MULTIBAND OFDM
PHYSICAL LAYER SPECIFICATION

Making High-Speed Wireless A Reality ...

PHY SPECIFICATION: FINAL DELIVERABLE 1.5
AUGUST 11, 2009

WiMedia Limited Copyright License Agreement

By receiving, installing, copying, reviewing or otherwise using the WiMedia OFDM Physical Layer Specification (the "***Specification***"), you (the "***Specification Recipient***") agree to the terms and conditions of this WiMedia Limited Copyright License Agreement (the "***Agreement***") by and between the WiMedia Alliance, Inc. ("***WiMedia***") and Specification Recipient.

NO WIMEDIA PROMOTER, CONTRIBUTOR OR ADOPTER MEMBER SHALL BE BOUND TO THE TERMS OR CONDITIONS OF THIS AGREEMENT WHILE IT IS A PROMOTER, CONTRIBUTOR OR ADOPTER MEMBER. THIS AGREEMENT DOES BIND ALL WIMEDIA SUPPORTER MEMBERS AND NON-MEMBERS.

1. The Specification. "***Specification***" shall mean this WiMedia OFDM Physical Layer Specification document. WiMedia reserves the right to change the Specification at any time without notice to Specification Recipient.

2. Limited Copyright Grant. Provided Specification Recipient complies with all terms and conditions of this Agreement, WiMedia grants Specification Recipient a non-exclusive, revocable, temporary, royalty-free, personal copyright license to copy, display and distribute the Specification.

3. Other Restrictions. Specification Recipient shall not disclose the Specification without prominently displaying the terms of this Agreement with the Specification and binding each recipient to the terms of this Agreement.

4. Ownership of the Specification. All title and intellectual property in and to the Specification are owned by WiMedia and its licensor(s), if any.

5. Termination. This Agreement and any and all rights hereunder may be terminated by WiMedia upon notice for any reason or no reason at all. Upon termination of this Agreement, Specification Recipient shall immediately cease any and all use of the Specification and destroy all copies of the Specification within its control.

6. No Warranties. SPECIFICATION RECIPIENT ACKNOWLEDGES AND AGREES THAT THE SPECIFICATION IS PROVIDED "AS IS" AND WITH NO WARRANTIES WHATSOEVER, WHETHER EXPRESS, IMPLIED OR STATUTORY, INCLUDING, BUT NOT LIMITED TO ANY WARRANTY OF MERCHANTABILITY, NONINFRINGEMENT, TITLE, FITNESS OF ANY PARTICULAR PURPOSE, OR ANY WARRANTY OTHERWISE ARISING OUT OF THE SPECIFICATION AND/OR THIS AGREEMENT. THE SPECIFICATION RECIPIENT'S USE OF THE SPECIFICATION IS SOLELY AT THE SPECIFICATION RECIPIENT'S OWN RISK.

7. Limitation of Liability. IN NO EVENT SHALL WIMEDIA OR ANY WIMEDIA MEMBER BE LIABLE OR OBLIGATED TO THE SPECIFICATION RECIPIENT OR ANY THIRD PARTY IN ANY MANNER FOR ANY DIRECT, SPECIAL, NON-COMPENSATORY, CONSEQUENTIAL, INDIRECT, INCIDENTAL,

STATUTORY OR PUNITIVE DAMAGES OF ANY KIND, INCLUDING, WITHOUT LIMITATION, LOST PROFITS AND LOST REVENUE, REGARDLESS OF THE FORM OF ACTION, WHETHER IN CONTRACT, TORT, NEGLIGENCE, STRICT PRODUCT LIABILITY, OR OTHERWISE, EVEN IF WIMEDIA OR ANY WIMEDIA MEMBER HAS BEEN INFORMED OF OR IS AWARE OF THE POSSIBILITY OF ANY SUCH DAMAGES IN ADVANCE.

THE LIMITATIONS SET FORTH ABOVE SHALL BE DEEMED TO APPLY TO THE MAXIMUM EXTENT PERMITTED BY APPLICABLE LAW AND NOTWITHSTANDING THE FAILURE OF THE ESSENTIAL PURPOSE OF ANY LIMITED REMEDIES AVAILABLE TO THE SPECIFICATION RECIPIENT. THE SPECIFICATION RECIPIENT ACKNOWLEDGES AND AGREES THAT THE SPECIFICATION RECIPIENT HAS FULLY CONSIDERED THE FOREGOING ALLOCATION OF RISK AND FINDS IT REASONABLE, AND THAT THE FOREGOING LIMITATIONS ARE AN ESSENTIAL BASIS OF WIMEDIA AND THE WIMEDIA MEMBERS PERMITTING ACCESS TO THE SPECIFICATION. SPECIFICATION RECIPIENT FURTHER ACKNOWLEDGES AND AGREES THAT WIMEDIA AND THE WIMEDIA MEMBERS WOULD NOT HAVE PROVIDED THE SPECIFICATION RECIPIENT WITH ACCESS TO THE SPECIFICATION UNLESS THE SPECIFICATION RECIPIENT FULLY AGREED TO THE LIMITATIONS SET FORTH ABOVE. SPECIFICATION RECIPIENTS' SOLE AND EXCLUSIVE REMEDIES AND EXCLUSIVE LIABILITIES ARE SET FORTH IN THIS AGREEMENT.

8. Third Party Rights. Certain elements of the Specification may be subject to third party intellectual property rights, including without limitation, patent, trademark and copyright rights. WiMedia is not responsible and shall not be held responsible in any manner for identifying or failing to identify any or all such third party intellectual property rights.

9. Non-Applicability to Certain WiMedia Members. Notwithstanding anything to the contrary in this Agreement, no WiMedia promoter, contributor or adopter member shall be bound to the terms or conditions of this Agreement while it is a member of WiMedia. This Agreement does bind all WiMedia supporter members and non-members.

10. General. If any provision of this Agreement is found by a court of competent jurisdiction to be invalid or unenforceable, such invalidity or unenforceability shall not invalidate or render unenforceable any other part of this Agreement, but this Agreement shall be construed as not containing the particular provision or provisions held to be invalid or unenforceable. No delay or omission by either party to exercise any right occurring upon any noncompliance or default by the other party with respect to any of the terms of this Agreement shall impair any such right or power or be construed to be a waiver thereof. A waiver by either of the parties hereto of any of the covenants, conditions or agreements to be performed by the other shall not be construed to be a waiver of any succeeding breach thereof or of any covenant, condition or agreement herein contained. Nothing set forth in this Agreement shall be deemed or construed to render the parties as joint venturers, partners or employer and employee. This Agreement, together with any documents referenced herein, sets forth the entire, final and exclusive agreement between the parties as to the subject matter hereof and supersedes all prior and contemporaneous agreements, understandings, negotiations and discussions, whether oral or written, between the parties; provided, however, that a WiMedia promoter, contributor or adopter member shall not be bound to the terms of this Agreement while it is a promoter, contributor or adopter member of WiMedia. This Agreement may be modified only pursuant to a writing executed by authorized representatives of WiMedia and Specification Recipient. This Agreement, and all the rights and duties of the parties arising from or relating in any way to the subject matter of this Agreement or the transaction(s) contemplated by it, shall be governed by, construed and enforced in accordance with the laws of the State of California (excluding any conflict of laws provisions of the State of California that would refer to and apply the substantive laws of another jurisdiction). **SPECIFICATION RECIPIENT CONSENTS TO THE EXCLUSIVE PERSONAL JURISDICTION OF THE FEDERAL AND STATE COURTS AND VENUE LOCATED IN SAN FRANCISCO, CALIFORNIA.**

11. Trademarks. WiMedia is a registered trademark or service mark of the WiMedia Alliance, Inc. in the US and other countries. All other trademarks, registered trademarks, or service marks used in this document are the property of their respective owners and are hereby recognized. Specification Recipient shall not have any rights to reproduce WiMedia's trademarks or service marks except with WiMedia's prior written consent.

Chair:	Charles Razzell, ST Ericsson
Vice Chair:	Sorin Goldenberg, Wisair
Technical Editor:	William Stoye, Staccato Communications

AUTHORS

William Abbott	Texas Instruments
Abu Amanullah	Olympus
Roberto Aiello	Staccato Communications
Anand Anandakumar	Jaalaa
Naiel Askar	General Atomics
Yehuda Azenkot	Texas Instruments
Ramesh Babu	Alereon
Jaiganesh Balakrishnan	Texas Instruments
Anuj Batra	Texas Instruments
Nathan Belk	Texas Instruments
Friedbert Berens	ST Microelectronics
Paul Berg	MCCI
Roger Bertschmann	SiWorks
Dagnachew Birru	Philips
Ken Boehlke	Focus Enhancements
Leo Bogod	Nokia
Png Khiam Boon	Institute for Infocomm Research
Chuck Brabenac	Intel
Miguel Bravo-Escos	CSR
Vern Brethour	Alereon
Stephan ten Brink	Realtek Semiconductor
Nick Carboni	Staccato Communications
Bill Carney	WiQuest Communications
Sujai Chari	Tzero
Jonathon Cheah	Femto Devices
Francois Chin	Institute for Infocomm Research
Sean Coffey	Realtek Semiconductor
Anand Dabak	Texas Instruments
Joe Decuir	MCCI
Shahriar Emami	Focus Enhancements
Yossi Erlich	Infineon
Valerio Filauro	Focus Enhancements
Eran Fishler	Infineon

Jeff Foerster	Intel
Paul Fontaine	Texas Instruments
Cathy French	Sigma Designs
Vasanth Gaddam	Philips
Miki Genossar	Adimos
Ranjit Gharurey	University of Michigan
Manish Goel	Texas Instruments
Sorin Goldenberg	Wisair
Danielle Griffith	Texas Instruments
Assaf Gurevitz	Infineon
Chris Hansen	Broadcom
Ghobad Heidari	Olympus
Yamaguchi Hirohisa	Texas Instruments
Jin-Meng Ho	Texas Instruments
Dale Hocevar	Texas Instrements
Eyal Hochdorf	Infineon
Srinath Hosur	Texas Instruments
Bob Huang	Sony
Osamu Inagawa	NEC Electronics
Mihai Ionescu	Olympus
Brian Joseph	WiQuest Communications
Daryl Kaiser	Tzero
Joy Kelly	Alereon
HaeSik Kim	Samsung Advanced Institute of Technology
YongSuk Kim	Samsung Advanced Institute of Technology
Miguel Kirsch	ST Microelectronics
Noam Kogos	Adimos
Rajeev Krishnamoorthy	Tzero
Nishant Kumar	Staccato Communications
Haim Kupershmidt	Wisair
Do-Hoon Kwon	Samsung Advanced Institute of Technology
Jim Lansford	Alereon
Torbjorn Larsson	Staccato Communications
Joe Lauer	Broadcom
Simon Lee	Texas Instruments
David Leeper	Intel
Jerry Lin	Texas Instruments
Mau-Lin Wu	Faraday Technology Corporation
Susan Lin	General Atomics
Srinivas Lingam	Texas Instruments
Moti Litochevsky	Infineon
Simon Litsyn	Wisair
Steve Lo	Tzero
Ron Lu	Sigma Designs
Mike Lynch	Synopsys
Ian Macnamara	Nokia
David Magee	Texas Instruments

Ravishankar Mahadevappa	Realtek Semiconductor
Sanjay Mani	Tzero
Tom Matheney	Alereon
Dan Meacham	Staccato Communications
Alireza Mehrnia	WiLinx
Suzuki Mitsuhiro	Sony
Shaomin Mo	Panasonic
Takuji Mochizuki	NEC Electronics
Andreas F. Molisch	Mitsubishi Electric Research Laboratories
Lars Mucke	Staccato Communications
Yves-Paul Nakache	Mitsubishi Electric Research Laboratories
Nadege Noisette	France Telecom
Hideo Ohba	NEC Electronics
Eric Ojard	Broadcom
Philip Orlik	Mitsubishi Electric Research Laboratories
SeungYoung Park	Samsung Advanced Institute of Technology
Shrenik Patel	Alereon
Christian Politano	ST Microelectronics
Sridhar Rajagopal	WiQuest Communications
Pekka Ranta	Nokia
Yaron Rashi	Infineon
Charles Razzell	ST Ericsson
Rick Roberts	Intel
Jaeho Roh	Samsung Advanced Institute of Technology
JuneChul Roh	Texas Instruments
Alan Roth	Alereon
Tony Rouphael	Alereon
Ebrahim Saberinia	University of Nevada, Las Vegas
Tomoki Saito	Intel
Yasufumi Sasaki	NEC Electronics
Takahiro Sato	NEC Electronics
Andreas Schmitt	Infineon
Adam Schwartz	TZero
Assaf Sella	Wisair
Eran Sharon	Wisair
Kevin Shelby	Alereon
Siddharth Shetty	Staccato Communications
Matthew Shoemake	WiQuest Communications
Gadi Shor	Wisair
Manoneet Singh	Texas Instruments
Srinivasa Somayazulu	Intel
William Stoye	Staccato Communications
Robert Sutton	TDK R&D
Jim Svoboda	Focus Enhancements
Kazuhisa Takamura	Sony
Nir Tal	Texas Instruments
Jun Tang	University of Minnesota

Jarvis Tao	Kalon Semiconductors
Larry Taylor	Staccato Communications
Ahmed Tewfik	University of Minnesota
Takashi Usui	Sony
Dong Wang	Philips
Sai Ho Wong	Institute for Infocomm Research
Peng Xiaoming	Institute for Infocomm Research
Hirohisa Yamaguchi	Texas Instruments
Jun Yang	Philips
Jin Zhang	Mitsubishi Electric Research Laboratories
Rui Zhang	NXP Semiconductors
Lin Zhiwei	Institute for Infocomm Research
Anat Zilber	Adimos

Page Intentionally Left Blank.

