International Telecommunication Union

ITU-R

Radiocommunication Sector of ITU

Recommendation ITU-R M.2084-0
(09/2015)

Radio interface standards of vehicle-to-vehicle and vehicle-to-infrastructure communications for Intelligent Transport System applications

M Series

Mobile, radiodetermination, amateur and related satellite services

150 ITU 1865-2015

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Note: *This ITU-R Recommendation was approved in English under the procedure detailed in Resolution ITU-R 1.*

Electronic Publication
Geneva, 2015

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RECOMMENDATION ITU-R M.2084-0

Radio interface standards of vehicle-to-vehicle and vehicle-to-infrastructure communications for Intelligent Transport System applications

(Question ITU-R 205-5/5)

(2015)

Scope

This Recommendation identifies specific radio interface standards of vehicle-to-vehicle and vehicle-to-infrastructure communications for Intelligent Transport System applications. The technical and operational characteristics described in this Recommendation are based on current and existing frequency bands already in use for Intelligent Transport Systems (ITS) and the applications in the mobile service.

Keywords

ITS, vehicle-to-vehicle communications, vehicle-to-infrastructure communications

Acronyms and abbreviations

ARIB	Association of Radio Industries and Businesses
ATS	Abstract Test Suite
BPSK	Binary phase shift keying
CEN	European Committee for Standardization (Comité européen de normalisation)
CSMA/CA	Carrier sense multiple access/collision avoidance
DCC	Decentralized Congestion Control
DSRC	Dedicated short range communications
EFC	Electronic Fee Collection
ETSI	European Telecommunications Standards Institute
FEC	Forward error correction
IEEE	Institute of Electrical and Electronics Engineers
ITS	Intelligent Transport Systems
OFDM	Orthogonal frequency-division multiplexing
PICS	Protocol Implementation Conformance Statement
PIXIT	Protocol Implementation eXtra Information for Testing
QAM	Quadrature amplitude modulation
QPSK	Quadrature phase shift keying
TSS & TP	Test Suite Structure and Test Purposes
TTA	Telecommunications Technology Association
V2I	Vehicle-to-infrastructure
V2V	Vehicle-to-vehicle
WAVE	Wireless Access in Vehicular Environments

Related ITU Recommendations

Recommendation ITU-R M.1453	Intelligent Transport Systems – dedicated short-range communications at 5.8 GHz
Recommendation ITU-R M.1890	Intelligent Transport Systems – Guidelines and Objectives

The ITU Radiocommunication Assembly,

considering

a) that standards development organizations (SDOs) are developing specific standards for vehicle-to-vehicle and vehicle-to-infrastructure communications in Intelligent Transport Systems (ITS);

b) that using the ITU-R Recommendation identifying these standards, manufacturers and operators should be able to determine the most suitable standards for their needs,

noting

Recommendation ITU-R M.1453, which recommends dedicated short-range communications (DSRC) operating at 5.8 GHz,

recommends

that the radio interface standards in Annexes 1 to 4 should be used for vehicle-to-vehicle and vehicle-to-infrastructure communications.

NOTE – The technical characteristics of these standards are summarized in Annex 5.

Annex 1

ETSI standards

ETSI Standards developed for the access and media layer are based on features such as:

– 5.9 GHz spectrum usage;

– multichannel operation;

– decentralized congestion control (DCC);

– coexistence of ITS and EFC (using CEN DSRC) applications in the 5.8 GHz and 5.9 GHz bands.

