IEEE P802.11
Wireless LANs

Draft text for the Higher Speed Extension of the standard

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Abstract

Draft text is provided for the high speed extension of the 2.4 GHz standard. The text specifies additional data rates of 5.5 and 11 Mbit/s to the Direct Sequence standard. The specified modulation method for the high rate extension is Complementary Code Keying (CCK) a version of MOK.

1. Extension of the Direct Sequence Spread Spectrum Physical Layer Specification for the 2.4 GHz ISM Band

1.1 Introduction

This clause describes the high speed extension of the physical layer for the Direct Sequence Spread Spectrum (DSSS) system (clause 15 in the standard). The Radio Frequency LAN system is initially aimed for the 2.4 GHz ISM band as provided in the USA according to Document FCC 15.247, in Europe by ETS 300-328 and other countries according to clause **Error! Reference source not found.**.

Above the 1 Mbit/s and a 2 Mbit/s data payload as described in clause 15, the extension of the DSSS system provides for 5.5 and 11 Mbit/s payload data rates. To provide the higher rates, 8 chip Complementary Code Keying (CCK) is employed as the modulation scheme. The chipping rate will be 11 MHz, which is the same as the current DSSS system, thus providing the same channel bandwidth.

The higher speed system is fully coexistent and interoperable with the 1 and 2 Mbit/s DSSS systems. It can use the same PLCP peamble and PLCP header as the 1 and 2 Mbit/s system and thus can make use of the rate switching capabilities as provided in the standard. To optimize data throughput at the higher rates an optional short PLCP preamble is provided. For interoperability with FH systems an optional FH interoperable PLCP Frame format is defined.

1.1.1 Scope

This clause describes the extension of the physical layer services provided to the 802.11 wireless LAN MAC by the 2.4 GHz Direct Sequence Spread Spectrum system. The clause will only describe deviations from the 802.11 spec for DSSS.

To be conformant to the higher speed standard the 5.5 and 11 Mbit/s data rates (in addition to the 1 and 2 Mbit/s, in this document referred to as current standard) are both mandatory.

The specification also provides an optional short preamble and header for the higher rates and a optional FH interoperable Frame format.

1.2 5.5 and 11 Mbit/s DSSS Physical Layer Convergence Procedure Sublayer

1.2.1 Introduction

This clause provides a convergence procedure for the 5.5 and 11 Mbit/ specification in which MPDUs are converted to and from PPDUs. During transmission, the MPDU shall be prepended with a PLCP preamble and header to create the PPDU. Three different preambles and headers are defined: the mandatory supported long preamble and header as defined in the current 1 and 2 Mbit/s DSSS specification, an optional short preamble and header, and an optional FH interoperable preamble and header. At the receiver, the PLCP preamble and header are processed to aid in demodulation and delivery of the MPDU.

1.2.2 Physical Layer Convergence Procedure Frame Format

The format for the PPDU including the long DSSS PLCP preamble, the long DSSS PLCP header and the MPDU do not differ from the current standard. The only exceptions are the added rates in the rate Signal Field and the use of a bit in the Service field used to resolve an ambiguity in packet length in bytes when the length is expressed in whole microseconds.

In addition an optional short DSSS PLCP preamble and header is defined. The short preamble and header can be used to minimize overhead and thus maximize the data throughput. The frame format of the PPDU with short preamble and header is depicted in the following figure.

