RECOMMENDATION ITU-R M.1032

TECHNICAL AND OPERATIONAL CHARACTERISTICS OF LAND MOBILE SYSTEMS USING MULTI-CHANNEL ACCESS TECHNIQUES WITHOUT A CENTRAL CONTROLLER

(Question ITU-R 71/8)

(1994)

The ITU Radiocommunication Assembly,

considering

a) that new land mobile applications, such as personal radios, providing communications up to a maximum of 5 km in urban areas and 15 km in rural areas, are being introduced;

b) that these personal radios have characteristics differing from existing services and may be available to a large public;

c) that the utilization of the radio spectrum should be as economical as possible and that the use of multi-channel access techniques conserves frequency spectrum;

d) that highly flexible and economical systems can be achieved without using a central controller for setting up control of the radio path,

recommends

1. that these personal radio applications should include the use of multi-channel access techniques and appropriate protocols that do not require the use of a central controller for the detection of an idle radio channel;

2. that the technology as described below should be used in the development of systems:

2.1 Principle of operation

The principle of operation of multi-channel techniques without a central controller is as follows:

All radios in the system are normally in the standby state on a control channel, ready to receive a selective calling signal. A calling station looks for and finds an idle traffic channel and stores its number in its memory. Then the calling station transmits on a control channel, a selective calling signal including at least its own identity, the identity of the called station and the number of the identified idle channel. The standby stations detecting their identity code in the received signal, move to the indicated traffic channel and enter into communication. At the end of the communication all units return again to the standby mode.

2.2 Specific systems

Two systems have been developed according to this principle.

System 1 – “Personal Radio System”, based on analogue modulation techniques and provides voice services in a one-frequency simplex mode of operation.

System 2 – “Digital Short Range Radio”, based on digital modulation techniques and provides voice and data services which can be applied both in a one-frequency simplex mode of operation and a two-frequency semi-duplex mode of operation.

Both systems work in the 900 MHz frequency band. They provide up to 80 channels and use a transmit power of up to 5 W. More detailed data of these systems are given in Annexes 1 and 2.

2.3 Summary

The design of systems using multi-channel access techniques without a central controller allows for economical communication with relatively high reliability. It may combine the advantages of digital modulation for voice and data and the ability to operate in either single or two-frequency mode. Further, the protocols allow both modes of operation with the same frequency allocation to co-exist in the same geographical area.

ANNEX 1

Personal radio system

1. Introduction

This Annex relates to the personal radio system used in Japan and introduces the basic characteristics, connecting procedure, and receiver input level versus connection reliability.

2. Basic characteristics

2.1	Frequency:	903.0125 to 904.9875 MHz
2.2	Channel separation:	25 kHz
2.3	Number of channels:	80 (one control channel and 79 traffic channels)
2.4	Class of emission:	F2D: control channel
		F3E: traffic channels
2.5	Type of operation:	Simplex
2.6	RF power output:	5 W

3. Connecting procedure

3.1 Configuration of control signal

An automatic transmitter identification system (ATIS) is included in a read-only memory (ROM) obtained from the licensing authority. The ROM is required for the operation of the personal radio system (PRS) transceivers.

