**IEEE P802.15**

**Wireless Personal Area Networks**

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| Re: | 802.14.4k LECIM Draft Preparation | |
| Abstract | In response to informal comments and requests received during draft preparation, several issues are addressed: Allocation of a channel page for LECIM coordinated by WG ANA; Changes to existing PIB attributes, and addition of new attributes, for LECIM PHY; Definition of representation of PHY capabilities and operating mode suitable for over the air exchange | |
| Purpose | Support preparation of the LECIM draft in preparation for balloting | |
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Changes to existing PIB attributes, additional attributes, and PHY Capabilities Representation for TG4k

# Introduction and Purpose

The purpose of this document is to propose resolutions to informal comments received, and complete specification of some missing content, with respect to definition and use of PIB attributes, including and the representation of PHY capabilities and operating mode for over the air communication.

# Channel Page Values for LECIM

According to an email exchange with the working group numbering authority (WGNA) the first channel page assigned for LECIM is 13. Caveat: this is a preliminary assignment and may change prior to, or in conjuction with, publication of the standard, and is sufficient stability for preparation of the draft.

For simplicity, it is suggested we use channel page 13 to indicate all LECIM PHYs, we add a PIB attribute to differentiate between the DSSS and FSK LECIM PHYs.

Change to Table 71, description of *phyCurrentPage*, as follows:

For LECIM, this is used in conjunction with *phyCurrentBand*, *phyCurrentChannel* , *phyCurrentChannelSpacing* and current *phyCurrentPHYType* (or a subsets there of where appropriate for the band) to uniquely specify the channel being used (see 8.12)

The existing second sentence is not correct where multiple bands and channel spacing are provided, which is the case for both LECIM PHYs as well as the PHYs defined in 802.15.4g-2012.

The additional PIB attributes are defined in the following section.

In connection with this change, in 8.2.1.11 of the LECIM draft (Page 73, line 14 of 15-0086-05) add reference to phyCurrentChannel:

Change: *“NumChan* is the channel number from 0 to *TotalNumChan*–1”

To: “*NumChan* is the channel number (*phyCurrentChannel*) from 0 to *TotalNumChan*–1”.

# PHY Mode PIB attributes for LECIM FSK

*Note: In this section and subsequently, Table 1, Table 195 and Table 196 refer to tables in Document 15-12-0089-05; Clause numbers refer 802.15.4-2011, 802.15.4g-2012, 802.15.4f-2012, 802..15.4e-2012 and document 12-0089-04.*

Explanation: The FSK Mode is fully determined by the current band, current channel, symbol rate, modulation type, FEC enabled, spreading factor. FEC covered by and *phyLECIMFECEnabled* and *phyLECIMFSKInterleavingEnabled* attributes; Position modulation is controlled by *phyLECIMFSKPSDUPositionMod;* Spreading is controlled by *phyLECIMFSKSpreading* and *phyLECIMFSKSpreadingFactor*. Pseudo-Gaussian transmit shaping is determined by table 195 and 196 based on direction. There are also controls for configuring transmit preamble in the PIB.

Current channel is already defined in the PIB *phyCurrentChannel* as a logical channel with reference to 8.1.2 which includes reference to the appropriate new subclauses for LECIM PHYs.

To fully specify the FSK operating mode, then, we need two more attributes:

Band : Operating frequency band currently selected. Type is enumeration. Valid range is {169, 433, 470, 780, 863, 915, 917, 920, 2450} for both LECIM FSK and LECIM DSSS. Alternately we could call it “channel sub-page” (*phyCurrentSubPage*).

Symbol rate: Symbols per second, from table 66. Note: we should change column headings in tables 195 and 196 to “symbol rate” to avoid confusion of FEC coded or not coded. Then “symbol rate” and “current band” fully define the other modulation parameters.

It is proposed to combine *phyLECIMFSKSpreading* and *phyLECIMFSKSpreadingFactor* into one attribute, with the spreading factor value of 1 being equivalent to no spreading.

