Designation: E 2158 – 01

Standard Specification for Dedicated Short Range Communication (DSRC) Physical Layer Using Microwave in the 902 to 928 MHz Band[1]

This standard is issued under the fixed designation E 2158; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

INTRODUCTION

FOREWORD

This specification is intended to form a part of a series of standards defining the framework of DSRC link in the North American Intelligent Transportation Systems (ITS) environment. In addition to this specification, Subcommittee E17.51 (and other committees) will issue other standards to form a complete set of standards for the DSRC link.

The Physical Layer Task Group consists primarily of experts from the telecommunications and transport sectors. The most active participating companies and organizations are: equipment manufacturers, systems integrators, toll and turnpike agencies, research consultants, and interested groups and associations.

Recommendations and decisions made by the United States Federal Communications Commission (FCC) and Industry Canada have served as references in the preparation of this specification (refer to Section 2—Referenced Documents).

Additional inputs came from experts from Europe and Japan (see Appendix X1—Bibliography).

This specification is applicable to operations in Canada, Mexico and the US to the extent allowed by national regulatory agencies

INTRODUCTION

DSRC is intended to meet the requirements for many of the applications that need short range communication as defined by the National ITS Architecture and the Intelligent Transportation Society of America. These applications include Advanced Traveller Information Systems (ATIS), Commercial Vehicle Operations (CVO), Advanced Vehicle Control Systems (AVCS), Electronic Toll and Traffic Management Systems (ETTM), Advanced Public Transportation Systems (APTS), and Advanced Transportation Management Systems (ATMS).

This specification comprises requirements for Open Systems Interconnection (OSI) Layer 1 in the 902 to 928 MHz Location and Monitoring Service (LMS) band for DSRC. This specification does not include associated measurement procedures for verification of the requirements. Measurement guidelines will be developed in another document as a separate work item.

The presented requirements distinguish between default and optional parameter values. Procedures for using optional parameters include consideration of upper OSI layers. The elaboration of such procedures will be subject to further work within Subcommittee E17.51.

This specification provides information for onboard equipment based on active as well as backscatter technologies, and allows for interoperability between systems based on both of these technologies. Furthermore, this specification allows for mixed time, frequency, and space division multiple access approaches.

This specification is conceived for the 2+10+2 MHz part, — 902 to 904 MHz, 909.75 to 919.75 MHz, and 919.75 to 921.75 MHz, of the LMS band. The 902 to 904 MHz region is used for unmodulated carriers to provide backscatter capability in this portion of the band. All of these frequencies in the LMS band are currently available for use in the US and Canada.

This specification contains requirements that minimize interference between sites and between active and backscatter systems. The active legacy systems currently operate and will continue to operate uplinks and downlinks on the 915.00 and 915.75 MHz center frequencies. This specification adds the possibility of operating new active downlink center frequencies on and between 915.00 and 918.75 MHz. However, the primary active downlink operating frequencies will be 915 and 918.75

MHz. The backscatter systems operate on all the frequencies between 902 and 904 MHz and 909.75 and 921.75 MHz while using power levels consistent with the out-of-band emissions requirements. However, in order to operate at the power levels allowed in this specification and minimize interference between systems and sites, the following designations have been made. 912.75 and 918.75 MHz will be the primary backscatter downlink operating frequencies just as 915 and 918.75 MHz will be the primary active downlink operating frequencies. The required active uplink frequency is 915.00 MHz. The primary backscatter uplink sideband frequencies are 910.75, 914.75, 916.75, and 920.75 MHz. Fig. 1, shows the ASTM — 902 to 928 MHz ISM Band Utilization.

The above described frequency usage plan enables reduced separation distance between sites for both active and backscatter systems. Multiple active installations, with 918.75 MHz for the active downlink and 915.00 MHz for the active uplink, can be installed with less separation distance than the current 915.00 MHz systems. This is possible because the uplink receiver experiences less interference from a downlink signal that is offset in frequency by 3.75 MHz. In addition, for the backscatter systems, this frequency use plan allows the operation of multiple sets of independent, simultaneously operating, channels of data transfer, which can be very closely spaced. The backscatter operation achieves this by operating one downlink channel at 912.75 MHz, with the uplink sidebands at 910.75 and 914.75 MHz, and another downlink channel at 918.75 MHz with uplink sidebands at 916.75 and 920.75 MHz. The spectral mask attenuation in this specification enables a significant reduction in the interference signal over 4 MHz separation from one downlink (for example, 912.75 MHz) to the adjacent channel uplink receiver (for example, 916.75 MHz). A third uplink sideband set for either downlink can be operated at 901 and 905 MHz with a CW signal at 903 MHz.

