VOLUME 9 **NETWORK - TRAFFIC CONTROL AND COMMUNICATIONS**

SECTION 4 **SYSTEMS DESIGN**

PART 4

TA 75/97

MOTORWAY TRANSMISSION DESIGN

SUMMARY

This Advice Note contains detailed descriptions of the local and national transmission networks required for motorway communications. It also provides details on the design and requirements of Transmission Stations, and explains the importance of maintaining the operational integrity of the transmission network.

INSTRUCTIONS FOR USE

This is a new document to be inserted into the Manual.

1. Insert TA 75/97 into Volume 9 Section 4.

2. Archive this sheet as appropriate.

Note: A quarterly index with a full set of Volume Contents Pages is available separately from the Stationery Office Ltd.

THE HIGHWAYS AGENCY

THE SCOTTISH OFFICE DEVELOPMENT DEPARTMENT

THE WELSH OFFICE
Y SWYDDFA GYMREIG

THE DEPARTMENT OF THE ENVIRONMENT FOR NORTHERN IRELAND

Motorway Transmission Design

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Volume 9 home page

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Contents

Chapter

1. INTRODUCTION

General

1.1 This Advice Note contains detailed descriptions of the local and national transmission networks required for motorway communications. It also provides details on the design and requirements of Transmission Stations, and explains the importance of maintaining the operational integrity of the transmission network.

Scope

1.2 This Advice Note is applicable to the cable network to be installed for the National Motorway Communications Systems, within motorway communications, motorway construction and motorway improvement schemes.

1.3 The specific requirements for each Overseeing Organisation are contained in the relevant Annex to this Advice Note. They are as follows:

Annex A for England

Annex B for Scotland

Annex C for Wales

Annex D for Northern Ireland.

1.4 This Advice Note is intended to be used by Overseeing Organisation staff, their consultants, Agents and maintenance contractors.

Related Standards and Advice Notes

1.5 There are no Technical Directives related to transmission networks.

1.6 The following Advice Notes are of relevance:

TA 70: Introduction

TA 71: Design and Implementation (Overview)

TA 72: National Motorway Communications Systems (NMCS)

TA 77: Motorway Infrastructure Design

Implementation

1.7 The appropriate Annex should be used forthwith on all motorway communications, motorway construction and improvement schemes currently being prepared, provided that, in the opinion of the Overseeing Organisation, this would not result in significant additional expense or delay progress. Design Agents should confirm its application to particular schemes with the Overseeing Organisation.

2. REFERENCES

TA 70: Introduction (DMRB 9.2.1)

TA 71: Design and Implementation (Overview) (DMRB 9.3.1)

TA 72: National Motorway Communications Systems (NMCS) (DMRB 9.4.1)

TA 77: Motorway Infrastructure Design (DMRB 9.5.1)

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VOLUME 9a NETWORK - TRAFFIC CONTROL AND COMMUNICATIONS

SECTION 4 SYSTEMS DESIGN

PART 4

TA 75/97 Annex A (England Only)

MOTORWAY TRANSMISSION DESIGN

Contents

Chapter

A1. INTRODUCTION

A1.1 General

1. This Annex is for the specific requirement of motorway communications in England.

DMRB Structure

2. Section 1 of Volume 9 of the Design Manual for Roads and Bridges (DMRB) contains Technical Directives (TD) which detail the Standards of Provision.

3. Section 2 onwards contains Technical Advice (TA) Notes which reflect current practice in the field of motorway communications and control.

Design Loop

4. Figure A1.1a shows the 'Design Loop' illustrating the general sequence in the iterative design process which starts with the design for emergency telephones and signals followed by transmission and Control Office designs. Last in the cycle is the design of the infrastructure that will be required to support all communications equipment and systems.

Glossary

5. A Glossary of Terms is given in Chapter A9.

Standard Drawings and Specifications

6. Standard MCX and MCY drawings and MCH and TR specifications are issued by Network Control Division (NCD) of the Highways Agency (HA).

