ECMA

EUROPEAN COMPUTER MANUFACTURERS ASSOCIATION

LOCAL AREA NETWORKS

CSMA/CD 10 MBit/s BASEBAND PLANNING AND INSTALLATION GUIDE

TR/26

March 1985

Free copies of this document are available from ECMA,
European Computer Manufacturers Association
114 Rue du Rhône – 1204 Geneva (Switzerland)

ECMA

EUROPEAN COMPUTER MANUFACTURERS ASSOCIATION

LOCAL AREA NETWORKS

CSMA/CD 10 MBit/s BASEBAND PLANNING AND INSTALLATION GUIDE

TR/26

March 1985

TABLE OF CONTENTS

TABLE OF CONTENTS (cont'd)

1. GENERAL

1.1 Scope

This Technical Report is intended to assist in the planning, design, installation and system testing of the Standard for CSMA/CD Baseband Local Area Networks (LAN), ECMA-80, ECMA-81 and ECMA-82.

The main component of the transmission medium, a trunk cable of unique design and specification, requires no special installation techniques. In addition to the passive Trunk Cable the Network System comprises terminators, drop cables, transceivers, and repeaters. These items, once installed and connected together constitute the transmission medium that supports the LAN.

Simplicity of installation and flexibility of layout are important characteristics of the approach in providing a high-performance, high-integrity Local Area Network. Equally important is the ease with which a system may be enlarged to cope with expanding needs. A small Network System concentrated on one floor, supporting a small number of DTEs may be progressively enlarged to a final system servicing an entire multi-storey building as well as multiple buildings with up to 1024 units of Data Terminal Equipments (DTE).

Such a system may also be connected to remote DTEs of systems via a communications gateway and external transmission lines. Clearly, the planning and installation activity will vary greatly depending on the size and complexity of the system.

Successful network operation is the end product of good and thorough planning. The planner will evaluate the restrictions imposed by the building lease, type of structure, facilities requirements, health and safety regulations, equipment location and quantity, cable performance specifications, floor plan and budget.

The key activities consistent with the above are:

- To plan and design the cable route according to the distribution of the DTEs.
- To install the network hardware.
- To test the network hardware.

As it is anticipated that most networks will grow and evolve over a period of time, this must be taken into consideration at the initial design stage.

1.2 References

ECMA-80	Local Area Networks (CSMA/CD Baseband) Coaxial Cable System. 2nd. Edition-March 1984.
ECMA-81	Local Area Networks (CSMA/CD Baseband) Physical Layer. 2nd. Edition-March 1984.
ECMA-82	Local Area Networks (CSMA/CD Baseband) Link Layer. 2nd. Edition-March 1984.

ECMA/TR 19 Local Area Networks, Safety Requirements. March 1984.

IEEE 802.3 CSMA/CD 10-Mbit/s Baseband, Local Area Network.

1.3 Definition

For the purpose of this Technical Report the following definitions apply.

1.3.1 Coaxial Cable

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

1.3.2 Coaxial Connector

Type N connectors, attached to each end of a cable section.

1.3.3 Cable Section

A continuous length of coaxial cable, fitted with connectors at each end.

1.3.4 Cable segment

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

1.3.5 Data Terminal Equipment (DTE)

The source and sink for all communications on the network.

1.3.6 Local Area Network (LAN)

A data communications system supporting Layers 1 and 2 of the ISO Reference Model for Open Systems Interconnections; having a geographic coverage of at least 1 km end-end, and possessing sufficient performance to support the aggregate data throughput required by the stations (DTEs) being used.

1.3.7 Networks components

The hardware elements that make up the transmission system of the network (ie. cables, transceivers, repeaters, connectors).

1.3.8 Repeater

A device used to extend the length and topology of the network beyond that imposed by a single segment, up to the allowable end-end trunk transmission line length. Repeaters perform the basic functions of restoring the signal in both amplitude and time domain.

1.3.9 Station

A single addressable site on the LAN.

1.3.10 Transceiver (MAU)

The unit which forms the node between a coaxial cable segment and the transceiver cable.

1.3.11 Trunk cable

The coaxial cable used to form a segment.

2. SYSTEM OVERVIEW

2.1 General

Before planning and designing the physical layout of a Network System, it is necessary to become familiar with the components and configuration specifications. This section:

- provides details of the network components,
- provides component configuration guidelines and specifications to ensure a properly designed Network System.

2.2 Component Descriptions

2.2.1 Trunk Cable

The Trunk Cable is a constant impedance transmission line of circular cross section. It is used to interconnect the Transceiver.

The Trunk Cable is marked at 2,5 m intervals, all measurements should be made with respect to this marking to a tolerance of ± 0,05 m.

Care should be taken to ensure that the cable materials are compatible with the installation environment. Normal PVC materials should satisfy the majority of situations, however local safety codes may in some cases prohibit this. Low smoke and fume grades of PVC or PTFE may be required for plenums or lift shafts for example.

PVC cables will have a nominal outside diameter of 10,3 mm and PTFE cables 9,5 mm.

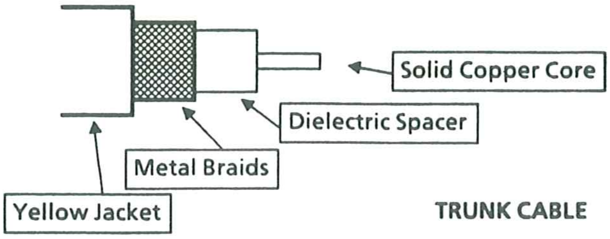
Coaxial cable connectors are used to join Trunk Cable sections and attach Terminators:

All connectors are 'N' series, 50-Ohm constant impedance. As frequencies in the transmitted data are band-limited to approximately 20 MHz, military versions of the connectors are unnecessary, but are acceptable.

- Male plugs are fitted at the ends of all Trunk Cables.
- Female-to-female Barrel Connectors are used to join Trunk Cable sections.
- Female terminators are used for terminating both ends of a Trunk Cable segment.

Care should be taken to ensure that the connector shell (connected to the trunk cable screen) is insulated using an insulation boot, from any building metal, or other unintended conductor.

The insulation boot must be used to cover the connector during the installation phase, and must be replaced after any subsequent work which entails its removal.



TRUNK CABLE

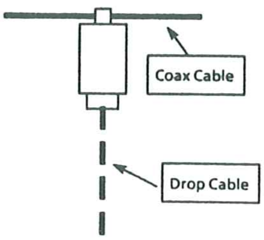
2.2.2 Transceiver (MAU)

The Transceiver is the device that connects directly to the Trunk Cable, by means of either a tap block connector or directly in line. It provides the electronics to transmit and receive encoded signals on the cable and to provide the required electrical isolation.

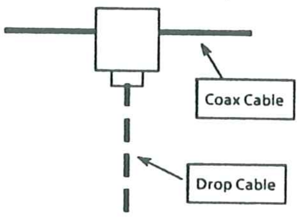
One cable segment (up to 500 m) will support up to 100 transceivers.

One network will support up to 1024 transceivers.

Transceivers should be placed every 2,50 m ± 0,05 m or multiples thereof. The Trunk Cable is physically marked every 2,5 m to assist with the transceiver placement.



TRANSCEIVER
(TAP BLOCK TYPE)



TRANSCEIVER
(IN-LINE TYPE)

2.2.3 Transceiver Interface (Drop) Cable

The Drop cable connects a transceiver to a DTE, allowing that DTE access to the network. It is made up of a length (variable) of cable (with 8 conductors consisting of 4 individually shielded twisted pairs, plus an overall shield and insulating jacket) with 15 pin D connectors (1 male; 1 female) at either end. The D Connectors are fitted with slide lock strain relief mechanisms. The maximum length of drop cable attached to any transceiver is 50 m.

In normal usage a single drop cable should be used to connect a user device to a transceiver on the Trunk Cable. Theoratically multiple lengths of drop cable could be chained like extension cords, but each additional connector introduces performance and reliability degradation. If chaining is deemed necessary to meet an unusual layout requirement two lengths may be chained. Chaining of more than two lengths is not recommended.

An installed drop cable should be physically restrained in order to protect the slide lock mechanism of the D connectors from accidental strain or damage.

DROP CABLE

2.2.4 Data Ports

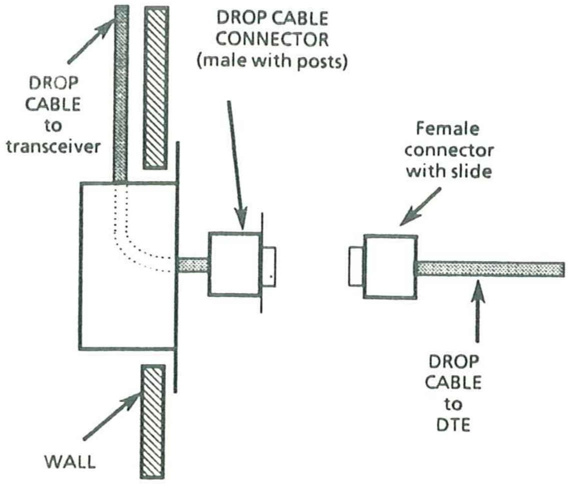
These provide a neat and unobstrusive means of pre-cabling a building, or part of building, such that connection points are provided at convenient points. These can be selected, as required, as equipment connectivity needs change.

A data port is connected via a drop cable to a transceiver installed on the Trunck Cable, the drop cable being concealed in or behind a wall. The DTE is then connected to the data port by means of a second drop cable.

When planning this type of installation care must be taken to ensure that the maximum length restriction of 50 m is adhered to.

The stale and configuration of this device will vary, but the following must be ensured:

- The 15-pin 'D'-type socket must be male with posts.
- The body of the Data Port must totally enclose the Drop Cable termination and must be an effective radiation screen (e.g. steel).



DATA PORT

2.2.5 Repeater

Although a cable segment is restricted to a maximum length of 500 m, two or more segments can be linked using Repeaters. These extend the signal between two segments of Trunk Cable.

A maximum of two Repeaters is permitted in any communicating path on the network. Thus the maximum separation between any two workstations is 1500 m (three segments) plus the drop cable lengths.