Code configuration for ATIS and circuit linkage

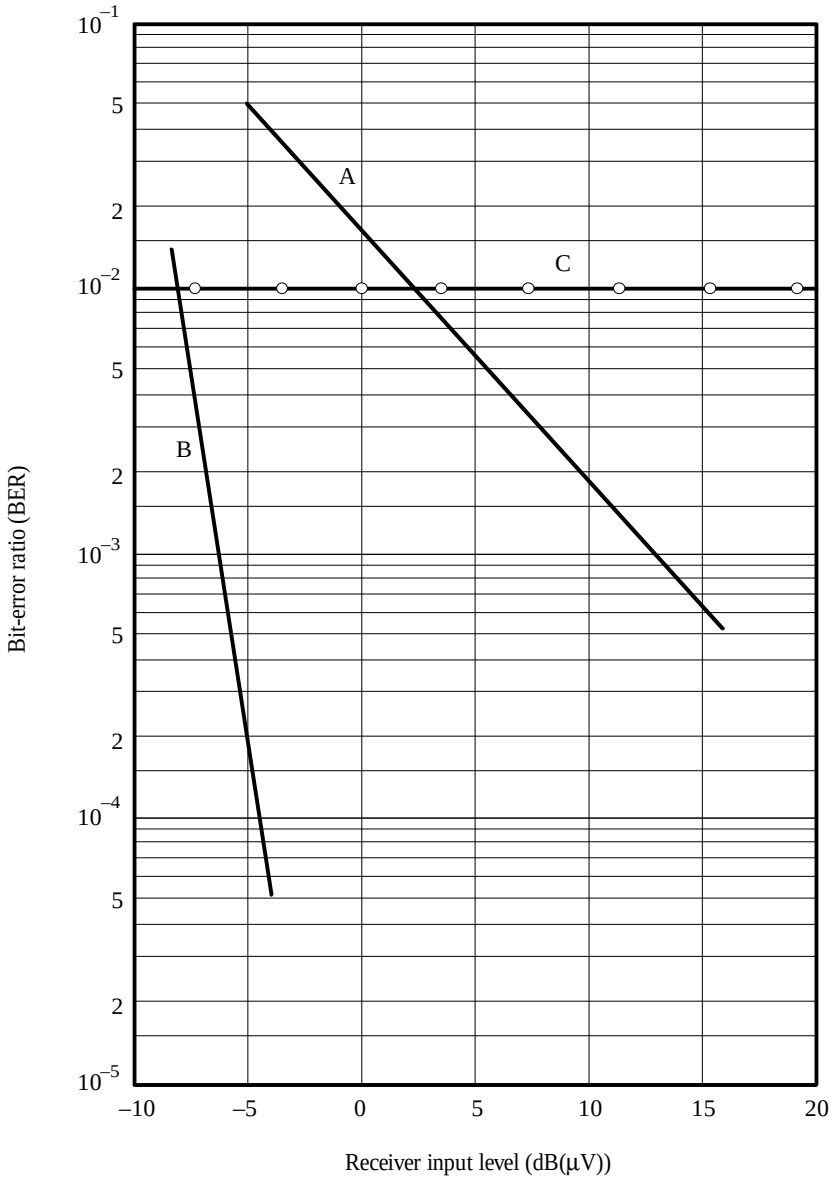
Bit synchronization:	50 bits, 101010...
Word synchronization:	15 bits, 111011001010000
Selective calling number:	20 bits, 5 BCD bits
Channel number:	8 bits, binary
Reserved bits:	4 bits, 0000
ATIS code:	48 bits binary: identification codes (for more than ten million stations, licence issue date and scrambling)
Length of Hagelbarger code:	2 × data bit length + 12 = 172 bits
Total:	172 + 65 = 237 bits (197.5 ms)
Code type:	NRZ
Bit-rate:	1 200 bit/s
Modulation method:	MSK 1 200 Hz, mark 1 800 Hz, space

3.2 Receiver (RX) input versus connection reliability

In Fig. 1, an example of receiver input level versus bit-error ratio (BER) is shown. Line C of BER = 10^{-2} corresponds to 90% connection reliability for the personal radio system.

FIGURE 1

Receiver input level versus bit-error ratio performance



Curves A: Rayleigh fading:
– centre frequency: 903.8875 MHz
– fading frequency: 20 Hz