TABLE OF CONTENTS

Page Intentionally Left Blank.

LIST OF FIGURES

LIST OF TABLES

1. INTRODUCTION

This standard specifies an ultra wideband (UWB) physical layer (PHY) for a wireless personal area network (PAN), utilizing the unlicensed 3100 - 10600 MHz frequency band, supporting data rates of 53.3, 80, 106.7, 160, 200, 320, 400, 480, 640, 800, 960 and 1024 Mb/s. Support for transmitting and receiving data rates of 53.3, 106.7, and 200 Mb/s using the convolutional code shall be mandatory. For each of the rates 160, 200, 320, 400 and 480, if LDPC coding is provided then convolutional coding should also be provided.

The UWB spectrum is divided into 14 bands, each with a bandwidth of 528 MHz. The first 12 bands are then grouped into 4 band groups consisting of 3 bands. The last two bands are grouped into a fifth band group. A sixth band group is also defined within the spectrum of the first four, consistent with usage within worldwide spectrum regulations. At least one of the band groups (BG1 - BG6) shall be implemented.

This standard specifies a MultiBand Orthogonal Frequency Division Modulation (MB-OFDM) scheme to transmit information. A total of 110 sub-carriers (100 data carriers and 10 guard carriers) are used per band to transmit the information. In addition, 12 pilot subcarriers allow for coherent detection. Frequency-domain spreading, time-domain spreading, modulation and forward error correction (FEC) coding are used to vary the data rates.

The coded data is spread using a time-frequency code (TFC). This standard specifies three types of time-frequency codes (TFCs): one where the coded information is interleaved over three bands, referred to as Time-Frequency Interleaving (TFI); one where the coded information is interleaved over two bands, referred to as two-band TFI or TFI2; and one where the coded information is transmitted on a single band, referred to as Fixed Frequency Interleaving (FFI). Support for TFI, TFI2 and FFI shall be mandatory.

Within the first four and the sixth band groups, four time-frequency codes using TFI and three time-frequency codes using each of TFI2 and FFI are defined; thereby, providing support for up to ten channels in each band group. For the fifth band group, two time-frequency codes using FFI and one using TFI2 are defined. For the sixth band group, the FFI channels and one of the TFI2 channels overlap fully with channels in the third and fourth band groups. Not all channels are designed to be mutually orthogonal.

A mechanism is provided to allow individual OFDM subcarriers to be nulled. This, together with the choice of frequency bands and of TFI, TFI2 and FFI time frequency codes, provides substantial control over the use of spectrum by the transmitted signal, allowing the PHY to be used in a range of regulatory and radio coexistence scenarios.

2. NOTATIONAL CONVENTIONS

The use of the word *shall* is meant to indicate a requirement which is mandated by the standard, i.e. it is required to support that particular feature with no deviation in order to conform to the standard. The use of the word *should* is meant to recommend one particular course of action over several other possibilities, however without mentioning or excluding these others. The use of the word *may* is meant to indicate that a particular course of action is permitted. The use of the word *can* is synonymous with is able to – it is meant to indicate a capability or a possibility.

All floating-point values have been rounded to 4 decimal places.

3. ABBREVIATIONS AND ACRONYMS

BER	Bit Error Rate
BM	Burst Mode
CC	Convolutional Code
CCA	Clear Channel Assessment
CPE	Common Phase Error
CRC	Cyclic Redundancy Check
DAC	Digital-to-Analog Converter
DCM	Dual Carrier Modulation
EIRP	Equivalent Isotropically Radiated Power
FCS	Frame Check Sequence
FDS	Frequency-Domain Spreading
FEC	Forward Error Correction
FER	Frame Error Rate
FFI	Fixed-Frequency Interleaving
FFT	Fast Fourier Transform
GF	Galois Field
HCS	Header Check Sequence
IDFT	Inverse Discrete Fourier Transform
IFFT	Inverse Fast Fourier Transform
LDPC	Low Density Parity Check
LSB	Least Significant Bit
LQI	Link Quality Indicator
MAC	Medium Access Control
MDCM	Modified Dual Carrier Modulation
MIB	Management Information Base
MIFS	Minimum Interframe Spacing
MLME	MAC Layer Management Entity
MMDU	MAC Management Protocol Data Unit
MPDU	MAC Protocol Data Unit
MSB	Most Significant Bit
OFDM	Orthogonal Frequency Division Multiplexing
PAN	Personal Area Network
PAL	Protocol Adaptation Layer
PER	Packet Error Rate

PDU	Protocol Data Unit
PHY	Physical (layer)
PHY-SAP	Physical Layer Service Access Point
PLCP	Physical Layer Convergence Protocol
PLME	Physical Layer Management Entity
PMD	Physical Medium Dependent
PMD-SAP	Physical Medium Dependent-Service Access Point
PPDU	PLCP Protocol Data Unit
PPM	Parts per Million
PRBS	Pseudo-Random Binary Sequence
PSD	Power Spectral Density
PSDU	PLCP Service Data Unit
PT	Preamble Type
QPSK	Quadrature Phase Shift Keying
RF	Radio Frequency
RMS error	root mean squared error
RS	Reed-Solomon
RSSI	Received Signal Strength Indicator
RX	Receive or Receiver
SAP	Service Access Point
SDU	Service Data Unit
SIFS	Short Interframe Spacing
SME	Station Management Entity
TDS	Time-Domain Spreading
TF	Time-Frequency
TFC	Time-Frequency Code
TFI	Time-Frequency Interleaving
TFI2	Time-Frequency Interleaving over 2 bands
TX	Transmit or Transmitter
UWB	Ultra Wideband
WPAN	Wireless Personal Area Network
ZPS	Zero Padded Suffix

4. PHY LAYER PARTITIONING

This subsection describes the PHY services provided to the MAC. The PHY layer consists of two protocol functions:

1. A PHY convergence function, which adapts the capabilities of the physical medium dependent (PMD) device to the PHY service. This function is supported by the physical layer convergence protocol (PLCP), which defines a method of mapping the PLCP service data units (PSDU) into a framing format suitable for sending and receiving user data and management information between two or more stations using the associated PMD device.
2. A PMD device whose function defines the characteristics and method of transmitting and receiving data through a wireless medium between two or more stations, each using the PHY.

4.1 PHY Function

The PHY contains three functional entities: the PMD function, the PHY convergence function, and the layer management function. The PHY service is provided to the MAC through the PHY service primitives.

4.2 PLCP Sublayer

In order to allow the MAC to operate with minimum dependence on the PMD sublayer, the PHY convergence sublayer is defined. This function simplifies the PHY service interface to the MAC services.

4.3 PMD Sublayer

The PMD sublayer provides a means to send and receive data between two or more stations.

4.4 PHY Layer Management Entity (PLME)

The PLME performs management of the local PHY functions in conjunction with the MAC management entity.

5. DESCRIPTION OF SIGNAL

5.1 Mathematical Framework

The transmitted RF signal can be written in terms of the complex baseband signal as follows:

$$s_{RF}(t) = \mathrm{Re}\left\{ \sum_{n=0}^{N_{packet}-1} s_n(t - nT_{SYM}) \exp(j2\pi f_c(q(n))t) \right\}, \tag{5-1}$$

where $\mathrm{Re}(\cdot)$ represents the real part of the signal, T_{SYM} is the symbol length, N_{packet} is the number of symbols in the packet, $f_c(m)$ is the center frequency for the m^{th} frequency band, $q(n)$ is a function that maps the n^{th} symbol to the appropriate frequency band and $s_n(t)$ is the complex baseband signal representation for the n^{th} symbol, which must satisfy the following property: $s_n(t) = 0$ for $t \notin [0, T_{SYM})$. The exact structure of the n^{th} symbol depends on its location within the packet:

$$s_n(t) = \begin{cases} s_{sync,n}(t) & 0 \le n < N_{sync} \\ s_{hdr,n-N_{sync}}(t) & N_{sync} \le n < N_{sync} + N_{hdr} \\ s_{frame,n-N_{sync}-N_{hdr}}(t) & N_{sync} + N_{hdr} \le n < N_{packet} \end{cases}, \tag{5-2}$$

where $s_{sync,n}(t)$ describes the n^{th} symbol of the preamble, $s_{hdr,n}(t)$ describes the n^{th} symbol of the header, $s_{frame,n}(t)$ describes the n^{th} symbol of the PSDU, N_{sync} is the number of symbols in the preamble, N_{hdr} is the number of symbols contained in the header and $N_{packet} = N_{frame} + N_{sync} + N_{hdr}$ is the number of symbols in the packet. The exact values of N_{sync}, N_{hdr}, N_{frame}, and N_{packet} will be described in more detail in Section 6.

The potentially complex time-domain signal $s_n(t)$ shall be created by passing the real and imaginary components of the discrete-time signal $s_n[k]$ through digital-to-analog converters (DACs) and anti-alias filters as shown in Fig. 5-1. When the discrete-time signal $s_n[k]$ is real, only the real digital-to-analog converter and anti-aliasing filter need to be used. Section 6 describes how to generate $s_n[k]$.

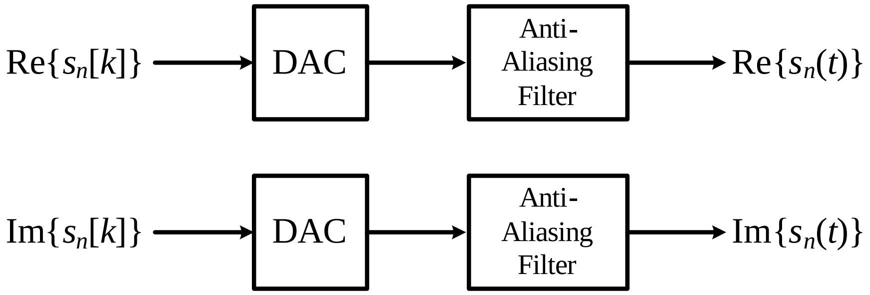

Fig. 5-1. Conversion from discrete-time signals to continuous-time signals

Fig. 5-2 shows one realization of the transmitted RF signal using three frequency bands, where the first symbol is transmitted on a center frequency of 3432 MHz, the second symbol is transmitted on a center frequency of 3960 MHz, the third symbol is transmitted on a center frequency of 4488 MHz, the fourth symbol is transmitted on a center frequency of 3432 MHz and so on. In addition, it is apparent from Fig. 5-2 that the symbol is created by appending a zero-padded suffix (ZPS) to the IFFT output, or equivalently, to the OFDM symbol. The zero-padded suffix serves two purposes: it provides a mechanism to mitigate the effects of multi-path; and, it provides a time window (a guard interval) to allow sufficient time for the transmitter and receiver to switch between the different center frequencies.