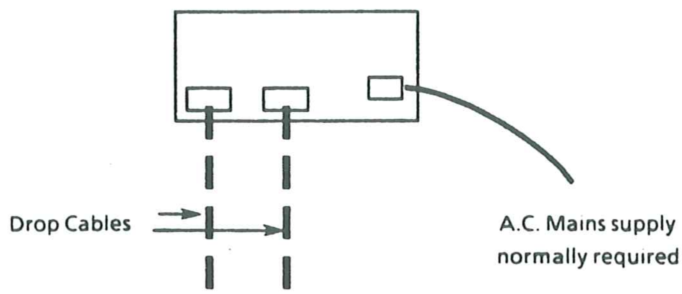
Repeaters must not be connected in parallel, therefore, before installing a Repeater ensure that the two segments are not already connected via Repeaters.

Repeaters can be used to create branches from a main Network Segment as required.

Repeaters require access to an a.c. mains electricity supply.

To link two segments:

- Install a Transceiver in both Trunk Cable segments in the normal manner (at a 2,5 m placement mark on each Trunk Cable).
- Connect both Transceivers to the Repeater using normal drop cable.



REPEATER

2.2.6 Terminators

Terminators must be fitted at each end of a Trunk Cable cable segment. If they are not present, the Network System will malfunction.

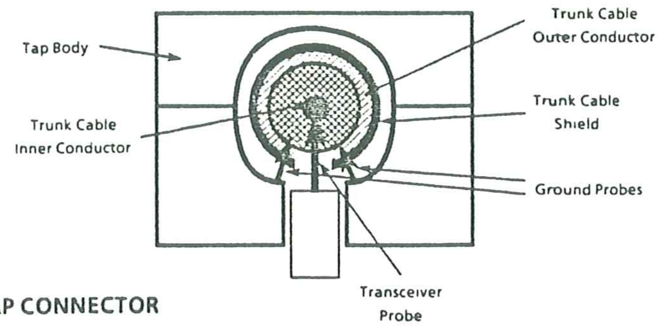
The terminators are 50-Ohm, 1-watt devices with a female connector. Provision may be made for earth attachment at the terminator (see section 2.2.7). The terminator must be insulated by a boot after it has been located.

2.2.7 Earthing Clip (optional)

The outer screen of the cable must be earthed once only. An electrical earthing clip provides a means of attachment to a barrel connector, or terminator, and should be connected to the nearest incoming mains electricity earth using 4 mm copper wire.

2.2.8 Tap Connectors

Tap Connectors allow Transceivers to be connected to the Trunk Cable without disrupting the data traffic. Eventually Tap Connectors will allow casual attachment and disconnection from the Trunk Cable.

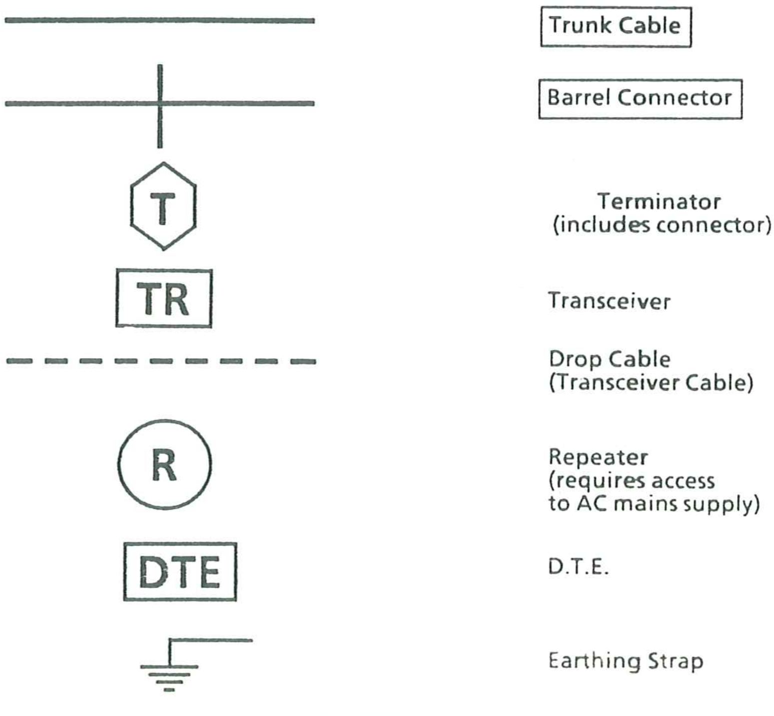


TAP CONNECTOR

2.3 Network Configuration

2.3.1 Network Symbols

These symbols are used to represent the network equipment on the floor plan.



NETWORK SYMBOLS

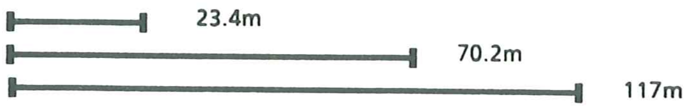
2.3.2 <u>Network Formula</u>

i) If possible, a coaxial cable should be made from one homogeneous length (no-breaks). This approach is usually used for shorter networks and minimizes reflections from cabling discontinuities.

ii) If the coaxial cable must be cut into sections, as long as a homogeneous segment is used (i.e., the same cable lot and extruder run), the coaxial cable may be cut at any point and connectors added. One way of obtaining a coaxial cable length from a single extruder run is to purchase 500 m segments of coaxial cable and cut these known single segments into smaller pieces.

iii) If a single-section segment is impractical, and cutting a known single segment is also impractical, the installation of coaxial cable sections cut to the standard lengths of odd-integer multiple of 23,4 m is strongly recommended. These particular lengths minimize the successive in-step buildup (in-phase addition) of reflections from adjacent sections.

Recommended lengths are:

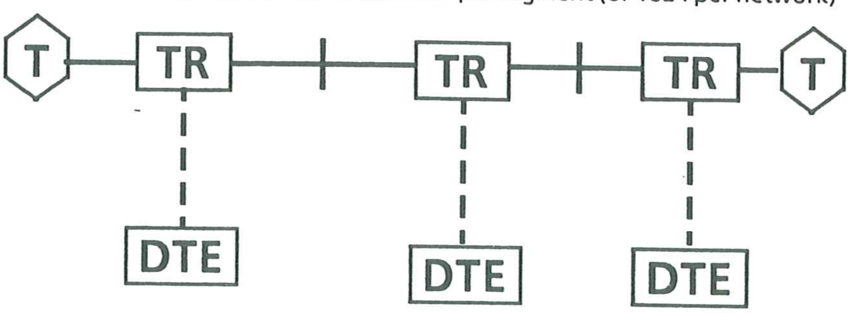


Trunk cable comes in sections with connectors at each end.

Multiple sections can be connected using barrel connectors to make a segment of cable - up to 500 metres

Terminators are placed at both ends of every segment (500 metres maximum)

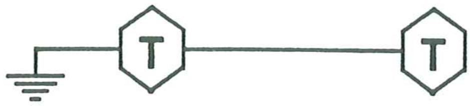
Transceivers are attached to the cable near user device locations. Transceivers shall be placed on the 2.5m annular markers, no closer together than 2.5m (±0.05). The maximum is 100 transceivers per segment (or 1024 per network)



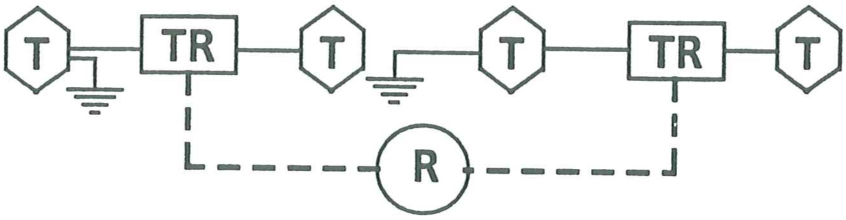
Drop cables attach transceivers to Data Terminal Equipment (DTE)

2.3.3 <u>Repeater Usage</u>

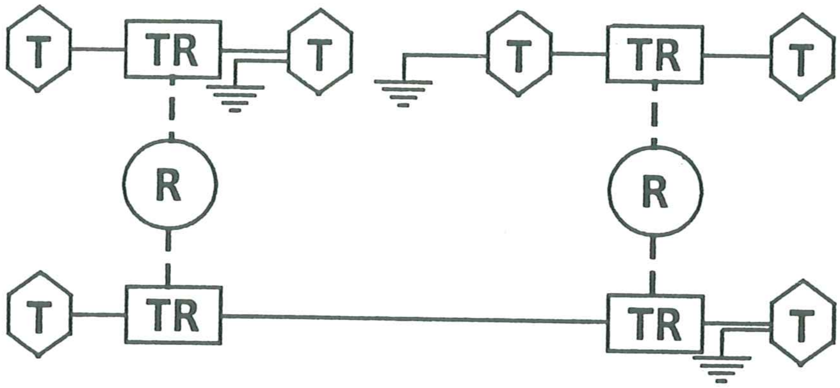
(Repeater normally require access to an A.C. mains supply)



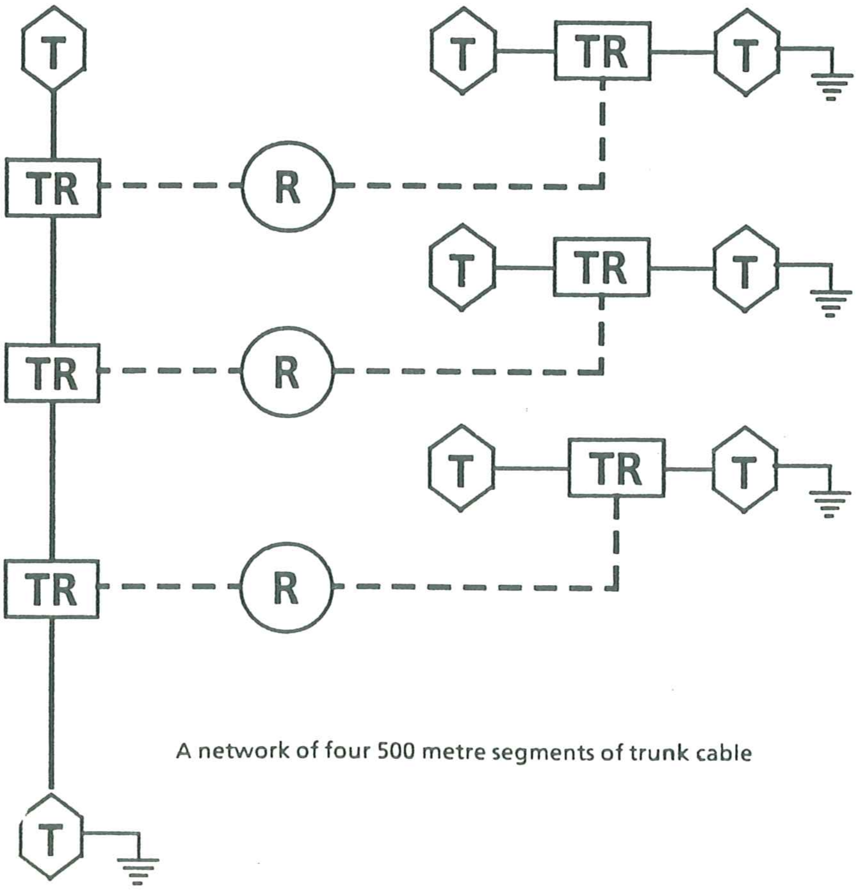
A network of one 500 metre segment of trunk cable



