MPT 1317

CODE OF PRACTICE

Transmission of digital information over Land Mobile Radio Systems

Revised and reprinted October 1996

First published April 1981

Revised and Reprinted May 1993

Revised and Reprinted October 1996

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FOREWORD

This Code of Practice has been produced by the Radiocommunications Agency.

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/rahome.htm*. It is planned that all of the MPT 1300 series of specifications will be available on here.

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1 INTRODUCTION

This digital signalling system is one in which radio equipment is fitted with devices which at the transmitter encode messages into a specific digital format and the receiver decode this format to give a suitable response.

2 APPLICATION OF THIS CODE OF PRACTICE

This code of practice covers the minimum performance considered necessary in order to make the best use of the available frequencies. It does not necessarily include all the characteristics which may be required by a user.

It applies to digital signalling operated in the land mobile services with radio equipment using amplitude or angle modulation. Typical applications of this signalling system are selective calling, status reporting, precoded messages, vehicle location, monitoring and supervisory systems, direct dialling, trunking and mobile terminals (including printers and visual display units).

3 TEST CONDITIONS, ATMOSPHERIC CONDITIONS AND POWER SUPPLIES

3.1 General

Tests shall be made under normal test conditions (Clause 3.3) and also, where stated, under extreme test conditions (Clause 3.4). In the event that any clause in the appropriate radio equipment specification concerning extreme test conditions differs from the relevant clause in this code of practice, the clause for the radio equipment may be applied as an alternative. Otherwise, the test conditions and procedures shall be as specified in clauses 3.2 and 3.5.

3.2 Test power source

During tests, the power supply for the equipment may be replaced by a test power source, capable of producing normal and extreme test voltages as specified in clauses 3.3.2 and 3.4.2. The internal impedance of the test power source shall be low enough for its effects on the test results to be negligible. For the purpose of tests, the supply voltage shall be measured at the input terminals of the equipment. if the equipment is provided with a permanently connected power cable, the test voltage shall be measured at the point of connection of the power cable to the equipment.

During the tests the power source voltage shall be maintained within a tolerance of ± 3 % relative to the voltage at the beginning of each test.

In equipment in which batteries are incorporated, the test power source shall be applied as close to the battery terminals as practicable.

3.3 Normal test conditions

3.3.1 Normal temperature and humidity

The normal temperature and humidity conditions for tests shall be any convenient combination of temperature and humidity within the following ranges:

Temperature	+ 15°C to + 35°C
Relative humidity	20% to 75%

NOTE: When it is impracticable to carry out the tests under the conditions stated above, a note to this effect, stating the actual temperature and relative humidity during the tests, shall be added to the test report.

3.3.2 Normal test source voltage

3.3.2.1 Mains voltage

The normal test source voltage for equipment to be connected to the mains shall be the nominal mains voltage. For the purpose of this code of practice, the nominal voltage shall be the declared voltage or any of the declared voltages for which the equipment was designed.

The frequency of the test power source corresponding to the AC mains shall be between 49 and 51 Hz.

3.3.2.2 Regulated lead-acid battery power sources

When the equipment is intended for operation from the usual type of regulated lead-acid battery source, the normal test source voltage shall be 1.1 times the nominal voltage of the battery (6 volts, 12 volts, etc.).

3.3.2.3 Other power sources

For operation from other power sources or types of battery, either primary or secondary, the normal test source voltage shall be that declared by the equipment manufacturer.

3.4 Extreme test conditions

3.4.1 Extreme temperatures

For tests at extreme temperatures, measurements shall be made in accordance with the procedures specified in clause 3.5, at an upper value of + 55°C and at a lower value of - 10°C.

3.4.2 Extreme test source voltages

3.4.2.1 Mains voltage

The extreme test source voltages for equipment to be connected to an AC mains source shall be the nominal mains voltage ± 10 %. The frequency of the test power source shall be between 49 and 51 Hz

3.4.2.2 Regulated lead acid battery power sources

When the equipment is intended for operation from the usual type of regulated lead-acid power source the extreme test voltages shall be 1.3 and 0.9 times the nominal voltage of the battery.