This band usage plan allows active and backscatter systems to operate with minimum interference, dual-mode systems to have North American-wide compatibility, and a high density of application deployments in congested areas.

1. Scope

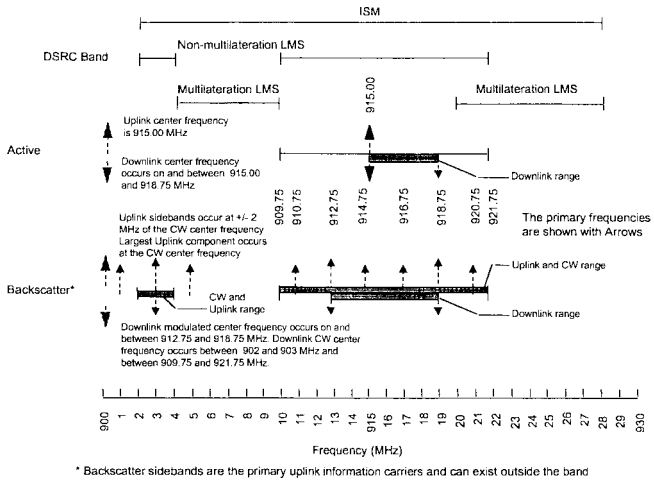
1.1 *Purposes*:

1.1.1 This specification defines the Open Systems Interconnection (OSI) layer 1, physical layer, for dedicated short-range communications (DSRC) equipment, operating in two-way, half-duplex, active and backscatter modes.

1.1.2 This specification establishes a common framework for the physical layer in the 902 to 928 MHz LMS band. This band is allocated for DSRC applications by the FCC in Title 47, Code of Federal Regulations (CFR), Part 90, Subpart M and by Industry Canada in the Spectrum Management, Radio Standard Specification, Location and Monitoring Service (902-928 MHz), RSS-137.

1.1.3 This specification defines an air interface for both wide-area (multi-lane, open road) and lane-based applications that enables accurate and valid message delivery between moving vehicles randomly entering a communications zone and fixed roadside communication equipment. This air interface also enables accurate and valid message delivery between moving or stationary vehicles and fixed or portable roadside communication equipment.

1.1.4 This specification does not include associated measurement guidelines for verification of the formulated requirements in this specification. It is intended that readers will be able to refer to the ASTM standard on Technical Characteristics and Test Methods for Data Transmission Equipment Operating in the 902 to 928 MHz LMS Band for the measurement guidelines, when it is developed.



* Backscatter sidebands are the primary uplink information carriers and can exist outside the band

FIG. 1 ASTM 902 to 928 MHz ISM Band Utilization Plan

1.1.5 This specification does not consider any one specific ITS application, but rather describes a communication means to be used by several ITS applications. This specification also may be used for any non-roadway environment that can utilize this type of dedicated short-range radio communication.

1.1.6 While this specification defines frequencies and power levels that are compatible with the North American regulatory requirements, the technical methodology used in their selection can be utilized in other regions of the world.

1.2 *Equipment*:

1.2.1 The DSRC equipment is composed of two principle components: road-side equipment (RSE) and on-board equipment (OBE) or transponder.

1.2.2 The RSE controls the protocol, schedules the activation of the OBE, reads from or writes to the OBE, and assures message delivery and validity. It is intended for, but not

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restricted to, installation at a fixed location on the roadway.

1.2.3 The OBE communicates with the RSE and is intended for, but not restricted to, installation in or on a motor vehicle.

1.2.4 The RSE must be capable of communicating with closely spaced OBE in the same lane or closely spaced OBE in adjacent lanes.

1.2.5 This specification provides requirements for the communication medium to be used for exchange of information between RSE and OBE. Active, backscatter, and dual-mode technologies are described.

1.3 *Structure*:

1.3.1 This specification defines an open (non-proprietary) architecture using the simplified OSI seven-layer reference model (per ISO 7498). The following sub-section describe the relationships of the OSI layers that support DSRC.

1.3.1.1 The physical layer (Layer 1) is defined as a half-duplex radio frequency medium, in the 902 to 928 MHz band. Layer 1 interfaces with Layer 2.

