

# ECMA

EUROPEAN COMPUTER MANUFACTURERS ASSOCIATION

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**STANDARD ECMA-80**

**LOCAL AREA NETWORKS  
(CSMA/CD BASEBAND)**

**COAXIAL CABLE SYSTEM**

September 1982

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## BRIEF HISTORY

Open Systems Interconnection standards are intended to facilitate homogeneous interconnection of heterogeneous information processing systems. This Standard is within the framework for the coordination of standards for Open Systems Interconnection which is defined by ISO 7498. It is based on the practical experience of ECMA Member Companies world-wide, and the results of their active participation in the current work of ISO, CCITT, IEEE and national standardization bodies in Europe and the USA. It represents a pragmatic and widely based consensus.

This standard is one of a series of standards to be developed and published by ECMA in the field of Local Area Networks. These ECMA standards refer to several LAN techniques:

- Carrier Sense Multiple Access with Collision Detection (CSMA/CD)
- Token Techniques (Bus, Ring).

This Standard ECMA-80 was adopted by the General Assembly of ECMA in June 1982.

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## 1. GENERAL

### 1.1 Scope

For the purpose of compatible interconnection of data processing equipment via a local area network using the carrier sense multiple access with collision detection technique (CSMA/CD) and baseband transmission mode at 10 Mbit/s, this Standard ECMA-80:

- specifies the electrical and physical characteristics of the cable (see section 3);
- specifies the electrical and physical characteristics of the cable connectors and terminators (see section 4);
- specifies configuration rules for the network (see section 5);
- specifies the installation rules for the coaxial trunk cable (see section 6);
- specifies environmental specifications for the cable system (see section 7).

A particular emphasis of this Standard is to specify the homogeneous externally visible characteristics needed for interconnection compatibility, while avoiding unnecessary constraints upon and changes to the internal design and implementation of the heterogeneous data processing equipment to be interconnected.

### 1.2 Conformance

Equipment conforming to this Standard shall implement all of the provisions specified in sections 3, 4, 5, 6 and 7.

### 1.3 References

ISO 7498	Data Processing - Open Systems Interconnection - Basic Reference Model
IEC 364	Regulations for Electrical Installations
ECMA-72	Transport Protocol
ECMA-81	Local Area Networks (CSMA/CD Baseband) - Physical Layer
ECMA-82	Local Area Networks (CSMA/CD Baseband) - Link Layer
ECMA-TR/14	Local Area Networks - Layers 1 to 4 Architecture and Protocols
ECMA-57	Safety Requirements for Data Processing Equipment.

### 1.4 Definitions

For the purpose of this Standard the following definitions apply.

#### 1.4.1 Baseband transmission mode

A technique whereby information is directly encoded on and such that conveyed by the transmission medium, only one information signal at a time can be present without disruption.

1.4.2 Cable

A constant impedance transmission line representing the medium.

1.4.3 Cable section

A continuous length of cable, fitted with connectors at its ends.

1.4.4 Cable segment

A length of cable made up from one or more cable sections and connectors, electrically terminated at each end with its characteristic impedance.

1.4.5 Coaxial cable

A two-conductor (centre conductor, shield), concentric constant impedance transmission line.

1.4.6 Collision

The result of multiple transmissions overlapping in the transmission medium, resulting in corrupted data and necessitating retransmission.

1.4.7 Data Terminal Equipment (DTE)

The source and sink for all communication on the network. It includes all equipments attached to the medium, including the means of connection to the cable.

1.4.8 Preamble

A sequence of encoded bits generated by the Link Layer which the Physical Layer transmits before each frame to allow synchronization of clocks and other Physical Layer circuitry at the DTEs on the network.

1.4.9 Repeater

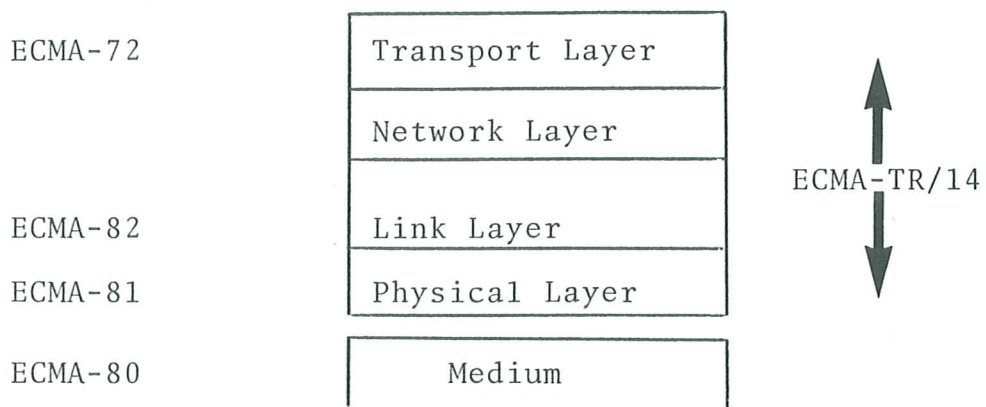
A device used to extend the length and topology of the network beyond that imposed by a single segment.

