

ANSI EIA/TIA-232-E Interface Standard

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Note: The content of this report has been revised and revalidated. It is being published with a new date to indicate that the information is current.

Datapro Summary

ANSI EIA/TIA-232-E is the revision of EIA-232-D (1986). The standard, approved in July 1991, is a set of specifications that applies to the transfer of data between data terminal equipment (DTE) and data circuit-terminating equipment (DCE). It defines the interface circuit functions and their corresponding connector pin assignments. The updated standard also includes specifications for a smaller alternative (26-pin) connector. Full- or half-duplex operations are supported for synchronous or asynchronous transmissions at speeds up to 20K bps. For data rates above 20K bps, ANSI EIA/TIA-530-A is the recommended standard. Copies of EIA/TIA-232-E can be obtained from the Electronic Industries Association, Engineering Department, 2001 I Street NW, Washington, DC 20006.

Analysis

The ANSI Electronic Industries Association (EIA) Standard EIA/TIA-232-E (simply EIA-232-E, hereafter) is the July 1991 revision of EIA-232-D (1986). The revision comprises the following changes:

- Specification for alternative interface connector (Alt A).
- Addition of Circuit CJ (Ready for Receiving).
- Use of Circuit CB (Clear to Send) for hardware flow control.
- Use of Local Loopback for "Busy Out."
- Slight modifications to Circuits CE (Ring Indicator) and CC (DCE Ready).

None of the changes create compatibility problems with any previous version of EIA/TIA-232. EIA-232-E also conforms to the following international standards: CCITT V.24 and V.28; EIA/TIA TSB-24 and TSB-26; and ISO IS2110.

EIA-232-E applies to all classes of service: private line, dial-up, point-to-point, multipoint, switched, nonswitched, two-wire, and four-wire service. Asynchronous and synchronous data transmission is supported at speeds up to 20K bps in full- or half-duplex mode. EIA-232-E is a single-ended or unbalanced interface; all of the interchange signals share a common electrical ground.

EIA-232-E defines the electrical and mechanical characteristics of the interface for connecting data terminal equipment and data circuit-terminating equipment using serial binary data communications. As the terms relate to this interface, DTE comprises business machine hardware such as teleprinters, CRTs, front-end processors, and CPUs, while DCE includes hardware such as modems, CSU/DSUs, limited distance data sets, and multiplexers.

Electrical Characteristics

The EIA-232-E standard prescribes polar-voltage serial data transmission between communicating devices. On data interchange circuits, transmitted data is represented by the "Marking" condition for binary one and the "Spacing" condition for binary zero. A data signal on an interchange circuit is in the Marking condition when the voltage at the interface point is more negative than -3 volts with respect to Signal Ground (Circuit AB). When the data signal at the interface point is more positive than +3 volts, with respect to Signal Ground, the data signal is in the Spacing condition. The area between -3 and +3 volts is the transition region; the signal state is not defined in the transition region.

On timing or control interchange circuits, the function is considered OFF when the voltage at the interface point is more negative than -3 volts, with respect to Signal Ground. It is considered

Interchange Circuit Sample

Notation	Interchange Voltage	
	Negative	Positive
Binary State	1	0
Signal Condition	Marking	Spacing
Function	OFF	ON

ON if the voltage at the interface point is more positive than +3 volts, with respect to Signal Ground. The function is not defined for voltages in the transition region between -3 and +3 volts. See Table "Interchange Circuit Sample."

Mandatory Interchange Circuit conditions are as follows (see Figure "Electrical Interchange Circuit Characteristics"):

- Open circuit generator voltage, with respect to Signal Ground, must not exceed 25 volts with respect to ground.
- The potential at the interface point must not be less than 5 volts nor more than 15 volts in magnitude when the receiver resistance is between 3000 and 7000 ohms, and the receiver open voltage is 0.
- The effective shunt capacitance associated with the receiver must not exceed 2500 picofarads at the interface point.
- The open circuit receiver voltage must not exceed 2 volts.
- Request to Send (Circuit CA), DCE Ready (Circuit CC), DTE Ready (Circuit CD), and Secondary Request to Send (Circuit SCA), where implemented, are used to detect the power-off condition or the disconnection of the interconnecting cable.

Certain limitations apply to all interchange signals (data, control, and timing) as follows:

- Interchange signals entering transition must proceed to the opposite signal state, and may not reenter the transition region until the next significant change in signal condition.

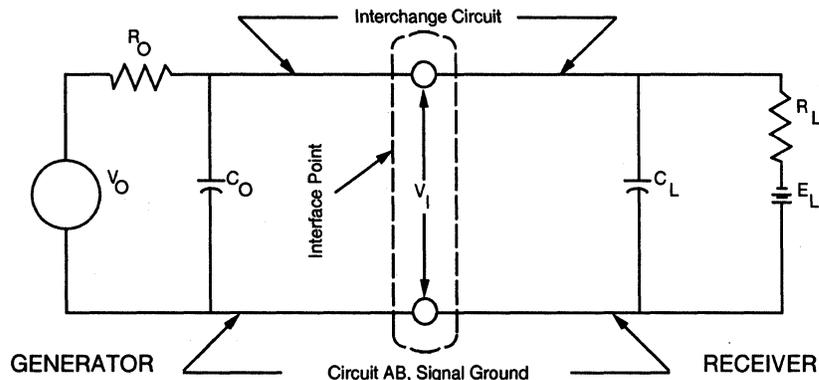
- The direction of voltage must not change while in the transition region.
- The time required for a control signal to pass through the transition region must not exceed one millisecond.
- The time required for a data or timing signal to pass through the transition region must not exceed one millisecond or 4% of the normal duration of a signal element on that interchange circuit, whichever is the lesser.
- The maximum instantaneous rate of voltage must not exceed 30 volts per microsecond.

Mechanical Characteristics

The physical connection between DTE and DCE is made through plug-in, 25-pin connectors. The connectors are keyed with 13 pins on the top row and 12 pins on the bottom row to prevent improper connection (see Figure "EIA-232-E 25-pin Connectors"). The male connector is always associated with the DTE and the female is always associated with the DCE. The cable is provided by the DTE. The maximum length of cables is not defined. Proximity to heavy rotating machinery or other noisy/radiating devices will limit the practical cable length.

Pin assignments are explicit and unalterable, unless unassigned (see Table "EIA-232-D Interface Connector Pin Assignments"). Special functions, not specifically defined, should be allotted to unassigned pins. For example, pin 11 (unassigned) could be used to "busy out" a connected modem that is associated with a switched application. This would cause the modem to go

Figure
Electrical Interchange Circuit
Characteristics



- V_O - Open-Circuit generator voltage
- R_O - Generator internal dc resistance
- C_O - Total effective capacitance associated with the generator
- V_I - Voltage at interface point
- C_L - Total effective capacitance associated with the receiver
- R_L - Receiver load dc resistance
- E_L - Open circuit receiver voltage (bias)

EIA-232-D Interface Connector Pin Assignments

Pin Number	Function	Circuit (Source)	Signal Type	CCITT Equiv.
1	Shield	—	—	—
2	Transmitted Data	BA (DTE)	Data	103
3	Received Data	BB (DCE)	Data	104
4	Request to Send (1)	CA/CJ (DTE)	Control	105
5	Clear to Send	CB (DCE)	Control	106
6	DCE Ready	CC (DCE)	Control	107
7	Signal Ground	AB	Ground	102
8	Received Line Signal Detector	CF (DCE)	Control	109
9	Reserved for Testing	—	—	—
10	Reserved for Testing	—	—	—
11	Unassigned (2)	—	—	—
12	Secondary Received Line Signal Detector/Data Signal Rate Selector (DCE) (3)	SCF/CI (DCE)	Control	122/112
13	Secondary Clear to Send	SCB (DCE)	Control	121
14	Secondary Transmitted Data	SBA (DTE)	Data	118
15	Transmitter Signal Element Timing (DCE)	DB (DCE)	Timing	114
16	Secondary Received Data	SBB (DCE)	Data	119
17	Receiver Signal Element Timing (DCE)	DD (DCE)	Timing	115
18	Local Loopback	LL (DTE)	Control	141
19	Secondary Request to Send	SCA (DTE)	Control	120
20	DTE Ready	CD (DCE)	Control	108.2
21	Remote Loopback/Signal Quality Detector	RL/CG (DCE/DTE)	Control	140/110
22	Ring Indicator	CE (DCE)	Control	125
23	Data Signal Rate Selector (DTE/DCE) (3)	CH/CI (DCE/DTE)	Control	111/112
24	Transmit Signal Element Timing (DTE)	DA (DTE)	Timing	113
25	Test Mode	TM (DCE)	Control	142
26	No Connection (4)	—	—	126

(1) When hardware flow control is required, Circuit CA may take on the functionality of Circuit CJ.

