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ITU-R

Radiocommunication Sector of ITU

Recommendation ITU-R M.1452-2

(05/2012)

Millimetre wave vehicular collision avoidance radars and radiocommunication systems for intelligent transport system applications

M Series

Mobile, radiodetermination, amateur and related satellite services

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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.1452-2

Millimetre wave vehicular collision avoidance radars and radiocommunication systems for intelligent transport system applications

(Question ITU-R 205/5)

(2000-2009-2012)

Scope

This Recommendation provides system requirements, technical and operational characteristics of millimetre wave radiocommunication systems for intelligent transport system applications to be used for system design objectives. The Recommendation covers vehicular collision avoidance radar operating in the 76-77 GHz and 77-81 GHz bands, as well as integrated millimetre wave radiocommunication systems for ITS applications in the 57-66 GHz range for vehicle-to-vehicle radiocommunications and radiocommunications between the vehicle and roadside infrastructure.

The ITU Radiocommunication Assembly,

considering

a) that intelligent transport systems (ITS) will significantly contribute to the improvement of transportation and public safety;

b) that international standards would facilitate worldwide applications of ITS and provide for economies of scale in bringing ITS equipment and services to the public;

c) that harmonization of ITS applications is dependent on common radio spectrum allocations;

d) that high-capacity transmission systems will be required for ITS radiocommunication systems in order to support multimedia and high-resolution applications;

e) that low-capacity transmission systems will also be required for ITS radiocommunication systems to support safe vehicle operation, such as a collision avoidance radar;

f) that an integrated system of radar with radiocommunications is beneficial for safe driving and driver comfort;

g) that millimetre wave high-speed ITS communication systems using radio-over-fibre technology have been intensively studied in research fora and industries;

h) that millimetre wave frequencies have significant advantages and provide a wide bandwidth for such integrated ITS radar and communication systems;

j) that millimetre wave frequencies are also used by other radio systems and services operating in accordance with the Radio Regulations;

k) that strong absorption in a part of millimetre wave frequency ranges due to atmospheric oxygen and water vapour has a potential to reduce the interference among different radio services operating in the ranges;

l) that technical and operational characteristics of integrated millimetre wave radiocommunication systems for ITS applications need to be identified to facilitate the global deployment of such a system,

noting

a) that the International Organization for Standardization (ISO) has published standards on non-radio aspects of ITS in ISO/TC204, taking into account the work of recognized external organizations;

b) that the European Telecommunications Standards Institute (ETSI) has published standards on radio aspects of ITS in ETSI/ERM (Electromagnetic compatibility and Radio Spectrum Matters) which may further contribute to the efforts in ITU-R;

c) that the Institute of Electrical and Electronics Engineers (IEEE) is addressing millimetre wave communication standards for wireless personal networks in the frequency range 57-66 GHz;

d) that the Land Mobile Handbook (Volume 4 on ITS) contains information on millimetre wave communications, including propagation characteristics for vehicle-to-vehicle communications and inter-vehicle communications and radar,

recognizing

a) that the band 77.5-78 GHz is allocated worldwide on a primary basis to the amateur and amateur-satellites services;

b) that the bands 76-77.5 GHz and 78-81 GHz are allocated worldwide on a primary basis to the radiolocation and radio astronomy services,

recommends

1 that the operational and technical characteristics of automotive radars operating in the 76-77 GHz band, as given in Annex 1, should be used as a guideline for system design objectives;

2 that the operational and technical characteristics for automotive radar equipment operating in the 77-81 GHz band, as given in Annex 2, should be used as a guideline for system design objectives;

3 that the operational and technical characteristics of millimetre wave radiocommunication systems for ITS applications for data communication between vehicle-to-vehicle and vehicle-to-roadside, as given in Annex 3, should be used as a guideline for system design objectives.

Annex 1

Vehicular collision avoidance radar at 76-77 GHz

1 General

1.1 Introduction

Several millimetre wave bands are considered for vehicular radar. The 76-77 GHz band has already been designated by the Federal Communications Commission (FCC) in the United States of America and by the Ministry of Internal Affairs and Communications (MIC) in Japan for these purposes. In the United States, vehicular radars operating in the 76-77 GHz band are regulated according to FCC 47 part 15.253 and as part 15 device; may not cause harmful interference and must accept interference that may be caused by the operation of an authorized radio system, by another intentional or unintentional radiator, by industrial, scientific and medical (ISM) equipment,

or by an incidental radiator. Furthermore, in accordance with European spectrum requirements for Road Transport and Traffic Telematics (RTTT), ETSI has adopted European standards for automative radar operating in the 76-77 GHz band (ETSI EN 301 091) and ECC adopted a decision (ECC/DEC/(02)01) on the frequency bands to be designated for the coordinated introduction of RTTT, including the band 76-77 GHz. In Japan, the 76-77 GHz band is designated for this kind of application (ARIB STD-T48).