1.4.10 Round trip delay

The total elapsed time for a signal to travel from one point to another point, and back again.

2. GENERAL DESCRIPTION

ECMA-TR/14 discusses the relationship between this Standard and other ECMA Standards for Local Area Network Interconnection. This relationship is illustrated diagrammatically below.





The medium provides the electrical and mechanical means for data transmission between DTEs.

For the purpose of this Standard, connections made to the medium (i.e. to a cable segment) are considered to be an integral part of the associated DTE. The DTE may in particular implementation be remote from its connection to the medium, in which case it would be logically and electrically linked by a branch cable in ways not defined by this Standard.

### 3. CHARACTERISTICS OF THE CABLE

The cable shall be of constant impedance, coaxial construction. It shall be terminated at each end by a terminator (as specified in 4.2). Coaxial cable connectors shall be used to make the connection from the cable to the terminators, and between cable sections (if applicable). The cable shall have the electrical and physical parameters defined below.

#### 3.1 Cable Electrical Parameters

##### 3.1.1 Characteristic impedance

The cable shall have an average characteristic impedance of 50 Ohm + 2 Ohm. Periodic variations in impedance along a single piece of cable may be up to + 3 Ohm sinusoidal, centred around the average value, with a period of less than 2 m.

##### 3.1.2 Attenuation

The attenuation of a 500 m cable segment shall not exceed 8,5 dB when measured at 10 MHz, and not exceed 6,0 dB when measured at 5 MHz.

##### 3.1.3 Velocity of propagation

The cable shall have a velocity of propagation of at least 0,77 c (c = velocity of light in vacuum).

##### 3.1.4 Pulse distortion

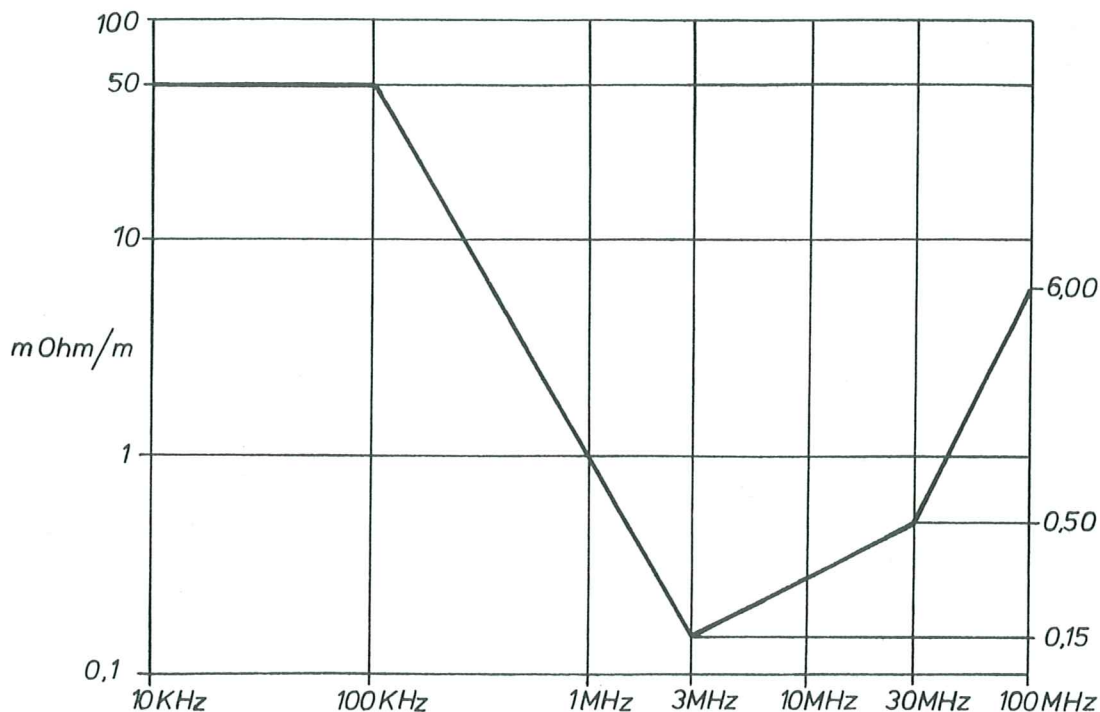
The cable shall produce a pulse distortion not exceeding + 7 ns over a 500 m length of cable, measured relative to zero axis crossings of the AC component, when driven at 10 Mbit/s with any data pattern encoded in accordance with Standard ECMA-81.

