

**Supplement to 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:**

**Higher-Speed Physical Layer Extension in the
2.4 GHz Band**

Sponsor

**LAN/MAN Standards Committee
of the
IEEE Computer Society**

Approved 16 September 1999

IEEE-SA Standards Board

Abstract: Changes and additions to IEEE Std 802.11, 1999 Edition are provided to support the higher rate physical layer (PHY) for operation in the 2.4 GHz band.

Keywords: 2.4 GHz, high speed, local area network (LAN), radio frequency (RF), wireless

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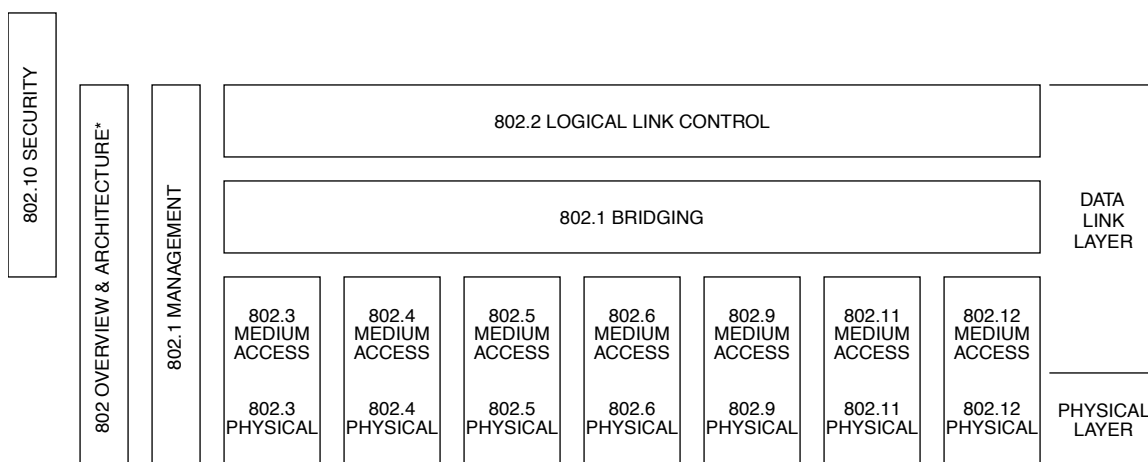
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Introduction

[This introduction is not part of IEEE Std 802.11b-1999, Supplement to 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: Higher-Speed Physical Layer Extension in the 2.4 GHz Band.]

This standard is part of a family of standards for local and metropolitan area networks. The relationship between the standard and other members of the family is shown below. (The numbers in the figure refer to IEEE standard numbers.)



* Formerly IEEE Std 802.1A.

This family of standards deals with the Physical and Data Link layers as defined by the International Organization for Standardization (ISO) Open Systems Interconnection (OSI) Basic Reference Model (ISO/IEC 7498-1:1994). The access standards define seven types of medium access technologies and associated physical media, each appropriate for particular applications or system objectives. Other types are under investigation.

The standards defining the access technologies are as follows:

- IEEE Std 802 *Overview and Architecture.* This standard provides an overview to the family of IEEE 802 Standards.
- ANSI/IEEE Std 802.1B and 802.1k [ISO/IEC 15802-2] *LAN/MAN Management.* Defines an OSI management-compatible architecture, and services and protocol elements for use in a LAN/MAN environment for performing remote management.
- ANSI/IEEE Std 802.1D [ISO/IEC 15802-3] *Media Access Control (MAC) Bridges.* Specifies an architecture and protocol for the interconnection of IEEE 802 LANs below the MAC service boundary.
- ANSI/IEEE Std 802.1E [ISO/IEC 15802-4] *System Load Protocol.* Specifies a set of services and protocol for those aspects of management concerned with the loading of systems on IEEE 802 LANs.
- IEEE Std 802.1F *Common Definitions and Procedures for IEEE 802 Management Information*
- ANSI/IEEE Std 802.1G [ISO/IEC 15802-5] *Remote Media Access Control Bridging.* Specifies extensions for the interconnection, using non-LAN communication technologies, of geographically separated IEEE 802 LANs below the level of the logical link control protocol.

- ANSI/IEEE Std 802.2 [ISO/IEC 8802-2] *Logical Link Control*
- ANSI/IEEE Std 802.3 [ISO/IEC 8802-3] *CSMA/CD Access Method and Physical Layer Specifications*
- ANSI/IEEE Std 802.4 [ISO/IEC 8802-4] *Token Passing Bus Access Method and Physical Layer Specifications*
- ANSI/IEEE Std 802.5 [ISO/IEC 8802-5] *Token Ring Access Method and Physical Layer Specifications*
- ANSI/IEEE Std 802.6 [ISO/IEC 8802-6] *Distributed Queue Dual Bus Access Method and Physical Layer Specifications*
- ANSI/IEEE Std 802.9 [ISO/IEC 8802-9] *Integrated Services (IS) LAN Interface at the Medium Access Control and Physical Layers*
- ANSI/IEEE Std 802.10 *Interoperable LAN/MAN Security*
- IEEE Std 802.11 [ISO/IEC DIS 8802-11] *Wireless LAN Medium Access Control and Physical Layer Specifications*
- ANSI/IEEE Std 802.12 [ISO/IEC DIS 8802-12] *Demand Priority Access Method, Physical Layer and Repeater Specifications*

In addition to the family of standards, the following is a recommended practice for a common Physical Layer technology:

- IEEE Std 802.7 *IEEE Recommended Practice for Broadband Local Area Networks*

The following additional working groups have authorized standards projects under development:

- IEEE 802.14 *Standard Protocol for Cable-TV Based Broadband Communication Network*
- IEEE 802.15 *Wireless Personal Area Networks Access Method and Physical Layer Specifications*
- IEEE 802.16 *Broadband Wireless Access Method and Physical Layer Specifications*

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[This supplement is based on IEEE Std 802.11, 1999 Edition.]

EDITORIAL NOTE—The editing instructions contained in this supplement define how to merge the material contained herein into the existing base standard to form the new comprehensive standard, as created by the addition of IEEE Std 802.11b-1999.

The editing instructions are shown in ***bold italic***. Three editing instructions are used: change, delete, and insert. ***Change*** is used to make small corrections in existing text or tables. This editing instruction specifies the location of the change and describes what is being changed either by using ~~striketrough~~ (to remove old material) or underscore (to add new material). ***Delete*** removes existing material. ***Insert*** adds new material without disturbing the existing material. Insertions may require renumbering. If so, renumbering instructions are given in the editing instructions. Editorial notes will not be carried over into future editions.

3.8 Basic service set (BSS) basic rate set

Change the text in this subclause as shown:

The set of data transfer rates that all the stations in a BSS will be capable of using to receive and transmit frames to/from the wireless medium (WM). The BSS basic rate set data rates are preset for all stations in the BSS.

