IEEE P802.15 Wireless PAN

# Proposed text with regard to BPSK-DSSS part of IEEE802.15.4d Japanese 950MHz PHY amendment

		Date: 2008-05-13		
Author(s):	-	-		
Name	Company	Address	Phone	email
Shusaku Shimada	Yokogawa Co.	2-9-32 Nakacho Musashinoshi Tokyo, 180-8750 Japan	+81 422-52-5543	shusaku@ieee.org

# Abstract

This document presents the proposed text to the editor to include in IEEE802.15.4d standard draft document which is expected to ask the IEEE802.15 membership to its first Letter Ballot.

Following text is the part of consolidated proposal of IEEE802.15.4d Japanese 950MHz PHY amendment, which is regarding to BPSK-DSSS modulation scheme. This part is to enhance the world wide commonality of IEEE802.15.4 technologies, especially for US 915MHz band, EU 868MHz band and similar sub-GHz band in other countries.

#### AMENDMENT 3: ALTERNATIVE PHYSICAL LAYER EXTENSION TO SUPPORT THE JAPANESE 950MHz BAND IEEE P802.15.4d/D0.1. May 2008

	. PHY speci	PHY specification					
6.	.3 PPDU for	mat					
Tl	his subclause	subclause specifies the format of the PPDU packet.					
Fo	or convenien	ce, the P	PDU packet	t structure is present	ed so th	at the leftmost field	as written in this stand
sh	hall be tran	smitted	or received	d first. All multip	le octet	fields shall be tra	ansmitted or received
si	ignificant oc	tet first a	ind each oc	tet shall be transmi	tted or 1	received least signi	ficant bit (LSB) first.
sa	ame transmi	ssion ord	ler should a	ipply to data fields	transter	red between the PI	TY and MAC sublaye
Ea	ach PPDU p	acket co	nsists of th	e following basic c	ompone	ents:	
-	A synchron	nization l	neader (SH	R), which allows a	receivir	ng device to synchr	onize and lock onto t
_	A PHY her	nder (PH	R) which c	contains frame leng	th infor	mation	
-	A variable	length pa	ayload, whi	ich carries the MA	C sublay	/er frame	
	-	0 1	- /				
<b></b>		.1.4.4		1 . C		·	
11	ne PPDU pa	icket stru	icture shall	be formatted as illu	ustrated	in Figure 16.	
					Octets		
1		· · · · ·		1		4	variable
	Preamble	SFD	Frame length (7 bits)	Reserved/PHR-Extens (1 bit)	sion exists	PHR-Extension field	PSDU
	Preamble RH	SFD R	Frame length (7 bits)	n Reserved/PHR-Extens (1 bit) PHR	sion exists	PHR-Extension field	PSDU PHY payload
	Preamble RH	SFD IR	Frame length (7 bits)	Reserved/PHR-Extens (1 bit) PHR	sion exists	PHR-Extension field	PSDU PHY payload
	Preamble RH	SFD	Frame length (7 bits) Figure 1	Reserved/PHR-Extens (1 bit) PHR 16 - Format of the I	sion exists PPDU	PHR-Extension field	PSDU PHY payload
	Preamble RH	SFD IR	Frame length (7 bits) Figure 1	Reserved/PHR-Extens (1 bit) PHR 16 - Format of the I	sion exists PPDU	PHR-Extension field	PSDU PHY payload
6.	Preamble RH	SFD IR	Frame length (7 bits)	Reserved/PHR-Extens (1 bit) PHR	PPDU	PHR-Extension field	PSDU PHY payload
6. TI	Preamble RH	SFD R le field	Frame length (7 bits) Figure 1	Reserved/PHR-Extens (1 bit) PHR	PPDU	PHR-Extension field	PSDU PHY payload
6. Tl m	Preamble RH	SFD IR le field field is u	Frame length (7 bits) Figure 1 used by the t	Reserved/PHR-Extens (1 bit) PHR 16 - Format of the I ransceiver to obtain able for the differer	PPDU chip annt PHYs	PHR-Extension field d symbol synchroni	PSDU PHY payload zation with an incomin
6. Tl m	Preamble RH .3.1 Preamb he Preamble nessage. The	SFD R le field field is u length c	Frame length (7 bits) Figure 1 used by the t	Reserved/PHR-Extens (1 bit) PHR 16 - Format of the I ransceiver to obtain able for the differer	PPDU chip an nt PHYs	PHR-Extension field d symbol synchroni is shown in Table	PSDU PHY payload zation with an incomin 19.
6. Tl m	Preamble RH	SFD IR le field field is u length c	Frame length (7 bits) Figure 1 used by the t	Reserved/PHR-Extens (1 bit) PHR 16 - Format of the I ransceiver to obtain able for the differer	PPDU chip and nt PHYs	PHR-Extension field d symbol synchroni	PSDU PHY payload zation with an incomin 19.
6. Tl m	Preamble RH	SFD R le field field is u length c	Frame length (7 bits) Figure 1 ased by the t of the pream Table 19	Reserved/PHR-Extens (1 bit) PHR 16 - Format of the I ransceiver to obtain able for the differer 9 - Preamble field 1	PPDU chip an nt PHYs ength	PHR-Extension field d symbol synchroni	PSDU PHY payload zation with an incomin 19.