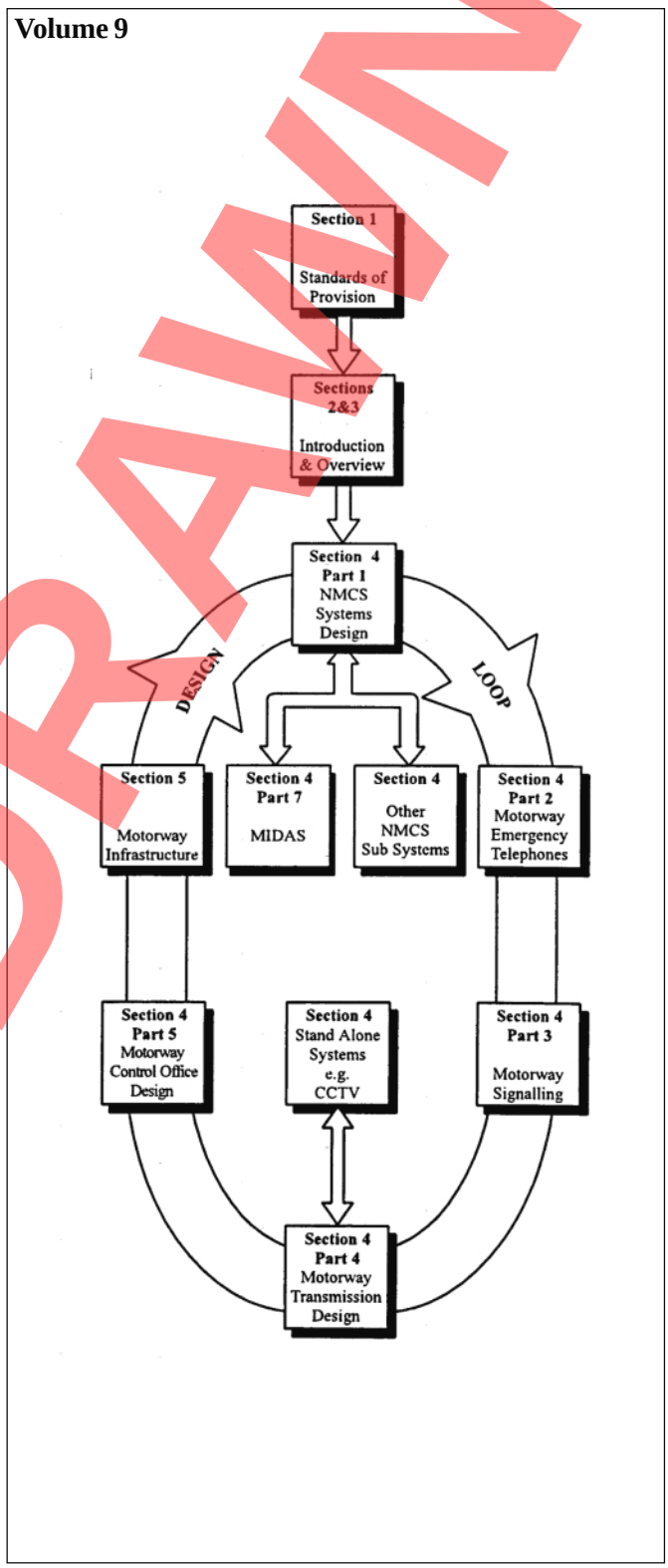

Figure A1.1a Structure of Volume 9 of the Design Manual for Roads and Bridges

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A2. SYSTEM OVERVIEW

A2.1 General

1. Motorway equipment such as telephones and signals is connected by transmission networks to computers and control equipment, which are generally located in Control Offices. There are two systems currently in use in England - National Motorway Communications System, first generation (NMCS1) and second generation (NMCS2). The Highways Agency (HA) is responsible for transmission networks in England and has a rolling programme for the upgrading of NMCS1 to NMCS2.

Transmission Networks

2. Transmission networks exist at three levels and there are different networks for NMCS1 and NMCS2. The three levels are:

(i) National

(ii) Control Office (CO) Area

(iii) Local (to equipment)

3. National Networks are purely for data. CO Area and Local Networks carry data, speech and video signals.

4. It is essential that any work taking place on these networks is planned such that disruption is kept to the absolute minimum.

Transmission Stations

5. Transmission Stations (TS) are provided throughout the motorway network for signal amplification, connection to transmission networks, multiplexing and demultiplexing audio and data. They house equipment consisting of High Frequency Carrier (HFC) equipment, both 12 channel and sub-equipped (mini-carrier) and Pulse Code Modulation (PCM) equipment. The distance between adjacent TSs should not exceed 20 km. TS equipment is housed either in a building or in a Cabinet Type 617.

Transmission Records

6. The HA is responsible for keeping Transmission Records for each CO Area. These contain details of all circuits between TSs and also the equipment contained within TSs.

Longitudinal Cables

7. A cable network is provided to support NMCS1 and NMCS2.

8. Where a ducted network is installed the longitudinal cable network comprises a 40 pair cable, and a 24 fibre optical fibre cable.

9. Where the network is direct buried armoured cable, the longitudinal cable is a 20 pair or 30 pair cable; a longitudinal optical fibre cable will not be provided as standard.

A3. NMCS2

A3.1 National Network

1. When NMCS2 is fully implemented there will be a packet switched Wide Area Network (WAN) linking Regional Communications Controllers (RCC) and a central fault logging facility (CENLOG). This will allow all NMCS2 COs to communicate with each other.

2. MCH 1627 summarises how the network will be set up, and upgraded from NMCS1 to NMCS2.

3. For further information on the RCC network contact the Highways Agency.

A3.2 Control Office Area Network

Data Network

1. Within the CO Area there are two High Level Data Link Control (HDLC) data links:

(i) A point to point link between the CO and the Local Communications Controller (LCC).

(ii) A multidrop link on each port of the LCC to take information to and from Standard Transponders.

2. On longitudinal cable HDLC data links are 4-wire circuits (Control and Reply) loaded with 22mH coils at nominal 1000m intervals. RS485 links from Transponder to equipment are 2-wire circuits, with a maximum length of 4km.

Telephone Network

3. When 30-pair and 40-pair longitudinal cable is used, up to six 2-wire telephone lines are available between the CO and its Telephone Responders. 40-pair longitudinal cable will provide up to six 4-wire lines for this purpose when 4-wire telephones and transmission equipment are available.

4. The telephone network uses Sector or Block Interface Equipment containing Sector Switches to switch individual lines to Telephone Responders. A full description of 'Sectoring' is contained in TA 72/95: National Motorway Communications Systems. With 4-wire telephones, the Sector Interface Equipment also amplifies telephone line levels.

5. Telephone circuits are loaded with 88mH coils at nominal 2000m intervals on the longitudinal cable pairs.

A3.3 Local Connections

Data Connections

1. A 2-wire RS 485 multidrop link is required to link the motorway devices, such as signals, to the Standard Transponder. These circuits are unloaded and have a maximum transmission distance of 4km.

Telephone Connections

2. 2-wire circuits are provided from the telephones to the Telephone Responders. These circuits are unloaded and have a maximum transmission distance of 3.2km.

A3.4 Signalling and Data Rates

1. NMCS2 data transmission is entirely digital. Information on the components of the network is contained in TA 72/95: National Motorway Communications System. Further details are contained in NMCS specifications listed in Table A3.4a.

Specification	Title
TR 1329	Phase 3 Telephone Data Transmission
TR 1330	Telephone Responder
TR 1334	Sector Interface
TR 2045	Standard Transponder
TR 2046	Local Communications Controller
TR 2049	HDLC Point to Point Communications
TR 2066	HDLC Multidrop Communications
TR 2067	RS 485 Communications
TR 2070	Message Control

Table A3.4a

2. The NMCS2 Phase 3 Telephone System uses 50 baud signalling centred at 2600Hz within each audio channel. It is filtered out at each end of the circuit.

3. NMCS2 data transmission data rates, protocols and uses are given in Table A3.4b.

NMCS2 Data Transmission

Level	Protocol	Bit Rate Details	Use
National	HDLC X.25 Level 3	9.6k kbits/s Asynchronous Packet Switched Network	1)CO to RCC 2)RCC Network 3)CO to Central Logging
CO Area	HDLC X.25 Level 2	9.6k kbits/s Full Duplex Asynchronous Point to Point	CO to LCC
		2.4k bit/s Half Duplex Asynchronous Multidrop	LCC to Transponder
Local	RS 485	2.4k kbit/s Half Duplex Asynchronous Multidrop	Transponder to Device

Table A3.4b

A4. NMCS1

A4.1 National Network

1. NMCS1 has a national high frequency carrier (HFC) network linking the Central Processors (CP) at Coleshill and Westhoughton with all Control Offices (CO). This system is also known as the Main Line Carrier Network. A National Carrier Maintenance Contractor (NCMC) is employed by the Highways Agency (HA) to maintain this network.

