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**IEEE P802.15 Wireless Personal Area Networks**

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Project	IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs)		
Title	<b>Channel paging for 4g PHY</b>		
Date Submitted	[17 February 2010]		
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Re:	Draft text contribution for 15.4g		
Abstract	The proposed Channel Paging provides a method for structuring standard and vendor defined PHY modes, with respect to existing 802.15.4-2006 standard channel paging.		
Purpose	Draft text contribution		
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## Introduction

The 2006 Edition of 802.15.4 Standard uses a Channel Paging mechanism that uniquely identifies a PHY type by the tuple <*Channel Page*, *Channel Frequency Plan*>, where *Channel Page* is an integer variable ranging from 0 to 31 and *Channel Frequency Plan* is a bitmap variable. Each bit position from the *Channel Frequency Plan* variable uniquely identifies a channel from a given band of frequencies. A *Channel Page* contains channel frequencies within at most one band of frequencies.

This mode of functioning is challenged by the 4g Amendment because the latter introduces an increased number of optional PHYs. That is, by using the existing mode of channel page structuring the 802.15.4-2006 paging mechanism cannot accommodate the total number of 4g PHYs. Yet, 4g Amendment introduces vendors defined PHYs which additionally increase the number of PHYs.

The proposed approach focuses on optimally using of the existing channel paging space and requires as few as two additional channel pages. We notice that although the proposed approach can accommodate standard and vendor defined PHYs into a single channel page, for the sake of simplicity and clarity, we advocate for using different page numbers for standard and vendor defined PHYs.

The main idea behind our solution is to define different bit-masking utilization for the two channel pages dedicated to the 4g PHY. For short, instead of using all bits from the *Channel Frequency Plan* variable as a bitmap, we propose to use some of them as integer variables and the remaining ones as a bitmap variable.

## Description of the proposed solution

### Text changes to 802.15.4-2006

#### 3. Definitions

##### Add the following:

**3.a Frequency Band Page:** A set of communication channel frequency in a specified range of frequencies using one or several modulation methods and PHY types.

**3.b Modulation method:** The process of varying one or more properties of a high frequency periodic waveform, the so-called the *carrier signal*, with respect to a *modulating signal*.

**3.c Modulation Method Page:** A modulation method, such as FSK, OFDM and O-QPSK.

**3.d PHY type:** A group of PHY parameters uniquely identifying a modulation method.

**3.e PHY Type Switching:** Switching from a PHY type to a different PHY type. The new PHY type does not necessarily use the same modulation method.

**3.f Frequency Band Page Edge:** The lowest available frequency from a specified frequency band page.

**3.g Channel separation:** The frequency offset between two adjacent channel center frequencies.

### Text changes to clause 6 fsk 122409

#### 6.1.2 Channel assignments

##### Replace the existing contents of 6.1.2 Channel assignments with:

##### *Change the last paragraph as follows:*

The upper 5 most significant bits (MSBs) of the 32-bit channel bitmaps in *phyChannelsSupported* shall be used as an integer value to specify 32 possible channel pages. The lower 27 bits of the channel bit map shall be used as a bit mask to specify channel numbers within a channel page, except for channel pages 7 and 8, where the number of channels may exceed 27;

##### *Insert the following text after the last paragraph:*

To support the growing number of channels, channel assignments for pages 7 and 8 shall be defined through a combination of channels pages, frequency band pages, modulation method pages and PHY types; the channel assignments for pages 7 and 8 are described in 6.1.2a.

##### *Insert the following text and create new sub-clause 6.1.2a:*

#### **6.1.2a Channel assignments for SUN PHYs**

The PHY PIB attribute *phyChannelsSupported* shall indicate that channel page 7 is supported for standard defined MR-FSK, OFDM and MR-OQPSK PHYs. Support for channel page 8 is optional, but when supported in an implementation, shall be so indicated in *phyChannelsSupported*.