6. Tl m	Preamble RH	SFD R le field field is u length c	Frame length (7 bits) Figure 1 used by the t of the pream Table 19	Reserved/PHR-Extens (1 bit) PHR 16 - Format of the I ransceiver to obtain able for the differer 9 - Preamble field 1	PPDU chip an t PHYs ength	PHR-Extension field d symbol synchroni is shown in Table	PSDU PHY payload Zation with an incomin 19. Duration (uS)
6. Tl m	Preamble RH .3.1 Preamb he Preamble nessage. The 868–866	SFD R le field field is u length o PHY 8.6 MHz BH	Frame length (7 bits) Figure 1 Ised by the t of the pream Table 19	Reserved/PHR-Extens (1 bit) PHR 16 - Format of the I ransceiver to obtain able for the differer 9 - Preamble field 1 I 4 octets	PPDU chip ann nt PHYs ength 	PHR-Extension field d symbol synchroni is shown in Table 32 symbols	PSDU PHY payload zation with an incomin 19. Duration (uS) 1600
6. Tl m	Preamble RH .3.1 Preamble he Preamble hessage. The 868–864 902–92	SFD IR le field field is u length c PHY 8.6 MHz BF 8 MHz BP	Frame length (7 bits) Figure 1 used by the t of the pream Table 19 PSK SK	ransceiver to obtain ble for the differer 9 - Preamble field l 1 4 octets 4 octets	PPDU chip an at PHYs ength _ength	PHR-Extension field d symbol synchroni is shown in Table 32 symbols 32 symbols	PSDU PHY payload zation with an incomin 19. Duration (uS) 1600 800
6. Tl m	Preamble RH .3.1 Preamble he Preamble hessage. The 868–864 902–92 950.9–5	SFD R le field field is u length o PHY 8.6 MHz BF 8 MHz BP 955.7 MHz	Frame length (7 bits) Figure 1 sed by the t of the pream Table 19 PSK SK BPSK	ransceiver to obtain ble for the differer 9 - Preamble field 1 14 octets 4 octets 4 octets	PPDU chip and the PHYs ength	PHR-Extension field d symbol synchroni is shown in Table 32 symbols 32 symbols 32 symbols	PSDU PHY payload zation with an incomin 19. Duration (uS) 1600 800 800
6. T] m	Preamble RH .3.1 Preamble he Preamble hessage. The 868-864 902-92 950.9-9 868-86	SFD IR le field field is u length c PHY 8.6 MHz BP 955.7 MHz 8.6 MHz A	Frame length (7 bits) Figure 1 sed by the t of the pream Table 19 PSK SK BPSK SK	ransceiver to obtain ble for the differer 9 - Preamble field 1 1 4 octets 4 octets 5 octets	PPDU chip an at PHYs ength	PHR-Extension field d symbol synchroni is shown in Table 32 symbols 32 symbols 32 symbols 2 symbols	PSDU PHY payload PHY payload zation with an incomin 19. Duration (uS) 1600 800 800 160 160
6. Tl m	Preamble RH .3.1 Preamble .3.1 Preamble he Preamble hessage. The 868-864 902-92 950.9-5 868-86 902-92	SFD IR le field field is u length c PHY 8.6 MHz BI 8 MHz BB 955.7 MHz 8.6 MHz AS	Frame length (7 bits) Figure 1 sed by the t of the pream Table 19 PSK SK BPSK SK K	Reserved/PHR-Extens (1 bit) PHR 16 - Format of the I ransceiver to obtain able for the differer 9 - Preamble field 1 1 4 octets 4 octets 5 octets 3.75 octets	PPDU chip annt PHYs ength	PHR-Extension field d symbol synchroni is shown in Table 32 symbols 32 symbols 32 symbols 32 symbols 6 symbols	PSDU PHY payload PHY payload Duration (uS) 1600 800 160 160 120
6. Tl m	Preamble RH .3.1 Preamble he Preamble hessage. The 868–86 902–92 868–86 902–92 868–86	SFD R le field field is u length o length o PHY 8.6 MHz BF 8 MHz BP 955.7 MHz 8.6 MHz A 8 MHz AS 68.6 MHz	Frame length (7 bits) Figure 1 sed by the t of the pream Table 19 PSK SK BPSK SK K O-QPSK	ransceiver to obtain ble for the differer 9 - Preamble field 1 4 octets 4 octets 5 octets 3.75 octets 4 octets	PPDU chip and the PHYs ength	PHR-Extension field d symbol synchroni is shown in Table 32 symbols 32 symbols 32 symbols 32 symbols 32 symbols 33 symbols	PSDU PHY payload PHY payload zation with an incomin 19. Duration (uS) 1600 800 800 160 120 320
6. Tl m	Preamble RH .3.1 Preamble he Preamble hessage. The 868–86 902–92 950.9–3 868–86 902–92 868–86 902–92 868–86 902–92	SFD IR le field field is u length c PHY 8.6 MHz BI 8.6 MHz BI 8.6 MHz AS 68.6 MHz AS 68.6 MHz AS	Frame length (7 bits) Figure 1 sed by the t of the pream Table 19 PSK SK SK BPSK SK K O-QPSK -QPSK	ransceiver to obtain ble for the differer 9 - Preamble field l 4 octets 4 octets 5 octets 3.75 octets 4 octets 4 octets	PPDU chip and t PHYs ength	PHR-Extension field d symbol synchroni is shown in Table 32 symbols 32 symbols 32 symbols 32 symbols 6 symbols 8 symbols 8 symbols	PSDU PHY payload PHY payload Duration (uS) Duration (uS) 1600 800 160 120 320 128

