**IEEE P802.15**

**Wireless Personal Area Networks**

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| Project | IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs) |
| Title | TFD of NB CCA for assisting UWB channel access |
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| Re: | Contribution to IEEE 802.15.4ab  |
| Abstract |  |
| Purpose | This submission proposes text to for the IEEE Std 802.15.4ab specification framework document.  |
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*… …*

*In the following, the original text of IEEE 802.15.4-2020 is shown in blue whereas the proposed add-on texts are shown in black.*

**10.2.8 Clear channel assessment (CCA)**

**… …**

An HRP UWB PHY shall implement one CCA Mode 1 through CCA Mode 4 or one of the following methods:

… …

* *CCA Mode 5: HRP UWB preamble sense based on the SHR of a frame.* CCA shall report a busy medium upon detection of a preamble symbol as specified in 15.2.6. An idle channel shall be reported if no preamble symbol is detected up to a period not shorter than the maximum packet duration plus the maximum period for acknowledgment.
* *CCA Mode 6: HRP UWB preamble sense based on the packet with the multiplexed preamble as specified in 15.6.* CCA shall report a busy medium upon detection of a preamble symbol as specified in 15.2.6.
* *CCA Mode 7: UWB medium access coupled with CCA of narrow-band assisted PHY (NBA-PHY) as specified in Clause X.* Transmission of NB radio and NB CCA conducted by the coupled NBA-PHY are used to indicate the UWB-PHY medium access status. NB CCA shall report a busy UWB medium upon detection of the NB radio as specified in Clause X.

**… …**

***Clause X* O-QPSK PHY for NB CCA for assisting UWB channel access**

To use CCA mode 7 as defined in 10.2.8, a compliant device should contain a UWB PHY and a coupled NBA-PHY that are operated with a same or synchronized clock. One out of the next two O-QPSK PHYs can be used as the NBA-PHY for NB CCA for assisting UWB channel access. The first is the O-QPSK PHY operated at UNII-3 band as defined in NBA TFD. The second is the O-QPSK PHY operated at 915 MHz band as defined in Clause 21 of IEEE 802.15.4-2020 using the chosen parameters given in X.1. Use of the above two O-QPSK PHYs depends on local regulations.

X.1 O-QPSK at 915 MHz band

The channelization parameters of O-QPSK PHY operated at 915 MHz band are as follows.

* Frequency band: 902.1 – 927.9 MHz
* Channel spacing: 0.2 MHz
* Total number of channels: 129
* Center frequency: $f\_{k}=f\_{0}+k×0.2, \left(k=0, 1, \cdots ,128\right)$ [MHz]

$f\_{0}=902.2$ [MHz]

Among different combinations of parameters of O-QPSK at 915 MHz band in Clause 21 of IEEE 802.15.4-2020, the modulation diagram shown in Figure. X-1 as well as the coding and spreading parameters given in Table X-1 are chosen for NBA PHY for NB CCA for assisting UWB channel access.



Figure X-1 Modulation diagram

Table X-1 Coding and Spreading parameters

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Chip rate** **(kchips/s)** | **Spreading mode** | **coding** |
| SHR | 1000 | (64, 1)-DSSS | BDE |
| PHR | 1000 | (16, 1)0/1-DSSS | BDE and rate ½ FEC+interleaver |
| PSDU | 1000 | (16, 1)0/1-DSSS |

The following half-sine pulse shape is chosen as modulation pulse shape.

 $\begin{array}{c}p\left(x\right)=\left\{\begin{array}{c}sin\left(\frac{πt}{2T\_{c}}\right), \&0\leq t<2T\_{c}\\0 , \&otherwise\end{array}\right.\#\left(X-1\right)\end{array}$

All other parameters except for the above are the same as those defined in Clause 21 of IEEE 802.15.4-2020.

X.2 NB CCA for UWB channel access

When a compliant device intends to access a UWB channel, it shall perform NB CCA using the NBA-PHY against a NB channel which is paired with the intended UWB channel. The listening duration for NB CCA shall be at least 8 symbols. When a compliant device obtains channel access right and intends to send UWB signal at a UWB channel, it should also send a NB signal at a single NB channel which is paired with the intended UWB channel to declare UWB medium occupancy. UWB channel $i$ ($i=0, 1, 2, \cdots , 15$ ) of Table 10-9 is respectively paired to NB channels using the following formulas, where the channel orders are adjusted so that the two NB channels paired to UWB ch5 and ch9 have maximum frequency separation.

* UNII-3 band

$$\begin{array}{c}\begin{matrix}\left\{\begin{matrix}f\_{i×3+j}=5726.25+i×7.5+j×2.5&i=1, \cdots , 4, 6, \cdots ,8, 10, \cdots ,14\\f\_{5×3+j}=5726.25+5×7.5+j×2.5;&i=0\\\begin{matrix}f\_{0}=5726.25+j×2.5;\\f\_{15×3+j}=5726.25+15×7.5+j×2.5\\f\_{9×3+j}=5726.25+9×7.5+j×2.5;\end{matrix};&\begin{matrix}i=5\\i=9\\i=15\end{matrix}\end{matrix}\right.&j=0, 1, 2\end{matrix}\#\left(X-2\right)\end{array}$$

where, *j* represents the number of channel groups. Details of pairing between UWB channels and NBA channels at UNII-3 band are given in Table X-2.

