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TIA/EIA-232-F

TIA/EIA STANDARD

Interface Between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange

TIA/EIA-232-F

(Revision of EIA/TIA-232-E)

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(From Standards Proposal No. 3761, formulated under the cognizance of the TIA TR 30.2 Subcommittee on DTE-DCE Interfaces.)

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INTERFACE BETWEEN DATA TERMINAL EQUIPMENT AND DATA CIRCUIT-TERMINATING EQUIPMENT EMPLOYING SERIAL BINARY DATA INTERCHANGE

(From TIA/EIA Standard EIA/TIA-232-E and Standards Proposal No. 3761 formulated under the cognizance of TIA Subcommittee TR-30.2 on Data Transmission Interfaces.)

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FOREWORD

(This foreword is not part of this Standard)

No technical changes have been incorporated into TIA/EIA-232-F that will create compatibility problems with equipment conforming to previous versions of EIA/TIA-232.

This standard is a revision to EIA/TIA-232-E, which brings it in line with international standards ITU-T V.24, *List Of Definitions For Interchange Circuits Between Data Terminal Equipment (DTE) And Data Circuit-Terminating Equipment (DCE),* V.28, *Electrical Characteristics For Unbalanced Double-Current Interchange Circuits,* and ISO/IEC 2110, *25-pole DTE/DCE Interface Connector and Contact Number Assignments.*

The changes incorporated into this revision include:

– the addition of the alternate use of connector pin 22 for Circuit CK, Received Energy Present,

– the addition of definitions for rate change in Circuits DB, Transmitter Signal Element Timing, and DD, Receiver Signal Element Timing,

– the addition of Section 6.9, Use of Circuits for Testing, and

– the deletion of Section 7, Glossary.

As with previous versions of EIA/TIA-232, TIA/EIA-232-F provides operation to a maximum data signaling rate of 20 kbit/s. For operation at rates greater than 20 kbit/s, EIA/TIA standards EIA/TIA-530-A, *High Speed 25-Position Interface for Data Terminal Equipment and Data Circuit-Terminating Equipment, Including Alternative 26-Position Connector,* EIA/TIA-561, *Simple 8-Position Non-Synchronous Interface Between Data Terminal equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange,* EIA/TIA-574, *9-Position Non-Synchronous Interface Between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange,* and TIA/EIA-687, *Medium Speed Interface for Data Terminal Equipment and Data Circuit-Terminating Equipment,* are recommended. TIA Subcommittee TR-30.2 has initiated work on the development of a new High Speed Interface, PN-3855, which will provide a DTE/DCE interface for operation at data rates up to 512 kbit/s.

1 SCOPE

1.1 Abstracts

This standard is applicable to the interconnection of data terminal equipment (DTE) and data circuit-terminating equipment (DCE) employing serial binary data interchange. It defines:

Section 2 Signal Characteristics:

Electrical and grounding characteristics of the interchange signals and associated circuitry.

Section 3 Interface Mechanical Characteristics:

Definition of the mechanical characteristics of the interface between the DTE and the DCE.

Section 4 Functional Description of Interchange Circuits:

Functional description of a set of data, timing and control interchange circuits for use at a digital interface between a DTE and a DCE.

Section 5 Standard Interfaces for Selected Communication System Configurations:

Standard subsets of specific interchange circuits are defined for a specific group of data communication system applications.

In addition, the standard includes:

Section 6 Recommendations and Explanatory Notes

1.2 Interface Configurations

This standard includes thirteen specific interface configurations intended to meet the needs of fifteen defined system applications. These configurations are identified by type, using alphabetic characters A through M. In addition, type Z has been reserved for applications not covered by types A through M, and where the configuration of interchange circuits is to be specified, in each case, by the supplier.

1.3 Data Signaling Rates

This standard is applicable for use at data signaling rates up to a nominal limit of 20,000 bits per second.

1.4 Signal Common

This standard is applicable for the interchange of data, timing and control signals when used in conjunction with electronic equipment, each of which has a single common return (Signal Common), which can be interconnected at the interface point. It does not apply where electrical isolation between equipment on opposite sides of the interface point is required.

1.5 Synchronous/Nonsynchronous Communication

This standard applies to both synchronous and nonsynchronous serial binary data communication systems.

1.6 Classes of Service

This standard applies to all classes of data communication service, including:

1.6.1 Dedicated leased or private line service, either two-wire or four-wire. Consideration is given to both point-to-point and multipoint operation.

1.6.2 Switched service, either two-wire or four-wire. Consideration is given to automatic answering of calls; however, this standard does not include all of the interchange circuits required for automatically originating a connection using EIA-366-A, *Interface Between Data Terminal Equipment and Automatic Calling Equipment for Data Communication*. Serial dialing and control is described in TIA/EIA-602, *Data Transmission Systems and Equipment - Serial Asynchronous Automatic Dialing and Control.*

1.7 Allocation of Functions

The DCE may include transmitting and receiving signal converters as well as control functions. Other functions, such as pulse regeneration, error control, etc., may or may not be provided. Equipment to provide these additional functions may be included in the DTE or in the DCE, or it may be implemented as a separate unit interposed between the two.

1.7.1 When such additional functions are provided within the DTE or the DCE, this interface standard shall apply only to the interchange circuits between the two classes of equipment.

1.7.2 When additional functions are provided in a separate unit inserted between the DTE and the DCE, this standard shall apply to both sides (the interface with the DTE and the interface with the DCE - see 3.3.3 and 3.4.2) of such separate unit.

1.8 Modes of Operation

This standard applies to all of the modes of operation described under the system configurations indicated in Section 5, Standard Interfaces for Selected Communication System Configurations.

2 SIGNAL CHARACTERISTICS

2.1 Electrical Characteristics

2.1.1 Figure 1, Interchange Equivalent Circuit, shows the electrical parameters which are specified in the subsequent paragraphs of this section. The equivalent circuit shown in Figure 1 is applicable to all data, timing or control circuits. The equivalent circuit is independent of whether the generator is located in the DCE and the receiver in the DTE or vice versa.

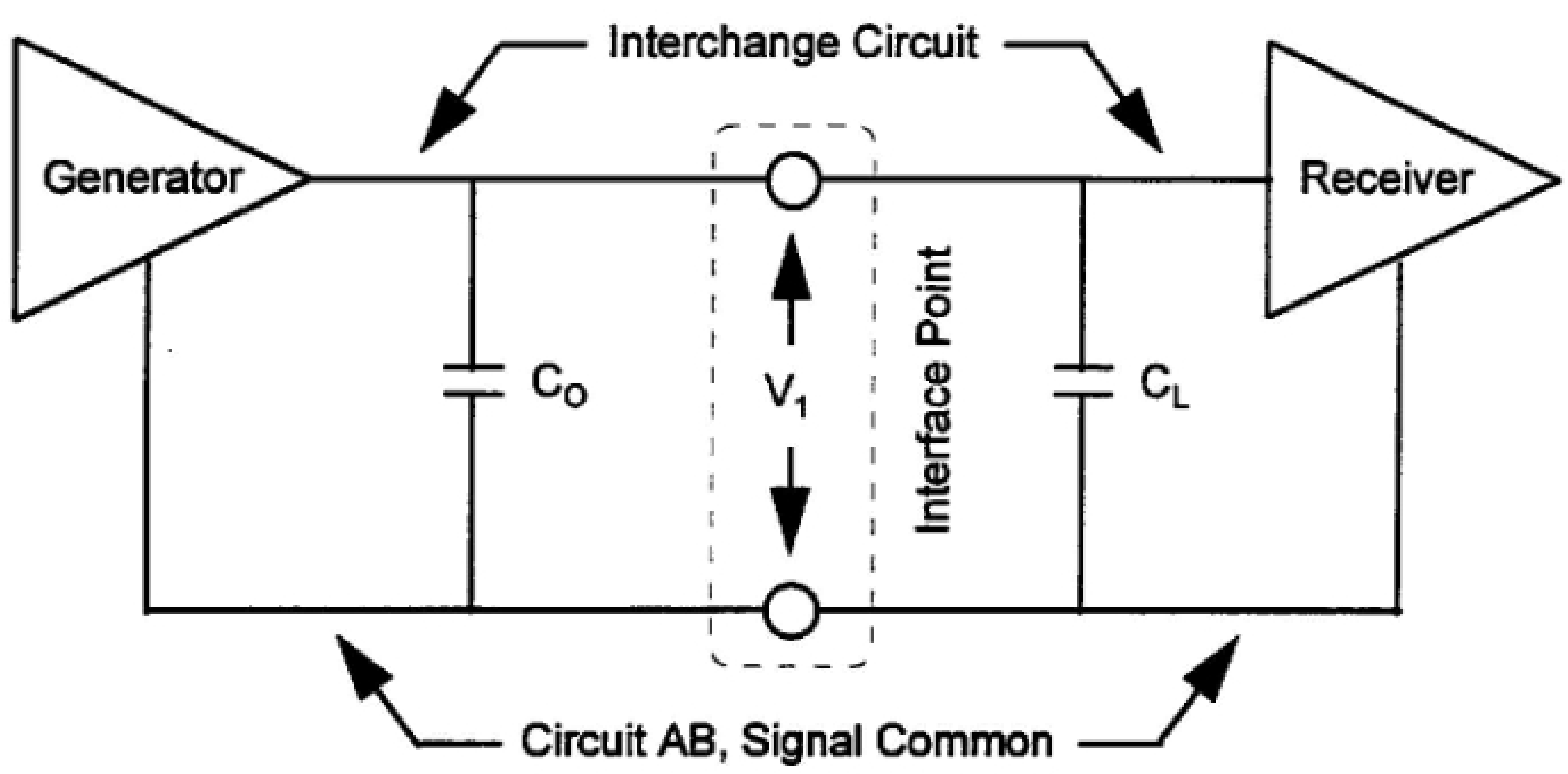
2.1.2 The generator on an interchange circuit shall be designed to withstand an open circuit, a short circuit between the conductor carrying that interchange circuit in the interconnecting cable and any other conductor in that cable, or any passive non-inductive load connected between that interchange circuit and any other interchange circuit including Circuit AB (Signal Ground), without sustaining damage to itself or its associated equipment. The receiver on an interchange circuit shall be designed to withstand (not be damaged by) any input signal within the 25 volt limit specified in 2.1.6.

2.1.3 For data interchange circuits, the signal shall be considered in the marking condition when the voltage (V_1) on the interchange circuit, measured at the interface point, is more negative than -3 volts with respect to Circuit AB (Signal Common). The signal shall be considered in the spacing condition when the voltage (V_1) is more positive than +3 volts with respect to Circuit AB (see 6.2). The region between ±3 volts is defined as the transition region. The signal state is undefined when the voltage (V_1) is in this transition region. See Table 1.

During the transmission of data, the marking condition shall be used to denote the binary state ONE and the spacing condition shall be used to denote the binary state ZERO. See Table 1.

Table 1 - Interchange State

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



C_o is the total effective capacitance associated with the generator, measured at the interface point and including any cable to the interface point.

V_1 is the voltage at the interface point.

C_L is the total effective capacitance associated with the receiver measured at the interface point and including any cable to the interface point.

Figure 1 - Interchange Equivalent Circuit

For timing and control interchange circuits, the function shall be considered ON when the voltage (V_1) on the interchange circuit is more positive than +3 volts with respect to circuit AB, and shall be considered OFF when the voltage (V_1) is more negative than -3 volts with respect to Circuit AB. The function is not uniquely defined for voltages in the transition region between ±3 volts. See Table 1.

This specification neither implies nor precludes the use of receiver circuits which utilize hysteresis techniques to enhance their noise immunity; however, the requirements of 2.1.5 must also be satisfied.

2.1.4 The load impedance of the receiver side of an interchange circuit is defined for an applied voltage range of 3 volts to 15 volts in magnitude. It shall have a dc resistance of not less than 3000 ohms, nor more than 7000 ohms, measured with an applied voltage of 3 to 15 volts in magnitude. The effective shunt capacitance (C_L) of the receiver side of an interchange circuit, including the capacitance of cable, measured at the interface point, shall not exceed 2500 picofarads. The reactive component of the load impedance shall not be inductive. The open circuit receiver voltage shall not exceed 2 volts in magnitude. (see 6.3, 6.4, and 6.5).

