IEEE P802.11
Wireless LANs
Draft text for the Higher Speed Extension of the standard

Date: January 13, 1998

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Abstract

Draft text is provided for the high speed extension of the 2.4 GHz standard. The text specifies additional datarates to the Direct Sequence standard of 5, 8 and optional 10 Mbit/s. The specified modulation method is Barker Code Position Modulation (BCPM).

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 a 5 and 8 Mbit/s payload and an optional 10 Mbit/s. According to the FCC regulations, the DSSS system shall provide a processing gain of at least 10 dB. This shall be accomplished by chipping the baseband signal at 11 MHz with an 11-chip PN code. To provide the higher rates Barker Code Position Modulation (BCPM) will be employed. The DSSS system uses baseband modulations of Differential Binary Phase Shift Keying (DBPSK) and Differential Quadrature Phase Shift Keying (DQPSK) to provide the 1 and 2 Mbit/s data rates, respectively.

The higher speed system is fully coexistent and interoperable with the 1 and 2 Mbit/s 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.

1.1.1 Scope

This clause describes the extension of the 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 and 8 Mbit/s datarates (in addition to the 1 and 2 Mbit/s ,in this document refered to as current standard) are mandatory. The 10 Mbit/s datarate is optinal.

1.2 5, 8 and10 Mbit/s DSSS Physical Layer Convergence Procedure Sublayer

1.2.1 Introduction

This clause provides a convergence procedure for the 5 and 8 Mbit/s mandatory specification and the 10 Mbit/s optional 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. 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 DSSS PLCP preamble, the DSSS PLCP header and the MPDU do not differ from the current standard.

1.2.3 PLCP Field Definitions

As in the current standard the entire 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 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) 32h   5Mbit/s PPM
         d) 50h   8Mbit/s PPM

The extended DSSS PHY supports one optinal modulation service. The actual datarate of the 10 Mbit/s optional mode is 9.77 Mbit/s and is established by increasing the symbolrate with a factor 11/9. Two signal field values are defined for this service:

         e) 61h   9.7Mbit/s PPM   (optional)
         f) 62h   9.8Mbit/s PPM   (optional)

The values 61h and 62h are used depending on the number of bytes in the MPDU. While converting the number of bytes into a value for the LENGTH field (see next paragraph) two byte bounderies can fall within a microsecond.

         If the remainder of (#bytes * 9/11) is between 0 and 3/11:   Signal = 61h
                                              else: Signal = 62h

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 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:

         a)   1Mbit/s DBPSK: Length = #bytes * 8.
         b)   2Mbit/s DQPSK   Length = #bytes * 4.
         c)   5Mbit/s PPM   Length = #bytes * 8/5, rounded to the next integer.
         d)   8Mbit/s PPM   Length = #bytes.
         e)   10Mbit/s PPM   Length = #bytes *9/11, rounded to the next integer.

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

         a)   1Mbit/s DBPSK: #bytes = Length / 8.
         b)   2Mbit/s DQPSK   #bytes = Length / 4.
         c)   5Mbit/s PPM   #bytes = Length * 5/8, truncated to the last integer.
         d)   8Mbit/s PPM   #bytes = Length.

e)	10Mbit/s PPM	#bytes = Length *9/11-1, truncated, if Signal = 61h.
f)	10Mbit/s PPM	#bytes = Length *9/11 , truncated, if Signal = 62h.

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 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, 5 bits for 5 Mbit/s PPM, 8 bits for 8Mbit/s PPM or 8 bits for 10 Mbit/s (with the symbol rate increased with a factor 11/9)) 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 **Error! Reference source not found.**.

1.2.5 PLCP Transmit and Receive Procedure

The transmit and receive procedures are described in the sections 15.2.7. and 15.2.8 and will not change apart from the ability the transmit and receive 5, 8 or optional 10 Mbit/s.

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, 8 and 10 Mbit/s. The values 02h upto 10h are mandatory to be conformant to this extended specification. The value 14 is optional.

agPhyRateGroup		
aSupportedDataRatesTx	02h, 04h, 0Ah, 10h, 14h	Static
aSupportedDataRatesRx	02h, 04h, 0Ah, 10h, 14h	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, 8 and 10Mbit/s is BCPM, a pulse position modulation scheme based on the Barker sequence. 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, 8 and 10 Mbit/s BCPM uses the same

spectrum mask, operating channels, powerlevels, turnaround times, slot time and CCA mechanism. Different is (of cours) 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 : joint BCPM (5Mbit/s) 00h-FFh : disjoint BCPM (8 and 10Mbit/s)
RXD_UNIT	PMD_DATA.indicate	One(1), Zero(0): DBPSK di bit combinations 00,01,11,10: DQPSK 00h-1Fh : joint BCPM (5Mbit/s) 00h-FFh : disjoint BCPM (8 and 10Mbit/s)

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

1.4.1.2 Modulation and Mandatory Channel Data Rates of 5 and 8 Mbit/s

The extended Direct Sequence specification defines two mandatory additional datarates. The modulation scheme for 5 Mbit/s is joined Barker Code Position Modulation (joined BCPM), the modulation scheme for 8 Mbit/s is disjoined BCPM.

