

MPT 1351
CODE OF PRACTICE
For Repeater Operation at Communal
Sites
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FOREWORD

The growth of the radio services has resulted in an increase in the number of radio sites required and in the number of users who are required to share facilities.

The radio frequency spectrum is finite natural resource for which there are many competing demands, therefore radio systems must be designed so that individual systems are very efficient and operate with minimum interference to other systems.

This code of practice has been prepared to assist radio system designers to obtain the optimum use of repeater facilities, with the minimum of interference to the repeater system and to other users of the radio spectrum.

The engineering problems encountered on sites should be dealt with in relation to the site as a whole and with the interests of all sites users in mind, and not simply in relation to a single user.

It is a requirement of the Wireless Telegraphy Act 1949 that no radio apparatus shall be installed or used in the United Kingdom except under the authority granted by the Secretary of State. It is a condition of this authority that the performance of the apparatus must meet certain minimum standards. These minimum standards of performance are given in specifications prepared by the Radiocommunications Agency in consultation with the relevant manufacturers.

Applicants who wish to submit equipment for type approval testing should apply to one of the accredited test houses. Guidance for applicants is given in the RA Information Sheet 'RA 207 (Rev 1): Type Approval - UK Type Approval Requirements for Land Mobile and Maritime Mobile Radiocommunications Equipment'. This is available on a single copy basis free from the RA Information & Library Service.

Applicants who wish to demonstrate compliance with the EMC directive are advised to refer to the RA Information sheets 'RA 200: Electromagnetic Compatibility for Radio' and 'RA 277 (Rev. 1): EMC - The EC Type Examination Route to compliance for Radiocommunication Transmission Apparatus'. These are available on a single copy basis free from the RA Information & Library Service.

It may be necessary for amendments to this specification to be issued. Amendment sheets will be available from the RA Information and Library Service.

For the latest information concerning Type Approval Status and Licensing conditions, refer to the RA Information Sheet 'RA 275: Status of Land Mobile Radio Specifications (MPT 1300 series)'. This publication also contains contact names and telephone numbers for Agency staff who are able to assist you with licensing and technical enquiries and is available on a single copy basis free from the RA Information & Library Service.

This revision was required in order to allow for;

- a) This document to be updated in line with the Agency's current Standard format and layout for the MPT 1300 series specifications.

The Radiocommunications Agency has a 'web site' which can be accessed on <http://www.open.gov.uk/radiocom> ;it is planned that all of the MPT 1300 series of specifications will be available here using 'LIBRARY' and 'MPT Specifications' options.

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1 SCOPE OF THE CODE

This code provides guidelines for the correct repeater (talk through) operation. The code examines the objectives of good design and the effects of common deficiencies in some methods employed for control of repeaters. It provides recommendations designed to ensure that users avoid interactions which result in operational or interference problems arising.

References and appendices are provided for further reading.

A bibliography at the end of this document gives relevant information on:

- a) Department of Trade and Industry Performance Specifications.
- b) Department of Trade and Industry Codes of Practice relating to radio equipment.

2 SYSTEM DESIGN OBJECTIVES

Radio equipment for the mobile services is designed to meet specifications which ensure the efficient use of the radio spectrum. A well designed radio installation, and an efficient repeater control system are essential if reliable interference free repeater operation is to be achieved.

The objectives of this code of practice are as follows:

- a) to obtain the coverage required from the chosen site;
- b) to cause minimal interference to other co-sited users;
- c) to provide reliable and correct repeater operation.

3 SYSTEM DEFICIENCIES

3.1 Generation of unwanted products

There are two main sources of radiated products and these are defined as follows:

- a) the noise and spurious products generated by transmitters; these occupy a broad bandwidth on both sides of the carrier frequency (see Appendices 3 and 4 of MPT 1331 - Code of Practice for Radio Site Engineering).
- b) intermodulation products caused by mixing of two or more source frequencies which produce well defined and often high level signals. If several stations operate in the repeater mode on a single site intermodulation products based on a + b - c are a problem. This form of interference can limit the number of repeaters per site. In particular, sites located in city areas will require a high standard of site engineering to be employed.

3.2 Free running talk-through

In the free-running (carrier controlled) mode the problem of widespread interference, due to triggering by noise signals or by local or distant mobiles not associated with the radio system, is a serious limitation; thus this is not a satisfactory method of control.

The use of free running talk-through will not normally be authorised.

4 RECOMMENDATIONS

4.1 Control of Unwanted Products

The origins of unwanted products are related to mixing processes that take place in any non-linear component of a complete system. (See Annexes 3, 4 and 5 of MPT 1331). Guidelines for increasing the isolation between components of the mixing process which will result in a reduction of the intermodulation product level are given in Section 5 of MPT 1331.

A problem arises on-sites where there are several based stations having repeater or talk-through facilities, i.e. the transmitters and receivers are in use simultaneously. If the transmitter/receiver spacing is constant (D) an incoming signal from a nearby mobile station will produce in the base station transmitter output stage a difference frequency, D. Any other base station transmitter may now mix with D to produce its own receiver frequency in the same band. This problem can be overcome by strict discipline on this topic or a complete ban on the use of mobile transmitters near the site.