A symbol is defined as an OFDM symbol (IFFT output) plus a zero-padded suffix.

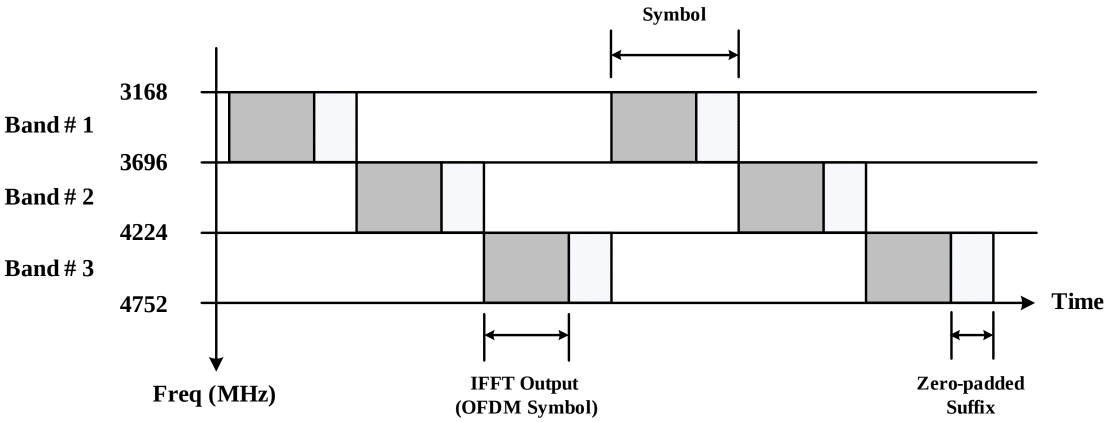

Fig. 5-2. Example realization of a transmitted RF signal using three bands.

5.2 Tone Nulling

In order to support avoidance of other users of the UWB band, the transmitted signal is sent in the context of a configured array TN of 384 tone nulling elements. These correspond to the subcarriers of each band within the current band group, so that TN[0 to 127] apply to the subcarriers of the lowest frequency band in the current band group, TN[128 to 255] to the middle band, and TN[256 to 383] to the highest band, if present. Within each band the TN bits are ordered by the frequency of the corresponding subcarrier, so that the N-th bit corresponds to the carrier at (N-64)*4.125MHz from the center frequency of the band. See Section 7-1 for a description of bands and band groups.

Each tone nulling element can take the value one or zero. If the value is zero, then the transmitter should take steps to minimize the transmitted signal energy at the frequency of the corresponding subcarrier. If the value is one, then the signal is unaffected by tone nulling. No specific reduction in energy for any tone null is specified in this document. Tone nulling is an optional feature. Tone nulling applies to all symbols, including the preamble sequence.

A device shall transmit at least 86 useful tones per band, where useful tones relate to tones containing data, pilot, the preamble or the channel estimation sequence. This limit prevents unacceptable degradation of packet detection performance, and other receive performance. If more tones in a band must be avoided, the entire band cannot be used for transmission. It is expected that the controlling MAC will implement this logic.

A device may null additional tones beyond those specified, for instance to improve or preserve symmetry within the transmitted symbols, subject to the constraint that at least 86 useful tones shall be transmitted per band. If additional tones are nulled then this shall be done consistently throughout the packet.

The simplest possible implementation is to set to zero the corresponding values of IFFT inputs, and to generate the sync symbols through the same IFFT process as other symbols.

6. PLCP SUBLAYER

This clause provides a method for converting a PSDU into a PPDU. During the transmission, the PSDU shall be pre-appended with a PLCP preamble and a PLCP header in order to create the PPDU. At the receiver, the PLCP preamble and PLCP header serve as aids in the demodulation, decoding, and delivery of the PSDU.

6.1 PPDU

Fig. 6-1 shows the format for the PPDU, which is composed of three components: the PLCP preamble, the PLCP header and the PSDU. The components are listed in the order of transmission. The PLCP preamble is the first component of the PPDU and can be further decomposed into a packet/frame synchronization sequence, and a channel estimation sequence (see Section 6.2). The goal of the PLCP preamble is to aid the receiver in timing synchronization, carrier-offset recovery and channel estimation.

The PLCP header is the second component of the PPDU. The goal of this component is to convey necessary information about both the PHY and the MAC to aid in decoding of the PSDU at the receiver. The PLCP header can be further decomposed into a PHY header, MAC header, header check sequence (HCS), tail bits and Reed-Solomon parity bits (see Section 6.3). Tail bits are added between the PHY header and MAC header, HCS and Reed-Solomon parity bits, and at the end of the PLCP header in order to return the convolutional encoder to the "zero state". The Reed-Solomon parity bits are added in order to improve the robustness of the PLCP header.

The PSDU is the last component of the PPDU (see Section 6.4). This component is formed by concatenating the frame payload with the frame check sequence (FCS), tail bits and finally pad bits, which are inserted in order to align the data stream on the boundary of the symbol interleaver. Tail bits only apply for data rates that use CC.

When transmitting the packet, the PLCP preamble is sent first, followed by the PLCP header and finally by the PSDU. The PLCP header is a codeword of a systematic Reed-Solomon code, appended with tail bits as explained above. As shown in Fig. 6-1, the systematic part of the PLCP header is always sent at a data rate of 39.4 Mb/s. The PSDU is sent at the desired data rate of 53.3, 80, 106.7, 160, 200, 320, 400, 480, 640, 800, 960 or 1024 Mb/s.

The least significant bit (LSB) of an octet shall be the first bit transmitted.

6.1.1 PSDU RATE-dependent parameters

The PSDU data rate-dependent modulation parameters are listed in Table 6-1.

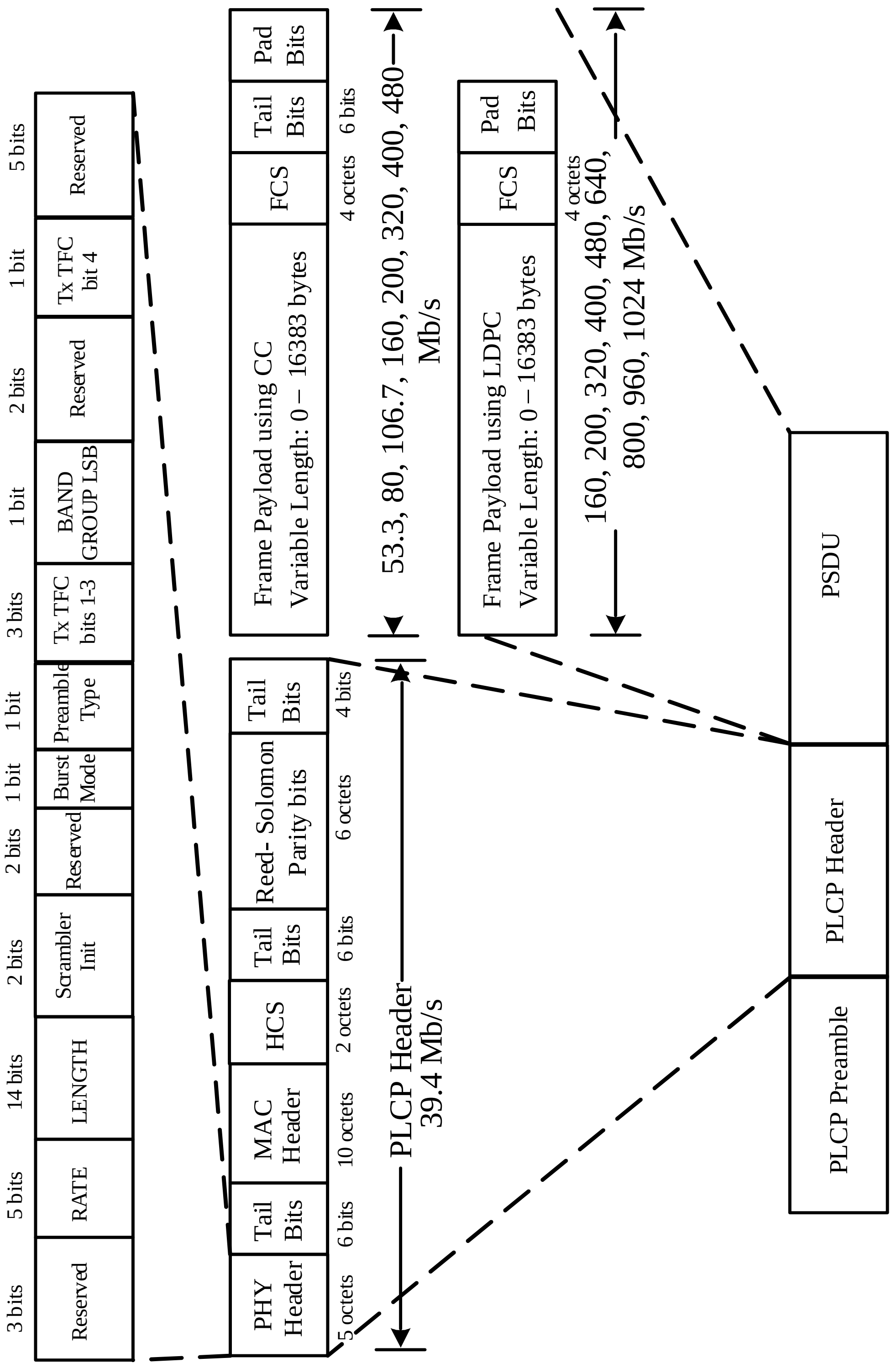

Fig. 6-1. Standard PPDU structure

TABLE 6-1. PSDU rate-dependent parameters

Data Rate (Mb/s)	Modulation	Coding Rate (R)	FDS	TDS	Coded Bits / 6 OFDM Symbol (N_{CBP6S})	Info Bits / 6 OFDM Symbol (N_{IBP6S})
53.3	QPSK	1/3	YES	YES	300	100
80	QPSK	1/2	YES	YES	300	150
106.7	QPSK	1/3	NO	YES	600	200
160	QPSK	1/2	NO	YES	600	300
200	QPSK	5/8	NO	YES	600	375
320	DCM	1/2	NO	NO	1200	600
400	DCM	5/8	NO	NO	1200	750
480	DCM	3/4	NO	NO	1200	900
640	MDCM	1/2	NO	NO	2400	1200
800	MDCM	5/8	NO	NO	2400	1500
960	MDCM	3/4	NO	NO	2400	1800
1024	MDCM	4/5	NO	NO	2400	1920

6.1.2 Timing-Related Parameters

The timing parameters associated with the OFDM PHY are listed in Table 6-2.

TABLE 6-2. Timing-related parameters

Parameter	Description	Value
f_s	Sampling frequency	528 MHz
N_{FFT}	Total number of subcarriers (FFT size)	128
N_D	Number of data subcarriers	100
N_P	Number of pilot subcarriers	12
N_G	Number of guard subcarriers	10
N_T	Total number of subcarriers used	122 (= $N_D + N_P + N_G$)
Δ_f	Subcarrier frequency spacing	4.125 MHz (= f_s / N_{FFT})
T_{FFT}	IFFT and FFT period	242.42 ns (Δ_f^{-1})
N_{ZPS}	Number of samples in zero-padded suffix	37
T_{ZPS}	Zero-padded suffix duration in time	70.08 ns (= N_{ZPS} / f_s)
T_{SYM}	Symbol interval	312.5 ns (= $T_{FFT} + T_{ZPS}$)
F_{SYM}	Symbol rate	3.2 MHz (= T_{SYM}^{-1})
N_{SYM}	Total number of samples per symbol	165 (= $N_{FFT} + N_{ZPS}$)

6.1.3 Frame-related parameters6-2

The frame parameters associated with the PHY are listed in Table 6-3, where $\lceil \cdot \rceil$ is the ceiling function, which returns the smallest integer value greater than or equal to its argument.