2.1.5 The following interchange circuits, where implemented, shall be used to detect either a power-off condition in the equipment connected across the interface, or the disconnection of the interconnecting cable:

-- Circuit CA (Request to Send)

-- Circuit CC (DCE Ready)

-- Circuit CD (DTE Ready)

-- Circuit SCA (Secondary Request to Send)

The power-off source impedance of the generator side of these circuits shall not be less than 300 ohms, measured with an applied voltage not greater than 2 volts in magnitude referenced to Circuit AB (Signal Common). The receiver for these circuits shall interpret the power-off condition or the disconnection of the interconnecting cable as an OFF condition.

2.1.6 The open-circuit generator voltage with respect to Circuit AB (Signal Common) on any interchange circuit shall not exceed 25 volts in magnitude. The source impedance of the generator side of an interchange circuit including any cable to the interface point is not specified; however, the impedance shall be such that a short circuit between any two conductors (including ground) in the interconnecting cable shall not result in a current in excess of 100 mA. Additionally, the generator design shall be such that, with a test load of

3000 ohms to 7000 ohms, the potential (V_1) at the interface point shall not be less than 5 volts nor more than 15 volts in magnitude (see 6.5).

2.1.7 The characteristics of signals transmitted across the interface point, exclusive of external interference, shall conform to the limitations specified in this section. These limitations shall be satisfied at the interface point when the interchange circuit is terminated with any receiving circuit which meets the requirements given in 2.1.4. These limitations apply to all interchange circuits (Data, Control and Timing) unless otherwise specified.

-- All interchange signals entering into the transition region shall proceed through the transition region to the opposite signal state and shall not reenter the transition region until the next change of signal condition.

-- There shall be no reversal of the direction of voltage change while the signal is in the transition region.

-- For Control Interchange Circuits, the time required for the signal to pass through the transition region during a change in state shall not exceed one millisecond.

-- For Data and Timing Interchange Circuits, the maximum allowable transition time (i.e., the time required for the signal to pass through the transition region) is based on the Unit Interval (bit time) of the data signaling rate, and shall be in accordance with Table 2.

Table 2 - Transition Time

Duration of Unit Interval (UI)	Maximum allowable transition time
UI ≥ 25 ms	1 millisecond
25 ms > UI ≥ 50 us	4% of a Unit Interval

Note: Good engineering practice requires that the rise and fall times of the data and timing signals should be approximately equal (within a range of 2 or 3 : 1).

The maximum instantaneous rate of voltage change shall not exceed 30 volts per microsecond.

2.2 Protective Ground (Frame Ground)

In DTEs and DCEs, protective ground is a point which is electrically bonded to the equipment frame. It may also be connected to external grounds (e.g., through the third wire of the power cord).

Protective ground (frame ground) is not an interchange circuit in this standard. If bonding of the equipment frames of the DCE and the DTE is necessary, a separate conductor should be used which conforms to the appropriate national or local electrical codes. Attention is called to the applicable Underwriters' Laboratories regulation applying to wire size and color coding.

2.3 Shield

In order to facilitate the use of shielded interconnecting cable, interface connector contact number 1 is assigned for this purpose. This will permit the extension of shield continuity through tandem connectorized sections. Normally the DCE should make no connection to interface connector contact number 1. Electromagnetic interference (EMI) suppression requirements are beyond the scope of this standard.

3 INTERFACE MECHANICAL CHARACTERISTICS

3.1 Definition of Mechanical Interface

The point of demarcation between the DTE and the DCE is located at a pluggable connector signal interface point between the two equipments which is less than 3 meters (10 feet) from the DCE (see Figure 2). A 25-position connector is the normal connector specified for all interchange circuits. An alternative 26-position connector (Alt A) is specified for use when a smaller physical connector is required. When the Alt A connector is used the interface shall be referred to as ***"TIA/EIA-232-F Alt A".*** The female connector shall be associated with, but not necessarily physically attached to, the DCE. An interface cable with a male connector should be provided with the DTE.

3.2 Cable Length

The maximum length of the cable is not defined; it is determined by the electrical requirement in 2.1.4 (see Annex A for guidance).

3.3 25-Position Interface Connector

3.3.1 Figure 3 illustrates the DTE connector which has male (pin) contacts and a female shell (plug connector). Figure 4 illustrates the DCE connector which has female (socket) contacts and a male shell (receptacle connector). Contact numbering is also illustrated in these figures. Figures 5, 6 and 7 illustrate contact spacing and dimensions.

3.3.2 Multiple arrangements are currently in use for fastening the connectors together. No method is recommended.

3.3.3 When additional functions are provided in a separate unit inserted between the DTE and the DCE (see 1.7), the female connector shall be associated with the side of this unit which interfaces with the DTE while the cable with the male connector shall be provided on the side which interfaces with the DCE (Figure 2(a)).

3.4 Alt A 26-Position Interface Connector

3.4.1 Figure 8 illustrates the Alt A Cable connector which has male (pin) contacts and a female shell (plug connector). Figure 9 illustrates the Alt A Equipment connector which has female (socket) contacts and a male shell (receptacle connector). Contact numbering is also illustrated in these figures.

3.4.2 For all separable connections at the DTE, DCE, or intermediate equipment between the DTE and the DCE; the Equipment connector (Figure 9) shall be used on the equipment and the Cable connector (Figure 8) shall be used on the cable. The cable assemblies utilizing the Alt A connector option will therefore always use the Cable connector (see Figures 3.1(b) and 3.7).