3.4.2.3 Other power sources

The lower extreme test voltage for equipment with power sources using primary batteries shall be as follows:

For Leclanche type of battery; 0.85 times the nominal voltage of the battery.
For mercury type of battery; 0.9 times the nominal voltage of the battery.
For other types of primary batteries; End point voltage declared by the equipment manufacturer.

For equipment using other power sources or capable of being operated form a variety of power sources the extreme test voltages shall be those agreed between the equipment manufacturer and the testing authority and shall be recorded with the test results

3.5 Procedure for tests at extreme temperatures

3.5.1 General

Before making measurements, the equipment shall be placed in a temperature controlled chamber for a period of one hour or for such period as may be judged necessary for thermal balance to be attained. The equipment shall be switched off during the temperature stabilisation period. The sequence of tests shall be chosen and the humidity content in the test chamber shall be controlled so that excessive condensation does not occur.

3.5.2 Test procedure

3.5.2.1 Equipment designed for continuous operation

For tests at the upper temperature, after thermal balance has been attained (Clause 3.5.1), the equipment shall be switched on in the transmit condition for half an hour, after which the appropriate tests shall be carried out. For tests at the lower temperature, after thermal balance has been attained.(Clause 3.5.1), the equipment shall be switched on in the standby or receive condition for one minute, after which the appropriate tests shall be carried out.[1]

3.5.2.2 Equipment designed for intermittent operation only

The procedure shall be as described in Clause 3.5.2.1, except that at the upper temperature, the half hour transmit condition shall be replaced by one minute in the transmit condition followed by four minutes in the receive condition before measurements are made.

4 RECOMMENDED DIGITAL CODE FORMAT

4.1 Format definition

The digital signalling system should be capable of providing a data stream in the format illustrated in figure 1.

preamble	Sync. word	Address code word	Optional Data code words

Minimum length of transmission 96 bits

Figure 1: The Format

The component words making up the format are defined below.

4.1.1 Preamble

The transmissions should commence with a preamble of bit reversals 1010...10 such that the receiver data demodulator can acquire bit synchronisation. The preamble should consist of a minimum of 16 bits, which is considered adequate for a transmitter which has already powered up. This may be extended as required to allow for link establishment, and always ends with a binary ‘0’.

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[1] If the equipment contains temperature stabilisation circuits designed to operate continuously, the equipment may be switched on for 15 minutes before measurements are made.

4.1.2 Synchronisation word

Each message should begin with a 16 bit synchronisation word as shown in figure 2, to enable the decoder to establish code word framing.

Bit No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Bit value.	1	1	0	0	0	1	0	0	1	1	0	1	0	1	1	1

(Bit number 1 is transmitted first)

Figure 2: Synchronisation word

4.1.3 Code Words

Messages should be transmitted in 64 bit code words, and each message may occupy one or more code words as determined by the message length. Each code word will contain 48 information bits and 16 check bits which are used for error detection. There are two types of code word:

address code words and
data code words.

4.1.3.1 Address code word

The first code word of every message must be an address code word as shown in figure 3.

Bit No.	1	2 8	9 48	49 64
No. of bits	1	7	40	16
	'1'	user's identity	address & data	check bits

Figure 3: Address code word structure

Bit 1 of a address code word is always binary '1' to distinguish the word from a data code word.

bits 2 to 8 inclusive specify the user's identity
bits 9 to 48 inclusive may be assigned to represent addresses and data
bits 49 to 64 inclusive are check bits

It is recommended that bits 9 to 48 in the address code word be allocated as follows:

bits 9 to 20 specify the addressee's identity (i.e. "to")
bits 21 to 32 specify the addresser's identity (i.e. "from")
bits 33 to 48 may be used for data.

This method of bit allocation is expected to satisfy most user requirements, but it may be freely changed to suit specific requirements.

