IEEE P802.11
Wireless LANs

|  |
| --- |
| TGbb:Proposed text for 11bb mandatory and optional LC HE PHY modes |
| Date: 2020-04-03 |
| Author(s): |
| Name | Affiliation | Address | Phone | Email |
| Nikola Serafimovski | pureLiFi |  |  | nikola.serafimovski@purelifi.com  |
| Stephan Berner |  |  | stephan.berner@purelifi.com  |
| Chong Han |  |  | chong.han@purelifi.com |
| Ardimas Purwita | University of Edinburgh |  |  | a.purwita@ed.ac.uk |
| Harald Haas | University of Edinburgh |  |  | h.haas@ed.ac.uk  |

Abstract

This document provides text to be incorporated in the 11bb draft for the common and LC HE PHY modes.

Table of Contents

[Table of Contents 2](#_Toc38360682)

[1 LC PHY 2](#_Toc38360683)

[1.1 Introduction 2](#_Toc38360684)

[1.2 LC Common Mode 2](#_Toc38360685)

[1.2.1 Introduction 2](#_Toc38360686)

[1.2.2 OFDM Mode specific service parameter list 2](#_Toc38360687)

[1.2.3 OFDM Mode 2](#_Toc38360688)

[1.2.4 OFDM PLME 5](#_Toc38360689)

[1.3 LC High Efficiency (HE) Mode 5](#_Toc38360690)

[1.3.1 Introduction 5](#_Toc38360691)

[1.3.2 LC HE PHY service interface 5](#_Toc38360692)

[1.3.3 LC HE PHY 6](#_Toc38360693)

[1.3.4 LC PHY PLME 8](#_Toc38360694)

# 1 LC PHY

## 1.1 Introduction

This clause defines the light communications (LC) PHY. There are three versions of the LC PHY, the LC common-mode (CM) PHY, as well as two options, i.e. the LC High Efficiency (HE) PHY and the LC-optimized (LCO) PHY. The LC PHY is based on intensity modulation and direct detection (IM/DD) and modulation covers the frequency range of near DC up to a few hundred MHz, see the respective sections about channelization for details.

## 1.2 LC Common Mode

### 1.2.1 Introduction

The LC common mode PHY is based on the OFDM PHY in 17. In the following, the differences to the OFDM PHY in clause 17 are described.

### 1.2.2 OFDM Mode-specific service parameter list

TXVECTOR is the same as in section 17.2.2.

RXVECTOR is the same as in section 17.2.3, except that the parameters RX\_ANTENNA, CH\_BANDWIDTH \_IN\_NON\_HT and DYN\_BANDWIDTH \_IN\_NON\_HT are not used.

### 1.3 OFDM PHY

#### 1.2.3.1 Introduction

The OFDM PHY shall be the same as in section 17.3 except for the data scrambling which is described in section 1.2.3.5.5 and the OFDM modulation, which is described in 1.2.3.8.

#### 1.2.3.2 PPDU format

The PPDU format shall be the same as in section 17.3.2.

#### 1.2.3.3 PHY preamble (SYNC)

This shall be the same as in section 17.3.3.

#### 1.2.3.4 SIGNAL field

This shall be the same as in section 17.3.4.

#### 1.2.3.5 DATA field

##### 1.2.3.5.1 General

The data field shall be the same as in section 17.3.5 2 except for the scrambler seed (described in section 1.2.3.5.5) and the OFDM modulation (described in section 1.2.3.8)

##### 1.2.3.5.2 SERVICE field

This shall be the same as in section 17.3.5.2.

##### 1.2.3.5.3 PPDU TAIL field

This shall be the same as in section 17.3.5.3.

##### 1.2.3.5.4 Pad bits (PAD)

This shall be the same as in section 17.3.5.4.

##### 1.2.3.5.5 PHY DATA scrambler and descrambler

Unlike the text in section 17.3.5.5, the scrambler seed shall be initialized with a pseudorandom nonzero value. It shall not convey any information.