##### 3.1.5 Transfer impedance

The cable shall have a transfer impedance not exceeding the values shown in the graph below.

#### NOTE 1

*The transfer impedance value of the cable determines, to a large extent, the EMC performance of the cable.*



Maximum Transfer Impedance of Cable as a Function of Frequency

### 3.1.6 Loop resistance

The loop resistance of a coaxial cable segment which has been short-circuited at its terminators shall not exceed 5 Ohm, including any connectors in the loop. If DTEs are attached to the segment by severing the cable as specified in 4.3.1, then the connectors plus all internal series interconnection shall also be included in this figure.

## 3.2 Cable Physical Parameters

### 3.2.1 Mechanical requirements

The cable shall be suitable for routing in various environments, including but not limited to, dropped ceilings, raised floors, and cable troughs. The jacket shall provide insulation between the cable sheath and any building structural metal. The cable shall be capable of accepting connectors, as specified in 4.1. The cable shall in addition conform to the following requirements:

- the centre conductor shall be solid copper with a diameter of  $2,17 \text{ mm} \pm 0,013 \text{ mm}$ .
- the core dielectric material shall be foamed.

- the inside diameter of the shield system shall be 6,15 mm min.
- the outside diameter of the shield system shall be 8,28 mm  $\pm$  0,178 mm.
- the outermost shield shall be tinned copper braid giving a coverage greater than 90%.
- the outside diameter of the jacket shall be 10,3 mm  $\pm$  0,257 mm ; -0,515 mm.
- the cable concentricity shall be such that the axis of the centre conductor is within 0,515 mm of the axis of the jacket outer surface.
- the cable shall have a bend radius of 254 mm min.

For some environments (e.g. outdoors, lift shafts, air-conditioning ducts), the cable need not conform to these requirements.

### 3.2.2 Jacket marking

The cable jacket shall be marked with annular rings in a colour contrasting with the background colour of the jacket. Each ring shall be spaced 2,50 m  $\pm$  0,05 m from the previous ring regularly along the entire length of the cable. It is permissible for the 2,5 m spacing to be interrupted at discontinuities between cable sections joined by connectors.

#### NOTE 2

*Section 6.2 specifies DTE connection rules which necessitate these cable markings.*

The base colour of the cable jacket should be a bright colour different from that normally used for power mains cables (yellow is preferred). The cable should carry a suitable inscription in order to aid its identification. The inscription should be printed along the cable at a regular interval of not more than 0,5 m and it should not be possible to erase the printing during normal installation and use.

## 4. CABLE CONNECTORS

The cable shall be terminated as specified in 4.1. If the cable is partitioned into cable sections, the connectors shall be as defined in 4.2. DTE connection to the cable shall be as specified in 4.3.

Reference is made in the following sections to type N connectors, these are specified in IEC 169/16 and shall be of the 50 Ohm constant impedance type.

Cable sections shall be physically terminated with type N male connectors. Since the frequencies present in the transmitted data are well below UHF range (being band-limited to

approximately 20 MHz), military versions of the connectors are not required (but are acceptable).

#### 4.1 Cable Terminator

The purpose of cable terminators is to provide a termination impedance for the cable equal in value to its characteristic impedance, thereby minimizing reflection from the ends of the cables.

The cable terminators shall be type N female. The termination impedance shall be  $50 \text{ Ohm} + 0,5 \text{ Ohm}$  measured from DC to 20 MHz, with the magnitude of the phase angle of the impedance not to exceed 5 degrees. The terminator power rating shall be 1 watt or greater.

The cable terminator should have provision for making earth connection.

#### 4.2 Cable Extension Connector

The male connectors of adjacent cable sections shall be joined using a type N female-to-female, in-line barrel connector.

#### 4.3 DTE-to-Cable Connection

A means shall be provided to allow for attaching a DTE to the cable. This shall be accomplished either by severing the cable as specified in 4.3.1, or by tapping the cable as specified in 4.3.2. Both methods of connection may be used within the same cable segment.

