IEEE P802.15
Wireless Personal Area Networks

Project	IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs)	
Title	**LB34 Ranging comment resolution**	
Date Submitted	[29 June, 2006]	
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Re:	[]	
Abstract	[This document is a record of comment resolutions and text for The UWB PHY comments received on LB34.]	
Purpose	[To provide a record of the proposed changes to D2 of the WG recirculation letter ballot as a result of comments received from LB34.]	
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1. UWB PHY comment text development based on 6/265r4

CID 158 "*Unclear what is required by "A compliant device is required to implement support for at the two PANs channels that operate in at least one of the frequency bands 0, 3, or 0 in table 39i""*,

CID 159 "*A conclusion? In other words, a compliant device shall be capable of transmitting pulses at a chipping rate of 499.2 MHz*"

CID 160 "*PANs channels' and "acquisition codes" only appear in this paragraph. What do they mean?*"

CID 94 "'*Typo "for at the*"

Resolution: 2nd paragraph of 6.8a UWB PHY Specification reads:

"Within each frequency band there is support for up to two PANs channels to have unique acquisition codes. A compliant device is required to implement support for at the two PANs channels that operate in at least one of the frequency bands 0, 3, or 9 in Table 39i. Support for other frequency bands is optional. In other words, a compliant device shall be capable of transmitting pulses at a chipping rate of 499.2 MHz. This is equivalent to chip duration of approximately 2 ns."

Replace with the following text:

"Within each frequency band there is support for up to two channels to have unique SHR preamble codes. The combination of a channel and a preamble code is termed a complex channel. A compliant device shall implement support for at least one of the channels (0,3 or 9) in Table 39i. In addition each device shall support the two unique preamble codes for these channels as defined in Table 39d. Support for the other frequency bands listed in table 39i is optional."

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CID: 10 "*Page 51, Tables 39d and 39e. The two tables identify the ternary sequences to be used for Channel Number 0 to 4*

Replace Table 39d with following correction. This version is now complete and assigns codes to the remaining channels.

Replace Table 39e with the following

Table 1—

Code Index	Code Sequence	Channel Number*
1	-0000+0-0+++0+-000+-+++00-+0-00	0, 1, 8, 12
2	0+0+-0+0+000-++0-+---00+00++000	0, 1, 8, 12
3	-+0++000-+-++00++0+00-0000-0+0-	2, 5, 9, 13
4	0000+-00-00-++++0+-+000+0-0++0-	2, 5, 9, 13
5	-0+-00+++-+000-+0+++0-0+0000-00	3, 6, 10, 14
6	++00+00---+-0++-000+0+0-+0+0000	3, 6, 10, 14
7	+0000+-0+0+00+000+0++---0-+00-+	4, 7, 11, 15
8	0+00-0-0++0000--+00-+0++-++0+00	4, 7, 11, 15

*Note that Codes indexed 1 through 6 may also be used for UWB channels 4, 7, 11, and 15 (i.e. channels whose bandwidth is wider that 500 MHz) if interchannel communication is desired

In addition to the modified tables above change the text in clause 6.8a.5.1 SHR Synchronization (SYNC) field. The original text is

"Each PAN is identified by a code Ci of length 31 or 127. The different codes and their assignment to different UWB channels are shown in Table 39d and Table 39e.

For PAN number i, the SYNC field shall consist of NSYNC repetition of symbol $\mathbf{S}_i$, where symbol $\mathbf{S}_i$, is the code $\mathbf{C}_i$ spread by the delta function δ_L of length L as shown in Table 39e"

Replace with the following:

"Each PAN operating on one of the UWB PHY channels {0-15} is also identified by a preamble code. The preamble code is used to construct symbols which constitute the SYNC portion of the SHR preamble as shown in Figure 27d. The UWB PHY supports two lengths of preamble code a length 31 code and a length 127 code. Each preamble code is a sequence of code symbols drawn from a ternary alphabet {-1,0,1} and have been selected for use in the UWB PHY because the their perfect periodic autocorrelation properties. The length 31 code sequences are shown in table 39d while the length 127 code sequences are shown in table 39e where they are indexed from 1-24 ($\boldsymbol{C_i}$ i = 1,2,...24). The first 8 codes (index 1-8) are length 31 while the remaining 16 (index 9-24) are length 127. There is a restriction as to which codes may be used in each of the UWB PHY channels and particular code assignments are made in tables 39d and 39e. Specifically, the last column in each table indicates the set of UWB channel numbers which permit the use the code. This restriction of codes is to ensure that codes with the lowest cross-correlation are used in the same UWB PHY channel. Additionally, 8 of the length 127 codes are reserved for use with the private ranging protocol only and are not used during normal WPAN operation this restriction is indicated in the third column of table 39e as well