6.2 PLCP Preamble

A PLCP preamble shall be added prior to the PLCP header to aid the receiver in timing synchronization, carrier-offset recovery, and channel estimation. In this section both a standard PLCP preamble and a burst PLCP preamble are defined. A unique preamble sequence shall be assigned to each time-frequency code (TFC).

The preamble is defined to be a real baseband signal, which shall be inserted into the real portion of the complex baseband signal. Tone nulling (see Section 5.2), if implemented, is then applied. The PLCP preamble consists of two portions: a time-domain portion (packet ⁄ frame synchronization sequence) followed by a frequency-domain portion (channel estimation sequence).

In this section two preambles are defined: a standard PLCP preamble and a burst PLCP preamble. The burst preamble shall only be used in burst mode when a burst of

TABLE 6-3. Frame-related parameters

Parameter	Description	Value
N_{pf}	Number of symbols in the packet/frame synchronization sequence	Standard Preamble: 24 Burst Preamble: 12
T_{pf}	Duration of the packet/frame synchronization sequence	Standard Preamble: 7.5 μs Burst Preamble: 3.75 μs
N_{ce}	Number of symbols in the channel estimation sequence	6
T_{ce}	Duration of the channel estimation sequence	1.875 μs
N_{sync}	Number of symbols in the PLCP Preamble	Standard Preamble: 30 Burst Preamble: 18
T_{sync}	Duration of the PLCP Preamble	Standard Preamble: 9.375 μs Burst Preamble: 5.625 μs
N_{hdr}	Number of symbols in the PLCP Header	12
T_{hdr}	Duration of the PLCP Header	3.75 μs
N_{tail}	Number of PSDU tail bits	data rates that use CC: 6 data rates that use LDPC: 0
N_{frame}	Number of symbols in the PSDU	Rate of 160 or 200 Mb/s using LDPC: $12 \times \left\lceil \frac{8 \times LENGTH + 32}{2 \times N_{IBP6S}} \right\rceil$ Other rate of 480 Mb/s and lower: $6 \times \left\lceil \frac{8 \times LENGTH + 32 + N_{tail}}{N_{IBP6S}} \right\rceil$ Rate of 640 Mb/s and higher $3 \times \left\lceil \frac{2 \times (8 \times LENGTH + 32)}{N_{IBP6S}} \right\rceil$

TABLE 6-3. Frame-related parameters

Parameter	Description	Value
N_{pad}	Number of pad bits in the PSDU	$\frac{N_{frame} \times N_{IBP6S}}{6} - (8 \times LENGTH + 32 + N_{tail})$
T_{frame}	Duration for the PSDU	$N_{frame} \times T_{SYM}$
N_{packet}	Total number of symbols in the packet	$N_{sync} + N_{hdr} + N_{frame}$
T_{packet}	Duration of the packet	$(N_{sync} + N_{hdr} + N_{frame}) \times T_{SYM}$

packets is transmitted, separated by a minimum inter-frame separation time (pMIFS-Time). For data rates of 200 Mb/s and lower, all the packets in the burst shall use the standard PLCP preamble. However, for data rates higher than 200 Mb/s, the first packet shall use the standard PLCP preamble, while the remaining packets may use either the standard PLCP preamble or the burst PLCP preamble. Support for transmission and reception of burst PLCP preamble is mandatory for all supported data rates above 200Mbps. The preamble type (PT) bit in the PHY header (see Section 6.3.1.5) describes the type of preamble that shall be used in the next packet.

6.2.1 Standard PLCP Preamble

Fig. 6-2 shows the structure of the standard PLCP preamble. The preamble can be sub-divided into two distinct portions: a packet/frame synchronization sequence and a channel estimation sequence. The packet/frame synchronization sequence shall be constructed as shown in Fig. 6-3:

1. For a given time-frequency code, select the appropriate base time-domain sequence $s_{base}[l]$ from Table 6-4 through Table 6-13 and the appropriate standard cover sequence $s_{cover}[m]$ from Table 6-14.
2. Form an extended time-domain sequence $s_{ext}[l]$ by appending N_{ZPS} “zero samples” to the length N_{FFT} sequence $s_{base}[l]$.
3. The k^{th} sample of the n^{th} symbol in the standard preamble $s_{sync,n}[k]$, corresponding to the packet/frame synchronization sequence, is given by:

$$s_{sync,n}[k] = s_{cover}[n] \times s_{ext}[k] \tag{6-1}$$

where $n \in [0, N_{pf} - 1]$, $k \in [0, N_{SYM} - 1]$, N_{pf} is defined in Table 6-3 and N_{SYM} is defined in Table 6-2.

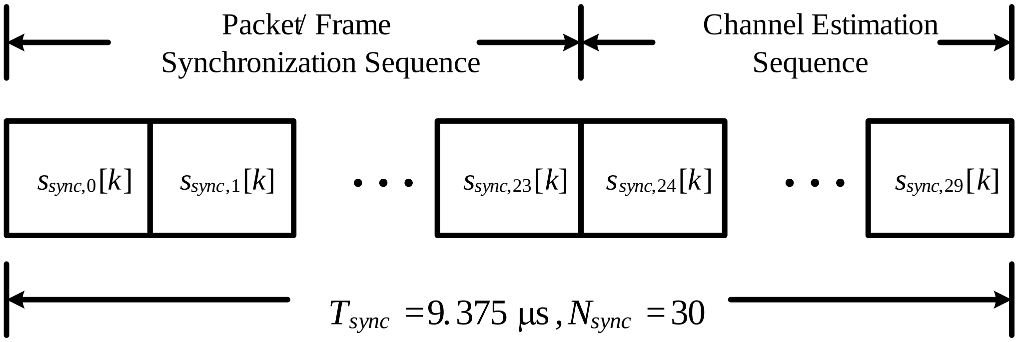

Fig. 6-2. Block diagram of the standard PLCP preamble

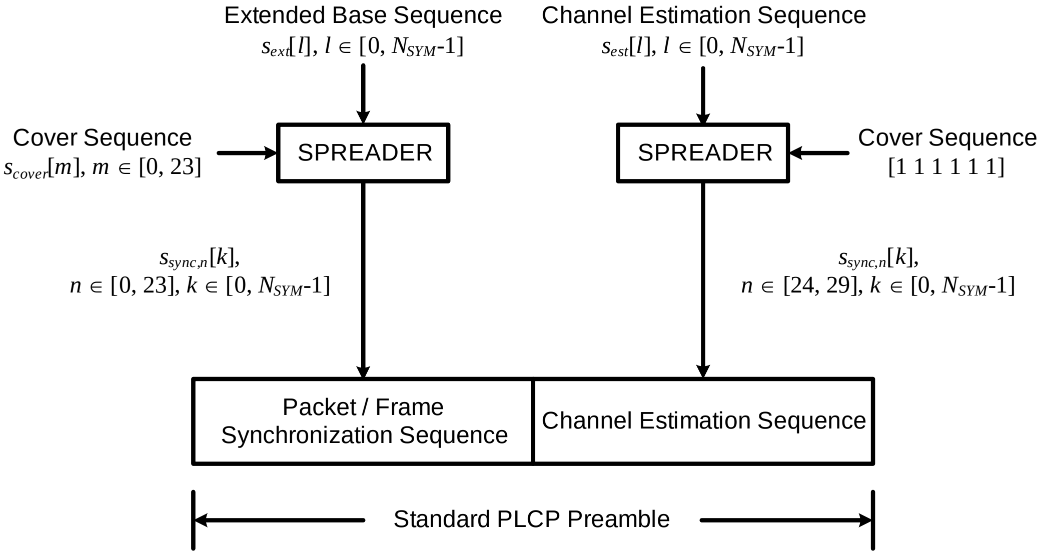

Fig. 6-3. Block diagram of standard PLCP preamble construction

The channel estimation sequence shall also be constructed as shown in Fig. 6-3. A base channel estimation sequence $s_{est}[l]$ is created by taking the inverse discrete Fourier transform (IDFT) of the frequency-domain sequence defined in Table 6-16, and appending a zero-padded suffix consisting of N_{ZPS} “zero samples” to the resulting time-domain output. The channel estimation sequence portion of the standard preamble is created by successively appending N_{ce} periods of the base estimation sequence, or equivalently, spreading the base channel estimation sequence with a sequence of [1 1 1 1 1 1]. Mathematically, the channel estimation sequence portion of the standard preamble can be written as:

$$s_{sync,n}[k] = s_{est}[k], \tag{6-2}$$

where $n \in [N_{pf}, N_{sync} - 1]$, $k \in [0, N_{SYM} - 1]$, N_{pf} is defined in Table 6-3 and N_{SYM} is defined in Table 6-2.

The packet/frame synchronization sequence can be used for packet acquisition and detection, coarse carrier frequency estimation, coarse symbol timing, and for synchronization within the preamble. Whereas, the channel estimation sequence can be used for estimation of the channel frequency response, fine carrier frequency estimation, and fine symbol timing. The first sample of the first channel estimation symbol, $s_{sync, N_{pf}}[0]$, shall be used as the timing reference point for range measurements, as described in Section 10.

The time-domain sequences in Table 6-4 through Table 6-10 and the frequency-domain channel estimation sequence defined in Table 6-16 should be normalized (as needed) to ensure that these sequences have the same average power as the PLCP header and the PSDU.

6.2.2 Burst PLCP Preamble

The burst PLCP preamble, which is shown in Fig. 6-4, is similar in structure to the standard PLCP preamble. This preamble can also be sub-divided into two distinct portions: a packet/frame synchronization sequence and a channel estimation sequence. The packet/frame synchronization sequence shall be constructed as shown in Fig. 6-5:

1. For a given time-frequency code, select the appropriate base time-domain sequence $s_{base}[l]$ from Table 6-4 through Table 6-13 and the appropriate burst cover sequence $s_{cover}[m]$ from Table 6-15.
2. Form an extended time-domain sequence $s_{ext}[l]$ by appending N_{ZPS} “zero samples” to the length N_{FFT} sequence $s_{base}[l]$.
3. The k^{th} sample of the n^{th} symbol in the burst preamble $s_{sync,n}[k]$, corresponding to the packet/frame synchronization sequence, is given by:

$$s_{sync,n}[k] = s_{cover}[n] \times s_{ext}[k], \qquad (6\text{-}3)$$

where $n \in [0, N_{pf} - 1]$, $k \in [0, N_{SYM} - 1]$, N_{pf} is defined in Table 6-3 and N_{SYM} is defined in Table 6-2.