(2) Pin 11 is assigned and will not be assigned in future versions of EIA-232. International standard ISO 2110, however, assigns this pin to CCITT Circuit 126 (Select Transmit Frequency).

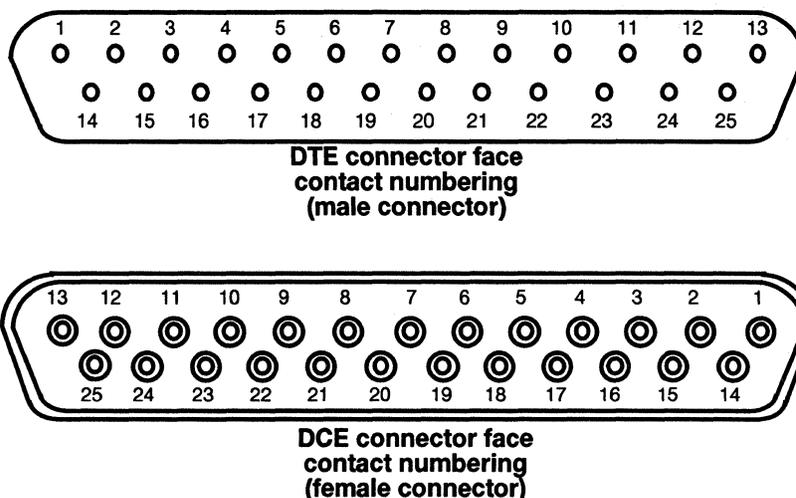
(3) Interchange circuits CH and CI are assigned to pin 23 for designs using interchange circuit SCF. If SCF is not used, CI is assigned to pin 12.

(4) Pin 26 is contained on the Alt A connector only. No connection is to be made to this pin.

"off hook," preventing an incoming call from being connected/answered. Because one pin is unassigned and because all of the functions defined by EIA-232-E are not necessarily required for a specific application, all 25 pins are not usually used. (Contact the DTE vendor to determine the specific configuration.)

Although the 25-pin version is still the most popular connector, EIA-232-E provides for an alternative physical interface (Alt A) for applications requiring a smaller connector. At about 3/4" wide, the Alt A connector is about half the size of the 25-pin version.

Figure
EIA-232-E 25-pin Connectors



Channels

The data transmission channel includes the transmission media, plus the intervening equipment involved in the transfer of information between DTEs. When the DCE is capable of multiple speeds (e.g., 1200 bps in one direction and 300 bps in the opposite direction), a channel is defined for each speed capability. EIA-232-E defines these two types of data transmission channels as primary and secondary channels.

The primary data transmission channel has the highest signaling rate capability of all the channels sharing a common interface connector. The primary channel may support information transfer in one direction only (simplex), both directions alternately (half duplex), or both directions simultaneously (full duplex).

A secondary channel is a channel that has a lower signaling rate capability than the primary channel. Secondary channels may be simplex, half duplex, or full duplex. Secondary channels are established because in some communications systems, greater channel efficiency can be achieved by using a lower-speed sub-channel to carry control responses. Two types of secondary channels are defined: auxiliary and backward.

An auxiliary channel is one in which the direction of transmission is independent of the primary channel; the channel is controlled by the secondary control interchange circuits. A backward channel is one in which the direction of transmission is always opposite to that of the primary channel.

Interchange Circuits

An interchange circuit is defined as a circuit between the DTE and the DCE. EIA-232-E describes the four categories of interchange circuits that apply generally to all systems. They are Ground or Common Return, Data, Control, and Timing circuits.

Ground Circuits

The ground interchange circuit is *Signal Ground* or *Common Return* (Circuit AB). Signal Ground establishes a common reference for all interchange circuits. Within the DCE, this circuit is brought to one point, and is connected to Protective Ground via a wire strap inside the equipment. This wire strap can be connected or removed at installation, as may be required to meet applicable regulations or to minimize the introduction of noise into electronic circuitry.

Data Circuits

Four types of data circuits are described: Transmitted Data, Received Data, Secondary Transmitted Data, and Secondary Received Data.

Transmitted Data (Circuit BA) and *Received Data* (Circuit BB) are used on the primary channel—the data transmission channel with the highest signaling rate of all channels sharing a common interface connector. Signals on Circuit BA are generated by the DTE and sent to the local transmitting signal converter (e.g., a modem) for transmission of data to remote DTEs or for maintenance or control of the local transmitting signal converter. For the DTE to transmit data, an ON condition must be present on the following four circuits: CA (Request to Send), CB (Clear to Send), CC (DCE Ready), and CD (DTE Ready). (These circuits are described in the Control Circuits section of this report.)

Signals on Circuit BB are generated by the receiving signal converter in response to data signals received from the remote DTE, or in response to maintenance or control data signals from the local DTE. Circuit BB is held in the binary one (Marking) condition when Circuit CF (Received Line Signal Detector) is in the OFF condition.

Secondary Transmitted Data (Circuit SBA) is equivalent to Circuit BA, except it is used to transmit data on the secondary channel. The secondary channel has a lower signaling rate than the primary channel in a system where two channels share a common interface connector.

Secondary Received Data (Circuit SBB) is equivalent to Circuit BB, except it is used to receive data on the secondary channel.

Secondary circuits may be independent of other interchange circuits in terms of direction and speed. The secondary interchange circuits, however, are additional circuits that function in the same manner as their basic counterparts, and follow the same conditions that govern corresponding basic circuits.

When any data circuit is idle, it is held in the Marking condition. Data is transferred in bipolar fashion; a binary "one" (mark) is represented by a voltage more negative than -3 volts, and a binary "zero" (space) is represented by a voltage more positive than +3 volts.

Control Circuits

Control signals are used to enable and disable data transmission and reception, and to indicate the operational status and condition of the DTE and DCE. A control function is considered to be in the ON condition when the voltage is more positive than +3 volts; it is considered to be in the OFF condition when the voltage is more negative than -3 volts.

EIA-232-D Data Transmission Configuration Interfaces

Interface Type	Configuration
A	Transmit only
B	Transmit only*
C	Receive only
D	Half duplex
D	Full duplex*
E	Full duplex
F	Primary channel transmit only*/secondary channel receive only
G	Primary channel receive only/secondary channel transmit only*
H	Primary channel transmit only/secondary channel receive only
I	Primary channel receive only/secondary channel transmit only
J	Primary channel transmit only*/half-duplex secondary channel
K	Primary channel receive only/half -duplex secondary channel
L	Half-duplex primary channel/half-duplex secondary channel
L	Full-duplex primary channel*/full duplex secondary channel*
M	Full-duplex primary channel/full-duplex secondary channel
Z	Circuit specified by supplier

*Indicates the Request to Send (RTS) circuit in a simplex or full-duplex arrangement where RTS might not ordinarily be expected. Can be used to indicate a nontransmit mode to the DCE or to permit the DCE to remove a line signal or to send synchronization signals.

Control circuits include Request to Send, Clear to Send, DCE Ready, DTE Ready, Ring Indicator, Received Line Signal Detector, Signal Quality Detector, Data Signal Rate Selector (DTE), Data Signal Rate Selector (DCE), Secondary Request to Send, Secondary Clear to Send, and Secondary Received Line Signal Detector.