The electrical requirements common to 4.3.1 and 4.3.2 are:

- The total capacitance of the DTE connection, including any active circuitry connected directly, shall be not greater than 4 pF, when measured at 10 MHz with a DC bias of -1 V applied to the coaxial cable line connection with respect to the coaxial cable shield connection.
- The total capacitance of the DTE connection, excluding any active circuitry, should be not greater than 2 pF, when measured at 10 MHz.
- The stub length of the DTE connection should not exceed 3 cm.
- Unless otherwise mandated by the safety requirements in 7.1, the AC breakdown voltage of the insulation shall be at least 250 V AC rms.

##### 4.3.1 Severed cable connection

DTE-to-cable connections shall be made via type N connectors. Severed cable connections shall meet the following specific requirements:

- The cable segment shall meet the sectioning requirements specified in 6.1.

- The severed cable connection shall not contribute more than 10 mOhm to the loop DC resistance specified in 3.1.6. Use of industry standard connectors should enable this parameter to be realized.
- The characteristic impedance of a severed cable connection shall be 50 Ohm  $\pm$  2 Ohm.

#### 4.3.2 Tapped cable connection

Tapped cable connections shall meet the following specific requirements:

- Contact resistance shall be 50 mOhm max. for both centre conductor probe and shield probe over the useful lifetime of the connector.
- Contact surface material on the centre conductor probe shall be tin, silver or gold.
- Contact surface material on the shield probe shall be tin.
- Probe current rating shall be at least 0,1 A per contact.

Appendix A illustrates a possible implementation of a tapped cable connector.

### 5. NETWORK CONFIGURATION

#### 5.1 Round Trip Delay

Round trip delay is dependent upon network configuration. Total round trip delay shall be less than 46,4 us.

#### 5.2 Length of Cable

A cable, terminated with its characteristic impedance at each end, constitutes a cable segment. A segment shall contain not more than 500 m of cable.

#### 5.3 Repeaters

There should be not more than 2 repeaters in the transmission path between any two DTEs. However, if the network configuration requires more than 2 repeaters or point-to-point links that have a combined length of more than 1 km, the round trip delay specified in 5.1 shall be met. In addition, each DTE shall receive a minimum of 16 bits of preamble.

Repeaters do not have to be located at the ends of segments, nor is the user limited to one repeater per segment. In fact, repeaters can be used not only to extend the length of the network, but to extend the topology from one to three dimensional. Repeaters occupy DTE positions on each cable segment and count towards the maximum number of DTEs on a segment.

For a functional description of repeaters see Appendix C.

#### 5.4 Acceptable Network Configuration

A network configuration shall satisfy the requirements specified in 5.1, 5.2 and 5.3.

Appendix B illustrates some examples.

### 6. INSTALLATION OF THE CABLE

#### 6.1 Cable Sectioning

A cable segment need not be made from a single, homogeneous length of cable. The boundary between two cable sections (joined by coaxial connectors; two male plugs and a barrel) represents a signal reflection point due to the impedance discontinuity caused by the batch-to-batch impedance tolerance of the cable. Since a deviation from 50 Ohm is possible, a reflection may result from the joining of two cable sections. The configuration of long cable segments (up to 500 m) from smaller sections must be made with care.

The following requirements apply:

- The total cable segment should if possible be made from one section. This is feasible for short segments and results in minimal reflections from cable impedance discontinuities.
- If cable segments are built from smaller cable sections, then all cable sections should be from the same manufacturer and lot. This is equivalent to using a single cable, since the cable discontinuities are due to extruder limitations, and not extruder-to-extruder tolerances. There are no restrictions in cable sectioning if this method is used. However, if a cable section in such a system is later replaced, it should be replaced either with another cable from the same manufacturer and lot, or with one of the standard lengths described below.
- If uncontrolled cable sections are used to build up a longer segment, the lengths should be chosen such that reflections, when they occur, do not have a high probability of adding in phase. This can be accomplished by using lengths which are odd integral multiples of a half-wavelength in the cable at 5 MHz; this corresponds to using lengths of 23,4 m; 70,2 m and 117 m ( $\pm 0,5$  m) for all cable sections. These are considered to be the standard lengths for all cable sections. Using these lengths exclusively, any mix or match of cable sections may be used to build up a 500 m segment without incurring excessive reflections.

#### NOTE 3

*If cable segments are to be added to existing installations, then care shall be taken (explicit physical or Time Domain Reflectometry measurements) to assure that no more than 500 m cable segments results.*

- As a last resort, an arbitrary configuration of cable sections may be employed, if it has been confirmed by analysis or measurement that the worst-case signal reflection amplitude due to the impedance discontinuities at any point on the cable does not exceed 7% of the incident wave then driven by a signal source meeting the signal rise and fall time requirements specified in Standard ECMA-81.