2. The Main Line Carrier Network is used to provide data transmission circuits between the CP and the carrier terminal associated with a particular CO. At the carrier terminal the data is split into that for the CO 304 minicomputer equipment at the CO, and that for the CO Area data network (Main Data circuit). The carrier termial is located within a Transmission Station (TS).

3. The carrier network consists of two rings forming a 'figure of 8', with additional rings in the Midlands, North East and North West. There are also some spur links to COs. The carrier network is on unloaded pairs in the longitudinal cable. The figure of 8 allows dual routing of the network. If any work is planned that will affect this dual routing, prior permission to carry out the work must be obtaied from the NCMC. This is to ensure that no part of the network is isolated because of cable breaks or ongoing work elsewhere on the network.

4. The national network is shown on drawings MCY 0310 and MCY 5070.

A4.2 Control Office Area Network

Data Network

1. Within the CO Area the data network uses a 4-wire circuit (Control and Reply) connected as a multidrop link between the carrier terminal Transmission Stations (TS) and the NMCS1 Responders.

2. Installations before 1987 used two 4-wire circuits. The first 'Main Data' connected 'Local Data' between the carrier terminal and TSs, the second between the TS and the Responders. This practice was discontinued in some CO areas to free pairs in the longitudinal cable.

3. Data circuits are known variously as Main or Main/Local Signal Data Circuits or the Responder Data Link. These circuits are loaded with 22mH coils at nominal 1000m intervals on the longitudinal cable.

4. MCL 5504 and MCL 5505 give further information on the data network for NMCS1.

NMCS1 Telephone Network

5. There are four telephone lines per Responder group. They are taken back from the network to the CO via a dedicated link, which is often a Private Wire (PW). A pair is allocated in the longitudinal cable for each line. These circuits are loaded with 88mH coils at nominal 2000m intervals on the longitudinal cable pairs.

6. In many CO areas a mini-carrier system is used to increase the communications capacity of the local network. This allows telephone circuits at the distant ends of the local network to be multiplexed together. This technique frees pairs in the longitudinal cable that can then be used for sections closer to the CO connections node. The cable pairs used for the mini-carrier are unloaded.

A4.3 Local Connections

Signal Data Connections

1. 9 cable pairs are required to make each connection to a signal from a parallel Responder. The cable pairs are unloaded and there is a maximum cable length of 1060m.

Telephone Connections

2. A 2-wire circuit is required from each Responder to each telephone. The cable is unloaded. The maximum length of this cable is 2.5km for NMCS1 Responders (700 Series) or 3.2km for NMCS1 Telephone Only Responders.

A4.4 Signalling and Data Rates

1. The CCITT channel frequencies in Tables 4.4a, b and c are used for NMCS1. This shows the allocation for a CO Area with two Responder groups (RG1 and RG2). For a CO Area with only one Responder group, RG2 references should be ignored.

2. When a CO Area has two Responder groups it is necessary to shift the frequencies for RG2 to channels not used by RG1. This is done in the RG1 area or, more normally, to allow Responder data to be combined onto a mini-carrier channel. The Responders are only set up to operate with the tones and modem bandwidths of RG1 channels. Therefore Data Frequency Changing (DFC) equipment is installed at the Transmission Stations where RG1 ends and RG2 starts.

3. The 420Hz Interrogation Request Tone generated by Responders is being phased out.

4. An operational description of NMCS1 is contained in TA 72/95: National Motorway Communications Systems.

5. For transmission level information refer to the HA.

50 Baud Channel - Control Direction

Channel	Tone Frequency	Use
102	540Hz	Telephone Calling Tone (TCT) Lines 5 to 8
103	660Hz	Transmission Integrity Tone (TIT)
104	780Hz	TCT Lines 1 to 4

Table A4.4a

50 Baud Channels - Reply Direction

Channel	Tone Frequency	Use
101	420Hz	Interrogation Request Tone (IRT) Sub-group 1 IRT 1 - RG1 Responders to CP RG2 - DFC to CP and/or Responders to DFC
102	540Hz	IRT 0 - RG1 Responders to CP RG2 Responders to DFC
103	660Hz	IRT 1 - RG1 Responders to CP DFC to CP and/or RG2 Responders to DFC
104	780Hz	IRT 0 - RG2 DFC to CP

Table A4.4b

200 Baud Channels - Control and Reply Directions

Channel	Centre Frequency	Use
402	1080Hz	Control Office data
403	1560Hz	Remote Engineers Terminal Data
404	2040Hz	RG1 data between Responders & CP RG2 data between Responders & DFC
405	2520Hz	RG2 data between DFC & CP
406	3000Hz	Supervisory data (HF carrier monitoring etc)

Table A4.4c

A5. SYSTEM DESCRIPTION

A5.1 Analogue Carrier Circuits

Overview

1. Carrier circuits are not provided within the longitudinal 40 pair cable. Where carrier circuits are required, a separate carrier quad cable or cables are provided for this purpose. Where the longitudinal cable is 30 pair, the carrier circuits are catered for within the 30 pair cable.

2. Carrier circuits provide extra signal capacity on a cable pair. This is achieved by using Frequency Division Multiplexing (FDM) techniques to provide twenty four 4kHz bandwidth 'channels' on one unloaded cable pair. To achieve full duplex communication, 12 + 12 channel carrier systems to the International Telegraph and Telephone Consultative Committee (CCITT) recommendation G.325 are used.

3. The 4kHz channel bandwidth can accommodate a telephone line circuit or an NMCS1 main data circuit:

(i) All NMCS1 and NMCS2 telephone channels require a frequency band width of 300Hz to 3400Hz;

(ii) To combine all the 50 and 200 baud NMCS1 data channels listed in 4.4 would require a frequency band from 370Hz to 3120Hz (ie 50Hz less than Channel 101 tone to the top frequency of Channel 406).