4. Abbreviations and acronyms

Insert the following abbreviations alphabetically in the list in Clause 4:

CCK	complementary code keying
HR/DSSS	High Rate direct sequence spread spectrum using the Long Preamble and header
HR/DSSS/short	High Rate direct sequence spread spectrum using the optional Short Preamble and header mode
HR/DSSS/PBCC	High Rate direct sequence spread spectrum using the optional packet binary convolutional coding mode and the Long Preamble and header
HR/DSSS/PBCC/short	High Rate direct sequence spread spectrum using the optional packet binary convolutional coding mode and the optional Short Preamble and header

7.2.3.1 Beacon frame format

Change Notes 1 and 2 of Table 5 as shown:

Table 5—Beacon frame body

Order	Information	Note
1	Timestamp	—
2	Beacon interval	—
3	Capability Information	—
4	SSID	—
5	Supported Rates	—
6	FH Parameter Set	1
7	DS Parameter Set	2
8	CF Parameter Set	3
9	IBSS Parameter Set	4
10	TIM	5

NOTES:

1—The FH Parameter Set information element is ~~only~~ present within Beacon frames generated by STAs using frequency-hopping PHYs.

2—The DS Parameter Set information element is ~~only~~ present within Beacon frames generated by STAs using direct sequence PHYs.

3—The CF Parameter Set information element is only present within Beacon frames generated by APs supporting a PCF.

4—The IBSS Parameter Set information element is only present within Beacon frames generated by STAs in an IBSS.

5—The TIM information element is only present within Beacon frames generated by APs.

7.2.3.9 Probe Response frame format*Change Notes 1 and 2 of Table 12 as shown:***Table 12—Probe Response frame body**

Order	Information	Note
1	Timestamp	—
2	Beacon interval	—
3	Capability Information	—
4	SSID	—
5	Supported Rates	—
6	FH Parameter Set	1
7	DS Parameter Set	2
8	CF Parameter Set	3
9	IBSS Parameter Set	4

NOTES:

1—The FH Parameter Set information element is ~~only~~ present within Probe Response frames generated by STAs using frequency-hopping PHYs.

2—The DS Parameter Set information element is ~~only~~ present within Probe Response frames generated by STAs using direct sequence PHYs.

3—The CF Parameter Set information element is only present within Probe Response frames generated by APs supporting a PCF.

4—The IBSS Parameter Set information element is only present within Probe Response frames generated by STAs in an IBSS.

7.3.1.4 Capability Information field*Change the text in 7.3.1.4 and Figure 27 as shown:*

The Capability Information field contains a number of subfields that are used to indicate requested or advertised capabilities.

The length of the Capability Information field is 2 octets. The Capability Information field consists of the following subfields: ESS, IBSS, CF-Pollable, CF-Poll Request, ~~and~~ Privacy, Short Preamble, PBCC, and Channel Agility. The format of the Capability Information field is as illustrated in Figure 27.

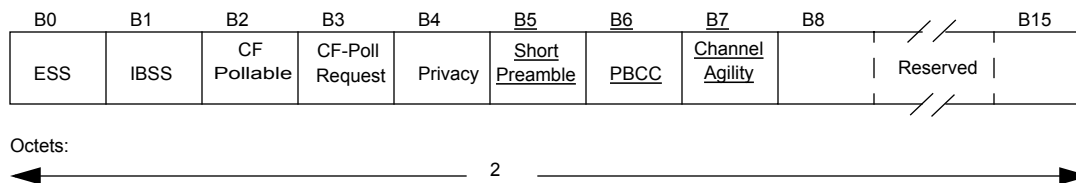


Figure 27—Capability Information fixed field

Insert the following text at the end of 7.3.1.4:

APs (as well as STAs in IBSSs) shall set the Short Preamble subfield to 1 in transmitted Beacon, Probe Response, Association Response, and Reassociation Response management MMPDUs to indicate that the use of the Short Preamble option, as described in 18.2.2.2, is allowed within this BSS. To indicate that the use of the Short Preamble option is not allowed, the Short Preamble subfield shall be set to 0 in Beacon, Probe Response, Association Response, and Reassociation Response management MMPDUs transmitted within the BSS.

STAs shall set the Short Preamble subfield to 1 in transmitted Association Request and Reassociation Request MMPDUs when the MIB attribute dot11ShortPreambleOptionImplemented is true. Otherwise, STAs shall set the Short Preamble subfield to 0 in transmitted Association Request and Reassociation Request MMPDUs.

APs (as well as STAs in IBSSs) shall set the PBCC subfield to 1 in transmitted Beacon, Probe Response, Association Response, and Reassociation Response management MMPDUs to indicate that the use of the PBCC Modulation option, as described in 18.4.6.6, is allowed within this BSS. To indicate that the use of the PBCC Modulation option is not allowed, the PBCC subfield shall be set to 0 in Beacon, Probe Response, Association Response, and Reassociation Response management MMPDUs transmitted within the BSS.

STAs shall set the PBCC subfield to 1 in transmitted Association Request and Reassociation Request MMPDUs when the MIB attribute dot11PBCCOptionImplemented is true. Otherwise, STAs shall set the PBCC subfield to 0 in transmitted Association Request and Reassociation Request MMPDUs.

Bit 7 of the Capabilities Information field shall be used to indicate the usage of Channel Agility by the HR/DSSS PHY. STAs shall set the Channel Agility bit to 1 when Channel Agility is in use, and shall set it to 0 otherwise.

Bits 8–15 of the Capability Information field are reserved.

7.3.1.9 Status Code field

Add three Status Codes to Table 19 as shown:

Table 19—Status Codes

Status Code	Meaning
<u>19</u>	<u>Association denied due to requesting station not supporting the Short Preamble option.</u>
<u>20</u>	<u>Association denied due to requesting station not supporting the PBCC Modulation option.</u>
<u>21</u>	<u>Association denied due to requesting station not supporting the Channel Agility option.</u>

7.3.2.2 Supported Rates element

Change the text in 7.3.2.2 as shown.

The Supported Rates element specifies all the values rates that this station is capable of receiving in the Operational-Rate-Set parameter, as described in the MLME Join.request and MLME Start.request primitives. The information field is encoded as 1–8 octets, where each octet describes a single Supported Rate in units of 500 kbit/s.

Within Beacon, Probe Response, Association Response, and Reassociation Response management frames, each Supported Rate belonging to the ~~BSSBasicRateSet~~ BSS basic rate set is encoded as an octet with the msb (bit 7) set to 1 (e.g., a 1 Mbit/s rate belonging to the ~~BSSBasicRateSet~~ BSS basic rate set is encoded as X'82'). Rates not belonging to the ~~BSSBasicRateSet~~ BSS basic rate set are encoded with the msb set to 0 (e.g., a 2 Mbit/s rate not belonging to the ~~BSSBasicRateSet~~ BSS basic rate set is encoded as X'04'). The msb of each Supported Rate octet in other management frame types is ignored by receiving STAs.