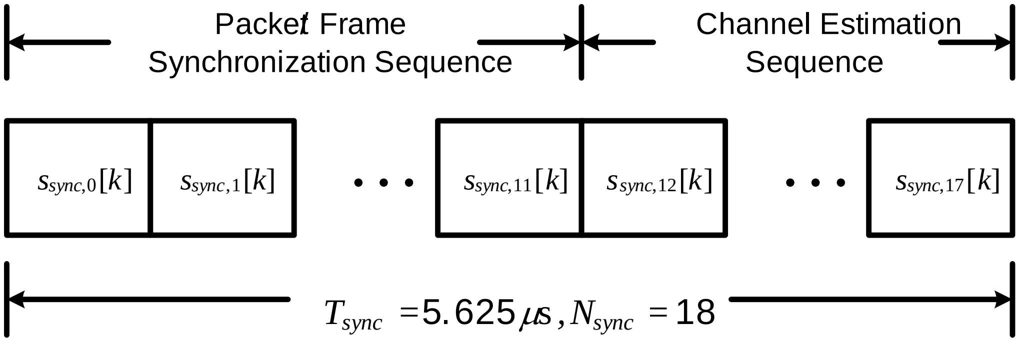

Fig. 6-4. Block diagram of the burst PLCP preamble

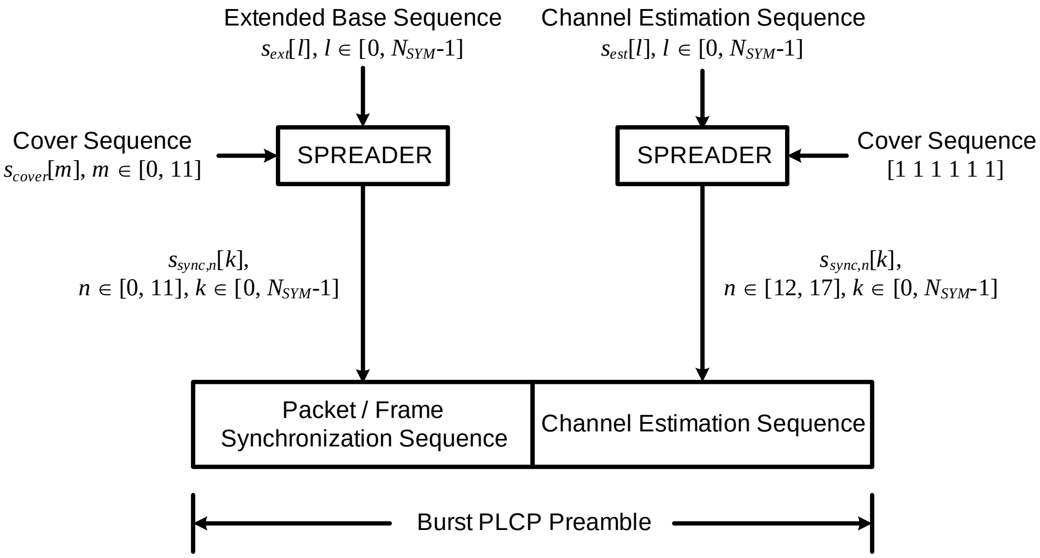

Fig. 6-5. Block diagram of burst PLCP preamble construction

The construction method used to create the channel estimation sequence portion of the burst preamble is identical to the method used to construct the channel estimation sequence portion of the standard preamble. Mathematically, the channel estimation sequence portion of the burst preamble can be written as:

$$s_{sync,n}[k] = s_{est}[k], \tag{6-4}$$

where $n \in [N_{pf}, N_{sync} - 1]$, $k \in [0, N_{SYM} - 1]$, N_{pf} is defined in Table 6-3 and N_{SYM} is defined in Table 6-2.

TABLE 6-4. Base time-domain sequence for TFC 1

l	$s_{base}[l]$	l	$s_{base}[l]$	l	$s_{base}[l]$	l	$s_{base}[l]$
0	0.6564	32	-0.0844	64	-0.2095	96	0.4232
1	-1.3671	33	1.1974	65	1.1640	97	-1.2684
2	-0.9958	34	1.2261	66	1.2334	98	-1.8151
3	-1.3981	35	1.4401	67	1.5338	99	-1.4829
4	0.8481	36	-0.5988	68	-0.8844	100	1.0302
5	1.0892	37	-0.4675	69	-0.3857	101	0.9419
6	-0.8621	38	0.8520	70	0.7730	102	-1.1472
7	1.1512	39	-0.8922	71	-0.9754	103	1.4858
8	0.9602	40	-0.5603	72	-0.2315	104	-0.6794
9	-1.3581	41	1.1886	73	0.5579	105	0.9573
10	-0.8354	42	1.1128	74	0.4035	106	1.0807
11	-1.3249	43	1.0833	75	0.4248	107	1.1445
12	1.0964	44	-0.9073	76	-0.3359	108	-1.2312
13	1.3334	45	-1.6227	77	-0.9914	109	-0.6643
14	-0.7378	46	1.0013	78	0.5975	110	0.3836
15	1.3565	47	-1.6067	79	-0.8408	111	-1.1482
16	0.9361	48	0.3360	80	0.3587	112	-0.0353
17	-0.8212	49	-1.3136	81	-0.9604	113	-0.6747
18	-0.2662	50	-1.4447	82	-1.0002	114	-1.1653
19	-0.6866	51	-1.7238	83	-1.1636	115	-0.8896
20	0.8437	52	1.0287	84	0.9590	116	0.2414
21	1.1237	53	0.6100	85	0.7137	117	0.1160
22	-0.3265	54	-0.9237	86	-0.6776	118	-0.6987
23	1.0511	55	1.2618	87	0.9824	119	0.4781
24	0.7927	56	0.5974	88	-0.5454	120	0.1821
25	-0.3363	57	-1.0976	89	1.1022	121	-1.0672
26	-0.1342	58	-0.9776	90	1.6485	122	-0.9676
27	-0.1546	59	-0.9982	91	1.3307	123	-1.2321
28	0.6955	60	0.8967	92	-1.2852	124	0.5003
29	1.0608	61	1.7640	93	-1.2659	125	0.7419
30	-0.1600	62	-1.0211	94	0.9435	126	-0.8934
31	0.9442	63	1.6913	95	-1.6809	127	0.8391

TABLE 6-5. Base time-domain sequence for TFC 2

l	$s_{base}[l]$	l	$s_{base}[l]$	l	$s_{base}[l]$	l	$s_{base}[l]$
0	0.9679	32	-1.2905	64	1.5280	96	0.5193
1	-1.0186	33	1.1040	65	-0.9193	97	-0.3439
2	0.4883	34	-1.2408	66	1.1246	98	0.1428
3	0.5432	35	-0.8062	67	1.2622	99	0.6251
4	-1.4702	36	1.5425	68	-1.4406	100	-1.0468
5	-1.4507	37	1.0955	69	-1.4929	101	-0.5798
6	-1.1752	38	1.4284	70	-1.1508	102	-0.8237
7	-0.0730	39	-0.4593	71	0.4126	103	0.2667
8	-1.2445	40	-1.0408	72	-1.0462	104	-0.9564
9	0.3143	41	1.0542	73	0.7232	105	0.6016
10	-1.3951	42	-0.4446	74	-1.1574	106	-0.9964
11	-0.9694	43	-0.7929	75	-0.7102	107	-0.3541
12	0.4563	44	1.6733	76	0.8502	108	0.3965
13	0.3073	45	1.7568	77	0.6260	109	0.5201
14	0.6408	46	1.3273	78	0.9530	110	0.4733
15	-0.9798	47	-0.2465	79	-0.4971	111	-0.2362
16	-1.4116	48	1.6850	80	-0.8633	112	-0.6892
17	0.6038	49	-0.7091	81	0.6910	113	0.4787
18	-1.3860	50	1.1396	82	-0.3639	114	-0.2605
19	-1.0888	51	1.5114	83	-0.8874	115	-0.5887
20	1.1036	52	-1.4343	84	1.5311	116	0.9411
21	0.7067	53	-1.5005	85	1.1546	117	0.7364
22	1.1667	54	-1.2572	86	1.1935	118	0.6714
23	-1.0225	55	0.8274	87	-0.2930	119	-0.1746
24	-1.2471	56	-1.5140	88	1.3285	120	1.1776
25	0.7788	57	1.1421	89	-0.7231	121	-0.8803
26	-1.2716	58	-1.0135	90	1.2832	122	1.2542
27	-0.8745	59	-1.0657	91	0.7878	123	0.5111
28	1.2175	60	1.4073	92	-0.8095	124	-0.8209
29	0.8419	61	1.8196	93	-0.7463	125	-0.8975
30	1.2881	62	1.1679	94	-0.8973	126	-0.9091
31	-0.8210	63	-0.4131	95	0.5560	127	0.2562

TABLE 6-6. Base time-domain sequence for TFC 3

l	$s_{base}[l]$	l	$s_{base}[l]$	l	$s_{base}[l]$	l	$s_{base}[l]$
0	0.4047	32	-0.9671	64	-0.7298	96	0.2424
1	0.5799	33	-0.9819	65	-0.9662	97	0.5703
2	-0.3407	34	0.7980	66	0.9694	98	-0.6381
3	0.4343	35	-0.8158	67	-0.8053	99	0.7861
4	0.0973	36	-0.9188	68	-0.9052	100	0.9175
5	-0.7637	37	1.5146	69	1.5933	101	-0.4595
6	-0.6181	38	0.8138	70	0.8418	102	-0.2201
7	-0.6539	39	1.3773	71	1.5363	103	-0.7755
8	0.3768	40	0.2108	72	0.3085	104	-0.2965
9	0.7241	41	0.9245	73	1.3016	105	-1.1220
10	-1.2095	42	-1.2138	74	-1.5546	106	1.7152
11	0.6027	43	1.1252	75	1.5347	107	-1.2756
12	0.4587	44	0.9663	76	1.0935	108	-0.7731
13	-1.3879	45	-0.8418	77	-0.8978	109	1.0724
14	-1.0592	46	-0.6811	78	-0.9712	110	1.1733
15	-1.4052	47	-1.3003	79	-1.3763	111	1.4711
16	-0.8439	48	-0.3397	80	-0.6360	112	0.4881
17	-1.5992	49	-1.1051	81	-1.2947	113	0.7528
18	1.1975	50	1.2400	82	1.6436	114	-0.6417
19	-1.9525	51	-1.3975	83	-1.6564	115	1.0363
20	-1.5141	52	-0.7467	84	-1.1981	116	0.8002
21	0.7219	53	0.2706	85	0.8719	117	-0.0077
22	0.6982	54	0.7294	86	0.9992	118	-0.2336
23	1.2924	55	0.7444	87	1.4872	119	-0.4653
24	-0.9460	56	-0.3970	88	-0.4586	120	0.6862
25	-1.2407	57	-1.0718	89	-0.8404	121	1.2716
26	0.4572	58	0.6646	90	0.6982	122	-0.8880
27	-1.2151	59	-1.1037	91	-0.7959	123	1.4011
28	-0.9869	60	-0.5716	92	-0.5692	124	0.9531
29	1.2792	61	0.9001	93	1.3528	125	-1.1210
30	0.6882	62	0.7317	94	0.9536	126	-0.9489
31	1.2586	63	0.9846	95	1.1784	127	-1.2566

TABLE 6-7. Base time-domain sequence for TFC 4

l	$s_{base}[l]$	l	$s_{base}[l]$	l	$s_{base}[l]$	l	$s_{base}[l]$
0	1.1549	32	-1.2385	64	1.3095	96	-1.0094
1	1.0079	33	-0.7883	65	0.6675	97	-0.7598
2	0.7356	34	-0.7954	66	1.2587	98	-1.0786
3	-0.7434	35	1.0874	67	-0.9993	99	0.6699
4	-1.3930	36	1.1491	68	-1.0052	100	0.9813
5	1.2818	37	-1.4780	69	0.6601	101	-0.5563
6	-1.1033	38	0.8870	70	-1.0228	102	1.0548
7	-0.2523	39	0.4694	71	-0.7489	103	0.8925
8	-0.7905	40	1.5066	72	0.5086	104	-1.3656
9	-0.4261	41	1.1266	73	0.1563	105	-0.8472
10	-0.9390	42	0.9935	74	0.0673	106	-1.3110
11	0.4345	43	-1.2462	75	-0.8375	107	1.1897
12	0.4433	44	-1.7869	76	-1.0746	108	1.5127
13	-0.3076	45	1.7462	77	0.4454	109	-0.7474
14	0.5644	46	-1.4881	78	-0.7831	110	1.4678
15	0.2571	47	-0.4090	79	-0.3623	111	1.0295
16	-1.0030	48	-1.4694	80	-1.3658	112	-0.9210
17	-0.7820	49	-0.7923	81	-1.0854	113	-0.4784
18	-0.4064	50	-1.4607	82	-1.4923	114	-0.5022
19	0.9035	51	0.9113	83	0.4233	115	1.2153
20	1.5406	52	0.8454	84	0.6741	116	1.5783
21	-1.4613	53	-0.8866	85	-1.0157	117	-0.7718
22	1.2745	54	0.8852	86	0.8304	118	1.2384
23	0.3715	55	0.4918	87	0.4878	119	0.6695
24	1.8134	56	-0.6096	88	-1.4992	120	0.8821
25	0.9438	57	-0.4322	89	-1.1884	121	0.7808
26	1.3130	58	-0.1327	90	-1.4008	122	1.0537
27	-1.3070	59	0.4953	91	0.7795	123	-0.0791
28	-1.3462	60	0.9702	92	1.2926	124	-0.2845
29	1.6868	61	-0.8667	93	-1.2049	125	0.5790
30	-1.2153	62	0.6803	94	1.2934	126	-0.4664
31	-0.6778	63	-0.0244	95	0.8123	127	-0.1097

