ECMA

EUROPEAN COMPUTER MANUFACTURERS ASSOCIATION

STANDARD ECMA-80

LOCAL AREA NETWORKS
CSMA/CD BASEBAND

COAXIAL CABLE SYSTEM

2nd Edition – March 1984

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BRIEF HISTORY

Open Systems Interconnection standards are intended to facilitate homogeneous interconnection of hererogeneous information precessing systems. This Standard is within the framework for the co-ordination 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 second edition of ECMA-80 was adopted by the General Assembly of ECMA on December 13, 1983

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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
IEEE Standard 802.3	CSMA/CD Access Method and Physical Layer Specifications
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
ECMA-TR/19	Safety Requirements for Local Area Networks.

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 the transmission medium, such that 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

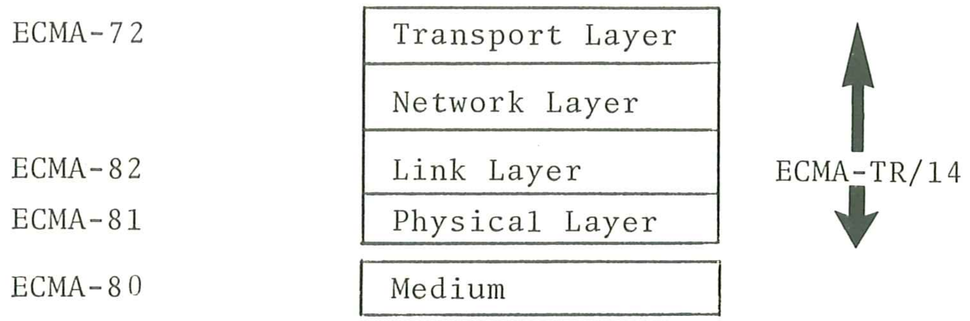
A device used to extend the length and topology of the network beyond that imposed by a single segment.

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 a 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. Standards ECMA-80, ECMA-81 and ECMA-82 constitute together a subset of Standard IEEE 802.3.

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).

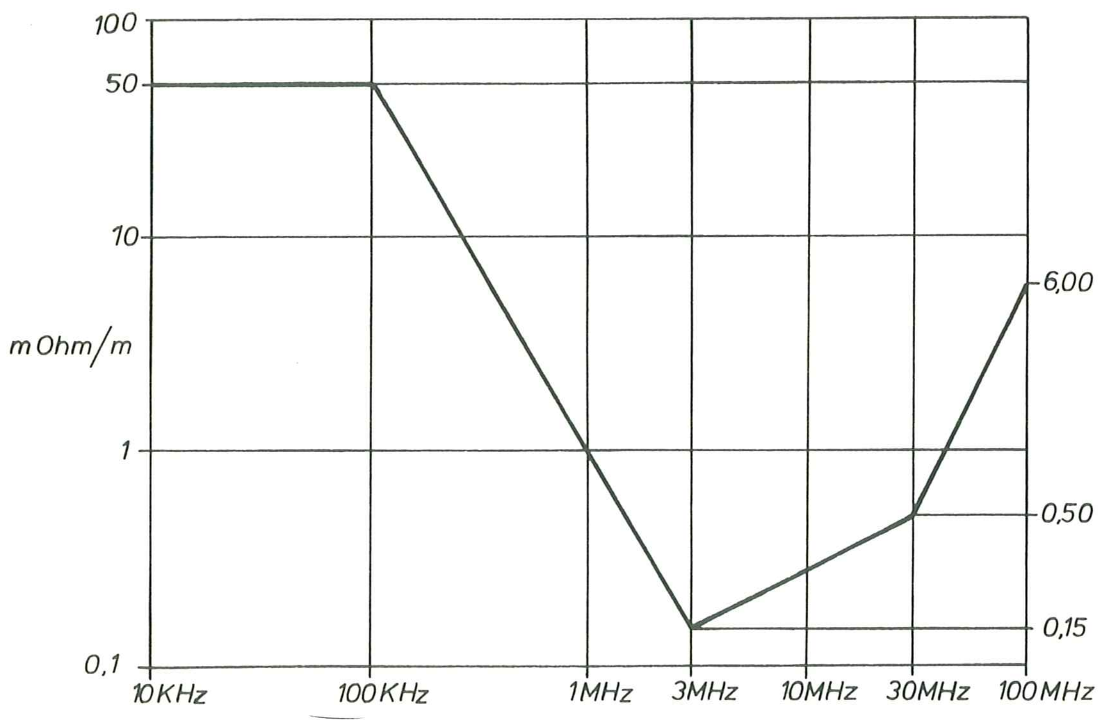
3.1.4. Pulse Distorsion

The cable shall produce a pulse distorsion 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. DC Resistance

The total DC resistance of the coaxial cable shield system plus centre conductor shall not exceed 10 mOhm per metre when measured at 20°C.