~~BSSBasicRateSet~~ The BSS basic rate set information in Beacon and Probe Response management frames is delivered to the management entity in an STA via the ~~BSSBasicRateSet~~ BSS basic rate set parameter in the MLME Scan.confirm primitive. It is used by the management entity in an STAs in order to avoid associating with a BSS if the STA cannot receive and transmit all the data rates in the ~~BSSBasicRateSet~~ BSS basic rate set (see Figure 36).

9.2 DCF

Change the eleventh paragraph in 9.2 as shown.

The medium access protocol allows for stations to support different sets of data rates. All STAs shall be able to receive and transmit at all the data rates in the aBasicRateSet specified parameter of the MLME Join.request and MLME Start.request primitives and transmit at one or more of the aBasicRateSet

~~data rates.~~ To support the proper operation of the RTS/CTS and the Virtual Carrier Sense mechanism, all STAs shall be able to detect the RTS and CTS frames. For this reason, the RTS and CTS frames shall be transmitted at one of the rates in the BSS basic rate set ~~aBasicRateSet rates.~~ (See 9.6 for a description of multirate operation.)

9.6 Multirate support

Change the existing text as shown:

Some PHYs have multiple data transfer rate capabilities that allow implementations to perform dynamic rate switching with the objective of improving performance. The algorithm for performing rate switching is beyond the scope of this standard, but in order to ensure coexistence and interoperability on multirate-capable PHYs, this standard defines a set of rules that shall be followed by all STAs.

All Control frames shall be transmitted at one of the rates in the ~~BSSBasicRateSet~~ BSS basic rate set (see 10.3.10.1), ~~or at one of the rates in the PHY mandatory rate set so that they will be understood by all STAs in the BSS.~~

All frames with multicast and broadcast RA shall be transmitted at one of the rates included in the ~~BSSBasicRateSet~~ BSS basic rate set, regardless of their type or subtype.

Data and/or management MPDUs with a unicast ~~immediate address~~ RA shall be sent on any supported data rate selected by the rate switching mechanism (whose output is an internal MAC variable called ~~MACCurrentRate, defined in units of 500 kbit/s,~~ which is used for calculating the Duration/ID field of each frame). An STA shall not transmit at a rate that is known not to be supported by the destination STA, as reported in the Supported Rates element in the management frames. For frames of type Data + CF – ACK, Data + CF – Poll + CF – ACK, and CF – Poll + CF – ACK, the rate chosen to transmit the frame must be supported by both the addressed recipient STA and the STA to which the ACK is intended.

~~In order to~~ To allow the transmitting STA to calculate the contents of the Duration/ID field, the responding STA shall transmit its Control Response and Management Response frames (either CTS or ACK) at the highest rate in the BSS basic rate set that is less than or equal to the rate of at the same rate as the immediately previous frame in the frame exchange sequence (as defined in 9.7). if this rate belongs to the PHY mandatory rates, or else at the highest possible rate belonging to the PHY rates in the BSSBasicRateSet. ~~In addition, the Control Response frame shall be sent using the same PHY options as the received frame.~~

For the HR/DSSS 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, both defined in 1.3.4.

10.3.2.2 MLME_scan.confirm

Change "set" to "sets" in the Name and Description columns for the PHY Parameter Set.

10.3.2.2.2 Semantics of the service primitive*Change the table as shown:*

Name	Type	Valid range	Description
BSSID	MACAddress	N/A	The BSSID of the found BSS.
SSID	Octet string	1–32 octets	The SSID of the found BSS.
BSSType	Enumeration	INFRASTRUCTURE, INDEPENDENT	The type of the found BSS.
Beacon Period	Integer	N/A	The Beacon period of the found BSS (in TU).
DTIM Period	Integer	As defined in frame format	The DTIM period of the BSS (in beacon periods).
Timestamp	Integer	N/A	The timestamp of the received frame (probe response/beacon) from the found BSS.
Local Time	Integer	N/A	The value of STA's TSF timer at the start of reception of the first octet of the timestamp field of the received frame (probe response or beacon) from the found BSS.
PHY Parameter Set	As defined in frame format	As defined in frame format	The parameter set relevant to the PHY.
CF Parameter Set	As defined in frame format	As defined in frame format	The parameter set for the CF periods, if found BSS supports CF mode.
IBSS Parameter Set	As defined in frame format	As defined in frame format	The parameter set for the IBSS, if found BSS is an IBSS.
Capability Information	As defined in frame format	As defined in frame format	The advertised capabilities of the BSS.
BSSBasicRateSet	Set of integers	1–27 inclusive (for each integer in the set)	The set of data rates (in units of 500 kb/s) that must be supported by all STAs that desire to join this BSS. The STAs must be able to receive and transmit at each of the data rates listed in the set.

10.3.3.1.2 Semantics of the service primitive

Change the table as shown:

Name	Type	Valid range	Description
BSSDescription	BSSDescription	N/A	The BSSDescription of the BSS to join. The BSSDescription is a member of the set of descriptions that was returned as a result of a MLME-SCAN.request.
JoinFailureTimeout	Integer	≥ 1	The time limit, in units of beacon intervals, after which the join procedure will be terminated.
ProbeDelay	Integer	N/A	Delay (in μ s) to be used prior to transmitting a Probe frame during active scanning.
OperationalRateSet	Set of integers	1–127 inclusive (for each integer in the set)	The set of data rates (in units of 500 kbit/s) that the STA desires to use for communication within the BSS. The STA must be able to receive at each of the data rates listed in the set. The OperationalRateSet This set is a superset of the BSS-BasicRateSet BSS basic rate set advertised by the BSS.

10.3.10 Start

Change "set" to "sets" in the Name and Description columns for the PHY Parameter Set.

10.3.10.1.2 Semantics of the service primitive*Change the table as shown:*

Name	Type	Valid range	Description
SSID	Octet string	1–32 octets	The SSID of the BSS.
BSSType	Enumeration	INFRASTRUCTURE, INDEPENDENT	The type of the BSS.
Beacon period	Integer	≥ 1	The Beacon period of the BSS (in TU).
DTIM period	Integer	As defined in 7.3.12.6	The DTIM period of the BSS (in Beacon periods).
CF Parameter Set	As defined in Frame Format	As defined in 7.3.2.5	The Parameter Set for CF periods, if the BSS supports CF mode. aCFPPeriod is modified as a side effect of the issuance of a MLME-START.request primitive.
PHY Parameter Set	As defined in Frame Format	As defined in 7.3.2.3 or 7.3.2.4	The Parameter Set relevant to the PHY.
IBSS Parameter Set	As defined in Frame Format	As defined in 7.3.2.7	The Parameter Set for the IBSS, if BSS is an IBSS.
ProbeDelay	Integer	N/A	Delay (in μs) to be used prior to transmitting a Probe frame during active scanning.
CapabilityInformation	As defined in Frame Format	As defined in 7.3.1.4	The capabilities to be advertised for the BSS.
BSSBasicRateSet	Set of integers	1–127 inclusive (for each integer in the set)	The set of data rates (~~in units of 500 kbit/s~~) that must be supported by all STAs that desire to join this BSS. The STA that is creating the BSS must be able to receive <u>and transmit</u> at each of the data rates listed in the set.
OperationalRateSet	Set of integers	1–127 inclusive (for each integer in the set)	The set of data rates (~~in units of 500 kbit/s~~) that the STA desires to use for communication within the BSS. The STA must be able to receive at each of the data rates listed in the set. ~~The OperationalRateSet~~ This set is a superset of the <u>BSS basic rate set BSSBasicRateSet</u> advertised by the BSS.