## 6.2 DTE Connection Placement

DTE connections shall only be made to the cable at the jacket markings defined in 3.2.2. The total quantity of DTEs permitted to be attached to a cable segment shall not exceed 100.

The purpose of these requirements is to ensure that DTE connections to the cable do not cause unacceptable signal reflections due to their non-infinite bridging impedance. In addition to this impedance being implemented as specified in Standard ECMA-81, the placement of DTE connections along the cable also need to be controlled to ensure that reflections from the connections do not add in phase to a significant degree. The 2,5 m spacing of DTE connections guarantees both a minimum spacing between connections as well as controlling their relative spacing in order to ensure non-alignment of fractional wavelength boundaries.

## 6.3 Cable Segment Earthing

The shield conductor(s) of each cable segment shall make electrical contact with an effective earth reference at a single point. It is recommended that this point be at one of the segment terminators (see IEC 364). The shield conductor(s) of the coaxial cable shall not make electrical contact with earth elsewhere on such objects as building structural metal, ducting, plumbing fixtures, or other unintentioned conductor. Insulators may be used to cover any connectors used to join cable sections and terminators, to ensure that this requirement is met.

## 7. ENVIRONMENTAL SPECIFICATION

### 7.1 Safety Requirements

Local Area Networks meeting this Standard shall conform to Standards IEC 364 and ECMA-57.

In addition to the requirements specified in this Standard, the installed network may need to conform to locally prescribed safety requirements.

All exposed materials shall meet flammability classification V1 of Standard ECMA-57. Low smoke and fume materials shall be used as mandated by local requirements.

Appropriate electrical isolation shall be used if independent earth connections are provided for the grounding of different DTEs within a network (e.g. optical cables to link electrical cable segments located in separate buildings, via remote repeaters).

## 7.2 Electromagnetic Environment

Sources of interference from the environment include but are not limited to electromagnetic fields, electrostatic discharge, transient voltages between earth connections.

Several sources of electromagnetic disturbance will contribute to the potential difference between the coaxial cable and the DTE earth connection.

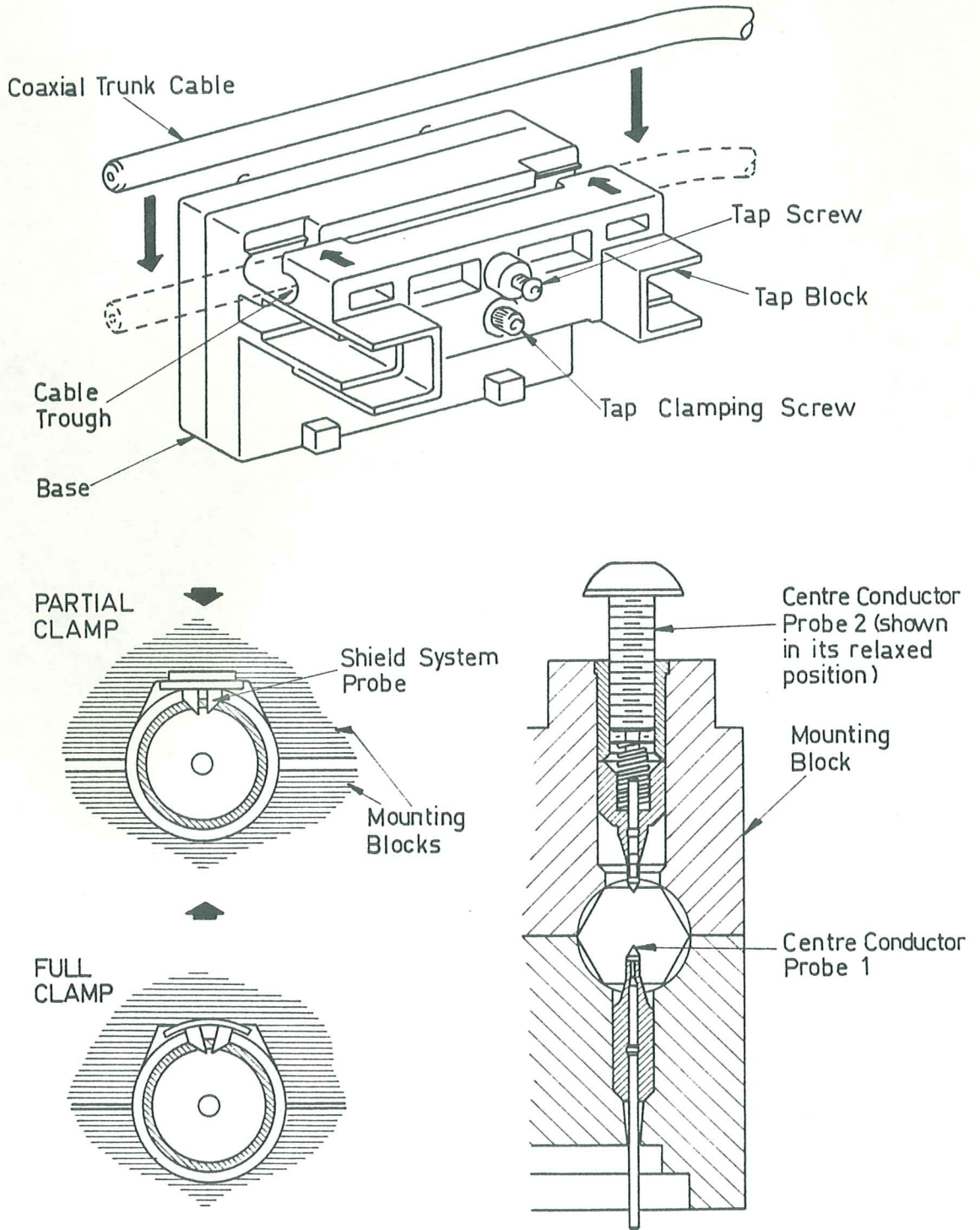
The DTE hardware shall meet its specifications when operating in the following electromagnetic fields:

- ambient plane wave field of -
  - 2 V/m from 10 KHz to 30 MHz
  - 5 V/m from 30 MHz to 1 GHz
- interference voltage of 0,25 V to 1 V/ns peak slope (to be defined), between the coaxial cable and the DTE earth connection; e.g. 3,95 V to 15,8 V peak for a 10,1 MHz sine wave.



APPENDIX A

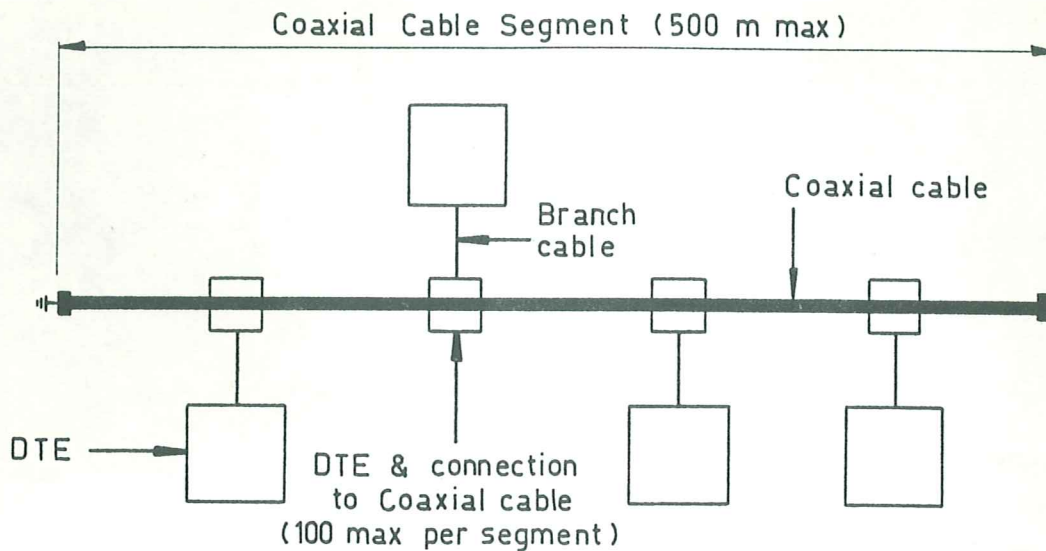
ILLUSTRATION OF A POSSIBLE IMPLEMENTATION OF A TAPPED CABLE CONNECTOR



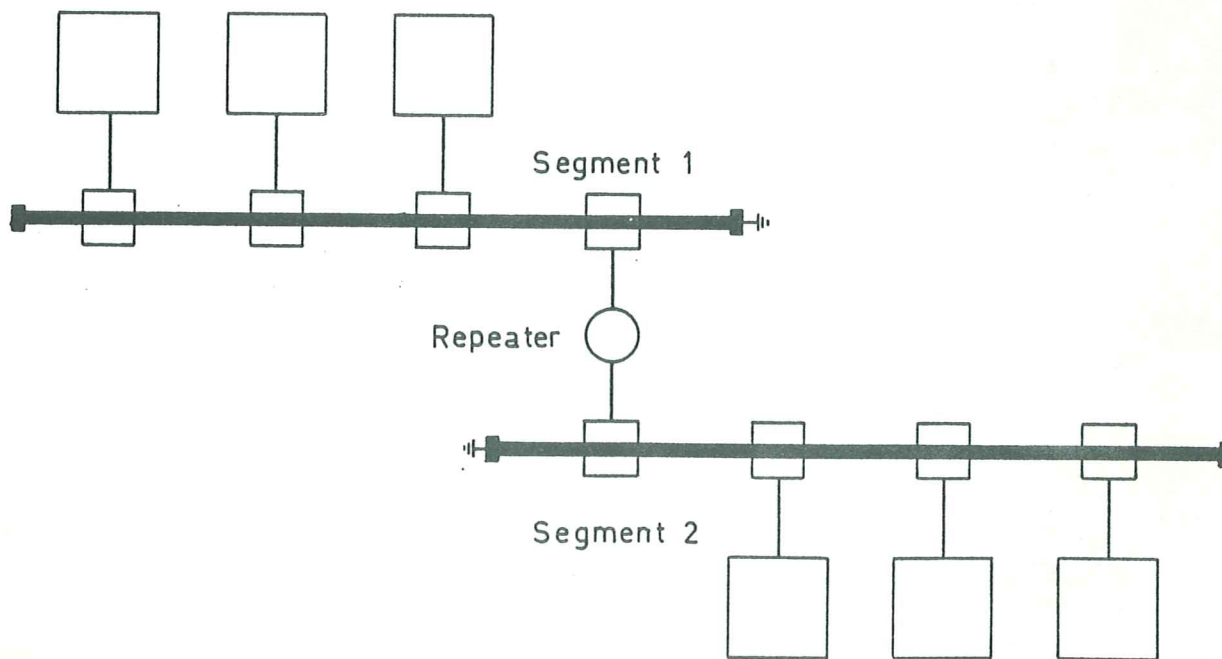
- The DC insulation resistance should be higher than 1 GOhm when measured between the Coaxial Cable shield system and the DTE earth connection.
- The voltage rating should be 600 V DC or AC rms.