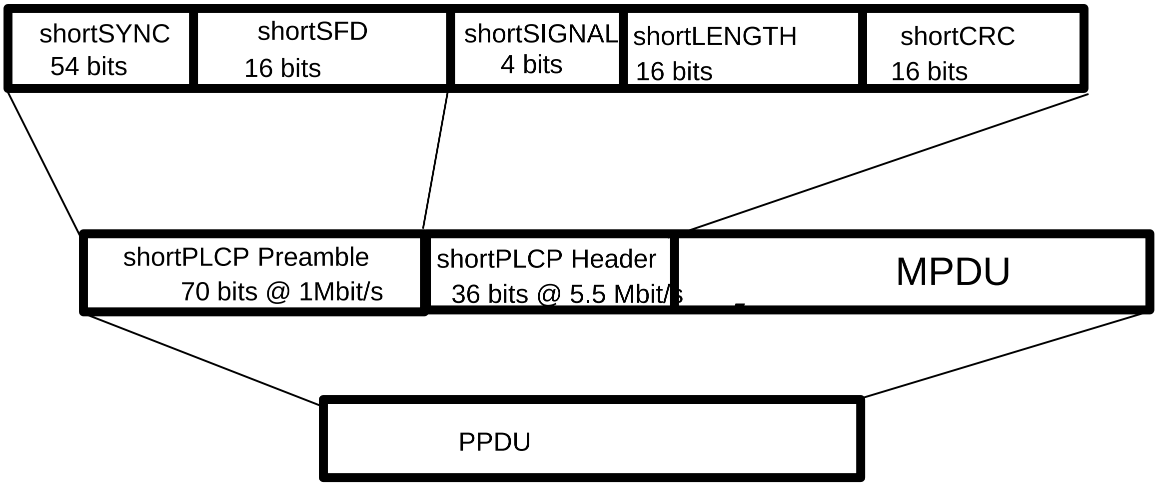

Figure xxx short PLCP Frame Format

Usage of the short preamble and header is optional. A transmitter using the short PLCP will be not interoperable with a receiver not capable on receiving this PLCP. However coexistence is to a high degree guaranteed. This is explained in the Transmit and Receive Procedure clause. To be interoperable with a receiver that is not capable to receive a short PLCP, the transmitter should 'fall back' to the original long PLCP preamble and header.

Figure 90 shows the optional Frequency Hopping interoperability format for the PPDU. This includes the standard FH PLCP preamble, the FH PLCP header, an 8 microsecond gap, and the short preamble and header and the MPDU. The FH interoperability mode uses the FH preamble and header to establish the channel the signal will be radiated on and the rate it will use. When in this mode, the HR DS channel will be chosen as the closest DS channel from the set of: 1, 3, 5, 7, 9, and 11 (plus 13 in Europe). The receiver IF which will process the HR DSSS data must be wide enough in bandwidth to encompass the FH preamble. When operating on the lowest TBD or the highest TBD FH channels, the HR DS will not be used and all FH transmissions will occur at the 1 or 2 Mbit/s rates. These channels are too far away from the available DS channels to be processed within the IF bandwidth.

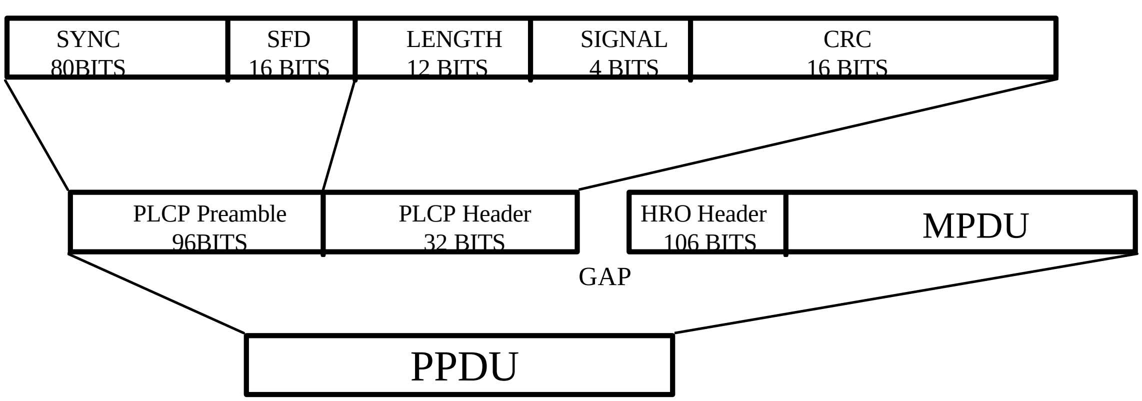

Figure 90, FH interoperable PLCP Frame Format

In the following PLCP field definition clauses first the definitions for the long i.e. original PLCP fields are described. Subsequent the definitions of the short PLCP are defined. The names for the short PLCP fields are preceded with the term short. The names of the FH interoperable fields are preceded with the term FH.

1.2.3 Long PLCP Field Definitions

As in the current standard the entire long PLCP preamble and header shall be transmitted using the 1 Mbit/s DBPSK modulation described in clause **Error! Reference source not found.**. All transmitted bits shall be scrambled using the feedthrough scrambler described in clause **Error! Reference source not found.**. The definitions do not differ from the current standard. The possible values in the Signal Field (SIGNAL) are extended

1.2.3.1 Long PLCP 802.11 Signal Field (SIGNAL)

The 8 bit 802.11 Signal Field indicates to the PHY the modulation which shall be used for transmission (and reception) of the MPDU. The data rate shall be equal to the Signal Field value multiplied by 100kbit/s. The extended DSSS PHY supports four mandatory modulation services given by the following 8 bit words, where the LSB shall be transmitted first in time:

a) 0Ah (MSB to LSB) for 1 Mbit/s DBPSK
b) 14h (MSB to LSB) for 2 Mbit/s DQPSK
c) 37h 5.5 Mbit/s CCK
d) 6Eh 11 Mbit/s CCK

The DSSS PHY rate change capability is described in clause 1.2.3.2. This field shall be protected by the CCITT CRC-16 frame check sequence described in clause **Error! Reference source not found.**.