10.4.4 PLME_DSSSTESTMODE

Add switches for the new options as shown:

```
PLME-DSSSTESTMODE.request (
    TEST_ENABLE,
    TEST_MODE,
    SCRAMBLE_STATE,
    SPREADING_STATE,
    DATA_TYPE,
    DATA_RATE;
    PREAMBLE_TYPE;
    MODULATION_CODE_TYPE;
)
```

Name	Type	Valid range	Description
TEST_ENABLE	Boolean	True, false	If true, enables the PHY test mode according to the remaining parameters.
TEST_MODE	Integer	1, 2, 3	TEST_MODE selects one of three operational modes: — 01 = transparent receive — 02 = continuous transmit — 03 = 50% duty cycle
SCRAMBLE_STATE	Boolean	True, false	If true, sets the operational state of the scrambler to ON.
SPREADING_STATE	Boolean	True, false	If true, selects the operational state of the chipping.
DATA_TYPE	Integer	1, 2, 3	Selects one of three data patterns to be used for the transmit portions of the tests; for example: all one, all zeros, and random data patterns.
DATA_RATE	Integer	2, 4, <u>11</u> , <u>22</u>	Selects: — 02 = 1 Mbit/s — 04 = 2 Mbit/s — 11 = 5.5 Mbit/s — 22 = 11 Mbit/s
<u>PREAMBLE_TYPE</u>	<u>Boolean</u>	<u>null, 0, 1</u>	<u>Selects the preamble length.</u> — <u>0 = long</u> — <u>1 = short</u> <u>Can be null.</u>
<u>MODULATION_CODE_TYPE</u>	<u>Boolean</u>	<u>null, 0, 1</u>	<u>Selects the modulation code:</u> — <u>0 = CCK</u> — <u>1 = PBCC</u> <u>Can be null.</u>

Add Clause 18 as follows:

18. High Rate, direct sequence spread spectrum PHY specification

18.1 Overview

This clause specifies the High Rate extension of the PHY for the Direct Sequence Spread Spectrum (DSSS) system (Clause 15 of IEEE Std 802.11, 1999 Edition), hereinafter known as the High Rate PHY for the 2.4 GHz band designated for ISM applications.

This extension of the DSSS system builds on the data rate capabilities, as described in Clause 15 of IEEE Std 802.11, 1999 Edition, to provide 5.5 Mbit/s and 11 Mbit/s payload data rates in addition to the 1 Mbps and 2 Mbps rates. To provide the higher rates, 8-chip complementary code keying (CCK) is employed as the modulation scheme. The chipping rate is 11 MHz, which is the same as the DSSS system described in Clause 15 of IEEE Std 802.11, 1999 Edition, thus providing the same occupied channel bandwidth. The basic new capability described in this clause is called High Rate Direct Sequence Spread Spectrum (HR/DSSS). The basic High Rate PHY uses the same PLCP preamble and header as the DSSS PHY, so both PHYs can co-exist in the same BSS and can use the rate switching mechanism as provided.

In addition to providing higher speed extensions to the DSSS system, a number of optional features allow the performance of the radio frequency LAN system to be improved as technology allows the implementation of these options to become cost effective.

An optional mode replacing the CCK modulation with packet binary convolutional coding (HR/DSSS/PBCC) is provided.

Another optional mode is provided that allows data throughput at the higher rates (2, 5.5, and 11 Mbit/s) to be significantly increased by using a shorter PLCP preamble. This mode is called HR/DSSS/short, or HR/DSSS/PBCC/short. This Short Preamble mode can coexist with DSSS, HR/DSSS, or HR/DSSS/PBCC under limited circumstances, such as on different channels or with appropriate CCA mechanisms.

An optional capability for Channel Agility is also provided. This option allows an implementation to overcome some inherent difficulty with static channel assignments (a tone jammer), without burdening all implementations with the added cost of this capability. This option can also be used to implement IEEE 802.11-compliant systems that are interoperable with both FH and DS modulations. See Annex F for more details.

18.1.1 Scope

This clause specifies the PHY entity for the HR/DSSS extension and the changes that have to be made to the base standard to accommodate the High Rate PHY.

The High Rate PHY layer consists of the following two protocol functions:

- a) A PHY convergence function, which adapts the capabilities of the physical medium dependent (PMD) system to the PHY service. This function is supported by the PHY convergence procedure (PLCP), which defines a method for mapping the MAC sublayer protocol data units (MPDU) into a framing format suitable for sending and receiving user data and management information between two or more STAs using the associated PMD system. The PHY exchanges PHY protocol data units (PPDU) that contain PLCP service data units (PSDU). The MAC uses the PHY service, so each MPDU corresponds to a PSDU that is carried in a PPDU.

- b) A PMD system, whose function defines the characteristics of, and method of transmitting and receiving data through, a wireless medium between two or more STAs, each using the High Rate PHY system.

18.1.2 High Rate PHY functions

The 2.4 GHz High Rate PHY architecture is depicted in the ISO/IEC basic reference model shown in Figure 137. The High Rate PHY contains three functional entities: the PMD function, the PHY convergence function, and the layer management function. Each of these functions is described in detail in 18.1.2.1, 18.1.2.2, and 18.1.2.3. For the purposes of MAC and MAC management, when Channel Agility is both present and enabled (see 18.3.2 and Annex C), the High Rate PHY shall be interpreted to be both a High Rate and a frequency-hopping PHY.

The High Rate PHY service shall be provided to the MAC through the PHY service primitives described in Clause 12 of IEEE Std 802.11, 1999 Edition.

18.1.2.1 PLCP sublayer

To allow the MAC to operate with minimum dependence on the PMD sublayer, a PLCP sublayer is defined. This function simplifies the PHY service interface to the MAC services.

18.1.2.2 PMD sublayer

The PMD sublayer provides a means and method of transmitting and receiving data through a WM between two or more STAs, each using the High Rate system.

18.1.2.3 PHY management entity (PLME)

The PLME performs management of the local PHY functions in conjunction with the MAC management entity.

18.1.3 Service specification method and notation

The models represented by figures and state diagrams are intended to be illustrations of functions provided. It is important to distinguish between a model and a real implementation. The models are optimized for simplicity and clarity of presentation; the actual method of implementation is left to the discretion of the High Rate PHY compliant developer.