In table 195 and 196, change “kbps” to “ksps” (i.e. specify symbol rate) and then the ambiguous footnote can be deleted. The following assumes that change is made, i.e. we specify the signaling rate as k symbols/sec unambiguously, avoiding confusion over what “bit rate” means payload bit rate, coded bit rate or signaled bit rate.

Proposed change:

*Insert the following rows into Table 71:*

**Table 71—PHY PIB attributes**

|  |  |  |  |
| --- | --- | --- | --- |
| Attribute | Type | Range | Description |
| *phyLECIMCurrentBand* | Enumeration | 169, 433, 470, 780, 863, 915, 917, 920, 2450 | Operating frequency band currently selected when phyCurrentPage is k or k+1. |
| *phyLECIMFSKSymbolRate* | Float | See Table 66 | Currently selected symbol rate in k-symbols per second. The valid symbol rates per band are given in Table 66. |
| *phyCurrentPHYType* | Enumeration | DSSS, FSK | Specifies the LECIM PHY Type in use. |
| *phyChannelSpacing* | Enumeration | 100KHZ, 200KHZ | Channel spacing. Used with phyCurentBand and phyCurrentChannel to specify frequency channel being used.  NOTE: Still need to add values for DSSS when finalized by the DSSS group. |
|  |  |  |  |

# PHY Mode PIB attributes for LECIM DSSS

The LECIM DSSS PHY mode is fully described by operating band, channel number, chip rate, modulation type (order), spreading factor, code selection (preamble and body), controls for when to reset the codes, and various controls for preamble configuration. Currently the draft has PIB attributes defined for each control parameter. FEC coding and interleaving are always “on”.

# Why we don’t need details of PHY modes supported in the PIB

The concept of indicating in the PHY PIB which modes are supported by an implementation is unnecessary. In reality, the capabilities of a given implementation are documented in a datasheet. In the real world, attributes such as *phyChannelsSupported* exists only in the datasheet, i.e. there is no requirement for an implementation to include a readable register or other physical mechanism. The PIB is an abstraction, and in the case of implementation capabilities, the only physical form that may exist is in PDF.

The down-side of trying to define it in the PIB is that people get confused about the scope of a PIB attribute, and seem to confuse this with something that can be signaled over the air. It is best to avoid the confusion all together.

# Encoding PHY capabilities over the air

We can define a standard format for signaling capabilities over the air as an Information Element, similar to what is in 802.15.4g-2012 5.2.4.20b. For LECIM PHYs it is much simpler. This allows leveraging the mechanisms already defined in the base standard to provide an obvious and interoperable means to advertise and discover capabilities of peer devices.

The following IE definition subclauses are inserted at the end of 5.2.4 (where “x” and “z” are to be determined by the editors):

**5.2.4.x LECIM Capabilites IEs**

*Organization may need work – the two IEs share two field definitions. Will reorganize when integrating into the draft. The Editors will figure it out.*

**5.2.4.x.1 LECIM FSK Capabilities IE**

The following IE declares the LECIM FSK Capabilities supported by a device. The presence of this IE in a transmitted frame indicates that the device supports a LECIM FSK PHY. The format is shown in Figure 1k.

|  |  |  |
| --- | --- | --- |
| Octest: 2 | 2 | Variable |
| LECIM Bands Supported | LECIM FSK Features Supported | Channels Supported  [xref ] |

**Figure k1: LECIM FSK Capabilities IE**

The LECIM Bands Supported field shall be formatted as described in 5.2.4.x.3. The LECIM FSK Features shall be formatted as described in 5.2.4.x.4. The Channels Supported Field shall be formatted as described in 5.2.4.x.6**.**

**5.2.4.x.2 LECIM DSSS Capabilities IE**

The following IE declares the LECIM DSS Capabilities supported by a device. The presence of this IE in a transmitted frame indicates that the device supports a LECIM FSK PHY. The format is shown in Figure k4.

|  |  |  |
| --- | --- | --- |
| Octest: 2 | 2 | Variable |
| LECIM Bands Supported | LECIM DSSS Features Supported | Channels Supported  [xref ] |

**Figure k4: LECIM FSK Capabilities IE**

The LECIM Bands Supported field shall be formatted as described in 5.2.4.x.3. The LECIM DSSS Features shall be formatted as described in 5.2.4.x.5. The Channels Supported Field shall be formatted as described in 5.2.4.x.6**.**

**5.2.4.x.3 LECIM Bands Supported Field**

The Bands Supported field is encoded as shown in table k1.