4.2 Operation and Control of Repeaters

Common base stations (cbs) and trunked systems use the repeater/talk-through mode of operation which must use some form of signalling. Other private mobile radio users

may only use talk-through if they have been granted permission to do so by the licensing department, in which case this will be shown on the licence schedule. All control systems must be designed to avoid interference caused by spurious or incorrect base station operation in the talk-through mode. All control systems should incorporate fail safe means to terminate talk-through operation, when this mode is set by incorrect triggering or other unwanted signals, or if the close down signal is missing or incorrect.

Apart from cbs and trunked systems it is recommended that the talk-through facility is controlled by the base station operator during normal working hours.

Below are listed various methods of controlling the talk-through facility, which may be used independently or in any combination, depending on the requirements of the system.

4.2.1 Free running talk-through

This method of control will usually only be considered if the system has an exclusive channel assignment within the service area of the scheme, and any interference caused by use of the talk-through facility will only affect the users own system.

All mobiles on the system will receive the transmissions, similarly any unwanted co-channel signals within the signal range of the base station receiver will be repeated when in the talk-through mode.

This mode of operation should not normally be used.

There are two basic methods of operation, which are detailed below:

4.2.1.1 Operator controlled

If the talk-through facility is required then a user will call the base station operator to switch the system to the repeater mode. At the end of the message the operator should then switch the system back to normal operational working.

It is essential for an operator to be present to monitor the traffic and to manually switch the base station.

Under no circumstances must the base station be left in the free running talk-through mode.

4.2.1.2 Automatic or link fail control

If the link to a remote controlled base station should fail then the base station will automatically switch over to the repeater mode of operation. If this should happen then every effort should be made to rectify the fault and restore the system to normal operational working conditions.

4.2.2 Continuous signalling

The two basic methods of continuous signalling are described as follows:

4.2.2.1 Continuous Tone Controlled Signalling System - CTCSS (MPT 1306)

A sub-audio tone is present with the transmitted carrier and only mobiles with the correct tone can access the repeater. Once the sub-audio tone is not detected then the talking-through facility should be terminated and the base station reverts to normal working.

Mobiles on the wanted system may be grouped by allocating different sub-audio tones to each group, then only mobiles with the same sub-audio tone will receive a message. Any users will be prevented from accessing the system unless they are using the same sub-audio tone.

4.2.2.2 Hand-shaking

This is normally a coded digital signal which is regularly transmitted whilst the wanted carrier is present. If consecutive coded signals are missed then the base station will follow a predetermined close down procedure, thus preventing unauthorised access to the system.

4.2.3 Tone burst or sequential signalling

4.2.3.1 Tone burst

Normally a single audio tone is transmitted at the start of a message which will switch the base station in to the talk-through mode. At the end of the message a second tone

is sent to cancel the talk-through mode. If for some reason the second tone is not received then the base station will stay in the repeater mode, therefore, a time out facility must be included to revert the base station to normal working after a reasonable time, e.g. 5 minutes. The timing period should be set from when the first tone was sent. A disadvantage of this system is that it is prone to signal limitation (receiver response to an unwanted similar signal) due to interference.

4.2.3.2 Sequential signalling - (MPT 1316, 1317)

This may be an analogue consisting of two or more tones or a digital coded signal. Sequential signalling is used in a similar manner to that described for a tone burst signal.

Using sequential signalling it may be possible for users to:

- a) select a particular mobile without disturbing other mobile in the scheme
- b) select a particular group of mobiles
- c) select a particular base station repeater in the wanted scheme.

4.3 Operation and control of trunked radio systems

4.3.1 Description of a typical trunked system

- a) In the unoccupied condition, one of the Base Station channels will radiate a continuous data stream of FFSK (1200 baud). Periodically, this control stream will change to another channel. In this way no single Base Station failure will cause an overall system failure. All mobiles automatically search for this control channel.
- b) When a call is initiated, say by a mobile user pressing his request button, the mobile transmits a call data stream to the Base Station (on the duplex control channel). This call is acknowledged (assuming it is a valid call), and the other party is called. If their mobile is available, it will reply accordingly. This series of events all occur on the control channel pair of frequencies, and at 1200 baud.
- c) If both parties are available, the Base Station will allocate a working channel, and automatically switch these users to that channel. An indication will be given to the mobile originating the call and only now will his PTT button operate the mobile transmitter. Simplex talk-through operation can now be undertaken by the users.
- d) Closedown of the call is initiated by the mobile station sending, on the working channel, the relevant closedown data stream. The Base Station controller responds to this by returning both parties to the stand by condition, and the working channel is vacated.

This description represents an example of system operation only, and is intended to indicate the nature of Base Station control. Either party might actually have a group of mobiles, for example, or the call could have come from a 'Despatcher' (an enhanced 'fixed' mobile). Further information is available in MPT's 1318, 1327 and 1343.