At 5 Mbit/s 5 bits (d0 to d4; d0 first in time) are transmitted per symbol. The first two bits define in the same way as in the 2 Mbit/s DQPSK encoder the phase change of a DQPSK signal (see section 15.4.6.4, Table 67). The in-phase and quadrature components I and Q are spreaded with the 11 chip Barker sequence as defined in section 15.4.6.3. Contrarary to 2 Mbit/s the first chip is not aligned at the start of a transmitted symbol but the start is dependent on the value of the third, fourth and fifth bit. The symbol duration is 11 chips long. The chips in the symbol define the starting points (position) of the Barker sequence. Only the first 8 positons (P0 to P7) are used. For 5 Mbit/s the Barker sequences for the I and Q component start at the same time (joined BCPM). The Table X defines the positions.

d4	d3	d2	position
0	0	0	p0
1	0	0	p1
1	1	0	p2
0	1	0	p3
0	1	1	p4
1	1	1	p5
1	0	1	p6
0	0	1	p7

Table X: joined BCPM position encoding table

At 8 Mbit/s 8 bits (d0 to d7) are transmitted per symbol. In BCPM scheme d2 to d4 define the position of the start of the Barker sequence for the I component, d5 to d8 define the position for the Q component (disjoined BCPM). d5 to d8 are defined in the same way as d2 to d4. See Table Y.

b4	b3	b2	position of I	b5	b6	b7	position of Q
0	0	0	p0	0	0	0	p0
1	0	0	p1	1	0	0	p1
1	1	0	p2	1	1	0	p2
0	1	0	p3	0	1	0	p3
0	1	1	p4	0	1	1	p4
1	1	1	p5	1	1	1	p5
1	0	1	p6	1	0	1	p6
0	0	1	p7	0	0	1	p7

Table Y: disjoined BCPM encoding table

The next figure shows a modulation example for three 8 Mbps symbols.
Data-in is the output of the scrambler, I-n and Q-n are the contribution of the n-th symbol to the final I and Q signals at the D/A output.
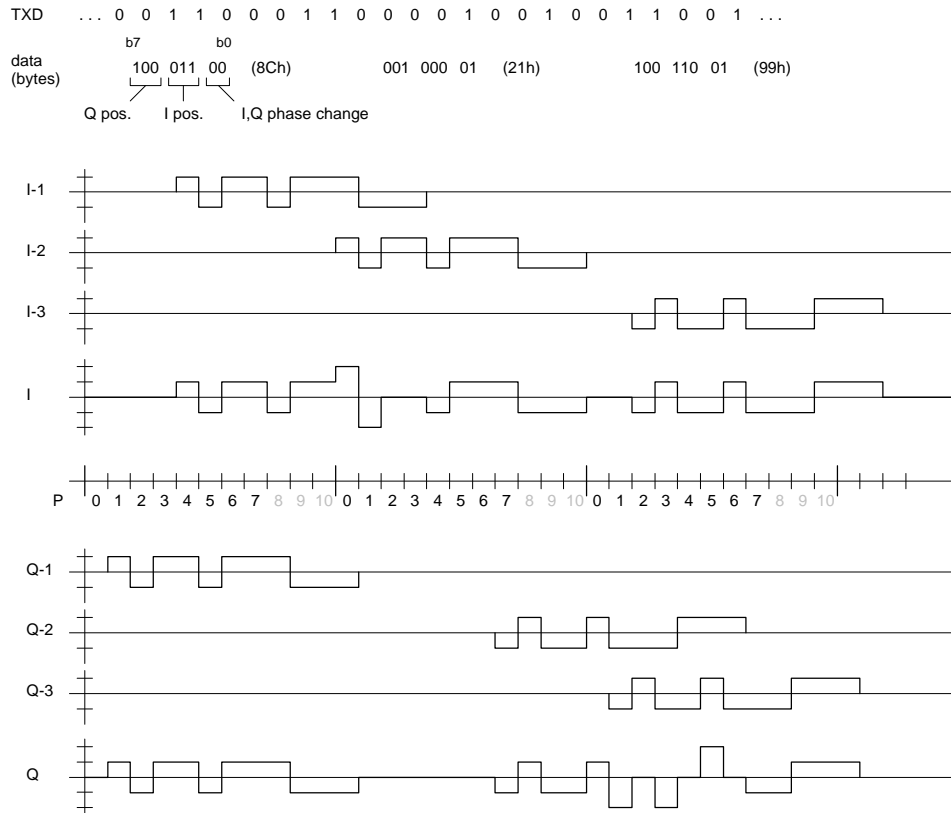Assume I-0 has been transmitted at $\pi/4$ (I'=1 and Q'=1).