4.1.3.2 Data code word

An arbitrary number of data code words, as shown in figure 4, may follow an address code word, as required to accommodate the message.

Bit No. 1 2 48 49 64

No. of bits	1	47	16
	'0'	data	check bits

Figure 4: Data code word structure

Bit 1 of a data code word is always binary ‘O’ to distinguish the word from an address code word.

Bits 2 to 48 may be assigned arbitrarily to represent data
Bits 49 to 64 are check bits

4.1.4 Encoding and Error checking

The sixteen check bits are calculated in 3 steps:

a) Fifteen check bits are appended to the 48 information bits by encoding them in a (63, 48) cyclic code. For encoding, the information bits 1 to 48 may be considered to be the co-efficients of a polynomial having terms from x^{62} down to x^{15}. This polynomial is divided module 2 by the generating polynomial.

$$x^{15}+x^{14}+x^{13}+x^{11}+x^{4}+x^{2}+1$$

The fifteen check bits code word bits 49 to 63, correspond to the co-efficients of the terms from x^{14} to x^{0} in the remainder polynomial found at the completion of the division. The (63,48) cyclic code has a minimum distance of 5 and so guarantees detection of up to 4 bit errors in one code word.

b) The final check bit of the (63,48) cyclic code (code word bit 63) is inverted to protect against misframing in the decoder.

c) One bit is appended to the 63 bit block to provide an even bit parity check of the whole 64 bit code word. The overall parity bit ensures that all odd numbers of errors can be detected, so the overall 64 bit code guarantees that up to 5 bit errors can be detected.

At the receiver each code word may be checked for errors by recalculating the check bits for the received information bits. Any differences between the received check bits and the recalculated check bits indicates that the received code word contains errors.

4.1.5 Concatenated Messages

Figure 5 illustrates how several messages may be sent in one transmission.

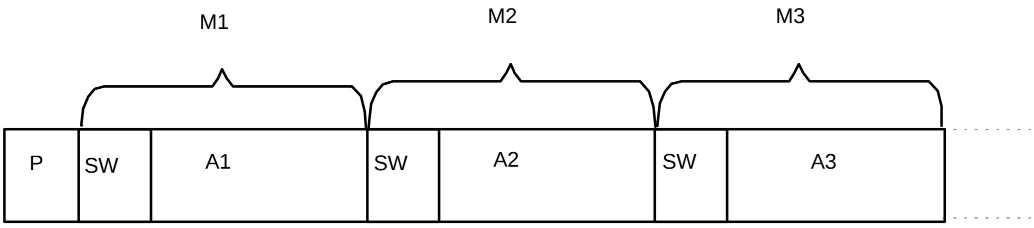

Figure 5(a): Short messages

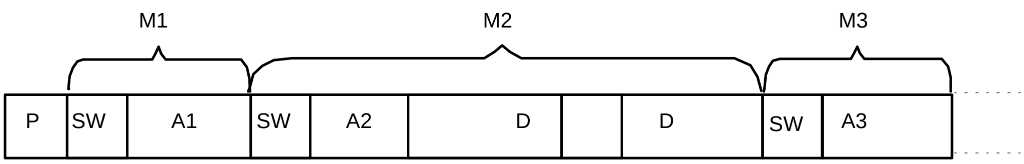

Figure 5(b): Mix of short and arbitrary length messages

Figure 5: Concatenated messages

P	=	preamble
SW	=	synchronisation word
A	=	address code word
D	=	data code word
M	=	message

It is not necessary to send the preamble at the start of every message in a concatenated series of messages.

5 GENERAL CONDITIONS

5.1 Data modulation method

The data modulation method should be by subcarrier modulation employing fast frequency shift keying. The parameters of the modulation should be as follows:

Bit rate	1200 bit/s
Modulation rate	1200 baud
Binary ‘0’	1800 Hz
Binary ‘1’	1200 Hz

Each binary ‘0’ and ‘1’ subcarrier wave form starts with either phase 0° or 180°, so as to ensure phase continuity. The first bit transmitted may have either phase.

