**IEEE P802.15**

**Wireless Personal Area Networks**

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| Abstract |  |
| Purpose | This submission proposes texts for the IEEE Std 802.15.4ab specification. |
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Contents

[1. Acronyms and Abbreviations 3](#_Toc145450498)

[2. Mandatory NBA-UWB MMS Operating Parameter Sets 4](#_Toc145450499)

[2.1 MMRS Configurations 4](#_Toc145450500)

[2.2 NBA-UWB RSF-Only MMS Configurations 5](#_Toc145450501)

[2.3 NBA-UWB Mixed MMS Configurations 5](#_Toc145450502)

[3. Recommended Operating Parameter Sets for UWB Data Packets 7](#_Toc145450503)

1. Acronyms and Abbreviations

NBA narrow-band assistance

MMS multi-millisecond

NBA-UWB narrow-band assisted ultra-wideband

RSF ranging sequence fragment

RIF ranging integrity fragment

MMRS multi-millisecond ranging sequence

N\_MSR number of MMRS symbol repetitions within one RSF

RSF-RMARKER ranging marker in ranging sequence fragment

RIF-RMARKER ranging marker in ranging integrity fragment

1. Mandatory NBA-UWB MMS Operating Parameter Sets

In this section, we provide a list of mandatory operating parameter sets as a subset of the full set of all allowed 4ab configurations. This brings down the testing cost and facilitates inter-operation.



**Generic MMS Packet with/without NBA**

* 1. MMRS Configurations

The following table provides a mandatory set of combinations of MMRS sequence index and gap size. All the gap sizes are chosen such that the resulting MMRS symbol periods are coprime to {31, 91, 127}. For each particular network operation, a subset can be chosen to enable optimum interference suppression, e.g., by ensuring the GCD among the MMRS periods to be as small as possible. One such subset of gap sizes could be {0, 3, 5, 7, 9, 15, 19, 21, 25, 33, 37, 39, 43, 45, 49, 57}. Another subset of gap sizes could be {64, 61, 59, 57, 49, 45, 43, 39, 37, 33, 25, 19, 15, 9, 7, 3}.

Note that a larger gap size leads to a larger MMRS symbol period. Accordingly, a smoother spectrum is realized with a larger gap size, which enables higher energy efficiency in the sense that more energy can be transmitted within one millisecond while meeting the UWB spectral mask.

Mandatory MMRS Configuration Sets

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **MMRS Config Set#** | **MMRS Code Index** | **Gap Size** | **MMRS Period with Gap** | **Note** |
| 1 ~ 6 | 37  Note-1 | 0, 2, 3, 4, 5, 7 | 128 ~ 142 | Note-2 |
| 7 ~ 12 | 37  Note-1 | 8, 9, 10, 11, 12, 15 | 144 ~ 158 | Note-2 |
| 13 ~ 18 | 37  Note-1 | 16, 17, 18, 19, 21, 22 | 160 ~ 172 | Note-2 |
| 19 ~ 24 | 37  Note-1 | 23, 24, 25, 26, 28, 30 | 174 ~ 188 | Note-2 |
| 25 ~ 30 | 37  Note-1 | 31, 32, 33, 35, 36, 37 | 190 ~ 202 | Note-2, Note-3 |
| 31 ~ 36 | 37  Note-1 | 38, 39, 42, 43, 44, 45 | 204 ~ 218 | Note-2, Note-3 |
| 37 ~ 42 | 37  Note-1 | 46, 47, 49, 50, 51, 52 | 220 ~ 232 | Note-2, Note-3 |
| 43 ~ 49 | 37  Note-1 | 54, 56, 57, 58, 59, 61, 64 | 236 ~ 256 | Note-2, Note-3 |
| Note-1: each one of the 16 MMRS codes can be used in this table. Code 37 with zero mean is picked to facilitate inter-op.  Note-2: all the sequence periods are coprime with {31, 91, 127}  Note-3: a larger gap size enables higher energy efficiency | | | | |

* 1. NBA-UWB RSF-Only MMS Configurations

The following table provides a mandatory set of configurations for NBA-UWB RSF-only MMS operations. Each configuration set will be able to maximize the link budget improvement:

* a total of 16 RSFs can be coherently combined
* each RSF can utilize the energy budget efficiently
* each RSF is kept around 64us to minimize the chance of collision to other MMS packets
  + a larger gap size is thus combined with a smaller N\_MSR