4. The carrier system itself requires a frequency band of 6kHz to 108kHz. To achieve this bandwidth the cable pairs used are unloaded and the signal is amplified at every Transmission Station.

5. Carrier equipment is used in two different ways:

(i) High Frequency Carrier (HFC) to provide the national communications network;

(ii) Mini carrier,

(a) to compensate for long speech lines on a motorway,

(b) to provide extra capacity in an NMCS1 CO Area,

(c) to transmit NMCS1 data to a CO Area that is off the national network,

(d) inter CO telephone links.

HF Carrier

6. HF Carrier is used to provide data communication between the Central Processors (CP) at Westhoughton and Coleshill and NMCS1 Control Offices. A national figure of 8 HF carrier network exists. MCY 5070 shows how the National Data link is configured. All HF carrier terminals are in Transmission Station buildings.

7. The criteria for providing HF carrier circuits are as follows:

(i) Where more than three main signal data circuits are required along a section of motorway;

(ii) Where the length of 22mH loaded cable between the Central Processor (CP) and the first transmission station associated with the local signal data circuits exceeds 100 km. This is to limit absolute delay and group delay distortion.

8. First line maintenance of HF carrier is by the National Carrier Maintenance Contractor (NCMC).

Mini Carrier

9. The maximum transmission loss in a telephone circuit in a CO area should not exceed 10dB. By using channels in a mini carrier system, which because the system is regularly amplified, do not suffer appreciably from loss, this problem can be overcome. In an NMCS1 CO area, channels 5 to 8 are used for 4-line working and channels 1 to 8 are used if 8-line working is required.

10. Mini carrier might be used to link telephones and data from a remote section of motorway isolated from its CO by motorway in an adjacent CO area. This may include NMCS2 telephone circuits.

11. A mini carrier channel can also be used to distribute CO Responder group data.

12. In some parts of England mini carrier is used to provide an Inter Control Office Link. This is a dedicated telephone line between adjacent COs.

13. A typical mini carrier system is made up of two terminals A and B comprising channel, group translating and line equipment. Where it is necessary for it to operate over longer distances, repeaters are installed. Some sites include frequency changing equipment where the circuit (channel) needs to be re-routed onto another channel to avoid power level conflicts.

14. Most mini carrier systems do not require the full 12 channel capability and operate as 6 + 6 systems.

15. All mini carrier equipment can be located in either a Transmission Station building or a cabinet Type 617 Transmission Station.

16. First line maintenance of mini carrier system is by the specialist Regional Maintenance Contractor (RMC).

A5.2 Pulse Code Modulation

1. Pulse Code Modulation (PCM) circuits provide additional signal capacity by the use of optical fibres. This is achieved by using Time Division Multiplexing to provide 30 Duplex 4KHz bandwidth channels in a 2Mbit/s system.

2. 2Mbit/s systems can be combined. Currently 8Mbit/s are used.

3. PCM is used in two different ways:

(i) To provide national communications;

(ii) To provide local communications:

(a) to compensate for long speech lines;

(b) to provide extra capacity in an NMCS1 CO Area;

(c) inter CO telephone links.

4. Where PCM is provided it is used as a main data and telephone link with local copper communications cable to equipment.

5. First line maintenance of fibre optic PCM is by the National Carrier Maintenance Contractor (NCMC).

A5.3 Cable Loading and Line Terminations

Overview

1. The various signals carried on longitudinal copper communications cables require the cables to have certain characteristics. These vary from minimum loss for telephone circuits to maximum bandwidth for carrier circuits.

2. MCL 5502 describes line transmission principles as applied to copper communications cables on motorways. Cables are mainly capacitive and consequently for a given length of cable, an increase in frequency will produce an increase in attenuation. By adding inductance in the form of loading coils at regular intervals, a relatively constant attenuation/frequency characteristic over a given bandwidth can be produced.

3. Impedance matching of transmission links is important if they are to function correctly. This is done at equipment connections by nature of their specification, or at the end of the transmission link by a close tolerance termination resistor.

Cable Loading

4. Longitudinal telephone circuits for both NMCS1 and NMCS2 have a bandwidth of 300Hz to 3000Hz with a loss of approximately 0.2dB/km. This is achieved by loading the cable with 88mH coils at nominal intervals of 2km.

5. Longitudinal cable pairs (NMCS1 main data and NMCS2 HDLC multidrop) have a bandwidth of 200Hz to 8000Hz with a loss of approximately 0.4dB/km. This is achieved by loading the cable with 22mH coils at nominal intervals of 1km.

6. It is not necessary to load local telephone and data links because of their short length.

7. It is not possible to load carrier pairs to improve their frequency characteristics because of the large bandwidth required for these circuits. Where the longitudinal cable is a 40 pair cable and quad cables are used for carrier, the carrier pairs are joined using insulation displacement type connectors (IDC). Where 20 and 30-pair cables are used, the carrier pairs are soldered through at cable jointing cabinets.

8. Further details of cable loading, how to design cable loading patterns and how to use build-out capacitors in conjunction with loading frame arrangements to compensate for short lengths of cable, are contained in the TA 77/95: Motorway Infrastructure.

Line Terminations

9. When a circuit is terminated, either at equipment or at the end of a line, the 'power' of signal on that circuit is recovered by placing an impedance across that line. This power, or level, is at its maximum when the line termination impedance is matched to the characteristics of the cable. If there is no equipment at the end of a line, which is the case on a multidrop circuit, then a termination resistor is placed at the end of the line across the cable pair. This termination resistor is of the value of the line impedance (matched) and so absorbs the 'power' of the signal. Also, because the resistor is matched there are no problems with signals being reflected back along the line.

