19Z604 Embedded Systems

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Transmission Line Basics

- Transmission lines in communication carry telephone signals, computer data in LANs, TV signals in cable TV systems, and signals from a transmitter to an antenna or from an antenna to a receiver.
- Their electrical characteristics are critical and must be matched to the equipment for successful communication to take place.
- Transmission lines are also circuits.

Transmission line basics

- The two primary requirements of a transmission line are:
  1. The line should introduce minimum attenuation to the signal.
  2. The line should not radiate any of the signal as radio energy.

Balanced Transmission

- **Definition**: Uses two conductors of equal impedance to ground, carrying equal and opposite signals.
- **Key Characteristics**:
  - The signals are inverted versions of each other (+V and -V).
  - External noise affects both conductors equally (common-mode noise) and gets canceled at the receiver.
  - Provides better noise immunity and longer transmission distances.

Unbalanced Transmission

- **Definition**: Uses a single conductor for the signal and a ground reference.
- **Key Characteristics**:
  - Signal travels through one conductor, with the ground acting as the return path.
  - More susceptible to external noise and interference.
  - Suitable for short-distance transmission.

RS-232

- **Transmission Line Used**: **Unbalanced Transmission**
  - RS-232 uses a single conductor for the signal and a ground reference, making it an unbalanced transmission system.
  - **Key Details**:
    - Signal travels over a single wire, with ground as the return path.
    - Susceptible to noise and interference, especially over long distances.
    - Maximum cable length: ~15 meters (50 feet) for reliable communication.
    - Operates at low data rates (up to ~20 kbps in standard configurations).
  - **Common Cable Types**:
    - Cables with multiple unshielded or shielded single-ended wires (e.g., standard serial cables).

RS-422

- **Transmission Line Used**: **Balanced Transmission**
  - RS-422 uses two conductors for each signal, carrying differential signals (one wire carries +V, the other -V).
  - **Key Details**:
    - Differential signaling improves noise immunity and minimizes electromagnetic interference.
    - Suitable for long-distance communication, up to 1200 meters (~4000 feet).
    - Higher data rates compared to RS-232 (up to ~10 Mbps for short distances).
  - **Common Cable Types**:
    - **Twisted Pair Cables**: These are ideal for balanced transmission in RS-422, as the twisting helps cancel out common-mode noise.

RS-422

- RS422 standard for serial communication is used in noisy environments
- In RS-422the distance between the two devices is 1200 meters
- Twisted copper cable is used as transmission medium
- Unlike in RS-232,the voltage levels are measured with reference to local ground, In RS-422 the voltage difference between the two copper wires represent the logical levels. Hence RS-422 uses balanced transmission
- Two channels are used for transmit and receive paths

RS-485

- RS-485 is a variant of RS-422 to connect a number of devices in a network
- RS-485 protocols operate in Master/Slave configuration. Upto 512 devices can be connected in a network
- Using one twisted pair half-duplex communication can be achieved and using two twisted pairs full-duplex communication can be achieved.

Transmission Line Basics

- The most widely used type of transmission line is the **coaxial cable.** It consists of a solid center conductor surrounded by a dielectric material, usually a plastic insulator such as Teflon.
    - A second conducting shield made of fine wires covers the insulator, and an outer plastic sheath insulates the braid.
  - Coaxial cable comes in sizes from ¼ inch to several inches in diameter.
- **Twisted-pair cable** uses two insulated solid copper wires covered with insulation and loosely twisted together.
  - Two types of twisted-pair cable are
    - Unshielded twisted-pair (UTP) cable
    - Shielded twisted-pair (STP) cable