5.2 Standard test modulation

Standard test modulation shall be in accordance with that laid down in the relevant performance specification for the associated radio equipment.

5.3 Arrangements for test signals applied to the receiver input

Sources of test signals for application to the receiver input shall be connected in such a way that the impedance presented to the receiver input is 50 ohms. This requirement shall be met irrespective of whether one or more signals are applied to the receiver simultaneously.

The levels of the test signals shall be expressed in terms of the emf presented to the receiver input terminals.

The effects of any intermodulation products and noise produced in the signal generators shall be negligible.

6 DIGITAL ENCODER AND ASSOCIATED TRANSMITTER

6.1 Encoder frequencies

6.1.1 Method of measurement

a) The transmitter and its associated encoder unit shall be connected via a suitable load and attenuator to a modulation meter, and operated in accordance with the manufacturers instructions.
b) The encoder shall be so arranged such as to produce either a train of binary 0s or 1s.

c) The output of the modulation meter shall be connected to a frequency counter and the modulation frequencies associated with the transmission of binary 0s and 1s measured.

d) The measurements shall be made under normal test conditions (Clause 3.3) and repeated under extreme test conditions (Clauses 3.4.1 and 3.4.2 applied simultaneously).

Note: The encoder frequencies should under all test conditions be within ±1 part in 10^4 of the standard frequencies.

6.2 Encoder modulation

6.2.1 Method of measurement

The equipment shall be arranged as in Clauses 6.1.1 (a) and 6.1.1 (b) and the binary signalling modulation level shall be measured.

The measurement shall be made under normal test conditions (Clause 3.3) and repeated under extreme test conditions (Clauses 3.4.1 and 3.4.2 applied simultaneously).

NOTE: Where it is impracticable to carry out these tests the manufacturer shall propose an alternative method.

6.2.2 Limits

The binary signalling modulation under all test conditions should be within the following limits.

Table 1

SYSTEM	**AMPLITUDE**	**ANGLE**
Channel spacing (kHz)	Modulation depth (%)	Peak deviation (± kHz)
12.5/25	60 ± 20 %	(60 ± 20)% of maximum deviation

If the encoding of all ‘1s’ or ‘0s’ is not practical then a manufacturers specified sequence of continuous code words shall be used as the test modulation to set up the modulation level.

6.3 Encoder data rate

6.3.1 Method of Measurement

Arrange the digital encoder to give normal operation.

a) An output from the bit rate clock shall be connected to a frequency counter and its frequency measured.

b) The measurements shall be made under normal test conditions Clause 3.3 and under extreme test conditions, Clauses 3.4.1 and 3.4.2 applied simultaneously.

The encoder data rate should under all conditions be within ± part in 10^4 of the nominal bit rate.

6.4 Adjacent channel power

6.4.1 Definition

The adjacent channel power is that part of the total power output of a transmitter, under defined conditions of modulation, which falls within the bandwidth of a receiver of the type normally used in the system and operating in either of the adjacent channels.

6.4.2 Method of measurement

The transmitter output shall be connected to a power measuring receiver (Clause 6.4.4) via a 50 ohm attenuator, set to produce an appropriate level at the receiver input.

The transmitter shall be operated at the rated carrier power as declared by the radio equipment manufacturer.

The transmitter shall be modulated by a data stream at a level 20 dB above that to produce a modulation depth of 60 %. For equipment without modulation limits which are intended to operate at a fixed input level, the measurement should be made using the input signal level, specified by the manufacturer.

The test receiver shall be tuned to the nominal frequency of the transmitter and the receiver attenuator adjusted to a value ‘p’ such that a meter reading of the order of 5dB above the receiver noise level is obtained.

The test receiver shall then be tuned to the nominal frequency of the higher adjacent channel and the receiver attenuator re-adjusted to a value ‘q’ such that the same meter reading is again obtained.

The ratio, in decibels of the adjacent channel power to the carrier power is the difference between the attenuator settings ‘p’ and ‘q’.