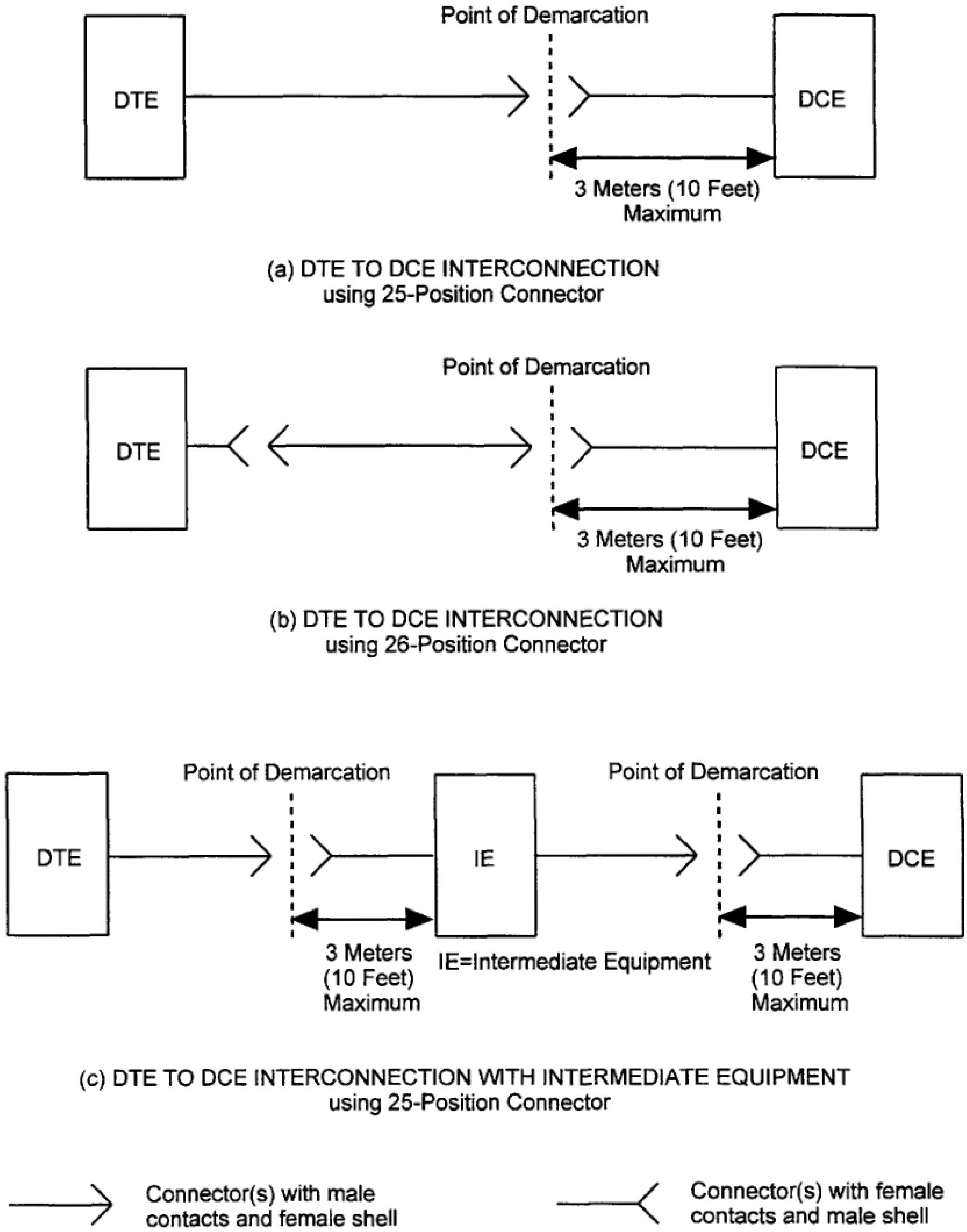


Figure 2 - Interconnection of Equipment

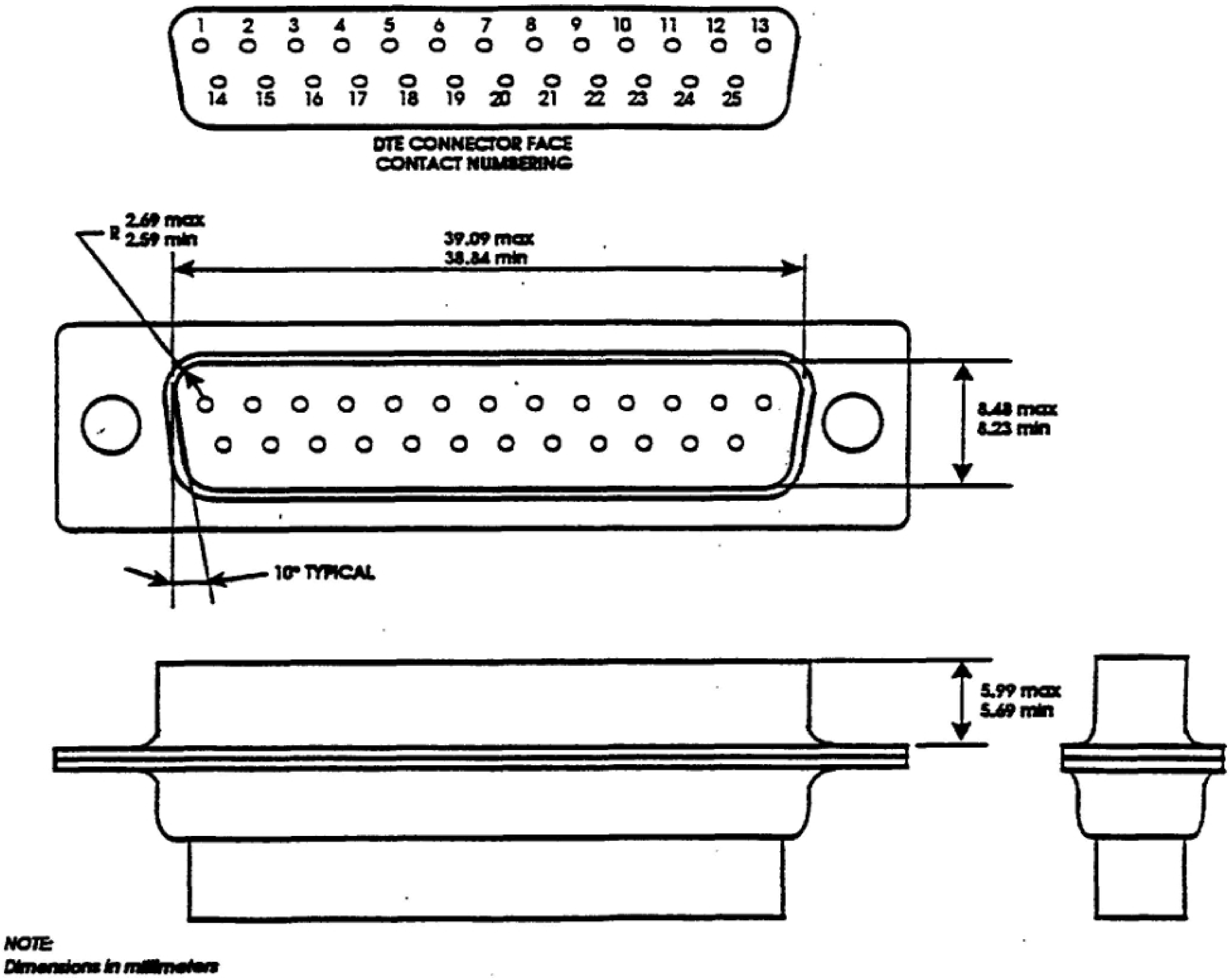


Figure 3 - DTE Interface Connector

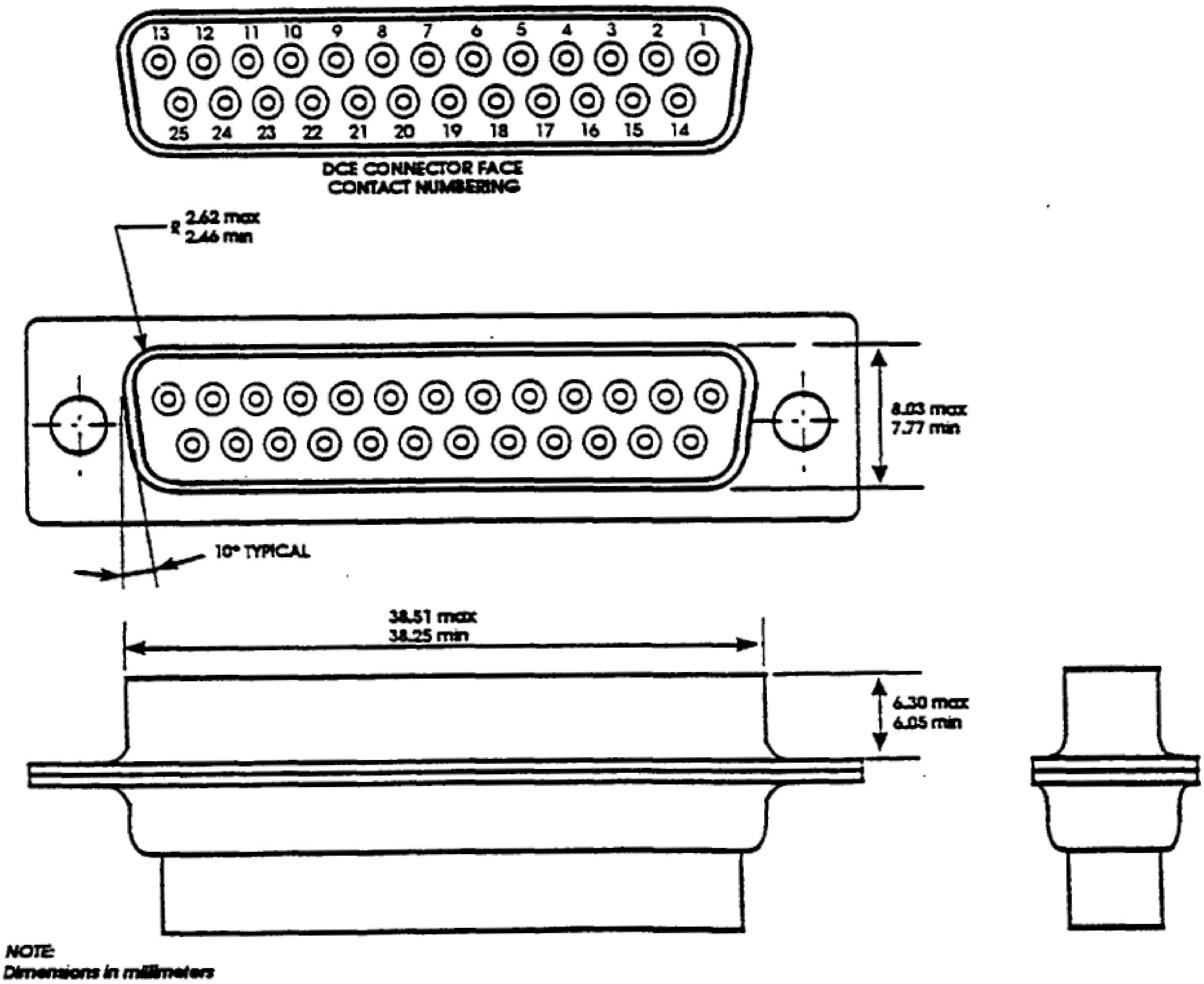
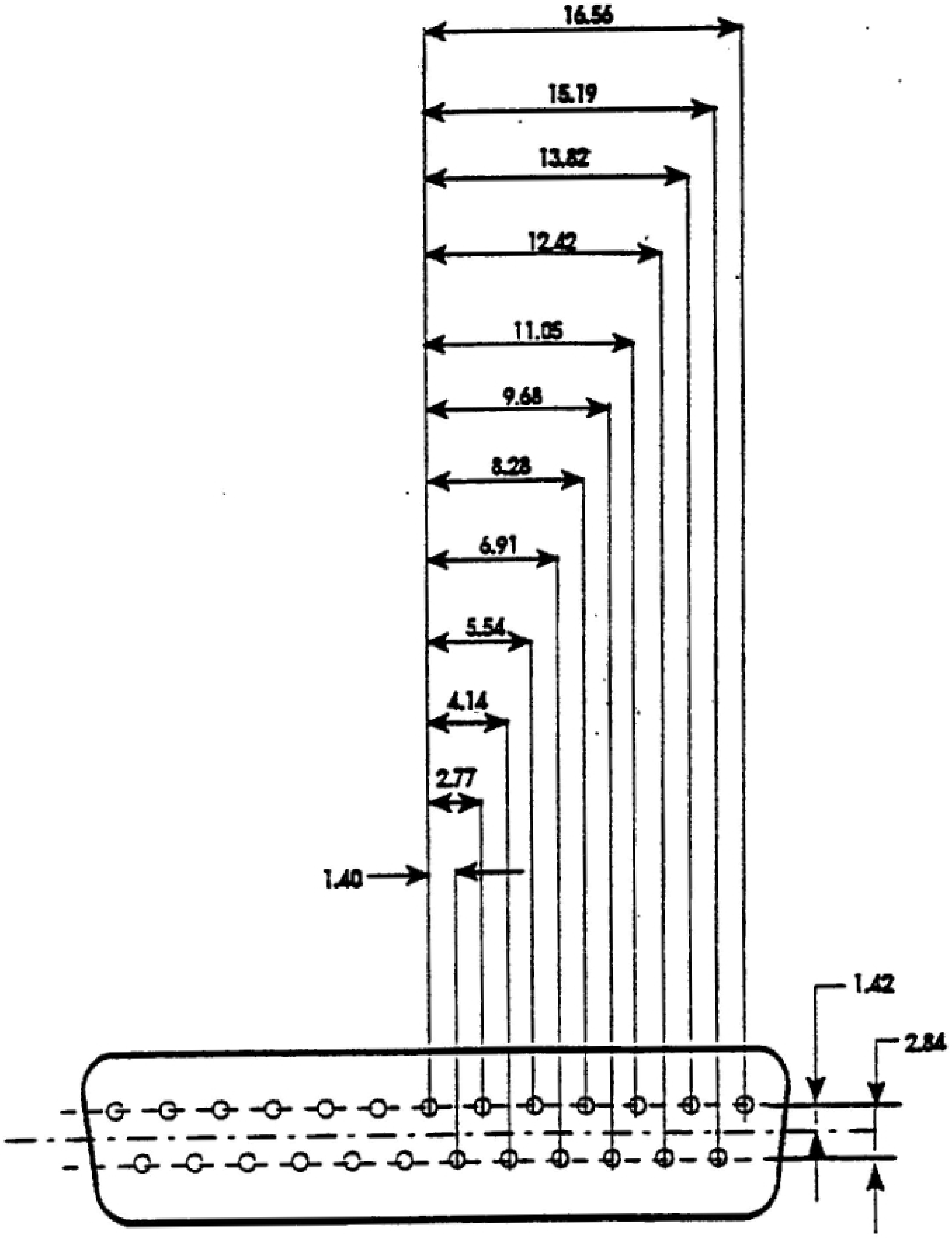