1.3.1.2 The data link control layer (Layer 2) defines a Time Division Multiple Access (TDMA) messaging protocol in which both the downlink and uplink are completely controlled by the RSE. The data link control layer provides a mechanism to ensure reliable completion of each transaction in the communications zone. This layer includes data organization, sequence control, flow control, error detection and error recovery among other functions. Layer 2 interfaces with Layer 7.

1.3.1.3 The application layer (Layer 7) defines specific functions and message formats to support ITS and other services. Implicit or pre-set message formats may be used. Data encryption, data certification, and manual OBE and RSE authentication may be performed.

1.3.1.4 The functions of the network layer (Layer 3), transport layer (Layer 4), session layer (Layer 5), and presentation layer (Layer 6) are included where necessary in Layer 2 or Layer 7.

1.3.2 The physical layer communications requirements for the signals sent from the RSE in the OBE are accounted for as downlink parameters. The requirements associated with the signals sent from the OBE to the RSE are accounted for as uplink parameters.

1.3.3 Physical layer requirements related to the interface to other DSRC communications layers are accounted for in 4.3.

1.4 The values stated in SI units are to be regarded as the standard.

2. Referenced Documents

2.1 This specification incorporates (by dated and undated reference) provisions from other publications. These references are cited at the appropriate places in the text and publications are listed below. For dated references, subsequent amendments to or revisions of any of these publications apply to this specification only when incorporated in it by amendment or revision. For undated references, the latest edition of the publication referred to applies.

2.1.1 Certain parameters in this specification allow compliance with regulations of the country in which the equipment is used. For the U.S., the regulations are maintained by the Federal Communications Commission and in Canada, the regulations are maintained by Industry Canada. In other countries, contact the regulatory agency for spectrum management to obtain the regulations that apply to this specification. The relevant parameters are marked with an asterisk (*) in the tables and the corresponding regulations are contained in 2.4. These parameters should not be changed without due consideration of the installation country's regulations.

2.2 *ISO Standard:*

ISO 7498 Open Systems Interconnection—Basic Reference Model[2]

2.3 *IEEE Standard:*

IEEE P 1455 Dedicated Short Range Communications Applications for Intelligent Transportation System[3]

2.4 *Government Standard:*

Title 47 Code of Federal Regulations (CFR) Part 90, Subpart M[4]

2.5 *Industry Canada Standard:*

RSS-137, Issue 1 (Provisional), Spectrum Management, Radio Standard Specification, Location and Monitoring Service (902-928-MHz)[5]

3. Terminology

3.1 *Abbreviations:*

3.1.1 *ASTM*—American Society for Testing and Materials.

3.1.2 *AM*—Amplitude Modulation.

3.1.3 *ant*—antenna.

3.1.4 *APTS*—Advanced Public Transportation Systems.

3.1.5 *ASK*—Amplitude Shift Keying.

3.1.6 *ATIS*—Advanced Traveller Information Systems.

3.1.7 *ATMS*—Advanced Transportation Management Systems.

3.1.8 *AVCS*—Advanced Vehicle Control Systems.

3.1.9 *AVI*—Automatic Vehicle Identification.

3.1.10 *Backsc*—Backscatter.

3.1.11 *B.E.R.*—Bit Error Rate.

3.1.12 *CFR*—Code of Federal Regulations.

3.1.13 *contd*—continued.

3.1.14 *CVO*—Commercial Vehicle Operations.

3.1.15 *CW*—Continuous Wave.

3.1.16 *DSRC*—Dedicated Short Range Communications.

3.1.17 *E.I.R.P.*—Equivalent Isotropic Radiation Power.

3.1.18 *EM*—Electromagnetic.

3.1.19 *ETTM*—Electronic Toll and Traffic Management Systems.

3.1.20 *f*—frequency.

3.1.21 *FCC*—Federal Communications Commission.

3.1.22 *FDMA*—Frequency Division Multiple Access.

3.1.23 *FSK*—Frequency Shift Keying.

3.1.24 *ITS*—Intelligent Transportation Systems.

3.1.25 *kbps*—kilobits per second (1000 bits per second).

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[2] Available from American National Standards Institute, 25 West 43rd Street, 4th Floor, New York, NY 10036.

[3] Available from The Institute of Electrical and Electronics Engineers, Inc., 345 E. 47th Street, New York, NY 10017.

[4] Available from Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

[5] Available from Canadian Standards Association, 178 Rexdale Boulevard, Etobicoke, Ontario Canada M9W1R3.