**Table k1: LECIM Bands Supported field encoding**

|  |  |
| --- | --- |
| Bit Number | Description |
|  | Bands Supported. Bit-map. 1 indicates supported, 0 indicates NOT supported |
| 0 | 169 band supported |
| 1 | 433 band supported |
| 2 | 470 band supported |
| 3 | 780 band supported |
| 4 | 863 band supported |
| 5 | 915 band supported |
| 6 | 917 band supported |
| 7 | 920 band supported |
| 8 | 2450 band supported |
| 9:15 | Reserved for future use |

**5.2.4.x.4 LECIM FSK Features Supported field**

The FSK Features Supported field is encoded as shown in Table k2.

**Table k2: LECIM FSK Features Supported field encoding**

|  |  |
| --- | --- |
| Bit Number | Description |
| 0 | 2-Level FSK supported |
| 1 | Positional modulation supported |
| 2 | Symbol rate 37.5 ksps supportd, 200kHz channel spacing (Table 195) |
| 3 | 25 ksps supportd, 200kHz channel spacing (Table 195) |
| 4 | 12.5 ksps supportd, 200kHz channel spacing (Table 195) |
| 5 | 37.5 ksps supportd, 100 kHz channel spacing (Table 196) |
| 6 | 25 ksps supportd, 100 kHz channel spacing (Table 196) |
| 7 | 12.5 ksps supportd, 100 kHz channel spacing (Table 196) |
| 8 | FEC supported |
| 9 | Interleaving supported |
| 10 | Scrambling supported |
| 11 | Short PHR supported |
| 12 | Long PHR supported |

**5.2.4.x.5 DSSS FSK Features Supported field**

The DSSS Features Supported field is encoded as shown in Table k3.

**Table k3: LECIM DSSS Features Supported field encoding**

|  |  |
| --- | --- |
| Bit Number | Description |
| 0 | BPSK modulation supported |
| 1 | OQPSK modulation supported |
| 2:5 | Maximum spreading factor supported |
| 6:7 | PPDU Sizes supported  00 = Variable size PPDU Supported  01 = Fixed size 16 PPDU Supported  10 = Fixed size 24 PPDU Supported  11 = Fixed size 32 PPDU Supported |
| 8:15 | Reserved |

**5.2.4.x.6 Channels Supported Field**

***[Two suggestions to pick from]***

***[choice A]***

The Channels supported field is a set of channel maps, as shown in Figure k2.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Octets: 0/1** | **0/1** | **0/25** | **0/5** | **0/5** | **0/17** | **0/2** | **0/1** | **0/52** |
| Channel Map for Band 0 | Channel Map for Band 1 | Channel Map for Band 2 | Channel Map for Band 3 | Channel Map for Band 4 | Channel Map for Band 5 | Channel Map for Band 6 | Channel Map for Band 7 | Channel Map for Band 8 |

**Figure k2: Channels Supported Field format**

The Channels Supported field content depends on the value of the bands supported field. For each band, the channel numbering is given in 8.1.2 (*which should have reference to 8.1.2.9*) and Table 1. For each band indicated as supported, a corresponding channel bit map is constructed with one bit per channel as shown in Table 1 for that band, plus pad bits with a value of zero to make the bit map an integral number of octets. The order of the bit map shall be the bit field representing channel 1 is transmitted first in time, followed by channel 2 through the last valid channel for the band in increasing numerical order, followed by pad bits. The bit field corresponding to a channel number is set to 1 to indicate the channel is supported and set to 0 to indicate the channel is not supported. When multiple bands are supported as indicated in the LECIM Bands Supported field, the corresponding channel maps are concatenated in order such that the channel maps occur in the order of the bands given in Table k1.