B: no fading

C: connection reliability: 90% or more

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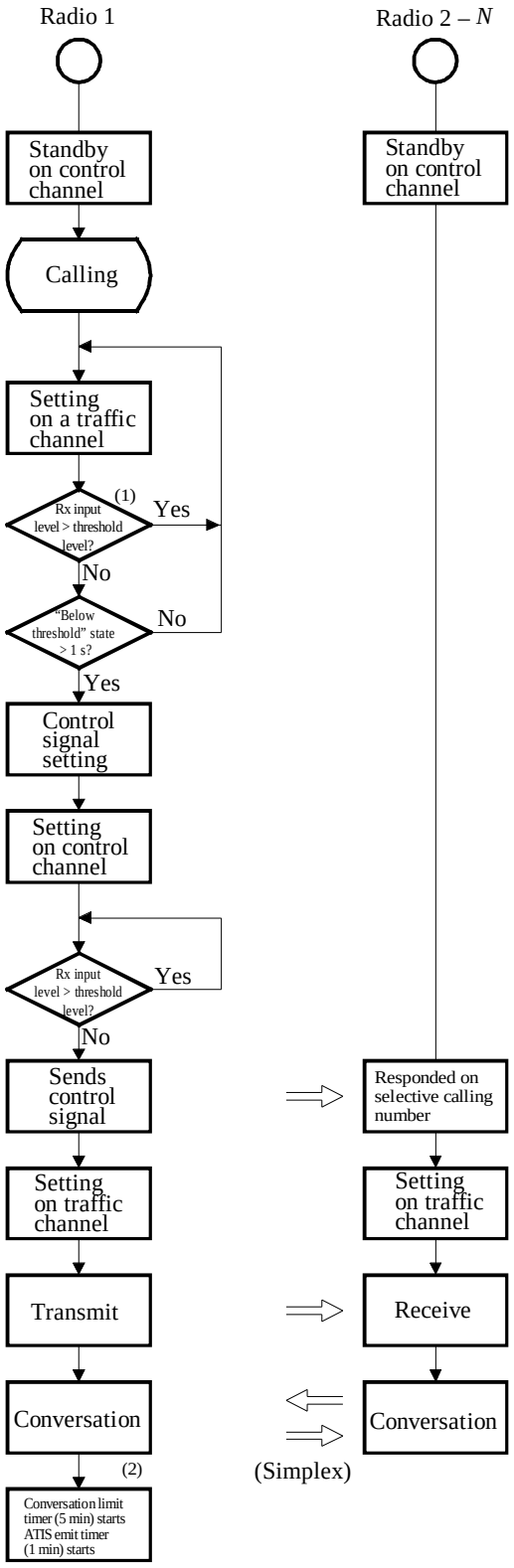
3.3 Flow chart

Figure 2 is a simplified communication procedure flow chart for the personal radio system. The procedure of connection is as follows. All the radios in the system are in the standby state on the control channel. The calling station looks for and finds an idle traffic channel and stores the channel number in its memory. Then it emits the control signal on the control channel. Those radios whose selective call number coincides with the control signal transfer to the specified traffic channel and enter into conversation. The call sign consisting of the ATIS code is automatically transmitted before the start of conversation, every 60 s during the conversation and at the end of the conversation. A selective call number is specified before transmission. On the other hand, up to two selective call numbers can be set for receiving.

FIGURE 2

Simplified communication procedure flow chart



(1) Threshold level.

The standard threshold carrier level for the receiver is set at 1 μV (open voltage).

(2) In consideration of traffic congestion, a conversation timer is provided. D02

ANNEX 2

Digital short range radio

1. Introduction

This Annex relates to the Digital Short Range Radio (DSRR) according to an Interim-European Telecommunication Standard developed by the European Telecommunications Standards Institute (ETSI) [ETSI, 1993].

2. Basic characteristics

2.1 The DSRR system consists of two control channels and 76 traffic channels with a channel separation of 25 kHz. It is capable of operating in either a single frequency simplex and/or in a two frequency semi-duplex mode. Direct carrier modulation is used to send the selective signalling codes and voice or data messages. Three principle elements are specified: units, master units and repeaters.

2.2	Frequencies:	simplex:	933.0375-934.9625 MHz
		semi-duplex:	888.0375-889.9625 MHz (unit transmit)
		paired with:	933.0375-934.9625 MHz (master unit and repeater transmit)
2.3	Channel separation:		25 kHz
2.4	Number of channels:		78
2.5	Channel allocation:		control channels 26 and 52 traffic channels 01 to 25, 27 to 51, 53 to 78
2.6	Type of modulation:		GMSK
2.7	Modulation rate:		16 kbit/s (speech and data) (*BT* value of 0.3) 4 kbit/s (signalling) (*BT* value of 0.5)
2.8	RF power output:		4 W maximum
2.9	Transmitter adjacent channel power:		less than –70 dBc outside the 2 MHz sub-band less than –50 dBc inside the 2 MHz sub-band

3. Signalling

3.1 The selective signalling code (SSC) consists of a bit synchronizing preamble followed by the frame synchronization and codeword repeated three times.

