



Designation: E 2213 – 02

Standard Specification for Telecommunications and Information Exchange Between Roadside and Vehicle Systems — 5 GHz Band Dedicated Short Range Communications (DSRC) Medium Access Control (MAC) and Physical Layer (PHY) Specifications¹

This standard is issued under the fixed designation E 2213; 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.

1. Scope

1.1 This specification² describes a medium access control (MAC) and physical layer (PHY) specification for wireless connectivity using dedicated short-range communications (DSRC) services. This standard is based on and refers to IEEE Standards 802.11, *Wireless LAN Medium Access Control and Physical Layer Specifications*, and 802.11a, *Wireless LAN Medium Access Control and Physical Layer Specifications High-Speed Physical Layer in the 5 GHz Band*, with permission from the IEEE society. This specification is meant to be an extension of IEEE 802.11 technology into the high-speed vehicle environment. As presented here, this specification contains just enough information to explain the difference between IEEE 802.11 and IEEE 802.11a operating parameters required to implement a mostly high-speed data transfer service in the 5.9-GHz Intelligent Transportation Systems Radio Service (ITS-RS) Band or the Unlicensed National Information Infrastructure (UNII) Band, as appropriate.

1.2 *Purpose*—The purpose of this specification is to provide wireless communications over short distances between information sources and transactions stations on the roadside and mobile radio units, between mobile units, and between portable units and mobile units. The communications generally occur over line-of-sight distances of less than 1000 m between roadside units and mostly high speed, but occasionally stopped and slow moving, vehicles or between high-speed vehicles. This specification also offers regulatory bodies a means of standardizing access to the 5.9-GHz frequency band for the purpose of interoperable communications to and between vehicles at line-of-sight distances on the roadway.

1.3 Specifically, this specification accomplishes the following:

1.3.1 Describes the functions and services required by a

DSRC and IEEE 802.11 compliant device to operate in a high-speed mobile environment.

1.3.2 Refers to IEEE 802.11 MAC procedures.

1.3.3 Defines the 5.9-GHz DSRC signaling technique and interface functions that are controlled by the IEEE 802.11 MAC.

1.3.4 Permits the operation of a DSRC or IEEE 802.11 conformant device within a wireless local area network (LAN) that may coexist with multiple overlapping DSRC communication zones or IEEE 802.11 wireless LANs.

1.3.5 Describes the requirements and procedures to provide privacy of user information being transferred over the wireless medium (WM) and authentication of the DSRC or IEEE 802.11 conformant devices.

2. Referenced Documents

2.1 IEEE Standards:

802.11 Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications³

802.11a Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications—Amendment 1: High-Speed Physical Layer in the 5 GHz Band³

2.2 Federal Document:

CFR 47 Title 47 on Telecommunication⁴

3. Terminology

3.1 *Definitions*—See IEEE 802.11, Clause 3, in addition to the following information:

3.1.1 *onboard unit (OBU)*—an onboard unit (OBU) is a DSRC transceiver that is normally mounted in or on a vehicle, but which in some instances may be a portable unit. An OBU can be operational while a vehicle or person is either mobile or stationary. The OBUs receive and contend for time to transmit on one or more RF channels. Except where specifically excluded, OBU operation is permitted wherever vehicle operation or human passage is permitted. The OBUs mounted in

¹ This specification is under the jurisdiction of ASTM Committee E17 on Vehicle–Pavement Systems and is the direct responsibility of Subcommittee E17.51 on Vehicle Roadside Communication.

Current edition approved June 10, 2002. Published October 2002.

² This specification is based on IEEE Std 802.11, 1999 Edition and IEEE Std 802.11a, 1999 Edition. This specification explains the DSRC parameters as an extension of the IEEE Std 802.11 and IEEE Std 802.11a documents.

³ Available from Institute of Electrical and Electronics Engineers, Inc. (IEEE), 445 Hoes Ln., P.O. Box 1331, Piscataway, NJ 08854-1331

⁴ Available from Available from U.S. Government Printing Office Superintendent of Documents, 732 N. Capitol St., NW, Mail Stop: SDE, Washington, DC 20401.

vehicles are generally unlicensed and communicate with roadside units (RSUs) and other OBUs. Portable OBUs are licensed and restricted to communication with vehicle-mounted OBUs when operating in the ITS-RS Band. OBU operations are neither licensed nor restricted when operating in the UNII Bands.