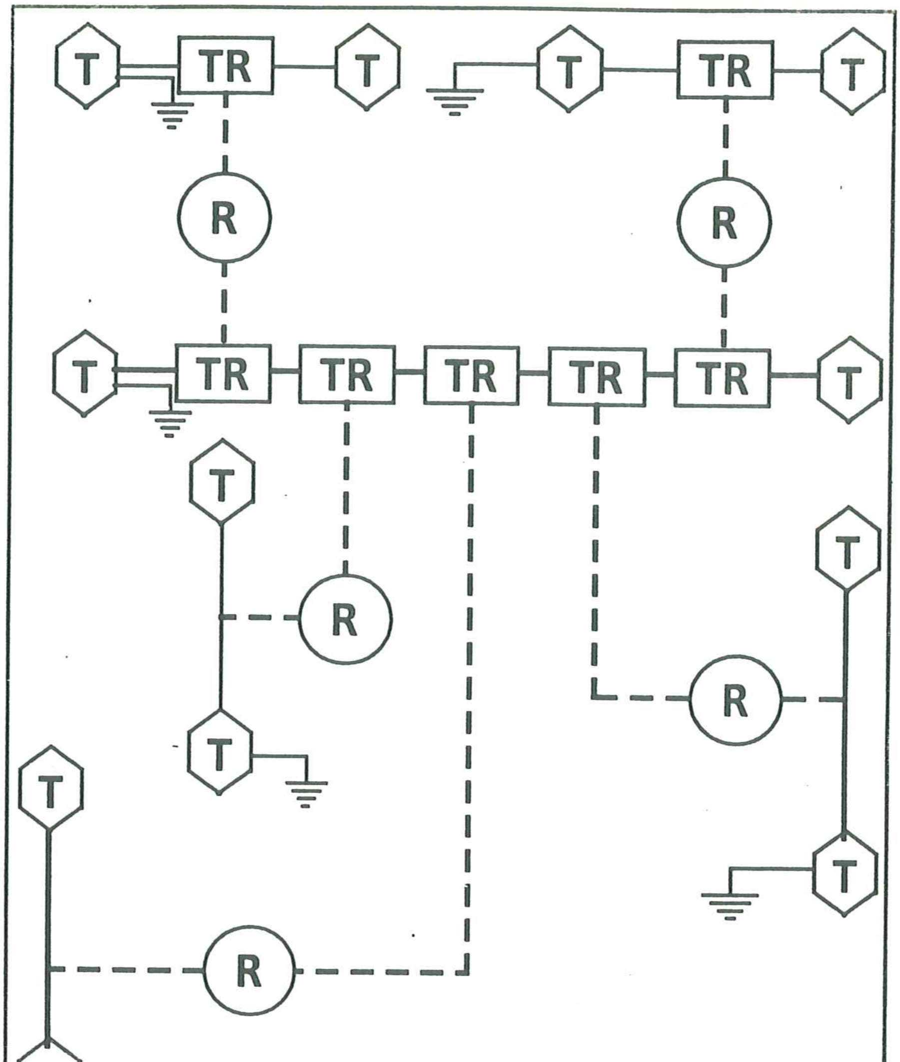
A network of two 500 metre segments of trunk cable



A network of three 500 metre segments of trunk cable



A network of four 500 metre segments of trunk cable



A network of six 500 metre segments of trunk cable

3. PLANNING AND DESIGN

3.1 Introduction

When planning and designing the physical layout of a Network System the following factors should be considered:

- Type of building structure.
- Type of the occupancy of the building.
- Local building regulations.
- The network configurations specifications.

This section addresses these areas and provides:

- General guidelines for planning a cable system for an entire building when one occupant decides to install a network system.
- General information on common building types, structures, and occupancy to enable the designer/planner to evaluate the building for installation feasibility.

- An outline set of rules for cables routing.
- A description of possible methods of equipment connection to enable the designer/planner to select an appropriate method and develop a plan based on this.
- A method of planning a Network System using Customer floor plans, showing all System components and equipment on these plans.
- A procedure for designing a schematic drawing that shows Network System configurations.

3.2 Building Types

3.2.1 Existing Building

When a customer occupies only part of a building it may be to his advantage to cable the entire building.

The building owner and other occupants should be consulted regarding this. Cooperation between parties may be of mutual benefit.

The building owner could regard this facility as an attractive asset for the future, enhancing its market value. For other occupants it would provide networking capabilities at a much reduced installation cost.

3.2.2 New Buildings

These provide a unique opportunity for installing a network physical infrastructure. The architect has the opportunity to provide concealed ducting to accomodate the Trunk Cable and the Drop Cables, and to provide data ports as required in every office.

One, or more, central points, may be allocated to house shared services (File, Communications, Print Output, etc.). At these points extra cabling and outlets should be provided.

3.3 Network Site Requirements

The installation planner must survey the site thouroughly, with assistance from the authorities responsible for the premises (e.g. the Site Service Manager). This authority should have intimate knowledge of the existing power sources, risers, conduits, wireways, firewalls, etc., and provide floor plans and consultancy services.

During the survey the following facts should be taken into consideration.

Type of Occupancy

This may have an effect on the installation of the cable plan. Outright ownership of the facilities will present the fewest restrictions.

A lease in a facility may impose a number of restrictions. Leases may permit only the building owner's personnel to install the cable or require the tenant to submit plans of the intended installation for approval.

Type of Structure

Check the following structural points:

Building construction

This will be the largest factor affecting the cost of the installation of the Network System.

Modern multi-storey buildings usually have risers between the floors that can be used for routing the cables. Also modern buildings may have T bar suspended ceilings that are ideal for routing the Trunk Cable. However, concealed spline ceilings can give access problems. This type of building structure requires few structural changes to incorporate the System.

Number of floors equipment will occupy

If equipment is to be located on two or more floors, special attention must be given to the method of floor penetration.

If possible use existing risers to pass Trunk Cable between floors. Alternatively, concrete core drilling, wireways, air ducts, etc., may be considered. The Site Manager, or local contractor, may provide advice on this matter.

Lightning Protection

The building must have sufficient protection to safeguard its contents from lightning. For advice on protection, consult a specialist in lightning protection.

Trunk Cable Routing

The Trunk Cable must be installed to comply with local codes, aesthetic values, security, cost criteria, and the physical limits of the equipment to be attached.

Before drawing up any plans, the network planner should make a detailed site inspection, to determine the optimum route for the Trunk Cable and the sitting of the Transceivers, Repeaters and other associated devices.

The planner should also ensure that the route chosen complies with all cable routing requirements detailed in this section.

Ideally the Trunk Cable should be routed above the ceiling. Other possibilities are:

- Under the floor
- In the floor trunking
- In the wall, or on the wall.

Vertical Risers

The cable should be supported every 3 m to 4 m regardless of where it is installed to prevent stress on the connectors.

Suspended Ceilings

To cause the minimum of disruption within the building it is advisable to route the Trunk Cable in the suspended ceiling in corridors. Where this is not possible other routes should be selected as required. The Trunk Cable should be attached to the ceiling hangers every 2 m to 3 m, for support using tie wraps.

Where firewall penetration is required ensure that the local fire regulations are obeyed, and note the penetration on the floor plan.

Floor Conduits

Concrete floors often include built-in wireways. These may be used for routing the Trunk Cable, but special care must be taken to ensure that cable is not bent to less than a 250 mm bend radius, and will not be crushed or crimped.

Raised Floors

The Trunk Cable can be laid under the floor in the normal manner. Ensure that the cable will not be crushed, crimped, or bent through a bend radius of less than 250 mm.

Environmental Air Space (air plenums)

Many structures use the suspended ceiling space for air plenums. It is advised that PVC cable should not be used in air plenums. In some countries it is mandatory not to use PVC, but PTFE acceptable.

Where PVC is used, care should be exercised in specifying the cable type, as local fire regulations may restrict the type of PVC Cable that can be used in these situations.

Mains Supply Areas

Do not install any of the hardware between areas supplied by more than one medium voltage (i.e. greater than 450 V rms) mains feeder without equipotential bonding of the power transformers.

Between Buildings

The Trunk Cable may only pass outside buildings if it is fully protected from being struck by lightning.

Lightning Protection

The cables should not be exposed to the possibility of being struck by lightning.

Electrical Noise

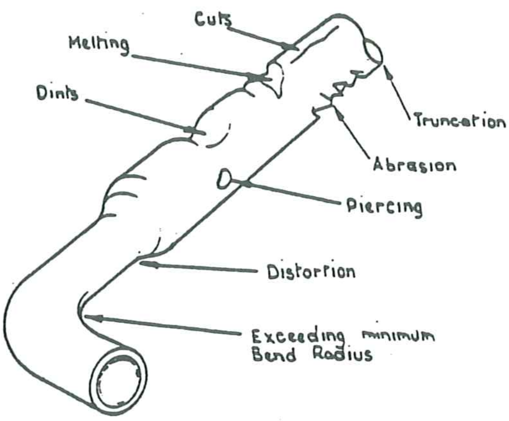
High power electrical plant produce switching transients and radio frequency emissions that may induce interference on the Trunk Cable.

A minimum separation of 10 m between the Network Cables and a source of high energy emissions (such as lift contractors, electric arc welders, a.c. substations, generators, etc.) is recommended.