1.2.3.2 Long PLCP Length Field (LENGTH)

The PLCP length field shall be an unsigned 16 bit integer which indicates the number of microseconds (16 to 2^{16}-1 as defined by aMPDUMaxLngth) required to transmit the MPDU. The transmitted value shall be determined from the LENGTH parameter in the TXVECTOR issued with the PHY-TXSTART.request primitive described in clause **Error! Reference source not found.**. The length field provided in the TXVECTOR is in bytes 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 bytes that will be described by a length in microseconds, an extra bit will be placed in the service field to indicate when the larger potential number is correct.

a) 5.5Mbit/s CCK Length = #bytes * 8/5.5, rounded up to the next integer.
b) 11Mbit/s CCK Length = #bytes * 8/11 , rounded up to the next integer and the service field LSB bit shall indicate a ‘0’ if the rounding took less than 0.5 or a ‘1 if the rounding took more than 0.5.

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

a) 5.5Mbit/s CCK #bytes = Length * 5.5/8, rounded up to the next integer
b) 11Mbit/s CCK #bytes = Length * 11/8 , rounded up to the next integer, plus 1 if the service field LSB bit is a ‘1’.

The LSB (least significant bit) shall be transmitted first in time. This field shall be protected by the CCITT CRC-16 frame check sequence described in clause **Error! Reference source not found.**.

1.2.3.3 Long PLCP Data Modulation and Modulation Rate Change

The PLCP preamble shall be transmitted using the 1 Mbit/s DBPSK modulation. The 802.11 SIGNAL field shall indicate the modulation which shall be used to transmit the MPDU. The transmitter and receiver shall initiate the modulation indicated by the 802.11 SIGNAL field starting with the first symbol (1bit for DBPSK , 2 bits for DQPSK, 4 bits for 5.5 Mbit/s, 8 bits for 11Mbit/s (with the symbol rate increased with a factor 11/8 for the high rates)) of the MPDU. The MPDU transmission rate shall be set by the DATARATE parameter in the TXVECTOR issued with the PHY-TXSTART.request primitive described in clause TBD.

1.2.4 Short PLCP Field Definitions

The entire short PLCP preamble shall be transmitted using the 1 Mbit/s DBPSK modulation described in clause **Error! Reference source not found.**. The short PLCP header shall be transmitted using 5.5 Mbit/s CCK modulation as described in clause 1.4.1.2.

All transmitted bits shall be scrambled using the feedthrough scrambler described in clause **Error! Reference source not found.**.

1.2.4.1 Short PLCP Synchronization (shortSYNC)

The short PLCP synchronization field shall consist of 54 scrambled all zeros. The preamble is used for energy or carrier detection (CCA as described in clause ..), antenna diversity (if desirable) and receiver synchronization.

1.2.4.2 Short PLCP Start Frame Delimiter Field (shortSFD)

The shortSFD shall be 16 bit field and be the bit reverse of the field of the SFD in the long PLCP preamble (clause 15.2.3.1). The field is 05CFh (MSB to LSB). The LSB shall be transmitted first in time.

1.2.4.3 Short PLCP Signal Field (shortSignal)

The 4 bit 802.11 Signal Field indicates to the PHY the modulation which shall be used for transmission (and reception) of the MPDU. The extended DSSS PHY operating with a short preamble and header supports two mandatory modulation services given by the following 3 bit words, where the LSB shall be transmitted first in time:

a) 0000b 5.5Mbit/s PPM
b) 0001b 11Mbit/s PPM

1.2.4.4 Short PLCP Length Field (shortLENGTH)

The short PLCP length field shall be an unsigned 16 bit integer which indicates the number of microseconds (16 to 2^{16}-1 as defined by aMPDUMaxLngth) required to transmit the MPDU. The transmitted value shall be determined from the LENGTH parameter in the TXVECTOR issued with the PHY-TXSTART.request primitive described in clause **Error! Reference source not found.**. The length field provided in the TXVECTOR is in bytes and is converted to microseconds for inclusion in the PLCP shortLENGTH field. The shortLength field is calculated as follows:

a) 5.5Mbit/s CCK Length = #bytes * 8/5.5, rounded up to the next integer.
b) 11Mbit/s CCK Length = #bytes * 8/11 , rounded up to the next integer and the signal field LSB+1 bit shall indicate a ‘0’ if the rounding took less than 0.5 or a ‘1 if the rounding took more than 0.5.