The service of a layer or sublayer is a set of capabilities that it offers to a user in the next-higher layer (or sublayer). Abstract services are specified here by describing the service primitives and parameters that characterize each service. This definition is independent of any particular implementation.

18.2 High Rate PLCP sublayer

18.2.1 Overview

This subclause provides a convergence procedure for the 2, 5.5, and 11 Mbit/s specification, in which PSDUs are converted to and from PPDU. During transmission, the PSDU shall be appended to a PLCP preamble and header to create the PPDU. Two different preambles and headers are defined: the mandatory supported Long Preamble and header, which interoperates with the current 1 Mbit/s and 2 Mbit/s DSSS specification (as described in IEEE Std 802.11, 1999 Edition), and an optional Short Preamble and header. At the receiver, the PLCP preamble and header are processed to aid in demodulation and delivery of the PSDU.

The optional Short Preamble and header is intended for applications where maximum throughput is desired and interoperability with legacy and non-short-preamble capable equipment is not a consideration. That is, it is expected to be used only in networks of like equipment, which can all handle the optional mode.

18.2.2 PPDU format

Two different preambles and headers are defined: the mandatory supported Long Preamble and header which is interoperable with the current 1 Mbit/s and 2 Mbit/s DSSS specification (as described in IEEE Std 802.11, 1999 Edition) and an optional Short Preamble and header.

18.2.2.1 Long PLCP PPDU format

Figure 127 shows the format for the interoperable (long) PPDU, including the High Rate PLCP preamble, the High Rate PLCP header, and the PSDU. The PLCP preamble contains the following fields: synchronization (Sync) and start frame delimiter (SFD). The PLCP header contains the following fields: signaling (SIG-
NAL), service (SERVICE), length (LENGTH), and CCITT CRC-16. Each of these fields is described in detail in 18.2.3. The format for the PPDU, including the long High Rate PLCP preamble, the long High Rate PLCP header, and the PSDU, do not differ from IEEE Std 802.11, 1999 Edition for 1Mbit/s and 2 Mbit/s. The only exceptions are

- The encoding of the rate in the SIGNAL field;
- The use of a bit in the SERVICE field to resolve an ambiguity in PSDU length in octets, when the length is expressed in whole microseconds;
- The use of a bit in the SERVICE field to indicate if the optional PBCC mode is being used;
- The use of a bit in the SERVICE field to indicate that the transit frequency and bit clocks are locked.

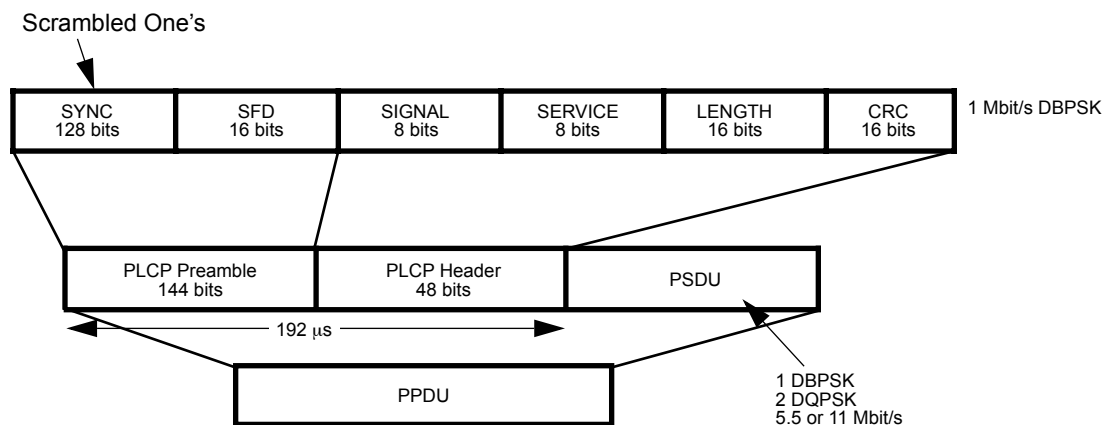


Figure 127—Long PLCP PPDU format

18.2.2.2 Short PLCP PPDU format (optional)

The short PLCP preamble and header (HR/DSSS/short) is defined as optional. The Short Preamble and header may be used to minimize overhead and, thus, maximize the network data throughput. The format of the PPDU, with HR/DSSS/short, is depicted in Figure 128.

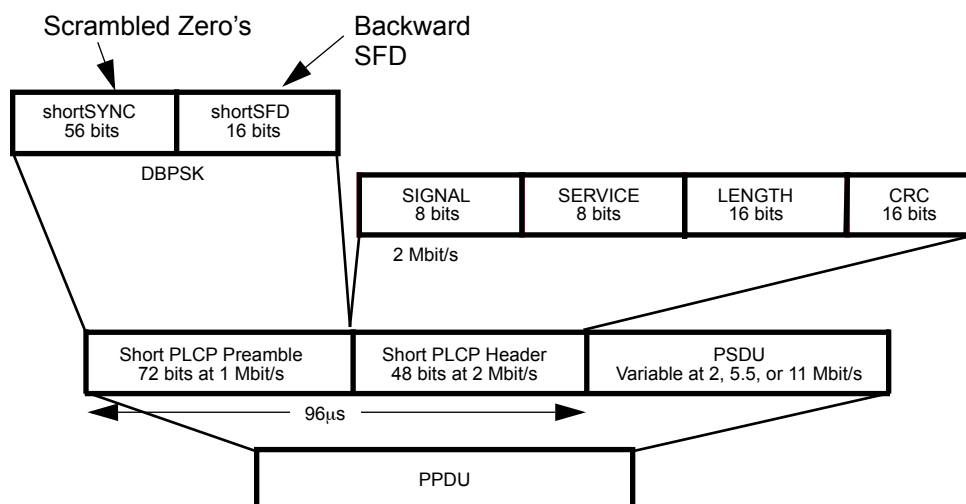


Figure 128—Short PLCP PDU format

A transmitter using the short PLCP will only be interoperable with another receiver that is also capable of receiving this short PLCP. To interoperate with a receiver that is not capable of receiving a Short Preamble and header, the transmitter shall use the long PLCP preamble and header. The short PLCP preamble uses the 1 Mbit/s Barker code spreading with DBPSK modulation. The short PLCP header uses the 2 Mbit/s Barker code spreading with DQPSK modulation, and the PSDU is transmitted at 2Mbit/s, 5.5 Mbit/s, or 11 Mbit/s.

Stations not implementing this option that do active scanning will get a response even when the network is using Short Preambles, because all management traffic is returned with the same type preamble as received.

18.2.3 PLCP PDU field definitions

In the PLCP field definition subclauses (18.2.3.1 through 18.2.3.14), the definitions of the long (Clause 15) PLCP fields are given first, followed by the definitions of the short PLCP. The names for the short PLCP fields are preceded by the term “short.”