Due to the construction of the cable and the error dectection/recovery capabilities of the Network System, electrical noise will not normally produce data errors in the system, perceptible to the user, provided the 10 m separation isobserved.

Avoide Mechanical Damage

The Network Cables should be installed in an area where they could be exposed to mechanical damage. This is an obvious precaution but, nevertheless, must be highlighted as prolonged down-time on data networks cannot be tolerated. Network Systems will not necessarily be confined to an office environment and must be protected accordingly.



If the outer jacket is accidentally severed during installation the exposed inner layers should be insulated and protected from environmental contaminants (ie. moisture).

The most accessible route

To allow the system to be easily extended, re-routed or damaged sections swiftly replaced, free access to the cables, is important.

The shortest route

A short route will reduce the installation cost and the chance of physical damage to equipment.

Trunk Cable Sectioning

The Trunk Cable should be laid in sections to allow break points for:

- System trouble-shooting and testing purposes.
- To allow network enlargement and enhancement.

These separate sections are joined using standard 'N' series coaxial connectors. These connectors once installed should be disturbed as little as possible.

Hazardous Environments

If an optical fibre based link for use between Repeaters becomes available in the future, this will enable the Network installation to be continued through an area with a hazardous environment such as :

- Unprotected from lightning.
- Subject to electrical noise.
- Subject to extreme temperatures.
- Requiring bend radius down to 30 mm.
- Through structures requiring the minimum of removed material.
- High security paths.

Equipment Connection Method

Two methods for running the Drop Cable from the Transceiver to the User Device are:

- The Drop Cable is suspended from the ceiling or wall and attached to the equipment.
- The Drop Cable is routed inside a wall, through an outlet (Data Port), and then attached to the equipment by a separate drop cable.

3.4 Plans

Once the Network Site Survey has been completed, and the building structure has been evaluated to determine where the cables will go (above the ceiling, under the floor, in the walls, etc.), the Network System can be drawn up on the floor plan, as follows:

Obtain Floor Plan

Obtain a floor plan from the facilities manager, architect or other appropriate source. Alternatively, a sketch can be drawn and the appropriate measurements noted.

The floor plan will be used to show the layout of the Trunk Cable between devices and will allow its total length to be calculated. This will help to determine the size and number of Trunk Cable sections to order, as well as the other network components that are required.

Identify Data Terminal Equipment (DTE) Locations on the Floor Plan

Identify all DTE's locations on the floor plan.
Identify planned future user devices on the floor plan, for cable layout planning purposes. The DTE symbol should be used when drawing the plan. Label each symbol with a unique equipment identifier.

When planning the positions of the DTE the following factors should be considered:

- The equipment should be readily accessible to both Users and support personnel.
- The Drop Cablelength determines the distance from DTE to the Trunk Cable, in the early planning phase allow 4,5 m for false ceiling installations, and 1,5 m for underfloor installations.
- Include the vertical rise when determining the distance from the DTE to the Transceiver, and make a horizontal allowance for equipment movement for service or repair.
- Remember the maximum length of Drop Cable for each Transceiver should not exceed 50 m, and consist of no more than two sections.
- The Product Description for a DTE will give power, heat dissipation and space requirements.

The location of DTE should be correlated using a Time Domain Reflectometer (TDR) map on the Network System when the installation is completed (see Appendix B). Unauthorised users can then be identified by subsequent TDR mappings.

<u>Identify cable route on floor plan</u>

Factors to consider when planning the Trunk Cable sectioning are:

- A Trunk Cable segment must not exceed 500 m.
- The longest data path in the network may involve a maximum of three segments of Trunk Cable utilising a repeater between each segment (maximum of two repeaters in series), plus the drop cables connecting the repeaters and DTEs.
- It may be more cost effective when covering larger floor areas to use longer Drop Cables, rather than to make extra Trunk Cable runs, thus resorting to fewer repeaters.
- The signal informations carried on the Trunk Cable is very low energy (low voltage and low electrical current). Optimum performance is achieved by ensuring that the cable does not run closer than 10 m to any source of high energy emissions, i.e. lift contractors, electric arc welders, a.c. substations, etc.
- Plan sections of Trunk Cable with connectors conveniently located service access, maintenance and ease of installation. A combination of Trunk Cable sections (23,70 or 117 m) will normally ensure this.
- Avoid locating connectors in risers or conduits. If this is not possible, pull-boxes should be installed to house the connectors, thus allowing ease of access.

Other Network Components

Mark the floor plan with approximate location of Terminators, Repeaters, Connectors, Transceivers and Drop Cables. Network component symbols are shown in section 2.

Calculate the length of Trunk Cable

Calculate the length of Trunk Cable required to ensure accessibility to the equipment. Allow additional Trunk Cable to route round obstacles and for other contingencies.

Where the length of Trunk Cable exceeds 500 m, a repeater will be required to ensure reliable network performance.

Schematic Layout

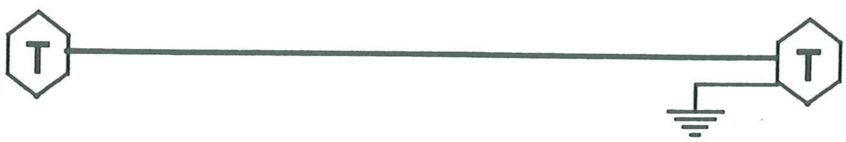
Examples of network schematics are shown in the following diagrams. While a schematic cannot show detailed placement of DTE, Transceivers, and Drop Cables, it can give a 'snap-shot' of a network and can help determine the following:

- How many sections of cable are required to make up a given segment of Trunk Cable.
- If multiple segments or repeaters exist.
- The number of barrel connectors used.
- The number of floors the network serves.

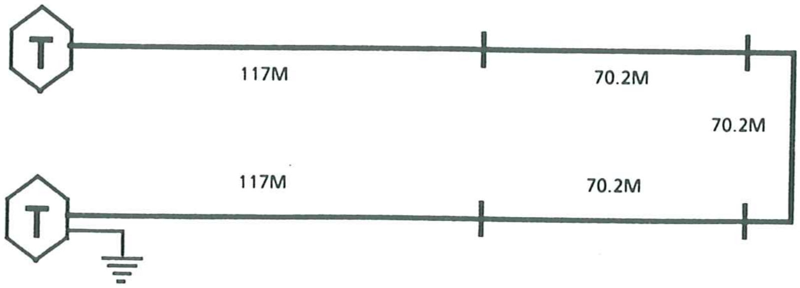
The schematic is created from information obtained from the floor plan layout. While floor plans should also show the equipment locations and a close approximation of the Trunk Cable within the facility, the schematic is useful in summarising and cross checking the network component order.

Each Trunk cable segment can be shown by drawing a solid line

Terminators should be placed at each end of a segment

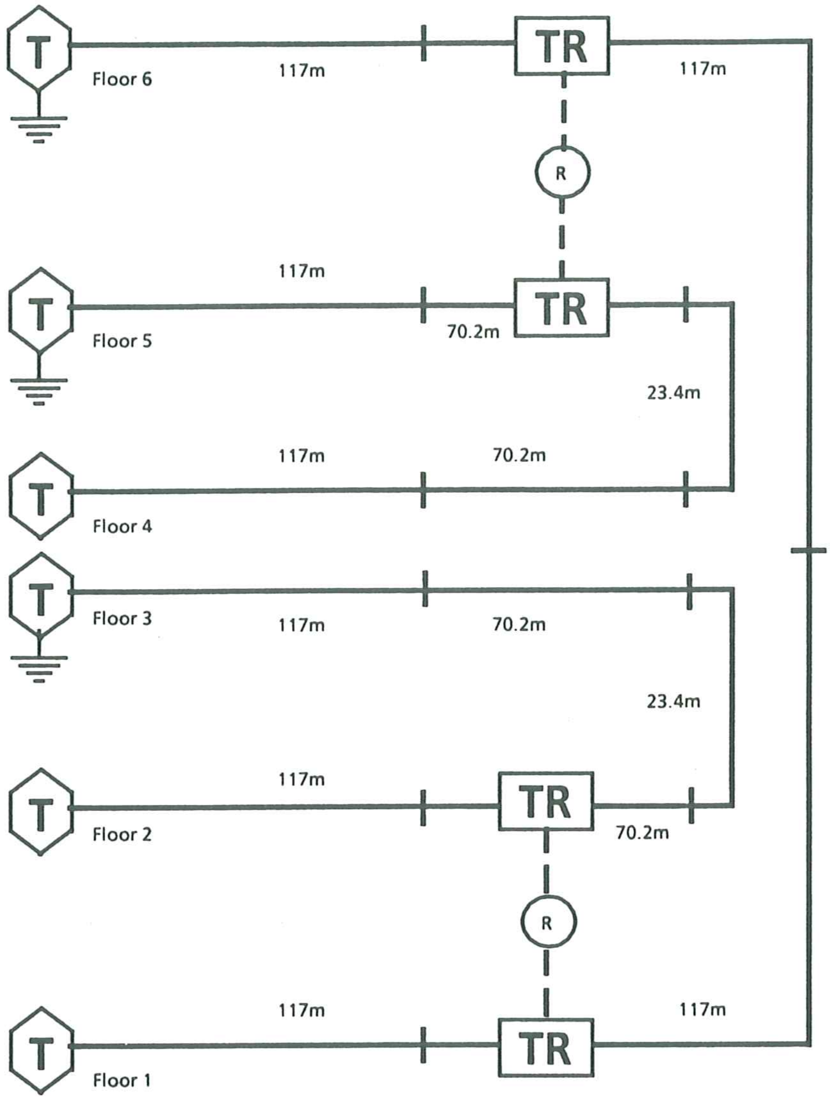


Barrel connectors should be placed on the trunk cable segment to show how many sections were used to form a segment. Write in the length of each section



Each Trunk cable segment must be earthed in one place only, either at a terminator or barrel connector with earth lugs.

Schematics can be drawn to show multiple floors, multiple segments, and repeaters.
This is an example of such a schematic.



**Note: Repeaters require access to an AC mains power source.
Earth placement is optional.**

4. NETWORK SYSTEM INSTALLATION

4.1 Introduction

As performance specifications are stringent, the installation equipment connection and maintenance must only be performed by trained technicians.