Figure xx, Example of 8 Mbit/s Modulation

1.4.1.3 Modulation and Optional Channel Data Rates of 10 Mbit/s

The extended Direct Sequence specification defines one optional additional datarate of 10 Mbit/s. The modulation is in essence similar to the modulation method of 8Mbit/s. The only difference is that the symbol duration is reduced from 11 to 9 chips. The duration of a chip is not changed. The first 8 chips again define the possible positions (P0 to P7) for the starting points of the Barker sequence. The ninth chip is not used. The next figure illustrates the modulation method for 10 Mbit/s. The same datastream and assumption are used is in figure xx for 8 Mbit/s.
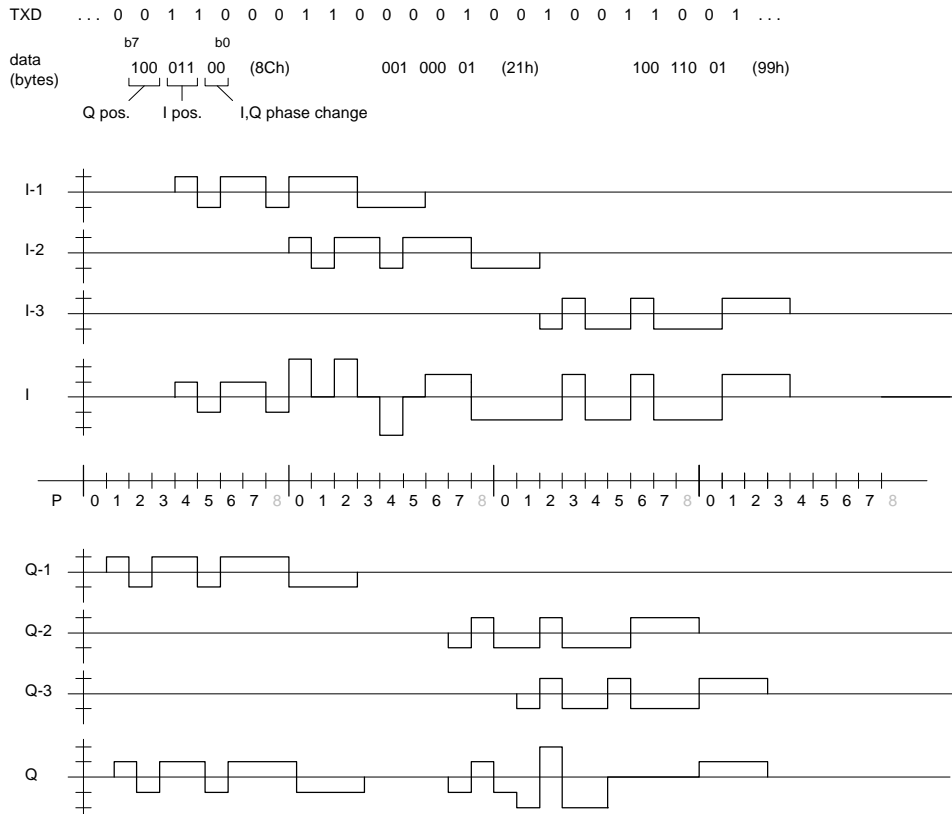
Figure xxx. Example of 10 Mbit/s modulation.

1.4.1.4 Amplitude Levels

As can be seen in the figures xx and xxx BCPM has five amplitude levels. This paragraph specifies the levels and the accuracy of these levels relative to the levels of the 1 Mbit/s signal. The 1 Mbit/s signal has two levels defined as -A and A.

The BCPM amplitude levels are specified as follows:

$(4/3 \pm x) * A$:the high positive level, sum of two positive Barker pulses
$(2/3 \pm y) * A$:the low positive level, only one Barker pulse adds to the BCPM signal
$\pm z * A$:zero level, sum of a positive and negative Barker pulse
$-(2/3 \pm y) * A$:the low negative level, only one Barker pulse adds to the BCPM signal
$-(4/3 \pm x) * A$:the high negative level, sum of two negative Barker pulses

The accuracy x,y and z have to be defined.

Implementation note: setting the levels to these values means that the power level of the BCPM signal is ≈3.5 dB lower then the 1 Mbit/s DPSK signal (preamble and header). More back-off of the Power Amplifier compared to the back-off required for the 1 and 2 Mbit/s signals is not necassary. Some linear distortion of the peaks (high levels) does not significantly add to the sidelobs of the power spectrum, because the frequency of appearance of the high peaks is relatively low. The performance degradation as a result will not be more than 1 dB.

1.4.1.5 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.