10. Table A5.3a shows the resistors used and where they are located.

Resistor Value	Circuit	Location
600Ω	NMCS1 Main signal Data	Control Office Area Limit (Marshalling Cabinet)
	NMCS2 HDLC Multidrop	Control Office Area Limit (Marshalling Cabinet)
140Ω	NMCS2 RS 485 Transponder Ports (30 pair)	Port 0 Pair 21 at furthest point (max 4km) Port 1 Pair 21 at furthest point (max 4km) Port 2 At Transponder Port 3 Dependent on application
140Ω	NMCS2 RS 485 Transponder Ports (40 pair)	Port 0 Pair 3 at furthest point (max 4km) Port 1 Pair 3 at furthest point (max 4km) Port 2 At Transponder Port 3 Dependent on application

Table A5.3a Termination Resistors

11. For 2-wire telephone circuits 1200Ω impedance matching is used. For 4-wire circuits, which includes Private Wire circuits, 600Ω is used. For NMCS2 600Ω matching for Sector Interface Equipment and Telephone Responders is set at the factory.

A5.4 Telemetry System

Overview

1. Throughout the National Network is a Telemetry System which is carried on two 22mH loaded cable pairs in the longitudinal cable, and by National Carrier back to Coleshill where the Telemetry Master Station is located.

2. The telemetry system allows maintenance engineers to access information held on a computer at the Coleshill Computer building from a laptop computer known as a Remote Engineers Terminal (RET). The issue of RETs and the access procedure are strictly controlled by the Highways Agency. RETs contain modems that allow them to be used via the Public Switched Telephone Network (PSTN) or from special jack sockets installed at Transmission Stations (buildings and cabinets) from the motorway cables.

Telemetry Information

3. The telemetry system itself monitors alarm conditions at Transmission Stations (TS) and at selected Control Offices. These conditions vary from signal failure (very useful for pinpointing a cable break to a section of cable), to recording that the TS door has been opened. The telemetry system also monitors additional equipment such as radio, mini carrier and fibre systems.

4. Other facilities include an engineer's notice board.

5. Full access to NMCS1 CP fault logs can also be obtained by use of the RET and PSTN modem by direct link to the CPs, though 'on line' connection cannot be made.

Maintenance

6. Maintenance of the telemetry system is by the NCMC.

A6. DESIGN PROCEDURES

A6.1 Design Responsibilities

General

1. The design responsibility for the National Motorway Communications System (NMCS) Transmission Network lies with the Highways Agency (HA). Where schemes will amend or affect the transmission in any way, Project Managers should follow the procedures detailed in MCH 1593.

MCH 1593

2. This instruction details the information required by the HA's Transmission Branch when a change to, or re-configuration of, the communications network is required.

3. The Operating Unit should submit the relevant form (MCH 1628 - MCH 1632) detailing scheme requirements at the earliest stage.

Design Liaison

4. During the design stage it is essential that close liaison between the Project Manager and the HA's Transmission Branch is maintained to assess and monitor the scheme's impact on the network.

5. To enable the scheme to progress to completion with the least amount of disruption, an agreement between the HA's Transmission Branch and the scheme/ project group is required and will cover the mutual responsibilities and timescales for the completion of tasks. This agreement may need to be modified as the scheme progresses.

Transmission Works Team

6. In addition to maintaining the National Transmission Network, the HA's Transmission Branch design, co-ordinate and install new or updated equipment, termination arrangements and network links. These tasks are achieved by the Transmission Works Team.

7. Typical examples of their work would be network rearrangements for NMCS2 changeover, equipment trials, and NMCS1 responder group transmission alterations.

Transmission Records

8. To provide and maintain a reliable and effective transmission infrastructure, it is important that up to date records are accurately maintained and copies forwarded to the HA.

A6.2 Maintenance Responsibilities

1. The HA's Transmission Branch have overall responsibility for the provision and performance of the National Transmission Network. Before any infrastructure can be added to or removed from the network, sufficient notification should be given to the Highways Agency. This allows arrangements to be made with the National Carrier Maintenance Contractor (NCMC) to take the circuits into or out of maintenance.

2. The NCMC carries out all maintenance of National Carrier Network circuits, fibre optic multiplex equipment, the telemetry system and radio systems. They are also responsible for the safe and efficient operation of Transmission Stations (TS).

3. The specialist Regional Maintenance Contractor (RMC) is responsible for the mini-carrier systems (see MCH 1453), NMCS2 Sector Interfaces, and local transmission both on the longitudinal cables and on local cabling to devices.

A6.3 Transmission Records

1. Transmission Records exist for every Control Office (CO) area. They have been prepared by the HA's Transmission Branch and the NCMC with input from the Operating Units, RMCs and scheme designers. The NCMC is responsible for updating the records, and keeping them available as CAD drawings.

2. Each CO area is allocated a block of unique MCL six figure drawing references by the Highways Agency. The Transmission Records typically contain the following information.

(i) National cable pair allocations between Transmission Stations (TS);

(ii) Regional Area NMCS1 data and telephone circuit overviews;

(iii) Regional Private Wire (PW) details;

(iv) Regional mini carrier allocations;

(v) Regional data circuits (NMCS1 & NMCS2);

(vi) Regional telephone circuits (Phase 1, 2 & 3);

(vii) Details of circuit arrangements with transmission Stations, including Fog and Telemetry;

(viii) CO and TS site locations and floor plan layouts;

(ix) TS equipment rack layouts.

A6.4 Standard Drawings

1. Standard drawings for installation and terminations are contained in TRH 1239 (MCX Drawings).

A7. TRANSMISSION STATION DESIGN

A7.1 Equipment Requirements

1. Transmission Stations (TS) are provided to support the national infrastructure for motorway communications. They are equipped to national common standards and are maintained by the Highways Agency under national contracts.

2. Equipment may only be installed in TSs with prior agreement from the HA's Transmission Branch.

3. The types of equipment presently allowed to be sited within TS are as follows:

(i) National Carrier and Pulse Code Modulation (PCM) transmission equipment;

(ii) Local audio amplifying and hybriding equipment;

(iii) Local Data Frequency Changing (DFC) and Interrogation Request Tone (IRT) equipment;

(iv) Transmission Telemetry equipment;

(v) Microwave radio transmission equipment;

(vi) Closed Circuit Television (CCTV) Transmission equipment;

(vii) NMCS2 Communications Controllers and Sector Interfaces.

4. All equipment racks/cabinets should have a maximum footprint of 600mm x 600mm coincident with a tile.

5. The height of all equipment racks/cabinets should not exceed two metres.

6. The maximum number of equipment racks/cabinets to be housed in any TS should be agreed with the HA's Transmission Branch. The proposal for any new racks/cabinets should be made to the HA's Transmission Branch in the form of a marked floor plan MCL 3035 (old buildings) or MCL 3036 (new buildings) for each site. These should show the existing and proposed rack positions.