This Section:

- describes the installation procedures for Network Systems components,
- describes the procedure for connecting User Devices to the network components,
- gives a procedure for testing and accepting the installed network components.

4.2 Standards and Specifications

The installation of the network hardware shall conform to

Standard ECMA-80. Deviation from this Standard may cause performance degradation in this installed network. In addition, all local codes and regulations must be obeyed, where applicable.

- Installation of the network system must be in accordance with the marked floor plan, as agreed with all parties concerned.
- Trunk Cable segments must be constructed as defined in Standard ECMA-80.
- Trunk Cable must have a minimum bend radius of 250 mm when installed, and 200 mm during installation.
- Conduit used for Trunk Cable must have a minimum bend radius of 250 mm.
- The Trunk Cable must not be compressed, crimped, crushed or stretched.
- The Trunk Cable sheath must not be damaged or cut in any way to expose the metal screen.
- Protection must be provided against sharp edges or possible damage caused by work done in the vicinity of the network facility.
- Trunk Cable must be separated from radiating energy devices (i.e. high current switches and r.f. transmissions) by at least 10,0 m.
- Trunk Cable spanning an open area, must be supported at least every 3,0 m.
- Location for terminated ends of segments must conform with Service Access Guidelines as described on the following page.
- Excess Trunk Cable must be coiled (250 mm minimum radius) close to the terminated ends.
- Transceivers must be placed on the Trunk Cable at the annual marks on the sheath, these are every 2,50 m ± 0,05 m.
- When installing Trunk Cable in conduit, pull boxes must be used to house Transceivers, connectors and Terminators. For Transceivers, the pull-box must be installed so that the Trunk Cable is routed through the upper portion.
- The outer screen must be earthed once only to the nearest standard mains earth point using a 4 mm2 copper wire. This must be attached to either a barrel or Terminator connector using an earthing strap.
- Other network components and DTEs must be insulated from earth ground and conducting surfaces of the building structure.
- Trunk Cable must rest directly on a flat supporting surface to minimize the risk of sharp bends or kinks.

4.3 Service Accessibility

Where possible, connectors and Transceivers should be within 3,0 m of the floor and readily accessible from a step ladder.

For Trunk Cable installations above ceiling, access to connections Terminators and Transceivers should preferably not require moving more than a single, easily removable section of the ceiling or reaching more than 300 mm from the opening.

All connections, Terminators, Transceivers and Transceiver cable locations should be marked on floor plans during installations.

Sufficient slack should be left at the terminated ends of the segment to allow the ends to be brought within easy reach of floor level to facilitate Time Domain Reflectometer (TDR) testing.

4.4 Trunk Cable

See Standards and Specifications (section 4.2)

4.5 N Series Connector

See Manufacturers data sheet.

4.6 Tap Connector

Transceivers with tap connectors will be made available. Installation instructions will follow when the style of this connection is completed.

4.7 Barrel Connector

- Install Female to Female barrel connector.
- Insulate Barrel connectors with insulation boots. The boots must cover all metallic parts of the connection and be secured with tie wraps.

4.8 Terminator

- Install the Terminator
- Insulate the Terminator and Connector with insulation boots. The boots must cover all metallic parts of the connection and be secured with a tie wrap.

4.9 Earthing Arrangements

The outer screen must be earthed once only to the nearest standards mains earth point using a 4 mm^2 copper wire. This must be attached to either a Barrel or Terminator connector.

The local earth on equipment is isolated from the Trunk Cable earth at the Transceiver.

Note 1:

All large areas (and lengths) of exposed metal that personnel can come into contact with should also be earthed.

4.10 Data Port

The following must be ensured:

- The overall screen must be connected to the Data Port screen (e.g. steel case) by as short a tail as possible (e.g. 19 mm max.).
- Each twisted pair must remain twisted right up to termination at the 'D' type connector.
- The Drop Cable must be securely clamped to prevent it from pulling its connection outside the data port screen.
- The body of the 'D'-type bulkhead connector must take a short circuit contact to the data port screen (i.e. the steel case).

If the above is not observed, the connection will cause local radio interference and seriously degrade the signals on the Drop Cable cable.

4.11 Transceiver (MAU)

4.11.1 Transceiver with 'N'-Type Connections

Attachment at an existing 'N'-type cable joint.

Notify users that the network is going to be interrupted.

- Without touching the metal of the Trunk Cable connectors cut the tie wraps and pull back the insulation boots to expose a small section of the connectors.
- Measure the voltage on the connectors shell with respect to local earth potential.
- If more than 30 V a.c. exists, a fault exists and must be corrected before proceeding.
- Draw back the insulation boots to expose the complete connector shells.
- Connect a jump lead (copper wire of at least 4 mm^2) between the rear of each connector shell.
- Remove the barrel connector and replace with the Transceiver.

Note 2:

The 'N'-type connectors should only be hand tightened.

- Remove the jump lead from the connectors.
- Push home the insulating boots and secure with tie wraps. No part of the connectors must be left exposed.

Attachment to the Trunk Cable

Notify users that the network is going to be interrupted.

Locate the nearest convenient Transceiver tap marker on the Trunk Cable (these are bands every 2,50 ± 0,05).

Locate the nearest connector each side of the chosen marker. If there is no connector nearby, a piece of insulation may be removed at the marker chosen for the connection. This insulation should be removed carefully so that the screen does not touch earth.

Taking each of the two connectors in turn; cut the tie wrap and draw back the insulation boots to expose a small section of the connector.

Measure the voltage on each connector or the exposed screen with respect to local earth potential.

If more than 30 V a.c. exists a fault exists and must be rectified before proceeding.

Draw back the insulation boots on both connectors to expose the complete shells or remove more insulation around the marker to satisfy the connector plus room for a jump lead.

Connect a jump lead (copper wire of at least 4 mm^2) between the rear of the connector shells or across the exposed screen area.

Cut the Trunk Cable at the marker and slide the insulation boots on to each end.

Fit 'N'-Type connectors to the two ends of the cable.

Fit the 'N'-Type connectors to each side of the Transceiver.

Note 3:

The 'N'-Type connectors should only be hand tightened.

Push home the insulation boots (no part of the N-type connectors must be left exposed) and secure with tie wraps.

Remove the jump leads, relocate the boots if moved over the connector barrels and secure with new tie wraps.

A tag must be placed on the cable next to the transceiver to indicate its position on the schematic layout, or at least to indicate which Trunk Cable segment it is connected to.

4.11.2 Transceivers with Tap Connectors

As the introduction of tap connectors does not interfere with normal communications on the network there is no need to inform users of installation activity based on this method.

If the accessible parts of the tap connectors are metallic then firstly measure the voltage on the earth cable shield with respect to local earth potential. If more than 30 V a.c. exists on the cable a fault exists and must be corrected before proceeding.

If no hazardous voltages exist the tap connector is applied to the Trunk Cable as defined in the manufacturers instructions.

Any metallic parts of a tap connector which are connected to the Trunk Cable must be insulated by the application of a suitable boot. The insulation boot must then be secured by some means.

If the tap connector is fully insulating (i.e. plastic), then no precautions need be taken regarding the test for hazardous voltages, and no additional insulation boot is required.

4.12 Acceptance Checks/Tests

Responsibility

The installation personnel should be responsible for the network acceptance checks and tests.

These responsibilities are:

- Using the site plans, make a physical inspection and check that:

  The installation matches the customer approved plan.

  The installation meets all specifications.

  Verify integrity of cable by performing the acceptance tests as given in Appendix B.

4.13 Repair

The normal method of isolating specific Trunk Cable faults is to use a Time Domain Reflectometer (TDR) Cable Tester.

4.13.1 Trunk Cable

- Notify users that the network is going to be interrupted.
- Locate the position of the Trunk Cable fault as described in Appendix B.
- Proceed as indicated in 4.11.1 for attachment to Trunk Cable, up to connection of the jump lead.
- Remove (cut-out) only that portion of the cable that is defective.
- Place insulation boots onto each end of the cable.
- Follow the connector installation procedure as specified in the manufacturers data sheet.
- Insert a barrel connector between the newly installed connectors on the Trunk Cable.
- Pull the insulation boots to overlap in the middle of the Barrel Connector and secure with tie wraps.
- Remove the jump lead from the two connector barrels, relocate the boots and secure with new tie wraps.

Note 4:

No part of any of the 'N'-Type connectors must be left exposed.

- Update the Site Plan, using the connection symbol, to indicate the point of the repair.

4.13.2 Connections

- Proceed as indicated in 4.13.1, up to the connection of the jump lead.
- Remove the insulation boot from the faulty connector.
- Disconnect the faulty connector from the adaptor or Terminator.
- Cut the faulty connector from the Trunk Cable as close to the connector as possible.
- Place insulation boot onto the end of the cable.

- Follow the connector installation procedure as specified in the manufacturers data sheet.
- Remove the jump leads from the two connectors, replace the boots over the connector barrels and secure with new tie wraps.

Note 5:

No part of any of the 'N'-type connectors may be left exposed.

5. INSTALLATION TEST

5.1 Introduction

The integrity of the network hardware is crucial to the performance and reliability of the System. It is, therefore of utmost importance that the quality of the installation is ensured and proved by the results of rigorous testing.

Note 6:

The importance of cable network testing cannot be overstressed.

This Section:

- describes why rigorous and exhaustive testing is required,
- details the tests and procedures that are required to ensure that a network is continued and homogeneous.

5.2 The Need For Rigorous Testing

The characteristics of a network consisting of a number of joined lengths of Trunk Cable, together with associated network components must be as close as possible to those displayed by an equivalent, unbroken length of Trunk Cable.

All joints and terminations in the network are points of discontinuity at which reflections will take place, thus causing standing waves on the line. Badly formed joints and terminations will cause reflections of an unacceptable level.

Sharp bends in the Trunk Cable or continuous movement due to mechanical disturbances may damage the dielectric material, with resultant unacceptable signal attenuation.

5.3 Acceptance Tests

5.3.1 Trunk Cable

The simplest cable network will consist of one continuous run of Trunk Cable (see Appendix A). This should present no problems regarding points of discontinuity.

When tested with a Time Domain Reflectometer (TDR), it should display no step on the TDR's display. If the 50 Ohm Terminator had been omitted from the Trunk Cable end, there should be a very definite upwards step response on the TDR, indicating an open circuit.