Table 2—

Code Index	Code Sequence	Channel Number*
9	+00+000-0--00--+0+0+00-+-++0+0000++-000+00-00--0-+0+0--0-+++0++000+-0+00-0++-0+++00-+00+0+0-0++-+--+000000+00000-+0000-0-000--+	0-4, 5, 6, 8-10, 12-14
10	++00+0-+00+00+000000-000-00--000-0+-+0-0+-0-+00000+-00++0-0+00--+00++-+0+-0+0000-0-0-0-++-+0+00+0+000-+0+++000----+++0000+++0--	0-4, 5, 6, 8-10, 12-14
11	-+-0000+00--00000-0+0+0+-0+00+00+0-00-+++00+000-+0+0-0000+++++-+0+--0+-0++--0-000+0-+00+0+----000-000000-+00+-0++000++-00++-0-0	0-4, 5, 6, 8-10, 12-14
12	-+0++000000-0+0-+0---+-++00-+0++0+0+0+000-00-00-+00+-++000-+-0-++0-0++++0-00-0++00+0+00++-00+000+-000-0--+0000-0000--0+00000+--	0-4, 5, 6, 8-10, 12-14
13	+000--0000--++0-++++0-0++0+0-00-+0++00++-0++0+-+0-00+00-0--000-+-00+0000-0++-00000+-0-000000-00-+-++-+000-0+0+0+++-00--00+0+000	Private Ranging Only
14	+000++0-0+0-00+-0-+0-00+0+0000+0+-0000++00+0+++++-+0-0+-0--+0++--000---0+000+0+0-+-000000+-+-0--00++000-00+00++-00--++-00-00000	Private Ranging Only

Table 2—

Code Index	Code Sequence	Channel Number*
15	0+-00+0-000-++0000---++000+0+-0-+00-+000--0-00--0--+++-+0-++00+-++0+00000+0-0+++-00+00+000-0000+00--+0++0+0+0-00-0-+-0+0++00000	Private Ranging Only
16	++0000+000+00+--0+-++0-000--00+-0+00++000+++00+0+0-0-+-0-0+00+00+0++----+00++--+0+-0--+000000-0-0000-+0--00+00000+-++000-0-+0+0	Private Ranging Only
17	+--000-0-0000+-00000+000000+--+-++0-0+0+00+-00+++0-++0-00+0-+000++0+++-0--0+0+-0--00-00+000-++0000+0++-+-00+0+0+--00--0-000+00+	4, 7, 11, 15
18	--0+++0000+++----000+++0+-000+0+00+0+-++-0-0-0-0000+0-+0+-++00+--00+0-0++00-+00000+-0-+0-0+-+0-000--00-000-000000+00+00+-0+00++	4, 7, 11, 15
19	-0-++00-++000++0-+00+-000000-000----+0+00+-0+000-0--++0-+0--+0+-+++++0000-0+0+-000+00+++-00-0+00+00+0-+0+0+0-00000--00+0000-+-0	4, 7, 11, 15
20	--+00000+0--0000-0000+--0-000-+000+00-++00+0+00++0-00-0++++0-0++-0-+-000++-+00+-00-00-000+0+0+0++0+-00++-+---0+-0+0-000000++0+-	4, 7, 11, 15
21	+0+00--00-+++0+0+0-000+-++-+-00-000000-0-+00000-++0-0000+00-+-000--0-00+00-0+-+0++0-++00++0+-00-0+0++0-0++++-0++--0000--000+000	Private Ranging Only
22	0-00-++--00-++00+00-000++00--0-+-+000000-+-0+0+000+0---000--++0+--0-+0-0+-+++++0+00++0000-+0+0000+0+00-0+-0-+00-0+0-0++000+0000	Private Ranging Only
23	000++0+0-+-0-00-0+0+0++0+--00+0000-000+00+00-+++0-0+00000+0++-+00++-0+-+++--0--00-0--000+-00+-0-+0+000++---0000++-000-0+00-+000	Private Ranging Only
24	+0+-0-000++-+00000+00--0+-0000-0-000000+--0-+0+--++00+----++0+00+00+0-0-+-0-0+0+00+++000++00+0-+00--000-0++-+0--+00+000+0000++0	Private Ranging Only

*Note that Codes indexed 9 through 13 may also be used for UWB channels 4, 7, 11, and 15 (i.e. channels whose bandwidth is wider that 500 MHz) if interchannel communication is desired