7. Equipment housings may not be fixed to TS walls.

8. Should equipment cabinets require a protected dc supply, this should be sought in advance of tendering. The information provided should indicate the maximum load required for the batteries. The dc fuse position should be allocated by the HA's Transmission Branch.

9. Any mains inverters connected to the dc/battery supply should be specified so they do not inject more than 100 mV of noise back to the batteries (when measured as a wideband reading) and less than 10 mV (when measured as a psophometrically weighted reading).

10. The maximum current drawn by a single rack/cabinet connected to a dc/battery supply during normal 'mains on' conditions should not exceed 20 A. (This does not include the quiescent current of any mains inverters, which should be negligible.)

11. The maximum current drawn by a single rack/cabinet connected to the dc/battery supply for protection during a mains failure condition should not exceed 50 A.

12. It may be necessary for the dc/battery supply of the TS to be upgraded. This will be carried out by the HA, but funding should be provided from the scheme.

13. Any new equipment requiring an ac mains supply will require an allocated ac fuse position from the HA's Transmission Branch. Should no ac fuse position be available, funds should be available from within the scheme to upgrade the ac distribution.

14. New TS buildings to MCL 10470 (post October 1991) are designed to have an internal ambient temperature range of 10 degrees C minimum to 30 degrees maximum (measured 1.9 metres above floor level). The maximum temperature in the old type TSs cannot be specified. It may therefore be necessary for a wall mounted air conditioning unit to be installed as part of a scheme to install new equipment. This should be decided by the Design Agent prior to tendering. The appropriate course of action, funded from the scheme, should be agreed with the HA's Transmission Branch prior to any construction.

A7.2 Cable Terminations

Fibre Optic Terminations

1. Where motorway fibre optic cables are brought into TS buildings they should be terminated within an optical distribution cabinet as detailed on MCX 0863. This cabinet is not bulk purchased and should be included as part of the cabling scheme for which it is being used.

2. All fibres within the optical distribution cabinet should be terminated in connectors.

3. All equipment connecting through the optical distribution cabinet should use connectorised joints. All connectorised pig tails within the cabinet and patch cords connecting with Transmission equipment should be assembled by an approved company.

4. When testing the longitudinal fibres connected through optical distribution cabinets, the connectorised joints should also be tested.

Copper Cable Terminations

5. All copper cables should be terminated in a Marshalling cabinet. They should be terminated directly outside the transmission station with tie cables installed between the Cabinet Type 600 and the TS Cabinet 2303.

6. Copper cables within the transmission station should be terminated within the Cabinet 2303. If this involves changes to existing terminations, appropriate funds should be included in the scheme to allow for re-arrangement work.

7. Longitudinal cable tests on copper cables should be measured from the Cabinet 2303.

A7.3 Transmission Station Buildings

General

1. All new TS buildings should be built to MCL 10470 and MCX 0557.

Transmission Circuits

2. Provision of all Private Wires to the building should be in accordance with MCX Drawings. The Public Switched Telephone Network (PSTN) Master Jack Socket should be installed in the fence-line cabinet. The socket within the building will be installed by the HA's Transmission Branch Works team.

A7.4 Transmission Station Cabinets

1. Where the TS cannot be accommodated in a building, a Cabinet Type 617 can be used to house transmission equipment.

A8. TEMPORARY CIRCUITS

A8.1 Overview

1. Various methods exist for the provision of temporary circuits to maintain national or Control Office (CO) Area communications during major roadworks. These include high capacity Public Telecommunications Operator (PTO) data links (eg Megastream), Radio links and temporary cable.

2. For National circuits and circuits carried over fibre optic Pulse Code Modulation (PCM), agreement should be obtained from the Highways Agency for the method of maintaining the circuits. The funding for the agreed method should be from the scheme.

3. For local circuits Design Agents should consult with the Highways Agency to agree the level of provision. Order times for PTO circuits in rural areas can be lengthy.

A9. GLOSSARY

Armoured Cable
A cable which incorporates a layer of steel wire wrapped helically around the cable to provide mechanical protection from damage. The armour wire is protected from moisture by a polyethylene sheath. The sheath is coated with graphite - this graphite coating is used when testing the integrity of the sheath.

Block
A section of carriageway between two Geographic addresses. If there could be multiple routes between the two addresses (eg clockwise and counter-clockwise on a circular route), a third Geographic Address is specified to identify a unique route.

Block Interface
An item of equipment within the Phase 3 Telephone system which connects up to eight telephone responders to a sector interface. Electronically, it is the same equipment as a sector interface, but it performs a different function.

Build Out Capacitor
Capacitors are used to equalise cable lengths to the standard length of 500m. The additional capacitance equates to that required to make the cable length appear to be 500m. Located in the Cable Joint Enclosure (CJE) furthest from both TS.

Bulk Purchase
Standard items of motorway communications equipment are purchased by the Highways Agency in quantity. This ensures the equipment conforms to the relevant specifications, is available from several sources and benefits from economies of scale.

Cabinet Type 600
Standard motorway equipment cabinet, for use on motorway verges, to house equipment such as Standard Transponders, MIDAS Transponders, Responders, Sector Interfaces and Sector Blocks. Also used as a Marshalling Cabinet.

Cabinet Type 617
Standard motorway cabinet, for use on motorway verges, to house transmission equipment.

Carrier
A signal comprising several individual signals multiplexed together. The carrier signal is at a higher frequency than the individual signals in analogue transmission and at a higher bit rate in digital transmission.

Carrier Network
Two types of network are installed each using a different type of carrier system:

(a) Copper cable networks use frequency division multiplex (FDM) to transmit the standard carrier of 12 analogue channels. A mini-carrier of six analogue channels is provided as an option;

(b) Optical fibre networks use time division multiplex (TDM) to transmit 30 digital Pulse Code Modulation (PCM) channels.

Carrier Quad Cable
A cable comprising 4 conductor wires used for transmitting high frequency Frequency Division Multiplex (FDM) signals.