- 53
- 54

PART 15.4: WIRELESS MAC AND PHY SPECIFICATIONS FOR LR-WPANs

Preamble lengths for ASK are expressed in equivalent octet times as the preamble for ASK is defined using
 a special symbol. For all PHYs except the ASK PHY, the bits in the Preamble field shall be binary zeros.
 The ASK preamble format is described in 6.7.4.1.

# 5 6.3.2 SFD field

The SFD is a field indicating the end of the SHR and the start of the packet data. The length of the SFD for the different PHYs is shown in Table 20.

Table 20 - SFD field length

РНҮ		Length
868–868.6 MHz BPSK	1 octet	8 symbols
902–928 MHz BPSK	1 octet	8 symbols
950.9–955.7 MHz BPSK	1 octet	8 symbols
868–868.6 MHz ASK	2.5 octets	1 symbol
902–928 MHz ASK	0.625 octets	1 symbol
868–868.6 MHz O-QPSK	1 octet	2 symbols
902–928 MHz O-QPSK	1 octet	2 symbols
2400–2483.5 MHz O-OPSK	1 octet	2 symbols

For all PHYs, exept for the ASK PHY, the SFD is an 8-bit field. For the ASK PHY, the SFD is defined using a special symbol. The lengths of the SFD for the ASK PHY are expressed in equivalent octet times. The SFD for all PHYs except the ASK PHY shall be formatted as illustrated in Figure 17. The SFD for the ASK PHY is defined in 6.7.4.2.

Bits: 0	1	2	3	4	5	6	7
1	1	1	0	0	1	0	1

Figure 17 - Format of the SFD field (except for ASK)

37 6.3.3 Frame Length field38

The Frame Length field is 7 bits in length and specifies the total number of octets contained in the PSDU
(i.e., PHY payload). It is a value between 0 and aMaxPHYPacketSize (see 6.4). Table 21 summarizes the
type of payload versus the frame length value.

