# IEEE P802.15
# Wireless Personal Area Networks

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| Purpose | [Description of what the author wants P802.15 to do with the information in the document.] | |
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The Hopping Sequence List Flag field shall be set to one if an Association Request command is received before the Enhanced Beacon frametransmission and the Hopping Sequence ID of one is used in the DSME-enabled PAN.

The Time Synchronization Specification field is described in 6.5.1.5.

The Beacon Bitmap field is described in 6.5.1.5.

The Channel Hopping Specification field is described in 6.5.1.5 and is present only if the Channel Diversity Mode field in the Extended DSME Superframe Specification is set to indicate channel hopping.

The Hopping Sequence Length field is described in 6.5.1.5 and is present only if the Hopping Sequence List Flag field of the Extended DSME Superframe Specification field is one.

The Hopping Sequence field is described in 6.5.1.5 and is present only if the Hopping Sequence List Flag field of the Extended DSME Superframe Specification field is one.

### 6.5.1.10 Fragment Sequence Context Description (FSCD) IE

The Fragment Sequence Context Description (FSCD) IE Content field shall be formatted as illustrated in Figure 122.

| **Octets: 2** | | | | | **2** | | |
|---|---|---|---|---|---|---|---|
| **Bits: 1** | **6** | **6** | **2** | **1** | **10** | **6** | |
| Secure Fragment | Reserved | TID | Inc-Ack Policy | TID Extension | PSDU Size / Success Threshold | Addressing Information | ... |

| | **0/1/3/5** | **variable** | **0/4** | |
|---|---|---|---|---|
| | | | **26** | **6** |
| ... | TID Extension Parameters | Addressing | PSDU Counter | Reserved |

**Figure 122—FSCD IE Content field format**

The Secure Fragment field is used to indicate whether the fragments in this transaction will be sent with authentication. When set, the PSDU Counter field shall be present in the FSCD IE, and the fragment validation field shall be set to the MIC, as described in 7.4. The field shall be set to one when *phyPSDUFragSecure* is set to TRUE.

A Transaction Identifier (TID) field value of zero indicates that the TID field will not be present in the fragments that follow. When the TID field value is nonzero, the value identifies the fragment sequence. It associates the context information with each fragment in the transaction. The higher layer sets the TID and should assure that the current value is different from the preceding value.

The Incremental Acknowledgment (Inc-Ack) Policy field shall be set to one of the values given in Table 302.

The TID Extension field shall be set to one to indicate that the TID Extension Parameters field is present. Otherwise, the TID Extension Parameters field is absent.

The PSDU Size/Success Threshold field is described in Table 302.

The Addressing Information field shall be formatted as illustrated in Figure 123.

| Bit: 0 | 1 | 2–3 | 4–5 |
|---|---|---|---|
| Source PAN ID Present | Destination PAN ID Present | Source Address Mode | Destination Address Mode |

**Figure 123—Addressing Information field format**

The setting of the Addressing Information field shall be determined by the PAN ID and addressing mode fields of the PSDU being fragmented. The Addressing Information field may indicate any combination of source PAN ID, destination PAN ID, source address, and destination address in any of the allowable addressing modes.

The Source PAN ID Present field shall be set to one if the source PAN ID is included in the Addressing field and shall be set to zero otherwise.

The Destination PAN ID Present field shall be set to one if the destination PAN ID is included in the Addressing field and shall be set to zero otherwise.

The Source Address Mode field shall be set to one of the values given in Table 6.

The Destination Address Mode field shall be set to one of the values given in Table 6.

The TID Extension Parameters field is present only when the TID Extension field is set to one. The TID Extension Parameters field shall be formatted as illustrated in Figure 124..

| Bits: 1 | 7 | 16 or 32 |
|---|---|---|
| FICS RIV Present | FICS Offset Value | FICS RIV |

**Figure 124—TID Extension Parameters field format**

The FICS Remainder Initialization Value (RIV) Present field shall be set to one to indicate that the FICS RIV field is present. It shall be set to zero otherwise.

The FICS Offset Value field indicates whether the location of the FICS value is offset within the packet, and the field contains the value of the offset in octets. A value of zero indicates that no offset was used, (i.e., the FICS value is located at the end of the packet). A value greater than zero indicates that the FICS value is offset within the packet; the offset value is counted back from the last octet of the packet. If the FICS offset feature is not supported by a receiving device, the receiving device shall ignore any fragment or Inc-Ack received with this field set to a value greater than zero.