- Request to Send (Circuit CA)—conditions the local DCE for data transmission, and controls the direction of transmission on half-duplex channels. On half-duplex channels, Circuit CA maintains the DCE in the transmit mode and inhibits the receive mode; on simplex channels, it maintains the DCE in the transmit mode. An OFF to ON transition on Circuit CA causes the DCE to enter transmit mode and turn Clear to Send ON. An ON to OFF transition causes the DCE to complete the data transmission, enter the receive or nontransmit mode, and turn Clear to Send OFF.
- Clear to Send (Circuit CB)—indicates to the DTE that data can be transmitted (Circuit CB ON) or cannot be transmitted (Circuit CB OFF). The ON condition on Circuit CB is delayed until the remote DCE is initialized. When Circuit CA is not implemented, Circuit CB must be ON continuously.
- DCE Ready (Circuit CC)—indicates the status of the local DCE. ON indicates that the DCE is connected to the communications channel (in switched services, "Off Hook"), and is not in test, talk (alternative voice/data), or dial mode. The ON condition of this circuit should not be interpreted as either the status of any remote station equipment or an indication that a communications channel has been established to a remote data station. ON indicates completed timing functions, if any, required for call establishment (switched service). ON indicates completed transmission of a discreet answer tone, the duration of which is controlled by the local DCE. OFF indicates that the local DCE is not ready to operate, that a fault condition has been detected, or that a disconnect indication has been detected. When the OFF condition occurs during transmission, the connection has been lost.
- DTE Ready (Circuit CD)—controls the switching of the DCE to the communications channel. The ON condition prepares the DCE to connect and maintain connection to the communications channel. With automatic answering equipment, connection to the communications channel occurs when both the DTE Ready and the Ring Indicator circuit are in the ON condition. The OFF condition of Circuit CD causes the DCE to be removed from the communications channel upon completion of any *in process* transmission. The OFF condition does not disable the Ring Indicator signal. In switched systems, Circuit CD cannot be turned ON until Circuit CC (DCE Ready) is turned OFF by the DCE.
- Ring Indicator (Circuit CE)—indicates that a ring (call) signal is being received on the communications channel through the switched network. Circuit CE is held in the ON condition during ringing and the OFF condition between rings or when ringing is not present.
- Received Line Signal Detector (Circuit CF)—presents an ON condition to indicate that data signals are being received, and that they are acceptable for demodulation. An OFF condition indicates that no signal is being received or that the signal is not acceptable for demodulation. The OFF condition causes the Received Data (Circuit BB) to be held in the Marking condition.
- Signal Quality Detector (Circuit CG)—indicates whether there is a high probability of error in received data. The ON condition is maintained, unless a high probability of error has occurred. Probable error is indicated by the OFF condition. This condition can be used to effect retransmission.
- Data Signal Rate Selector (DTE Source), Data Signal Rate Selector (DCE Source) (Circuits CH and CI, respectively)—selects between two signaling rates when either the DCE or DTE accommodates dual rates. The ON condition selects the higher rate or range of rates. Circuit CH indicates that the DTE provides the selection signal. Circuit CI indicates that the DCE

Required Interchange Circuits for Standard Interface Types

Interchange Circuits	Interface Type													
	A	B	C	D	E	F	G	H	I	J	K	L	M	Z
AB Signal Ground
BA Transmitted Data	°
BB Received Data	°
CA Request to Send	°
CB Clear to Send	°
CC DCE Ready	°
CD DTE Ready	†	†	†	†	†	†	†	†	†	†	†	†	†	°
CE Ring Indicator	†	†	†	†	†	†	†	†	†	†	†	†	†	°
CF Received Line Signal Detector	°
CG Signal Quality Detector	°
CH/CI Data Signaling Rate Selector (DTE/DCE)	°
CJ Ready for Receiving	°
DA/DB Transmitter Signal Element Timing (DCE/DTE)	§	§	.	§	§	§	.	§	.	§	§	§	§	°
DD Receiver Signal Element Timing (DDE)	.	.	§	§	§	.	§	.	§	.	§	§	§	°
SBA Secondary Transmitted Data	°
SBB Secondary Received Data	°
SCA Secondary Request to Send	°
SCB Secondary Clear to Send	°
SCF Secondary Received Line Signal Detector	°
LL Local Loopback	.	.	.	∅	∅	∅	∅	°
RL Remote Loopback	.	.	.	∅	∅	∅	∅	°
TM Test Mode	∅	∅	∅	∅	∅	∅	∅	∅	∅	∅	∅	∅	∅	°

Legend:

- Basic interchange circuit—all systems.
- †—Additional interchange circuits required for switched service.
- §—Additional interchange circuits required for synchronous service.
- °—To be specified by the supplier.
- ∅—Optional.

provides the selection signal. Selection is between two asynchronous rates or between two synchronous rates.

- Ready for Receiving (Circuit CJ)—controls data transfer (flow control) on Circuit BB (Received Data) when an intermediate function such as error control is being used in the DCE. The ON condition indicates that the DTE is capable of receiving data, while the OFF condition indicates that the DTE is not capable of receiving data and causes the DCE to retain the data. In some DCEs, the OFF condition also causes a signal to be transmitted to the distant DTE causing an OFF condition to be placed on Circuit CB (Clear to Send) extending the flow control to the distant DTE.

- Secondary Request to Send (Circuit SCA)—functions the same as Circuit CA, except that it requests the establishment of the secondary channel.
- Secondary Clear to Send (Circuit SCB)—functions the same as Circuit CB, except that it indicates the availability of the secondary channel.
- Secondary Received Line Signal Detector (Circuit SCF)—functions the same as Circuit CF, except that it indicates the proper reception of the secondary channel line signal.

Timing Circuits

Three circuits are used to provide timing: Transmitter Signal Element Timing (DTE Source), Transmitter Signal Element Timing (DCE Source), and Receiver Signal Element Timing (DCE Source).

- Transmitter Signal Element Timing (DTE Source) (Circuit DA)—provides signal element timing information to the transmitting signal converter, the DCE. The ON-OFF transition indicates the occurrence of the center of the data element. The DTE normally provides timing information on this circuit when the DTE is powered ON. If Circuit CA (Request to Send) is OFF, timing information on Circuit DA may be withheld by the DTE for short periods.
- Transmitter Signal Element Timing (DCE Source) (Circuit DB)—provides signal element timing to the DTE. A data signal on Circuit BA (Transmitted Data) is provided from the DTE in which the transition between signal elements occurs at the time of the ON-OFF transition in Circuit DB. If Circuit CC (Data Set Ready) is OFF, it is permissible for the DCE to withhold timing information for short periods. The performance of maintenance tests within the DCE, for example, may require the withholding of timing information.
- Receiver Signal Element Timing (DCE Source) (Circuit DD)—provides timing to the data terminal from the data set. The ON-OFF transition indicates the center of the received data elements.

Standard Interfaces for Selected Configurations

EIA-232-E describes a selected set of data transmission configurations or interfaces. A provision is made for the addition of custom configurations. Determining factors in the selection of an

interface type are whether the DTE transmits, receives, or does both; whether the mode of operation is half or full duplex; and whether a secondary channel is used. The interface designations do not relate to which terminal originates or answers the call, but rather to the data transmitted.

EIA-232-E defines selected interface types by letter designation. These types are described in Table "EIA-232-D Data Transmission Configuration Interfaces," where the direction of data transfer pertaining to the interface is stated (function), and the use of Request to Send and Received Line Signal Detector interchange circuits is stipulated (comment). This list indicates that interfaces A and B, which are one-way only transmissions, differ only in terms of the use of RTS. Interface D is normally employed with half-duplex operation using RTS, and interface E is normally employed with full-duplex operation, without using RTS. When interface D is used in full-duplex operation, however, RTS is used with special significance.

Interfaces E, F, G, and H define two-way transmission where both the primary and secondary directions are one way only.

Interfaces J, K, L, and M define less restrictive primary and secondary arrangements.

Interface Z simply allows a special arrangement to be established.

The complete relationship of interchange circuits to standard interface types is depicted in Table "Required Interchange Circuits for Standard Interface Types."

ANSI EIA/TIA-232-E Interface Standard

In this report:

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Note: This report on EIA-232-E replaces the report on EIA-232-D. The two interfaces are completely compatible, and the minor revisions contained in the updated standard are included in this report.

Datapro Summary

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The EIA-232-E standard prescribes polar-voltage serial data transmission between communicating devices. On data interchange circuits, transmitted data is represented by the "Marking" condition for binary one and the "Spacing" condition for binary zero. A data signal on an interchange circuit is in the Marking condition when the voltage at the interface point is more negative than -3 volts with respect to Signal Ground (Circuit AB). When the data signal at the interface point is more positive than +3 volts, with respect to Signal Ground, the data

—By Vance Macdonald
Research Analyst

signal is in the Spacing condition. The area between -3 and $+3$ volts is the transition region; the signal state is not defined in the transition region.

On timing or control interchange circuits, the function is considered OFF when the voltage at the interface point is more negative than -3 volts, with respect to Signal Ground. It is considered ON if the voltage at the interface point is more positive than $+3$ volts, with respect to Signal Ground. The function is not defined for voltages in the transition region between -3 and $+3$ volts.