Central Logging
Collecting and processing of log information from a number of Control Offices (CO) throughout the NMCS at a central location.

Central Processor (CP)
The main computer used in the Computer Centre, used to control, via the Control Offices, the motorway telephone and signals a number of COs. CPs in current use are:

CP303 (Ferranti Argus) at Coleshill
CP305 (Ferranti Argus) at Westhoughton

The CP is the central component in an NMCS1 system.

Control Office (CO)
The Control Office (CO) is the location from where the Highways Agency's motorway communications equipment, for the motorways in a given Police Force Area, are controlled. The CO is used by the Police Authority for day-to-day control of motorway traffic. More than thirty Police Authorities are involved in operating the national system, each Police Authority

being issued with a code of practice approved by the Association of Chief Police Officers, in order to standardise the use of motorway signals for each region.

Control Office Area (COA)
The area of influence and interest within a Control Office as defined by motorway devices with which it can communicate via the Local Communications Controller.

Control Office Area Network
The data and telephone network within a Control Office Area.

Device
A physically self-contained part of the overall system which performs a discrete set of functions, and communicates with other parts of the system via one or more communication paths.

Frequency Division Multiplex (FDM)
An analogue transmission system where individual signals are multiplexed with a high frequency carrier to allow several signals to share a transmission circuit.

Full Duplex
A channel which allows simultaneous transmitting and receiving.

Half Duplex
A channel which allows transmission and receiving but only in one direction at any time.

High Frequency Carrier (HFC)
The High Frequency Carrier system is an analogue transmission system where individual 4KHz bandwidth signals are multiplexed with a higher frequency signal, the carrier, to allow the signals to share the transmission circuit.

High Level Data Link Control (HDLC)
A protocol, at link level, which forms the basis of all inter-station communications on the NMCS2 data system, Closed Circuit Television (CCTV) system and the Regional Communications Controller (RCC) network. When each station communications link is set up, point to point or multidrop, the delivery, security and integrity of each frame of data is assured.

HDLC is the basis of a family of protocols which form the main data highway(s) for communication between Data Base Processor, Local Communications Controller, Regional Communications Controller and Transponders providing the packet message handling network.

Interrogation Request Tone (IRT)
A signal switched on at an NMCS1 Responder when a telephone handset is lifted off the hook. This signal is used by the central processor to initiate the handling of a telephone call. The tone is allocated channels CH101 (420 Hz), CH102 (540 Hz) or CH103 (660 Hz).

Line Termination
Resistors placed at the end of a circuit to allow the optimum transfer of signal energy to devices and to reduce interference on a cable.

Loaded/Loading
A cable pair is said to be loaded when its characteristic impedance has been altered. Loading is achieved by including inductance coils over the total length at joints between individual cable lengths.

Local Communications Controller (LCC)
An NMCS2 data system message switching unit, the most significant CO area data system communications node. Sited at the most strategic point on the motorway network, it provides the downside on the Database Processor (DBP) - LCC level 2 link and the master on the four LCC-Transponder HDLC links.

Longitudinal Cable
The 40 pair copper and 24 fibre cables (two separate cables) running parallel to the motorway in the duct network, each pair and fibre is dedicated to a specific purpose. Historically 20 pair NMCS1 and 30 pair NMCS2 cables were direct buried. The 20/30 pair copper cables may be augmented by composite copper/ optical fibre cables dedicated to CCTV or carrier circuits.

Main Line Carrier Network
A National carrier network between Central Processors.

Marshalling Cabinet
A Cabinet Type 600 immediately outside a Transmission Station (TS) into which all the longitudinal copper cables are terminated and jointed to cables from the TS.

Megastream
British Telecommunications name for a 2M-bit/s digital transmission link providing 30 PCM channels for point to point links. A Megastream link would be used instead of several individual Private Wire circuits.

Microwave Radio Link
Non cable based radio transmission system using frequencies in the GHz range. Can use either digital or analogue transmission.

Mini Carrier
Sub equipped high frequency Frequency Division Multiplex (FDM) carrier system used for local communications.

Multiplex
Individual signals mixed together into a single signal or carrier for transmission are said to be multiplexed, and applies to all types of signals. To recover the individual signals the carrier signal is demultiplexed.

National Carrier Maintenance Contractor (NCMC)
The Contractor responsible for the maintenance of the Carrier Network throughout the motorway network.

National Motorway Communications System (NMCS)
The motorway traffic control and emergency telephone network adopted to serve the motorways of England.

National Motorway Communications System 1 (NMCS1)
A combined signalling and telephone system controlled from Regional and National central processors, installed up to 1988.

National Motorway Communications System 2 (NMCS2)
A system using locally based distributed processing to control telephones and signals, installed from 1988.

Packet Switch
Data network that divides messages into easily handled packages for transmission. Destination information is added to each package. The national transmission network linked by the Regional Communications Controllers (RCC) is a packet switched network.

Phase 3 Telephone System
The system of telephones installed along motorways as part of the second generation National Motorways Communications System (NMCS2).

Port
Telecommunications terminology for a physical interface or connection between equipment or between equipment and cables. A standard transponder has one High Level Data Link Connection (HDLC) port to the Local Communications Controller (LCC) and four RS485 ports.

Private Wire (PW)
A dedicated permanent circuit provided by a Public Telecommunications Operator between two locations.

Public Switched Telephone Network (PSTN)
PSTN is provided by a Public Telecommunications Operator (eg British Telecommunications Ltd, Mercury Communications Limited), ie a telephone connection accessed by the user dialling numbers.

Public Telecommunications Operator (PTO)
A licensed provider of Public accessible telecommunications services (eg British Telecommunications Ltd, Mercury Communications Limited).

Pulse Code Modulation (PCM)
Pulse Code Modulation is a process of converting an analogue signal into a digital signal. A sample of the analogue signal is taken and equated to the nearest digital level. Each digital level is associated with a binary code. This code is transmitted instead of the analogue signal. This process operates on an individual signal and does not create additional capacity. The analogue signals are sampled at 8KHz and produce 8-bit codes. This gives a single channel with a bit rate of 64,000 bits per second or 64Kbit/s.

PCM is commonly used to describe multi channel digital transmission systems. This is not totally correct as PCM is not a transmission system. PCM is generally used with Time Division Multiplexing (TDM) transmission systems.