The FICS RIV field is only present if the value used as the initial remainder in the CRC calculation is not equal to the default initialization value for the remainder given in 5.2.1.9. In a transmitting device, this field is used to signal that an alternate CRC RIV was used when generating the fragment or Inc-Ack. In a receiving device, when a FICS RIV value other than zero is present, the CRC calculation initial value shall

be set to the FICS RIV field contents. The length of the field is determined by the current value of *phyFragmentFICSType*.

The Addressing field contains source and/or destination addressing information associated with the PSDU being fragmented and shall be formated as illustrated in Figure 125.

| **Octets: 0/16** | **0/16** | **0/8/16/64** | **0/8/16/64** |
|---|---|---|---|
| Source PAN ID | Destination PAN ID | Source Address | Destination Address |

**Figure 125—Addressing field format**

The content of the Addressing field shall be set according to the addresses contained in the MHR of the MPDU being fragmented. Addresses may be elided to fit into the PSDU size of the PHY in use; algorithms for address suppression are implementation-dependent.

The PSDU Counter field shall be present when the Secure Fragment field is set to one (*phyPSDUFragSecure* is set to TRUE). The MAC shall maintain a counter that is incremented with each fragmentation transaction, initiated such that the counter value is not repeated, as described in 8.4.2.

#### 6.5.1.11 Simplified Superframe Specification IE

The Simplified Superframe Specification IE Content field shall be formatted as illustrated in Figure 126.

| **Octets: 2** | **2** | **2** |
|---|---|---|
| Timestamp | Superframe Specification | CFP Specification |

**Figure 126—Simplified Superframe Specification IE Content field format**

The Timestamp field shall be incremented between transmissions; the initial value, resolution (LSB value), and accuracy are implementation dependent.

The Superframe Specification field is as defined in 6.3.1.3.

. The CFP Specification field shall be encoded as illustrated in Figure 127.

| **Bits: 0–3** | **4–7** | **8–11** | **12** | **13–15** |
|---|---|---|---|---|
| Number of GTSs | First CFP Slot in Superframe | Last CFP Slot in Superframe | GTS Permit | Reserved |

**Figure 127—CFP Specification field format**

The Number of GTSs field shall be set to the number of GTSs allocated by the coordinator.

TheFirst CFP Slot in Superframe field shall be set to the slot number in which the CFP begins

The Last CFP Slot in Superframe field shall be set to the slot number in which the CFP ends.

The GTS Permit field shall be set to one if *macGTSPermit* is equal to TRUE, indicating that the coordinator is accepting GTS requests. Otherwise, the field shall be set to zero.

**Table 301—Example of OVSF code output**

| Chip rate counter $b_2\ b_1\ b_0$ | Operation $V_0\ V_1\ V_2$ with code index $i = 5$ | OVSF code output $C^5{}_8$ | |
|---|---|---|---|
| | | CMOS logic mapping form | Form in Figure 335 |
| 1 0 0 | $V_0$ | 1 | –1 |
| 1 0 1 | $V_0 \oplus V_2$ | 0 | 1 |
| 1 1 0 | $V_0 \oplus V_1$ | 1 | –1 |
| 1 1 1 | $V_0 \oplus V_1 \oplus V_2$ | 0 | 1 |

The chip sequences are modulated onto the carrier using BPSK with pulse shaping. A chip value of one corresponds to a positive pulse and a chip value of zero corresponds to a negative pulse.

Chip rates/bands are shown in Table 164.

During each symbol period, chip $C_0$ is transmitted first and $C_{SF-1}$ is transmitted last.

#### 22.2.7.2 O-QPSK modulation

The chip sequences representing each data symbol are modulated onto the carrier using offset quadrature phase-shift keying (O-QPSK). Even-indexed chips are modulated onto the in-phase (I) carrier, and odd-indexed chips are modulated onto the quadrature-phase (Q) carrier. To form the offset between I-phase and Q-phase chip modulation, the Q-phase chips shall be delayed by $T_c$ with respect to the I-phase chips, as illustrated in Figure 338, where $T_c$ is the inverse of the chip rate and SF is *phyLECIMDSSSPSDUSpreadingFactor*.

