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| **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** |

Foreword

The role of the Radiocommunication Sector is to ensure the rational, equitable, efficient and economical use of the radio-frequency spectrum by all radiocommunication services, including satellite services, and carry out studies without limit of frequency range on the basis of which Recommendations are adopted.

The regulatory and policy functions of the Radiocommunication Sector are performed by World and Regional Radiocommunication Conferences and Radiocommunication Assemblies supported by Study Groups.

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ITU-R policy on IPR is described in the Common Patent Policy for ITU-T/ITU-R/ISO/IEC referenced in Annex 1 of Resolution ITU-R 1. Forms to be used for the submission of patent statements and licensing declarations by patent holders are available from <http://www.itu.int/ITU-R/go/patents/en> where the Guidelines for Implementation of the Common Patent Policy for ITU‑T/ITU‑R/ISO/IEC and the ITU-R patent information database can also be found.

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| Series of ITU-R Recommendations  (Also available online at <http://www.itu.int/publ/R-REC/en>) | |
| **Series** | Title |
| **BO** | Satellite delivery |
| **BR** | Recording for production, archival and play-out; film for television |
| **BS** | Broadcasting service (sound) |
| **BT** | Broadcasting service (television) |
| **F** | Fixed service |
| M | Mobile, radiodetermination, amateur and related satellite services |
| **P** | Radiowave propagation |
| **RA** | Radio astronomy |
| **RS** | Remote sensing systems |
| **S** | Fixed-satellite service |
| **SA** | Space applications and meteorology |
| **SF** | Frequency sharing and coordination between fixed-satellite and fixed service systems |
| **SM** | Spectrum management |
| **SNG** | Satellite news gathering |
| **TF** | Time signals and frequency standards emissions |
| **V** | Vocabulary and related subjects |

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

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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](http://www.itu.int/rec/R-REC-M.1453/en) Intelligent Transport Systems – dedicated short-range communications at 5.8 GHz

Recommendation ITU-R [M.1890](http://www.itu.int/rec/R-REC-M.1890/en) 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]](#footnote-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 |

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 |

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>). [↑](#footnote-ref-1)