##### 1.2.3.5.6 Convolutional encoder

This shall be the same as in section 17.3.5.6.

##### 1.2.3.5.7 Data interleaving

This shall be the same as in section 17.3.5.7.

##### 1.2.3.5.8 Subcarrier modulation mapping

This shall be the same as in section 17.3.5.8.

##### 1.2.3.5.9 Pilot subcarriers

This shall be the same as in section 17.3.5.9.

##### 1.2.3.5.10 OFDM modulation

This shall be the same as in section 17.3.6.10.

#### 1.2.3.6 CCA

This shall be the same as in section 17.3.6.

#### 1.2.3.7 PHY data modulation and modulation rate change

This shall be the same as in section 17.3.7.6.

#### 1.2.3.8 Light Interface

Figure 1 illustrates how a light emitting diode (LED) is connected to the TX OFDM PHY and a photo diode (PD) to the RX OFDM PHY.



Figure 1: Interfacing OFDM PHY to light emitter and receiver

In the TX chain, the I and Q samples from the baseband shall be quadrature modulated, see 1.2.3.9.4 Operating channel frequencies for center frequencies. A DC bias is added before the signal is fed to the LED because the current through a diode can only be positive as illustrated in Figure 2.



Figure 2: Operation of LED with DC bias

In the RX chain, the light variations produced by the LED are converted into a current by a photo diode (PD) and amplified by a transimpedance amplifier (TIA). The DC component is removed, the signal shall be downconverted to baseband and fed to the RX OFDM PHY.

The light communications transmitter and receiver shall operate at a wavelength between 800 nm and 1000 nm.

#### 1.2.3.9 PHY operating specifications (general)

##### 1.2.3.9.1 General

The operating specifications shall be the same as in section 17.3.8 except for the regulatory requirements and operating frequencies.

##### 1.2.3.9.2 Outline description

The outline shall be the same as in section 17.3.8.2. In Figure 17-12 the antennas have to replaced by optical frontends (OFE)s, for example as described in document IEEE 802.11-19/0087r1.

##### 1.2.3.9.3 Regulatory requirements

The IEC 60825-1 laser eye safety regulations shall apply to all LC devices.

##### 1.2.3.9.4 Operating channel frequencies

The LC PHY with mandatory features operates at a center frequency of XX MHz or at an alternative center frequency of XX MHz. The common bandwidth shall be 20 MHz. These two center frequencies shall correspond to LC channel 0 and LC channel 1.

##### 1.2.3.9.5 Transmit and receive in-band and out-of-band spurious emissions

This does not apply to any LC PHY Mode

##### 1.2.3.9.6 Slot time

This shall be the same as in section 17.3.8.6.

##### 1.2.3.9.7 Transmit and receive impedance at the antenna connector

This shall be the same as in section 17.3.8.7.

#### 1.2.3.10 PHY transmit specifications

This shall be the shall be the same as in section 17.3.9.

#### 1.2.3.11 PHY receiver specifications

This shall be the same as in section 17.3.10.

#### 1.2.3.12 Transmit PHY

This shall be the same as in section 17.3.11.

#### 1.2.3.13 Receive PHY

This shall be the same as in section 17.3.12.

### 1.2.4 OFDM PLME

This shall be the same as in section 17.4, except that the parameter “dot11RegDomainsImplementedValue” in Table 17.20 does not apply to the LC Common Mode.

## 1.3 LC High Efficiency (HE) Mode

### 1.3.1 Introduction

The LC HE Mode is based on the HE PHY in Clause 27. In the following, the differences to the HE PHY in clause 27 are described.

### 1.3.2 LC HE PHY service interface

The LC HE PHY service interface shall be the same as in 27.2 except for the following fields which shall be set to zero,

1. BEAMFORMED
2. BEAM\_CHANGE

because beamforming is not supported.

### 1.3.3 LC HE PHY

#### 1.3.3.1 Introduction

This subclause describes the differences to the subclause 27.3.