TABLE 1

Base standards for the access and media layer

Standard title	Standard number
Intelligent Transport Systems (ITS); Radiocommunications equipment operating in the 5 855 MHz to 5 925 MHz frequency band; Harmonized EN covering the essential requirements of article 3.2 of the R&TTE Directive	ETSI EN 302 571
Intelligent Transport Systems (ITS); Access layer specification for Intelligent Transport Systems operating in the 5 GHz frequency band	ETSI EN 302 663
Intelligent Transport Systems (ITS); Decentralized Congestion Control Mechanisms for Intelligent Transport Systems operating in the 5 GHz range; Access layer part	ETSI TS 102 687
Intelligent Transport Systems (ITS); Mitigation techniques to avoid interference between European CEN Dedicated Short-Range Communication (CEN DSRC) equipment and Intelligent Transport Systems (ITS) operating in the 5 GHz frequency range	ETSI TS 102 792
Intelligent Transport Systems (ITS); Harmonized Channel Specifications for Intelligent Transport Systems (ITS) operating in the 5 GHz frequency band	ETSI TS 102 724

TABLE 2

Testing standards for the access and media layer

Testing Standard title	Standard number
Intelligent Transport Systems (ITS); Test specifications for the channel congestion control algorithms operating in the 5.9 GHz range; Part 1: Protocol Implementation Conformance Statement (PICS)	ETSI TS 102 917-1
Intelligent Transport Systems (ITS); Test specifications for the channel congestion control algorithms operating in the 5.9 GHz range; Part 2: Test Suite Structure and Test Purposes (TSS & TP)	ETSI TS 102 917-2
Intelligent Transport Systems (ITS); Test specifications for the channel congestion control algorithms operating in the 5.9 GHz range; Part 3: Abstract Test Suite (ATS) and partial Protocol Implementation eXtra Information for Testing (PIXIT)	ETSI TS 102 917-3
Intelligent Transport Systems (ITS); Test specifications for the methods to ensure coexistence of Cooperative ITS G5 with RTTT DSRC; Part 1: Protocol Implementation Conformance Statement (PICS)	ETSI TS 102 916-1

TABLE 2 (*end*)

Testing Standard title	Standard number
Intelligent Transport Systems (ITS); Test specifications for the methods to ensure coexistence of Cooperative ITS G5 with RTTT DSRC; Part 2: Test Suite Structure and Test Purposes (TSS&TP)	ETSI TS 102 916-2
Intelligent Transport Systems (ITS); Test specifications for the methods to ensure coexistence of Cooperative ITS G5 with RTTT DSRC; Part 3: Abstract Test Suite (ATS) and partial Protocol Implementation eXtra Information for Testing (PIXIT)	ETSI TS 102 916-3

Annex 2

IEEE standards

IEEE Standards developed for the access and media layer are based on features such as:

– 5.9 GHz spectrum usage;

– multichannel operation;

– coexistence of ITS and other services in the 5 850-5 925 MHz band.

The ITS program is managed by the United States Federal Highway Administration Joint Program Office for ITS. The requirement for use of multi-channel wireless communications is based on IEEE Std 802.11p™-2010 – IEEE Standard for Information technology – Local and metropolitan area networks – Specific requirements – Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications Amendment 6: Wireless Access in Vehicular Environments, originally developed as an amendment to IEEE 802.11™-2007 that has been incorporated into the revision of IEEE 802.11™-2012 – IEEE Standard for Information technology – Telecommunications and information exchange between systems Local and metropolitan area networks – Specific requirements Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications. The upper layer protocols and services requirements are described the IEEE 1609 family of standards that use IEEE Std 802.11. Standardization of the upper layer protocols and services support the vehicle-to-vehicle and vehicle-to-roadside communication requirements of the National ITS Architecture and the Joint Program Office initiatives. Benefits for the ITS program in enabling wireless communications is for vehicle operators, dispatch centres, traffic management centres, emergency response centres, route guidance, safety and amber alerts, and response to traveller emergencies, traceable to the National ITS Architecture.

