Industrial Data Communications – RS-232/RS-485

Tutorial 2

This tutorial on industrial data communications is broken down into the following sections:

- Balanced and Unbalanced Systems
- RS-232
- RS-485

Balanced and Unbalanced Systems

The choice between unbalanced and balanced transmission lines is an important consideration when selecting a data communications system. The RS-232 standard is a unbalanced standard; whereas the RS-485 standard is balanced. Strictly speaking these standards should be referred to as EIA-232E and EIA-485 respectively; but for the purposes of this tutorial, RS (or Recommended Standard) will be used.

In data communications systems using the RS232 interface standards, the voltage signal is said to be 'unbalanced' because only one wire carries the signal voltage. There is also a signal common wire, sometimes called the signal ground. The transmitted signal is the voltage between the signal conductor and the common reference conductor.

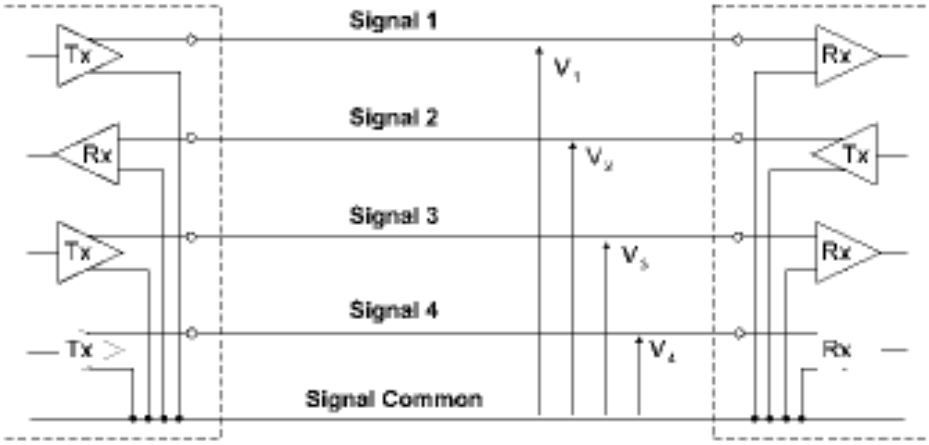

Figure 1 Data Communication with Unbalanced Interfaces

Communication interfaces operating in accordance with the EIA485 interface standards require two conductors to transmit each signal. The voltage at the receiving end is measured as the voltage difference between these two wires. This is known as a balanced or differential system. This eliminates many of the interference problems associated with the common reference wire.

The voltage between the signal conductor and the common reference conductor is known as a common mode voltage (CMV). Ideally the CMV on the two wires will cancel out completely but the greater the CMV, the higher the voltage difference and the the more likely that noise will affect the signal. If the CMV reaches a certain high threshold, the errors will increase to an unacceptable level.

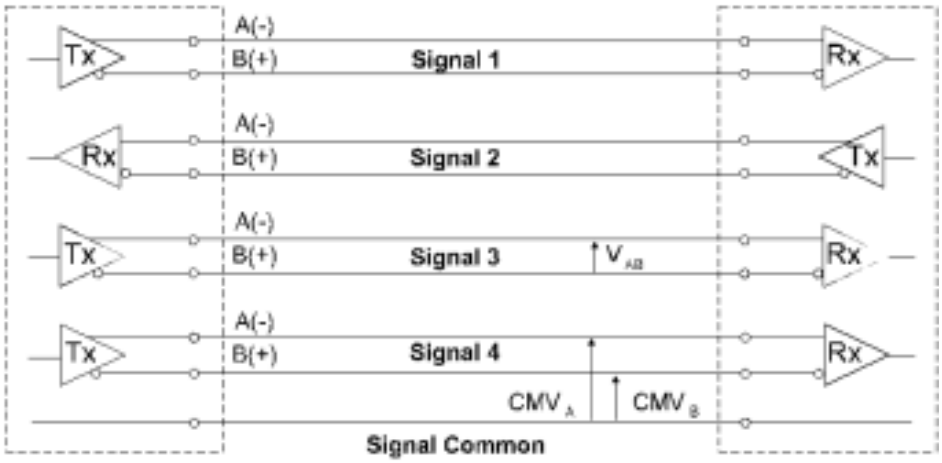

Figure 2 Data Communications with Balanced Interfaces

The balanced transmission line permits a higher rate of data transfer over longer distances. The differential method of data transfer is preferable in industrial applications where noise can be a major problem. The disadvantage is that a balanced system requires two conductors for every signal.