The LSB (least significant bit) shall be transmitted first in time. This field shall be protected by the CCITT CRC-16 frame check sequence described in clause **Error! Reference source not found.**

1.2.4.5 Short CCITT CRC-16 Field (shortCRC)

The shortCRC shall be the same as the CRCfield as defined for the long PLCP header. The CRC-16 is calculated over the shortSIGNAL and shortLENGTH fields.

1.2.4.6 Short PLCP Data Modulation and Modulation Rate Change

The PLCP preamble shall be transmitted using the 1 Mbit/s DBPSK modulation. The short PLCP header shall be transmitted using the 5.5 Mbit/s CCK modulation. The 802.11 SIGNAL field shall indicate the modulation which shall be used to transmit the MPDU. The transmitter and receiver shall initiate the modulation indicated by the 802.11 shortSIGNAL field starting with the first symbol (1bit for DBPSK , 2 bits for DQPSK, 4 bits for 5.5 Mbit/s CCK, 8 bits for 11 Mbit/s CCK. The MPDU transmission rate shall be set by the DATARATE parameter in the TXVECTOR issued with the PHY-TXSTART.request primitive described in clause **Error! Reference source not found.**

1.2.5 PLCP Transmit and Receive Procedure

1.2.5.1 PLCP Transmit Procedure

The transmit procedure for a transmitter not using the short PLCP preamble and header is described in the section 15.2.7. and will not change apart from the ability to transmit 5.5 and 11Mbit/s.

The transmit procedure for a transmitter employing the short PLCP preamble and header is in essence the same. The decision for using a long or short PLCP is not prescribed in this standard. The decision can be taken on a per frame basis by the Modem Management entity or can be set at network installation.

1.2.5.2 PLCP Receive Procedure

The receive procedure for a receiver configured to receive a long PLCP preamble and header is described in section 15.2.8. A receiver conformant to the extension of the standard is capable to receive 5.5 Mbit/s, 11 Mbit/s,.

If a PPDU with a short preamble and header is being transmitted this receiver will also react as described in the section 15.2.8. The receiver will detect energy or a carrier conform the CCA procedure and defer. The short preamble is a DSSS signal. The shortSFD will normally not been detected and the receiver defers until the energy or carrier drops, thus providing coexistence capabilities between the systems

The receiver configured to receive a short PLCP preamble and header shall perform CCA and synchronize on the short preamble (54 microseconds) in order to be able to detect the shortSFD. After detection of the shortSFD the receiver shall be set to be able to receive 5.5 Mbit/s, in order the process the rest of the header. After this the receive procedure is the same as described in section 15.2.8. The modulation rate change mechanism is described in clause 1.2.4.6.

The receiver configured to receive a shortPLCP shall also be capable of receiving a PPDU with a longPLCP preamble or header. The detection of the longPLCP preamble can be based on the data content of the preamble (scrambled all 1's compared to scrambled all 0's) or on the absence of the shortSFD after 54 microseconds. Once detected the long PLCP the receiver can follow the receive procedure as described in section 15.2.8.

1.3 DSSS Physical Layer Management Entity (PLME)

1.3.1 PLME_SAP Sublayer Management primitives

Extension to Table 1 lists the MIB attributes which may be accessed by the PHY sublayer entities and intra layer of higher Layer Management Entities (LME). Only values to agPhyRateGroup are added for 5.5 and 11 Mbit/s. The values 02h up to 16h are mandatory to be conformant to this extended specification.

agPhyRateGroup		
aSupportedDataRatesTx	02h, 04h, 0Bh, 16h	Static
aSupportedDataRatesRx	02h, 04h, 0Bh, 16h	Static

Extension to Table 1, MIB Attribute Default Values / Ranges

Notes: The column titled Operational Semantics contains two types: static and dynamic. Static MIB attributes are fixed and cannot be modified for a given PHY implementation. MIB Attributes defined as dynamic can be modified by some management entity.

1.4 DSSS Physical Medium Dependent Sublayer

1.4.1 General

The modulation scheme for 5.5 and 11Mbit/s is 8 chip Complementary Code Keying (CCK), an M-ary Orthogonal Keying (MOK) scheme based on complementary codes. The power spectrum is not different from the 1 and 2 Mbit/s schemes. As a result of this most Phy Medium Dependent specifications are not changed. 5.5 and 11 Mbit/s CCK uses the same spectrum mask, operating channels, powerlevels, turnaround times, slot time and CCA mechanism. Different is (of course) the specification of the modulation scheme and the parameters associated with it.