When the upper 5 bits of an element in the PIB attribute *phyChannelsSupported* is equal to 7 or 8, the lower 27 bits (*b0* up to *b26*) shall be used as follows (see also Figure 22a for an illustrative example):

- The first 5 (LSB) bits – ( $b_0, b_1, b_2, b_3, b_4$ ) - shall be used as an integer variable to specify 32 possible standard defined frequency band pages within the channel page 7, as described in 6.1.2.6a.
- The remaining 22 bits – ( $b_5 \dots b_{26}$ ) - shall be used as follows: The first 3 (LSB) bits – ( $b_5, b_6$ ) - shall be used as an integer variable to specify 4 possible standard modulation method pages for each frequency band page, as described in 6.1.2.6b.
- The remaining 20 bits – ( $b_7 \dots b_{26}$ ) - shall be used as a bit mask to specify 20 possible standard PHY Type numbers for each modulation method page, as described in 6.1.2.6c.

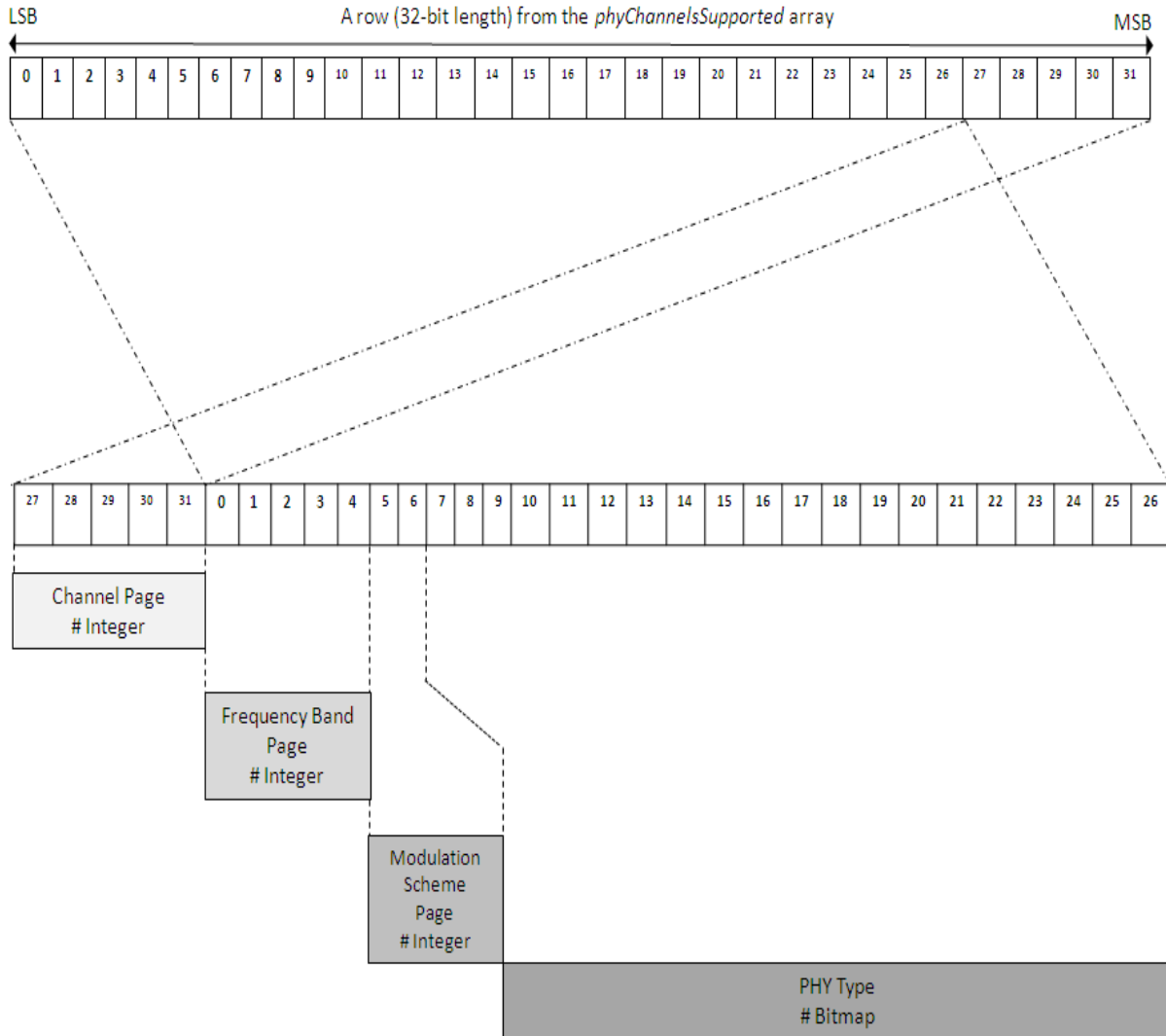


Figure 22a: The use of the lower 27 bits for channel pages 7 and 8.

An example of bitmap for the tuple <Channel Page = 7, Frequency Band Page = 1, Modulation Scheme Page = 0, PHY Type = 1>.

0 0 1 1 1 0 0 0 0 1 0 0 1 0

**6.1.2.1 Channel numbering**

**Replace the existing contents of 6.1.2.1 Channel numbering with:**

**Change first line as follows:**

A total of 27 channels numbered 0 to 26 are available per channel page, except for the channel page 7 and 8, where the channel assignments are described in 6.1.2.5a.

**Change last line in this clause to:**

An exception to this is the UWB PHY where specific mandatory and optional behaviors are as defined in 6.12.11.1 and the MR-FSK, OFDM and MR-OQPSK PHYs, where specific mandatory and optional behaviors are as defined in **[6.1.2.5a and *insert correct sub-clauses for each SUN PHY*]**.

**Insert the following text (between Sub-clause 6.1.2.5 Channel numbering for UWB PHY and Sub-clause 6.1.2.6 Channel pages).**

**6.1.2.5a Channel numbering for Multi-region FSK PHYs**

For channel page 7 and 8, a variable number of channels (*phyMaxChannels*) are available across all frequency band pages defined in 6.1.2.6a.