3.1.2 *roadside unit (RSU)*—a roadside unit (RSU) is a DSRC transceiver that is mounted along a road, other vehicle, or pedestrian passageway. An RSU may also be mounted on a vehicle or is hand carried, but it may only operate when the vehicle or hand-carried unit is stationary. Furthermore, an RSU operating under CFR 47 Part 90 rules is restricted to the location where it is licensed to operate. However, portable or hand-held RSUs are permitted to operate on the Control Channel and Service channels where they do not interfere with a site-licensed operation. A RSU broadcasts data to OBUs or exchanges data with OBUs in its communications zone. An RSU also provides channel assignments and operating instructions to OBUs in its communications zone, when required.

3.1.3 *private (application)*—implementation of a DSRC service to transfer data to and from individual or business-owned devices to enable business or user data transactions or to improve the efficiency of business data transactions.

3.1.4 *public safety (application)*—implementation of a DSRC service by a government or government sponsored activity as defined in CFR 47 USC section 309(j).

3.2 *Acronyms:*

3.2.1 *BPSK*—binary phase shift keying

3.2.2 *C-MPDU*—coded MPDU

3.2.3 *DSRC*—dedicated short-range communications

3.2.4 *FFT*—Fast Fourier Transform

3.2.5 *GI*—guard interval

3.2.6 *IFFT*—inverse Fast Fourier Transform

3.2.7 *MLME*—MAC sublayer management entity

3.2.8 *OBU*—onboard unit

3.2.9 *OFDM*—orthogonal frequency division multiplexing

3.2.10 *PER*—packet error rate

3.2.11 *PLME*—PHY management entity

3.2.12 *QAM*—quadrature amplitude modulation

3.2.13 *QPSK*—quadrature phase shift keying

3.2.14 *RSU*—roadside unit

3.2.15 *U-NII*—unlicensed national information infrastructure

4. General Description

4.1 This specification defines the Open Systems Interconnection (OSI) Layer 1, physical layer, and Layer 2, medium access control layer for DSRC equipment operating in a two-way or one-way, half-duplex, active mode. The physical layer is a special case implementation of IEEE 802.11a technology and the medium access control layer is the same as the IEEE 802.11 MAC. All references in this specification to IEEE 802.11 MAC concepts are incorporated in the DSRC implementation. This specification establishes a common framework for the physical layer in the 5.850 to 5.925-GHz ITS-RS 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 (5.850 to 5.925 GHz), Number TBD.

4.1.1 *General Description of the DSRC and IEEE 802.11 Architecture*—See IEEE 802.11, Clause 5.1.

4.1.1.1 *How Wireless LAN Systems are Different from Wired LAN Systems*—See IEEE 802.11, Clause 5.1.1 and sub-clauses:

4.1.1.2 *How DSRC Systems are Different from IEEE 802.11 Systems:*

(1) This specification defines a medium access control and air interface that enables accurate and valid message delivery with communication units that are primarily mounted in high-speed moving vehicles. These communications may occur with other units that are: (1) fixed along the roadside or above the roadway; (2) mounted in other high-speed moving vehicles; (3) mounted in stationary vehicles; or (4) portable or hand-held. Communications may also occur between stationary or low-speed mobile units and fixed or portable units on the roadside or off-the-road, in private or public areas. However, most IEEE 802.11 systems implement communications between stationary units or mobile units moving at low speeds. High-speeds are considered those achieved by the general public and emergency vehicles on North American highways. Low-speeds are considered as walking to running paces.

(2) As explained in the definitions, in-vehicle communications units are called on-board units (OBUs). Communication units fixed along the roadside, over the road on gantries or poles, or off the road in private or public areas are called roadside units (RSUs). The DSRC RSUs may function as stations or as access points (APs) and DSRC OBUs only have functions consistent with those of stations (STAs). The common function between all RSUs is that these stationary units control access to the RF medium for OBUs in their communication zone or relinquish control to broadcast data only.