Notation	Interchange Voltage	
	Negative	Positive
Binary State	1	0
Signal Condition	Marking	Spacing
Function	OFF	ON

Mandatory Interchange Circuit conditions are as follows (see Figure 1):

- Open circuit generator voltage, with respect to Signal Ground, must not exceed 25 volts with respect to ground.
- The potential at the interface point must not be less than 5 volts nor more than 15 volts in magnitude when the receiver resistance is between 3000 and 7000 ohms, and the receiver open voltage is 0.
- The effective shunt capacitance associated with the receiver must not exceed 2500 picofarads at the interface point.
- The open circuit receiver voltage must not exceed 2 volts.
- Request to Send (Circuit CA), DCE Ready (Circuit CC), DTE Ready (Circuit CD), and Secondary Request to Send (Circuit SCA), where implemented, are used to detect the power-off condition or the disconnection of the interconnecting cable.

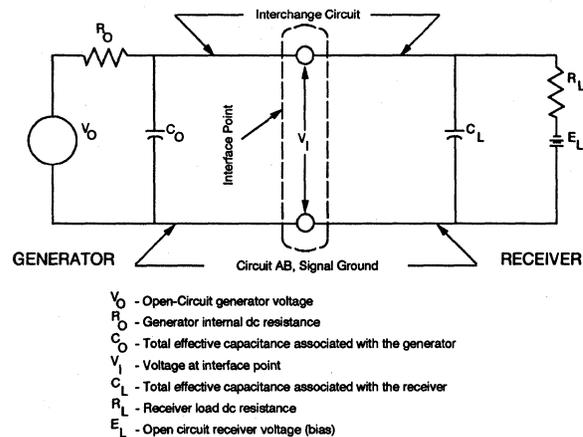
Certain limitations apply to all interchange signals (data, control, and timing) as follows:

- Interchange signals entering transition must proceed to the opposite signal state, and may not reenter the transition region until the next significant change in signal condition.
- The direction of voltage must not change while in the transition region.
- The time required for a control signal to pass through the transition region must not exceed one millisecond.
- The time required for a data or timing signal to pass through the transition region must not exceed one millisecond or 4% of the normal duration of a signal element on that interchange circuit, whichever is the lesser.
- The maximum instantaneous rate of voltage must not exceed 30 volts per microsecond.

Mechanical Characteristics

The physical connection between DTE and DCE is made through plug-in, 25-pin connectors. The connectors are keyed with 13 pins on the top row and 12 pins on the bottom row to prevent improper connection (see Figure 2). The male connector is always associated with the DTE and the female is always associated with the DCE. The cable is provided by the DTE. The maximum length of cables is not defined. Proximity to heavy rotating machinery or other noisy/radiating devices will limit the practical cable length.

Figure 1.
Electrical Interchange Circuit Characteristics



Pin assignments are explicit and unalterable, unless unassigned (see Table 1). Special functions, not specifically defined, should be allotted to unassigned pins. For example, pin 11 (unassigned) could be used to "busy out" a connected modem that is associated with a switched application. This would cause the modem to go "off hook," preventing an incoming call from being connected/answered. Because one pin is unassigned and because all of the functions defined by EIA-232-E are not necessarily required for a specific application, all 25 pins are not usually used. (Contact the DTE vendor to determine the specific configuration.)

Although the 25-pin version is still the most popular connector, EIA-232-E provides for an alternative physical interface (Alt A) for applications requiring a smaller connector. At about $\frac{3}{4}$ " wide, the Alt A connector is about half the size of the 25-pin version.

Channels

The data transmission channel includes the transmission media, plus the intervening equipment involved in the transfer of information between DTEs. When the DCE is capable of multiple speeds (e.g., 1200 bps in one direction and 300 bps in the opposite direction), a channel is defined for each speed capability. EIA-232-E defines these two types of data transmission channels as primary and secondary channels.

Figure 2.
EIA-232-E 25-pin Connectors

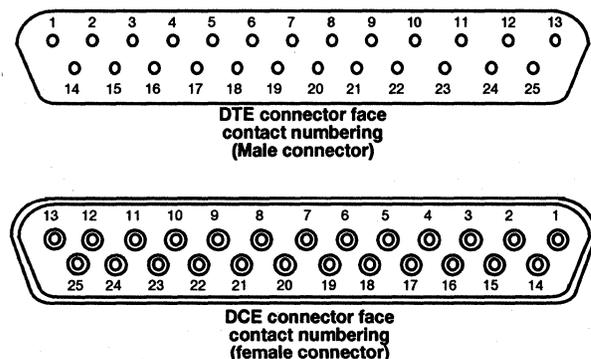


Table 1. EIA-232-D Interface Connector Pin Assignments

Pin Number	Function	Circuit/ (Source)	Signal Type	CCITT Equiv.
1	Shield	—	—	—
2	Transmitted Data	BA (DTE)	Data	103
3	Received Data	BB (DCE)	Data	104
4	Request to Send (1)	CA/CJ (DTE)	Control	105
5	Clear to Send	CB (DCE)	Control	106
6	DCE Ready	CC (DCE)	Control	107
7	Signal Ground	AB	Ground	102
8	Received Line Signal Detector	CF (DCE)	Control	109
9	Reserved for Testing	—	—	—
10	Reserved for Testing	—	—	—
11	Unassigned (2)	—	—	—
12	Secondary Received Line Signal Detector/ Data Signal Rate Selector (DCE) (3)	SCF/CI (DCE)	Control	122/112
13	Secondary Clear to Send	SCB (DCE)	Control	121
14	Secondary Transmitted Data	SBA (DTE)	Data	118
15	Transmitter Signal Element Timing (DCE)	DB (DCE)	Timing	114
16	Secondary Received Data	SBB (DCE)	Data	119
17	Receiver Signal Element Timing (DCE)	DD (DCE)	Timing	115
18	Local Loopback	LL (DTE)	Control	141
19	Secondary Request to Send	SCA (DTE)	Control	120
20	DTE Ready	CD (DCE)	Control	108.2
21	Remote Loopback/Signal Quality Detector	RL/CG (DCE/DTE)	Control	140/110
22	Ring Indicator	CE (DCE)	Control	125
23	Data Signal Rate Selector (DTE/DCE) (3)	CH/CI (DCE/DTE)	Control	111/112
24	Transmit Signal Element Timing (DTE)	DA (DTE)	Timing	113
25	Test Mode	TM (DCE)	Control	142
26	No Connection (4)	—	—	126

(1) When hardware flow control is required, Circuit CA may take on the functionality of Circuit CJ.

(2) Pin 11 is unassigned and will not be assigned in future versions of EIA-232. International standard ISO 2110, however, assigns this pin to CCITT Circuit 126 (Select Transmit Frequency).

(3) Interchange circuits CH and CI are assigned to pin 23 for designs using interchange circuit SCF. If SCF is not used, CI is assigned to pin 12.

(4) Pin 26 is contained on the Alt A connector only. No connection is to be made to this pin.

The primary data transmission channel has the highest signaling rate capability of all the channels sharing a common interface connector. The primary channel may support information transfer in one direction only (simplex), both directions alternately (half duplex), or both directions simultaneously (full duplex).

A secondary channel is a channel that has a lower signaling rate capability than the primary channel. Secondary channels may be simplex, half duplex, or full duplex. Secondary channels are established because in some communications systems, greater channel efficiency can be achieved by using a lower-speed sub-channel to carry control responses. Two types of secondary channels are defined: auxiliary and backward.

An auxiliary channel is one in which the direction of transmission is independent of the primary channel; the channel is controlled by the secondary control interchange circuits. A backward channel is one in which the direction of transmission is always opposite to that of the primary channel.

Interchange Circuits

An interchange circuit is defined as a circuit between the DTE and the DCE. EIA-232-E describes the four categories of interchange circuits that apply generally to all systems. They are Ground or Common Return, Data, Control, and Timing circuits.

Ground Circuits

The ground interchange circuit is *Signal Ground* or *Common Return* (Circuit AB). Signal Ground establishes a common reference for all interchange circuits. Within the DCE, this circuit is brought

to one point, and is connected to Protective Ground via a wire strap inside the equipment. This wire strap can be connected or removed at installation, as may be required to meet applicable regulations or to minimize the introduction of noise into electronic circuitry.

Data Circuits

Four types of data circuits are described: Transmitted Data, Received Data, Secondary Transmitted Data, and Secondary Received Data.

