IEEE P802.15
Wireless Personal Area Networks

Project	IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs)	
Title	Proposed Text for Sub-clause 12.2.1.1.1 and Annex D3 for OOK/DAMI	
Date Submitted	Sep., 2008	
Source	[C.S. Sum, M.A. Rahman, H. Harada, S. Kato] Affiliation: [NICT]	Voice: [+81-46-847-5092] Fax: [+81-46-847-5440] E-mail: [sum@nict.go.jp]
Re:	802.15.3c Teleconference Meeting	
Abstract	IEEE 802.15 Task Group TG3c Comment Resolution	
Purpose	Resolutions for the Comments on OOK and DAMI	
Notice	This document has been prepared to assist the IEEE P802.15. It is offered as a basis for discussion and is not binding on the contributing individual(s) or organization(s). The material in this document is subject to change in form and content after further study. The contributor(s) reserve(s) the right to add, amend or withdraw material contained herein.	
Release	The contributor acknowledges and accepts that this contribution becomes the property of IEEE and may be made publicly available by P802.15.	

Main changes:

1. **Class 4 is removed from Table 99 and Table 100 (refer tables 99 and 100 in this page), as we agreed.**
2. **A new sub-clause 12.2.1.1.1 is created to describe class 4 MCS in detail.**

Table 99 and 100 after removal of class 4 MCS:

Table 99 – MCS categorization for the SC PHY

Class	Categorization
Common Mode	Mandatory rate for all DEVs in SC PHY mode, and optional for other DEVs.
Mandatory Low Rate	Mandatory data transmission rate for all DEVs in SC PHY mode, and optional for other DEVs.
Class 1	Data rates at PHY-SAP < 1.5 Gbps
Class 2	1.6Gbps < Data rate at PHY-SAP < 3 Gbps
Class 3	Data rate at PHY-SAP > 3 Gbps

Table 100 – MCS dependant parameters

MCS Class	MCS Identifier	PHY-SAP Mbps	Modulation Scheme	Spreading Factor	FEC Type	FEC Rate
Class1	LR1	50.6	π/2-BPSK/(G)MSK	32	RS(255,239)	0.937
		379.6		4		
		759.2		2		
		1518.4		1		
	LR2	607.5	π/2-BPSK/(G)MSK	2	LDPC(672,504)	0.75
		1215		1		
	LR3	405	π/2-BPSK/(G)MSK	2	LDPC(672,336)	0.5
		810		1		0.5
Class2	MR1	1620	π/2-QPSK	1	LPDC(672,336)	0.5
	MR2	2430	π/2-QPSK	1	LPDC(672,504)	0.75
	MR3	2835	π/2-QPSK	1	LDPC(672,588)	0.875
	MR4	3024	π/2-QPSK	1	LDPC(1440,1344)	0.933
	MR5	3036.7	π/2-QPSK	1	RS(255,239)	0.937
Class3	HR1	4555.1	π/2–Star 8QAM	1	RS(255,239)	0.937
	HR2	6073.4	π/2-16QAM	1	RS(255,239)	0.937

12.2.1.1.1 Optional Low Complexity Modes

Besides the MCS classes in 12.2.1.1, low complexity and low power consumption MCS are important especially for SC applications. This sub-clause describes such MCS although they are part of the child piconet concept. OOK and DAMI may be employed for these applications. All OOK/DAMI PNC-capable devices shall be able to transmit and receive Common Mode signals, and shall conduct beaconing and transmit/receive in CP in Common Mode. Then, the OOK/DAMI PNC-capable DEVs may use respective MCS-formatted signals in CTA to create child piconet as stated in 8.2.5, with respective non-PNC capable devices. The MCS dependant parameters for OOK/DAMI shall be set according to Table 101.

12.2.1.1.1.1 Modulation and Coding for Optional Low Complexity Modes

The summary of the MCS for OOK and DAMI is given in Table 101. For PNC-capable devices, Common Mode with π/2-BPSK and RS(255,239) shall be supported to enable interoperability with SC devices. These PNC-capable devices may then create child piconet for respective non-PNC capable devices by using respective MCS-formatted signals. For OOK non-PNC-capable devices, OOK modulation and RS(255,239) is used. For DAMI non-PNC-capable devices, DAMI modulation and RS(255,239) is used. More information is given in the following sub-clauses and Annex D3.

12.2.1.1.1.1.1 OOK

OOK modulation uses variable amplitudes to represent the data, as shown in figure 189(a).