(3) In order to accommodate the more dynamic environment with essentially the same radio technology, DSRC uses a different channel access strategy than IEEE 802.11 units and employs additional operating rules. This additional System Management strategy is described primarily in the ASTM Layer Management Standard (under development) Number TBD.

(4) The essence of this strategy is the identification of a control channel and service channels, a system of priority access, and mandatory service channel data transfer time limits while in motion.

(5) RF power, sensitivity, and antenna pattern are intended to be referenced to a standard location on the vehicle. This standard location is intended to be the front bumper of a passenger vehicle or the equivalent on a commercial vehicle.

4.1.2 *Components of the IEEE 802.11 Architecture*—See IEEE 802.11, Clause 5.2.

4.1.3 *Logical Service Interfaces*—See IEEE 802.11, Clause 5.3.

4.1.4 *Overview of the Services*—See IEEE 802.11, Clause 5.4.

4.1.5 *Relationships Between Services*—See IEEE 802.11, Clause 5.5.

4.1.6 *Difference Between ESS and IBSS LANs*—See IEEE 802.11, Clause 5.6.

4.1.7 *Message Information Contents that Support the*

Services—See IEEE 802.11, Clause 5.7.

4.1.8 *Reference Model*—See IEEE 802.11, Clause 5.8.

4.1.9 *Implementation of DSRC Using IEEE 802.11 Architecture Components*:

4.1.9.1 The DSRC communications are conducted either between RSUs and OBUs, as shown in Figs. 1 and 2, or only between OBUs, as shown in Fig. 3.

4.1.9.2 The DSRC communications may be routed from or into wide area networks by portals from RSUs, as shown in Fig. 4.

4.1.9.3 The DSRC communications may be routed between wide area networks and in-vehicle networks by portals from OBUs and RSUs, as shown in Figs. 5-7.

5. IEEE 802.11a Referenced Paragraphs

5.1 *MAC Service Definition*—See IEEE 802.11, Clause 6.

5.2 *Frame Formats*—See IEEE 802.11, Clause 7.

5.3 *Authentication and Privacy*—See IEEE 802.11, Clause 8.

5.4 *MAC Sublayer Functional Description*—See IEEE 802.11, Clause 9.

5.5 *Multirate Support*—For the 5-GHz PHY, the time required to transmit a frame for use in the Duration/ID field is determined using the PLME-TXTIME.request primitive and the PLME-TXTIME.confirm primitive. The calculation method of TXTIME duration is defined in IEEE 802.11a, Clause 17.4.3.

6. Layer Management

6.1 See IEEE 802.11, Clause 10.

6.1.1 *PLME SAP Interface*:

Remove the references to a MPDUDurationFactor from 10.4.3.1.

10.4.6 PLME-TXTIME.request

10.4.6.1 Function

This primitive is a request for the PHY to calculate the time that will be required to transmit a PPDU containing a specified length MPDU, and using a specified format, data rate, and signaling onto the wireless medium.

10.4.6.2 Semantics of the service primitive

This primitive provides the following parameters:

PLME-TXTIME.request(TXVECTOR)

The TXVECTOR represents a list of parameters that the MAC sublayer provides to the local PHY entity in order to transmit a MPDU, as further described in 12.3.4.4 and 17.4 (which defines the local PHY entity).

10.4.6.3 When generated

This primitive is issued by the MAC sublayer to the PHY entity whenever the MAC sublayer needs to determine the time required to transmit a particular MPDU.

10.4.6.4 Effect of receipt

The effect of receipt of this primitive by the PHY entity shall be to generate a PHY-TXTIME.confirm primitive that conveys the required transmission time.

10.4.7 PLME-TXTIME.confirm

10.4.7.1 Function

This primitive provides the time that will be required to transmit the PPDU described in the corresponding PLME-TXTIME.request.

10.4.7.2 Semantics of the service primitive

This primitive provides the following parameters:

PLME-TXTIME.confirm(TXTIME)

The TXTIME represents the time in microseconds required to transmit the PPDU described in the corresponding PLME-TXTIME.request. If the calculated time includes a fractional microsecond, the TXTIME value is rounded to the next higher integer.

10.4.7.3 When generated

This primitive is issued by the local PHY entity in response to a PLME-TXTIME.request.