In October 2010, the Russian Federation identified the 76-77 GHz band for automotive radars.

This effort has led Asia-Pacific Telecommunity Standardization Program (ASTAP) to consider a proposal on a draft standard for vehicular collision avoidance radar operating in the 76-77 GHz band.

1.2 Scope

Today's vehicular radar systems in the millimetre wave are of two categories according to the measurement ranges and bandwidth:

– Category 1: Adaptive Cruise Control (ACC) and collision avoidance radar (CA), operating in the band 76-77 GHz, for measurement ranges up to 300 m.

– Category 2 "Short-range" radar for applications such as Blind Spot Detection (BSD), Lane-Change Assist (LCA), and Rear-Traffic-Crossing-Alert (RTCA), operating in the band 77-81 GHz for measurement ranges up to 100 m (see Annex 2 for Category 2).

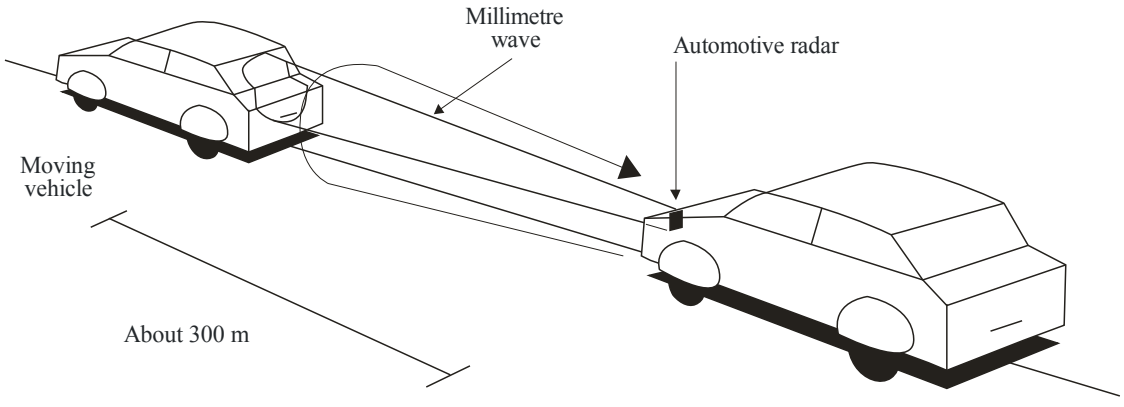
The rationale for separating these applications into two different frequency bands is given in ECC Report 56, which reveals, that sharing studies have concluded that sharing is not achievable between Category 1 and Category 2 if operated in a common frequency band.

Since vehicles are sold worldwide, the automotive industry is highly interested in a worldwide harmonization of these frequency bands and the corresponding parameters.

Figure 1 shows an application example of automotive radar.

FIGURE 1

Image of vehicle radar systems



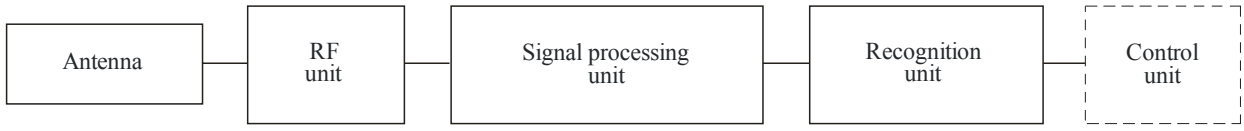
Depending on the number of radar sensors and their position it is possible to detect objects in sectors or even the complete surrounding of a car. The sensor signals are the basis not only for driver assistance systems like Adaptive Cruise Control but also for a broad variety of automotive applications of active and passive safety.

Systems for monitoring the proximity to vehicles will play an important role in ensuring driving safety. With its resistance to bad weather and dirt, automotive radar is suitable for vehicles driven in severe conditions.

Figure 2 shows the configuration of automotive radar.

FIGURE 2

Configuration of automotive radar



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Subsystems are as follows:

– *Antenna/RF unit*

This part consists of a transmitting antenna, a receiving antenna, receiving equipment and transmission equipment. Signal modulations, conversions to high frequencies, radio-wave transmission, and radio-wave reception are handled in this part. This part could be equipped with several antennas and could perform beam scanning.

– *Signal processing unit*

This unit renders distance and speed by calculating signals handed over from the RF unit. Rendering of average distance and speed, and mitigation of interference are sometimes handled here. When the antenna performs beam scanning, this unit calculates the direction of detected objects.

– *Recognition unit*

This unit can select and arrange the most wanted or necessary data depending on the needs of each system. For example, the unit will recognize the most relevant objects, and can judge whether the vehicle in front is in lane. The unit occasionally averages figures gathered, filters interference, and enhances measuring accuracy and reliability of data by tracking objects and by data fusion with data from other sensors.

2 System requirements

2.1 Radar and modulation methods

The following radar methods (with modulation methods) are recommended:

– Chirp radar (fast FM-CW) method;

– pulse method (pulse modulation);

– pulsed frequency hopping;

– two frequency CW method (no modulation or frequency modulation);

– spread spectrum method (direct sequence spread spectrum).