For a WPAN using the ternary code indexed by *i,* the SYNC field shall consist of NSYNC repetitions of the symbol $\boldsymbol{S_i}$, where $\boldsymbol{S_i}$ is the code $\boldsymbol{C_i}$ spread by the delta function δ_L of length L as shown in Table 39b"

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CID 112 "*Band group numbers in table 39i are wrong (only 3 band groups - one for < 1 GHz, one for low band, one for high band)*"

CID 115 "'*Table 39i: center frequency for < 1 GHz band should be 499.2 MHz (same as chip rate)*"ACCEPT replace table 39i with the following

BAND_GROUP* (Decimal)	Channel Number (Decimal)	Center Frequency f_c: MHz	Chip Rate: MHz	Mandatory/Optional
0	0	499.2	499.2	Mandatory below 1GHz
1	1	3494.4	499.2	Optional
	2	3993.6	499.2	Optional
	3	4492.8	499.2	Mandatory in "low-band"
	4	3993.6	1331.2	Optional
2	5	6489.6	499.2	Optional
	6	6988.8	499.2	Optional
	7	6489.6	1081.6	Optional
	8	7488.0	499.2	Optional
	9	7987.2	499.2	Mandatory in "high-band"
	10	8486.4	499.2	Optional
	11	7987.2	1331.2	Optional
	12	8985.6	499.2	Optional
	13	9484.8	499.2	Optional
	14	9984.0	499.2	Optional
	15	9484.8	1354.97	Optional

*Note Band Groups indicate a sequence of adjacent UWB center frequencies Band Group 0 is the sub GHz channel, Band Group 1 are the low band UWB channels and Band Group 2 are the "high-band" channels

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BEGIN incorporation of the following on 6/28

CIDs 78 "*'5. Table 39c is unintelligible, moreover, many parameters needed to understand the table are undefined."* PROPOSED Remedy: "*Fix the table and define all parameters in it."*

First paragraphs of 6.8a.4 PSDU preamble, rate, timing and frame parameters

"The PSDU rate-dependent parameters and timing-related parameters are summarized in Table 39a. The PSDU preamble parameters are summarized in Table 39b. The PSDU frame-dependent parameters for the default mandatory data rate and medium data rates are summarized in Table 39c.

A compliant UWB device shall support the mandatory chip rate of 499.2 MHz and the two mandatory mean Pulse Repetition Frequencies PRFs of 16.10 MHz and 4.03 MHz as well as the mandatory nominal data rate of 1Mbps."

Change to following: **DONE**

The PSDU rate-dependent parameters and timing-related parameters are summarized in Table 39a. Within each UWB channel {0:3, 5:6, 8:10, 12:14} the chipping rate (Chip Rate) shall be 499.2 MHz. This rate corresponds to the bandwidth of the pulses. Additionally, there are two possible preamble code lengths (31 or 127) and three possible mean PRFs (15.6 MHz, 3.90 MHz and 62.4 MHz). A compliant device shall implement support for the preamble code length of 31 and shall also support both the 15.6 and 3.90 MHz mean PRFs. The use of the length 127 code is optional and the mean PRF when implemented shall be 62.4 MHz.

UWB channels {4, 7, 11, 15} are all optional channels are differentiated from other UWB channels by the larger bandwidth (> 500 MHz) of the transmitted signals. These channels overlap the existing lower bandwidth channels and have chip rates that are proportional to the pulse bandwidth. The admissible data rates, preamble code lengths, PRFs and modulation timing parameters are listed in table 39a.

Each UWB channel allows for several data rates (Bit Rate) that are obtained by modifying the number of chips (pulses) within a burst (# Chips Per Burst). The total number of possible burst positions (# Bursts Per Symbol) remains constant so therefore the Symbol Duration (T_{sym}) changes to obtain the stated Symbol Rate and Bit Rates.

Due to the variability in the preamble code length and the PRF, there are several admissible values for the timing parameters of a preamble symbol. These values are summarized in Table 39b. In this section we define a preamble symbol as the waveform consisting of one whole repetition of the modulated preamble code (either length 31 or 127).Details on the construction of the preamble symbol for various code lengths and PRFs are given in 6.8a.5. For each target PRF the preamble constructed from a preamble code, C_i, by inserting a number of chip durations between code symbols. The number of chip durations to insert is denoted by δ_L and values for each code length and PRF are given in Table 39b.