10.4.7.4 Effect of receipt

The receipt of this primitive provides the MAC sublayer with the PPDU transmission time.

6.1.2 *MAC Sublayer Management Entity*—See IEEE 802.11, Clause 11.

7. IEEE 802.11a Section 17 Updates for DSRC

The following paragraphs define the changes in Clause 17 of

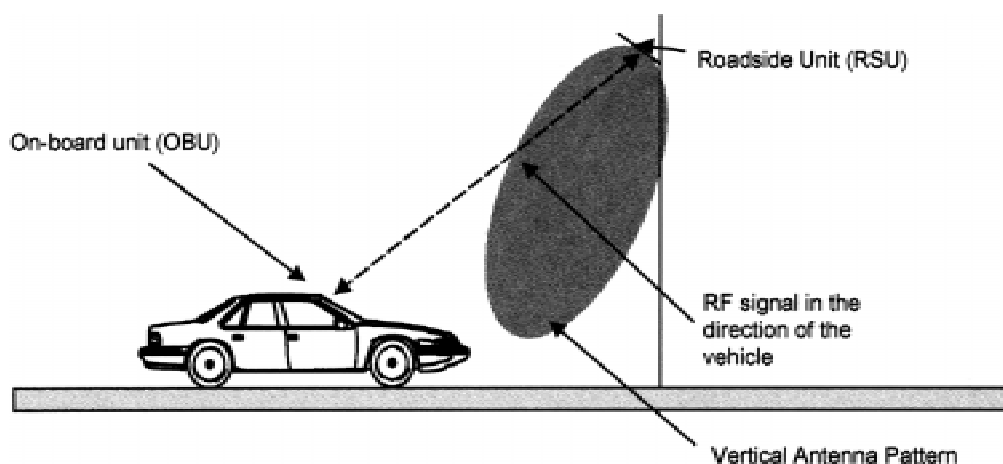


FIG. 1 RSU Communicating With an OBU

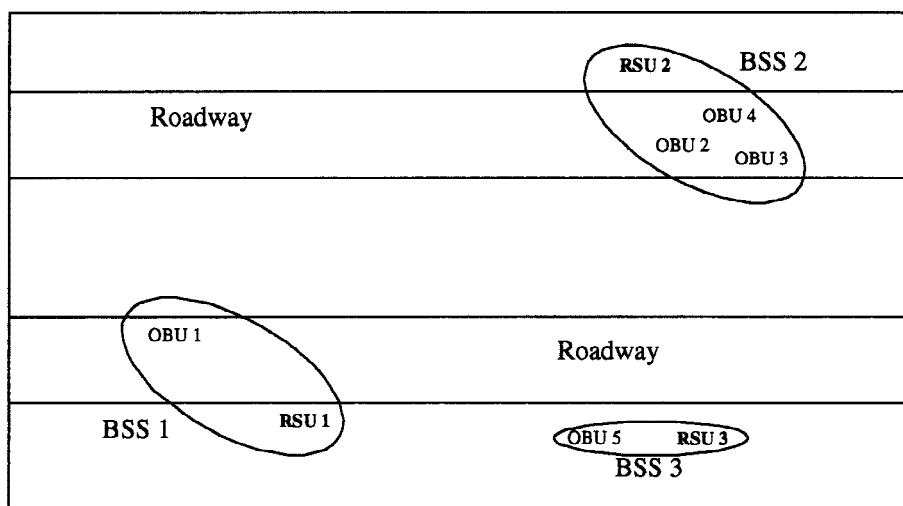


FIG. 2 Basic Service Sets With RSUs and OBUs

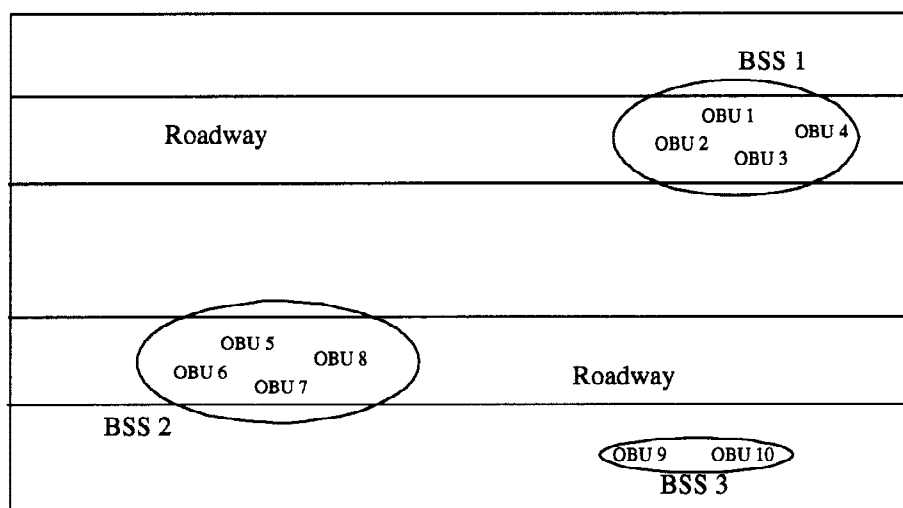


FIG. 3 Basic Service Sets With OBUs Only

the IEEE Standard 802.11a as modified to describe DSRC device implementations. IEEE Standard 802.11, the IEEE 802.11a Supplement, and the additions or modifications that follow fully describe the standard as it applies to a DSRC device.

NOTE 1—Clause 17 as it appears as follows only includes those portions of the document that have changed to incorporate DSRC.

7.1 DSRC PHY Specification for the 5-GHz Band:

7.1.1 *Introduction*—This clause specifies the PHY entity for an orthogonal frequency division multiplexing (OFDM) system and additions that have to be made to the base standard in order to accommodate the OFDM PHY. This DSRC radio frequency system is initially intended for the 5.850–5.925-GHz-licensed ITS Radio Services Band, as regulated in the United States by the Code of Federal