APPENDIX B

NETWORK CONFIGURATION EXAMPLES

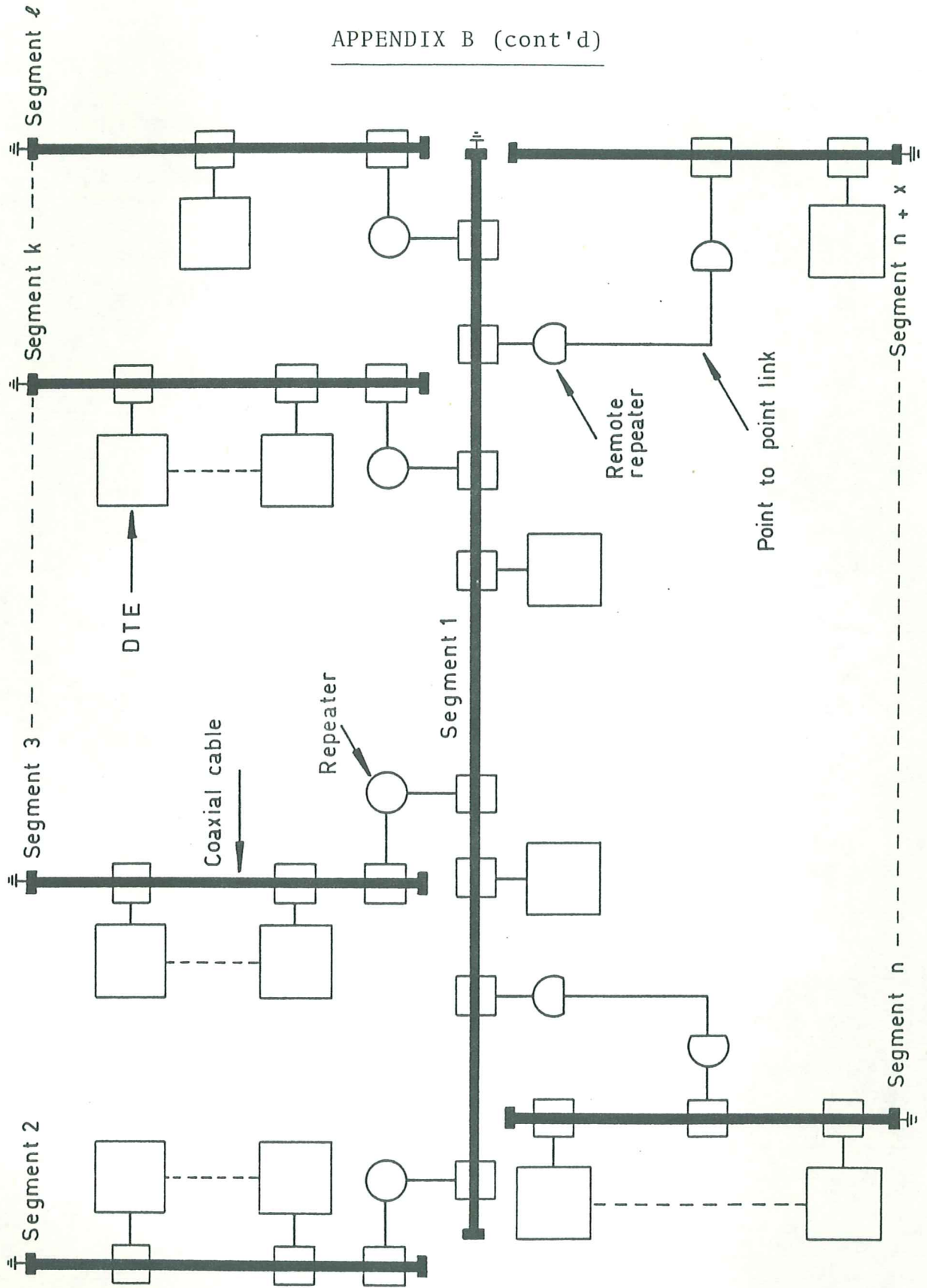


A MINIMAL NETWORK CONFIGURATION



A MEDIUM SCALE NETWORK CONFIGURATION

APPENDIX B (cont'd)



A LARGE SCALE NETWORK CONFIGURATION

Physical Layer Propagation Delay Budget Example (Note B1)

Element	Unit Steady- State Delay	Unit Startup Delay	Units Forward Path (note B2)	Units Return Path	Total Delay
Encoder	0,1 us	0	3	3	0,60 us
Branch Cable	5,13 ns/m	0	300 m	300 m	3,08 us
DTE (transmit path)	0,050 us	0,3 us	3	3	2,10 us
DTE (receive path)	0,050 us	0,6 us	3	0	1,95 us
DTE (collision path)	0	0,9 us	0	3	2,70 us
Coaxial cable	4,33 ns/m	0	1500 m	1500 m	13,00 us
Point-to-point Link Cable	5,13 ns/m	0	1000 m	1000 m	10,26 us
Repeater (repeat path)	0,8 us	0	2	0	1,60 us
Repeater (colli- sion path)	0,2 us	0	0	2	0,40 us
Decoder	0,1 us	0,8 us	2	0	1,80 us
Carrier Sense	0	0,2 us	3	0	0,60 us
Collision Detect	0	0,2 us	0	3	0,60 us
Signal Rise Time (to 70% in 500 m Note B3)	0	0,1 us	3	0	0,30 us
Signal Rise Time (50% to 93% 500 m Note B4)	0	2,4 us	0	3	7,20 us
Total Worst-Case Round Trip Delay					46,19 us

NOTE B1

All quantities given are worst-case (both number of units and unit delays per unit).

NOTE B2

The propagation delay has been separated into a "forward-path" and a "return path" delay. This is because in one direction it is carrier sense which is being propagated through the channel, and in the return direction it is collision detect which is being propagated. The two signals have different propagation delays.

NOTE B3