The successful transfer of voltage signals across two conductors in the presence of noise is based on the assumption that the conductors have similar characteristics and will be affected equally by noise and voltage drops, for example. It does not mean that noise does not exist in the balanced differential system. The voltages on both conductors should rise and fall together, and the differential voltage should remain the same.

The RS-232 standard

The RS-232 Interface Standard was developed for a single purpose which is clearly stated in its title, the “Interface between Data Terminal Equipment (DTE) and Data Circuit Terminating Equipment (DCE) employing serial binary data interchange”. In particular, EIA-232 was developed for interfacing data terminals to modems.
Poor interpretation of RS-232 has been responsible for many problems in interfacing equipment from different manufacturers, leading some users to dispute whether it is a ‘standard’. It should be emphasised that RS-232, and other related EIA standards, define the electrical and mechanical details of the interface and do not define a protocol (the actual packet and message structure).
The RS-232 interface standard specifies the method of connection of two devices, the DTE and DCE.
DTE Data Terminal Equipment, for example, may be a computer or a printer. A DTE device communicates with a DCE device. A DTE device transmits data on pin 2 and receives data on pin 3.

DCE Data Communications Equipment, now also called Data Circuit-terminating Equipment in EIA/TIA-232E, for example a modem. A DCE device receives data from the DTE and retransmits via another data communications link, such as the telephone system. A DCE device transmits data on pin 3 and receives data on pin 2.

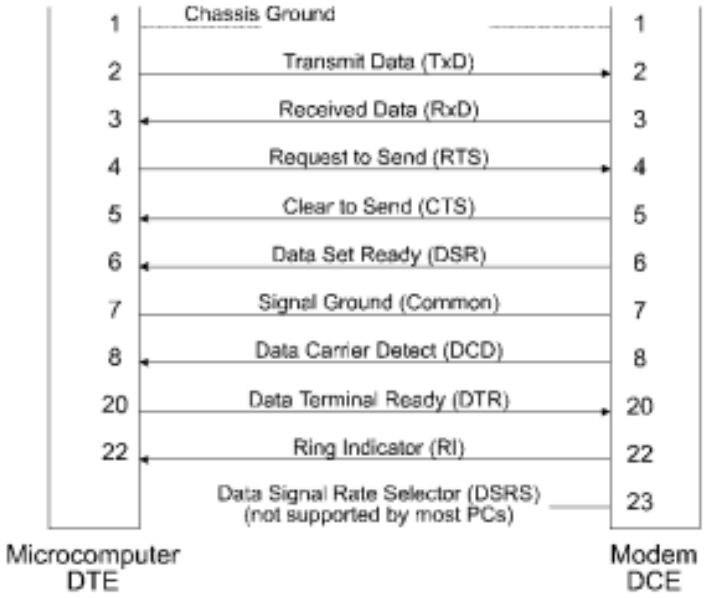

Figure 3 Connections Between the DTE and the DCE

Equipment that uses the RS-232 standard has the following features:

- point-to-point communication
- suitable for serial, binary and digital data communication
- communication is generally asynchronous, meaning that there is fixed timing between data bits, but variable time between character frames
- full duplex communications
- Unbalanced transmission (and therefore susceptible to noise)

voltage signals are:

logic 1: -3 V to -25 V
logic 0: +3 V to +25 V

reliable communication up to a distance of about 50ft, depending on the type of cable used and the speed data rates of up to about 20kbps according to the standard (but 115 kBaud in practice). The EIA-232 standard defines 25 electrical connections. The electrical connections are divided into four groups:

- data lines
- control lines
- timing lines
- special secondary functions

Pin No. DTE	DB-9 Connector EIA-232 Pin Assignment	DB-25 Connector EIA-232 Pin Assignment	DB-25 Connector EIA-530 Pin Assignment
1	Received Line Signal	Shield	Shield
2	Received Data	Transmitted Data	Transmitted Data (A)
3	Transmitted Data	Received Data	Received Data (A)
4	DTE Ready	Request to Send	Request to Send (A)
5	Signal/Common Ground	Clear to Send	Clear to Send (A)
6	DCE Ready	DCE Ready	DCE Ready (A)
7	Request to Send	Signal/Common Ground	Signal/Common Ground
8	Clear to Send	Received Line Signal	Received Line Signal (A)
9	Ring Indicator	+Voltage (testing)	Receiver Signal
			DCE Element Timing (B)
10		-Voltage (testing)	Received Line (B)
11		Unassigned	Transmitter Signal
			DTE Element Timing (B)
12		Sec Received Line Signal	Transmitter Signal
		Detector/Data Signal	DCE Element Timing
13		Sec Clear to Send	Clear to Send (B)
14		Sec Transmitted Data	Transmitted Data (B)
15		Transmitter Signal	Transmitter Signal
		DCE Element Timing	DCE Element Timing (A)
16		Sec Received Data	Received Data (B)
17		Receiver Signal	Receiver Signal
		DCE Element Timing	DCE Element Timing (A)
18		Local Loopback	Local Loopback
19		Sec Request to Send	Request to Send (B)
20		DTE Ready	DTE Ready (A)
21		Remote Loopback/Signal	Remote Loopback
		Quality Detector	
22		Ring Indicator	DCE Ready (B)
23		Data Signal Rate	DTE Ready (B)
24		Transmit Signal	Transmitter Signal
		DTE Element Timing	DTE Element Timing (A)
25		Test Mode	Test

Table 1 Table of Common DB-9 and DB-25 Pin Assignments for EIA-232 and EIA/TIA-530 (often used for EIA-422 and EIA-485)

The EIA-485 Interface Standard

The EIA-485 standard is the most versatile of the EIA interface standards and is a true balanced or differential standard. EIA-485 permits a ‘multidrop’ network connection on 2 wires and allows reliable serial data communication for:

- distances of up to 1200m
- data rates of up to 10 Mbps
- up to 32 line drivers on the same line
- up to 32 line receivers on the same line.

The major enhancement of EIA-485 is that a line driver can operate in three states called tri-state operation:

- logic 1
- logic 0
- high-impedance

In high impedance the line driver draws virtually no current and appears not to be present on the line. This is known as the ‘disabled’ state and can be initiated by a signal on a control pin on the line driver integrated circuit. Tri-state operation allows a multidrop network connection and up to 32 transmitters can be connected on the same line, although only one can be active at any one time. Each terminal in a multidrop system must be allocated a unique address to avoid conflicting with other devices on the system. EIA-485 includes current limiting in cases where contention occurs.

The EIA-485 interface standard is very useful for systems where several instruments or controllers may be connected on the same line. Special care must be taken with the software to co-ordinate which devices on the network can become active. In most cases a master terminal, such as a PC or computer, controls which transmitter/receiver will be active at any one time.

The 2-wire data transmission line does not normally require special termination. On long lines, the leading and trailing edges of data pulses will be much sharper if terminating resistors approximately equal to the characteristic impedance (Zo) of the line are fitted at the extreme ends. This is indicated in Figure 4. For twisted pairs the characteristic impedance is typically between 100 to 120 ohms.

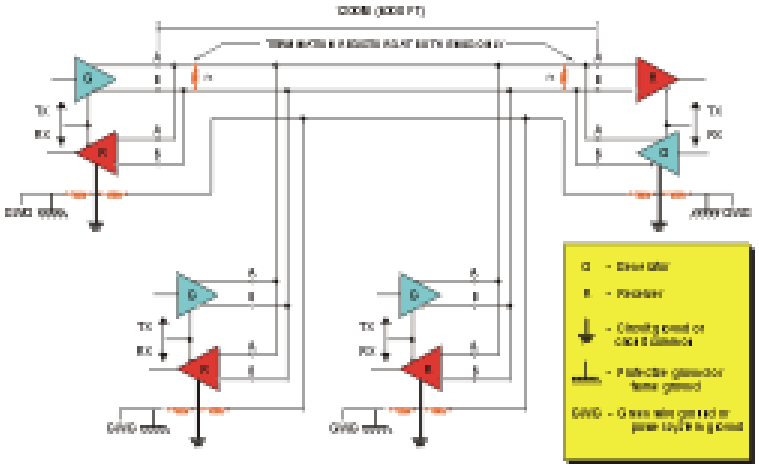

Figure 4 Typical Two Wire Multidrop Network

An EIA-485 network can also be connected as a four wire configuration. In this type of connection it is necessary that one node be a master node and all others be slaves. The master node communicates to all slaves, but a slave node can communicate only to the master. Since the slave nodes never listen to another slave’s response to the master, a slace node cannot reply incorrectly to another slace node. This is an advantage in a mixed protocol environment.

Now click here to go to the short quiz based on this tutorial.