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 mm ± 0,013 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 ± 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 ± 0,178 mm;
- the cable concentricity shall be such that the axis of the centre conductor is within 0,412 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 ± 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).

Connector components shall provide a means of making an earth connection to the coaxial cable segment (see section 6.3). It is recommended that either the terminator or extension connector be used.

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 Ohm ± 0,5 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.

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 magnitude of pulse reflection from the DTE connection shall not exceed that produced by a 4 pF capacitance when measured with a waveform of amplitude 0 to -2V and rise and fall times 25 nS. The DTE connection shall include any active circuitry connected directly.

- The total capacitance of the DTE connection, excluding any active circuitry, should be not greater than 2 pF.
- The stub length of the DTE connection should not exceed 3 cm.
- The AC Breakdown voltage of the insulation shall meet the safety requirements specified in 7.1.

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 (when measured at 20°C) to the loop DC resistance specified in 5.2. 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.

5. NETWORK CONFIGURATION

5.1. Round Trip Delay

Round Trip Delay is dependent upon network configuration. Total round trip delay shall not be greater than 51,2 us.

5.2. Segment Length

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.

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.

The actual segment length may therefore be limited by the introduction of connectors and severed-cable DTEs and will be dependent upon actual cable resistance and environmental temperature.

5.3. Repeaters

Repeaters are used to extend the channel length and topology beyond that which could be achieved by a single cable segment.

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.

5.4. Acceptable Network Configuration

A network configuration shall satisfy the requirements specified in 6.1., 6.2. and 6.3.

Appendix A 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-wave-length in the cable at 5 MHz; this corresponds to using lengths of 23,4 m; 70,2 m and 117 m (± 0,5 m) for all cable sections. These are considered to be the standard lenghts 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 be earthed at a single point in accordance with ECMA/TR19

7. ENVIRONMENTAL SPECIFICATION

7.1 Safety Requirements

Local Area Networks should be designed and installed in accordance with ECMA/TR19.

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 :