The center frequency ( $F_C$ ) of communication channels for each supported frequency band is given by Equation (1):

$$F_C(k) \stackrel{\text{def}}{=} F_{EDGE} + [(2 \cdot (k - 1) + 1) \cdot \Delta_{F_C}] \cdot \frac{1}{2} \quad (1)$$

where  $F_{EDGE}$  is the lowest frequency of the first available communication channel,  $\Delta_{F_C}$  is the channel separation, and  $k$  is the channel number (i.e., a number in the range 1 to *phyMaxChannelsBand*).

The operating frequency bands and channels are described in [insert correct reference for the sub-clause describing the mandatory and optional frequency bands and channels for FSK modulation].

For each PHY Type supported, a compliant device shall support all channels allowed by regulations for the region in which the device operates.

**6.1.2.5b Channel numbering for OFDM PHYs**

Channel numbering for equation (1) was validated for FSK approach. OFDM subgroup should provide feedback on the re-use of this mode of deriving channel numbering in their PHYs as well.

**6.1.2.5c Channel numbering for MR-O-QPSK PHYs**

Channel numbering for equation (1) was validated for FSK approach. MR-O-QPSK subgroup should provide a feedback on the re-use of this mode of deriving channel numbering in their PHYs as well.

## 6.1.2.6 Channel pages

Add to Table 4:

Channel page (decimal)	Channel page (binary) (b31, b30, b29, b28, b27)	Channel Number(s) (decimal)	Description
7	0 0 1 1 1	Variable	Standard defined channel numbers for the MR-FSK, OFDM and MR-OQPSK modulation methods. See section [ <i>insert subclause reference</i> ]
8	0 1 0 0 0	Variable	Vendor defined channel numbers for the MRFSK, OFDM and MR-OQPSK PHYs. See section [ <i>insert subclause reference</i> ]
9-31	0 1 0 0 1 – 1 1 1 1 1	Reserved	Reserved

## 6.1.2.6a Frequency Band Pages

A total of 32 frequency band pages are available for channel page 7 and 8, respectively. The *phyFrequencyBandPagesSupported* PHY PAN Information base (PIB) attribute indicates which frequency band pages are supported by the current PHY, while the *phyCurrentFrequencyBandPages* PHY PIB attribute identifies the frequency band page that is currently used. The PHY PIB attributes are described in 6.4.2.