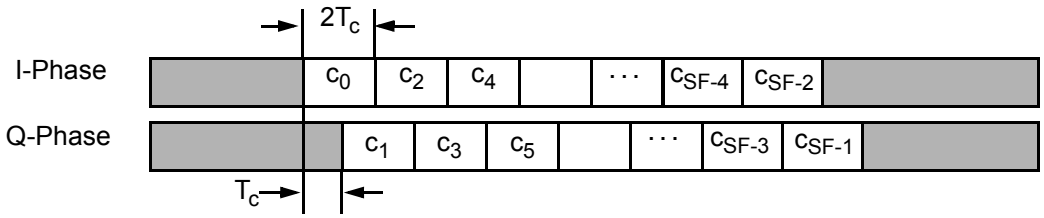


**Figure 338—O-QPSK chip modulation**

## 22.3 PSDU fragmentation

The LECIM DSSS PHY includes a fragmentation sublayer that divides the PSDU into a sequence of fragments. The synchronization and PHY header are prepended onto each fragment and a fragment integrity check sequence (FICS) is appended resulting in the PHY's PPDU. The FICS allows the recipient device to discard invalid PPDUs and the Inc-Ack provides for retransmission of only the discarded PPDUs. The recipient device's fragmentation sublayer reassembles the fragments into the original PSDU and passes it to the MAC for its processing.

Devices that support the LECIM DSSS PHY shall support PSDU fragmentation. When *phyPSDUFragmentationEnabled* is TRUE, the PSDU is processed into a sequence of fragments.

### 22.3.1 Configuration

To reduce the fragment packet overhead, both the initiating device and the recipient device shall be configured prior to the transmission of the fragment sequence. The configuration consists of the initiating device sending a data frame containing solely one FSCD IE as described in 6.5.1.10, to the recipient. The configuration information, identified by its TID, shall be used by the recipient device to process the received fragments identified with the same TID and reassemble them into the PSDU.

The data frame containing the FSCD IE shall be transmitted with the AR field set to one. If an acknowledgment is received, the initiating device shall transmit the fragments until either the transaction is complete or the transmission is aborted. A TID field value of zero in the FSCD IE shall be used to indicate that the TID field is not present in the fragments during that transaction. When the FSCD IE is received with the Secure Fragment field set to one, the PSDU Counter field shall be used with the fragment number to form the Frame Counter field used to construct the nonce, as described in 7.2.1, except that *macFrameCounter* is replaced with *phyFragmentFrameCounter*. The PIB attribute *phyFragmentFrameCounter* shall be comprised of the PSDU counter field, used as the most significant 26 bits, and the fragment number, used as the least significant 6 bits.

### 22.3.2 Fragmentation

The PSDU is prepared for fragment transmission according to the following steps:

d) Divide the remaining PSDU into fragments of the size supported by the current PHY configuration. All fragments, with the exception of the final fragment, shall contain the maximum number of data octets. For PHY configurations that use a fixed PPDU size (i.e., no PPDU length field transmitted), the final fragment data shall be padded with *phyPSDUFragPadValue*; the FICS field for the final fragment shall be calculated including the pad octets. When a PHY configuration only supports a fixed size PSDU, the size of each fragment shall be the PSDU size configured for that PHY; for all other PHYs, the fragment size shall be equal to the value of *phyFragmentSize*.

e) Determine the TID.

f) Determine the FSCD IE.

g) Construct the data frame containing the FSCD IE and then transmit it.

h) Upon acknowledgment of the data frame, transmit the fragments. Wait for the Inc-Ack cells according to the Inc-Ack policy value, described in 22.3.5.1, that is specified in the FSCD IE. Retransmit the cell preceding the Inc-Ack if the acknowledgment is not received within the Inc-Ack timeout period.

i) Upon reception of the final fragment and/or transmission of the final Inc-Ack as appropriate, the reassembled PSDU is processed as described in 5.7.

Fragments shall be transmitted beginning with fragment 1 and ending with fragment *n*. The Inc-Ack is described in 22.3.5. If the Inc-Ack retransmission count is exceeded during the transaction, the transaction is terminated and a fragment with the Fragment Number field set to zero is transmitted to signal the receiving device.