Figure 4 - DCE Interface Connector



NOTE:
Dimensions in millimeters

Figure 5 - Insert Dimensions

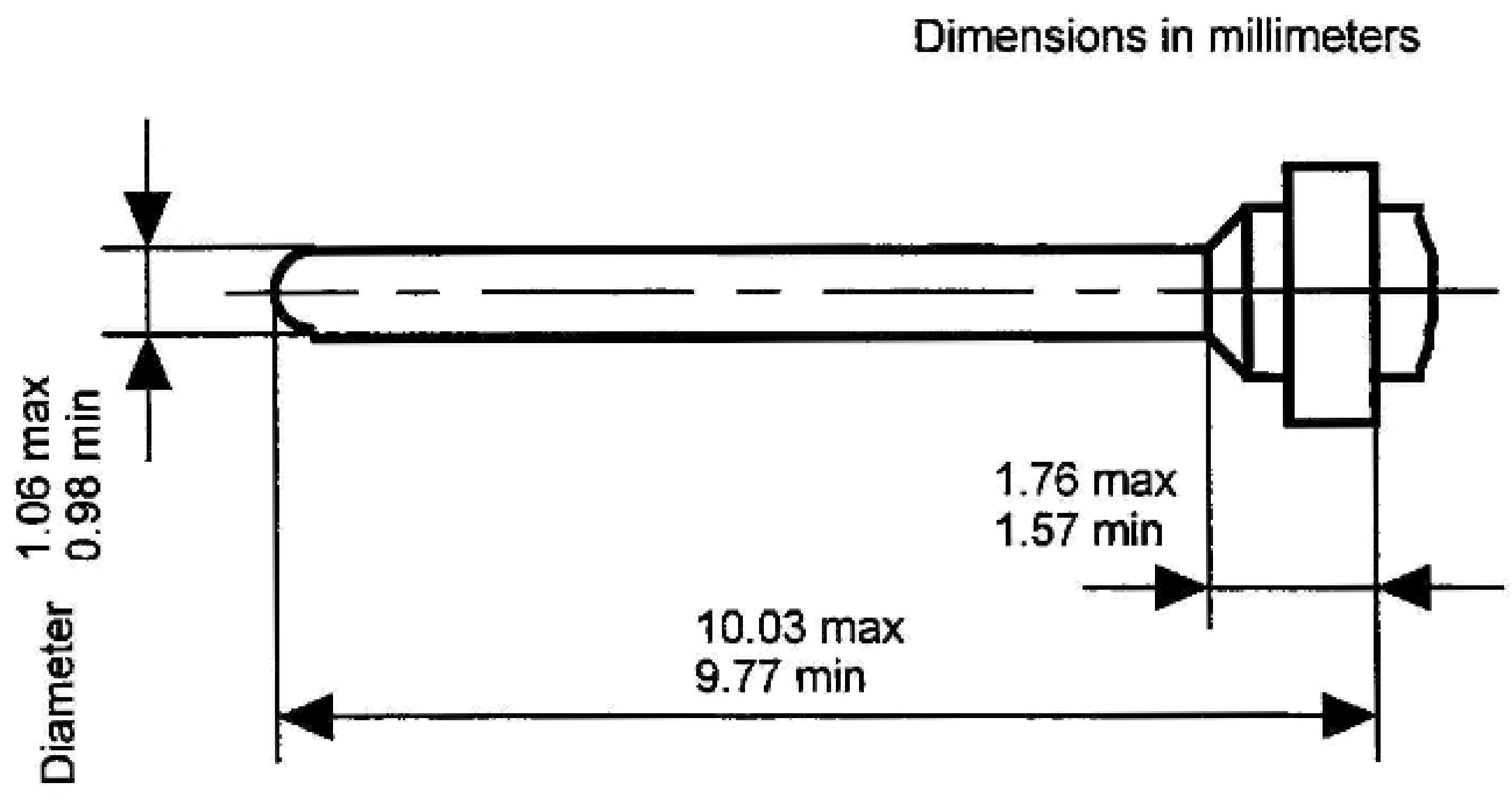
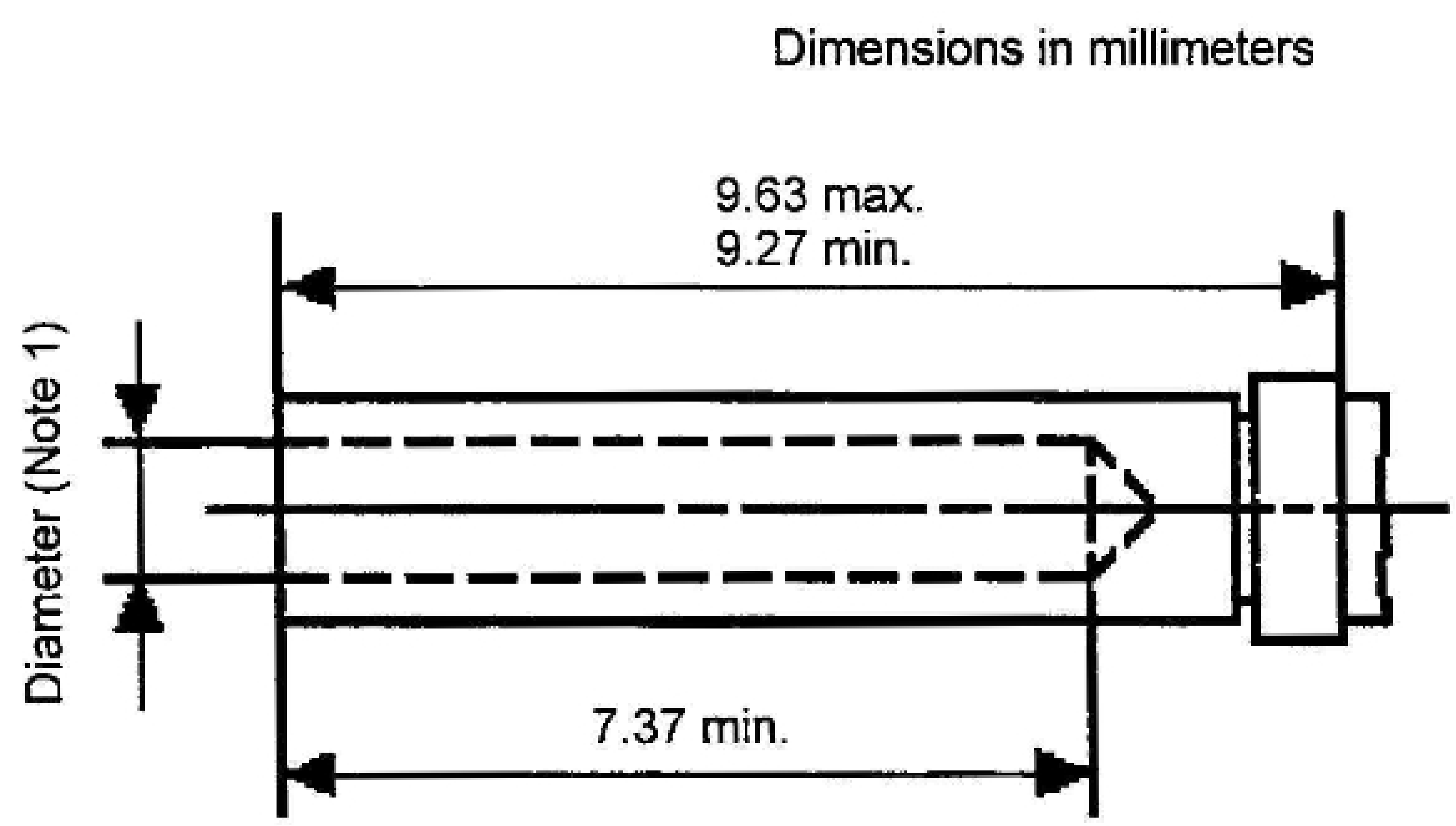
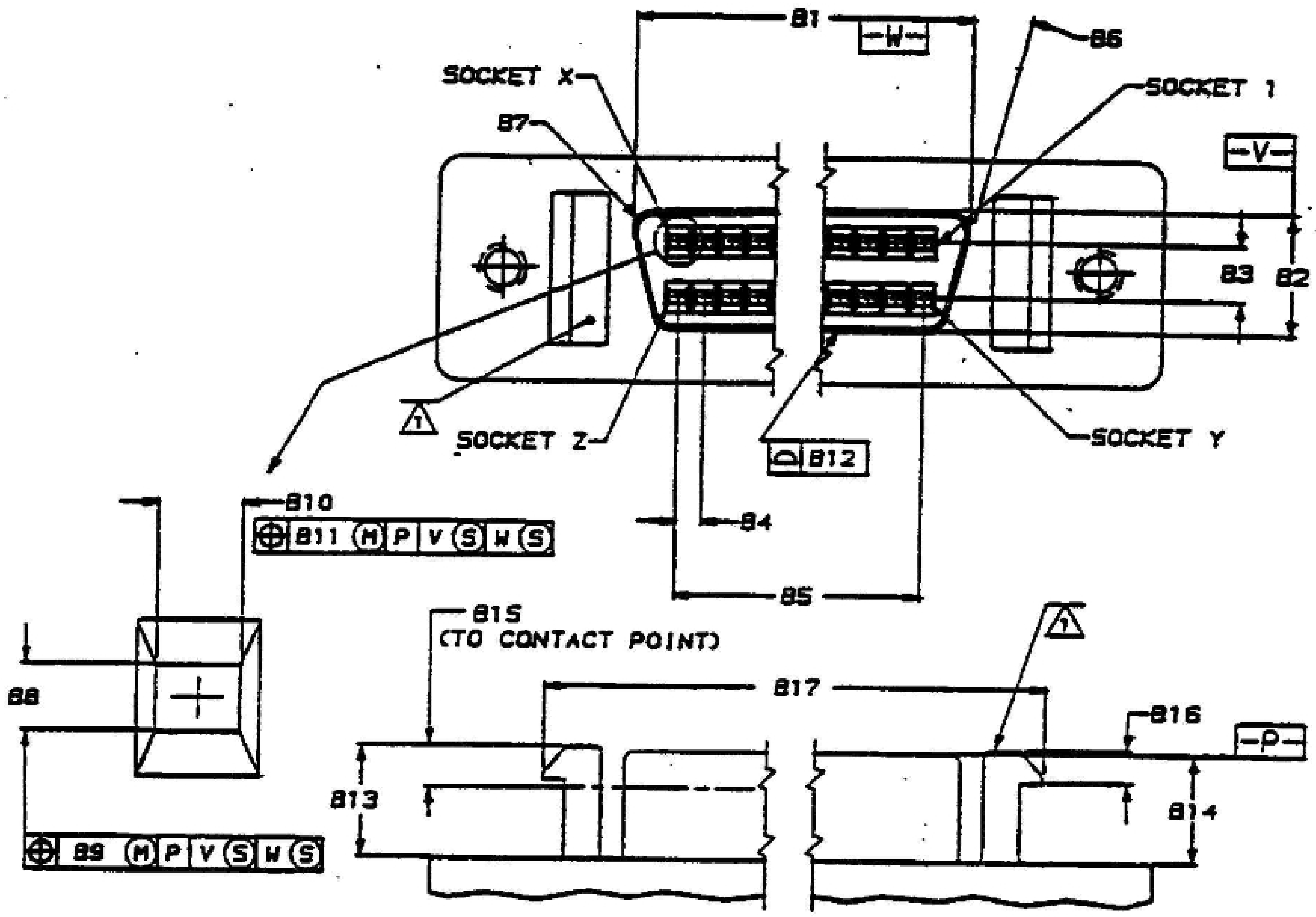


Figure 6 - Male Contact



Note 1: When the pin is mated with the socket, sufficient force shall be applied by the socket to ensure proper electrical contact.

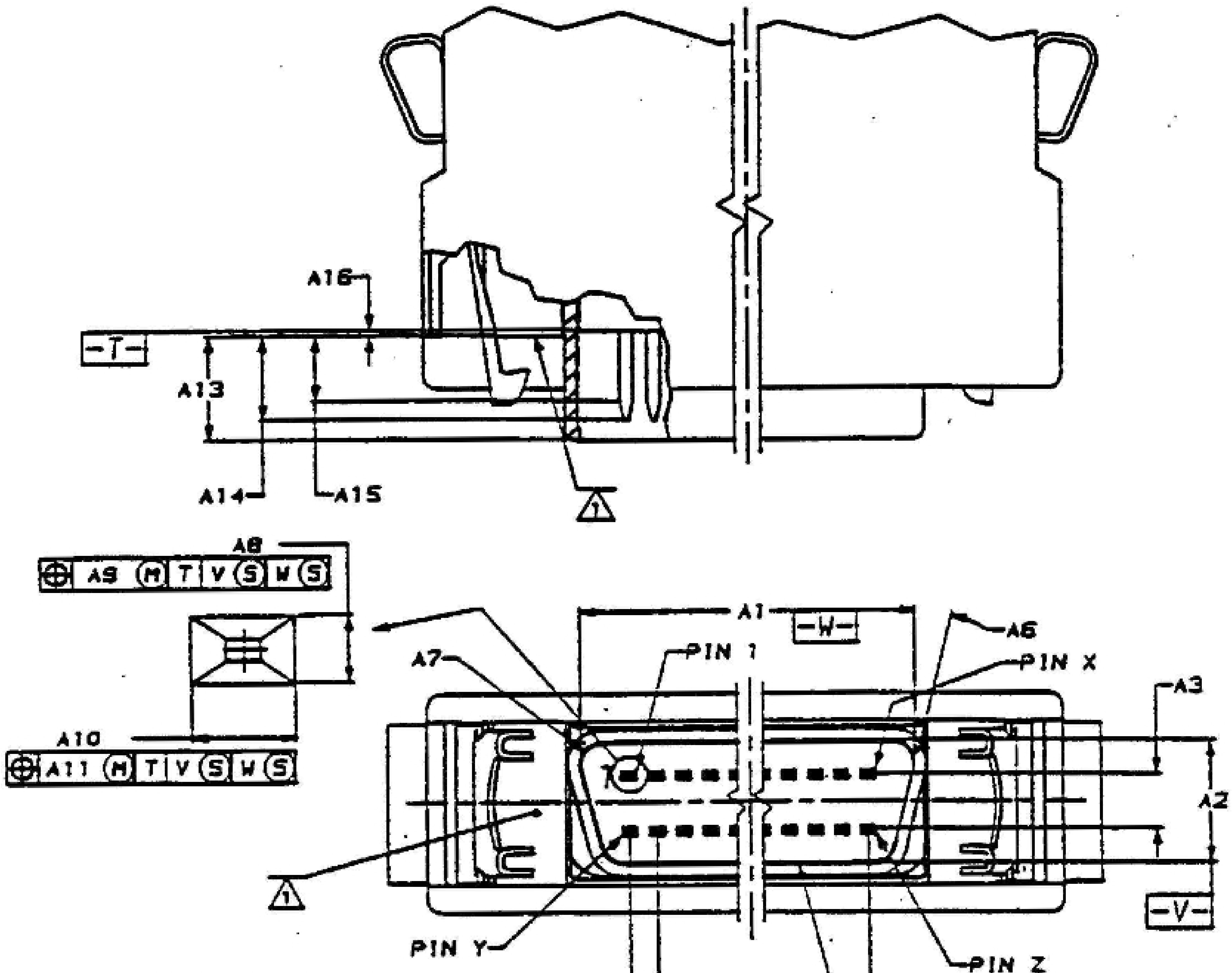
Figure 7 - Female Contact



DIMENSIONS	26 POSITION	
	MILLIMETERS	INCHES
B1	19.46	.766
B2	5.54	.218
B3	2.54	.100
B4	1.27	.050
B5	15.24	.600
B6	15°	15°
B7	1.00 R	.039 R
B8	0.61±.05	.024±.002
B9	0.15	.006
B10	0.86±.10	.034±.004
B11	0.15	.006
B12	0.05	.002
B13	5.10±.05	.201±.002
B14	5.00±.13	.197±.005
B15	1.85 MAX	.073 MAX
B16	1.50±.03	.059±.001
B17	27.05±.10	1.065±.004
SOCKET X	13	
SOCKET Y	14	
SOCKET Z	26	

⚠1 SEATING PLANE.

Figure 8 - ALT A Cable Connector



DIMENSIONS	26 POSITION	
	MILLIMETERS	INCHES
A1	19.61	.772
A2	5.69	.224
A3	2.54	.100
A4	1.27	.050
A5	15.24	.600
A6	15°	15°
A7	1.04 R	.041 R
A8	0.40±.01	.0156±.0004
A9	0.23	.009
A10	0.60±.03	.024±.001
A11	0.23	.009
A12	0.05	.002
A13	4.90±.10	.193±.004
A14	4.27 MAX	.168 MAX
A15	2.64 MIN	.104 MIN
A16	0.25±.13	.010±.005
PIN X	13	
PIN Y	14	
PIN Z	26	

⚠1 SEATING PLANE.

