**IEEE P802.15**

**Wireless Personal Area Networks**

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| Abstract | [Resolution to 802.15.4z comment CID i-0521] |
| Purpose | [Resolve 802.15.4z comment CID i-0521] |
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**This document provides a resolution to comment i-0521.**

***Remove 16.7 and add 5.9 as follows:***

**5.9 Ranging**

Support for ranging is optional. A PHY that supports ranging is called a ranging-capable device (RDEV), and it has optional and mandatory capabilities. An RDEV shall support the ranging counter described in 5.9.1 and the FoM described in 5.9.3. An RDEV may support optional crystal characterization described in 5.9.2 and the optional DPS, as described in “Applications of IEEE Std 802.15.4” [B3].

RDEVs produce ranging results, used by higher layers to compute the ranges between devices. These consist of 4-octet transmit and receive ranging counter values, and optionally 4-octet ranging tracking interval, 3-octet ranging tracking offset, and 1-octet ranging FoM.

**5.9.1 Ranging counter**

The ranging counter supported by an RDEV is a set of behavioral properties and capabilities of the RDEV that produce ranging counter values. A ranging counter value is a 32-bit unsigned integer. The unit of this counter is specified in 6.9.1.2 [*Ranging counter time unit].*

**5.9.2 Crystal characterization**

An RDEV that implements optional crystal characterization shall produce a tracking offset value and a tracking interval value for every timestamp that is produced. The tracking offset and the tracking interval are computed from measurements taken during an interval that includes the interval bounded by the ranging counter start value and the ranging counter stop value. Note that crystal characterization is relevant only if it is characterizing the crystal that affects the ranging counter.

**5.9.2.1 Ranging tracking offset**

The ranging tracking offset is a signed magnitude integer. The integer magnitude part of the number shall be 19 bits. The LSB of the integer represents a “part.” The sign bit of the signed magnitude integer shall be 0 when the oscillator at the transmitter operates at a higher frequency than the oscillator at the receiver, and the sign bit shall be 1 when the oscillator at the transmitter operates at a lower frequency than the oscillator at the receiver. The magnitude of the integer shall be a number that represents the difference in frequency between the receiver’s oscillator and the transmitter’s oscillator after the tracking offset integer is divided by the ranging tracking interval integer of 5.9.2.2. For example, if the difference between the oscillators is 10 × 10-6, then an acceptable value of the ranging tracking offset is 10 when the ranging tracking interval is 1 million. Another acceptable value for the ranging tracking offset is 15 when the ranging tracking interval is 1.5 million.

**5.9.2.2 Ranging tracking interval**

The ranging tracking interval shall be a 32-bit unsigned integer. The LSB of the ranging tracking interval represents a “part” that shall be exactly equal to the “part” in the LSB of the ranging tracking offset of 5.9.2.1. The size of the “part” is a time period that shall be smaller than128 times the ranging counter time unit specified in 6.9.1.2. Use of smaller “parts” for the LSB is encouraged, as described in “Applications of IEEE Std 802.15.4” [B3].

**5.9.3 Ranging FoM**

An RDEV shall produce a Ranging FoM for every ranging counter value that is produced. The Ranging FoM shall be formatted as shown in Figure AD1. The Confidence Level field is defined in Table AD2. The Confidence Level is the probability that the RMARKER arrived during the Confidence Interval. The Confidence Interval field is defined in Table AD3. The duration of the Confidence Interval in Table AD3 is the duration of the entire interval, not a plus or minus number. The Confidence Interval Scaling Factor field is defined in Table AD4.

The overall confidence interval is obtained according to the formula *Overall Confidence Interval = Confidence Interval × Confidence Interval Scaling Factor*. The MSB of the Ranging FoM octet is the extension bit. When the extension bit is 0, the fields have the normal meanings given in Table AD2, Table AD3, and Table AD4. When the extension bit is 1, the FoM has the meaning given in Table AD5.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Bit 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Extension | Confidence Interval Scaling Factor field | Confidence Interval field | Confidence Level field |

**Figure AD1 - Ranging FoM**

**Table AD2 — Confidence Level field**

|  |  |  |  |
| --- | --- | --- | --- |
| Confidence Level | Bit 2 | Bit 1 | Bit 0 |
| No FoM | 0 | 0 | 0 |
| 20% | 0 | 0 | 1 |
| 55% | 0 | 1 | 0 |
| 75% | 0 | 1 | 1 |
| 85% | 1 | 0 | 0 |
| 92% | 1 | 0 | 1 |
| 97% | 1 | 1 | 0 |
| 99% | 1 | 1 | 1 |

**Table AD3 — Confidence Interval field**

|  |  |  |
| --- | --- | --- |
| Confidence Interval | Bit 4 | Bit 3 |
| 100 ps | 0 | 0 |
| 300 ps | 0 | 1 |
| 1 ns | 1 | 0 |
| 3 ns | 1 | 1 |

**Table AD4 — Confidence Interval Scaling Factor field**

|  |  |  |
| --- | --- | --- |
| Confidence Interval Scaling Factor | Bit 6 | Bit 5 |
| Confidence interval × 1/2 | 0 | 0 |
| Confidence interval × 1 | 0 | 1 |
| Confidence interval × 2 | 1 | 0 |
| Confidence interval × 4 | 1 | 1 |

**Table AD5 — FoM values with the extension bit set**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Bit 7** | **6** | **5** | **4** | **3** | **2** | **1** | **0** |
| The timestamp report is uncorrected | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Reserved | 1 | Any nonzero value |

The FoM characterizes the accuracy of the PHY estimate of the arrival time of the RMARKER at the antenna. The FoM within a timestamp report shall characterize the accuracy of the timer counter value in the same timestamp report.

The FoM value of 0x80 is specifically used to signal to the next higher layer that the RxRangingCounter value is not correct and the higher layer should use the sounding primitives, e.g., MLME-SOUNDING.request, see 8.2.16, to retrieve the channel sounding information and use it to determine the ranging counter value to ascribe to the received packet.

The FoM value of 0x00 is special and means “no FoM.” No FoM means that no information is provided about the quality of a ranging measurement. The FoM value 0x00 is not used to report untrustworthy measurements. The most untrustworthy measurement reportable is 0x79.