Transmitted Data (Circuit BA) and *Received Data* (Circuit BB) are used on the primary channel—the data transmission channel with the highest signaling rate of all channels sharing a common interface connector. Signals on Circuit BA are generated by the DTE and sent to the local transmitting signal converter (e.g., a modem) for transmission of data to remote DTEs or for maintenance or control of the local transmitting signal converter. For the DTE to transmit data, an ON condition must be present on the following four circuits: CA (Request to Send), CB (Clear to Send), CC (DCE Ready), and CD (DTE Ready). (These circuits are described in the Control Circuits section of this report.)

Signals on Circuit BB are generated by the receiving signal converter in response to data signals received from the remote DTE, or in response to maintenance or control data signals from the local DTE. Circuit BB is held in the binary one (Marking) condition when Circuit CF (Received Line Signal Detector) is in the OFF condition.

Secondary Transmitted Data (Circuit SBA) is equivalent to Circuit BA, except it is used to transmit data on the secondary

channel. The secondary channel has a lower signaling rate than the primary channel in a system where two channels share a common interface connector.

Secondary Received Data (Circuit SBB) is equivalent to Circuit BB, except it is used to receive data on the secondary channel.

Secondary circuits may be independent of other interchange circuits in terms of direction and speed. The secondary interchange circuits, however, are additional circuits that function in the same manner as their basic counterparts, and follow the same conditions that govern corresponding basic circuits.

When any data circuit is idle, it is held in the Marking condition. Data is transferred in bipolar fashion; a binary "one" (mark) is represented by a voltage more negative than -3 volts, and a binary "zero" (space) is represented by a voltage more positive than +3 volts.

Control Circuits

Control signals are used to enable and disable data transmission and reception, and to indicate the operational status and condition of the DTE and DCE. A control function is considered to be in the ON condition when the voltage is more positive than +3 volts; it is considered to be in the OFF condition when the voltage is more negative than -3 volts.

Control circuits include Request to Send, Clear to Send, DCE Ready, DTE Ready, Ring Indicator, Received Line Signal Detector, Signal Quality Detector, Data Signal Rate Selector (DTE), Data Signal Rate Selector (DCE), Secondary Request to Send, Secondary Clear to Send, and Secondary Received Line Signal Detector.

- Request to Send (Circuit CA)—conditions the local DCE for data transmission, and controls the direction of transmission on half-duplex channels. On half-duplex channels, Circuit CA maintains the DCE in the transmit mode and inhibits the receive mode; on simplex channels, it maintains the DCE in the transmit mode. An OFF to ON transition on Circuit CA causes the DCE to enter transmit mode and turn Clear to Send ON. An ON to OFF transition causes the DCE to complete the data transmission, enter the receive or nontransmit mode, and turn Clear to Send OFF.
- Clear to Send (Circuit CB)—indicates to the DTE that data can be transmitted (Circuit CB ON) or cannot be transmitted (Circuit CB OFF). The ON condition on Circuit CB is delayed until the remote DCE is initialized. When Circuit CA is not implemented, Circuit CB must be ON continuously.
- DCE Ready (Circuit CC)—indicates the status of the local DCE. ON indicates that the DCE is connected to the communications channel (in switched services, "Off Hook"), and is not in test, talk (alternative voice/data), or dial mode. The ON condition of this circuit should not be interpreted as either the status of any remote station equipment or an indication that a communications channel has been established to a remote data station. ON indicates completed timing functions, if any, required for call establishment (switched service). ON indicates completed transmission of a discreet answer tone, the duration of which is controlled by the local DCE. OFF indicates that the local DCE is not ready to operate, that a fault condition has been detected, or that a disconnect indication has been detected. When the OFF condition occurs during transmission, the connection has been lost.
- DTE Ready (Circuit CD)—controls the switching of the DCE to the communications channel. The ON condition prepares the DCE to connect and maintain connection to the communications channel. With automatic answering equipment, connection to the communications channel occurs when both the DTE Ready and the Ring Indicator circuit are in the ON condition.

The OFF condition of Circuit CD causes the DCE to be removed from the communications channel upon completion of any *in process* transmission. The OFF condition does not disable the Ring Indicator signal. In switched systems, Circuit CD cannot be turned ON until Circuit CC (DCE Ready) is turned OFF by the DCE.

- Ring Indicator (Circuit CE)—indicates that a ring (call) signal is being received on the communications channel through the switched network. Circuit CE is held in the ON condition during ringing and the OFF condition between rings or when ringing is not present.
- Received Line Signal Detector (Circuit CF)—presents an ON condition to indicate that data signals are being received, and that they are acceptable for demodulation. An OFF condition indicates that no signal is being received or that the signal is not acceptable for demodulation. The OFF condition causes the Received Data (Circuit BB) to be held in the Marking condition.
- Signal Quality Detector (Circuit CG)—indicates whether there is a high probability of error in received data. The ON condition is maintained, unless a high probability of error has occurred. Probable error is indicated by the OFF condition. This condition can be used to effect retransmission.
- Data Signal Rate Selector (DTE Source), Data Signal Rate Selector (DCE Source), (Circuits CH and CI, respectively)—selects between two signaling rates when either the DCE or DTE accommodates dual rates. The ON condition selects the higher rate or range of rates. Circuit CH indicates that the DTE provides the selection signal. Circuit CI indicates that the DCE provides the selection signal. Selection is between two asynchronous rates or between two synchronous rates.

Table 2. EIA-232-D Data Transmission Configuration Interfaces

Interface Type	Configuration
A	Transmit only
B	Transmit only*
C	Receive only
D	Half duplex
D	Full duplex*
E	Full duplex
F	Primary channel transmit only*/ secondary channel receive only
G	Primary channel receive only/ secondary channel transmit only*
H	Primary channel transmit only/ secondary channel receive only
I	Primary channel receive only/ secondary channel transmit only
J	Primary channel transmit only*/ half-duplex secondary channel
K	Primary channel receive only/ half-duplex secondary channel
L	Half-duplex primary channel/ half-duplex secondary channel
L	Full-duplex primary channel*/ full-duplex secondary channel*
M	Full-duplex primary channel/ full-duplex secondary channel
Z	Circuit specified by supplier

*Indicates the Request to Send (RTS) circuit in a simplex or full-duplex arrangement where RTS might not ordinarily be expected. Can be used to indicate a nontransmit mode to the DCE or to permit the DCE to remove a line signal or to send synchronization signals.

Table 3. Required Interchange Circuits for Standard Interface Types

Interface Type	Interchange Circuits	Interface Type													
		A	B	C	D	E	F	G	H	I	J	K	L	M	Z
AB	Signal Ground	•	•	•	•	•	•	•	•	•	•	•	•	•	•
BA	Transmitted Data	•	•		•	•	•		•		•		•	•	○
BB	Received Data			•	•	•		•		•		•	•	•	○
CA	Request to Send		•		•		•			•		•		•	○
CB	Clear to Send	•	•		•	•		•		•		•	•	•	○
CC	DCE Ready	•	•	•	•	•		•	•	•		•	•	•	○
CD	DTE Ready	†	†	†	†	†		†	†	†		†	†	†	○
CE	Ring Indicator	†	†	†	†	†		†	†	†		†	†	†	○
CF	Received Line Signal Detector			•	•	•		•		•		•	•	•	○
CG	Signal Quality Detector														○
CH/CI	Data Signaling Rate Selector (DTE/DCE)														○
CJ	Ready for Receiving														○
DA/DB	Transmitter Signal Element Timing (DCE/DTE)	§	§		§	§		§		§		§	§	§	○
DD	Receiver Signal Element Timing (DCE)			§	§	§		§		§		§	§	§	○
SBA	Secondary Transmitted Data							•		•		•	•	•	○
SBB	Secondary Received Data							•		•		•	•	•	○
SCA	Secondary Request to Send							•		•		•	•	•	○
SCB	Secondary Clear to Send							•		•		•	•	•	○
SCF	Secondary Received Line Signal Detector							•		•		•	•	•	○
LL	Local Loopback				∅	∅							∅	∅	○
RL	Remote Loopback				∅	∅							∅	∅	○
TM	Test Mode	∅	∅	∅	∅	∅		∅	∅	∅		∅	∅	∅	○

Legend:

•—Basic interchange circuit—all systems.

†—Additional interchange circuits required for switched service.

§—Additional interchange circuits required for synchronous service.

○—To be specified by the supplier.

∅—Optional.