Figure 9 - ALT A Equipment Connector

3.5 Pin Identification

3.5.1 Pin assignments listed in Table 3 shall be used.

Table 3 - Interface Connector Pin Assignments

Pin Number	V.24 Number	Circuit	Description
1	--	--	Shield
2	103	BA	Transmitted Data
3	104	BB	Received Data
4	105/133	CA/CJ (Note 1)	Request to Send/Ready for Receiving
5	106	CB	Clear to Send
6	107	CC	DCE Ready
7	102	AB	Signal Common
8	109	CF	Received Line Signal Detector
9	--	--	(Reserved for Testing)
10	--	--	(Reserved for Testing)
11	126	(Note 4)	Unassigned
12	122/112	SCF/CI (Note 2)	Secondary Received Line Signal Detector/Data Signal Rate Selector (DCE Source)
13	121	SCB	Secondary Clear to Send
14	118	SBA	Secondary Transmitted Data
15	114	DB	Transmitter Signal Element Timing (DCE Source)
16	119	SBB	Secondary Received Data
17	115	DD	Receiver Signal Element Timing (DCE Source)
18	141	LL	Local Loopback
19	120	SCA	Secondary Request to Send
20	108/1, /2	CD	DTE Ready
21	140/110	RL/CG	Remote Loopback/Signal Quality Detector (see 4.4)
22	125/135	CE/CK (Note 5)	Ring Indicator/Received Energy Present
23	111/112	CH/CI (Note 2)	Data Signal Rate Selector (DTE/DCE Source)
24	113	DA	Transmit Signal Element Timing (DTE Source)
25	142	TM	Test Mode
26		(Note 3)	No Connection

Note 1: When hardware flow control is required Circuit CA may take on the functionality of Circuit CJ.

Note 2: For designs using interchange circuit SCF, interchange circuits CH and CI are assigned to pin 23. If SCF is not used, CI is assigned to pin 12.

Note 3: Pin 26 is contained on the Alt A connector only. No connection is to be made to this pin.

Note 4: Pin 11 is unassigned. It will not be assigned in future versions of TIA/EIA-232. However, in international standard ISO/IEC 2110, this pin is assigned to ITU-T Circuit 126, Select Transmit Frequency.

Note 5: When Received Energy Present is used, Circuit CK is assigned to pin 22 replacing Circuit CE.

3.5.2 Pin assignments for circuits not specifically defined in Section 4 (see 4.1.1) are to be made by mutual agreement. In the event that additional pins are required extreme caution should be taken in their selection.

4 FUNCTIONAL DESCRIPTION OF INTERCHANGE CIRCUITS

4.1 General

This section defines the basic interchange circuits which apply, collectively, to all systems.

4.1.1 Additional interchange circuits not defined herein, or variations in the functions of the defined interchange circuits, may be provided by mutual agreement. See 3.5.2 and 5.2.

4.1.2 DCE specifications (e.g., ITU-T Recommendations) define variations or limitations on the functions or specific behavior of the defined interchange circuits. A synchronous DCE specification might, for example, permit turning OFF Circuit CB (Clear to Send) during DCE/DCE resynchronization but not for flow control purposes.

4.2 Categories

Interchange circuits between DTEs and DCEs fall into four general categories:

- -- Signal Common
- -- Data Circuits
- -- Control Circuits
- -- Timing Circuits

4.2.1 A list of circuits showing category as well as equivalent ITU-T identification in accordance with Recommendation V.24, *List Of Definitions For Interchange Circuits Between Data Terminal Equipment (DTE) And Data Circuit-Terminating Equipment (DCE)*, is presented in Table 4.

Table 4 - Interchange Circuits By Category

Circuit Mnemonics	V.24 Number	Circuit Name	Circuit Direction	Circuit Type
AB	102	Signal Common	-	Common
BA	103	Transmitted Data	To DCE	Data
BB	104	Received Data	From DCE	Data
CA	105	Request to Send	To DCE	Control
CB	106	Clear to Send	From DCE	Control
CC	107	DCE Ready	From DCE	Control
CD	108/1, /2	DTE Ready	To DCE	Control
CE	125	Ring Indicator	From DCE	Control
CF	109	Received Line Signal Detector	From DCE	Control
CG	110	Signal Quality Detector	From DCE	Control
CH	111	Data Signal Rate Selector (DTE)	To DCE	Control
CI	112	Data Signal Rate Selector (DCE)	From DCE	Control
CJ	133	Ready for Receiving	To DCE	Control
CK	135	Received Energy Present	From DCE	Control
RL	140	Remote Loopback	To DCE	Control
LL	141	Local Loopback	To DCE	Control
TM	142	Test Mode	From DCE	Control
DA	113	Transmitter Signal Element Timing (DTE)	To DCE	Timing
DB	114	Transmitter Signal Element Timing (DCE)	From DCE	Timing
DD	115	Receiver Signal Element Timing (DCE)	From DCE	Timing
SBA	118	Secondary Transmitted Data	To DCE	Data
SBB	119	Secondary Received Data	From DCE	Data
SCA	120	Secondary Request to Send	To DCE	Control
SCB	121	Secondary Clear to Send	From DCE	Control
SCF	122	Secondary Received Line Signal Detector	From DCE	Control

4.3 Signal Characteristics, General

4.3.1 Interchange circuits transferring data signals across the interface point shall hold marking (binary ONE) or spacing (binary ZERO) conditions for the nominal duration of each signal element.

Tolerances for synchronous systems are specified in TIA/EIA-334-B, *Signal Quality at Interface Between Data Processing Terminal Equipment and Synchronous Data Communication Equipment for Serial Data Transmission.*

Standard nomenclature for specifying signal quality for nonsynchronous systems are set forth in EIA-363, *Standard for Specifying Signal Quality for Transmitting and Receiving Data Processing Terminal Equipment Using Serial Data Transmission at the Interface with Non-Synchronous Communication Equipment.*

Distortion tolerances for nonsynchronous systems are set forth in EIA/TIA-404-A, *Standard for Start-Stop Signal Quality for Non-Synchronous Data Communication Equipment.*

4.3.2 Interchange circuits transferring timing signal across the interface point shall hold ON and OFF conditions for nominally equal periods of time, consistent with acceptable tolerances as specified in TIA/EIA-334-B. During periods when timing information is not provided on a timing interchange circuit, this interchange circuit shall be clamped in the OFF condition.

4.4 Interchange Circuits

4.4.1 Circuit AB - Signal Common (V.24 102)

Direction: Not applicable

This circuit establishes the common ground reference potential for all interchange circuits.

Within the DCE, this circuit shall be brought to one point and it shall be possible to connect this point to Protective Ground by means of 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. The strap may be paralleled by an impedance (high at low frequencies) to provide for immunity to static discharges or for other purposes when the strap is removed. (The requirement for a removable strap is not intended to change the satisfactory status of existing DCEs which provide, in accordance with TIA/EIA-422-B, *Electrical Characteristics of Balanced Voltage Digital Interface Circuits,* a connection of Circuit AB (Signal Common) to Protective Ground with a 100-ohm resistor).

4.4.2 Circuit BA - Transmitted Data (V.24 103)

Direction: TO DCE

Signals on this circuit are generated by the DTE and are transferred to the local DCE for transmission of data to remote DCE(s) or for maintenance or control of the local DCE.

The DTE shall hold Circuit BA (Transmitted Data) in marking condition at all times when no signals are being transmitted.

In all systems, the DTE shall not transmit data unless an ON condition is present on all of the following circuits, where implemented:

-- Circuit CA (Request to Send)
-- Circuit CB (Clear to Send)
-- Circuit CC (DCE Ready)
-- Circuit CD (DTE Ready)

In DTEs supporting serial dialing DCEs, programming or control signals maybe transferred across the interface on Circuit BA (Transmitted Data) when the conditions listed below exist for the Circuits specified (where they are implemented):

-- Circuit CB (Clear to Send) = ON
-- Circuit CC (DCE Ready) = OFF
-- Circuit CD (DTE Ready) = ON

4.4.3 Circuit BB - Received Data (V.24 104)

Direction: FROM DCE

Signals on this circuit are generated by the DCE in response to data signals received from the remote DCE(s), or by the DCE for maintenance or control purposes. During data transfer phase, Circuit BB (Received Data) shall be held in the binary ONE (Marking) condition at all times when Circuit CF (Received Line Signal Detector) is in the OFF condition.

For half-duplex operation, Circuit BB (Received Data) shall be held in the binary ONE (Marking) condition when Circuit CA (Request to Send) is in the ON condition and for a brief interval following the ON to OFF transition of Circuit CA (Request to Send) to allow for the completion of transmission (See Circuit BA - Transmitted Data) and the decay of line reflections.

4.4.4 Circuit CA - Request to Send (V.24 105)

Direction: TO DCE

This circuit is used to condition the local DCE for data transmission and, when operating half-duplex, to control the direction of data transmission of the local DCE.

For simplex or duplex operation, the ON condition maintains the DCE in the transmit mode. The OFF condition maintains the DCE in a non-transmit mode.

For half-duplex operation, the ON condition maintains the DCE in the transmit mode and inhibits the receive mode. The OFF condition maintains the DCE in the receive mode.

A transition from OFF to ON instructs the DCE to enter the transmit mode (see 6.7). The DCE responds by taking such action as may be necessary and indicates completion of such actions by turning ON Circuit CB (Clear to Send), thereby indicating to the DTE that data may be transferred across the interface point on interchange Circuit BA (Transmitted Data).

A transition from ON to OFF instructs the DCE to complete the transmission of all data which was previously transferred across the interface point on interchange Circuit BA (Transmitted Data) and then assume a non-transmit mode or a receive mode as appropriate. The DCE responds to this instruction by turning OFF Circuit CB (Clear to Send) when it is prepared to again respond to a subsequent ON condition of Circuit CA (Request to Send).

NOTE: A non-transmit mode does not imply that all line signals have been removed from the communication channel. See 6.7.

When Circuit CA (Request to Send) is turned OFF, it shall not be turned ON again until Circuit CB (Clear to Send) has been turned OFF by the DCE.

It is permissible to turn Circuit CA (Request to Send) ON at any time when Circuit CB (Clear to Send) is OFF regardless of the condition of any other interchange circuit.

4.4.5 Circuit CB - Clear to Send (V.24 106)

Direction: FROM DCE

Signals on this circuit are generated by the DCE to indicate whether or not the DCE is ready to transmit data or, in the case of a serial automatic dialing DCE, to accept dialing or control signals.

The ON condition, together with the ON condition on interchange circuits CA (Request to Send), CC (DCE Ready) and, where implemented, CD (DTE Ready), is an indication to the DTE that signals presented on Circuit BA (Transmitted Data) will be presented to the communication channel.

The ON condition together with the OFF condition on Circuit CC (DCE Ready), is an indication to the DTE that it may transfer dialing or control signals (for the use of the serial automatic calling function of the DCE) across the interface on Circuit BA (Transmitted Data).

The OFF condition is an indication to the DTE that it should not transfer data across the interface on interchange Circuit BA (Transmitted Data) since this data will not be presented to the communication channel or to the serial automatic calling function of a DCE employing this option.

In the data and test phases (Circuits CC (DCE Ready) and, where implemented, CD (DTE Ready) both ON), the ON and OFF conditions of Circuit CB (Clear to Send) are normally responses to the ON and OFF condition of Circuit CA (Request to Send). Circuit CB (Clear to Send) may, however, be turned OFF during the data transfer or test phase independent of the condition of Circuit CA (Request to Send), to signal the DTE to interrupt the transfer of data on Circuit BA (Transmitted Data) for a finite period of time (e.g., for DCE flow control purposes or for DCE/DCE resynchronization). Data presented on Circuit BA (Transmitted Data) after Circuit CB (Clear to Send) turns OFF may be disregarded by the DCE. Circuit CB (Clear to Send) may be turned back ON again at any time, provided only that Circuit CA (Request to Send) is ON at that time.

Where Circuit CA (Request to Send) is not implemented, it shall be assumed to be in the ON condition at all times, and Circuit CB (Clear to Send) shall respond accordingly.

4.4.6 Circuit CC - DCE Ready (V.24 107)

Direction: FROM DCE

Signals on this circuit are used to indicate whether the DCE is ready to operate.