Regional Communications Controller (RCC)
An NMCS message switching unit, and the national network communications network. The RCC is an NMCS item of equipment which provides the facility of linking a Control Office, to other communication centres and Control Offices.

Regional Maintenance Contractor (RMC)
A Contractor responsible for the day to day maintenance of instation and outstation equipment. Also has first line responsibilities for the transmission equipment in their region.

Remote Engineers Terminal (RET)
A terminal allowing remote access to the NMCS1 Central Processor for maintenance purposes.

Responder
An NMCS1 outstation which controls telephones and signals.

RS485
A data protocol (EIA RS485) and practice adopted for use by NMCS2 between the Standard Transponder and motorway devices.

The RS485 Multidrop Link is the lowest hierarchical level of transmission in an NMCS2 data system and provides the means, parameters and protocol of communication between Transponders and motorway devices. It allows the Transponder to control several devices at once or individual devices. However, individual devices can only transmit to the Transponder.

Transmission is half duplex, ie transmission in only one direction at once. Each link caters for up to 30 motorway devices. Each message comprises 5 characters of 8 data, 1 parity, 1 start and 1 stop bits. The characters represent address, command, data byte 1, data byte 2 and longitudinal parity.

Sector
An NMCS2 telephone system term, see Sector Switch and Sector Interface.

Sector Interface
An NMCS2 telephone system unit. Sited at the most strategic point in the motorway, the SI is the most significant telephone node in the Control Office area network. The SI provides, for the telephone system, the transmission system facility for common speech and data circuits. It comprises 4 ports which are themselves comprised of Sector Switches needing one Sector switch for each Telephone Line Controller the port serves. It provides an interface between the Telephone Line Controller and the lower order telephone switching stations.

Sector Switch
An NMCS2 telephone system unit, the next most significant telephone node after the Sector Interface. Sector Switches are the units that make up a sector interface. There is one sector switch for each telephone circuit. The Sector Switch, when used as a station in its own right, performs as an intermediate level between the Sector Interface and Responders.

Sectoring
An NMCS2 telephone term for dividing the network into sectors.

Standard Transponder
Standard Transponder is at the lowest hierarchical level within the Control Office Area. It interfaces to Local Communications Controller/HDLC links and provides a star point on the RS485 local links. It also provides some of the signal sub-system functions and a post box service to other sub-systems. It controls up to 120 motorway devices.

Telemetry System
Telecommunications terminology for the remote monitoring and control of equipment, devices and systems.

Telephone Calling Tone (TCT)
A signal initiated at a transmission station and transmitted to the Control Office on channel CH104 at 780 Hz, used to check for normal telephone operation. The signal is turned off by an Interrogation Request Tone from a Responder.

Telephone Responder
A motorway based mini telephone exchange controlling the connection of telephones with an NMCS2 Control Office.

Time Division Multiplexing
Time Division Multiplexing is the process of sharing a single transmission channel between several signals by allocating time slots to the individual signals.

Each signal, generally a Pulse Code Modulation (PCM) signal, is given access, its Time Slot, to the transmission channel, in turn to allow its 8-bit code to be transmitted, in a continuous bit stream. To enable the receiving end to decode the bit stream into the individual channels, timing and other signalling information are sent in the first Time Slot. 30 PCM channels are multiplexed with two signalling channels also of 64Kbit/s, giving a 2048Kbit/s system. This is commonly referred to as a 2Mbit/s system.

2Mbit/s systems are also called Primary PCM multiplexed systems. 2Mbit/s can be multiplexed using TDM to Higher Order systems, these being 8Mbit/s, 34Mbit/s, 140Mbit/s and 565Mbit/s Systems.

Transmission Integrity Tone
A test signal used to check transmission lines. It is initiated in the central processor and transmitted to the Control Office on channel 103 at 660 Hz. The absence of a received signal causes a TA1 fault.

Transmission Station (TS)
A Transmission station is an outstation unit provided to house telecommunication equipment required to allow successful communications between the Instation and Outstation Services. The TS are either buildings or cabinets Type 617 and are spaced at approximately 20km intervals within a Control Office area.

Wide Area Network (WAN)
A data network that covers a large area and requires specialist transmission equipment to cater for all its interconnections.

2-wire
A circuit which uses 2 conductors, a single pair for both transmitting and receiving.

4-wire
A circuit which uses 4 conductors, 2 wires for transmitting and the other 2 wires for receiving. The cable may be constructed in pairs or as a quad cable.

X.25
ITU-T standard protocol for Packet Switched Data Networks.

A10. REFERENCES

MCH 1453 - Maintenance Instruction - Mini Carrier Systems

MCH 1593 - Maintenance Instruction Changes to Communication Infrastructure

MCH 1627 - RCC Network Implementation - Naming, Addressing & Renting in the RCC Network

MCH 1628 - Notification of new Motorways for the Provision of Transmission Equipment and Services

MCH 1629 - Notification of Motorway Widening for the Provision of Transmission Equipment and Services

MCH 1630 - Notification of Cable Upgrading for the Provision of Transmission Equipment and Services

MCH 1631 - Notification of Additions to Existing Systems for the

MCH 1632 - Notification of Reduction of Existing Systems to TCC Transmission Branch

MCL 5502 - Technical Guide to Loading of DTP Motorway Communications Cables

MCL 5504 - Local Signal Data Circuits Guide for Motorway Communications Systems

MCL 5505 - Main Signal Data Circuits Guide for Motorway Communications Systems

MCL 10470 - Transmission Station Building Specification 1993

TA 72/95: National Motorway
Communications Systems (DMRB 9a.4.1)

TA 77/95: Motorway Infrastructure
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TR 1329 - Phase 3 Telephone Data Transmission

TR 1330 - Phase 3 Telephone Responder for Phase 3 Telephone System

TR 1334 - NMCS2 Sector Interface for Phase 3 Telephone System

TR 2045 - NMCS2 Standard Transponder

TR 2046 - NMCS2 Local Comms Controller

TR 2049 - NMCS2 HDLC Point to Point Communications

TR 2066 - NMCS2 HDLC Multi-Drop Communications

TR 2067 - NMCS2 RS485 Communications

TR 2070 - NMCS2 Message Control