#### 1.3.3.2 Subcarrier and resource allocation

This section shall be the same as section 27.3.2.

#### 1.3.3.3 MU-MIMO

This section shall be the same as section 27.3.3.

#### 1.3.3.4 LC PPDU formats

This section shall be the same as section 27.3.4.

#### 1.3.3.5 Transmitter block diagram

This section shall be the same as section 27.3.5.

#### 1.3.3.6 Overview of the PPDU encoding process

This section shall be the same as section 27.3.6.

#### 1.3.3.7 LC modulation and coding schemes (HE-MCSs)

This section shall be the same as section 27.3.7.

#### 1.3.3.8 LC-SIG-B modulation and coding schemes (HE-SIG-B-MCSs)

This section shall be the same as section 27.3.8.

#### 1.3.3.9 Timing-related parameters

This section shall be the same as section 27.3.9.

#### 1.3.3.10 Mathematical description of signals

This section shall be the same as section 27.3.10.

#### 1.3.3.11 LC HE preamble

This section is the same as section 27.3.11.

#### 1.3.3.12 Data field

This section shall be the same as section 27.3.12.

#### 1.3.3.13 Packet extension

This section shall be the same as section 27.3.13.

#### 1.3.3.14 Non-HT duplicate transmission

This section shall be the same as section 27.3.14.

#### 1.3.3.15 Transmit requirements for PPDUs sent in response to a triggering frame

This section shall be the same as section 27.3.15.

#### 1.3.3.16 SU-MIMO and DL MU-MIMO beamforming

Beamforming shall be not supported for LC. Therefore, this section does not apply to the LC HE Mode.

#### 1.3.3.17 LC sounding NDP

This section shall be the same as section 27.3.17.

#### 1.3.3.18 LC TB feedback NDP

This section shall be the same as section 27.3.18.

#### 1.3.3.19 Transmit specification

This section shall be the same as section 27.3.19.

#### 1.3.3.20 Receiver specification

This section shall be the same as section 27.3.20.

#### 1.3.3.21 LC transmit procedure

This section shall be the same as section 27.3.21.

#### 1.3.3.22 LC receive procedure

This section shall be the same as section 27.3.22.

#### 1.3.3.23 Light Interface

##### 1.3.3.23.1 Introduction

The light interface shall be an extension of the light interface described in 1.2.3.8 Light Interface to multiple TX and RX streams.

##### 1.3.3.23.2 Multiple transmitters and receivers

Figure 3 shows multiple LEDs connected to the TX baseband and Figure 4 shows multiple PDs connected to the RX baseband.

The LEDs may all operate at the same wavelength or at different wavelengths.

The TX baseband outputs shall be all quadrature modulated to the same common center frequency, see 1.3.3.24.1 Case of multiple transmitters and receivers for details.



Figure 3: Connecting multiple LEDs to TX baseband



Figure 4: Connecting multiple PDs to RX baseband

#### 1.3.3.24 Channel numbering

##### 1.3.3.24.1 Case of multiple transmitters and receivers

In this case the setup described in 1.3.3.23.2 Multiple transmitters and receivers shall be used. The center frequencies depending on the CBW are shown in Table 1.

Table 1: Modulation frequencies

|  |  |
| --- | --- |
| PHY channel BW | Modulator LO |
| 20 MHz | XX MHz |
| 40 MHz | XX MHz |
| 80 MHz | XX MHz |
| 160 MHz | XX MHz |
| 320 MHz | XXX MHz |

#### 1.3.3.25 Regulatory Requirements

The IEC 60825-1 laser eye safety regulations shall apply to all LC devices.

### 1.3.4 LC PHY PLME

Two new values for the PHY MIB attribute “dot11PHYType” shall be introduced, LC1 and LC2. LC1 indicates an LC PHY with the light interface described in1.3.3.23.2 Multiple transmitters and receivers, LC2 shall be reserved for a different light interface to be defined in the future.