The ON condition, where Circuit TM (Test Mode) is OFF or is not implemented, indicates that the signal converter or similar equipment is connected to the line and that the DCE is ready to exchange further control signals with the DTE to initiate transfer of data.

The ON condition, in conjunction with the ON condition of Circuit TM (Test Mode), indicates that the DCE is prepared to exchange data signals with the DTE for maintenance test purposes.

The OFF condition, in conjunction with the ON condition on Circuit CB (Clear to Send), indicates that the DCE is ready to exchange data signals associated with the programming or control of serial automatic calling DCEs.

The OFF condition, in conjunction with the OFF condition on Circuit CB (Clear to Send), indicates:

– that the DCE is not ready to operate in the data transfer phase,

-- that the DCE has detected a fault condition (which may be network or DCE dependent) which has lasted longer than some fixed period of time, such period being network dependent, or

-- in switched network operation, that the DCE has detected a disconnect indication from the remote station or from the network.

The OFF condition, in conjunction with the ON condition on Circuit TM (Test Mode), indicates that the DCE is involved in tests from the network or remote station.

4.4.7 Circuit CD - DTE Ready (V.24 108/1, 108/2)

Direction: TO DCE

Signals on this circuit are used to control switching of the DCE to the communication channel. The ON condition prepares the DCE to be connected to the communication channel and maintains an already established connection.

When the station is equipped for automatic answering of received calls and is in the automatic answering mode, connection to the line occurs only in response to a combination of a ringing signal and the ON condition of Circuit CD (DTE Ready): however, the DTE is normally permitted to present the ON condition on Circuit CD (DTE Ready) whenever it is ready to transmit or receive data, except as indicated below.

The OFF condition causes the DCE to be removed from the communication channel following the completion of any "in process" transmission. See Circuit BA (Transmitted Data). The OFF condition shall not disable the operation of Circuit CE (Ring Indicator).

In switched network applications, when circuit CD (DTE Ready) is turned OFF, it shall not be turned ON again until Circuit CC (DCE Ready) is turned OFF by the DCE.

4.4.8 Circuit CE - Ring Indicator (V.24 125)

Direction: FROM DCE

The ON condition of this circuit indicates that a ringing signal is being received on the communications channel. The ON condition shall appear approximately coincident with the ON segment of the ringing cycle (audible ringing) on the communications channel. The OFF condition shall be maintained during the OFF segment of the ringing cycle (between rings) and at all other times when ringing is not being received.

NOTE: Where specialized ringing is used the DCE may be configured to only respond to particular ringing signals; in these cases the ON condition on Circuit CE (Ring Indicator) may only be in response to these predefined ringing signals.

The operation of this circuit shall not be disabled by an OFF condition on Circuit CD (DTE Ready). When Circuit CE (Ring Indicator) is implemented the DTE may decline to answer a call by not placing an ON condition on Circuit CD (DTE Ready) in response to Circuit CE (Ring Indicator) cycling.

4.4.9 Circuit CF - Received Line Signal Detector (V.24 109)

Direction: FROM DCE

The ON condition on this circuit is presented when the DCE is receiving a signal which meets its suitability criteria. These criteria are established by the DCE manufacturer.

The OFF condition indicates that no signal is being received or that the received signal does not meet the DCE's suitability criteria.

During the data transfer phase, the OFF condition of Circuit CF (Received Line Signal Detector) shall cause Circuit BB (Received Data) to be clamped to the Binary One (Marking) condition.

The indications on this circuit shall follow the actual onset or loss of signal by appropriate guard delays.

On half-duplex channels, Circuit CF (Received Line Signal Detector) is held in the OFF condition whenever Circuit CA (Request to Send) is in the ON condition and for a brief interval of time following the ON to OFF transition of Circuit CA (Request to Send) (See Circuit BB.).

4.4.10 Circuit CG - Signal Quality Detector (V.24 110)

Direction: FROM DCE

NOTE: Use of Circuit CG (Signal Quality Detector) is no longer recommended.

4.4.11 Circuit CH - Data Signal Rate Selector (DTE Source) (V.24 111)

Direction: TO DCE

Signals on this circuit are used to select between two data signaling rates in the case of multi-rate synchronous DCEs or the two ranges of data signaling rates in the case of dual-range non-synchronous DCEs.

An ON condition shall select the higher data signaling rate or range of rates.

The rate of timing signals, if included in the interface, shall be controlled by this circuit as may be appropriate.

4.4.12 Circuit CI - Data Signal Rate Selector (DCE Source) (V.24 112)

Direction: FROM DCE

Signals on this circuit are used to select one of two data signaling rates or ranges of rates in the DTE to coincide with the data signaling rate or range of rates in use in multi-rate synchronous or dual-range non-synchronous DCEs.

An ON condition shall select the higher data signaling rate or range of rates.

The rate of timing signals, if included in the interface, shall be controlled by this circuit as may be appropriate.

4.4.13 Circuit CJ - Ready for Receiving (V.24 133)

Direction: TO DCE

This circuit is used to control the transfer of data (flow control) on Circuit BB (Received Data) when an intermediate function such as error control is being used in the DCE.

The ON condition on Circuit CJ (Ready for Receiving) indicates that the DTE is capable of receiving data.

The OFF condition indicates that the DTE is not capable of receiving data and causes the DCE, or the intermediate function, to retain the data. In some DCEs the OFF condition on Circuit CJ (Ready for Receiving) 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.

> NOTE: When Circuit CJ (Ready for Receiving) is implemented, Circuit CA (Request to Send) must be considered to be permanently in the ON condition.

4.4.14 Circuit CK - Received Energy Present (V.24 135)

Direction: From DCE

Signals on this circuit indicate the presence of energy on the line.

The ON condition on this circuit indicates the instantaneous presence of energy on the line.

The OFF condition on this circuit indicates the absence of energy on the line.

NOTE: For certain applications, this circuit may be used to transfer an indication of the changing instantaneous levels of the received energy in an analogue manner. Details may be found in the appropriate DCE Standards and Recommendation.

4.4.15 Circuit LL - Local Loopback (V.24 141)

Direction: TO DCE

Signals on this circuit are used to control the local loopback test condition in the local DCE.

The ON condition of Circuit LL (Local Loopback) causes the DCE to transfer the output of its transmitting signal converter from the communication channel to its receiving signal converter through such circuitry as may be required for proper operation. After establishing the local loopback test condition, the DCE turns ON Circuit TM (Test Mode). After Circuit TM (Test Mode) is turned ON, the DTE may operate in a duplex mode, exercising all of the circuits in the interface.

The OFF condition of Circuit LL (Local Loopback) causes the DCE to release the local loopback test condition.

The local loopback test condition shall not disable Circuit CE (Ring Indicator).

4.4.16 Circuit RL - Remote Loopback (V.24 140)

Direction: TO DCE

Signals on the circuit are used to control the remote loopback test condition in the remote DCE.

The ON condition of Circuit RL (Remote Loopback) causes the local DCE to signal a request for the establishment of the remote loopback test condition in the remote DCE. After turning ON Circuit RL (Remote Loopback) and detecting an ON condition on Circuit TM (Test Mode), the local DTE may operate in a duplex mode, exercising the circuitry of the local and remote DCE. The OFF condition of Circuit RL (Remote Loopback) causes the DCE to signal a request for the release of the remote loopback test condition.

The remote loopback test condition places the communication system out of service to the DTE associated with the DCE containing the remote loopback. When Circuit RL (Remote Loopback) is activated, the DCE containing the remote loopback shall present an OFF condition on Circuit CC (DCE Ready) and present an ON condition on Circuit TM (Test Mode). If the remote loopback test condition in the remote DCE is activated from the local DCE (by manual means or by means of Circuit RL (Remote Loopback)), the local DCE shall allow Circuit CC (DCE Ready) to respond normally and shall present an ON condition on Circuit TM (Test Mode).

4.4.17 Circuit TM - Test Mode (V.24 142)

Direction: FROM DCE

Signals on this circuit indicate whether the local DCE is in a test condition.

The ON condition of Circuit TM (Test Mode) indicates to the DTE that the DCE has been placed in a test condition. The ON condition of Circuit TM (Test Mode) shall be in response to an ON condition of Circuit LL (Local Loopback) or Circuit RL (Remote Loopback) and indicates that the test condition has been established. The ON condition shall also be in response to either local or remote activation by other means of any DCE test condition. Activation of a telecommunications network test condition (e.g. facility loopback) which is known to the DCE shall also cause Circuit TM (Test Mode) to assume the ON condition. The OFF condition of Circuit TM (Test Mode) indicates that the DCE is not in a test mode and is available for normal service. When testing is conducted through the DTE/DCE interface, Circuit CC (DCE Ready) operates in a normal manner. When testing is not conducted through the DTE/DCE interface, Circuit CC (DCE Ready) is held in the OFF condition.

4.4.18 Circuit DA - Transmitter Signal Element Timing (DTE Source) (V.24 113)

Direction: TO DCE

Signals on this circuit are used to provide the DCE with transmitter signal element timing information.

The ON to OFF transition shall nominally indicate the center of each signal element on Circuit BA (Transmitted Data). When Circuit DA (Transmitter Signal Element Timing (DTE Source)) is implemented in the DTE, the DTE shall normally provide timing information on this circuit whenever the DTE is in a POWER ON condition. It is permissible for the DTE to withhold timing information on this circuit for short periods provided Circuit CA (Request to Send) is in the OFF condition. (For example, the temporary withholding of timing information may be necessary in performing maintenance tests within the DTE.)

4.4.19 Circuit DB - Transmitter Signal Element Timing (DCE Source) (V.24 114)

Direction: FROM DCE

Signals on this circuit are used to provide the DTE with transmitter signal element timing information.

The DTE shall provide a data signal on Circuit BA (Transmitted Data) in which the transitions between signal elements nominally occur at the time of the transitions from OFF to ON condition of the signal on Circuit DB (Transmitter Signal Element Timing (DCE Source)). When Circuit DB (Transmitter Signal Element Timing (DCE Source) is implemented in the DCE, the DCE shall normally provide timing information on this circuit at all times that the DCE is capable of generating it. However, the withholding of timing information may be necessary under some conditions, e.g., the performance of maintenance test routines in the DCE. (see 4.3.2)

Where variable transmitter signal element timing is required, the change to a different rate shall occur while this circuit is in the OFF condition. The new rate shall be an integer multiple or fraction of the old rate.

4.4.20 Circuit DD - Receiver Signal Element Timing (DCE Source) (V.24 115)

Direction: FROM DCE

Signals on this circuit are used to provide the DTE with receiver signal element timing information.

The transition from ON to OFF condition shall nominally indicate the center of each signal element on Circuit BB (Received Data). Timing information on Circuit DD (Receiver Signal Element Timing) shall be normally be provided by the DCE at all times that the DCE is capable of generating it. However, the withholding of timing information may be necessary under some conditions, e.g., the performance of maintenance routines in the DCE. (see 4.3.2).

Where variable receiver signal element timing is required, the change to a different rate shall occur while this circuit is in the OFF condition. The new rate shall be an integer multiple or fraction of the old rate.

4.4.21 Circuit SBA - Secondary Transmitted Data (V.24 118)
Direction: TO DCE

This circuit is equivalent to Circuit BA (Transmitted Data) except that it is used to transmit data via the secondary channel.

Signals on this circuit are generated by the DTE and are connected to the local secondary channel transmitting signal converter for transmission of data to the remote DTE.

The DTE shall hold Circuit SBA (Secondary Transmitted Data) in marking condition at all times when no data are being transmitted.

4.4.22 Circuit SBB - Secondary Received Data (V.24 119)

Direction: FROM DCE

This circuit is equivalent to Circuit BB (Received Data) except that it is used to receive data on the secondary channel.

4.4.23 Circuit SCA - Secondary Request to Send (V.24 120)

Direction: TO DCE

This circuit is equivalent to Circuit CA (Request to Send) except that it requests the establishment of the secondary channel instead of requesting the establishment of the primary data channel.

4.4.24 Circuit SCB - Secondary Clear to Send (V.24 121)

Direction: FROM DCE

This circuit is equivalent to Circuit CB (Clear to Send), except that it indicates the availability of the secondary channel instead of indicating the availability of the primary channel.

4.4.25 Circuit SCF - Secondary Received Line Signal Detector (V.24 122)

Direction: FROM DCE

This circuit is equivalent to Circuit CF (Received Line Signal Detector) except that it indicates the proper reception of the secondary channel line signal instead of indicating the proper reception of a primary channel received line signal.