- 43 6.3.4 PSDU field
- 45 The PSDU field has a variable length and carries the data of the PHY packet.
- 47 6.3.5 Reserved/PHR-Extension bit

This 1 bit has been reserved for future and is recommended to be "0" when it is not used. In case of 950
 MHz PHY, this bit indicates the presence of PHR Extension field which is 4 octet of fixed length. Refer
 to 6.3.5 with regard to the meaning of extension field.

# Frame length values Payload 0-4 Reserved 5 MPDU (Acknowledgment) \_8 Reserved to aMaxPHYPacketSize **MPDU** 6.6 868/915/950 MHz band binary phase-shift keying (BPSK) PHY specifications 6.6.1 868/915/950 MHz band data rates The data rate of the 868/915/950 MHz band BPSK PHY shall be 20 kb/s when operating in the 868/950 MHz band, and 40 kb/s when operating in the 915 MHz band. 6.6.2 Modulation and spreading The 868/915 MHz BPSK PHY shall employ direct sequence spread spectrum (DSSS) with BPSK used for chip modulation and differential encoding used for data symbol encoding. 6.6.2.1 Reference modulator diagram The functional block diagram in Figure 21 is provided as a reference for specifying the 868/915 MHz band BPSK PHY modulation and spreading functions. The number in each block refers to the subclause that describes that function. Each bit in the PPDU shall be processed through the differential encoding, bit-tochip mapping and modulation functions in octet-wise order, beginning with the Preamble field and ending with the last octet of the PSDU. Within each octet, the LSB, b0, is processed first and the MSB, b7, is processed last. Differential BPSK **Binary Data** Bit-to-Modulated From PPDU Signal Encoder Chip Modulator (6.6.2.2)(6.6.2.3) (6.6.2.4) Figure 21 - Modulation and spreading functions

Table 21—Frame length values

43 6.6.2.2 Differential encoding

Differential encoding is the modulo-2 addition (exclusive or) of a raw data bit with the previous encoded bit.
 This is performed by the transmitter and can be described by Equation (1):

$$\begin{bmatrix} E_n = & R_n \oplus E_{n-1} \end{bmatrix}$$
(1)

48 50

1

2 3

5

6

7

<u>8</u>

13 14

15

16 17

18 19

20 21

22

23 24

25 26

27

28 29

30

31

37

38

40 41

42

44

51 where

- 52 Rn is the raw data bit being encoded
- 53 En is the corresponding differentially encoded bit
- 54 En?1 is the previous differentially encoded bit

Copyright c 2008 IEEE. All rights reserved. This is an unapproved IEEE Standards Draft, subject to change 1

2 3

4

5

7 8

9

11 12

13 14 15

24 25

26

27

28 29

30

33

(2)

For each packet transmitted, R1 is the first raw data bit to be encoded and E0 is assumed to be zero.

Conversely, the decoding process, as performed at the receiver, can be described by Equation (2):

$$R_n = E_n \oplus E_{n-1}$$

For each packet received, E1 is the first bit to be decoded, and E0 is assumed to be zero.

10 6.6.2.3 Bit-to-chip mapping

Each input bit shall be mapped into a 15-chip PN sequence as specified in Table 27.

Table 27 - Symbol-to-chip mapping

Input bits	Chip values (c <sub>0</sub> c <sub>1</sub> c <sub>14</sub> )
0	111101011001000
1	000010100110111

# 6.6.2.4 BPSK modulation

The chip sequences are modulated onto the carrier using BPSK with raised cosine pulse shaping (roll-off factor = 1) where a chip value of one corresponds to a positive pulse and a chip value of zero corresponds to a negative pulse. The chip rate is 300 kchip/s for the 868 MHz band and 600 kchip/s in the 915 MHz band.

# 6.6.2.4.1 Pulse shape

The raised cosine pulse shape (roll-off factor = 1) used to represent each baseband chip is described by
 Equation (3):



42 6.6.2.4.2 Chip transmission order

44 During each symbol period, the least significant chip, c0, is transmitted first, and the most significant chip, 45 c15, is transmitted last.