Any reflection of amplitude greater that 4% will constitute an automatic rejection of the cable network. Using the distance readout, the location of the fault may be identified and remedial action taken.

If the reflection is caused by a poor joint, the faulty connector(s) must be replaced.

If reflections are caused by mechanical damage to a Trunk Cable section, it must be replaced by cable with the same characteristics, i.e. of the same drum as that installed. Alternatively, it can be replaced by one of the standard lengths.

5.3.2 Transceivers and Drop Cables

The proper functioning of transceivers, and drop cables will be verified by confirming successful transfer of data packets using two DTEs, or alternatively by special test equipment. The initial test should be carried out on the drop cable at the extremities of the Trunk Cable segment. Having thus verified the functionality of the network overall, the test will be carried out on the remaining transceiver drop cable installations. An acceptable test criterion is that a successful rate of transfer of data packets has been recorded at all access points to the network (ie. at each Drop Cable).

5.3.3 Repeaters

Two DTEs, or special test equipment may be used to test Repeaters by carrying out the same tests as above, using a drop cable-installation on the segments which are connected by the Repeaters under test. The same test criterion will apply.

All Repeaters require an a.c. power source.

6. NETWORK EXPANSION

6.1 Introduction

The characteristics of the network permits evolutionary growth. This section describes possible ways of expanding the network.

The passive nature of the network allows a DTE to be removed or relocated without affecting the operation of the network.

This benefits the User in terms of scheduled/unscheduled maintenance, and provides the flexibility to relocate equipment in any new area within reach of the network cables.

This section provides the planner with guidelines for:

- Network expansion.
- DTE expansion and/or relocation together with the associated Transceivers.
- Protecting the Trunk Cable from damage.

6.2 Expansion

When a DTE is to be installed in a new location which is beyond the range of the existing Trunk Cable, plus the maximum permissible length drop cable (50 m), the Trunk Cable system must be expanded.

Expansions must be planned and installed according to the procedures described in section 3 and 4, and the floor plan edited to reflect the expansion. In particular the rules regarding linking the earths, and that segment lengths must not exceed 500 m, should be strictly observed.

A TDR map of the extension should be marked-up to identify added features and attached to the existing TDR maps with a modified floor plan.

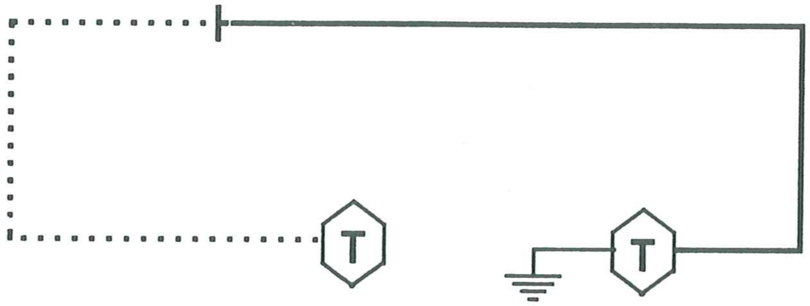
A network expansion can be achieved in one of three ways:

- Extend one end of a Trunk Cable Segment.
- Add a new Segment of Trunk Cable and link it to the existing network using a Repeater.
- Insert extra Trunk Cable in an existing Segment.

6.2.1 Extend one end of a segment

This entails moving the Terminator to the end of the new length of Trunk Cable.

- Obtain the required length of cable with connectors installed on each end.
- Remove the Terminator from the existing system.
- Connect the extension cable to the existing cable using a Barrel Connector.
- Install the Terminator on the end of the new section of Trunk Cable.
- Install Transceivers in the new Trunk Cable section to connect to the new/relocated DTE.



Extend one end of a segment.

A segment of Trunk Cable (existing plus extension) must not exceed 500 m in length, for longer lengths a Repeater must be used.

Show the addition on the floor plan as a new separate section.

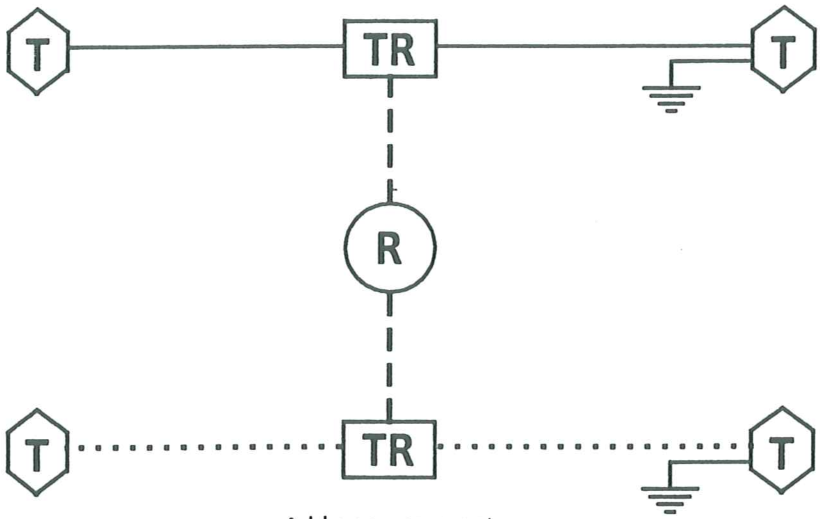
6.2.2 Add a New Segment

This is achieved as follows:

- Insert a Transceiver in the existing Trunk Cable, on a 2,5 m marker, at a point nearest to where the new segment is required.
- Install the new Trunk Cable Segment.

- Insert a Transceiver in the new segment, at a point nearest the Transceiver installed in the existing system.
- Using Drop Cables, connect the two Transceivers to a Repeater, thus linking the existing System and the new segment.
- Install Transceivers in the new Trunk Cable segment to connect to the new/relocated DTE.

Show the change on the Floor Plan as an additional segment, noting the Repeater, the locations of the terminated ends of the Trunk Cable segment and the additional DTE.



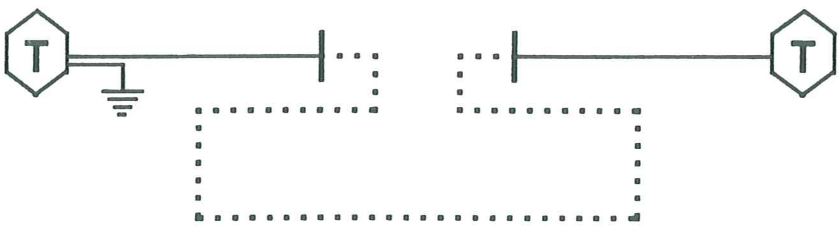
Add a new segment

6.2.3 <u>Insert a Section of Trunk Cable</u>

This is achieved as follows:

- Cut the existing Trunk Cable at the point nearest to where the extension is required (see section 2.3.2).
- Install connectors on both cut ends.
- Install the Trunk Cable extension in the new area and fit connectors on both ends if not pre-terminated.
- Attach the extension to the existing Trunk Cable, at the point where the cut was made using Barrel Connectors.
- Install Transceivers in the new Trunk Cable segment to connect to the new/relocated DTE.

Mark the change on the Floor Plan noting the position of the Barrel Connectors and the additional DTE.



Insert a section of trunk cable

6.3 Moving Transceivers

6.3.1 Transceivers with N type connections

If, for any reason, you require to move a Transceiver, this can be achieved in one of two ways, depending on whether or not a Barrel Connector is already installed at the required connection point:

At an existing 'N'-Type Connector

- Remove the Transceiver in accordance with the procedure in section 4.11, taking particular note of the instructions regarding the test for mains distribution faults and earthing requirements.
- Re-join the Trunk Cable sections using a Barrel Connector as detailed in 4.7.
- Install the Transceiver at the new location following the procedure in 4.11, i.e. by replacing the Barrel Connector with the Transceiver.

Mark the change on the Floor Plan noting the positions of the Barrel Connectors and the additional DTE.

Where an 'N'-Type Connection does not exist in the new location.

- Remove the Transceiver in accordance with the procedure in section 4.11, taking particular note of the instructions regarding the test for mains distribution faults and the earthing requirements.
- Re-join the Trunk Cable sections using a Barrel Connector as detailed in 4.7.
- Install the Transceiver at the new location following the procedure in 4.11. This involves cutting the Trunk Cable, installing Connectors on the cut ends and then connecting these to the Transceiver.

Mark the change on the Floor Plan noting the positions of the Barrel Connectors and the additional DTE.

6.3.2 Transceivers with Tap connectors

- Remove the Transceiver in accordance with the procedure in 4.11 (refer to manufacturers instructions).
- Seal any punctures in the Trunk Cable jacket with insulating tape or sealant.
- Install the transceiver in the new location following the procedures in 4.11.

Mark the change on the Floor Plan noting the position of the Barrel Connectors and the additional DTE.

6.4 Protection of the Cable Network

Deformation of the centre dielectric of a Trunk Cable can cause degradation of the network performance. This can be caused by folding, crushing, crimping or cutting the Trunk Cable.

Care must be taken to ensure no damage occurs to the network cable installation.

All persons working in the area of the network cables must be instructed to exercise caution in order to protect the cables from damage.