5 STANDARD INTERFACES FOR SELECTED COMMUNICATION SYSTEM CONFIGURATIONS

5.1 Abstract

This section addresses a selected set of data transmission configurations. For each of these configurations a standard set of interchange circuits (defined in Section 4) is listed. (see 6.1.)

5.1.1 Provision is made for additional data transmission configurations not addressed in this standard. Interchange circuits for these applications must be specified separately.

5.2 Conditions

Generators shall be provided for every interchange circuit included in the selected interface. Receivers need not be provided for every interchange circuit; however, degradation in functionality may result if all specified receivers are not provided.

In the interest of minimizing the number of different types of equipment, additional interchange circuits may be included in the design of a general unit capable of satisfying the requirements of several different applications.

5.2.1 For a given configuration, interchange circuits which are included in the standard list and for which generators are provided, but which the manufacturer of equipment at the receiving side of the interface does not use, shall be suitably terminated by means of a dummy load impedance in the equipment which normally would provide the receiver. See 2.1.4.

5.2.2 Where interchange circuits not on the standard list are provided for a given configuration, an open circuit on the other side of the interface shall not result in degradation of the basic service.

5.3 Configurations

Circuit configurations for which standard sets of interchange circuits are defined are listed in Tables 5 and 6.

5.4 Use of Signal Common

The use of Circuit AB (Signal Common) is mandatory in all systems. See 1.4.

6 RECOMMENDATIONS AND EXPLANATORY NOTES

6.1 Classes of Service

The control interchange circuits at the interface point are arranged to permit the alternative use of a higher class of communication service as follows:

– DTEs designed for Transmit-Only or Receive-Only service may also use either Half-duplex or Duplex service.

-- DTEs designed for Half-duplex service may also use Duplex service.

Table 5 - Interface Types For Data Transmission Configurations

Data Transmission Configuration	Interface Type
Transmit Only	A
Transmit Only*	B
Receive Only	C
Half Duplex	D
Duplex*	D
Duplex	E
Primary Channel Transmit Only*/Secondary Channel Receive Only	F
Primary Channel Transmit Only/Secondary Channel Receive Only	H
Primary Channel Receive Only/Secondary Channel Transmit Only*	G
Primary Channel Receive Only/Secondary Channel Transmit Only	I
Primary Channel Transmit Only*/Half Duplex Secondary Channel	J
Primary Channel Receive Only/Half Duplex Secondary Channel	K
Half Duplex Primary Channel/Half Duplex Secondary Channel	L
Duplex Primary Channel*/Duplex Secondary Channel*	L
Duplex Primary Channel/Duplex Secondary Channel	M
Special (Circuits specified by Supplier)	Z

NOTE: Data Transmission Configurations identified with an asterisk (*) indicate the inclusion of Circuit CA (Request to Send) in a One Way Only (Transmit) or Duplex configuration where it might ordinarily not be expected, but where it might be used to indicate a non-transmit mode to the DCE to permit it to remove a line signal or to send synchronizing or training signals as required.

6.2 Noise Considerations

The electrical specifications are intended to provide a two-volt margin in rejecting noise introduced either on interchange circuits or by a difference in reference ground potential across the interface. This is based on the difference between the ±3 volt receiver threshold and the ±5 volt minimum generator output level. The equipment designer should maintain this margin of safety on all interchange circuitry.

Table 6 - Standard Interfaces For Selected Communication Systems Configurations

Interchange Circuit		Interface Type													
		A	B	C	D	E	F	G	H	I	J	K	L	M	Z
AB	Signal Common	x	x	x	x	x	x	x	x	x	x	x	x	x	x
BA	Transmitted Data	x	x		x	x	x		x		x		x	x	o
BB	Received Data			x	x	x		x		x		x	x	x	o
CA	Request to Send		x		x		x				x		x		o
CB	Clear to Send	x	x		x	x	x		x		x		x	x	o
CC	DCE Ready	x	x	x	x	x	x	x	x	x	x	x	x	x	o
CD	DTE Ready	s	s	s	s	s	s	s	s	s	s	s	s	s	o
CE	Ring Indicator	s	s	s	s	s	s	s	s	s	s	s	s	s	o
CF	Received Line Signal Detector			x	x	x		x		x		x	x	x	o
CG	Signal Quality Detector														o
CH	Data Signaling Rate Selector (DTE)														o
CI	Data Signaling Rate Selector (DCE														o
CJ	Ready for Receiving														o
CK	Received Energy Present														o
LL	Local Loopback														o
RL	Remote Loopback														o
TM	Test Mode	-	-	-	-	-	-	-	-	-	-	-	-	-	o
DA	Transmitter Sig. Element Timing (DTE)	t	t		t	t	t		t		t	t	t	t	o
DB	Transmitter Sig. Element Timing (DCE)	t	t		t	t	t		t		t	t	t	t	o
DD	Receiver Signal Element Timing (DCE)			t	t	t		t		t		t	t	t	o
SBA	Secondary Transmitted Data							x		x	x	x	x	x	o
SBB	Secondary Received Data						x		x		x	x	x	x	o
SCA	Secondary Request to Send							x			x	x	x		o
SCB	Secondary Clear to Send							x		x	x	x	x	x	o
SCF	Secondary Received Line Sig. Detect.						x		x		x	x	x	x	o

Legend:
- o To be specified by the supplier
- \- optional
- s Additional Interchange Circuits required for Switched Service
- t Additional Interchange Circuits required for Synchronous Channel
- x Basic Interchange Circuits, All Systems

6.3 Use of Relays

To avoid inducing voltage surges on interchange circuits, signals from interchange circuits should not be used to drive inductive devices, such as relay coils. (Note that relay or switch contacts may be used to generate signals on an interchange circuit, with appropriate measures to assure that signals so generated comply with 2.1.7.)

6.4 Circuit Capacitance

Alphabetical parenthetical designations are added to the terms used in 2.1.3 and 2.1.4 to relate them to the equivalent circuit in 2.1 (Figure 1) and stress the point that the 2500 picofarad capacitance (C_L) is defined for the receiving end of the interchange circuit and that the capacitance (C_0) at the generating end of the interchange circuit, including cable, is not defined. A circuit must be capable of driving all of the capacitance in the generator circuitry plus the capacitance in its part of the interconnecting cable (not specified) plus 2500 pF in the load (including the cable on the load side of the interface point).

6.5 Test Receivers

The characteristics of an equivalent load (receiver) circuit used to test for compliance with each of the electrical specifications in Section 2 are a function not only of the parameter under test, but also of the tolerance limit to be tested. For example, a generator which delivers a minimum of 5 volts into a 7,000 ohm test load may fail the test if the load is reduced to 3,000 ohms, whereas, a generator with an output within the 15 volt limit when driving a 3,000 ohm load may exceed this limit when driving a 7,000 ohm load. The 5 volt tolerance should therefore be tested with a 3,000 ohm load while the 15 volt limit should be tested using a 7,000 ohm load.

6.6 Distortion

The operation of the transmitting and receiving circuits should minimize the effects of any circuit time constants which would delay the circuit response and introduce time distortion of the signals.

6.7 Line Signals

It is not within the scope of this standard to specify in detail what occurs on the communication channel (line) side of the DCE. Therefore the definition for Circuit CA (Request to Send) uses the terminology "transmit mode" intentionally avoiding reference to "carrier" or "line signals".

DCEs intended for multipoint operation should permit the sharing of a communication channel by more than one DCE transmitter and should (where required), when in a non-transmit mode, place no signal on the communication channel which might interfere with the transmission from another DCE in the network.

6.8 Use of Circuit LL for "Busy Out"

Many manufacturers of DCEs for use on the public switched telephone network provide the DTE with the ability to signal a "Busy Out" condition to the DCE. This is to allow the DCE to indicate to the public switched telephone network that it is "busy" and unable to accept an incoming call.

Circuit LL (Local Loopback) is sometimes used to provide this capability. Users should be aware that the DCE may provide an option to "Busy Out" when Circuit LL (Local Loopback) is ON

6.9 Use of Circuits for Testing

A group of three interchange circuits are defined to permit fault isolation testing to be done under control of the DTE. The three circuits are:

-- Circuit LL (Local Loopback),
-- Circuit RL (Remote Loopback), and
-- Circuit TM (Test Mode).

Figure 10 illustrates the local loopback (LL) and remote loopback (RL) tests as seen from the local DTE. A symmetrical set of loopback tests could exist as seen from the remote DTE.

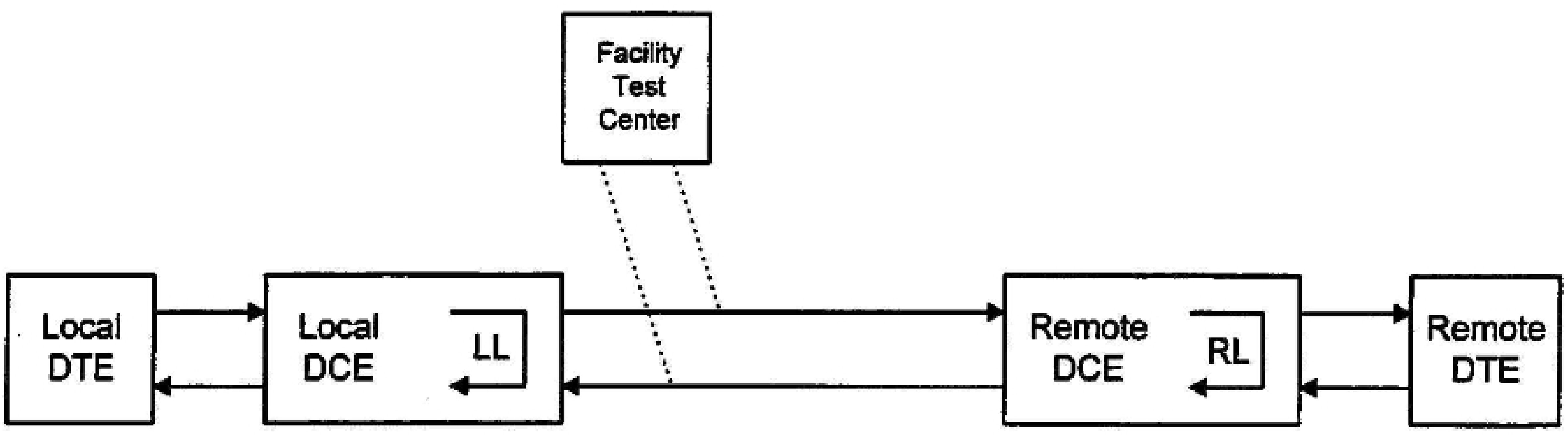


Figure 10 - Test Loops

6.9.1 Local Loopback

This test condition provides a means whereby a DTE may check the functioning of the DTE/DCE interface and the transmit and receive sections of the local DCE. The local DCE also may be tested with a test set in place of the DTE. In the LL test, the output of the transmitting section of the DCE is returned to the receiving section of the DCE, through such circuitry as may be required for proper operation. In many DCEs the transmitted signal is not suitable for direct connection to the receiver. In such cases it is preferable to include appropriate signal shaping or conversion in the loop-around circuitry so that most elements used in normal operation are checked in the test condition. In the LL test, the communication channel is electrically disconnected from the signal processing circuits of the DCE and terminated as appropriate.

The condition of various interchange control circuits at the local DTE/DCE interface during a local loopback (LL) test condition, is summarized in the following table:

Interchange Circuit	Condition
CC	ON
LL	ON
RL	OFF
TM	ON

6.9.2 Remote Loopback

This test condition provides a means whereby a DTE or a facility test center may check the transmission path up to and through the remote DCE to the DTE interface and the similar return transmission path. In this test, Circuit BA (Transmitted Data) and Circuit BB (Received Data) are disconnected or isolated from the remote DTE at the interface and connected to each other in the remote DCE. In synchronous DCEs, arrangements may be required to provide a suitable transmit clock when the RL test condition is activated, and in some instances buffer storage between Circuit BB (Received Data) and Circuit BA (Transmitted Data) may be required.

Remote control of the RL test at the distant DCE through the local DTE/DCE interface is highly desirable to permit automation of the end-to-end testing of a circuit from a central site. Test control is suitable primarily in point-to-point applications but could be used in multipoint configurations with the addition of an address detection capability in the DCE. This test permits circuit verification without the aid of the distant DTE and is supported by inherent remote loopback capability in many present-day DCEs.