12.2.1.1.1.1.2 DAMI

DAMI modulation is shown in figure 189(b). The transmitted RF signal for a DAMI system is a single-sideband (SSB) modulated signal accompanied by two low-power pilot tones.

12.2.1.1.1.1.3 FEC

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

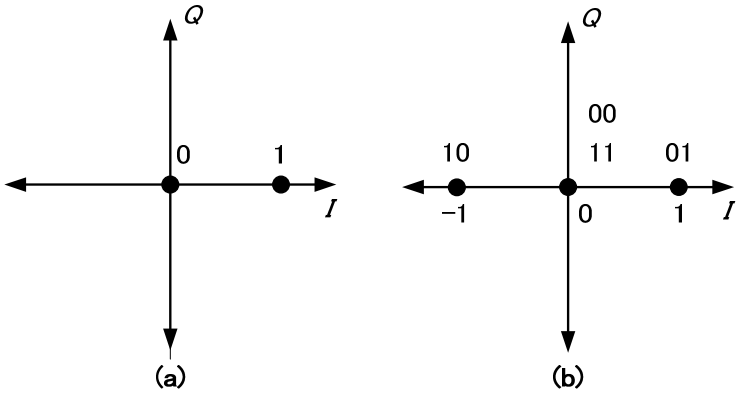

Figure 189 Constellation Diagram for (a) OOK and (b) DAMI

Table 101 MCS Dependant Parameters

Device Type	**MCS identifier**	**PHY-SAP (Mbps)**	**Modulation scheme**	**Spreading factor**	**FEC type**	**FEC rate**	**Support for Common Mode**
PNC capable devices	OOK	50.6	π/2-BPSK/ (G)MSK	32	RS(255,239)	0.937	Mandatory
	DAMI	50.6	π/2-BPSK/ (G)MSK	32	RS(255,239)	0.937	Mandatory
Non-PNC capable devices	OOK	759.2	OOK	2	RS(255,239)	0.937	Not mandatory
		1518.4		1			
	DAMI	3036	DAMI	1	RS(255,239)	0.937	Not mandatory

Annex D3

(Informative)

Optional Low Complexity Modes for millimeter-wave PHY

D3.1 Introduction

OOK and DAMI may be employed optionally for simple applications that require low complexity and low power consumption. The following sub-clauses discuss the MCS parameters of OOK/DAMI, and their operation descriptions in the child piconet.

D3.2 Modulation, Coding and Spreading

D3.2.1 OOK

The OOK modulation uses variable amplitudes to represent the data. As shown in Figure 189(a), OOK is 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 is$\sqrt{2}$.

D3.2.2 DAMI

In DAMI modulation scheme as shown in Figure 189(b), the coded binary serial input data, $b[k]$, where k = 0, 1, 2,…, shall be first precoded to form an intermediate data, b[k] , defined as follows:

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

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

$$d[k] = K_{mod}(I[k] + jQ[k])$$

where $I[k]$ and $Q[k]$ are given by Table D3.1. The resulting constellation is illustrated in figure 189(b). The normalization factor K_{mod} is $\sqrt{\mathbf{2}}$.

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:

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

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:

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

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 +-1dB tolerance) below the integrated power of the SSB signal.

Table D3.1 DAMI Encoding Table

Precoded input bits, b[k-2]b[k]	***I*[*k*]**	***Q*[*k*]**
00	0	0
01	1	
10	-1	
11	0	

D3.2.3 Forward Error Correction

The forward error correction scheme for OOK and DAMI can be referred to 12.2.2.

D3.2.4 Code Repetition

The spreading scheme for OOK is by LFSR code repetition of 2. For the code repetition, each bit is repeated twice similar to conventional spreading.

D3.3 PHY Preamble

For non-PNC capable DEVs, the preamble for OOK is modulated in OOK waveform with spreading factor of 2 in code repetition. The preamble for DAMI is modulated with DAMI waveform.

D3.2 PHY frame format

For non-PNC capable DEVs, the OOK frame header and pilot word are modulated in OOK waveform with spreading factor of 2 in code repetition. The DAMI frame header and pilot word are modulated in DAMI waveform.

D3.3 OOK/DAMI Child Piconet Operation

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

If an OOK/DAMI PNC-capable device does not detect any SC piconets and is starting a new piconet, the OOK/DAMI PNC-capable device shall first start an SC piconet by using Common Mode, and then create an OOK/DAMI child piconet to support respective non-PNC-capable OOK/DAMI devices.