a cable (the bit line and ground).
- Differential transmission can also be used in which case 2 wires are needed.
- The only practical way to transmit data over a fiber optical cable or a wireless link is by the serial method.

Serial Data Rate

- Serial transmissions are slower because the bits are transmitted one at a time.
- Yet very high speed connections eliminate this apparent disadvantage.
- The date rate is expressed in bits per second (bps). The data rate in bps is determined from the bit time interval as shown in Fig 5.
- Bit rate in bps is 1/t where t is the bit time.

Serial data calculations

- If a serial data stream has a bit time of 100 nanoseconds (ns), the data rate is: bps = 1/100 x 10^{-9} = 10,000,000 bps or 10 Mbps
- The bit time can be calculated from the data rate or t = 1/bps.
- If the data rate is 19200 bps, the bit time is 1/19200 = 52 microseconds.
- It takes 52 x 8 = 416 µs to transmit one byte of data at a 19.2 kbps rate.
- Practical serial data rates up to 10 Gbps are common in electronic and computer equipment.

Serial dominates

- Most digital data transfers are by serial methods today.
- There are literally dozens of different serial methods in use each with its own data protocol, electrical characteristics, and mechanical connections.
- The serial method is usually selected by its application and the required data speed.

Common Serial Interfaces

- The following serial data interfaces are covered in this presentation:
  - RS-232, RS-422/423, RS-485
  - Universal serial bus (USB)
  - Serial peripheral interface (SPI)
  - Serial communications interface (SCI)
  - I^2C bus
  - CAN bus
  - LIN bus
  - Flexray
- Most of these interfaces are built into microcomputers, embedded controllers, memory or other chips. However, some interfaces are offered separately as integrated circuits.