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Summary RS-232/422/485 Interface Standards

Designing an interface between systems is not a simple or straight-forward task. Parameters that must be taken into account include: data rate, data format, cable length, mode of transmission, termination, bus common mode range, connector type, and system configuration. Noting the number of parameters illustrates how complex this task actually is. Additionally, the interface's compatibility with systems from other manufacturers is also critically important. Thus, the need for standardized interfaces becomes evident. Interface Standards resolve both the compatibility issue, and ease the design through the use of non-custom standardized Drivers and Receivers.

Introduction

This application note provides a short summary of popular Interface Standards. In most cases, a table of the major electrical requirements and a typical application is illustrated. Interface Standards from the following standardization organizations are covered in this application note:

• TIA/EIA Telecommunications Industry Association/Electronics Industry Association
• ITU International Telecommunications Union
• CCITT International Telegraph and Telephone Consultative Committee—now replaced by the ITU
• MIL-STD United States Military Standards
• FED-STD Federal Telecommunications Standard Committee
• Other selected interface standards

There are two basic modes of operation for line drivers (generators) and receivers. The two modes are Unbalanced (Single-ended) and Balanced (Differential).

Unbalanced (Single-Ended) Data Transmission

Unbalanced data transmission uses a single conductor, with a voltage referenced to signal ground (common) to denote logical states. In unbalanced communication only one line is switched. The advantage of unbalanced data transmission is when multiple channels are required, a common ground can be used (see *Figure 1*). This minimizes cable and connector size, which helps to minimize system cost. The disadvantage of unbalanced data transmission is in its inability to reliably send data in noisy environments. This is due to very limited noise margins. The sources of system noise can include externally induced noise, cross talk, and ground potential differences.

Balanced (Differential) Data Transmission

Balanced data transmission requires two conductors per signal. In balanced communication two lines are switched. The logical states are referenced by the difference of potential between the lines, not with respect to ground. This fact makes differential drivers and receivers ideal for use in noisy environments (See *Figure 2*). Differential data transmission nullifies the effects of coupled noise and ground potential differences. Both of these are seen as common mode voltages (seen on both lines), not differential,

and are rejected by the receivers. In contrast to unbalanced drivers, most balanced drivers feature fast transition times allowing for operation at higher data rates.

TIA/EIA Data Transmission Standards

The Electronic Industry Association (EIA) and the Telecommunications Industry Association (TIA) are industry trade associations that have developed standards to simplify interfaces in data communication systems. The standards are intended for use in Data Terminal Equipment/Data Circuit-terminating Equipment (DTE/DCE) Interfaces. The classic example of the DTE/DCE interface is the "terminal to modem serial interface". However, the standards are not limited to use in DTE/DCE interfaces alone. In fact, many of the standards are commonly used in a wide variety of applications. Examples include Hard Disk Drive Interfaces, Factory Control Busses, and generic I/O Busses. Previously, EIA labeled the standards with the prefix "RS", which stood for recommended standard. This has been replaced with "TIA/ EIA", to help in identifying the source of the standard. The letter suffix represents the revision level of the standard. For example, TIA/EIA-232-E represents the fifth revision of RS-232. TIA/EIA Data Transmission Standards cover the following areas: Complete Interface Standards, Electrical Only Standards, and Signal Quality Standards. Complete standards define functional, mechanical, and electrical specifications. Electrical only standards, as their name implies only defines electrical specifications. They are intended to be referenced by complete standards. Signal Quality Standards define terms and methods for measuring signal quality. Examples of each type are listed below.

• Complete DTE/DCE Interface Standards
TIA/EIA-232-F
TIA/EIA-530-A
TIA/EIA-561
TIA/EIA-574
TIA/EIA-613
TIA/EIA-687
TIA/EIA-688
TIA/EIA-723

• Electrical Only Standards
• Unbalanced Standards
TIA/EIA-232-F (Section 2)
TIA/EIA-423-B
TIA/EIA-562
TIA/EIA-694

• Balanced Standards
TIA/EIA-422-B
TIA/EIA-485-A
TIA/EIA-612
TIA/EIA-644

• Signal Quality Standards
EIA-334-A
EIA-363
EIA-404-A

TIA/EIA—Unbalanced (Single-Ended) Standards
TIA/EIA-232-F (RS-232)
TIA/EIA-232-F is the oldest and most widely known DTE/DCE Interface Standard. It is a complete standard specifying the mechanical (connector(s)), electrical (driver/receiver characteristics), and functional (definition of circuits) requirements for a serial binary DTE/DCE Interface. Under the electrical section, the standard specifies an unbalanced, unidirectional, point-to-point interface. The drivers feature a controlled slew rate, this allows the cable to be seen as a lumped load, rather than a transmission line. This is due to the fact that the driver's transition time is substantially greater than the cable delay (velocity x length). The maximum capacitive load seen by the driver is specified at 2,500 pF. The standard allows for operation up to 20 kbps (19.2 kbps). For higher data rates TIA/EIA-562 or TIA/EIA-423-B are recommended. *Figure 3* illustrates a typical application, and *Table 1* lists the major electrical requirements.
Key Features of the standard are:

• Single-Ended
• Point-to-Point Interface
• Large Polar Driver Output Swing
• Controlled Driver Slew Rate
• Fully Defined Interface
• 20 kbps Maximum Data Rate

TABLE 1. TIA/EIA-232-F Major Electrical Specifications

Parameter	Limit & Units
Driver Loaded Output Voltages (3 kΩ)	≥ I 5.0V I
Driver Open Circuit Voltage	≤ I 25V I
Driver Short Circuit Current	≤ I 100 mA I
Maximum Driver Slew Rate	≤ 30 V/µs
Driver Output Resistance (Power Off)	≥ 300Ω
Receiver Input Resistance	3 kΩ to 7 kΩ
Maximum Receiver Input Voltage	±25V
Receiver Thresholds	±3V

TIA/EIA Balanced (Differential) Standards
TIA/EIA-422-B
TIA/EIA-422-B is an electrical standard, specifying a balanced driver and balanced receivers. The receivers' requirements are identical to the receivers' requirements

specified in TIA/EIA-423-B. This standard specifies a unidirectional, single driver, multiple receivers, terminated, balanced interface. *Figure 7* illustrates a point-to-point typical application with termination located at the receiver input (end of cable). *Figure 8* illustrates a fully loaded TIA/EIA-422-B interface. Again termination is located at the end of the cable, also stub length should be minimized to limit reflections. *Table 5* lists the major electrical requirements of the TIA/EIA-422-B Standard.
Key Features of the standard are:
• Balanced Interface
• Multi-Drop (Multiple Receiver Operation)
• 10 Mbps Maximum Data Rate (@ 40 feet)
• 4000 Foot Maximum Cable Length (@ 100 kbps)

TABLE 5. TIA/EIA-422-B Major Electrical Specifications

Parameter	Limit & Units
Driver Open Circuit Voltage	≤ | 10V |
Driver Loaded Output Voltage	≥ | 2.0V |
Balance of Loaded Output Voltage	≤ 400 mV
Driver Output Offset Voltage	≤ 3.0V
Balance of Offset Voltage	≤ 400 mV
Driver Short Circuit Current	≤ |150 mA |
Driver Leakage Current	≤ | 100 µA |
Driver Output Impedance	≤ 100Ω
Receiver Input Resistance	≥ 4 kΩ
Receiver Thresholds	±200 mV
Receiver Internal Bias	≤ 3.0V
Maximum Receiver Input Current	3.25 mA
Receiver Common Mode Range	±7V (±10V)
Receiver Operating Differential Range	±200 mV to ±6V
Maximum Differential Input Voltage	±12V

TIA/EIA-485-A
TIA/EIA-485-A is an electrical standard, specifying balanced drivers and receivers. It provides all the advantages of TIA/EIA-422-B along with supporting multiple driver operation. TIA/EIA-485-A is the only TIA/EIA standard that allows for multiple driver operation at this time. This fact allows for multipoint (party line) configurations. The standard specifies a bi-directional (half duplex), multipoint interface. *Figure 9* illustrates a typical multipoint application, and *Table 6* lists the major electrical requirements. For additional applications information, refer to the TIA System Bulletin (TSB89).
Key Features are:
• Balanced Interface
• Multipoint Operation
• Operation From a Single +5V Supply

• −7V to +12V Bus Common Mode Range
• Up to 32 Transceiver Loads (Unit Loads)
• 10 Mbps Maximum Data Rate (@ 40 feet)
• 4000 Foot Maximum Cable Length (@ 100 kbps)

TABLE 6. TIA/EIA-485-A Major Electrical Specifications

Parameter	Limit & Units
Driver Open Circuit Voltage	≤ | 6.0V |
Driver Loaded Output Voltage	≥ | 1.5V |
Balance of Driver Loaded Output Voltage	≤ | 200 mV |
Maximum Driver Offset Voltage	3.0V
Balance of Driver Offset Voltage	≤ | 200 mV |
Driver Transition Time	≤ 30% Tui
Driver Short Circuit Current (–7V to +12V)	≤ | 250 mA |
Receiver Thresholds	±200 mV
Maximum Bus Input Current +12V/–7V	≤1.0 mA/≤ 0.8 mA
Max. Unit Loads	32

Conclusion

This application note provides a brief overview of various interface standards from several standardization organizations. It is only intended to point out the major requirements of each standard and to illustrate a typical application. When selecting or designing a standardized interface it is highly recommended to carefully review the complete standard.