The standard frequency band pages are shown in Table 4a.

Table 4a: Frequency Band Pages.

Notice: The full table will be filled up completely once a final decision is made on the total number of bands to be supported by 4g.

Frequency Band Page (decimal)	Frequency Band Page (binary) (b0, b1,b2,b3,b4,b5)	Frequency band (MHz)	Comments
0	0 0 0 0 0	400-413	1 MHz within 400-413 MHz
1	0 0 0 0 1	470-510	
2	0 0 0 1 0	863-870	
3	0 0 0 1 1	902-928	
4	0 0 1 0 0	950-956	
5	0 0 1 0 1	2400-2483.5	
6-31	0 0 1 1 0 to 1 1 1 1 1	Reserved	

### 6.1.2.6b Modulation Method Pages

A total of 4 modulation method pages are available for each of the frequency band pages defined in 6.1.2.6a. The *phyModulationMethodPagesSupported* PHY PAN Information base (PIB) attribute indicates which modulation method page is supported by the current PHY, while the *phyCurrentModulationMethodPage* PHY PIB attribute identifies the modulation method page that is currently used. The PHY PIB attributes are described in 6.4.2.

The modulation method pages are shown in Table 4b.

Table 4b: Modulation Method Pages.

Modulation Scheme Page (decimal)	Modulation Scheme Page (binary) (b5, b6)	Comments
0	0 0	FSK modulation method See also [insert correct sub-clause from PHY Types for MR-FSK].
1	0 1	OFDM modulation method See also [insert correct sub-clause from PHY Types for OFDM].
2	1 0	O-QPSK modulation method See also [insert correct sub-clause from PHY Types for OFDM].
3	1 1	Reserved

### 6.1.2.6c PHY Types

A total of 20 PHY Type numbers are available for each tuple < Frequency band page, Modulation method page>, where Frequency band page ranges from 0 to 31, as defined in 6.1.2.6a, and Modulation method page ranges from 0-3 as defined in 6.1.26b.

An example of the PHY Type numbers is shown in Table 4c. The lowest 5 entries are allocated to the mandatory PHY Types while the remaining entries are allocated to the optional PHY Types.

Table 4c: PHY Types for each modulation scheme.

PHY Type (decimal)	PHY Type (binary) (b7, b9, b10 ... b26)	Comments
0	0 0 0 0 0 0 0 0 ... 0	Mandatory PHY Type #1
1	1 0 0 0 0 0 0 0 ... 0	Mandatory PHY Type #2
2	0 1 0 0 0 0 0 0 ... 0	Mandatory PHY Type #3
3	0 0 1 0 0 0 0 0 ... 0	Mandatory PHY Type #4
4	0 0 0 1 0 0 0 0 ... 0	Mandatory PHY Type #5
5	0 0 0 0 1 0 0 0 ... 0	Optional PHY Type #1

6	0 0 0 0 0 1 0 0 ... 0	Optional PHY Type #2
7	0 0 0 0 0 0 1 0 ... 0	Optional PHY Type # 3
8-19	0 0 0 0 0 0 0 1 ... 0 to 0 0 0 0 0 0 0 0 ... 1	Reserved



**Sub-clause 6.X.Y: Standard PHY Types for FSK Modulation Method**

Table Y.1: 4g Standard PHY Types supported for FSK modulation method and their associated PHY parameters for 915 MHz band.