- Ready for Receiving (Circuit CJ)—controls data transfer (flow control) on Circuit BB (Received Data) when an intermediate function such as error control is being used in the DCE. The ON condition indicates that the DTE is capable of receiving data, while the OFF condition indicates that the DTE is not capable of receiving data and causes the DCE to retain the data. In some DCEs, the OFF condition also causes a signal to be transmitted to the distant DTE causing an OFF condition to be placed on Circuit CB (Clear to Send) extending the flow control to the distant DTE.
- Secondary Request to Send (Circuit SCA)—functions the same as Circuit CA, except that it requests the establishment of the secondary channel.
- Secondary Clear to Send (Circuit SCB)—functions the same as Circuit CB, except that it indicates the availability of the secondary channel.
- Secondary Received Line Signal Detector (Circuit SCF)—functions the same as Circuit CF, except that it indicates the proper reception of the secondary channel line signal.

Timing Circuits

Three circuits are used to provide timing: Transmitter Signal Element Timing (DTE Source), Transmitter Signal Element Timing (DCE Source), and Receiver Signal Element Timing (DCE Source).

- Transmitter Signal Element Timing (DTE Source) (Circuit DA)—provides signal element timing information to the transmitting signal converter, the DCE. The ON-OFF transition indicates the occurrence of the center of the data element. The

DTE normally provides timing information on this circuit when the DTE is powered ON. If Circuit CA (Request to Send) is OFF, timing information on Circuit DA may be withheld by the DTE for short periods.

- Transmitter Signal Element Timing (DCE Source) (Circuit DB)—provides signal element timing to the DTE. A data signal on Circuit BA (Transmitted Data) is provided from the DTE in which the transition between signal elements occurs at the time of the ON-OFF transition in Circuit DB. If Circuit CC (Data Set Ready) is OFF, it is permissible for the DCE to withhold timing information for short periods. The performance of maintenance tests within the DCE, for example, may require the withholding of timing information.
- Receiver Signal Element Timing (DCE Source) (Circuit DD)—provides timing to the data terminal from the data set. The ON-OFF transition indicates the center of the received data elements.

Standard Interfaces for Selected Configurations

EIA-232-E describes a selected set of data transmission configurations or interfaces. A provision is made for the addition of custom configurations. Determining factors in the selection of an interface type are whether the DTE transmits, receives, or does both; whether the mode of operation is half or full duplex; and whether a secondary channel is used. The interface designations do not relate to which terminal originates or answers the call, but rather to the data transmitted.

EIA-232-E defines selected interface types by letter designation. These types are described in Table 2, where the direction of data transfer pertaining to the interface is stated (function), and the use of Request to Send and Received Line Signal Detector interchange circuits is stipulated (comment). This list indicates that interfaces A and B, which are one-way only transmissions, differ only in terms of the use of RTS. Interface D is normally employed with half-duplex operation using RTS, and interface E is normally employed with full-duplex operation, without using

RTS. When interface D is used in full-duplex operation, however, RTS is used with special significance.

Interfaces E, F, G, and H define two-way transmission where both the primary and secondary directions are one-way only.

Interfaces J, K, L, and M define less restrictive primary and secondary arrangements.

Interface Z simply allows a special arrangement to be established.

The complete relationship of interchange circuits to standard interface types is depicted in Table 3. ■

Electronic Industries Association (EIA) EIA-232-D Interface Standard

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Synopsis

Editor's Note

The subject of this report is considered as a mature standard. No significant developments are anticipated, but because of its importance in the industry, coverage is being continued.

Copies of EIA-232-D can be obtained from the Electronic Industries Association, Engineering Department, 2001 I Street NW, Washington, DC 20006.

Report Highlights

EIA-232-D is the revision of RS-232-C. EIA-232-D, approved in 1986, is a set of specifications that applies to the transfer of data between data terminal equipment (DTE) and data circuit-terminating equipment (DCE). It defines the interface circuit functions and their corresponding connector pin assignments. Full- or half-duplex operations are supported for synchronous or asynchronous transmissions at speeds up to 20K bps.

—By *Algis V. Salciunas*
Product Manager

Analysis

The Electronic Industries Association (EIA) Standard EIA-232-D is the November 1986 revision of RS-232-C. This revision brings the standard in line with international standards CCITT V.24, V.28, and ISO IS2110. This revision also reflects the inclusion of the Local Loopback, Remote Loopback, and Test Mode interchange circuits in the specification for the 25-pin interface connector.

EIA-232-D applies to all classes of service: private line, dial-up, point-to-point, multipoint, switched, nonswitched, two-wire, and four-wire service. Asynchronous and synchronous data transmission is supported at speeds up to 20K bps in full- or half-duplex mode. EIA-232-D is a single-ended or unbalanced interface; all of the interchange signals share a common electrical ground.

EIA-232-D defines the electrical and mechanical characteristics of the interface for connecting data terminal equipment (DTE) and data circuit-terminating equipment (DCE) using serial binary data communications. As the terms relate to this interface, DTE comprises business machine hardware such as teleprinters, CRTs, front-end processors, and CPUs, while DCE includes hardware such as modems, limited distance data sets, and data service units (DSUs).

Electrical Characteristics

The EIA-232-D standard prescribes polar-voltage serial data transmission between communicating devices. On data interchange circuits, transmitted data is represented by the "Marking" condition for binary one and the "Spacing" condition for binary zero. A data signal on an interchange circuit is in the Marking condition when the voltage at the interface point is more negative than -3 volts with respect to Signal Ground (Circuit AB). When the data signal at the interface point is more positive than $+3$ volts, with respect to Signal Ground, the data signal is in the Spacing condition. The area

between -3 and $+3$ volts is the transition region; the signal state is not defined in the transition region.

On timing or control interchange circuits, the function is considered OFF when the voltage at the interface point is more negative than -3 volts, with respect to Signal Ground. It is considered ON if the voltage at the interface point is more positive than $+3$ volts, with respect to Signal Ground. The function is not defined for voltages in the transition region between -3 and $+3$ volts.

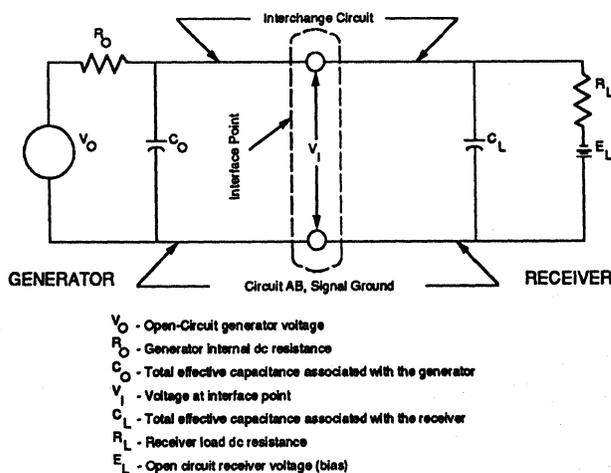
Notation	Interchange Voltage	
	Negative	Positive
Binary State	1	0
Signal Condition	Marking	Spacing
Function	OFF	ON

Mandatory Interchange Circuit conditions are as follows (see Figure 1):

- Open circuit generator voltage, with respect to Signal Ground, must not exceed 25 volts with respect to ground.
- The potential at the interface point must not be less than 5 volts nor more than 15 volts in magnitude when the receiver resistance is between 3000 and 7000 ohms, and the receiver open voltage is 0.

Figure 1.

Electrical Interchange Circuit Characteristics



- The effective shunt capacitance associated with the receiver must not exceed 2500 picofarads at the interface point.
- The open circuit receiver voltage must not exceed 2 volts.
- Request to Send (Circuit CA), DCE Ready (Circuit CC), DTE Ready (Circuit CD), and Secondary Request to Send (Circuit SCA), where implemented, are used to detect the power-off condition or the disconnection of the interconnecting cable.