TABLE 6-8. Base time-domain sequence for TFC 5

l	$s_{base}[l]$	l	$s_{base}[l]$	l	$s_{base}[l]$	l	$s_{base}[l]$
0	0.9574	32	0.8400	64	0.5859	96	-0.8528
1	0.5270	33	1.3980	65	0.3053	97	-0.6973
2	1.5929	34	1.1147	66	0.8948	98	-1.2477
3	-0.2500	35	-0.4732	67	-0.6744	99	0.6246
4	-0.2536	36	-1.7178	68	-0.8901	100	0.7687
5	-0.3023	37	-0.8477	69	-0.8133	101	0.7966
6	1.2907	38	1.5083	70	0.9201	102	-1.2809
7	-0.4258	39	-1.4364	71	-1.0841	103	1.1023
8	1.0012	40	0.3853	72	-0.8036	104	0.4250
9	1.7704	41	1.5673	73	-0.3105	105	-0.1614
10	0.8593	42	0.0295	74	-1.0514	106	0.7547
11	-0.3719	43	-0.4204	75	0.7644	107	-0.6696
12	-1.3465	44	-1.4856	76	0.7301	108	-0.3920
13	-0.7419	45	-0.8404	77	0.9788	109	-0.7589
14	1.5350	46	1.0111	78	-1.1305	110	0.6701
15	-1.2800	47	-1.4269	79	1.3257	111	-0.9381
16	0.6955	48	0.3033	80	0.7801	112	-0.7483
17	1.7204	49	0.7757	81	0.7867	113	-0.9659
18	0.1643	50	-0.1370	82	1.0996	114	-0.9192
19	-0.3347	51	-0.5250	83	-0.5623	115	0.3925
20	-1.7244	52	-1.1589	84	-1.2227	116	1.2864
21	-0.7447	53	-0.8324	85	-0.8223	117	0.6784
22	1.1141	54	0.6336	86	1.2074	118	-1.0909
23	-1.3541	55	-1.2698	87	-1.2338	119	1.1140
24	-0.7293	56	-0.7853	88	0.2957	120	-0.6134
25	0.2682	57	-0.7031	89	1.0999	121	-1.5467
26	-1.2401	58	-1.1106	90	-0.0201	122	-0.3031
27	1.0527	59	0.6071	91	-0.5860	123	0.9457
28	0.1199	60	0.7164	92	-1.2284	124	1.9645
29	1.1496	61	0.8305	93	-0.9215	125	1.4549
30	-1.0544	62	-1.2355	94	0.7941	126	-1.2760
31	1.3176	63	1.1754	95	-1.4128	127	2.2102

TABLE 6-9. Base time-domain sequence for TFC 6

l	$s_{base}[l]$	l	$s_{base}[l]$	l	$s_{base}[l]$	l	$s_{base}[l]$
0	1.2947	32	-0.9973	64	1.0703	96	0.9516
1	-0.8188	33	0.8548	65	-0.8625	97	-1.2593
2	0.9007	34	-0.6963	66	0.6986	98	0.4594
3	0.7786	35	-0.6874	67	1.0989	99	1.3038
4	0.6301	36	-0.5015	68	0.4600	100	0.1090
5	-0.1283	37	0.7003	69	-0.6559	101	-0.5082
6	-0.7972	38	0.3582	70	-0.6087	102	-1.8181
7	-0.3897	39	0.5772	71	-0.4206	103	-0.7747
8	1.1794	40	0.7421	72	-0.8454	104	0.7678
9	-1.2592	41	-0.6766	73	1.0317	105	-1.5342
10	0.8136	42	0.6242	74	-0.7624	106	0.4914
11	0.8872	43	0.4241	75	0.0619	107	0.7197
12	0.5797	44	0.5891	76	-0.7311	108	0.3353
13	-1.2304	45	-0.9045	77	1.3634	109	-1.5832
14	-0.5628	46	0.1625	78	-0.1379	110	-0.9947
15	-0.8272	47	-0.5105	79	0.8401	111	-1.0329
16	-1.5418	48	-1.4187	80	1.6371	112	-1.9669
17	1.2804	49	1.5169	81	-1.0201	113	0.9946
18	-1.1524	50	-0.9580	82	0.9243	114	-1.3273
19	-0.9846	51	-1.1237	83	2.0931	115	-1.5572
20	-0.9178	52	-0.6782	84	0.4511	116	-0.8746
21	1.1834	53	1.3557	85	0.0768	117	0.0579
22	0.4293	54	1.0229	86	-1.7974	118	1.2269
23	0.9021	55	0.9490	87	-0.4685	119	0.4497
24	1.1152	56	1.6308	88	1.4727	120	-1.4751
25	-0.9828	57	-0.9325	89	-1.3387	121	1.3897
26	0.7891	58	1.1461	90	0.7779	122	-0.9922
27	0.9391	59	1.1675	91	2.0080	123	-1.2950
28	0.5944	60	0.8163	92	0.3026	124	-0.6839
29	-0.8376	61	-0.1551	93	-0.4263	125	1.2113
30	-0.5320	62	-0.8657	94	-1.9751	126	1.0559
31	-0.6335	63	-0.3696	95	-0.8421	127	0.8147

TABLE 6-10. Base time-domain sequence for TFC 7

l	$s_{base}[l]$	l	$s_{base}[l]$	l	$s_{base}[l]$	l	$s_{base}[l]$
0	0.8147	32	-0.8421	64	-0.3696	96	-0.6335
1	1.0559	33	-1.9751	65	-0.8657	97	-0.5320
2	1.2113	34	-0.4263	66	-0.1551	98	-0.8376
3	-0.6839	35	0.3026	67	0.8163	99	0.5944
4	-1.2950	36	2.0080	68	1.1675	100	0.9391
5	-0.9922	37	0.7779	69	1.1461	101	0.7891
6	1.3897	38	-1.3387	70	-0.9325	102	-0.9828
7	-1.4751	39	1.4727	71	1.6308	103	1.1152
8	0.4497	40	-0.4685	72	0.9490	104	0.9021
9	1.2269	41	-1.7974	73	1.0229	105	0.4293
10	0.0579	42	0.0768	74	1.3557	106	1.1834
11	-0.8746	43	0.4511	75	-0.6782	107	-0.9178
12	-1.5572	44	2.0931	76	-1.1237	108	-0.9846
13	-1.3273	45	0.9243	77	-0.9580	109	-1.1524
14	0.9946	46	-1.0201	78	1.5169	110	1.2804
15	-1.9669	47	1.6371	79	-1.4187	111	-1.5418
16	-1.0329	48	0.8401	80	-0.5105	112	-0.8272
17	-0.9947	49	-0.1379	81	0.1625	113	-0.5628
18	-1.5832	50	1.3634	82	-0.9045	114	-1.2304
19	0.3353	51	-0.7311	83	0.5891	115	0.5797
20	0.7197	52	0.0619	84	0.4241	116	0.8872
21	0.4914	53	-0.7624	85	0.6242	117	0.8136
22	-1.5342	54	1.0317	86	-0.6766	118	-1.2592
23	0.7678	55	-0.8454	87	0.7421	119	1.1794
24	-0.7747	56	-0.4206	88	0.5772	120	-0.3897
25	-1.8181	57	-0.6087	89	0.3582	121	-0.7972
26	-0.5082	58	-0.6559	90	0.7003	122	-0.1283
27	0.1090	59	0.4600	91	-0.5015	123	0.6301
28	1.3038	60	1.0989	92	-0.6874	124	0.7786
29	0.4594	61	0.6986	93	-0.6963	125	0.9007
30	-1.2593	62	-0.8625	94	0.8548	126	-0.8188
31	0.9516	63	1.0703	95	-0.9973	127	1.2947

TABLE 6-11. Base time-domain sequence for TFC 8

l	sbase[l]	l	sbase[l]	l	sbase[l]	l	sbase[l]
0	-1.5418	32	1.5991	64	1.2724	96	-1.0853
1	-1.8693	33	0.9815	65	1.1826	97	-1.1578
2	0.7376	34	-0.3972	66	-1.0624	98	0.5002
3	0.7053	35	-0.6359	67	-0.8703	99	0.7837
4	-0.3894	36	0.9952	68	0.6785	100	-0.5400
5	0.1513	37	-0.7202	69	-0.9608	101	0.4289
6	-0.8805	38	0.7765	70	0.4801	102	-0.6101
7	-0.3779	39	-0.5651	71	-0.7947	103	0.4170
8	-1.9610	40	-0.8501	72	-0.8353	104	-1.6764
9	-2.4464	41	-0.7267	73	-0.7822	105	-1.3070
10	1.8548	42	0.7995	74	0.4953	106	1.4198
11	1.3662	43	0.7100	75	0.5068	107	1.1201
12	-0.3561	44	-0.3657	76	-0.3892	108	-1.0630
13	0.6816	45	1.1825	77	0.3455	109	1.6335
14	-0.8745	46	-0.2209	78	-0.3371	110	-0.4197
15	0.1451	47	0.9133	79	0.2327	111	1.4509
16	-1.2926	48	1.3556	80	-0.4013	112	1.4005
17	-1.9228	49	1.3781	81	-0.3826	113	1.3187
18	2.1127	50	-0.8677	82	0.4224	114	-1.2051
19	1.3233	51	-0.6018	83	0.1226	115	-1.2343
20	-0.1492	52	0.7494	84	-0.2534	116	0.6354
21	0.8520	53	-1.1510	85	0.5049	117	-0.9328
22	-0.3097	54	0.3856	86	-0.0474	118	0.5565
23	0.6189	55	-0.8235	87	0.3197	119	-0.8834
24	-0.4923	56	-1.2252	88	1.7224	120	0.6278
25	-0.9704	57	-0.8611	89	1.4156	121	0.5591
26	1.8042	58	0.9080	90	-1.2650	122	-0.9759
27	0.8076	59	0.9312	91	-1.2494	123	-0.7442
28	-0.0418	60	-0.8486	92	0.9556	124	0.4167
29	1.1869	61	1.2746	93	-1.6227	125	-1.1749
30	0.2464	62	-0.4500	94	0.4540	126	-0.0865
31	1.0491	63	1.0818	95	-1.3700	127	-1.1382

TABLE 6-12. Base time-domain sequence for TFC 9

l	sbase[l]	l	sbase[l]	l	sbase[l]	l	sbase[l]
0	-0.4504	32	1.5033	64	0.7954	96	1.3196
1	-0.0204	33	0.5800	65	0.3984	97	0.3051
2	0.6038	34	-1.1324	66	-0.7114	98	-1.4177
3	0.0037	35	0.8858	67	0.3112	99	0.4358
4	0.5454	36	-0.9642	68	-0.5845	100	-1.2758
5	0.6975	37	-1.7500	69	-0.9064	101	-1.6534
6	0.9859	38	-1.4395	70	-0.6956	102	-1.7531
7	-0.3032	39	0.8150	71	0.3741	103	0.5522
8	1.0388	40	-0.6062	72	-0.3981	104	-0.8554
9	1.1703	41	-1.3479	73	-0.8359	105	-1.2377
10	-0.7733	42	0.7825	74	0.6343	106	0.1667
11	1.3224	43	-1.3437	75	-0.7581	107	-1.5739
12	-1.3138	44	1.8374	76	1.3348	108	0.6861
13	-1.3965	45	1.4348	77	0.6902	109	1.0134
14	-1.1362	46	1.6233	78	1.5183	110	-0.0742
15	1.1048	47	-1.3284	79	-1.0704	111	-0.6555
16	-0.3635	48	0.9461	80	1.3250	112	-1.2438
17	-0.8869	49	1.2935	81	1.0208	113	-0.3798
18	0.3274	50	-0.3171	82	-0.3643	114	0.8051
19	-0.6917	51	1.4647	83	1.4068	115	-1.0598
20	1.3433	52	-1.2651	84	-0.8642	116	0.1969
21	1.0400	53	-1.2894	85	-1.8377	117	1.1021
22	1.1278	54	-0.2103	86	0.0604	118	0.0739
23	-0.8992	55	0.9035	87	0.4115	119	-0.0086
24	0.9160	56	1.0767	88	1.6933	120	-1.5732
25	1.0211	57	0.4032	89	0.3326	121	-0.6063
26	-0.1955	58	-1.1287	90	-1.3095	122	1.0575
27	1.0662	59	1.0066	91	1.2839	123	-0.8190
28	-0.6752	60	-0.3692	92	-0.7327	124	0.8400
29	-0.9876	61	-0.9377	93	-1.9623	125	1.7084
30	0.1600	62	-0.6635	94	-0.8701	126	0.7514
31	0.4137	63	0.2842	95	0.1927	127	-0.2507