18.2.3.1 Long PLCP SYNC field

The SYNC field shall consist of 128 bits of scrambled “1” bits. This field is provided so the receiver can perform the necessary synchronization operations. The initial state of the scrambler (seed) shall be [1101100], where the leftmost bit specifies the value to put in the first delay element (Z^1) in Figure 131, and the rightmost bit specifies the value to put in the last delay element in the scrambler.

To support the reception of DSSS signals generated with implementations based on Clause 15, the receiver shall also be capable of synchronization on a SYNC field derived from any non-zero scrambler initial state.

18.2.3.2 Long PLCP SFD

The SFD shall be provided to indicate the start of PHY-dependent parameters within the PLCP preamble. The SFD shall be a 16-bit field, [1111 0011 1010 0000], where the rightmost bit shall be transmitted first in time.

18.2.3.3 Long PLCP SIGNAL field

The 8-bit SIGNAL field indicates to the PHY the modulation that shall be used for transmission (and reception) of the PSDU. The data rate shall be equal to the SIGNAL field value multiplied by 100 kbit/s. The High Rate PHY supports four mandatory rates given by the following 8-bit words, which represent the rate in units of 100 kbit/s, where the lsb shall be transmitted first in time:

- a) X'0A' (msb to lsb) for 1 Mbit/s;
- b) X'14' (msb to lsb) for 2 Mbit/s;
- c) X'37' (msb to lsb) for 5.5 Mbit/s;
- d) X'6E' (msb to lsb) for 11 Mbit/s.

The High Rate PHY rate change capability is described in 18.2.3.14. This field shall be protected by the CCITT CRC-16 frame check sequence described in 18.2.3.6.

18.2.3.4 Long PLCP SERVICE field

Three bits have been defined in the SERVICE field to support the High Rate extension. The rightmost bit (bit 7) shall be used to supplement the LENGTH field described in 18.2.3.5. Bit 3 shall be used to indicate whether the modulation method is CCK <0> or PBCC <1>, as shown in Table 97. Bit 2 shall be used to indicate that the transmit frequency and symbol clocks are derived from the same oscillator. This locked clocks bit shall be set by the PHY layer based on its implementation configuration. The SERVICE field shall be transmitted b0 first in time, and shall be protected by the CCITT CRC-16 frame check sequence described in 18.2.3.6. An IEEE 802.11-compliant device shall set the values of the bits b0, b1, b4, b5, and b6 to 0.

Table 97—SERVICE field definitions

b0	b1	b2	b3	b4	b5	b6	b7
Reserved	Reserved	Locked clocks bit 0 = not 1 = locked	Mod. selection bit 0 = CCK 1 = PBCC	Reserved	Reserved	Reserved	Length extension bit

18.2.3.5 Long PLCP LENGTH field

The PLCP length field shall be an unsigned 16-bit integer that indicates the number of microseconds required to transmit the PSDU. The transmitted value shall be determined from the LENGTH and DataRate parameters in the TXVECTOR issued with the PHY-TXSTART.request primitive described in 18.4.4.2.

The length field provided in the TXVECTOR is in octets and is converted to microseconds for inclusion in the PLCP LENGTH field. The LENGTH field is calculated as follows. Since there is an ambiguity in the number of octets that is described by a length in integer microseconds for any data rate over 8 Mbit/s, a length extension bit shall be placed at bit position b7 in the SERVICE field to indicate when the smaller potential number of octets is correct.

- a) 5.5 Mbit/s CCK Length = number of octets $\times$ 8/5.5, rounded up to the next integer.
- b) 11 Mbit/s CCK Length = number of octets $\times$ 8/11, rounded up to the next integer; the service field (b7) bit shall indicate a “0” if the rounding took less than 8/11 or a “1” if the rounding took more than or equal to 8/11.

- c) 5.5 Mbit/s PBCC Length = (number of octets + 1) × 8/5.5, rounded up to the next integer.
- d) 11 Mbit/s PBCC Length = (number of octets + 1) × 8/11, rounded up to the next integer; the service field (b7) bit shall indicate a “0” if the rounding took less than 8/11 or a “1” if the rounding took more than or equal to 8/11.

At the receiver, the number of octets in the MPDU is calculated as follows:

- a) 5.5 Mbit/s CCK Number of octets = Length × 5.5/8, rounded down to the next integer.
- b) 11 Mbit/s CCK Number of octets = Length × 11/8, rounded down to the next integer, minus 1 if the service field (b7) bit is a “1.”
- c) 5.5 Mbit/s PBCC Number of octets = (Length × 5.5/8) – 1, rounded down to the next integer.
- d) 11 Mbit/s PBCC Number of octets = (Length × 11/8) – 1, rounded down to the next integer, minus 1 if the service field (b7) bit is a “1.”

An example for an 11 Mbit/s calculation described in pseudocode form is shown below. At the transmitter, the values of the LENGTH field and length extension bit are calculated as follows:

$$\text{LENGTH}'x = ((\text{number of octets} + P) \times 8) / R$$

$$\text{LENGTH} = \text{Ceiling}(\text{LENGTH}')$$

If

$$(R = 11) \text{ and } (\text{LENGTH} - \text{LENGTH}') \geq 8/11$$

then

$$\text{Length Extension} = 1$$

else

$$\text{Length Extension} = 0$$

where

R is the data rate in Mbit/s;
P = 0 for CCK;
P = 1 for PBCC;
Ceiling (X) returns the smallest integer value greater than or equal to X.

At the receiver, the number of octets in the MPDU is calculated as follows:

$$\text{Number of octets} = \text{Floor}(((\text{Length} \times R) / 8) - P) - \text{Length Extension}$$

where

R is the data rate in Mbit/s;
P = 0 for CCK;
P = 1 for PBCC;
Floor (X) returns the largest integer value less than or equal to X.

Table 98 shows an example calculation for several packet lengths of CCK at 11 Mbit/s.

Table 98—Example of LENGTH calculations for CCK

TX octets	Octets ($\times 8/11$)	LENGTH	Length extension bit	LENGTH ($\times 11/8$)	Floor (X)	RX octets
1023	744	744	0	1023	1023	1023
1024	744.7273	745	0	1024.375	1024	1024
1025	745.4545	746	0	1025.75	1025	1025
1026	746.1818	747	1	1027.125	1027	1026

Table 99 shows an example calculation for several packet lengths of PBCC at 11 Mbit/s.

Table 99—Example of LENGTH calculations for PBCC

TX octets	(Octets $\times 8/11$) + 1	LENGTH	Length extension bit	(LENGTH $\times 11/8$) – 1	Floor (X)	RX octets
1023	744.7273	745	0	1023.375	1023	1023
1024	745.4545	746	0	1024.750	1024	1024
1025	746.1818	747	1	1026.125	1026	1025
1026	746.9091	747	0	1026.125	1026	1026

This example illustrates why normal rounding or truncation of the number will not produce the right result. The length field is defined in units of microseconds and must correspond to the actual length, and the number of octets must be exact.

The least significant bit (lsb) shall be transmitted first in time. This field shall be protected by the CCITT CRC-16 frame check sequence described in 18.2.3.6.

