IEEE P802.15
Wireless Personal Area Networks

Project	IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs)	
Title	Proposed Text on Sub-clause 12.2.2.5 and Annex D3 for OOK/DAMI	
Date Submitted	Sep, 2008	
Source	[Zhan Yu[1], Michael Sim[1], Kazuaki Takahashi[1], Bruce Bosco[2], Paul Gorday[2]] Affliation: [Panasonic[1], Motorola[2]]	Voice: [+65-6550-5332] Fax: [+65-6550-5201] E-mail: [Raymond.Yuz@sg.panasonic.com]
Re:	802.15.3c Teleconference Meeting	
Abstract	IEEE 802.15 Task Group TG3c Comment Resolution	
Purpose	Resolutions for the Comments on OOK and DAMI	
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Main changes:

1. Class 4 is renamed to "Optional Low Complexity Mode" and removed from Table 99 and Table 100.

2. A new sub-clause 12.2.2.5 is created to describe class 4 MCS in detail.

12.2 SC mmWave PHY Mode

The SC PHY mode provides for four different classes of modulation and coding schemes (MCSs) targeting different wireless connectivity applications. Class 1 is designed to address the low-power low-cost mobile market while maintaining a relatively high data rate of up to 1.5 Gb/s. Class 2 achieves data rates up to 3 Gb/s, whereas Class 3 is aimed at high performance applications with data rates in excess of 6 Gb/s. There are two mandatory MCSs for all Class 1, Class 2 and Class 3 devices and PNC capable OOK/DAMI devices: the common rate (CR) and the mandatory low rate (MLR). The CR and MLR are specified separately, although they are both part of Class 1. The CR shall be the base rate for the SC PHY. The CR should be used only for command frames and omni-directional transmissions. Besides the MCS classes in Table 99, OOK and DAMI, described in 12.2.2.5, may be employed within a child piconet for low complexity and low power consumption applications, such as battery operated handheld/portable devices.

Deleted: The last MCS class is Class 4, which is supported by OOK and DAMI capable devices for low complexity and low power consumption applications.

12.2.2.5 Optional Low Complexity Modes

Besides the MCS classes in 12.2.1.1, optional low complexity and low power consumption MCS which are important especially for SC applications, may be employed within child piconets. As optional modes, OOK and DAMI may be employed for these applications. This sub-clause describes the OOK and DAMI MCS should implementers chose to implement these optional modes.

All PNC-capable OOK/DAMI devices shall be able to transmit and receive CR signals both in the beacon period and in the CP. OOK/DAMI PNC-capable DEVs may use OOK/DAMI signals in CTAs allocated for child piconet to support communication with non-PNC-capable OOK/DAMI devices. Details on child piconet creation and usage are described in 8.2.5.

The summary of the MCS for OOK and DAMI is given in Table 101. For PNC-capable

OOK/DAMI devices, Common Rate with $\pi/2$-BPSK and RS(255,239) in Table 100 shall be supported to enable the interoperability with SC devices. These PNC-capable OOK/DAMI devices may create child piconet for respective non-PNC-capable devices by using respective MCS-formatted signals in Table 101. For OOK non-PNC-capable devices, OOK modulation and RS(255,239) shall be used. For DAMI non-PNC-capable devices, DAMI modulation and RS(255,239) shall be used.

Table 101—MCS dependent parameters for optional low complexity modes

MCS class	MCS identifier	PHY-SAP (Mb/s)	Modulation scheme	Spreading factor	FEC type	FEC rate
Low complexity mode	OOK1	759.2	OOK	2	RS(255,239)	0.937
	OOK2	1518.4 1	OOK	1	RS(255,239)	0.937
	DAMI1	3036	DAMI	1	RS(255,239)	0.937

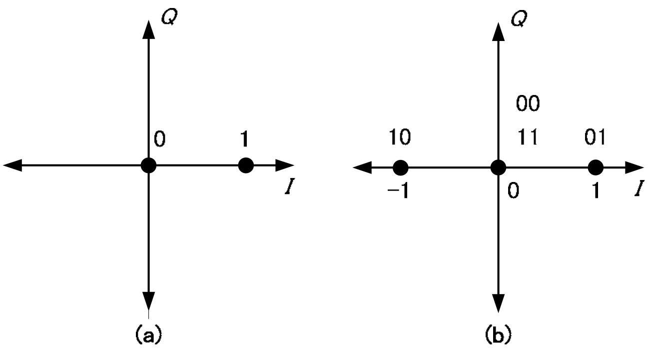

Figure 189 Constellation Diagram for (a) OOK and (b) DAMI

12.2.2.5.1 OOK

The OOK modulation shall use variable amplitudes to represent the data. As shown in Figure 189(a), OOK shall be represented by two points in the constellation map. The simplest form of OOK represents a binary ‘1’ with the presence of the signal, and a binary ‘0’ with the absence of it. The normalization factor shall be sqrt(2).

12.2.2.5.2 DAMI

DAMI modulation is shown in figure 189(b). The transmitted RF signal for a DAMI system shall be a single-sideband (SSB) modulated signal accompanied by two low-power pilot tones. Refer to Annex D3.2.1 for more details.