Transmission Line Basics

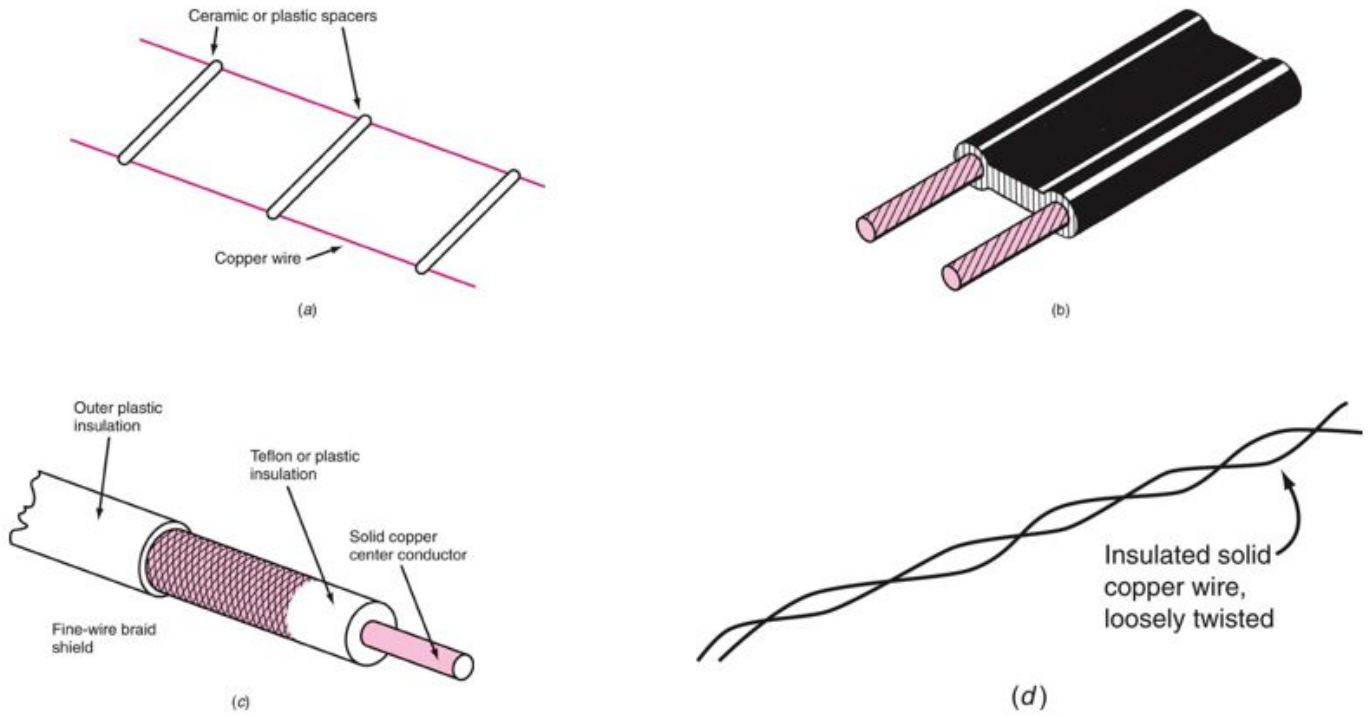


Figure 13-1: Common types of transmission lines. (a) Open-wire line. (b) Open-wire line called twin lead. (c) Coaxial cable (d) Twisted-pair cable.

Transmission Line Basics

Balanced Versus Unbalanced Lines

- Transmission lines can be **balanced** or **unbalanced.**
- A balanced line is one in which neither wire is connected to ground.
- The signal on each wire is referenced to ground.
- In an unbalanced line, one conductor is connected to ground.
- Open-wire line has a balanced configuration