### 22.3.3 Fragment packet

The Fragment packet shall be formatted as illustrated in Figure 339.

| Octets: 2 | variable | 2/4 |
|---|---|---|
| Fragment Header | Fragment Data | FICS |

**Figure 339—Fragment format**

The Fragment Header field shall be formatted as illustrated in Figure 340.

| Bits: 0–2 | 3–9 | 10–15 |
|---|---|---|
| Packet Type | TID | Fragment Number |

**Figure 340—Fragment Header field format**

The Packet Type field shall be set to 0b110 to indicate a packet fragment.

The TID field shall contain the value assigned to the transaction context, as indicated in the FSCD IE. Upon reception, if the TID field contains a value other than the TID of a currently active transaction, the Fragment packet is ignored (i.e., not acknowledged and not counted to reset the transaction timeout).

The Fragment Number field identifies the fragment contained in the Fragment Data field. Upon PSDU reassembly, the fragmented data shall be placed in order according to fragment number. A Fragment Number field value of 0x3f is reserved for future use.

The Fragment Data field contains the part of the fragmented PSDU indicated by the Fragment Number field. The size of the data field depends on the configuration of the PHY in use.The FICS field is used to validate the received fragment. When *phyMPDUFragSecure* is FALSE, the length of the field shall be determined by *phyFragmentFICSType*, and it shall be calculated according to 6.2.10, except that the initial remainder value used for CRC calculation shall be as described in 6.5.1.10. When *phyMPDUFragSecure* is TRUE, the length of the field shall be 4 octets and shall contain the MIC-32, as described in 6.7.1.1.

### 22.3.4 Fragment acknowledgment and retransmission

Two levels of acknowledgment are provided: acknowledgment of fragments during the transfer process (i.e., Inc-Ack), which provide “progress reports”; and acknowledgment of the reassembled PSDU, as described in 5.7.4.2.

To accommodate individual fragment acknowledgments, a FICS is included with each fragment. The recipient device uses the FICS and fragment number to determine which fragments of the sequence have been received correctly and which are missing.

The Inc-Ack reports the fragments that have been successfully received up to that point. It is generated incrementally during the fragment sequence transfer according to the Inc-Ack policy provided in the FSCD IE.

### 22.3.5 Inc-Ack

The Inc-Ack is used during the fragment sequence transfer to determine which fragments have been received successfully and which fragments need to be retransmitted. An Inc-Ack includes the status of one or more fragments. The format of the Inc-Ack is given in 22.3.5.2.

The interval of the Inc-Ack is determined by the Inc-Ack Policy field as shown in Table 302. Upon completing the transmission of the fragment preceding the expected Inc-Ack according to the Inc-Ack policy selected, the initiating device shall suspend transmission and wait for the expected Inc-Ack. Upon reception of the Inc-Ack, fragments indicated as not received correctly shall be retransmitted. The number of retransmissions shall be limited by *macMaxFrameRetries*.

Upon reception of a fragment, the FICS is verified. The receiving device shall generate an Inc-Ack according to the Inc-Ack policy in use; the Inc-Ack shall be transmitted at the next transmit opportunity following the triggering condition.

When Inc-Ack policy zero is in use, reception of an out-of-order fragment shall result in termination of the transaction.

#### 22.3.5.1 Inc_Ack Policy

The Inc-Ack Policy field shall be set to one of the values given in Table 302.

**Table 302—Inc-Ack Policy field values**

| Field value | PSDU Size/ Success Threshold field | Inc-Ack policy description |
|---|---|---|
| 0 | Number of octets in the PSDU | An Inc-Ack shall be sent upon reception of each fragment |
| 1 | Number of octets in the PSDU | Acknowledgment based on time: An Inc-Ack shall be generated if *phyIncAckProgressTimeout* has elapsed since the reception of the fragment context frame or the last received fragment, whichever is later. |
| 2 | Number of octets in the PSDU | Acknowledge the last outstanding fragment: An Inc-Ack shall be generated only when the last expected fragment is received, or if *phyIncAckProgressTimeout* has elapsed since the last received fragment. |
| 3 | Number of valid fragments required to be received in order to declare the transaction successful | Acknowledge after specified number of known good fragments received: The Inc-Ack shall be generated after the successful reception of at least the number of fragments specified in the PSDU Size/Success Threshold field have been received and validated. |

#### 22.3.5.2 Inc-Ack format

The Inc-Ack format shall be as depicted in Figure 341.

| Octets: 2 | variable | 2/4 |
|---|---|---|
| Inc-Ack Header | Fragment Status | Inc-Ack Validation |

**Figure 341—Inc-Ack format**

The Inc-Ack Header field shall be formatted as illustrated in Figure 342.

| Bits: 0–2 | 3–9 | 10–15 |
|---|---|---|
| Packet Type | TID | Fragment Number |

**Figure 342—Inc-Ack Header field format**

The Packet Type field shall be set to 0b110 to indicate a packet fragment.