18.2.3.6 PLCP CRC (CCITT CRC-16) field

The SIGNAL, SERVICE, and LENGTH fields shall be protected with a CCITT CRC-16 frame check sequence (FCS). The CCITT CRC-16 FCS shall be the one's complement of the remainder generated by the modulo 2 division of the protected PLCP fields by the polynomial

$$x^{16} + x^{12} + x^5 + 1$$

The protected bits shall be processed in transmit order. All FCS calculations shall be made prior to data scrambling. A schematic of the processing is shown in Figure 129.

As an example, the SIGNAL, SERVICE, and LENGTH fields for a DBPSK signal with a PPDU length of 192 μ s (24 octets) would be given by the following:

0101 0000 0000 0000 0000 0011 0000 0000 [leftmost bit (b0) transmitted first in time]
b0.....b48

The one's complement FCS for these protected PLCP preamble bits would be the following:

0101 1011 0101 0111 [leftmost bit (b0) transmitted first in time]
b0.....b16

Figure 129 depicts this example.

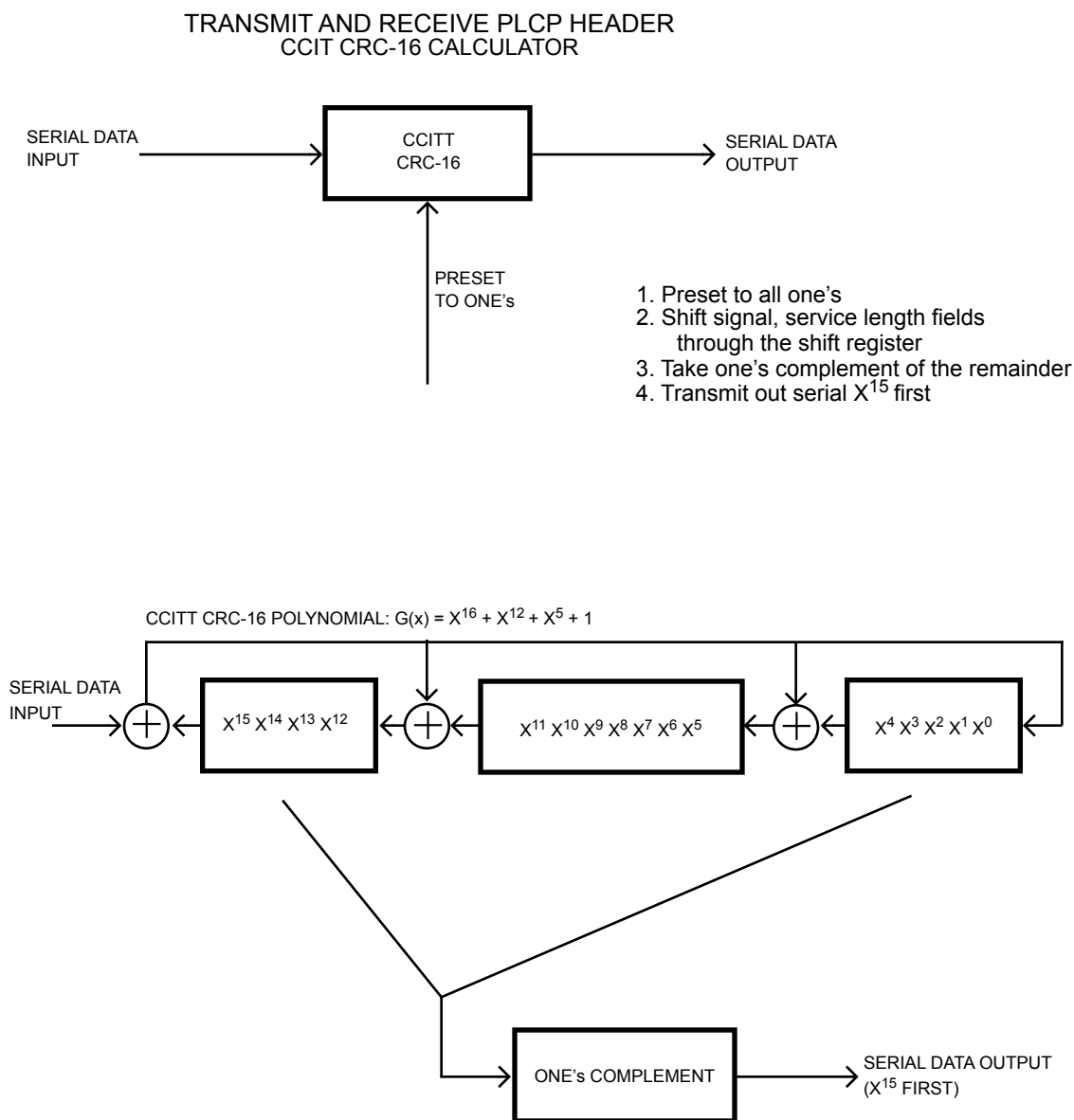


Figure 129—CCITT CRC-16 implementation

An illustrative example of the CCITT CRC-16 FCS using the information from Figure 129 is shown in Figure 130.

Data	CRC Registers	
	msb	lsb
	1111111111111111	; Initialize preset to one's
0	1110111111011111	
1	1101111111011110	
0	1010111101011101	
1	0101111010111010	
0	1011110101110100	
0	0110101011001001	
0	1101010110010010	
0	1011101100000101	
0	0110011000101011	
0	1100110001010110	
0	1000100010001101	
0	0000000100111011	
0	0000001001110110	
0	0000010011101100	
0	0000100111011000	
0	0001001110110000	
0	0010011101100000	
0	0100111011000000	
0	1001110110000000	
0	0010101100100001	
0	0101011001000010	
0	1010110010000100	
1	0101100100001000	
1	1010001000110001	
0	0101010001000011	
0	1010100010000110	
0	0100000100101101	
0	1000001001011010	
0	0001010010010101	
0	0010100100101010	
0	0101001001010100	
0	1010010010101000	

Figure 130—Example of CRC calculation

18.2.3.7 Long PLCP data modulation and modulation rate change

The long PLCP preamble and header shall be transmitted using the 1 Mbit/s DBPSK modulation. The SIGNAL and SERVICE fields combined shall indicate the modulation that shall be used to transmit the PSDU. The SIGNAL field indicates the rate, and the SERVICE field indicates the modulation. The transmitter and receiver shall initiate the modulation and rate indicated by the SIGNAL and SERVICE fields, starting with the first octet of the PSDU. The PSDU transmission rate shall be set by the DATARATE parameter in the TXVECTOR, issued with the PHY-TXSTART.request primitive described in 18.4.4.1.

18.2.3.8 Short PLCP synchronization (shortSYNC)

The shortSYNC field shall consist of 56 bits of scrambled “0” bits. This field is provided so the receiver can perform the necessary synchronization operations. The initial state of the scrambler (seed) shall be [001 1011], where the left end bit specifies the value to place in the first delay element (Z^1) in Figure 131, and the right end bit specifies the value to place in the last delay element (Z^7).

