**IEEE P802.15**

**Wireless Personal Area Networks**

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| Abstract |  |
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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. Recommended NBA-UWB MMS Baseline Operating Parameter Sets

In this section, we recommend a list of 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**

**16 Length-128 MMRS Sequences**

|  |  |
| --- | --- |
| Code Index | MMRS Sequence |
| 33 | **+-++-++++-+++---+-++-+++-+---++++-++-++++-+++----+--+---+-+++--- +-++-++++-+++---+-++-+++-+---+++-+--+----+---++++-++-+++-+---+++** |
| 34 | **+--++--+++----+++-+--+-++++++++++-+-+-+-++++----+--+-++-++--++-- +--++--+++----+++-+--+-+++++++++-+-+-+-+----++++-++-+--+--++--++** |
| 35 | **+--++--+-+-++-+-++++++++--++++--+--+-++--+-+-+-+++++------++--++ +--++--+-+-++-+-++++++++--++++---++-+--++-+-+-+-----++++++--++--** |
| 36 | **+---+----+---+--+----++++-++-+--+----+++-+--+-+++---+---+-+++-++ +---+----+---+--+----++++-++-+---++++---+-++-+---+++-+++-+---+--** |
| 37 | **+----++++-+++-+++---+---+-++-+--+----++++-+++-++-+++-+++-+--+-++ +----++++-+++-+++---+---+-++-+---++++----+---+--+---+---+-++-+--** |
| 38 | **++--+-+------++---++-+-+-----++---++-+-++++++--+--++-+-+-----++- ++--+-+------++---++-+-+-----++-++--+-+------++-++--+-+-+++++--+** |
| 39 | **------+++-+--++-++--++++-++-+-+-------+++-+--++---++----+--+-+-+ ++++++---+-++--+--++----+--+-+-+------+++-+--++---++----+--+-+-+** |
| 40 | **-----++------++---++-+-+++--+-+------++-+++++--+--++-+-+--++-+-+ +++++--++++++--+++--+-+---++-+-+-----++-+++++--+--++-+-+--++-+-+** |
| 41 | **--++-++------+-+++---++-----+-+------+-+--++-++-++++-+-+--+++--+ ++--+--++++++-+---+++--+++++-+-+-----+-+--++-++-++++-+-+--+++--+** |
| 42 | **-+---+---+++-++++-++-+---++++----+--+-++-++++---+-+++-++-+++-+++ +-+++-+++---+----+--+-+++----+++-+--+-++-++++---+-+++-++-+++-+++** |
| 43 | **-+---+--+-++-+---++++---+---+----+---+---+--+-++-++++----+++-+++ +-+++-++-+--+-+++----+++-+++-+++-+---+---+--+-++-++++----+++-+++** |
| 44 | **-+-++-+----------++--++---++++---++-+--+--++--++-+-+-+-+----++++ +-+--+-++++++++++--++--+++----++-++-+--+--++--++-+-+-+-+----++++** |
| 45 | **-++--++-++----++-+-++-+-+++++++++-+-+-+-----+++++--+-++---++--++ +--++--+--++++--+-+--+-+--------+-+-+-+-----+++++--+-++---++--++** |
| 46 | **+--++--+-+-++-+-++++++++--++++--+--+-++--+-+-+-+++++------++--++ -++--++-+-+--+-+--------++----+++--+-++--+-+-+-+++++------++--++** |
| 47 | **+--+----+--+-----+-+++--+-+---++-++-+++++--+----+-+---+++-+---++ -++-++++-++-+++++-+---++-+-+++---++-+++++--+----+-+---+++-+---++** |
| 48 | **++---+-+----+--+--+++-+-----+--+--+++-+-++++-++---+++-+-----+--+ --+++-+-++++-++-++---+-+++++-++---+++-+-++++-++---+++-+-----+--+** |

* 1. MMRS Configurations

The following table provides a recommended 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.

Recommended MMRS Configuration Sets

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **MMRS Config Set#** | **MMRS Code Index** | **Gap Size** | **MMRS Period with Gap** | **Note** |
| 1 ~ 6 | 37Note-1 | 0, 2, 3, 4, 5, 7 | 128 ~ 142 | Note-2 |
| 7 ~ 12 | 37Note-1 | 8, 9, 10, 11, 12, 15 | 144 ~ 158 | Note-2 |
| 13 ~ 18 | 37Note-1 | 16, 17, 18, 19, 21, 22 | 160 ~ 172 | Note-2 |
| 19 ~ 24 | 37Note-1 | 23, 24, 25, 26, 28, 30 | 174 ~ 188 | Note-2 |
| 25 ~ 30 | 37Note-1 | 31, 32, 33, 35, 36, 37 | 190 ~ 202 | Note-2, Note-3 |
| 31 ~ 36 | 37Note-1 | 38, 39, 42, 43, 44, 45 | 204 ~ 218 | Note-2, Note-3 |
| 37 ~ 42 | 37Note-1 | 46, 47, 49, 50, 51, 52 | 220 ~ 232 | Note-2, Note-3 |
| 43 ~ 49 | 37Note-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 recommended 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

Recommended 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 recommended 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.

Recommended 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. UWB-Only MMS Configurations

The following table provides a recommended set of configurations for UWB-only MMS operations. The recommended parameter sets reuse the HPRF set #24 and set #28 as defined in Table 15-16 in IEEE 802.15.4z.

Recommended UWB-only MMS Configuration Sets

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **UWB-only MMS Set#** | **UWB Sync PSR** | **UWB SFD #** | **SFD Length** | **Number of RSFs: X** | **Number of RIFs: Y** | **RIF: STS length** | **Note** |
| 1 | 32 | 2 | 8 | 0 | 1 | 32 | Ref to HPRF#28 in 4z Table 15-16 |
| 2 | 64 | 2 | 8 | 0 | 1 | 64 | Ref to HPRF#24 in 4z Table 15-16 |