Regulations, Title 47, Part 90. The OFDM system provides DSRC with data payload communication capabilities of 3, 4.5, 6, 9, 12, 18, 24, and 27 Mbit/s. In addition data payload capabilities of 6, 9, 12, 18, 24, 36, 48, and 54 Mbit/s can be supported in optional channel combinations. The support of transmitting and receiving at data

rates of 3, 6, and 12 Mbit/s is mandatory. The system uses 52 subcarriers, modulated using binary or quadrature phase shift keying (BPSK/QPSK), 16-quadrature amplitude modulation (QAM), or 64-QAM. Forward error correction coding (convolution coding) is used with a coding rate of 1/2, 2/3, or 3/4.

7.2 *TXVECTOR Parameters*—The parameters in Table 1⁵ are defined as part of the TXVECTOR parameter list in the PHY-TXSTART.request service primitive.

7.2.1 *TXVECTOR DATARATE*—The DATARATE parameter describes the bit rate at which the PLCP shall transmit the PSDU. Its value can be any of the rates defined in Table 1⁵. Data rates of 3, 6, and 12 Mbps shall be supported; other rates may also be supported.

⁵ This table is reprinted with permission from IEEE Standard 802.11a “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—Amendment 1: High-Speed Physical Layer in the 5 GHz Band,” Copyright 1999, by IEEE. The IEEE disclaims any responsibility or liability resulting from the placement and use in the described manner.