18.2.3.9 Short PLCP SFD field (shortSFD)

The shortSFD shall be a 16-bit field and be the time reverse of the field of the SFD in the long PLCP preamble (18.2.3.2). The field is the bit pattern 0000 0101 1100 1111. The right end bit shall be transmitted first in time. A receiver not configured to use the short header option will not detect this SFD.

18.2.3.10 Short PLCP SIGNAL field (shortSIGNAL)

The 8-bit SIGNAL field of the short header indicates to the PHY the data rate that shall be used for transmission (and reception) of the PSDU. A PHY operating with the HR/DSSS/short option supports three mandatory rates given by the following 8-bit words, where the lsb shall be transmitted first in time and the number represents the rate in units of 100 kBit/s:

- a) X'14' (msb to lsb) for 2 Mbits/s;
- b) X'37' (msb to lsb) for 5.5 Mbits/s;
- c) X'6E' (msb to lsb) for 11 Mbits/s.

18.2.3.11 Short PLCP SERVICE field (shortSERVICE)

The SERVICE field in the short header shall be the same as the SERVICE field described in 18.2.3.4.

18.2.3.12 Short PLCP LENGTH field (shortLENGTH)

The LENGTH field in the short header shall be the same as the LENGTH field described in 18.2.3.5

18.2.3.13 Short CCITT CRC-16 field (shortCRC)

The CRC in the short header shall be the same as the CRC field defined in 18.2.3.6. The CRC-16 is calculated over the shortSIGNAL, shortSERVICE, and shortLENGTH fields.

18.2.3.14 Short PLCP data modulation and modulation rate change

The short PLCP preamble shall be transmitted using the 1 Mbit/s DBPSK modulation. The short PLCP header shall be transmitted using the 2 Mbit/s modulation. The SIGNAL and SERVICE fields combined shall indicate the modulation that shall be used to transmit the PSDU. The SIGNAL field indicates the rate, and the SERVICE field indicates the modulation. The transmitter and receiver shall initiate the modulation and rate indicated by the SIGNAL and SERVICE fields, starting with the first octet of the PSDU. The PSDU transmission rate shall be set by the DATARATE parameter in the TXVECTOR, issued with the PHY-TXSTART.request primitive described in 18.4.4.1.

18.2.4 PLCP/High Rate PHY data scrambler and descrambler

The polynomial $G(z) = z^{-7} + z^{-4} + 1$ shall be used to scramble all bits transmitted. The feedthrough configuration of the scrambler and descrambler is self-synchronizing, which requires no prior knowledge of the transmitter initialization of the scrambler for receive processing. Figure 131 and Figure 132 show typical implementations of the data scrambler and descrambler, but other implementations are possible.

The scrambler shall be initialized as specified in 18.2.3.8 for the short PLCP and 18.2.3.1 for the long PLCP. For a Long Preamble, this shall result in the scrambler registers Z^1 through Z^7 in Figure 131 having the data pattern [1101100] (i.e., $Z^1=1\dots Z^7=0$) when the scrambler is first started. The scrambler shall be initialized with the reverse pattern [0011011] when transmitting the optional Short Preamble.

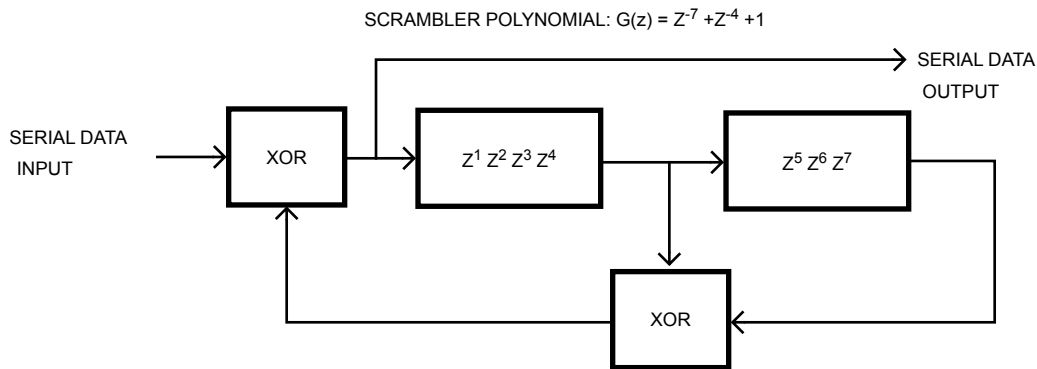


Figure 131—Data scrambler

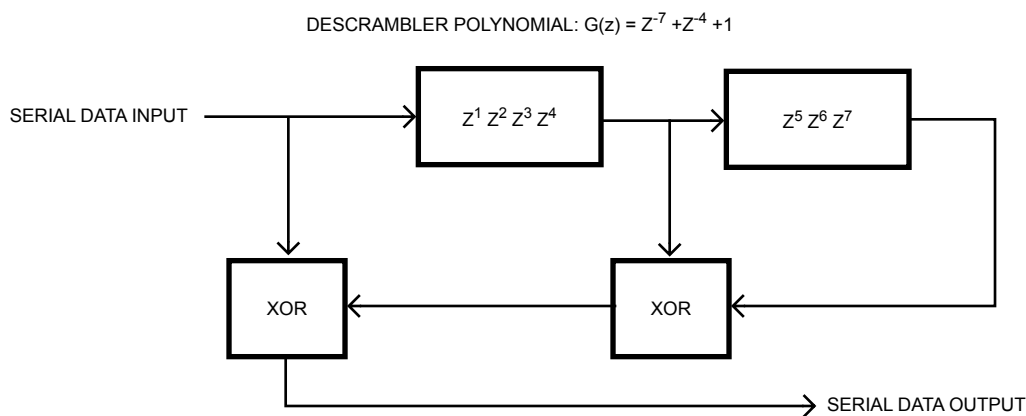


Figure 132—Data descrambler

18.2.5 PLCP transmit procedure

The transmit procedures for a High Rate PHY using the long PLCP preamble and header are the same as those described in IEEE Std 802.11, 1999 Edition (15.2.7 and 15.2.8), and do not change apart from the ability to transmit 5.5 Mbit/s and 11 Mbit/s.

The procedures for a transmitter employing HR/DSSS/short and HR/DSSS/PBCC/short are the same except for length and rate changes. The decision to use a long or short PLCP is beyond the scope of this standard.

The PLCP transmit procedure is shown in Figure 133.

A PHY-TXSTART.request (TXVECTOR) primitive will be issued by the MAC to start the transmission of a PPDU. In addition to DATARATE and LENGTH, other transmit parameters such as PREAMBLE_TYPE and MODULATION are set via the PHY-SAP with the PHY-TXSTART.request (TXVECTOR), as described in 18.3.5. The SIGNAL, SERVICE, and LENGTH fields of the PLCP header are calculated as described in 18.2.3.



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