The published IEEE Std 802.11-2012 is available for free download at the IEEE Get program: http://standards.ieee.org/about/get/802/802.11.html

A list of the IEEE 1609 family of standards is as follows:

IEEE 1609.0™-2013 – IEEE Guide for Wireless Access in Vehicular Environments (WAVE) – Architecture

IEEE 1609.2™-2013 – IEEE Standard for Wireless Access in Vehicular Environments – Security Services for Applications and Management Messages

IEEE 1609.3™-2010 – IEEE Standard for Wireless Access in Vehicular Environments (WAVE) – Networking Services

IEEE 1609.3™-2010/Cor 1-2012 – IEEE Standard for Wireless Access in Vehicular Environments (WAVE) – Networking Services Corrigendum 1: Miscellaneous Corrections

IEEE 1609.3™-2010/Cor 2-2014 – IEEE Standard for Wireless Access in Vehicular Environments (WAVE) – Networking Services – Corrigendum 2: Correct identified errors

IEEE 1609.4™-2010 – IEEE Standard for Wireless Access in Vehicular Environments (WAVE) – Multi-channel Operation

IEEE 1609.4™-2010/Cor 1-2014 – IEEE Standard for Wireless Access in Vehicular Environments (WAVE) – Multi-channel Operation – Corrigendum 1: Correct identified errors

IEEE 1609.11™-2010 – IEEE Standard for Wireless Access in Vehicular Environments (WAVE) – Over-the-Air Electronic Payment Data Exchange Protocol for Intelligent Transportation Systems (ITS)

IEEE 1609.12™-2012 – IEEE Standard for Wireless Access in Vehicular Environments (WAVE) – Identifier Allocations

Annex 3

ARIB standard

In Japan, for the use of the safe driving support systems, a part of the 700 MHz band (755.5-764.5 MHz) has been assigned in a new spectrum allocation on a primary basis in the digital dividend band. The technical characteristics of vehicle-to-vehicle and vehicle-to-infrastructure communications for safe driving support systems are shown in Table 3.

TABLE 3

Characteristics of the transmission scheme

Item	Technical characteristic
Operating frequency range	755.5-764.5 MHz (Single channel)
Occupied bandwidth	Less than 9 MHz
Modulation scheme	BPSK OFDM, QPSK OFDM, 16QAM OFDM
Forward error correction	Convolutional coding, rate = 1/2, 3/4
Data transmission rate	3 Mbit/s, 4.5 Mbit/s, 6 Mbit/s, 9 Mbit/s, 12 Mbit/s, 18 Mbit/s
Media access control	CSMA/CA

Table 3 shows basic specifications of ARIB standard; ARIB STD-T109[1], 700 MHz band Intelligent Transport Systems (ITS) which have been developed in February 2012.

A 9 MHz channel width in the 700 MHz radio frequency band will be used for the safe driving support systems.

Data transmission rate is variable based on the selection of modulation scheme and coding rate (R) as follows:

– 3 Mbit/s (BPSK OFDM, R = 1/2), 4.5 Mbit/s (BPSK OFDM, R = 3/4);

– 6 Mbit/s (QPSK OFDM/, R = 1/2), 9 Mbit/s (QPSK OFDM, R = 3/4);

– 12 Mbit/s (16QAM OFDM, R = 1/2), 18 Mbit/s (16QAM OFDM, R = 3/4).

The single channel accommodates both vehicle-to-vehicle and vehicle-to-infrastructure communications based on CSMA/CA media access control.

Annex 4

TTA standards

1 Technical characteristics

The advanced Intelligent Transport System radiocommunications have to consider the described V2V/V2I communications and its service requirements and WAVE standards for international harmonization. In V2V applications, it is required to consider the low packet latency because the life-saving time of safety message is useful in the span of 100 ms. Also it requires a highly activated radio channel when many vehicles try to activate radio channel simultaneously. In V2I applications, it needs to adopt the long packet transmission which includes a short message, map information and image information to be order of 2 Kbytes in a packet size in high mobility condition.

Thus the advanced Intelligent Transport System radiocommunications have the following features as shown in Table 4.