2.2 Operational and technical characteristics of 76-77 GHz automotive radar

Characteristics of 76-77 GHz automotive radar are given in Table 1.

TABLE 1

Characteristics of 76-77 GHz automotive radar

Characteristic (parameter)	Value
Operational characteristics	
Application	Adaptive cruise control (ACC) ACC stop & go Collision avoidance (CA)
Typical installation	One sensor (behind cooler grill)
Technical characteristics	
Typical range	0-300 m
Frequency range	76.00-77.00 GHz
Specified bandwidth (typical)	Up to 1 GHz
Peak power (e.i.r.p.)	Up to +55 dBm
Mean power (e.i.r.p.)	23.5 – 50 dBm

Annex 2

Vehicular collision avoidance radar in the band 77-81 GHz

1 General

1.1 Introduction

Existing automotive radar technology operating below 30 GHz leads to either limited range (24 GHz UWB equipment) or limited resolution (24 GHz ISM radar). Therefore, CEPT concluded that the band 77-81 GHz should be considered as the only globally harmonized frequency band for automotive radars. The 77-81 GHz band has been designated by the European Conference of Postal and Telecommunications Administrations (CEPT) in July 2004 (ECC/DEC/(04)03) for automotive radar. The European Commission has adopted the decision 2004/545/EC on the harmonization of radio spectrum in the 79 GHz range for the use of automotive radar. The harmonized standard EN 302 264 has been adopted by ETSI for short-range radar (SRR) operating in the 77-81 GHz band.

In March 2010, the Ministry of Internal Affairs and Communications (MIC) in Japan has started a study group in the Information and Communications Council for the introduction of high-resolution radar in the 77-81 GHz frequency band for national use.

In October 2010, the Russian Federation identified the 77-81 GHz band for automotive radar.

To enable future automotive radar applications for observing objects in the vicinity of a car, such as pedestrians and bicycles, extended range and high resolution are required simultaneously. As a consequence, vehicle applications will be improved for predictive safety functions. For this purpose, the 77-81 GHz frequency range is envisaged and already allocated in Europe.

2 System requirements

2.1 Radar and modulation methods

The following radar methods (with modulation methods) are recommended:

– FM-CW method (frequency modulation);
– Chirp radar (fast FM-CW) method;
– spread spectrum method (direct sequence spread spectrum);
– pulse method (pulse modulation);
– two frequency CW method (no modulation or frequency modulation);
– frequency code method.

2.2 Operational and technical characteristics of 77-81 GHz automotive radar

The typical automotive radar characteristics are given in Table 2.

TABLE 2

Characteristics of 77-81 GHz automotive radar

Parameter	**Value**	
	System A	**System B[1]**
Mean power spectral density (e.i.r.p.)	9 dBm/MHz	–3 dBm/MHz (NOTE 1)
Peak power (e.i.r.p.)	+45 dBm	+55 dBm (NOTE 2)
Transmit power	10 dBm	
Antenna gain	35 dBi	
Specified bandwidth	Up to 4 GHz	

NOTE 1 – The maximum mean power spectral density outside a vehicle resulting from the operation of one short-range radar shall not exceed −9 dBm/MHz e.i.r.p.

NOTE 2 – Peak power is defined in 50 MHz bandwidth.

[1] The parameters of System B are derived from ETSI EN 302 264.

Annex 3

Technical characteristics of millimetre wave radiocommunication systems for data communications between vehicles and between vehicles and roadside infrastructure

1 General technical characteristics

– Communications method: one-way, simplex, half duplex, full duplex, multicast;

– Modulation method: as required by application;

– Frequency band: 57.0-66.0 GHz (channel arrangements to be used for ITS applications will be specified by regions or countries separately);

– Transmitter power (power transferred to antenna): 10 mW or less/ e.i.r.p: 40 dBm or less;

– Permissible occupied bandwidth: 2.5 GHz or less.

2 Examples of technical characteristics of millimetre wave radiocommunication systems for ITS applications

The characteristics specified for millimetre wave radiocommunication systems for ITS are shown in Table 3.

TABLE 3

Technical characteristics of millimetre wave radiocommunication systems for ITS applications

Item	Technical characteristic		
	System A	System B	System C
Communication method	One way, simplex, half duplex, full duplex, multicast		
Modulation method	The modulation method is not provided for to correspond to the upgrade of the future use		
Frequency band	63.0-64.0 GHz	59.0-66.0 GHz	57.0-64.0 GHz
Transmitter power (power transferred to antenna)		10 mW or less	10 mW or less
Maximum e.i.r.p.	40 dBm		
Permissible occupied bandwidth		2.5 GHz or less	
Antenna gain	23 dBi or less (side lobe attenuation: 20 dB)	47 dBi or less	17 dBi (47 dBi for point to point application)