Certain limitations apply to all interchange signals (data, control, and timing) as follows:

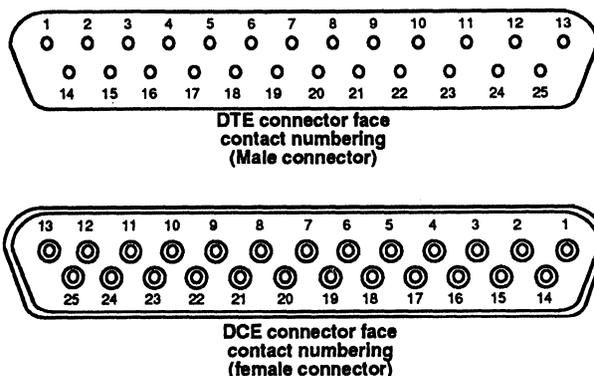
- Interchange signals entering transition must proceed to the opposite signal state, and may not reenter the transition region until the next significant change in signal condition.
- The direction of voltage must not change while in the transition region.
- The time required for a control signal to pass through the transition region must not exceed one millisecond.
- The time required for a data or timing signal to pass through the transition region must not exceed one millisecond or 4 percent of the normal duration of a signal element on that interchange circuit, whichever is the lesser.
- The maximum instantaneous rate of voltage must not exceed 30 volts per microsecond.

Mechanical Characteristics

The physical connection between DTE and DCE is made through plug-in, 25-pin connectors. The connectors are keyed with 13 pins on the top row and 12 pins on the bottom row to prevent improper connection (see Figure 2). The male connector is always associated with the DTE and the female is always associated with the DCE. The cable is provided by the DTE. The maximum length of cables is not defined. Proximity to heavy rotating machinery or other noisy/radiating devices will limit the practical cable length.

Pin assignments are explicit and unalterable, unless unassigned (see Table 1). Special functions, not specifically defined, should be allotted to unassigned pins. For example, pin 11 (unassigned) could be used to "busy out" a connected modem

Figure 2.
EIA-232-D Male and Female Connectors



that is associated with a switched application. This would cause the modem to go "off hook," preventing an incoming call from being connected/answered. Because one pin is unassigned and because all of the functions defined by EIA-232-D are not necessarily required for a specific application, all 25 pins are not usually used. (Contact the DTE vendor to determine the specific configuration.)

Channels

The data transmission channel includes the transmission media, plus the intervening equipment involved in the transfer of information between DTEs. When the DCE is capable of multiple speeds (e.g., 1200 bps in one direction and 300 bps in the opposite direction), a channel is defined for each speed capability. EIA-232-D defines these two types of data transmission channels as primary and secondary channels.

The primary data transmission channel has the highest signaling rate capability of all the channels sharing a common interface connector. The primary channel may support information transfer in one direction only (simplex), both directions alternately (half duplex), or both directions simultaneously (full duplex).

A secondary channel is a channel that has a lower signaling rate capability than the primary channel. Secondary channels may be simplex, half duplex, or full duplex. Secondary channels are established because in some communications systems, greater channel efficiency can be achieved by using a lower speed subchannel to carry control

Table 1. EIA-232-D Interface Connector Pin Assignments

Pin Number	Function	Circuit/ (Source)	Signal Type	CCITT Equiv.
1	Shield	—	—	—
2	Transmitted Data	BA (DTE)	Data	103
3	Received Data	BB (DCE)	Data	104
4	Request to Send	CA (DTE)	Control	105
5	Clear to Send	CB (DCE)	Control	106
6	DCE Ready	CC (DCE)	Control	107
7	Signal Ground	AB	Ground	102
8	Received Line Signal Detector	CF (DCE)	Control	109
9	Reserved for Testing	—	—	—
10	Reserved for Testing	—	—	—
11	Unassigned	—	—	—
12	Secondary Received Line Signal Detector/ Data Signal Rate Selector (DCE Source)	SCF/CI (DCE)	Control	122/112
13	Secondary Clear to Send	SCB (DCE)	Control	121
14	Secondary Transmitted Data	SBA (DTE)	Data	118
15	Transmitter Signal Element Timing (DCE)	DB (DCE)	Timing	114
16	Secondary Received Data	SBB (DCE)	Data	119
17	Receiver Signal Element Timing (DCE)	DD (DCE)	Timing	115
18	Local Loopback	LL (DTE)	Control	141
19	Secondary Request to Send	SCA (DTE)	Control	120
20	DTE Ready	CD (DCE)	Control	108.2
21	Remote Loopback/Signal Quality Detector	RL/CG (DCE/DTE)	Control	140/110
22	Ring Indicator	CE (DCE)	Control	125
23	Data Signal Rate Selector (DTE/DCE)	CH/CI (DCE/DTE)	Control	111/112
24	Transmit Signal Element Timing (DTE)	DA (DTE)	Timing	113
25	Test Mode	TM (DCE)	Control	142

responses. Two types of secondary channels are defined: auxiliary and backward.

An auxiliary channel is one in which the direction of transmission is independent of the primary channel; the channel is controlled by the secondary control interchange circuits. A backward channel is one in which the direction of transmission is always opposite to that of the primary channel.

Interchange Circuits

An interchange circuit is defined as a circuit between the DTE and the DCE. EIA-232-D describes the four categories of interchange circuits that apply generally to all systems. They are Ground or Common Return, Data, Control, and Timing circuits.

Ground Circuits

The ground interchange circuit is *Signal Ground* or *Common Return* (Circuit AB). Signal Ground establishes a common reference for all interchange circuits. Within the DCE, this circuit is brought to one point, and is connected to Protective Ground

via a wire strap inside the equipment. This wire strap can be connected or removed at installation, as may be required to meet applicable regulations or to minimize the introduction of noise into electronic circuitry.

Data Circuits

Four types of data circuits are described: Transmitted Data, Received Data, Secondary Transmitted Data, and Secondary Received Data.

Transmitted Data (Circuit BA) and *Received Data* (Circuit BB) are used on the primary channel—the data transmission channel with the highest signaling rate of all channels sharing a common interface connector. Signals on Circuit BA are generated by the DTE and sent to the local transmitting signal converter (e.g., a modem) for transmission of data to remote DTEs or for maintenance or control of the local transmitting signal converter. For the DTE to transmit data, an ON condition must be present on the following four circuits: CA (Request to Send), CB (Clear to Send), CC (DCE Ready), and CD (DTE Ready). (These circuits are described in the Control Circuits section of this report.)

Signals on Circuit BB are generated by the receiving signal converter in response to data signals received from the remote DTE, or in response to maintenance or control data signals from the local DTE. Circuit BB is held in the binary one (Marking) condition when Circuit CF (Received Line Signal Detector) is in the OFF condition.

Secondary Transmitted Data (Circuit SBA) is equivalent to Circuit BA, except it is used to transmit data on the secondary channel. The secondary channel has a lower signaling rate than the primary channel in a system where two channels share a common interface connector.

Secondary Received Data (Circuit SBB) is equivalent to Circuit BB, except it is used to receive data on the secondary channel.

Secondary circuits may be independent of other interchange circuits in terms of direction and speed. The secondary interchange circuits, however, are additional circuits that function in the same manner as their basic counterparts, and follow the same conditions that govern corresponding basic circuits.

When any data circuit is idle, it is held in the Marking condition. Data is transferred in bipolar fashion; a binary "one" (mark) is represented by a voltage more negative than -3 volts, and a binary "zero" (space) is represented by a voltage more positive than +3 volts.

Control Circuits

Control signals are used to enable and disable data transmission and reception, and to indicate the operational status and condition of the DTE and DCE. A control function is considered to be in the ON condition when the voltage is more positive than +3 volts; it is considered to be in the OFF condition when the voltage is more negative than -3 volts.

Control circuits include Request to Send, Clear to Send, DCE Ready, DTE Ready, Ring Indicator, Received Line Signal Detector, Signal Quality Detector, Data Signal Rate Selector (DTE), Data Signal Rate Selector (DCE), Secondary Request to Send, Secondary Clear to Send, and Secondary Received Line Signal Detector.

- Request to Send (Circuit CA)—conditions the local DCE for data transmission, and controls the direction of transmission on half-duplex channels. On half-duplex channels, Circuit CA maintains the DCE in the transmit mode and

Table 2. EIA-232-D Data Transmission Configuration Interfaces

Interface Type	Configuration
A	Transmit only
B	Transmit only*
C	Receive only
D	Half duplex
D	Full duplex*
E	Full duplex
F	Primary channel transmit only*/ secondary channel receive only
G	Primary channel receive only/ secondary channel transmit only*
H	Primary channel transmit only/ secondary channel receive only
I	Primary channel receive only/ secondary channel transmit only
J	Primary channel transmit only*/ half-duplex secondary channel
K	Primary channel receive only/ half-duplex secondary channel
L	Half-duplex primary channel/ half-duplex secondary channel
L	Full-duplex primary channel*/ full-duplex secondary channel*
M	Full-duplex primary channel/ full-duplex secondary channel
Z	Circuit specified by supplier

*Indicates the Request to Send (RTS) Circuit in a simplex or full-duplex arrangement where RTS might not ordinarily be expected. Can be used to indicate a nontransmit mode to the DCE or to permit the DCE to remove a line signal or to send synchronization signals.

inhibits the receive mode; on simplex channels, it maintains the DCE in the transmit mode. An OFF to ON transition on Circuit CA causes the DCE to enter transmit mode and turn Clear to Send ON. An ON to OFF transition causes the DCE to complete the data transmission, enter the receive or nontransmit mode, and turn Clear to Send OFF.