APPENDIX A

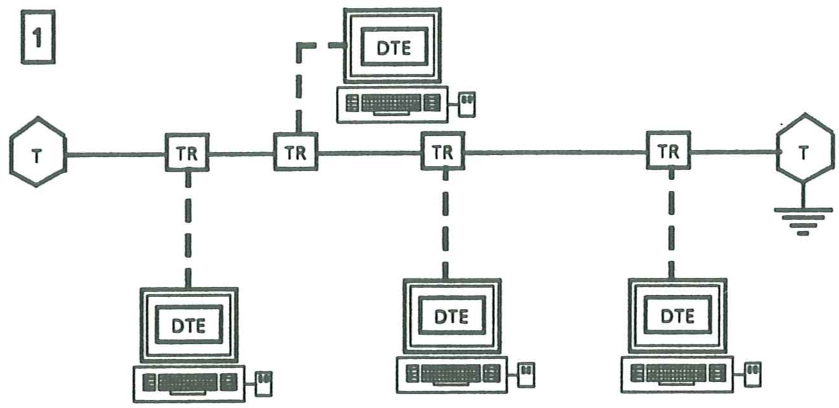
TYPICAL NETWORK TOPOLOGIES

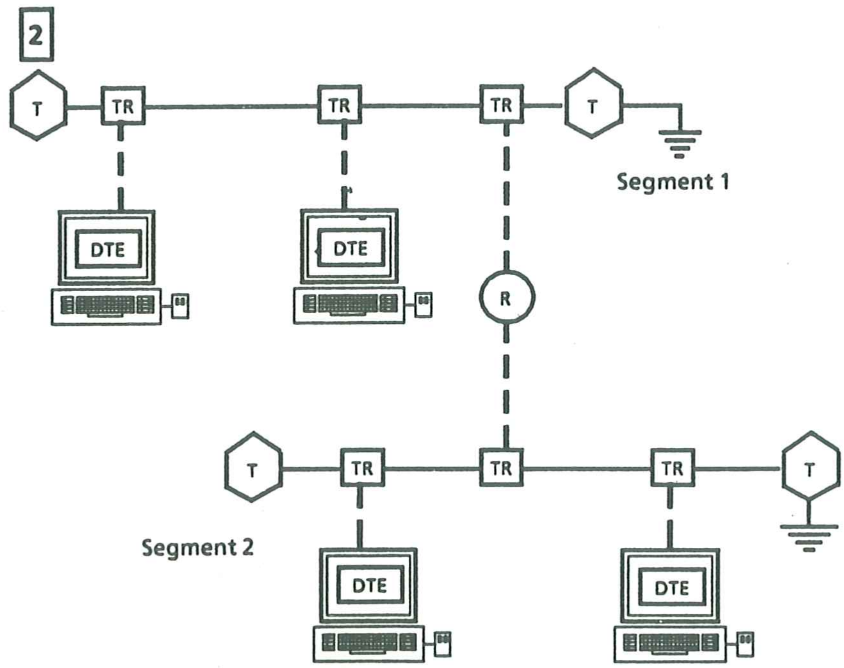
The following pages show network cable layouts with and without repeaters.

Transceivers serving repeaters may be connected at any 2,5 m marker point on the Trunk Cable, they are not restricted to the ends of Trunk Cables only.

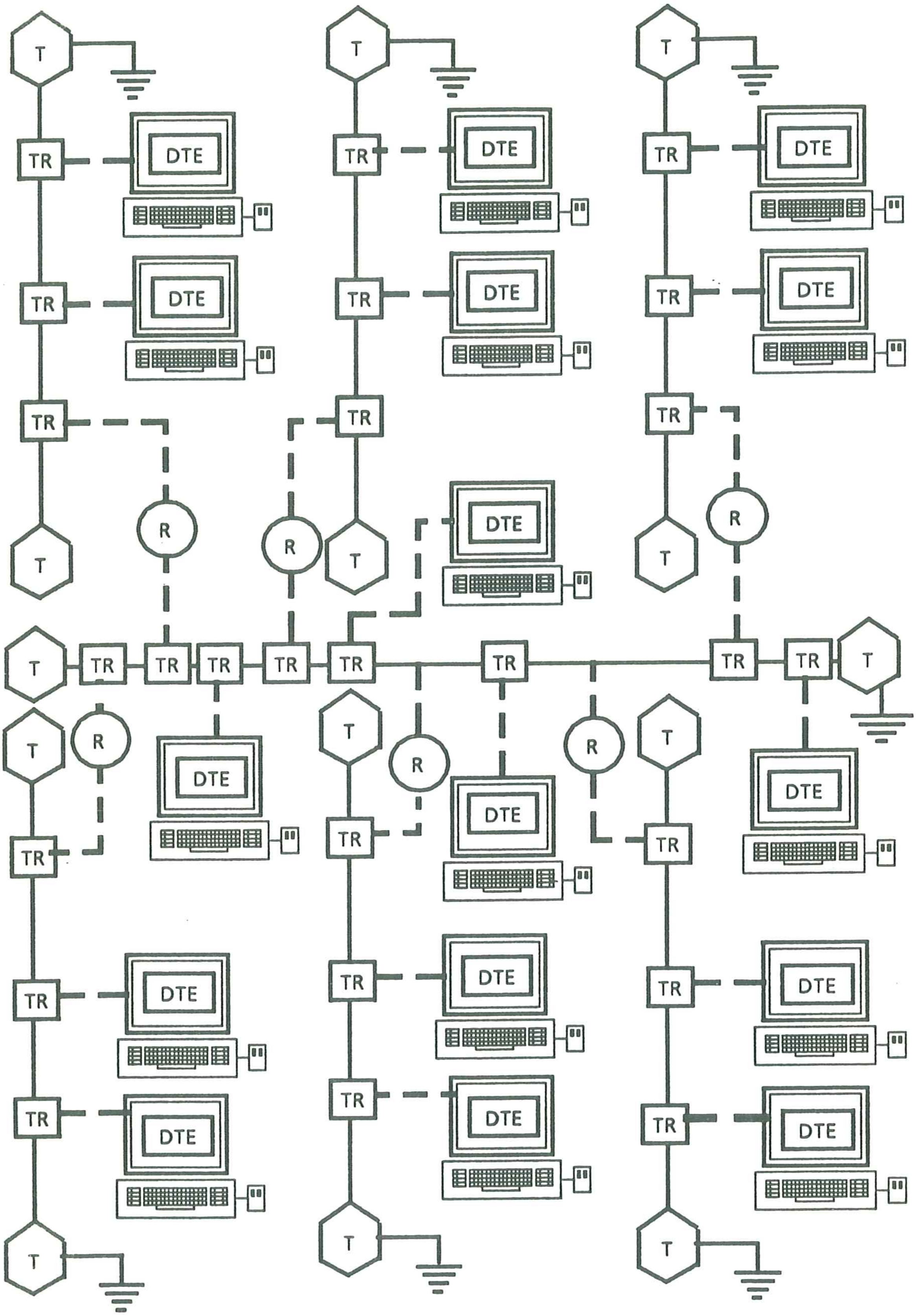
Two layouts depict multi-floor applications and show alternative uses for repeaters.

Trunk cable segment; 500 m maximum



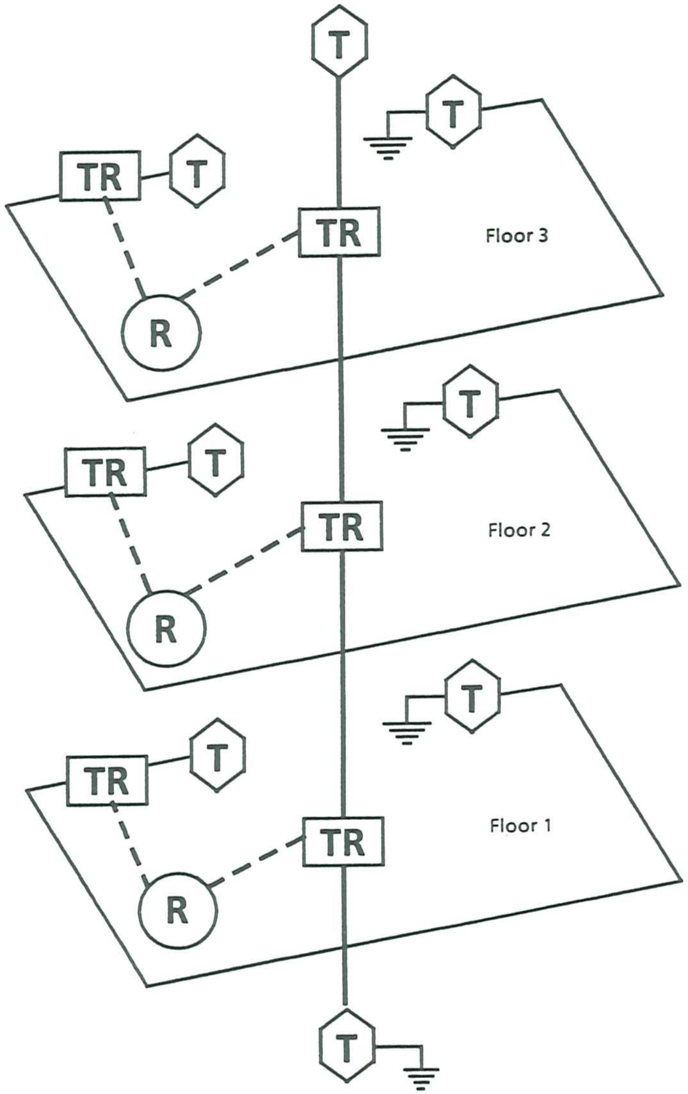


These two layouts are examples of simple passive (top) and active (bottom) network layouts. The bottom layout is active by virtue of the repeater, which requires a local mains power supply.

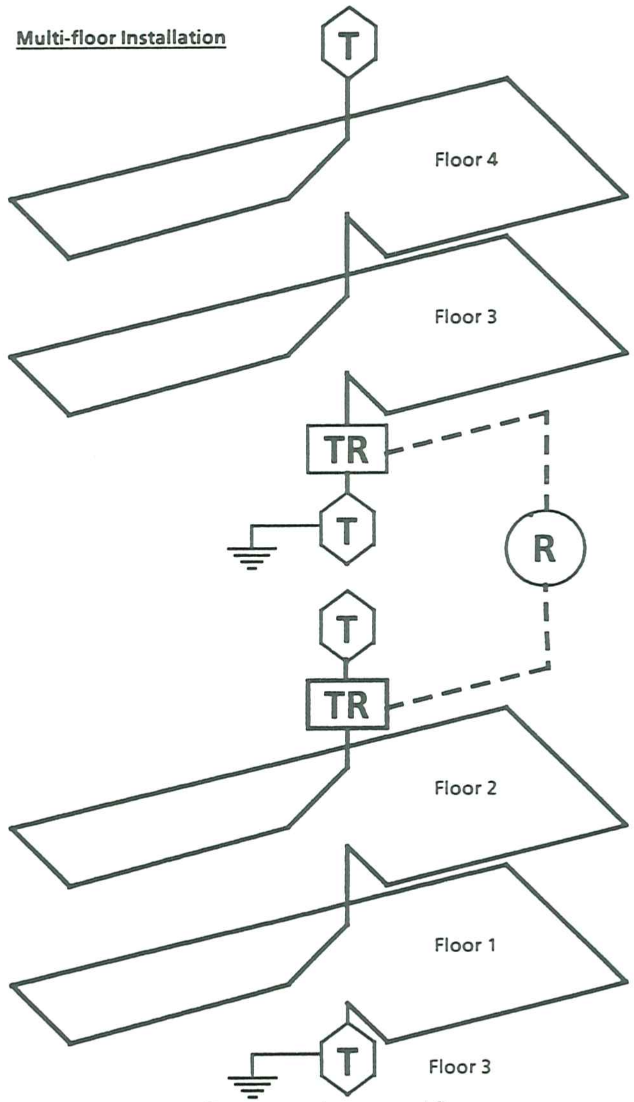


This layout is more complex, employing six repeaters; it does not however violate the rule that there will not be more than two repeaters in any station to station signal path.
Repeaters require local AC mains power.