TABLE 4

Technical characteristics

Item	Technical characteristic
RF frequency	5 855-5 925 MHz (Pilot system)
RF channel bandwidth	10 MHz
RF Transmit power	23 dBm
Modulation type	OFDM (BPSK, QPSK, 16QAM, Option: 64QAM)
Data rate	3, 4.5, 6, 9, 12, 18 Mbit/s, Option: 24, 27 Mbit/s
MAC	CSMA/CA, Option: Time Slot based CSMA/CA

[1] ARIB standard; ARIB STD-T109, 700MHz band intelligent transport systems (http://www.arib.or.jp/english/html/overview/doc/5-STD-T109v1_2-E1.pdf).

TABLE 4 (*end*)

Item	Technical characteristic
Networking	IPv4/IPv6, VMP(WSMP compatible)
Multi-hop	Location information based routing

2 TTA Standards related to advanced Intelligent Transport System radiocommunications

In the Republic of Korea, Telecommunication Technology Association (TTA) established four standards for advanced Intelligent Transport System radiocommunications. The detailed information of these standards is shown in Table 5.

TABLE 5

Base standards related to advanced Intelligent Transport System radiocommunications

Standard title	Standard number
Vehicle communication system Stage 1: Requirements	TTAK.KO-06.0175/R1
Vehicle communication system Stage 2: Architecture	TTAK.KO-06.0193/R1
Vehicle communication system Stage 3: PHY/MAC	TTAK.KO-06.0216/R1
Vehicle communication system State 3: Networking	TTAK.KO-06.0234/R1

Annex 5

Summary of the technical characteristics of the standards

Technical characteristics of each standard are shown in Table 6.

TABLE 6

Technical characteristics

Parameter	ETSI (Annex 1)	IEEE (Annex 2)	ARIB (Annex 3)	TTA (Annex 4)
Operating frequency range	5 855-5 925 MHz	5 850-5 925 MHz	755.5-764.5 MHz (Single channel)	5 855-5 925 MHz (Pilot system)
RF channel bandwidth	10 MHz	10 MHz or 20 MHz	Less than 9 MHz	Less than 10 MHz
RF Transmit Power/EIRP	Max 33 dBm EIRP		–	23 dBm
RF transmit power density			10 dBm/MHz	

TABLE 6 (*end*)

Parameter	ETSI (Annex 1)	IEEE (Annex 2)	ARIB (Annex 3)	TTA (Annex 4)
Modulation scheme	BPSK OFDM, QPSK OFDM, 16QAM OFDM, 64QAM OFDM	64-QAM-OFDM 16-QAM-OFDM QPSK-OFDM BPSK-OFDM 52 subcarriers	BPSK OFDM, QPSK OFDM, 16QAM OFDM	BPSK OFDM, QPSK OFDM, 16QAM OFDM, Option: 64QAM
Forward error correction	Convolutional coding, rate = 1/2, 3/4, 2/3	Convolutional coding, rate = 1/2, 3/4	Convolutional coding, rate = 1/2, 3/4	Convolutional coding, rate = 1/2, 3/4
Data transmission rate	3 Mbit/s, 4.5 Mbit/s, 6 Mbit/s, 9 Mbit/s, 12 Mbit/s, 18 Mbit/s, 24Mbit/s, 27Mbit/s	3, 4.5, 6, 9, 12, 18, 24 and 27 Mbit/s for 10 MHz channel spacing 6, 9, 12, 18, 24, 36, 48 and 54 Mbit/s for 20 MHz channel spacing	3 Mbit/s, 4.5 Mbit/s, 6 Mbit/s, 9 Mbit/s, 12 Mbit/s, 18 Mbit/s	3, 4.5, 6, 9, 12, 18 Mbit/s, Option: 24, 27 Mbit/s
Media access control	CSMA/CA	CSMA/CA	CSMA/CA	CSMA/CA, Option: Time Slot based CSMA/CA
Duplex method	TDD	TDD	TDD	TDD