- 47 6.6.3 868/915 MHz band radio specification
- 48 49

46

43

- 50 6.6.3.1 Operating frequency range 51
- The 868/915/950 MHz BPSK PHY operates in the 868.0?868.6 MHz frequency band and in the 902?928 MHz
   frequency band and 950.9-955.7MHz frequency band.

## 6.6.3.2 915/950 MHz band transmit PSD mask

The transmitted spectral products shall be less than the limits specified in Table 28. For both relative and absolute limits, average spectral power shall be measured using a 100 kHz resolution bandwidth. For the relative limit, the reference level shall be the highest average spectral power measured within  $\pm$  600 kHz of the carrier frequency in case of 915 MHz band and within  $\pm$  300 kHz of the carrier frequency in case of 950 MHz band.

<b>Frequency Band</b>	Frequency	<b>Relative limit</b>	Absolute limit
915MHz band	$ f - f_c  > 1.2 \text{ MHz}$	-20 dB	-20 dBm
950MHz band ( 1mW channels )	$ f - f_c  = 0.3 \text{ MHz}$	-20 dB	—
	$ f - f_c  > 0.5 \text{ MHz}$	—	-39 dBm
	$0.5MHz >  f - f_c  > 0.3MHz$	_	-26 dBm/200kHz
950MHz band ( 10mW channels )	$ \mathbf{f} - \mathbf{f}_{\mathbf{c}}  = 0.3 \text{ MHz}$	-20 dB	—
	$ f - f_c  > 0.5 \text{ MHz}$	—	-39 dBm
	$0.5MHz >  f - f_c  > 0.3MHz$		-18 dBm/200kHz

Table 28 - 915 MHz band transmit PSD limits

### 6.6.3.3 Symbol rate

The symbol rate of an 868/915 MHz BPSK PHY conforming to this standard shall be 20 ksymbol/s when operating in the 868 MHz band and 40 ksymbol/s when operating in the 915 MHz band with an accuracy of  $\pm$  40 ppm.

6.6.3.4 Receiver sensitivity

Under the conditions specified in 6.1.7, a compliant device shall be capable of achieving a sensitivity of -92 dBm or better.

6.6.3.5 Receiver jamming resistance

This subclause applies only to the 902 - 928 MHz band as there is only one channel available in the 868.0 - 868.6 MHz band.

The minimum jamming resistance levels are given in Table 29. The adjacent channel is one on either side of the desired channel that is closest in frequency to the desired channel, and the alternate channel is one more removed from the adjacent channel. For example, when channel 5 is the desired channel, channel 4 and channel 6 are the adjacent channels, and channel 3 and channel 7 are the alternate channels.

Table 29 - Minimum receiver jamming resistance requirements for 915 MHz PHY

Adjacent channel	Alternate channel
rejection	rejection
0 dB	30 dB

Copyright c 2008 IEEE. All rights reserved. This is an unapproved IEEE Standards Draft, subject to change

# AMENDMENT 3: ALTERNATIVE PHYSICAL LAYER EXTENSION TO SUPPORT THE JAPANESE 950MHz BAND IEEE P802.15.4d/D0,1, April 2008

1	The adjacent channel rejection shall be measured as follows: the desired signal shall be a compliant
2	915 MHz IEEE 802.15.4 BPSK PHY signal, as defined by 6.6.2, of pseudo-random data. The desired signal
3	is input to the receiver at a level 3 dB above the maximum allowed receiver sensitivity given in 6.6.3.4.
4	In either the adjacent or the alternate channel, a compliant IEEE 802.15.4 signal, as defined by 6.6.2, is input
5	at the relative level specified in Table 29 The test shall be performed for only one interfering signal at a
6	time. The receiver shall meet the error rate criteria defined in 6.1.7 under these conditions
7	tine. The receiver shan meet the error fate error a demica in 0.1.7 ander these conditions.
0	
8	
9	
10	
11	
12	
13	
14	
15	
16	
17	
10	
10	
19	
20	
21	
22	
23	
24	
25	
26	
27	
28	
29	
30	
31	
37	
22	
22	
34 25	
35	
36	
37	
38	
39	
40	
41	
42	
43	
44	
45	
46	
47	
т/ Л9	
+0 40	
47 50	
50	
51	
52	
53	
54	