1.4.1.1 Extension of PMD_SAP Service Primitive Parameters

Parameter	Associate Primitive	Value
TXD_UNIT	PMD_DATA.request	One(1), Zero(0): DBPSK di bit combinations 00,01,11,10: DQPSK 00h-1Fh : CCK (5.5 Mbit/s) 00h-FFh : CCK (11 Mbit/s)

RXD_UNIT	PMD_DATA.indicate	One(1), Zero(0): DBPSK di bit combinations 00,01,11,10: DQPSK 00h-1Fh : CCK (5.5 Mbit/s) 00h-FFh : CCK (11 Mbit/s)

Table 2, Extension to the List of Parameters for the PMD Primitives

1.4.1.2 Modulation for Channel Data Rates of 5.5 and 11 Mbit/s

The extended Direct Sequence specification defines two mandatory additional data rates. The modulation scheme for 5.5 Mbit/s and 11 Mbit/s is Complementary Code Keying (CCK).

The spreading code length is 8 and based on complementary codes. The chipping rate is 11 MHz. The symbol duration shall be exactly 8 chips long.

The following CCK code word shall be used spreading for both 5.5 and 11 Mbit/s:

$$c = \{e^{j(j_1+j_2+j_3+j_4)}, e^{j(j_1+j_3+j_4)}, e^{j(j_1+j_2+j_4)},$$
$$-e^{j(j_1+j_4)}, e^{j(j_1+j_2+j_3)}, e^{j(j_1+j_3)}, -e^{j(j_1+j_2)}, e^{jj_1}\}$$

The phases j_i (i=1..4) will be (D)QPSK encoded for 5.5 and 11 Mbit/s.

At 5.5 Mbit/s 4 bits (d0 to d3; d0 first in time) are transmitted per symbol..

d0 and d1 encode j_1 based on DQPSK. The DQPSK encoder is specified in Table 66. (In the tables, +jω shall be defined as counterclockwise rotation.). The phase change for j_1 is relative to the phase j_3 of the preceding symbol. For the case of the preamble to header transition, see clause …, the phase change for j_1 is relative to the phase of the preceding DBPSK or DQPSK (1 Mbit/s or 2 Mbit/s) symbol.

Dibit pattern (d(i),d(i+1)) **d(i) is first in time**	**Phase Change (+jω)**
00	0
01	π/2
11	π
10	3π/2 (-π/2)

Table 66, DQPSK Encoding Table

d2, and d3 CCK encode the basic symbol as specified in table 67

00	:	$1j$	1	$1j$	-1	$1j$	1	$-1j$	1
01	:	$-1j$	-1	$-1j$	1	$1j$	1	$-1j$	1
10	:	$-1j$	1	$-1j$	-1	$-1j$	1	$1j$	1
11	:	$1j$	-1	$1j$	1	$-1j$	1	$1j$	1

Table 67, CCK Encoding Table

At 11 Mbit/s 8 bits (d0 to d7; d0 first in time) are transmitted per symbol.

(d0,d1) encodes j_1 based on DQPSK. The DQPSK encoder is specified in Table 68. The phase change for j_1 is relative to the phase j_4 of the preceding symbol. In the case of rate change, see clause …, the phase change for j_1 is relative to the phase of the preceding DBPSK or DQPSK symbol in case of a rate change from 1 Mbit/s or 2 Mbit/s and relative to the phase j_4 of the preceding CCK symbol in case of a rate change from 5.5 Mbit/s.

Dibit pattern (d(i),d(i+1)) **d(i) is first in time**	**Phase Change (+jω)**
00	0
01	π/2
11	π
10	3π/2 (-π/2)

Table 68, DQPSK Encoding Table

(d2,d3), (d4,d5), (d6,d7) encode j_2 , j_3 , and j_4 respectively based on QPSK as specified in table 69

Dibit pattern (d(i),d(i+1)) **d(i) is first in time**	**Phase**
00	0
01	π/2
11	π
10	3π/2 (-π/2)

Table 69, QPSK Encoding Table

1.4.1.3 Transmit Center Frequency and Chip Clock Frequency coupling

The tolerance of both the Transmit Center Frequency and the Chip Clock Frequency shall be +/- 25 ppm maximum. The clocks of the Transmit Center Frequency and the Chip Clock Frequency are coupled. This makes the design of the demodulator tracking circuits simpler when coherent demodulation is used for increased performance.