PHY Type (decimal)	Channel Plan Index (decimal)	Data rate (kpbs)	Channel spacing (kHz)	Number of channels	BT	Modulation Index	Symbol rate (kpbs)	Symbols	Comments
0	0	50	400	TBD	$\infty$	1.0	50	Binary	Mandatory PHY Type
1	0	150	400	TBD	$\infty$	0.5	150	Binary	Optional PHY Type
2	0	200	400	TBD	TBD	0.5	200	Binary	Optional PHY Type
4-19									Reserved

Table Y.2: 4g Standard PHY Types supported for FSK modulation method and their associated PHY parameters for 2400 MHz band.

PHY Type (decimal)	phyFSKCurrentChannel Plan (decimal)	Data rate (kpbs)	Channel spacing (kHz)	Number of channels	BT	Modulation Index	Symbol rate (kpbs)	Symbols	Comments
0	0	50	200/400	TBD	$\infty$	1.0	50	Binary	Mandatory PHY Type
1	0	150	400	TBD	$\infty$	0.5	150	Binary	Optional PHY Type
2	0	200	400	TBD	TBD	0.5	200	Binary	Optional PHY Type
4-19									Reserved

Table Y.2: 4g Standard PHY Types supported for FSK modulation method and their associated PHY parameters for 868 MHz band.

PHY Type (decimal)	Channel Plan index (decimal)	Data rate (kpbs)	Channel spacing (kHz)	Number of channels	BT	Modulation Index	Symbol rate (kpbs)	Symbols	Comments
0	TBD	50	200	TBD	TBD	TBD	50	Binary	Mandatory PHY Type
2	TBD	150	400	TBD	TBD	TBD	150	Binary	Optional PHY Type
3	TBD	200	400	TBD	TBD	TBD	200	Binary	Optional PHY Type
4-19									Reserved

**Sub-clause 7.X.Y. PHY Types for OFDM Modulation Method**

Identical methodology will be used as for FSK.

### PHY Types for MR-O-QPSK

Identical methodology will be used as for FSK.

### 6.4.2 PHY PIB Attributes

Insert the following text in Table 31 (PHY PIB attributes), Sub-clause 6.4.2:

Attribute	Identifier	Type	Range	Description
<i>phyChannelsSupported</i>	0x01	Array	An Rx32 bit array, where R ranges from 1 to 32	The array is composed of R rows, each of which is a bit string with the following properties: The 5 MSBs (b27, ..., b31) indicate the channel page, and the 27 LSBs (b0, b1, ..., b26) indicate the status (1=available, 0=unavailable) for each of the up to 27 valid channels (b <sub>k</sub> shall indicate the status of channel k as in 6.1.2) supported by that channel page. <u>For channel pages 7 and 8, the 27 LSBs shall be interpreted as defined in 6.1.2a.</u> The device only needs to add the rows (Channel pages) for the PHY(s) it supports.
<i>phyCurrentFrequencyBand</i>	0x22	Integer	0-31	The frequency band to use for all following transmission and reception ( <i>insert appropriate sub-clause</i> )
<i>phyCurrentModulationMethod</i>	0x23	Integer	0-3	The modulation method to use for transmission and reception in one of the following frequency bands ( <i>insert appropriate sub-clause</i> )
<i>phyCurrentPHYType</i>	0x24	Integer	0-19	The PHY type to use for all transmission and reception ( <i>insert appropriate sub-clause</i> )
<i>phyFSKChannelsPlanSupported</i>	0x25	Array	An Kx(5 + <i>MaxNumberOfChannels</i> ) bit array, where K ranges from 1 to <i>aMaxNumberOfChannelsPlans</i>	The array is composed of K rows, each of which is a bit string with the following properties: The first 5 bits indicate the frequency band page, and the remaining <i>MaxChannels</i> bits indicate the status for each of the up to <i>MaxNumberOfChannels</i> valid channels (b <sub>k</sub> shall indicate the status of channel k as in 6.1.2.5a) supported by the device for a given frequency band page.

<i>phyFSKCurrentChannelsPlan</i>	0x26	Integer	0-31	The channel plan to use for transmission and reception for following PHY Type [insert appropriate sub-clause]
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