Bit sync (preamble)			256 bits
Frame sync		16 bits	
Codeword			
SSC number		1 bit	
Traffic channel code		7 bits	
First call code (unit to which the SSC is sent)		24 bits	
Command code		4 bits	
Reserved		2 bits	
Codeword counter		2 bits	
Manufacturers code		8 bits	
Second call code (the transmitting unit)		24 bits	
Cyclic redundancy check (CRC)		16 bits	
	Sub total	104 bits	
		× 3	
			312 bits
	Total		568 bits

4. Source coding

4.1 Voice transmissions

The speech coding algorithm for transmission and reception is in accordance with the standard adopted within the GSM Digital Pan-European Cellular Radio specification. The specification for transcoder delay is relaxed to a figure of less than 100 ms. The channel coding protects the 34 most important bits in the 260 bit speech frame by use of convolution coding, parity, tail-biting and interleaving techniques.

4.2 Data transmissions

The coding system used for data transmission and reception is left to the manufacturer's discretion.

5. Operating procedure

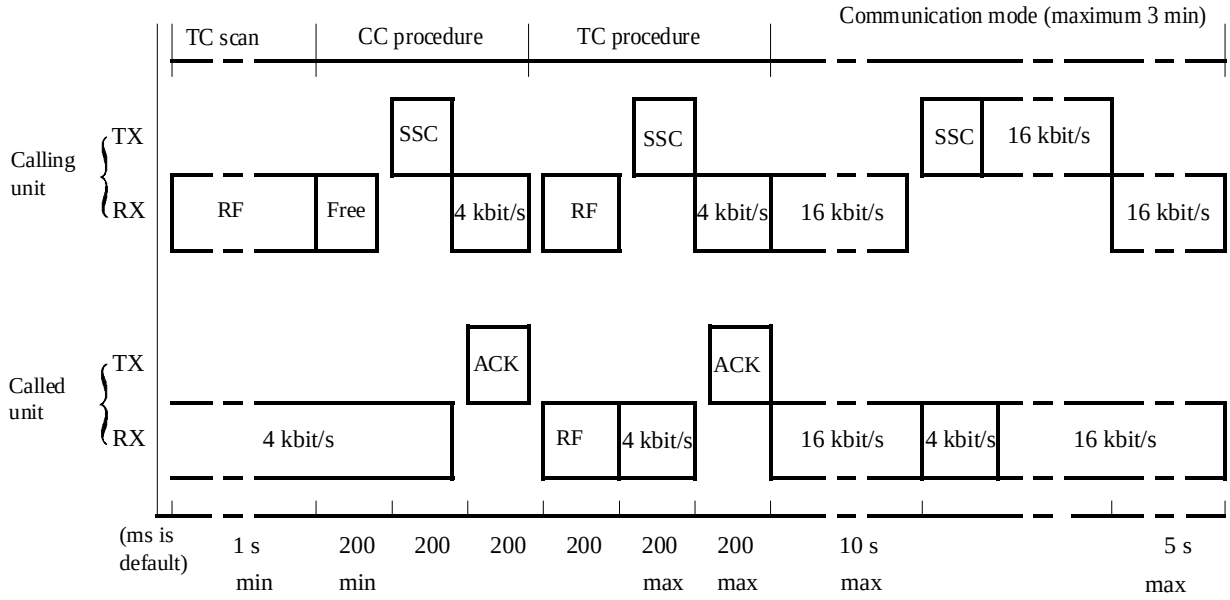
5.1 Single frequency working (see Fig. 3)

All radios in the system are normally in the standby state, that is ready to receive a SSC on one of the two control channels. (Units with even number serial numbers normally listen on their primary control channel 26 and odd serial numbers on channel 52.) A calling unit first scans and finds a free traffic channel, then communicates via the relevant control channel using the selective signalling code to alert an individual unit or group of units. These units transfer to the traffic channel and enter into conversation. At the end of the conversation all units return to the standby state.

5.2 Two frequency working (see Fig. 4)

A similar strategy to that described in § 5.1 is adopted with the exception that the protocol is modified such that the master unit or repeater always scans for a free traffic channel irrespective of the origin of the call. Should a two frequency unit initiate a call the first SSC contains no traffic channel number (set to all zeros) and the master unit or repeater has the responsibility of making the allocation. This is because in most systems of this type the master station or repeater will have a better antenna position giving greater coverage.