Multi-floor Installation



One segment per floor



One segment per several floors

APPENDIX B

CABLE NETWORK ACCEPTANCE TESTS AND EQUIPMENT

Checking the Trunk Cable before Transceiver Installation

Access is needed to both ends of the Trunk Cable to check insulation and loop resistance. The remote end of the cable must have a 'high voltage warning' notice during megger tests.

Insulation Resistance

Warning: Under no circumstances connect a megger to the centre conductor of the Trunk Cable as the high voltage will destroy all attached Transceivers.

Remove the earth wire from the Trunk Cable. The insulation resistance of the screen to mains earth must be less than 200 MOhms when measured with a megger at 500 V.

Loop Resistance

Warning: If Transceivers are attached, the voltage applied between the centre conductor of the Trunk Cable and screen must not exceed ± 2 V.

Access is required to both ends of the Trunk Cable. At one end, the inner and all screens should be connected together.

The loop resistance with Transceivers attached must be measured, and must not be greater than 5 Ohm.

If Transceivers are not attached to the Trunk Cble, the loop resistance must not exceed 10 MOhm/m at 20^{o} C.

Time Domain Reflectometer Tests.

Time Domain Reflectometer Description.

The Time Domain Reflectometer sends step voltage pulses down the cable under test.

Cable faults are points of discontinuity, and cause reflections down the cable to the source where they are detected by the TDR.

The reflected voltage is superimposed on the advancing initial step, and is displayed on the TDR as a step-up or a step-down transition.

Step-up transitions are caused by inductive, or resistive faults, which have a higher resistance than the resistive component of the characteristic impedance of the Trunk Cable.

Step-down transition results from capacitive faults, or faults of lower resistance than the normal resistive component of the characteristic impedance of the Trunk Cable.

The time delay between incident and reflected pulses gives the distance of the fault from the TDR. The TDR automatically converts this time interval to a distance (in meters).

Note

Transceivers must not transmit onto the Drop Cable during the TDR testing. If this occurs the TDR input could be destroyed.

TDR Resolution and Accuracy

It is important to distinguish between resolution and accuracy as applied to a TDR.

Resolution means the minimum separation of two independent cable faults which the TDR can detect. The primary factor determining this, is the rise time of the pulses received by the TDR.

Since the rise time of any pulse is degraded by its transmission through a long cable, the resolution will be dependent upon both the TDR and the length of cable under test.

Accuracy is measure of how close the TDR distance reading is to the actual distance of the fault from the TDR.

The TDR measures the electrical 'length' from the instrument to the cable fault. To relate electrical 'length' to actual physical length, take into account the following factors:

- Cable snaking, twist and loops.
- Propagation velocity variation in a given type of cable.
- Varying propagation velocities, caused by Trunk Cable Sections from different cable batches or manufacturers.
- Accurate physical cable length measurement.

'Propagation velocity' is the speed at which a signal travels down a cable. It depends on the dielectric material used for cable insulation and the geometry of the cable cross-section.

The accuracy to which the propagation velocity is known and controlled will determine the relationship between the electrical and physical lengths.

Most cable manufacturers can control propagation velocity to within 0,5%. The same cable from different manufacturers may have a variation of 2% to 3%. It is thus desirable not to mix cable from different manufacturers, in the same segment.

Improving Distance Accuracy

The Trunk Cable causes degeneration of the TDR waveform and thus the accuracy reduces with distance.

The shorter the length of Trunk Cable between the TDR, and the point under test the more accurate will be the results.

For example, the longest passive cable run will be 500 m. If the cable cannot be broken for test purposes, the worst case situation will be a point of discontinuity at a distance of 250 m from one end (i.e. the centre of the run). This point is identifiable to within 10 m.

There are two ways to improve the accuracy of distance measurements:

- Take multiple readings.
- Since all TDR distance errors are percentage errors of the 'scan length', a good technique is to progressively reduce the distance to the fault giving a more accurate result.
- Use all available information.
- Use known point on the cable to calibrate the TDR.
- Accuracy is improved if the Trunk Cable dielectric is the same for the entire length of the cable.
- For example, if the cable propagation velocity changes at 300 m, calibrate the TDR for the dielectric of the first section and then scan for 300 m only.

Four Common Mechanical Faults

During installation the Trunk Cable may suffer mechanical damage that results in either open circuit or full short circuit.

Intermediate faults may occur due to:

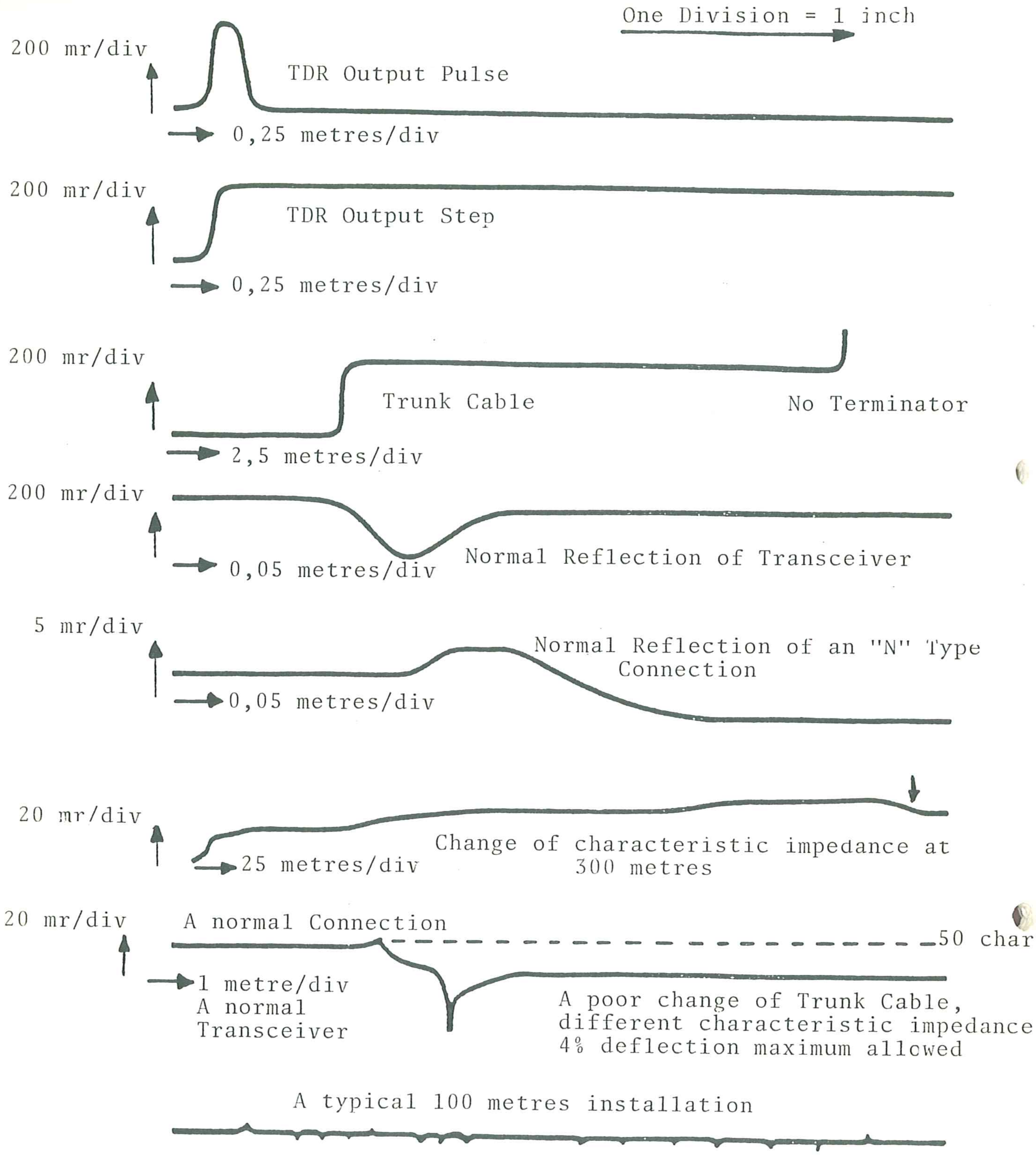
- Severe abrasion resulting in part of the sheath, screen and dielectric being worn away.
- Accidental cable crimping, resulting in a rupture to the dielectric.

Emission Levels

The installed network must comply with local codes with regard to Emission Levels.

TDR Displays

The waveforms following show examples of various TDR displays.



Note: mr = milli rho

Maximum reflection allowed at any point is 7%.
Maximum reflection from any single feature to be no more than 4%.

Features on the TDR maps of each trunk cable section should be identified and made available with the floor plan to the site engineer.

APPENDIC C

LAN INSTALLATION IN MULTIPLE BUILDINGS

Most LAN are installed in one building which is served by a single mains power supply, and are not exposed to very large interference voltages.

A LAN which is installed in more than one building, or which is supplied from more than one mains power supply transformer, may be subject to highest interference which could cause malfunction, equipment damage and safety hazards. Not all LAN equipment is designed to withstand these more severe conditions, although it would be perfectly satisfactory for the great majority of installations.

Guidance is given on the above matter, including suitable equipment safety design and installation procedures for more severe conditions in ECMA TR/19 (Technical Report on Safety Considerations for LAN).

Copies of ECMA TR/19 can be obtained free of charge from:

ECMA
114 Rue du Rhône

CH-1204 GENEVA
Switzerland