- Clear to Send (Circuit CB)—indicates to the DTE that data can be transmitted (Circuit CB ON) or cannot be transmitted (Circuit CB OFF). The ON condition on Circuit CB is delayed until the remote DCE is initialized. When Circuit CA is not implemented, Circuit CB must be ON continuously.
- DCE Ready (Circuit CC)—indicates the status of the local DCE. ON indicates that the DCE is connected to the communications channel (in switched services, "Off Hook"), and is not in test, talk (alternative voice/data), or dial mode. The ON condition of this circuit should not be interpreted as either the status of any remote station equipment or an indication that a communications channel has been established to a remote data station. ON indicates completed

timing functions, if any, required for call establishment (switched service). ON indicates completed transmission of a discreet answer tone, the duration of which is controlled by the local DCE. OFF indicates that the local DCE is not ready to operate, that a fault condition has been detected, or that a disconnect indication has been detected. When the OFF condition occurs during transmission, the connection has been lost.

- DTE Ready (Circuit CD)—controls the switching of the DCE to the communications channel. The ON condition prepares the DCE to connect and maintain connection to the communications channel. With automatic answering equipment, connection to the communications channel occurs when both the DTE Ready and the Ring Indicator circuit are in the ON condition. The OFF condition of Circuit CD causes the DCE to be removed from the communications channel upon completion of any *in process* transmission. The OFF condition does not disable the Ring Indicator signal. In switched systems, Circuit CD cannot be turned ON until Circuit CC (DCE Ready) is turned OFF by the DCE.
- Ring Indicator (Circuit CE)—indicates that a ring (call) signal is being received on the communications channel through the switched network. Circuit CE is held in the ON condition during ringing and the OFF condition between rings or when ringing is not present.
- Received Line Signal Detector (Circuit CF)—presents an ON condition to indicate that data signals are being received, and that they are acceptable for demodulation. An OFF condition indicates that no signal is being received or that the signal is not acceptable for demodulation. The OFF condition causes the Received Data (Circuit BB) to be held in the Marking condition.
- Signal Quality Detector (Circuit CG)—indicates whether there is a high probability of error in received data. The ON condition is maintained, unless a high probability of error has occurred. Probable error is indicated by the OFF condition. This condition can be used to effect retransmission.
- Data Signal Rate Selector (DTE Source), Data Signal Rate Selector (DCE Source), (Circuits

CH and CI, respectively)—selects between two signaling rates when either the DCE or DTE accommodates dual rates. The ON condition selects the higher rate or range of rates. Circuit CH indicates that the DTE provides the selection signal. Circuit CI indicates that the DCE provides the selection signal. Selection is between two asynchronous rates or between two synchronous rates.

- Secondary Request to Send (Circuit SCA)—functions the same as Circuit CA, except that it requests the establishment of the secondary channel.
- Secondary Clear to Send (Circuit SCB)—functions the same as Circuit CB, except that it indicates the availability of the secondary channel.
- Secondary Received Line Signal Detector (Circuit SCF)—functions the same as Circuit CF, except that it indicates the proper reception of the secondary channel line signal.

Timing Circuits

Three circuits are used to provide timing: Transmitter Signal Element Timing (DTE Source), Transmitter Signal Element Timing (DCE Source), and Receiver Signal Element Timing (DCE Source).

- Transmitter Signal Element Timing (DTE Source) (Circuit DA)—provides signal element timing information to the transmitting signal converter, the DCE. The ON-OFF transition indicates the occurrence of the center of the data element. The DTE normally provides timing information on this circuit when the DTE is powered ON. If Circuit CA (Request to Send) is OFF, timing information on Circuit DA may be withheld by the DTE for short periods.
- Transmitter Signal Element Timing (DCE Source) (Circuit DB)—provides signal element timing to the DTE. A data signal on Circuit BA (Transmitted Data) is provided from the DTE in which the transition between signal elements occurs at the time of the ON-OFF transition in Circuit DB. If Circuit CC (Data Set Ready) is OFF, it is permissible for the DCE to withhold timing information for short periods. The performance of maintenance tests within the DCE, for example, may require the withholding of timing information.

Table 3. Required Interchange Circuits for Standard Interface Types

Interchange Circuits	Interface Type														
	A	B	C	D	E	F	G	H	I	J	K	L	M	Z	
AB	Signal Ground	.	.	.	.	.	.	.	.	.	.	.	.	.
BA	Transmitted Data	.	.	.	.	.	.	.	.	.	.	.	.	.
BB	Received Data	.	.	.	.	.	.	.	.	.	.	.	.	○
CA	Request to Send	.	.	.	.	.	.	.	.	.	.	.	.	○
CB	Clear to Send	.	.	.	.	.	.	.	.	.	.	.	.	○
CC	DCE Ready	.	.	.	.	.	.	.	.	.	.	.	.	○
CD	DTE Ready	†	†	†	†	†	†	†	†	†	†	†	†	○	
CE	Ring Indicator	†	†	†	†	†	†	†	†	†	†	†	†	○	
CF	Received Line Signal Detector	.	.	.	.	.	.	.	.	.	.	.	.	○
CG	Signal Quality Detector	.	.	.	.	.	.	.	.	.	.	.	.	○
CH/CI	Data Signaling Rate Selector (DTE/DCE)	.	.	.	.	.	.	.	.	.	.	.	.	○
DA/DB	Transmitter Signal Element Timing (DCE/DTE)	§	§	.	§	§	§	.	§	.	§	§	§	○	
DD	Receiver Signal Element Timing (DCE)	.	.	§	§	§	.	§	.	§	§	§	.	○	
SBA	Secondary Transmitted Data	.	.	.	.	.	.	.	.	.	.	.	.	○
SBB	Secondary Received Data	.	.	.	.	.	.	.	.	.	.	.	.	○
SCA	Secondary Request to Send	.	.	.	.	.	.	.	.	.	.	.	.	○
SCB	Secondary Clear to Send	.	.	.	.	.	.	.	.	.	.	.	.	○
SCF	Secondary Received Line Signal Detector	.	.	.	.	.	.	.	.	.	.	.	.	○
LL	Local Loopback	.	.	.	∅	∅	∅	∅	○
RL	Remote Loopback	.	.	.	∅	∅	∅	∅	○
TM	Test Mode	∅	∅	∅	∅	∅	∅	∅	∅	∅	∅	∅	∅	∅	○

Legend:

•—Basic interchange circuit—all systems.

†—Additional interchange circuits required for switched service.

§—Additional interchange circuits required for synchronous service.

○—To be specified by the supplier.

∅—Optional.

- Receiver Signal Element Timing (DCE Source) (Circuit DD)—provides timing to the data terminal from the data set. The ON-OFF transition indicates the center of the received data elements.

Standard Interfaces for Selected Configurations

EIA-232-D describes a selected set of data transmission configurations or interfaces. A provision is made for the addition of custom configurations. Determining factors in the selection of an interface type are whether the DTE transmits, receives, or does both; whether the mode of operation is half or full duplex; and whether a secondary channel is used. The interface designations do not relate to which terminal originates or answers the call, but rather to the data transmitted.

EIA-232-D defines selected interface types by letter designation. These types are described in Table 2, where the direction of data transfer pertaining to the interface is stated (function), and the use of Request to Send and Received Line Signal Detector interchange circuits is stipulated (comment). This list indicates that interfaces A and B, which are one-way only transmissions, differ only in terms of the use of RTS. Interface D is normally employed with half-duplex operation using RTS, and interface E is normally employed with full-duplex operation, without using RTS. When interface D is used in full-duplex operation, however, RTS is used with special significance.

Interfaces E, F, G, and H define two-way transmission where both the primary and secondary directions are one-way only.

Interfaces J, K, L, and M define less restrictive primary and secondary arrangements.

Interface Z simply allows a special arrangement to be established.

The complete relationship of interchange circuits to standard interface types is depicted in Table 3. ■