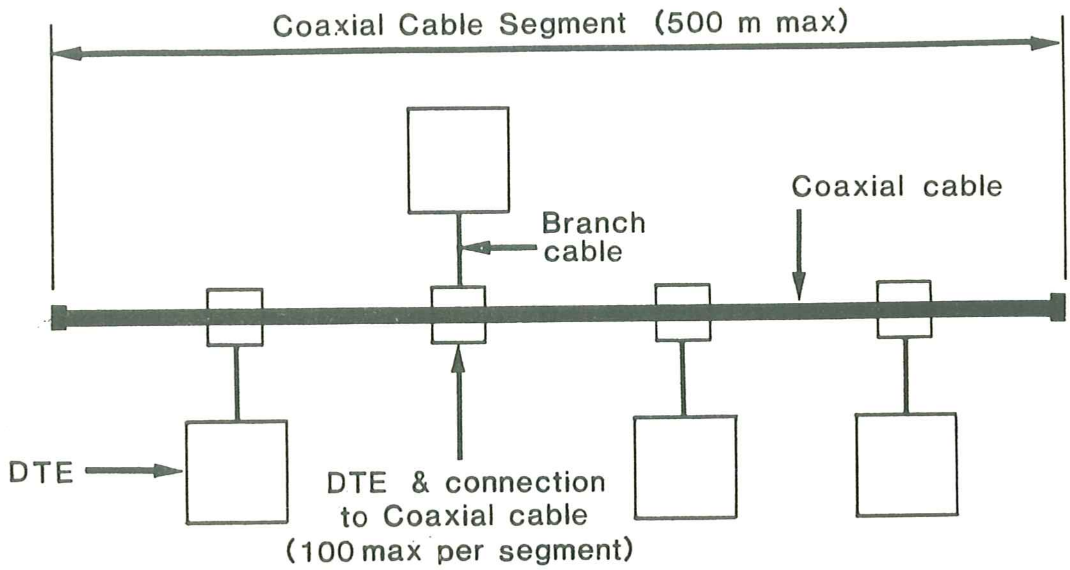
- ambient plane wave field of -

  2 V/m from 10 KHz to 30 MHz
  5 V/m from 30 MHz to 1 GHz

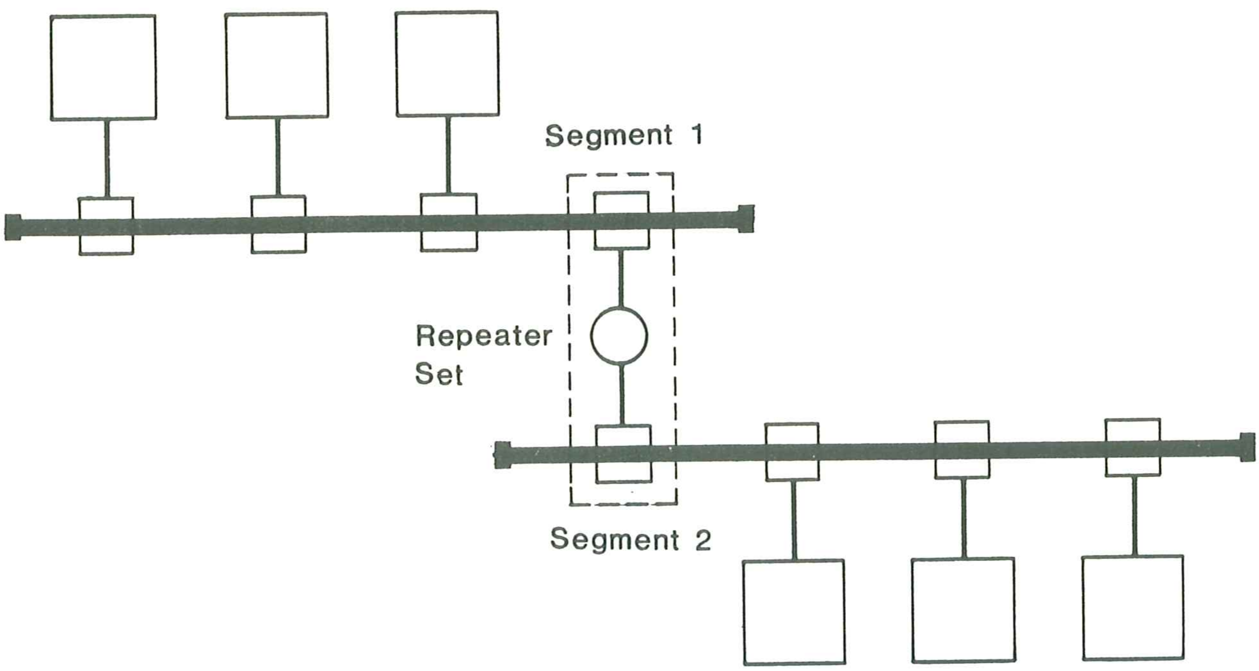
- interference voltage of 0,25 V to 1 V/ns peak slope (to be defined), between the coaxial cable and the DTE earth connection ; e.g. 3,95 V to 15,8 V peak for a 10,1 MHz sine wave.