FIGURE 3
Single frequency individual call set-up (no re-tries)



RF: observing the RF level on the traffic channel
Free: monitoring the control channel to determine whether it is free or not
4 kbit/s: receiving with the signalling modulation scheme (waiting for an SSC or an ACK)
SSC: transmitting an SSC (142 ms)
ACK: transmitting an ACK (142 ms)
16 kbit/s: transmitting or receiving with the voice/data modulation scheme

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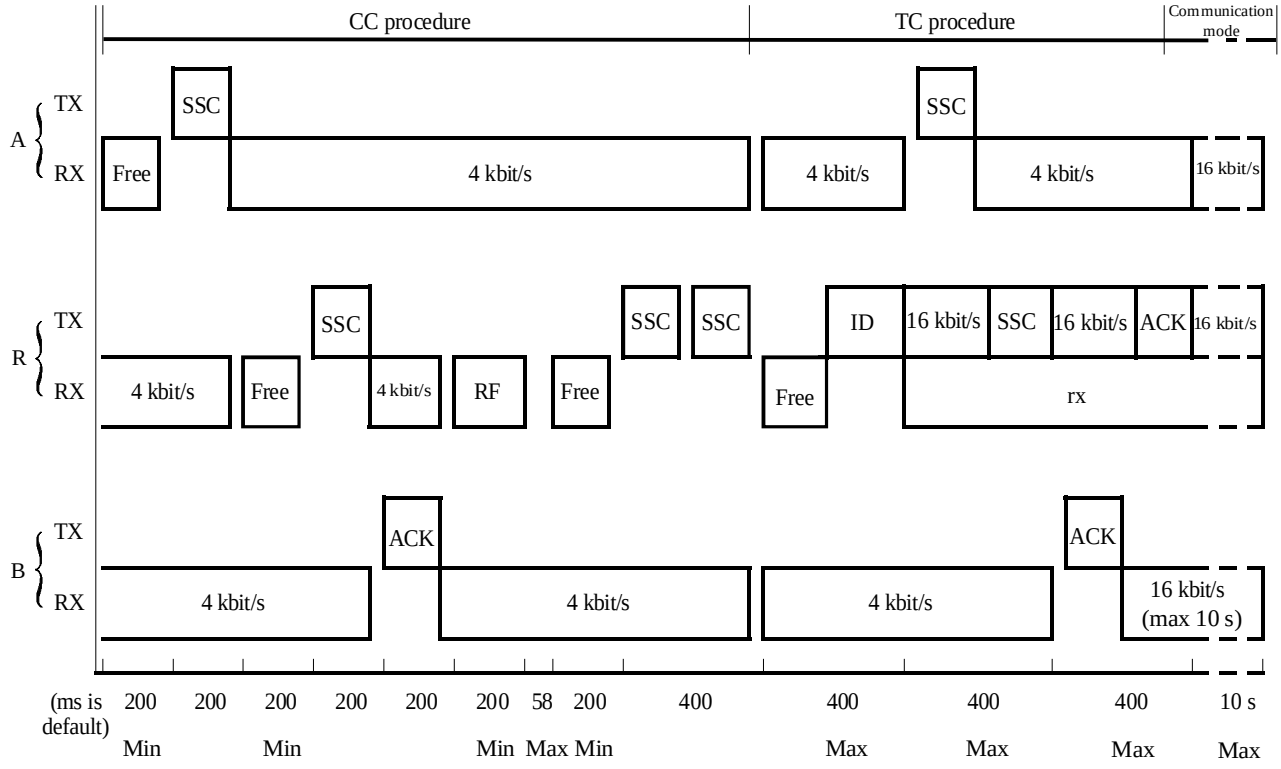
FIGURE 4

Two frequency call set-up unit to unit through a repeater (no re-tries)



A: calling unit (on B's primary CC)
R: repeater (on B's primary CC)
B: called unit (on B's primary CC)

Free:	monitoring the control channel to determine whether it is free or not
RF:	repeater observing the RF level on the traffic channel
4 kbit/s:	receiving with the signalling modulation scheme (waiting for an SSC or an ACK)
SSC:	transmitting an SSC (142 ms)
ACK:	transmitting an ACK (142 ms)
ID:	repeater transmitting its identification SSC (142 ms)
16 kbit/s:	transmitting or receiving with the voice/data modulation scheme

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REFERENCES

ETSI [1993] I-ETS 300-168, Digital Short Range Radio. European Telecommunications Standards Institute, Sophia Antipolis, F-06921, Valbonne Cedex, France.