Table X-2 Channel pairing between UWB channels and NB channels at UNII-3 band

|  |  |
| --- | --- |
| UWB channel number (Table 10-9) | NBA channel number @UNII-3 band  |
| $$j=0$$ | $$j=1$$ | $$j=2$$ |
| 0 | 15 | 16 | 17 |
| 1 | 3 | 4 | 5 |
| 2 | 6 | 7 | 8 |
| 3 | 9 | 10 | 11 |
| 4 | 12 | 13 | 14 |
| 5 | 0 | 1 | 2 |
| 6 | 18 | 19 | 20 |
| 7 | 21 | 22 | 23 |
| 8 | 24 | 25 | 26 |
| 9 | 45 | 46 | 47 |
| 10 | 30 | 31 | 32 |
| 11 | 33 | 34 | 35 |
| 12 | 36 | 37 | 38 |
| 13 | 39 | 40 | 41 |
| 14 | 42 | 43 | 44 |
| 15 | 27 | 28 | 29 |

* 915 MHz band

$$\begin{array}{c}\left\{\begin{matrix}\begin{matrix}f\_{i+j×16}=902.2+i×0.2+j×3.2;&0\leq i\leq 8\\f\_{i+j×16}=902.2+(i+4)×0.2+j×3.2;&9\leq i\leq 11\\f\_{i+j×16}=902.2+(i-3)×0.2+j×3.2;&12\leq i\leq 15\end{matrix}&j=0, 1, 2, \cdots ,7\end{matrix}\right.\#\left(X-3\right)\end{array}$$

where, *j* represents the number of channel groups. Details of pairing between UWB channels and NB channels are given in Table X-3.

Table X-3 Channel pairing between UWB channels and NB channels at 915 MHz band

|  |  |
| --- | --- |
| UWB channel number (Table 10-9) | Channel number @915 MHz band($j=0, 1, 2, \cdots ,7$) |
| 0 | $$f\_{0+j×16}$$ |
| 1 | $$f\_{1+j×16}$$ |
| 2 | $$f\_{2+j×16}$$ |
| 3 | $$f\_{3+j×16}$$ |
| 4 | $$f\_{4+j×16}$$ |
| 5 | $$f\_{5+j×16}$$ |
| 6 | $$f\_{6+j×16}$$ |
| 7 | $$f\_{7+j×16}$$ |
| 8 | $$f\_{8+j×16}$$ |
| 9 | $$f\_{13+j×16}$$ |
| 10 | $$f\_{14+j×16}$$ |
| 11 | $$f\_{15+j×16}$$ |
| 12 | $$f\_{9+j×16}$$ |
| 13 | $$f\_{10+j×16}$$ |
| 14 | $$f\_{11+j×16}$$ |
| 15 | $$f\_{12+j×16}$$ |

There are respectively 3 groups at UNII-3 band, and 8 groups at 915 MHz band. Each group consists of 16 NB channels. Selection of groups depends on availability of local regulation and on the order of group number. If multiple groups are allowed, then the smallest one shall be used. Only one group is used for NB CCA.

When a compliant device intends to transmit UWB signal, it sends NB signal to declare start of occupancy of the pairing UWB channel. When UWB channel occupancy ends, it sends NB signal to declare the end of occupancy of the pairing UWB channel. A NB end-time pattern of 24-symbol length is employed as described in the following. If the length of intended UWB transmission duration (UWB\_T) is shorter than 24 NB symbols, a compliant device sends the end-time pattern to declare both start and end of occupation of the pairing UWB channel as shown in Figure X-2. If UWB\_T is longer than 24 NB symbols but shorter than 36 NB symbols, a compliant device sends NB signal with a length of (UWB\_T – 24 symbols) followed by the end-time pattern as shown in Figure X-3. If UWB\_T is longer than 36 NB symbols, on the one hand it sends 12 NB symbols to declare start of occupation of the pairing UWB channel, on the other hand when UWB channel occupancy ends, it sends end-time pattern to declare the end of occupancy of the pairing UWB channel as shown in Figure X-4.



Figure X-2 When UWB duration is shorter than 24 NB symbols, end-time pattern is transmitted to declare both start and end of UWB channel occupancy



Figure X-3 When UWB duration is longer than 24 NB symbols but shorter than 36 NB symbols, 1 to 12 NB symbols flowed by the end-time pattern are transmitted to declare start and end of UWB channel occupancy

 

Figure X-4 When UWB duration is longer than 36 NB symbols, 12 NB symbols and end-time pattern are separately transmitted to respectively declare the start and end of UWB channel occupancy

Transmission of NB signal to declare UWB channel occupancy should start at the same time, within 1us, as transmission of UWB signal at the pairing UWB channel. Transmission of end-time pattern should end at the same time, within 1us, as the pairing UWB transmission. If a compliant device sensed the NB signal, it shall not further contend for channel access until it senses the end-time pattern or after a defined timeout duration which is equal to the largest length of a UWB packet. If a compliant device senses the end-time pattern or timeout is reached, it can start or resume contending for the channel.