TABLE 6-13. Base time-domain sequence for TFC 10

l	sbase[l]	l	sbase[l]	l	sbase[l]	l	sbase[l]
0	-0.8099	32	1.0287	64	-0.0911	96	-0.7048
1	0.8166	33	-1.7755	65	0.0387	97	0.1632
2	0.3982	34	-2.0498	66	-0.4587	98	1.5896
3	0.8259	35	-1.2207	67	0.1426	99	1.0531
4	-0.7634	36	1.1135	68	0.7377	100	-1.7931
5	0.1607	37	-1.5053	69	-0.6853	101	0.5738
6	-0.6491	38	0.7000	70	0.1525	102	-1.4225
7	0.0062	39	1.7468	71	0.8182	103	-1.4751
8	0.3393	40	0.5284	72	1.0921	104	0.6825
9	-1.0801	41	-0.0891	73	-0.4642	105	-1.7053
10	-1.3852	42	-1.5886	74	-1.2317	106	-1.1385
11	-0.5410	43	-0.8769	75	-1.2704	107	-1.2840
12	0.6630	44	1.4662	76	1.8690	108	0.2915
13	-1.1485	45	-0.5451	77	-0.5577	109	-1.0583
14	0.1131	46	1.0708	78	1.6865	110	0.3935
15	1.1727	47	1.4765	79	1.1413	111	0.7718
16	0.8227	48	-0.8321	80	-0.5640	112	-0.0863
17	-0.4298	49	1.2716	81	1.6869	113	-0.4593
18	-1.7785	50	0.3878	82	1.6904	114	-0.8533
19	-1.3826	51	1.1351	83	1.3886	115	-0.2236
20	1.5385	52	-0.4773	84	-0.6049	116	0.3308
21	-0.5791	53	0.4239	85	1.3708	117	-0.6704
22	1.4168	54	-0.7204	86	-0.5306	118	-0.1729
23	1.1445	55	0.1162	87	-1.3657	119	0.7400
24	-1.2942	56	0.4657	88	0.0404	120	0.2206
25	1.5208	57	-0.5644	89	0.4111	121	-0.1825
26	1.3324	58	-1.3117	90	1.2284	122	-1.3567
27	1.5427	59	-0.6569	91	0.3489	123	-0.6947
28	-1.0663	60	0.5908	92	-1.0410	124	0.6586
29	0.3656	61	-0.6399	93	1.1002	125	-0.3066
30	-1.0891	62	0.6638	94	-0.2467	126	0.4823
31	-0.4340	63	1.2183	95	-1.3720	127	0.8766

TABLE 6-14. Cover sequence for standard preamble

m	$s_{cover}[m]$ for TFCs 1,2	$s_{cover}[m]$ for TFCs 3,4	$s_{cover}[m]$ for TFCs 5,6,7	$s_{cover}[m]$ for TFCs 8,9,10
0	1	1	-1	1
1	1	1	-1	1
2	1	1	-1	-1
3	1	1	-1	-1
4	1	1	-1	1
5	1	1	-1	1
6	1	1	-1	-1
7	1	1	1	-1
8	1	1	-1	1
9	1	1	-1	1
10	1	1	1	-1
11	1	1	-1	-1
12	1	1	-1	1
13	1	1	1	1
14	1	1	-1	-1
15	1	1	-1	-1
16	1	1	1	1
17	1	1	-1	1
18	1	1	-1	1
19	1	-1	1	1
20	1	1	-1	1
21	-1	-1	1	1
22	-1	1	1	-1
23	-1	-1	1	-1

TABLE 6-15. Cover sequence for burst preamble

m	$s_{cover}[m]$ for TFCs 1,2	$s_{cover}[m]$ for TFCs 3,4	$s_{cover}[m]$ for TFCs 5,6,7	$s_{cover}[m]$ for TFCs 8,9,10
0	1	1	-1	1
1	1	1	-1	1
2	1	1	-1	-1
3	1	1	1	-1
4	1	1	1	1
5	1	1	-1	1
6	1	1	-1	1
7	1	-1	1	1
8	1	1	-1	1
9	-1	-1	1	1
10	-1	1	1	-1
11	-1	-1	1	-1

TABLE 6-16. Base frequency-domain channel estimation sequence

Tone	Value	Tone	Value	Tone	Value	Tone	Value
–61	(–1+*j*)/√2	–30	(1–*j*)/√2	1	(1+*j*)/√2	32	(1+*j*)/√2
–60	(–1+*j*)/√2	–29	(–1+*j*)/√2	2	(1+*j*)/√2	33	(1+*j*)/√2
–59	(–1+*j*)/√2	–28	(–1+*j*)/√2	3	(–1–*j*)/√2	34	(–1–*j*)/√2
–58	(–1+*j*)/√2	–27	(1–*j*)/√2	4	(1+*j*)/√2	35	(–1–*j*)/√2
–57	(–1+*j*)/√2	–26	(1–*j*)/√2	5	(–1–*j*)/√2	36	(1+*j*)/√2
–56	(1–*j*)/√2	–25	(1–*j*)/√2	6	(–1–*j*)/√2	37	(–1–*j*)/√2
–55	(1–*j*)/√2	–24	(–1+*j*)/√2	7	(1+*j*)/√2	38	(1+*j*)/√2
–54	(–1+*j*)/√2	–23	(1–*j*)/√2	8	(–1–*j*)/√2	39	(1+*j*)/√2
–53	(1–*j*)/√2	–22	(1–*j*)/√2	9	(1+*j*)/√2	40	(1+*j*)/√2
–52	(1–*j*)/√2	–21	(1–*j*)/√2	10	(–1–*j*)/√2	41	(–1–*j*)/√2
–51	(1–*j*)/√2	–20	(–1+*j*)/√2	11	(1+*j*)/√2	42	(–1–*j*)/√2
–50	(1–*j*)/√2	–19	(1–*j*)/√2	12	(1+*j*)/√2	43	(1+*j*)/√2
–49	(1–*j*)/√2	–18	(–1+*j*)/√2	13	(–1–*j*)/√2	44	(1+*j*)/√2
–48	(–1+*j*)/√2	–17	(1–*j*)/√2	14	(–1–*j*)/√2	45	(–1–*j*)/√2
–47	(1–*j*)/√2	–16	(1–*j*)/√2	15	(–1–*j*)/√2	46	(–1–*j*)/√2
–46	(–1+*j*)/√2	–15	(–1+*j*)/√2	16	(1+*j*)/√2	47	(1+*j*)/√2
–45	(–1+*j*)/√2	–14	(–1+*j*)/√2	17	(1+*j*)/√2	48	(–1–*j*)/√2
–44	(1–*j*)/√2	–13	(–1+*j*)/√2	18	(–1–*j*)/√2	49	(1+*j*)/√2

TABLE 6-16. Base frequency-domain channel estimation sequence

–43	$(1-j)/\sqrt{2}$	–12	$(1-j)/\sqrt{2}$	19	$(1+j)/\sqrt{2}$	50	$(1+j)/\sqrt{2}$
–42	$(-1+j)/\sqrt{2}$	–11	$(1-j)/\sqrt{2}$	20	$(-1-j)/\sqrt{2}$	51	$(1+j)/\sqrt{2}$
–41	$(-1+j)/\sqrt{2}$	–10	$(-1+j)/\sqrt{2}$	21	$(1+j)/\sqrt{2}$	52	$(1+j)/\sqrt{2}$
–40	$(1-j)/\sqrt{2}$	–9	$(1-j)/\sqrt{2}$	22	$(1+j)/\sqrt{2}$	53	$(1+j)/\sqrt{2}$
–39	$(1-j)/\sqrt{2}$	–8	$(-1+j)/\sqrt{2}$	23	$(1+j)/\sqrt{2}$	54	$(-1-j)/\sqrt{2}$
–38	$(1-j)/\sqrt{2}$	–7	$(1-j)/\sqrt{2}$	24	$(-1-j)/\sqrt{2}$	55	$(1+j)/\sqrt{2}$
–37	$(-1+j)/\sqrt{2}$	–6	$(-1+j)/\sqrt{2}$	25	$(1+j)/\sqrt{2}$	56	$(1+j)/\sqrt{2}$
–36	$(1-j)/\sqrt{2}$	–5	$(-1+j)/\sqrt{2}$	26	$(1+j)/\sqrt{2}$	57	$(-1-j)/\sqrt{2}$
–35	$(-1+j)/\sqrt{2}$	–4	$(1-j)/\sqrt{2}$	27	$(1+j)/\sqrt{2}$	58	$(-1-j)/\sqrt{2}$
–34	$(-1+j)/\sqrt{2}$	–3	$(-1+j)/\sqrt{2}$	28	$(-1-j)/\sqrt{2}$	59	$(-1-j)/\sqrt{2}$
–33	$(1-j)/\sqrt{2}$	–2	$(1-j)/\sqrt{2}$	29	$(-1-j)/\sqrt{2}$	60	$(-1-j)/\sqrt{2}$
–32	$(1-j)/\sqrt{2}$	–1	$(1-j)/\sqrt{2}$	30	$(1+j)/\sqrt{2}$	61	$(-1-j)/\sqrt{2}$
–31	$(1-j)/\sqrt{2}$			31	$(1+j)/\sqrt{2}$		

6.3 PLCP Header

A PLCP header shall be added after the PLCP preamble to convey information about both the PHY and the MAC that is needed at the receiver in order to successfully decode the PSDU. The scrambled and Reed-Solomon encoded PLCP header shall be formed as shown in Fig. 6-6:

1. Format the PHY header based on information provided by the MAC.
2. Calculate the HCS value (2 octets) over the combined PHY and MAC headers.
3. The resulting HCS value is appended to the MAC header. The resulting combination (MAC Header + HCS) is scrambled according to Section 6.5.
4. Apply a shortened Reed-Solomon code (23,17) to the concatenation of the PHY header (5 octets), scrambled MAC header and HCS (12 octets).
5. Insert 6 tail bits after the PHY header, 6 tail bits after the scrambled MAC header and HCS, and append the 6 parity octets and 4 tail bits at the end to form the scrambled and Reed-Solomon encoded PLCP header.

The resulting scrambled and Reed-Solomon encoded PLCP header is encoded, as shown in Fig. 6-7, using a $R = 1/3$, $K = 7$ convolutional code (see Section 6.7), interleaved using a bit interleaver (see Section 6.8), mapped onto a QPSK constellation (see Section 6.9) and finally, the resulting complex values are loaded onto the data subcarriers for the IDFT (see Section 6.10) in order to create the baseband signal. Tone nulling (see Section 5.2), if implemented, is then applied.