12.2.2.5.3 FEC

The forward error correction scheme for OOK and DAMI shall be RS(255, 239), as described in clause 12.2.2.

12.2.2.5.4 Code Repetition

The spreading scheme for OOK1 shall use simple code repetition with spreading factor of 2, so each bit shall be repeated twice.

Annex D3

(Normative)

Child Piconet Operation for OOK/DAMI Devices

D3.1 Introduction

PNC-capable OOK/DAMI devices shall use child piconet, as described in 8.2.5, for non-PNC-capable OOK/DAMI device communication.

D3.2 Child Piconet Operation

When a PNC-capable OOK/DAMI device detects an SC piconet, it may join the SC piconet and request to create child piconet for non-PNC-capable OOK/DAMI device communication.

Alternatively, if a PNC-capable OOK/DAMI device does not detect any SC piconet, it shall firstly start an SC piconet by using CR, and then create a child piconet to support non-PNC-capable OOK/DAMI device communication.

In child piconet operation, OOK/DAMI devices shall follow the optional low complexity mode descriptions in 12.2.2.5 and the following PHY requirements.

D3.2.1 DAMI

In DAMI modulation scheme, the coded binary serial input data, $b[k]$, where k = 0, 1, 2,…, shall be first precoded to form an intermediate data, $\tilde{b}[k]$, defined as follows:

$$\tilde{b}[k] = \tilde{b}[k-2] \oplus b[k]$$

where the two initial values $\tilde{b}[-2]=\tilde{b}[-1]=0$ shall be used for precoding. The output, $d[k]$ are formed by:

$$d[k]=K_{\mathrm{mod}}\left(I[k]+jQ[k]\right)$$

where $I[k]$ and $Q[k]$ are given by Table D3.5. The resulting constellation is illustrated in figure D3.4(b). The normalization factor is sqrt(2).

The transmitted RF signal for a DAMI system is a single-sideband (SSB) modulated signal accompanied by two low-power pilot tones. The SSB signal can be written as:

$$s_{\mathrm{SSB}}(t)=s(t)\cos(2\pi f_c t)+\tilde{s}(t)\sin(2\pi f_c t)$$

where f_c is the center frequency, $s(t)$ is the baseband signal, and $\tilde{s}(t)$ is the Hilbert transform of $s(t)$. The baseband signal $s(t)$ can be represented by:

$$s(t)=\sum_{k=0}^{N_p-1} d[k]g(t-kT_{\mathrm{sym}})$$

where N_p is the number of symbols in the packet, T_{sym} is the symbol length, and $g(t)$ is the baseband pulse shape. It is noted that one symbol corresponds to one bit for a DAMI system, meaning that the symbol length is the same as the bit length. The two pilot tones shall have frequencies f_c and f_c-1/(2T_{sym}), respectively. Both of them shall be in phase with the SSB signal. Their amplitudes shall be chosen such that the integrated power of each pilot is 25 dB (with ± 1 dB tolerance) below the integrated power of the SSB signal.

Table D3.1 DAMI Encoding Table

Precoded input bits, $\tilde{b}[k-2]\tilde{b}[k]$	$I[k]$	$Q[k]$
00	0	0
01	1	
10	-1	
11	0	

D3.2.2 PHY preamble

The preambles shall be modulated in OOK waveform with spreading factor of 2 in code repetition.

D3.2.3 PHY frame format

The frame header and the pilot word shall be modulated in OOK waveform with spreading factor of 2 in code repetition. OOK/DAMI devices shall not support PCES transmission in child piconet operation.

In OOK data payload, the transmit symbols shall be divided into block of length N = 508 x SF, where SF is the spreading factor in Table 101. This transmit symbol block shall be appended with pilot symbol as described in Figure D3.1. The pilot symbols consist of a sequence of length N_P = 4 x SF. The pilot symbols for OOK1 and OOK2 modes shall be chosen according to Table D3.2.

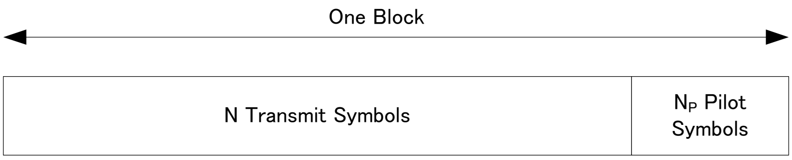

Figure D3.1 - Formation of Pilot Insertion

Table D3.2 OOK Pilot Symbols

Mode	Pilot symbols
OOK1	11001100
OOK2	1010

D3.2.4 Inter frame space

Compliant implementation shall use the PHY layer timing parameter values as defined in Table D3.3

Table D3.3 — PHY layer timing parameters

PHY parameter	Value	Subclause
pPHYMIFSTime	0.6 µs, 1.0 µs, 2.0 µs (default)	12.2.9.4
pPHYSIFSTime	1.0 µs, 2.0 µs, 2.5 µs, 6.0 µs (default)	12.2.9.3
pCCADetectTime	5 µs	12.2.8.5
pPHYChannelSwitchTime	100 µs	12.2.9.5