First we note that the preamble is sent at a slightly higher mean PRF than the data (see Table 39a). For example the two mandatory modes in channels {0:3, 5:6, 8:10, 12:14), the peak PRFs during the preamble are 31.2 MHz and 7.8 MHz, the corresponding mean PRF during the preamble are 16.10 MHz and 4.03 MHz respectively, and the corresponding mean PRF during the data are 15.60 MHz and 3.90 MHz respec-

tively. The remaining peak and mean PRF values for other optional UWB channels and the optional length 127 code are listed in Table 39b.

The base symbol rate is defined as the rate at which the preamble symbols are sent. The base rates corresponding to the two mandatory mean PRFs of 16.10 MHz and 4.03 MHz are 1MS/s and 0.25 MS/s respectively and are listed in the column with the heading Base Rate MS/s in Table 39b. These symbol rates correspond to a preamble symbol duration, T_{psym}, of 993.59 ns and 3974.36 ns.

Finally, for each UWB frame consisting of the synchronization header (SHR), Start Frame Delimiter (SFD), PHY Header (PHR), and a data field, there are there are four possible durations of the SHR. This is due to the four possible lengths of SYNC field in the SHR (see 6.8a.5). The SYNC field consists of repetitions of the preamble symbol. The number of preamble symbol repetitions are 16, 64, 1024, and 4096. These different SYNC field lengths yeild different time durations of the UWB frame. The relationship between SYNC field length and frame duration is shown in Figure 39c. For each UWB channel the number of chips in an individual preamble symbol is shown in the row titled, N_c. N_c is a function of the PRF used within the channel and therefore has either 2 or 3 values. For each value of N_c the admissable preamble symbol durations T_{psym}, are defined and the duration of the SYNC portion of the SHR for each length (16, 64, 1024, or 4096) is denoted as T_{sync}. After the insertion of the SFD, The total length (in preamble symbols) of the SHR may be 24, 72, 1032, or 4104 and this in turn leads to the possible SHR durations denoted as T_{SHR}. After creation of the SHR the frame is appended with the PHY header (PHR) whose length, N_{hdr} is 16 symbols and its duration is denoted as T_{hdr}. The values of the frame duration parameters are shown in Figure 39c for each of the UWB channels.

In addition to the insertion of the text above replace Table 39b - UWB PHY preamble parameters with the corrected version below DONE

Bands		**Preamble**						
Channel Number	**Chip Rate (MHz)**	**C_i Code Length**	**Peak PRF (MHz)**	**Mean PRF (MHz)**	**Delta Length δ_L**	**#Chips Per Symbol**	**Symbol Duration T_{psym}(ns)**	**Base Rate MS/s**
{0:3, 5:6, 8:10, 12:14}	499.2	31	31.20	16.10	16	496	993.59	1.01
		31	7.80	4.03	64	1984	3974.36	0.25
		127	124.80	62.89	4	508	1017.63	0.98
{4, 11}	1331.2	31	41.60	21.47	32	992	745.19	1.34
		127	166.40	83.86	8	1016	763.22	1.31
{7}	1081.6	31	33.80	17.45	32	992	917.16	1.09
		127	135.20	68.13	8	1016	939.35	1.06
{15}	1355.0	31	42.34	21.85	32	992	732.12	1.37
		127	169.37	85.35	8	1016	749.83	1.33

Also insert the corrected Table 39c - UWB PHY frame-dependent parameters into draft 3. The file name of the graphic is 15_4a_UWB_TABLE_PHY_Frame_parameters.emf

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CID 77 “Several types of preamble lengths: It is not clear if there are 3 or 4 lengths - see table 39c vs. Fig 27b” ACCEPT

Correct Figure 27b -- PPDU Encoding Process by inseting corrected graphic file 15_4a_UWB_PPDU_EncodingProcess.emf

This corrects the wrong SHR length values.

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CID 110 “Clock carrier allignment p59 "The chip rate clock and the chip carrier (center frequency) shall be provided from the same source": This spec is implementation oriented and therefor not appropriate "The transmitted center frequency and chip 26 clock frequency tolerances shall be 20 ppm maximum." This definition does not have lots of meaning for an UWB system. It also is influenced by a specific implementation where” *Agree in Principle*

Replace ALL text in 6.8a.11.3 with the following DONE

"A UWB transmitter shall be capable of chipping at a rate given in Table 39i with an accuracy of +/- 20 ppm. In addition, for each UWB PHY channel, the center of transmitted energy shall be within the values listed in Table 39i also with an accuracy of +/- 20 ppm."