Test RL and test LL cannot be performed simultaneously. Consequently, the ON states of Circuit RL (Remote Loopback) and Circuit LL (Local Loopback) are mutually exclusive.

Circuit RL (Remote Loopback) implies that the remote DCE be signaled from the local DCE to activate the RL test condition. Since such control is effected over the communication channel, appropriate measures must be taken to guard against false operation by data or noise.

The condition of various interchange control circuits at the local and remote DTE/DCE interfaces during a remote loopback (RL) test condition is summarized in the following table:

Interchange Circuit	Local Interface	Remote Interface
CC	ON	OFF
LL	OFF	OFF
RL	ON	OFF
TM	ON	ON

6.9.3 Test Mode

Circuit TM provides the indication from the DCE to the DTE that the DCE is in a test condition. This circuit:

a) Provides electrical indication that the DCE is in a test condition either in response to control from the DTE or in response to any other action (e.g., telecommunication network initiated testing or manually controlled DCE testing).

b) Provides action-reaction type control across the interface that verifies completion of requested action.

c) Permits Circuit CC (DCE Ready) to function normally during test modes where testing is conducted through the DTE/DCE interface and prevents any ambiguity between testing and other modes when Circuit CC (DCE Ready) is in the OFF condition.

Annex A (informative)

A.1 Interconnecting Cable Characteristics

The guidelines for characteristics of the interconnecting cable are discussed in paragraphs A.1.1 through A.1.3. An interchange cable may be composed of twisted or non-twisted pair (flat cable), or unpaired wires possessing the characteristics described in paragraphs A.1.1 through A.1.4 uniformly over its length. Most cable commonly used in DCE/DTE applications should meet these specifications.

A.1.1 Conductor Resistance

It is desirable for proper operation over the interchange cable that the dc wire resistance not exceed 25 per conductor.

A.1.2 Capacitive Cable Model

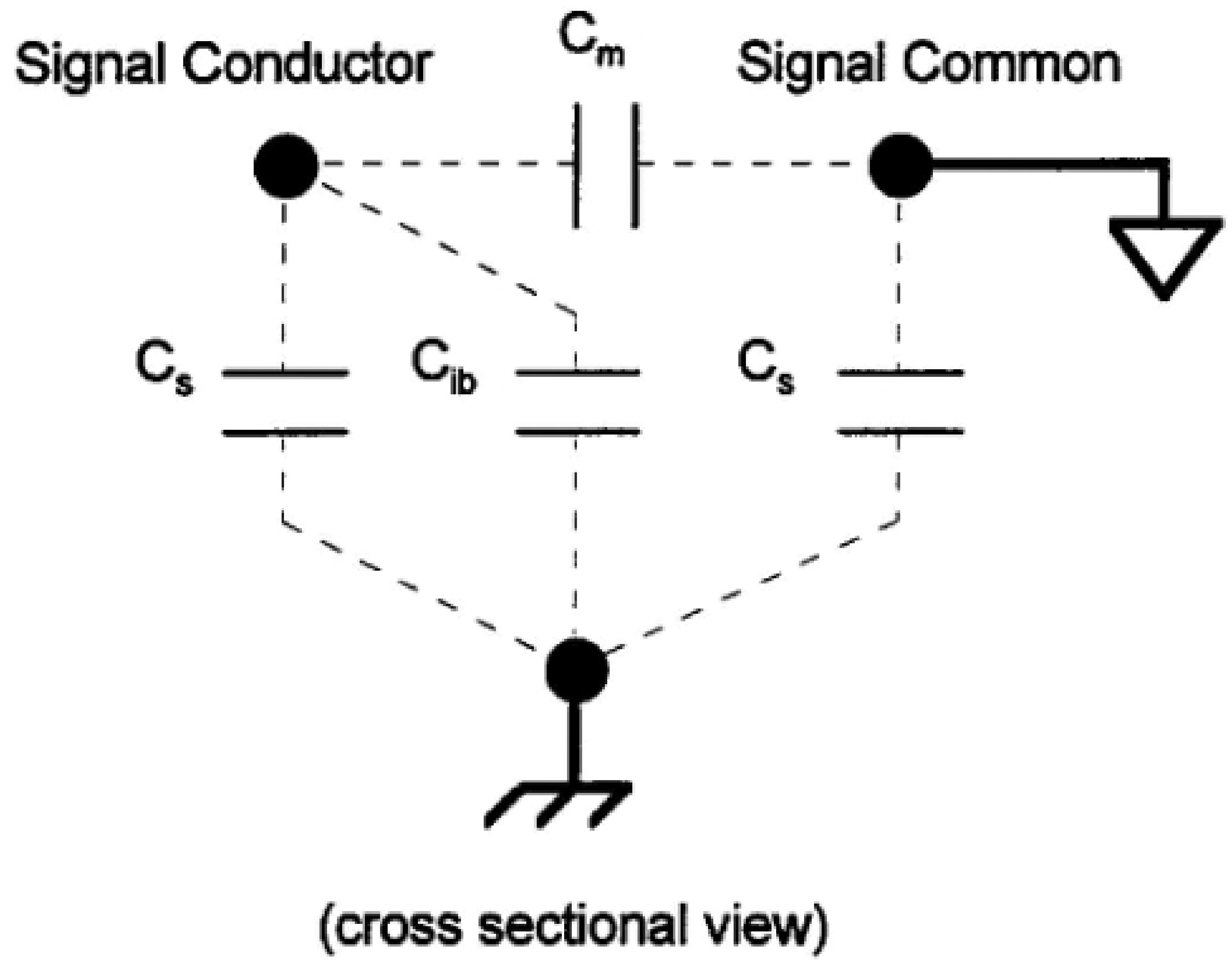
In order to assist the user in estimating cable capacitance, a model for capacitance is demonstrated in figure A.1. It is important to note that the capacitance that exists from any conductor to a shield, in the case of shielded cable, or the stray capacitance that exists from any conductor to Earth ground, in the case of non-shielded cable, is a significant factor in determining the maximum cable length and can not be ignored. As a general rule, the capacitance from any conductor to shield is approximately twice the mutual capacitance, or capacitance that exists between two conductors. Therefore, shielded cable tends to reduce the maximum length by a factor of 3 over a calculated length based on strictly mutual capacitance. A typical error that is also made in calculating the maximum cable length for non-shielded cable is to consider only the mutual capacitance. The stray capacitance to Earth ground is approximately 50% of the mutual capacitance and results in a reduction of approximately 33% of the original distance calculated based on only mutual capacitance.

A.1.3 Interchange Capacitance Limit

The maximum interchange circuit capacitance is 2,500 pF. (see 2.1.4 and 6.4)

A.1.4 Simplified Electrical Equivalent Circuit

In order to assist the user, a simplified electrical equivalent circuit is demonstrated in figure A.2. The intent of the figure is to demonstrate the fact that the receiver signal common potential is never the same as the generator signal common potential. Additionally, the capacitance of either conductor to shield or conductor to Earth ground becomes an integral part of the total capacitance load that the generator must drive in an unbalanced circuit.

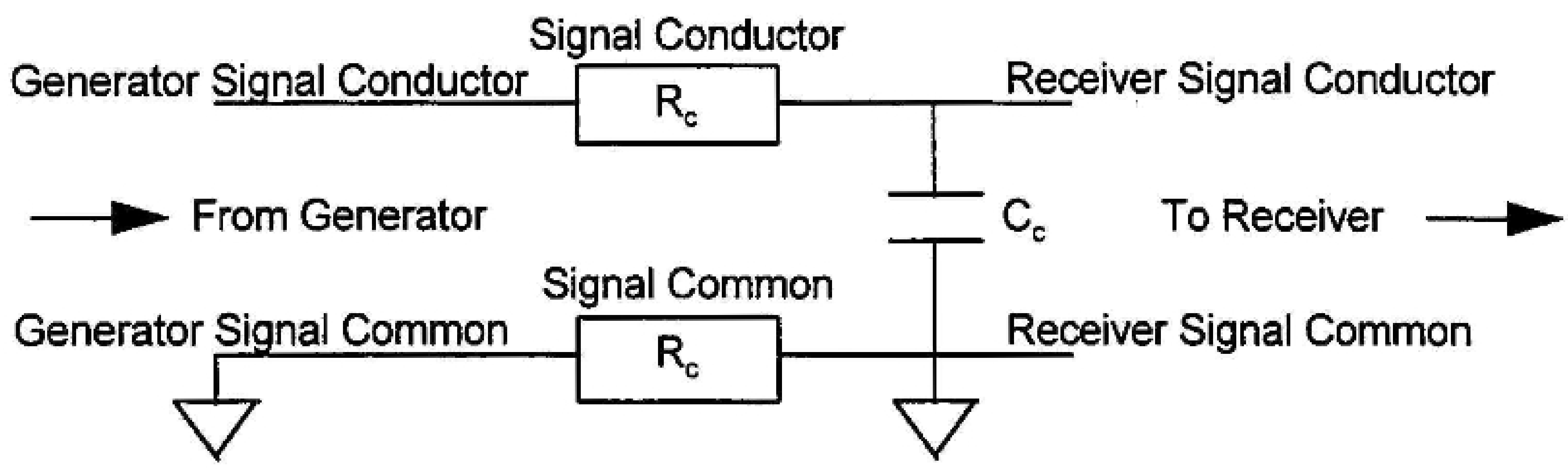


C_m = mutual capacitance between conductors

C_s = conductor to interchange cable shield capacitance (if shielded interchange cable is used) or stray capacitance to earth ground (if unshielded interchange cable is used)

C_{ib} = capacitor imbalance between 2 conductors and shield

FIGURE A.1 - Interchange Cable Capacitive Model per Unit Length



Where $C_c = C_m + C_s$

and $C_s = 2(C_m)$, For Shielded Cable

or $C_s = 0.5(C_m)$, For Non-Shielded Cable

and R_c = Cable Resistance

FIGURE A.2 - Interchange Cable (Simplified Model)

A.2 Example

The user has decided to use non-shielded cable when interconnecting the equipment. The user reads the cable specifications and discovers that the cable contains 20 pF per foot of mutual capacitance (C_m).

The input capacitance for the receiver is considered to be 100 pF. This leaves the user with 2,400 pF for the interconnecting cable.

In this example the cable is non-shielded, therefore the total capacitance (C_c) equals C_m (20 pF) + C_s (10 pF) or 30 pF per foot.

Dividing 2,400 pF by 30 pF reveals that the cable can only be 80 feet long. If the user requirements call for an interconnecting cable that is 200 feet long, then the user must select a cable that has only 8 pF of mutual capacitance (C_m).

Annex B (informative)

REFERENCES

B.1 ITU-T V.24, *List Of Definitions For Interchange Circuits Between Data Terminal Equipment (DTE) And Data Circuit-Terminating Equipment (DCE)*

B.2 ITU-T V.28, *Electrical Characteristics For Unbalanced Double-Current Interchange Circuits*

B.3 ISO/IEC 2110, *25-pole DTE/DCE Interface Connector and Contact Number Assignments*

B.4 ISO/IEC 11560, *Information Technology - Telecommunications and information exchange between systems - 26 pole interface connector mateability dimensions and contact number assignments*

B.5 TIA/EIA-334-B, *Signal Quality at Interface Between Data Processing Terminal Equipment and Synchronous Data Communication Equipment for Serial Data Transmission*

B.6 EIA-363, *Standard for Specifying Signal Quality for Transmitting and Receiving Data Processing Terminal Equipment Using Serial Data Transmission at the Interface with Non-Synchronous Communication Equipment*

B.7 EIA-366-A, *Interface Between Data Terminal Equipment and Automatic Calling Equipment for Data Communication*

B.8 EIA/TIA-404-A, *Standard for Start-Stop Signal Quality for Non-Synchronous Data Communication Equipment*

B.9 TIA/EIA-422-B, *Electrical Characteristics of Balanced Voltage Digital Interface Circuits*

B.10 EIA/TIA-530-A, *High Speed 25-Position Interface for Data Terminal Equipment and Data Circuit-Terminating Equipment, Including Alternative 26-Postion Connector*

B.11 EIA/TIA-561, *Simple 8-Position Non-Synchronous Interface Between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange*

B.12 EIA/TIA-574, *9-Position Non-Synchronous Interface Between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange*

B.13 TIA/EIA-602, *Data Transmission Systems and Equipment - Serial Asynchronous Automatic Dialing and Control*

B.14 TIA/EIA-687, *Medium Speed Interface for Data Terminal Equipment and Data Circuit-Terminating Equipment*