**[*choice B: if it can be expected that most implementations will support all the channels in the band, then this representation will be much more efficient*]**

The Channels supported field is a set of channel maps, as shown in Figure k2.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Octets: 0/1** | **0/1** | **0/1/25** | **0/1/5** | **0/1/5** | **0/1/17** | **0/1/3** | **0/1/2** | **0/1/52** |
| Channel Map for Band 0 | Channel Map for Band 1 | Channel Map for Band 2 | Channel Map for Band 3 | Channel Map for Band 4 | Channel Map for Band 5 | Channel Map for Band 6 | Channel Map for Band 7 | Channel Map for Band 8 |

**Figure k2: Channels Supported Field format**

The Channels Supported field content depends on the value of the bands supported field. For each band, the channel numbering is given in 8.1.2 (*which should have reference to 8.1.2.9*) and Table 1. For each band indicated as supported, a corresponding channel bit map is constructed, having the format as shown in Figure K3. The first bit field of each map is “all channels supported”. If this field is set to 1, then all channels defined for the band in 8.1.2 are supported and the channel map is 8 bits (1 octet). If the all channels supported field is set to 0, then the subsequent fields indicate which channels are supported. The bit field corresponding to a channel number is set to 1 to indicate the channel is supported and set to 0 to indicate the channel is not supported. When multiple bands are supported as indicated in the LECIM Bands Supported field, the corresponding channel maps are concatenated in order such that the channel maps occur in the order of the bands given in Table k1, i.e. channel map corresponding to the band indicated by bit 0 of the LECIM Bands Supported is transmitted first.

**Table k4: Channel Map format**

|  |  |
| --- | --- |
| Bit Position | Descriptoin |
| 0 | All channels in band supported |
| 1 | Channel 1 supported |
| 2 | Channel 2 supported |
| … | |
| ***TotalNumChan*** | Channel j supported where j= ***TotalNumChan*** fromTable 1 |

# Encoding Operating Mode for Over the Air Transmission

If it is necessary to signal a specific operating mode over the air, it is necessary to define the encoding explicitly. We can define an IE which can be included in beacons or other frames as determined by a higher layer management entity. One potential use would be in an adaptive protocol to change operating mode and/or frequency dynamically, such as the “channel switch notification” defined in the current 4k draft, where the IE described here could be used to complete the information needed to change to a new channel, band or set of operating parameters.

*Note: Need to finish for DSSS operating parameters.*

The following information can be encoded into an IE and describe an FSK operating mode. Other modulation parameters not explicitly transmitted are fully determined by the standard if these parameters are known.

* *Operating Band: There are 9 possible values;*
* *Channel number: Maximum value is 199;*
* *Position Modulation enabled or disabled;*
* *Symbol rate: up to 3 values per band.*
* *FEC mode: NO FEC, FEC w/o Interleaving, FEC w/interleaving*
* *Scrambling: on or off. NOTE: Expect that this will go away as an option and always be ON.*

The following text defines an IE containing this information.

**5.2.4.x1 FSK Operating Mode Description IE**

An encoding for representing a LECIM FSK operating mode is shown in []. The information field is encoded as shown in Table k5.

|  |
| --- |
| Octets: 2 |
| LECIM FSK Mode Description |

**Table k5: Encoding of the operating mode information field**

|  |  |
| --- | --- |
| Bit Number | Description |
| 0:3 | Operating Band:  0 = Invalid  1-9 defined  10-15 reserved |
| 4:12 | Channel Number. The maximum valid value depends on the operating band according to Table 1. |
| 13 | Position Modulation supported. |
| 14:15 | Symbol rate.  0 = 37.5 ksps  1 = 25 ksps  2 = 12.5 ksps |
| 16 | Channel spacing:  0 = Channel spacing for indicated operating band as given in Table 195  1 = Channel spacing for indicated operating band as given in Table 196 |
| 17 | FEC Enabled  0 = not enabled  1 = enabled |
| 18 | Interleaving Enabled:  0 = not enabled  1 = enabled |
| 19 | Scrambler enabled:  0 = not enabled  1 = enabled |
| 20 | Short PHR may be used 1= yes, 0 = no |
| 21 | Long PHR may be used 1= yes, 0 = no |
| 22:31 | Reserved |

**5.2.4.x1 DSSS Operating Mode Description IE**

[TBA]