In the worst-case, the propagated signal must reach 70% of its final value to be detected as valid carrier over a 500 m length of coaxial cable. This rise time must be included in the propagation delay budget.

NOTE B4

*In the worst-case the propagated collision on the return path must reach 93% of its final value to be detected as a collision over a 500 m length of coaxial cable.*

APPENDIX C

FUNCTIONAL DESCRIPTION OF REPEATERS

C.1 Repeaters

Repeaters are used to extend the channel length and topology beyond that which could be achieved by a single cable segment as defined in section 5. A repeater requires DTE functionality on each of the segments between which it is repeating signals. These DTEs are as specified throughout the document, and are counted towards the maximum specified in section 5.

C.2 Regenerative Repeaters

A regenerative repeater ensures that any signals repeated to a segment have the same waveform and frame format characteristics that are specified at the output of a DTE. Any loss of signal-to-noise ratio due to cable loss and noise pickup is thus regained. A regenerative repeater introduces a delay of 6 bits.

C.3 Non-Regenerative Repeaters

A non-regenerative repeater ensures that repeated signals exhibit a waveform as specified at the output of a DTE, but leads to preamble truncation of 8 bits. Except for transmission delay, a pair of remote repeaters (i.e. a point-to-point link) is considered to be functionally equivalent to a single segment-to-segment repeater.