The TID field shall contain the same value as the TID in the received fragments being acknowledged.

The Fragment Number field is set to the value of the last fragment received prior to Inc-Ack generation.

The Fragment Status field shall be formatted as illustrated in Figure 343.

| Bits: 0–3 | 4–7 | 8-23/8-39/8-55/8-71 |
|---|---|---|
| Inc-Ack Content | LQI | Fragments Received (Set 0–Set 3) |

**Figure 343—Fragment Status field format**

The Inc-Ack Content field shall be set to one of the values shown in Table 303 based on the number of fragment status flags that are included in the Fragment Status field. Setting all bit positions to zero indicates an aborted transaction.

**Table 303—Inc-Ack Content field**

| Bit position | Description |
|---|---|
| $b_0$ | Set to 1 if Fragment Received bits 0–15 are present, set to zero otherwise. |
| $b_1$ | Set to 1 if Fragment Received bits 16-31 are present, set to zero otherwise. |
| $b_2$ | Set to 1 if Fragment Received bits 32-47 are present, set to zero otherwise. |
| $b_3$ | Set to 1 if Fragment Received bits 48-63 are present, set to zero otherwise. |

The LQI field contains an indication of the signal quality of the received fragment(s) being acknowledged. The measurement method is implementation-dependent, and at least eight unique values of LQI should be provided.

The Fragments Received field indicates the status of received fragments up to the current point in the transaction. The status flags are grouped into 4 bitmaps of 16 bits each. Flags for fragment number *n* is contained bit *n* of the Fragments Received field. When more than one set is included in the Inc-Ack, the lowest numbered set is transmitted first in time, so that the corresponding fragment numbers go from low to high as transmitted.

The Inc-Ack Validation field is used to validate the received Inc-Ack. The length of the field shall be determined by *phyFragmentFICSType*, and it shall be calculated according to 6.2.10, except that the initial remainder value used for CRC calculation shall be as described in 6.5.1.10.

### 22.3.6 Reassembly

Upon reception of the data frame containing the FSCD IE, the data frame containing the FSCD IE is acknowledged and the transaction state is initialized for a new PSDU fragment sequence transaction. Each received fragment is placed into the reassembled PSDU based on the value of the corresponding Fragment Number field. Inc-Acks are generated according to 22.3.5. When the final fragment is received and validated, the FCS is presumed successful (without requiring an FCS of the frame) and processing proceeds according to 5.7.4.2.

## 22.4 DSSS PHY RF requirements

### 22.4.1 Radio frequency tolerance

The DSSS PHY radio frequency tolerance shall be ±2.5 ppm.

### 22.4.2 Channel switch time

Channel switch time shall be less than or equal to 500 µs. The channel switch time is defined as the time elapsed at the antenna between the trailing edge of the last symbol of one PPDU to the leading edge of the first symbol of a consecutive PPDU sent on a different channel.

### 22.4.3 Transmit spectral mask

Implementers are responsible to assure that the transmit spectral content conforms to all local regulations.

### 22.4.4 Receiver sensitivity

The receiver sensitivity information is given in Table 304. The PER is ≤ 1% for the following conditions: BPSK modulation, no tail biting, fragment length of 16 octets, a 2-octet preamble and an 8-bit SFD.

**Table 304—Minimum LECIM DSSS PHY receiver sensitivity (dBm)**

| Spreading factor (chips/bit) | Modulation rate (ksym/s) | | | | |
|---|---|---|---|---|---|
| | **200** | **400** | **600** | **800** | **1000** |
| **16** | –115 | –112 | –110 | –109 | –108 |
| **32** | –118 | –115 | –113 | –112 | –111 |
| **64** | –121 | –118 | –116 | –115 | –114 |
| **128** | –124 | –121 | –119 | –118 | –117 |
| **256** | –127 | –124 | –122 | –121 | –120 |
| **512** | –130 | –127 | –125 | –124 | –123 |
| **1024** | –133 | –130 | –128 | –127 | –126 |
| **2048** | –136 | –133 | –131 | –130 | –129 |