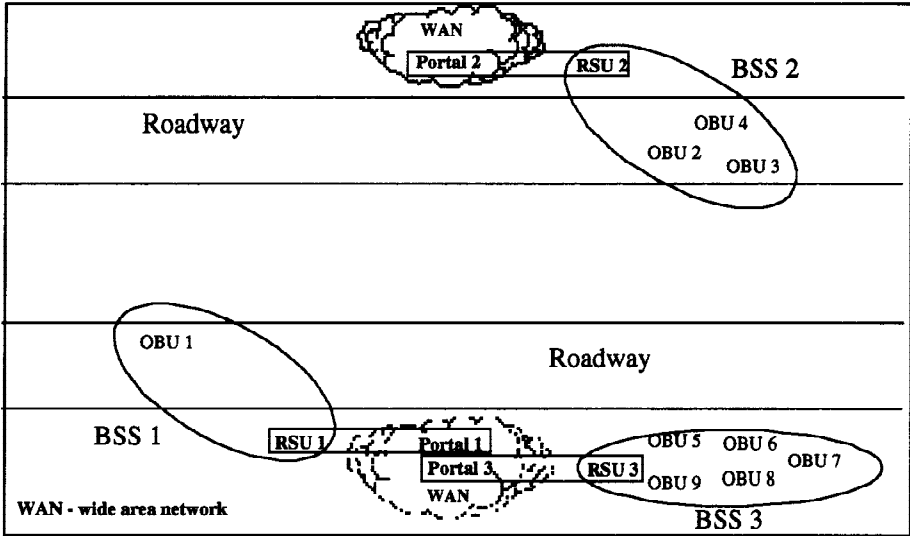


FIG. 4 Connecting OBUs to Wide-Area Networks

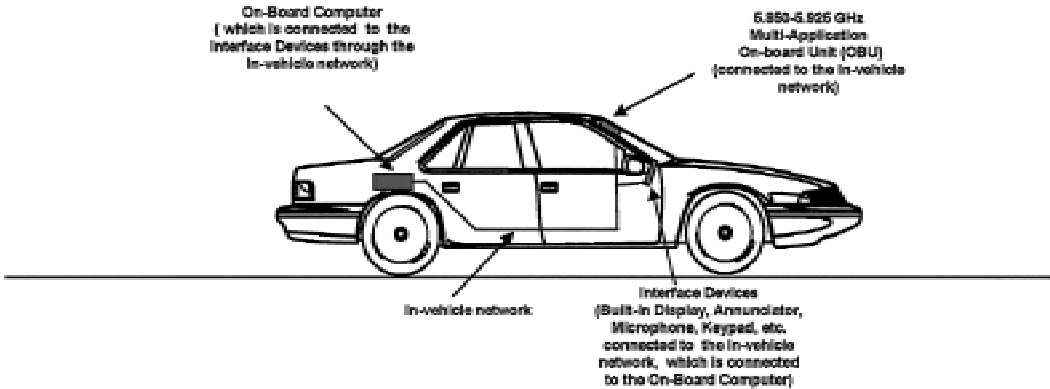


FIG. 5 Connecting an OBU to an In-vehicle Network

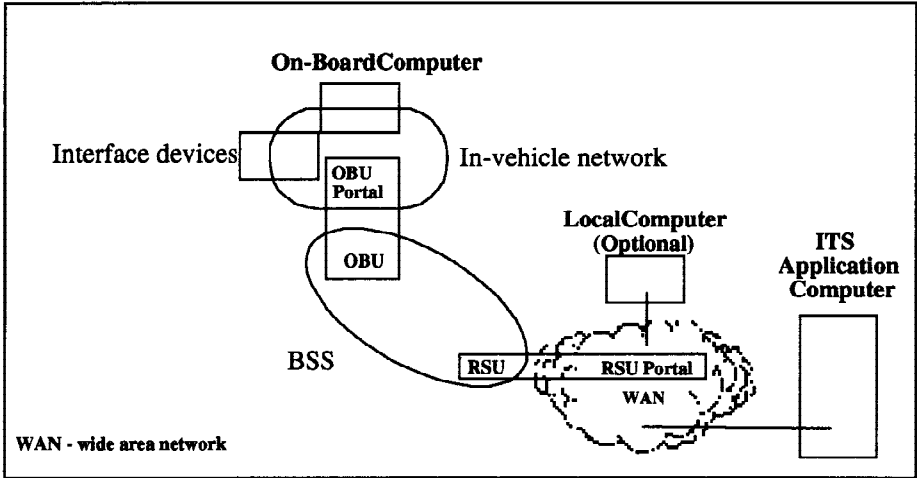


FIG. 6 BSS Connects On-board Computer Through the WAN to the ITS Application

7.3 RXVECTOR Parameters—The parameters listed in Table 2⁵ are defined as part of the RXVECTOR parameter list in the PHY- RXSTART.indicate service primitive.