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CID 63,66 -- Need UWB material in Clauses 3 and 4

Resolution: Add following to clause 3 and 4 **DONE**

AGC Automatic Gain Control

PRF Pulse Repetition Frequency

PRI Pusle Repetieion Interval

PPM Pulse Position Modulation

BPM Burst Position Modulation

BPSK Binary Phase Shift Keying

SHR Synchronization Header

PHR PHY Header

SFD Start Frame Delimiter

Definitions

Hybrid Modulation: The modulation used in the UWB PHY which combines both BPSK and PPM so that both coherent and noncoherent receivers can be used to demodulate the signal

Burst: A group of UWB pulses occuring at consecutive chip periods

Complex Channel: A set of UWB channel, PRF and ternary code sequence

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CID 8: "Table 39a: Rows 7, 8, and 12 of table. There seems to be some inconsistency for these three rows"

ACCEPT - **DONE**

Replace Table 39a with corrected version in which the product of Burst per symbol and and # of Chips per burst is equal to # of chips per symbol. File name of the correct graphic is 15_4a_UWB_TABLE_PHY_rate_dependent_timing_parameters.emf

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CID 114 Table 39c: Long preamble is not allowed for 3.9 MHz PRF mode

ACCEPT - **DONE**

Corrected Table 39c and added footnote explicitly preventing the use of long SYNC field at low PRF: ***insert new graphic: 15_4a_UWBTABLE_PHY_frame_parameters.emf***

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CID 12: Page 55, Section 6.8a.8.2 UWB PHY Spreading. Is the LFSR reset to the initial state after every data packet

Accept: Clarify the intention to reset the LFSR with each new frame transmission - DONE

In clause 6.8a.8.2

Replace the following sentence "The LFSR shall be initialized with the initial state shown in Table 39h" with the following

"The LFSR shall be initialized upon the transmission of each frame with the initial state shown in Table 39h"

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CID 113 "inequalities in 6.8a.11.2 are incorrect and do not describe the mask: should be |f-fc|>0.8Rchip, etc."

ACCEPT Replace ALL text in clause 6.8a.11.2 with the following - **DONE**

The transmitted spectrum shall be less than -12dBr (dB relative to the maximum spectral density of the signal) for $0.65R_{chip} < |f - f_c| < 0.8R_{chip}$, and -20dBr for $|f - f_c| > 0.8R_{chip}$. For example, the transmit spectrum mask for channel 4 is shown in Figure 27l. The measurements shall be made using 1 MHz resolution bandwidth and a 1 KHz video bandwidth.

==========CID 106 “SFD for nominal low data rates of 150Kbps repeats every symbol in the SFD part eight times. There would be 24*symbol_duration silent interval. It seems to be too long. Justification to repeat 8 times is not given”

CID 152 “Figure 27d is totally wrong in the bottom part where it is calling out the 8 repetitions”

CID 9 “Page 51, Figure 27d. SFD for nominal low data rates of 150 kbps should repeat the 8-symbol SFD sequence as a whole 8 times rather than repeat each SFD symbol (consecutively) 8 times”

CID 11 “Page 53, Section 6.8a.5.2 SHR start frame delimiter (SFD) The (short) SFD should be [-1 0 0 0 -1 +1 0 -1], not [-1 0 0 0 -1 +1 -1]

ACCEPT: The SFD for the nominal low data rate of 150 Kb/s is incorrect. A new SFD has been proposed and accepted by the BRC

Replace ALL text in 6.8a.5.2 SHR start frame delimiter (SFD) with the following. Also update Figure 27d to reflect changes file is 15_4a_UWB_SHR_PreambleStructure.emf

A SFD shall be added to establish frame timing. The UWB PHY supports a mandatory short SFD for default and medium data rates and an optional long SFD for the nominal low data rate of 150 Kbps as shown in Figure 27d. The mandatory short SFD shall be [-1 0 0 0 +1 -1 0 -1] spread by the preamble symbol S_i, where the leftmost bit shall be transmitted first in time. The optional long SFD shall be obtained by the spreading the sequence [-1 0 0 0 +1 -1 0 -1 -1 0 0 0 +1 -1 0 -1 0-1 +1 +1 0 0 +1 0 +1 0 0 0 -1 +1 0 +1 0 +1 -1 -1 0 0 -1 0 0-1 +1 +1 0 0 +1 0 0 +1 -1 -1 0 0 -1 0 +1 0 0 0 -1 +1 0 +1] by the preamble sequence S_i. We note that the long SFD is eight times longer than the short SFD and consists of 64 preamble symbols. The structure of the SHR preamble and the two possible SFDs are shown shown in Figure 27d.

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