Mandatory NBA-UWB RSF-only MMS Configuration Sets

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **RSF-Only**  **Set#** | **NB Config#** | **Number of RSFs: X** | **N\_MSR** | **MMRS Config** | | **RSF Length**  **(us)** | **Note** |
| **MMRS Config Set#** | **Gap Size** |
| 1 | 1 | 16 | 40 | 27 | 33 | 62.2 | Note-1 |
| 2 | 1 | 16 | 40 | 30 | 37 | 64.7 | Note-1 |
| 3 | 1 | 16 | 40 | 32 | 39 | 66.0 | Note-1 |
| 4 | 1 | 16 | 40 | 34 | 43 | 68.6 | Note-1 |
| 5 | 1 | 16 | 40 | 36 | 45 | 69.9 | Note-1 |
| 6 | 1 | 16 | 32 | 39 | 49 | 57.9 | Note-1 |
| 7 | 1 | 16 | 32 | 45 | 57 | 62.0 | Note-1 |
| 8 | 1 | 16 | 32 | 47 | 59 | 63.1 | Note-1 |
| 9 | 1 | 16 | 32 | 48 | 61 | 64.1 | Note-1 |
| 10 | 1 | 16 | 32 | 49 | 64 | 65.6 | Note-1 |
| Note-1: this configuration enables the max link budget gain by 4ab wrt 4z | | | | | | | |

* 1. NBA-UWB Mixed MMS Configurations

The following table provides a mandatory set of configurations for NBA-UWB Mixed MMS operations. Note that each configuration set ensures that each RSF contains the same number of UWB pulses as each RIF. Meanwhile, each RSF duration is kept below 92us while each RIF duration is 65.6us.

Mandatory NBA-UWB Mixed MMS Configuration Sets

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Mixed**  **MMS Set#** | **NB Config#** | **Number of RSFs: X** | **N\_MSR** | **MMRS Config** | | **Number of RIFs: Y** | **RIF: STS length** | **Note** |
| **MMRS Config Set#** | **Gap Size** |
| 1 | 1 | 1 | 64 | 21 | 25 | 1 | 64 | Note-1 |
| 2 | 1 | 1 | 64 | 21 | 25 | 2 | 64 | Note-1 |
| 3 | 1 | 1 | 64 | 21 | 25 | 4 | 64 | Note-1 |
| 4 | 1 | 1 | 64 | 21 | 25 | 8 | 64 | Note-1 |
| 5 | 1 | 2 | 64 | 21 | 25 | 2 | 64 | Note-1 |
| 6 | 1 | 4 | 64 | 21 | 25 | 4 | 64 | Note-1 |
| 7 | 1 | 8 | 64 | 21 | 25 | 8 | 64 | Note-1 |
| Note-1: each RSF and RIF contain the same number of pulses | | | | | | | | |

1. Recommended Operating Parameter Sets for UWB Data Packets

The following table provides the recommended set of operating modes for the UWB data packets, for the newly added HPRF mandatory PSDU rates in 4ab: 1.95 Mb/s, 7.8 Mb/s, 31.2 Mb/s, and 62.4 Mb/s.

Recommended Configurations of HPRF Data Packets

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Set#** | **Sync PSR** | **SFD #** | **SFD Length** | **#STS segments** | **STS Segment length (in 512 chips)** | **Data Rate**  **(Mb/s)** | **STS Configuration** | **Comments** |
| 1 | 64 | 2 | 8 | 0 | n/a | 1.95 | Config 0  (SHR, PHR, Data) | For transmission and reception |
| 2 | 128 | 3 | 16 | 0 | n/a | For transmission only |
| 3 | 64 | 2 | 8 | 1 | 64 | Config 1  (SHR, STS, PHR, Data) | For transmission and reception |
| 4 | 128 | 3 | 16 | 1 | 128 | For transmission only |
| 5 | 32 | 2 | 8 | 0 | n/a | 7.8 | Config 0  (SHR, PHR, Data) | For transmission and reception |
| 6 | 64 | 2 | 8 | 0 | n/a | For transmission and reception |
| 7 | 32 | 2 | 8 | 1 | 32 | Config 1  (SHR, STS, PHR, Data) | For transmission and reception |
| 8 | 64 | 2 | 8 | 1 | 64 | For transmission and reception |
| 9 | 32 | 2 | 8 | 0 | n/a | 31.2 | Config 0  (SHR, PHR, Data) | For transmission and reception |
| 10 | 32 | 2 | 8 | 1 | 32 | Config 1  (SHR, STS, PHR, Data) | For transmission and reception |
| 11 | 32 | 1 | 4 | 0 | n/a | 62.4 | Config 0  (SHR, PHR, Data) | For transmission and reception |
| 12 | 32 | 1 | 4 | 1 | 32 | Config 1  (SHR, STS, PHR, Data) | For transmission and reception |