The adjacent channel power shall be determined by applying this ratio to the rated carrier power as declared by the radio equipment manufacturer.

The measurement shall be repeated for the lower adjacent channel.

6.4.3 Limits

For a channel separation of 25 kHz, the adjacent channel power shall not exceed a value of 65 dB below the carrier power of the transmitter, without the need to be below 0.2 microwatt. For a channel separation of 12.5 kHz the adjacent channel power shall not exceed a value of 55 dB below the carrier power of the transmitter, without the need to be below 0.2 microwatt.

6.4.4 Power measuring receiver specification

The power measuring receiver shall comprise a mixer, a crystal filter, a variable attenuator, an intermediate frequency amplifier and a rms meter connected in cascade, using a low noise signal generator as a local oscillator. The bandwidth of the filter shall be as follows (with a tolerance of ± 10 %):

Table 2

Channel Spacing (kHz)	Bandwidth between 6 dB attenuation points (kHz)	Bandwidth between 70 dB attenuation points (kHz)	Bandwidth between 90 dB attenuation points (kHz)
25	16	35	50
12.5	8.5	17.5	25

The attenuator shall cover a range of at least 80 dB In 1 dB steps. The noise factor of the amplifier shall not be worse than 4 dB. Over the 6 dB bandwidth the amplitude/frequency characteristics of the amplifier shall not vary by more than 1 dB.

The combined response of the filter and amplifier outside the 90 dB bandwidth shall maintain an attenuation of at least 90 dB. The rms meter, if not a power meter, shall have a crest factor of at least 10 for the full scale readings. The measuring accuracy to the receiver over an input level range of 100 dB shall be better than 1.5 dB.

NOTE: Where it is impracticable to carry out these tests the manufacturer shall propose an alternative method.

7 DIGITAL DECODER AND ASSOCIATED RECEIVER

7.1 Digital signalling sensitivity of the receiver

7.1.1 Definition

The digital signalling sensitivity is the minimum level of a signal at the normal operating frequency modulated by a test message consisting of a minimum length transmission as given in Figure 1, which will produce a successful message reception rate of 80 %.

7.1.2 Method of Measurement

A test signal at the nominal frequency of the receiver and modulated with the normal encoded test message at the minimum value shown in Clause 6.2.2 shall be applied to the input of the receiver or test fixture.

The level of the test signal shall be adjusted to find the minimum level at which a successful calling rate of at least 80 % is achieved.

The measurements shall be made under normal test conditions (Clause 3.3) and repeated under extreme test conditions (Clauses 3.4.1 and 3.4.2 applied simultaneously).

7.1.3 Limits

The digital signalling sensitivity shall not exceed + 6 dB relative to 1 microvolt under normal test conditions and + 12 dB relative to 1 microvolt under extreme conditions.

7.2 False signalling

7.2.1 Definition

a) The decoder responds without a correctly encoded message having been transmitted.
b) The decoder responds incorrectly to a correctly encoded message.

7.2.2 Limits

The false signalling limits are a matter for agreement between equipment manufacturers and user. The acceptance of false signalling limits may be decided on the basis of calculations provided by the system designer.

8 ACCURACY OF MEASUREMENT

The tolerance for the measurement of the following parameters shall be as given below:

*	DC voltage	± 3 %
*	AC mains voltage	± 3 %
*	AC mains frequency	± 0.5 %
*	Audio frequency voltage, power etc.	± 0.5 dB
*	Audio frequency	± 1 %
*	Distortion, noise etc. of audio frequency generators	1 %
*	Radio frequency voltage	± 2 dB
*	Impedance of artificial loads, cables, plugs attenuators etc.	± 5 %
*	Source impedance of generators	± 10 %
*	Temperature	± 1 °C
*	Humidity	± 5 %

9 INTERPRETATION OF THIS CODE OF PRACTICE

In cases of doubt about the interpretation of this code of practice, the methods of carrying out the tests and the validity of statements made by the manufacturers of the equipment, the decision of the Radiocommunications Agency shall be final.