7.3.1 RXVECTOR RSSI—The allowed values for the receive signal strength indicator (RSSI) parameter are in the range from 0 to RSSI maximum. This parameter is a measure

by the PHY sublayer of the energy observed at the antenna used to receive the current PPDU. The RSSI shall be measured during the reception of the PLCP preamble. The RSSI is intended to be used in a relative manner, and it shall be a monotonically increasing function of the received power. Subsequent to a period of no less than 2 ms after a Clear Channel

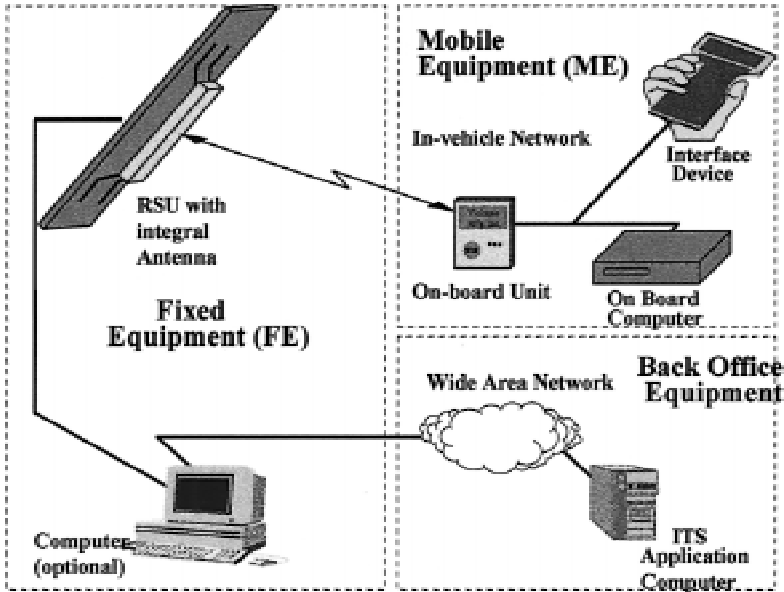


FIG. 7 Connecting a Remote ITS Application to On-board Systems

TABLE 1 TXVECTOR Parameters^A

Parameter	Associate Primitive	Value
LENGTH	PHY- TXSTART.request (TXVECTOR)	1-4095
DATARATE	PHY- TXSTART.request (TXVECTOR)	3, 4.5, 6, 9, 12, 18, 24, and 27 (Support of 3, 6, and 12 data rates is mandatory.)
SERVICE	PHY- TXSTART.request (TXVECTOR)	scrambler initialization; 7 null bits + 9 reserved null bits
TXPWR_LEVEL	PHY- TXSTART.request (TXVECTOR)	1-64

^A From IEEE Std. 802.11a. Copyright 1999 IEEE. All rights reserved.

TABLE 2 RXVECTOR Parameters^A

Parameter	Associate Primitive	Value
LENGTH	PHY- RXSTART.indicate	1-4095
RSSI	PHY- RXSTART.indicate (RXVECTOR)	0-RSSI maximum
DATARATE	PHY- RXSTART.request (RXVECTOR)	3, 4.5, 6, 9, 12, 18, 24, and 27
SERVICE	PHY- RXSTART.request (RXVECTOR)	null

^A From IEEE Std. 802.11a. Copyright 1999 IEEE. All rights reserved.

the minimum RSSI resolution should represent no more than 0.2-dB change of received signal and must be accurate to ± 1 dB across the entire operating temperature range within -60 to -30 dBm of the receiving signal range.

7.3.2 DATARATE—DATARATE shall represent the data rate at which the current PPDU was received. The allowed values of the DATARATE are 3, 4.5, 6, 9, 12, 18, 24, or 27 Mbps.

7.4 RATE-dependent Parameters—The modulation parameters dependent on the data rate used shall be set according to Table 3⁵.

7.4.1 Timing-Related Parameters—Table 4⁵ is the list of timing parameters associated with the OFDM PLCP.

7.4.2 Discrete Time Implementation Considerations—The following descriptions of the discrete time implementation are informational. In a typical implementation, the windowing function will be represented in discrete time. As an example, when a windowing function with parameters $T = 8.0 \mu s$ and a $T_{TR} = 200$ ns is applied, and the signal is sampled at 10 Msamples/s.

7.5 PLCP Preamble (SYNC):

7.5.1 The PLCP preamble field is used for synchronization. It consists of 10 short symbols and two long symbols that are shown in Fig. 8 and described as follows. Fig. 8 shows the OFDM training structure (PLCP preamble), where t_1 to t_{10}