Transmission Line Basics

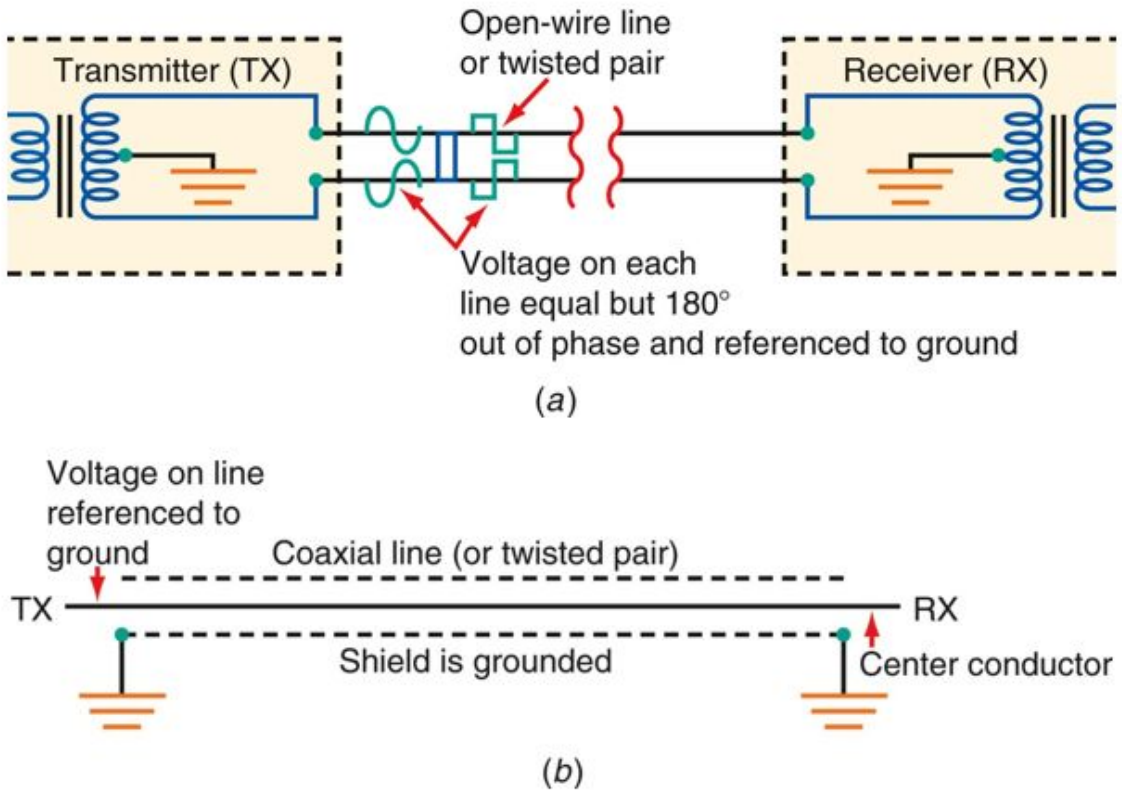


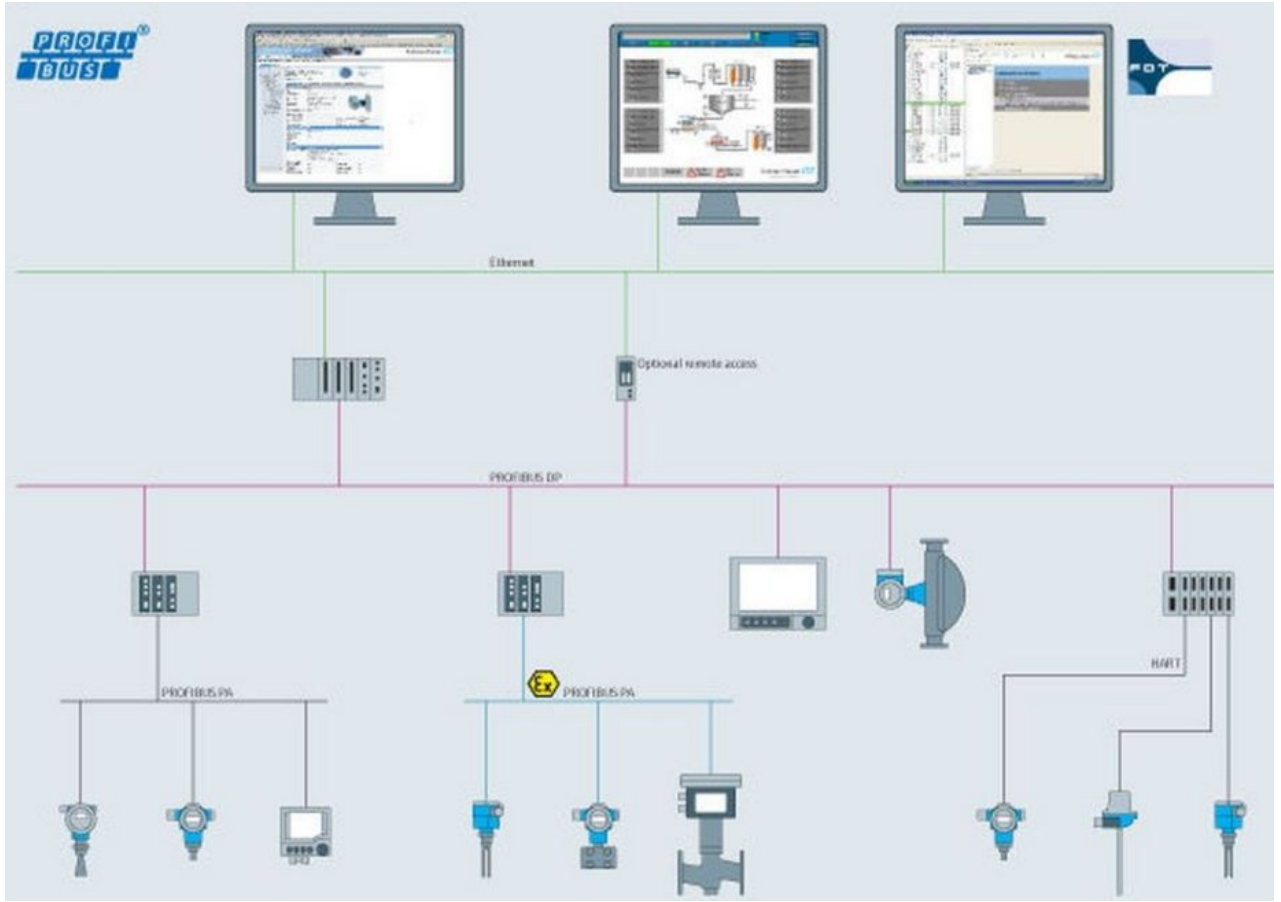
Figure 13-2: (*a*) Balanced line. (*b*) Unbalanced line.

Modbus

- **Modbus** is a data communications protocol originally published by Modicon (now Schneider Electric) in 1979 for use with its programmable logic controllers (PLCs). Modbus has become a *de facto* standard communication protocol and is now a commonly available means of connecting industrial electronic devices.
- Modbus is popular in industrial environments because it is openly published and royalty-free. It was developed for industrial applications, is relatively easy to deploy and maintain compared to other standards, and places few restrictions on the format of the data to be transmitted.
- The Modbus protocol uses character serial communication lines, Ethernet, or the Internet protocol suite as a transport layer.

FIELDBUS, PROFIBUS

- What is a fieldbus PLC?
- A fieldbus is **a serial bus system used in machines and systems to connect sensors and actuators (motors) to each other and to one or multiple masters (industrial PCs, PLCs)**. Fieldbuses make it possible to exchange data between different system components over long distances and under high external load.



Modbus Communication Example

Industrial power meters

- Industrial power meters **require voltage and current measurements in order to calculate power consumption and to produce more complex power quality statistics such as sags, peaks, and harmonics**.

Why power quality is important ?

- While demand is on the up, power quality is wavering, resulting in **poor performance of electrical systems, increased utility bills, additional unplanned maintenance and issues with continuity of supply**. Other concerns include non-compliance to grid codes and reduced lifetime of equipment.