APPENDIX A

NETWORK CONFIGURATION EXAMPLES

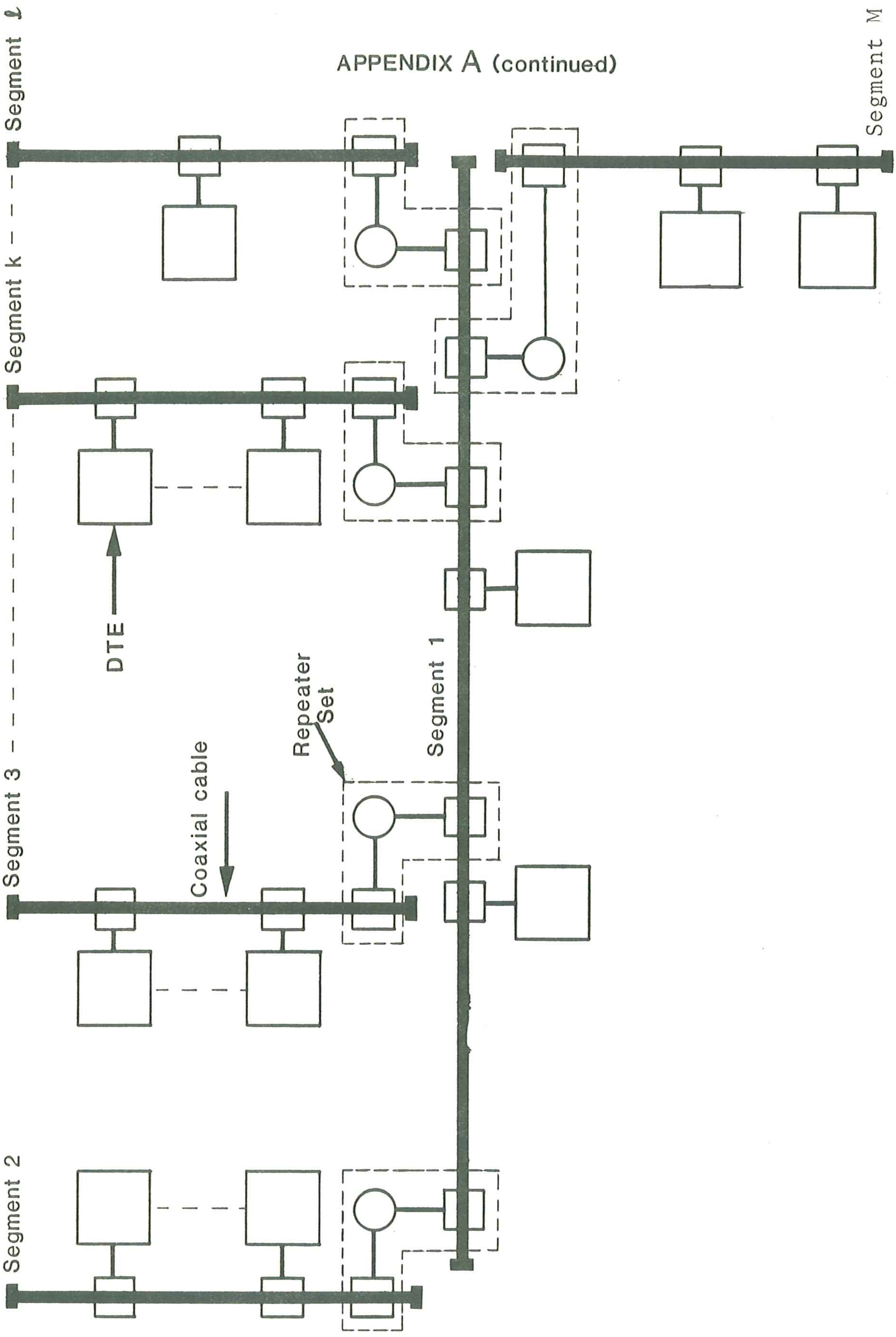


EXAMPLE OF A MINIMAL NETWORK CONFIGURATION



EXAMPLE OF A MEDIUM SCALE NETWORK CONFIGURATION

APPENDIX A (continued)



EXAMPLE OF A LARGE SCALE NETWORK CONFIGURATION

Physical Layer Propagation Delay Budget Corresponding to Large Scale Configuration Example on Page 12 (note A1)

Element	Unit Steady-State Delay	Unit Start up Delay	Units Forward Path (Note A2)	Units Return Path	Total Delay
Encoder	0,1 us	0,1 us	3	3	1,20 us
Branch Cable	5,13 ns/m	0	300 m	300 m	3,08 us
Transmit Data	0,050 us	0,3 us	3	3	2,10 us
Receive Data	0,050 us	0,6 us	3	0	1,95 us
Collision	0	0,9 us	0	3	2,70 us
Coaxial Cable	4,33 ns/m	0	1500 m	1500 m	12,99 us
Repeater (repeat path)	0,2 us	0,4 us	2	0	1,20 us
Repeater (Collision path)	0,2 us	0,2 us	0	2	0,80 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 A3)	0	0,1 us	3	0	0,30 us
Signal Rise Time (50 % to 94 % 500 m Note A4)	0	2,0 us	0	3	6,00 us
		Total Round Trip Delay			35,32 us
Worst case Round Trip Delay (Maximum Configuration)					51,2 us

NOTE A1 - All quantities given are worst-case (both number of units and unit delays per unit).

NOTE A2 - The propagation delay has been separed 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 A3 - In the worst-case, the propagated signal must reach 70 % of its final value to be detected as valid carrier over a 500 m lenght of coaxial cable. This rise time must be included in the propagation delay budget.

NOTE A4 - In the worst-case the propagated collision on the return path must reach 94 % of its final value to be detected as a collision over a 500 m length of coaxial cable.