4.4 Control stations providing access to individual, shared or trunked base stations.

Control stations should be located within the service area of the base station.

4.4.1 Calculation of link path between control station and base station

The link path between the control station and base station should be calculated for a base station receiver input of between 1 and 15 microvolts pd to be achieved. The erp radiated at the control station shall be the minimum for this purpose and shall not in any case exceed the licence conditions.

4.4.2 Control station antennas

At the control stations directional antennas should be used. It is recommended that for VHF services 3 element Yagi be used and for UHF services 8 element Yagi be used. However, where the control station is close to the base station and the effective radiated power to achieve the receiver input voltage given in Clause 4.4.2 above is less than 5 watts, a whip or integral antenna¹ may be used. Where the control station antenna is located within a building due consideration should be given to the effect of this form of operation on other radio and electronic systems contained within the building. Due attention should be paid to any relevant recommendations made by the Health and Safety Executive.

¹ An 'integral antenna' may be defined as an antenna connected permanently to the transmitter or receiver without the use of an external feeder.

ANNEX A: GLOSSARY OF TERMS FOR THE LAND-MOBILE SERVICE

A.1 STATIONS

A.1.1 Base Station

A land station carrying on a service with mobile stations.

A.1.2 Mobile Station

A station in the mobile service intended to be used while in motion or during halts at unspecified points.

A.1.3 Handportable Station

A land-mobile station capable of being carried by hand.

A.1.4 Repeater Station

A transmitter/receiver combination used to extend the range of radio communication by relaying the signal.

A.1.5 Community Repeater Station

A repeater station, control of which may be obtained by a number of users either by the use of land lines or control stations. This may be referred to also as a 'Common Base Station'.

A.1.6 Talk-Through Station

A base station arranged to re-transmit signals from land-mobile stations to other land-mobile stations or control stations.

A.1.7 Control Stations

A base station which, by operating on the frequencies of a land-mobile station, may operate a repeater station as a base station to other land-mobile stations.

A.1.8 Communal Site

A communal site shall be taken to mean a place where radio transmitters and/or receivers operated by one or more licensees are located.

Note: An 'integral antenna' may be defined as an antenna connected permanently to the transmitter or receiver without the use of an external feeder.

A.2 OPERATIONS

A.2.1 Simplex Operation

Operating method in which transmission is made possible alternately in each direction, for example, by means of manual control. Simplex operation may use either one or two frequencies.

A.2.2 Duplex Operation

Operating method in which transmission is possible simultaneously in both directions of a telecommunication channel.

A.2.3 Semi-Duplex Operation

Operating method which is simplex at one end of the circuit and duplex at the other. Semi-duplex operation generally requires the use of two frequencies, and it is normally the base station that operates in the duplex mode.

A.2.4 Talk-Through Operation

Operating method whereby two land-mobile stations may communicate with one another via a base station. Talk-through operation may be taken to be specific form of semi-duplex operation.

A.2.5 Single-Frequency Operation

Operating method in which the transmitted frequency is the same for both directions of transmission.

A.2.6 Two-Frequency Operation

Operating method in which the transmitted frequency is different for the two directions of transmission.

A.2.7 Reverse-Frequency Operation

Operating method of a two-frequency system in which a control station communicates with the land-mobile stations by relaying through the base station. This mode of operation is similar to talk-through the difference being that the control station (using vehicle mobile equipment usually with a directional antenna), operates from a fixed position.

A.3 SERVICES

A.3.1 Land-Mobile Service

A mobile service between base stations and land-mobile stations, or between land-mobile stations.

A.4 SIGNALLING AND CONTROL

A.4.1 Continuous signalling

A sub-audio tone or digital signal which is present with the wanted carrier.

A.4.2 Control System

A method of manual, semi-automatic or automatic control of the talk-through/repeater mode.

A.4.3 Selective signalling

A form of sequential signalling using in-band audio tones.

ANNEX B: BIBLIOGRAPHY

- MPT 1306 Code of practice for Continuous Tone Controlled Signalling System (CTCSS) for use in the Land Mobile Services.
- MPT 1315 Code of practice for duplex operation in the Land Mobile Services
- MPT 1316 Code of practice for selective signalling for use in the Private Mobile Radio Services
- MPT 1317 Code of practice for transmission of digital information over Land Mobile Radio Systems
- MPT 1318 Engineering Memorandum on Trunked Systems in the Land Mobile Service
- MPT 1327 A Signalling Standard for Trunked Private Land Mobile Radio Systems
- MPT 1331 Code of Practice for Radio Site Engineering
- MPT 1343 System interface specification for radio units to be used with commercial trunked networks operating in Band III sub-band 2.
- Advice Document Advice on the Protection of Workers and members of the public
National Radiological from possible hazards of electric and magnetic fields with
Protection Board frequencies below 3000 GHz.
May 1986
- C.B.S. Licensing Policy Document