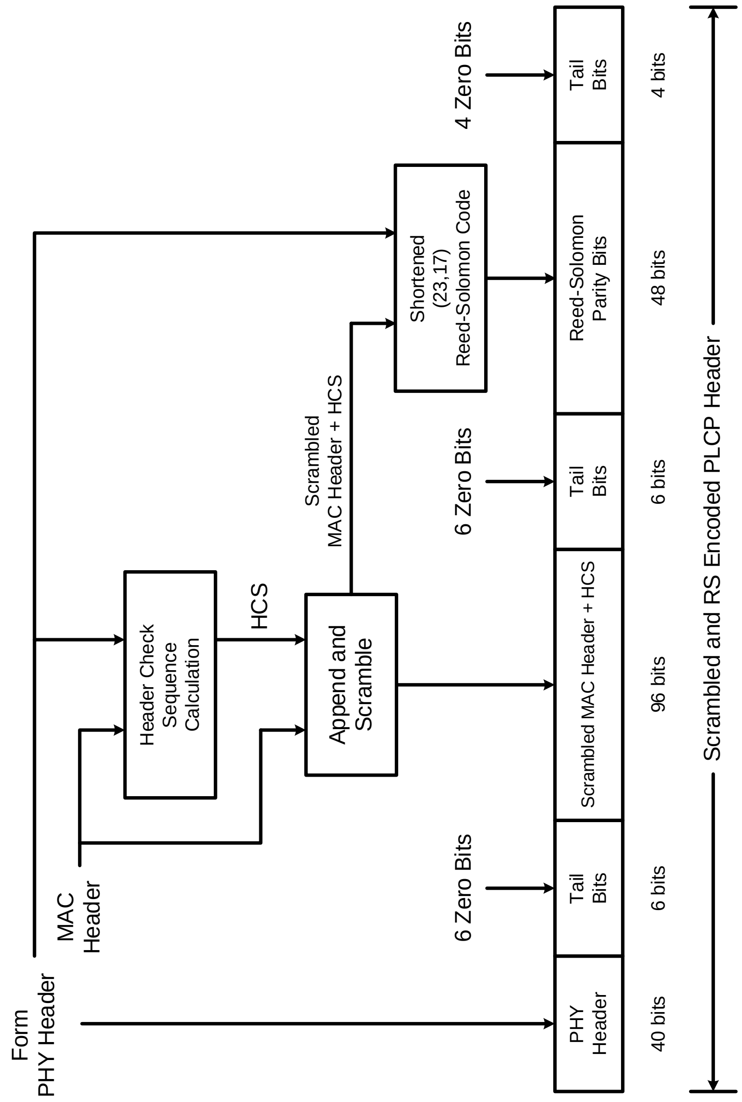

Fig. 6-6. Block diagram of PLCP header construction

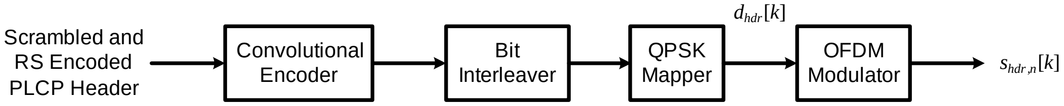

Fig. 6-7. Encoding process for the scrambled, Reed-Solomon encoded PLCP header

6.3.1 PHY Header

The PHY header contains information about the data rate of the MAC frame body, the length of the frame payload (which does not include the FCS), the seed identifier for the data scrambler, and information about the next packet – whether it is being sent in burst mode and whether it employs a burst preamble or not.

The PHY header field shall be composed of 40 bits, numbered from 0 to 39 as illustrated in Fig. 6-8. Bits 3-7 shall encode the RATE field, which conveys the information about the type of modulation, the coding rate and the spreading factor used to transmit the MAC frame body. Bits 8-21 shall encode the LENGTH field, with the least significant bit being transmitted first. Bits 22-23 shall encode the seed value for the initial state of the scrambler, which is used to synchronize the descrambler of the receiver. Bit 26 shall encode whether or not the packet is being transmitted in burst mode. Bit 27 shall encode the preamble type (standard or burst preamble) used in the next packet if in burst mode. Bits 28-30 shall be used to indicate the lower 3 LSBs of the TFC (T1 - T3) used at the transmitter. Bit 31 shall be used to indicate the LSB of the band group used at the transmitter. Bit 34 shall be used to indicate the MSB of the TFC (T4) used at the transmitter. All other bits which are not defined in this section shall be understood to be reserved for future use and shall be set to zero. The receiver shall ignore reserved bits on receive. The receiver shall not assume that reserved bits are zero on receive, for instance to assist the Viterbi algorithm or to decode the RATE quickly.

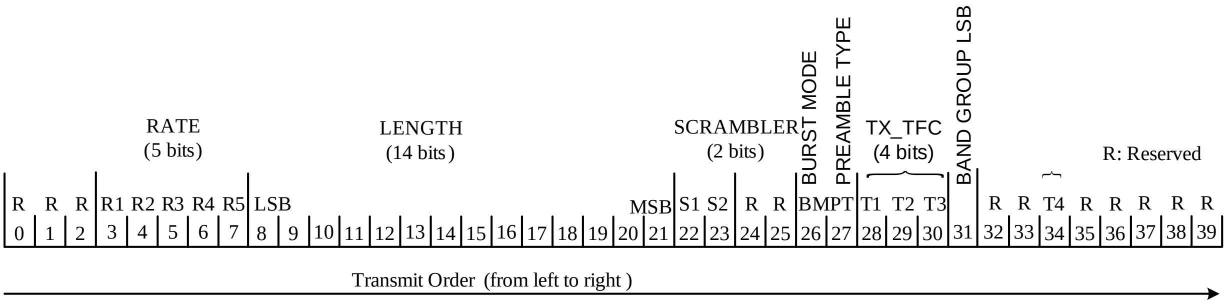

Fig. 6-8. PHY Header bit assignment

6.3.1.1 Data rate field (RATE)

Depending on the data rate (RATE), bits R1-R5 shall be set according to the values in Table 6-17.

TABLE 6-17. Rate Dependent Parameters

Rate (Mb/s)	Coding scheme used	R1 - R5
53.3	CC	00000
80	CC	00001
106.7	CC	00010
160	CC	00011
200	CC	00100
320	CC	00101
400	CC	00110
480	CC	00111
640	LDPC	01000
800	LDPC	01001
960	LDPC	01010
1024	LDPC	01011
Reserved		01100-10010
160	LDPC	10011
200	LDPC	10100
320	LDPC	10101
400	LDPC	10110
480	LDPC	10111
Reserved		11000-11111

The LENGTH and RATE fields together shall not indicate a PSDU duration exceeding 1024µs.

6.3.1.2 PLCP length field (LENGTH)

The PLCP length field shall be an unsigned 14-bit integer that indicates the number of octets in the frame payload (which does not include the FCS, the tail bits, or the pad bits). The LENGTH and RATE fields together shall not indicate a PSDU duration exceeding $1024\mu s$.

6.3.1.3 PLCP scrambler field (SCRAMBLER)

The MAC shall set bits S1-S2 according to the scrambler seed identifier value. This two-bit value corresponds to the seed value chosen for the data scrambler.

6.3.1.4 Burst Mode (BM) field

The MAC shall set the burst mode (BM) bit, as defined in Table 6-18, to indicate whether the next packet is part of a packet “burst”, i.e. burst mode transmission. Support for transmission and reception of burst mode is mandatory. In burst mode, the inter-frame spacing shall be equal to pMIFSTime (see Section 7.3).

In burst mode, the minimum value of LENGTH shall be 1; while, in standard mode, the minimum value of LENGTH shall be 0.

TABLE 6-18. Burst Mode field

Burst Mode (BM) bit	Next Packet Status
0	Next packet *is not* part of burst
1	Next packet *is* part of burst

6.3.1.5 Preamble Type (PT) field

The MAC shall set the preamble type (PT) bit in burst mode to indicate the type of PLCP preamble (standard or burst) used in the next packet according to Table 6-19. For data rates of 200 Mb/s and below, the PT bit shall be always set to zero (consistent with Section 6.2).

The preamble type bit only has meaning during a burst mode transmission. When devices are not in a burst mode transmission, the value of the preamble type bit shall be set to zero.

TABLE 6-19. Preamble Type field

Preamble Type (PT) bit	Type of Preamble Used for Next Packet
0	Standard Preamble
1	Burst Preamble

6.3.1.6 TFC Used at the Transmitter (TX_TFC) field

The MAC shall configure the TX_TFC field to indicate the time-frequency code used at the transmitter for the current packet. Depending on the time-frequency code used, bits T1-T4 shall be set according to the values in Table 6-20.

TABLE 6-20. Encoding of the TX_TFC field

TFC	T1 - T4
1	1000
2	0100
3	1100
4	0010
5	1010
6	0110
7	1110
8	0001
9	1001
10	0101
Reserved	all other values

6.3.1.7 LSB of Band Group Used at the Transmitter (BG_LSB) field

The MAC shall configure the BG_LSB field to indicate the LSB of the band group used at the transmitter for the current packet. Depending on the band group used at the transmitter, bit BG_LSB shall be set according to the values in Table 6-21.

TABLE 6-21. Encoding of the BG_LSB field

Band Group	Band Group LSB (BG_LSB)
1, 3, 5	1
2, 4, 6	0

6.3.2 Reed-Solomon Outer Code for the PLCP header

The PLCP header shall use a systematic (23, 17) Reed-Solomon outer code to improve upon the robustness of the $R = 1/3$, $K = 7$ inner convolutional code. The Reed-Solomon code is defined over $GF(2^8)$ with a primitive polynomial $p(z) = z^8 + z^4 + z^3 + z^2 + 1$, where α is the root of the polynomial $p(z)$. For brevity, this Galois field is denoted as F. As notation, the element $M = b_7z^7 + b_6z^6 + b_5z^5 + b_4z^4 + b_3z^3 + b_2z^2 + b_1z + b_0$, where $M \in F$, has the following binary representation $b_7b_6b_5b_4b_3b_2b_1b_0$, where b_7 is the MSB and b_0 is the LSB.

The generator polynomial is obtained by shortening a systematic (255, 249) Reed-Solomon code, which is specified by the generator polynomial:

$$g(x) = \prod_{i=1}^{6} (x - \alpha^i) = x^6 + 126x^5 + 4x^4 + 158x^3 + 58x^2 + 49x + 117, \qquad (6\text{-}5)$$

where $g(x)$ is the generator polynomial over F, $x \in F$ and the coefficients are given in decimal notation.

The mapping of the information bytes $\boldsymbol{m} = (m_{248}, m_{247}, \ldots, m_0)$ to codeword bytes $\boldsymbol{c} = (m_{248}, m_{247}, \ldots, m_0, r_5, r_4, \ldots, r_0)$ is achieved by computing the remainder polynomial $r(x)$,

$$r(x) = \sum_{i=0}^{5} r_i x^i = x^6 m(x) \bmod g(x), \qquad (6\text{-}6)$$

where $m(x)$ is the information polynomial:

$$m(x) = \sum_{i=0}^{248} m_i x^i, \qquad (6\text{-}7)$$

and r_i, $i = 0, \dots, 5$, and m_i, $i = 0, \dots, 248$, are elements of F.

The shortening operation pre-appends 232 zero elements to the incoming 17 octet message as follows:

$$m_i = 0, i = 17, \dots, 248, \tag{6-8}$$

where the 17 bytes message is formed by concatenating the 5 octets from the PHY header to the 12 octets from the scrambled MAC header and HCS. The message order is as follows: m_{16} is the first octet of the PHY header, m_{15} is the second octet of the PHY, m_{12} is the last octet of the PHY, m_{11} is the first octet of the scrambled MAC header and HCS, and m_0 is the last octet of the scrambled MAC header and HCS. The bit mapping within the PLCP header is LSB first, such that the first bit of the PLCP header (or PHY header) is mapped to the LSB of m_{16}, the 9th bit of the PLCP header is mapped to the LSB of m_{15} and so on. The order of parity octets is as follows: r_5 is the first octet, r_4 is the second octet and r_0 is the last octet of the Reed-Solomon parity section. Again, the mapping within the Reed-Solomon parity section of the PLCP header is LSB first, such that the first bit of the Reed-Solomon parity is mapped to the LSB of r_5, the 9th bit of the Reed-Solomon parity is mapped to the LSB of r_4 and so on. A shift-register implementation of this operation is shown in Fig. 6-9, with additions and multiplications over F. After m_0 has been inserted into the shift register, the switch shall be moved from the message polynomial input connection to the shift register output connection (right-to-left).

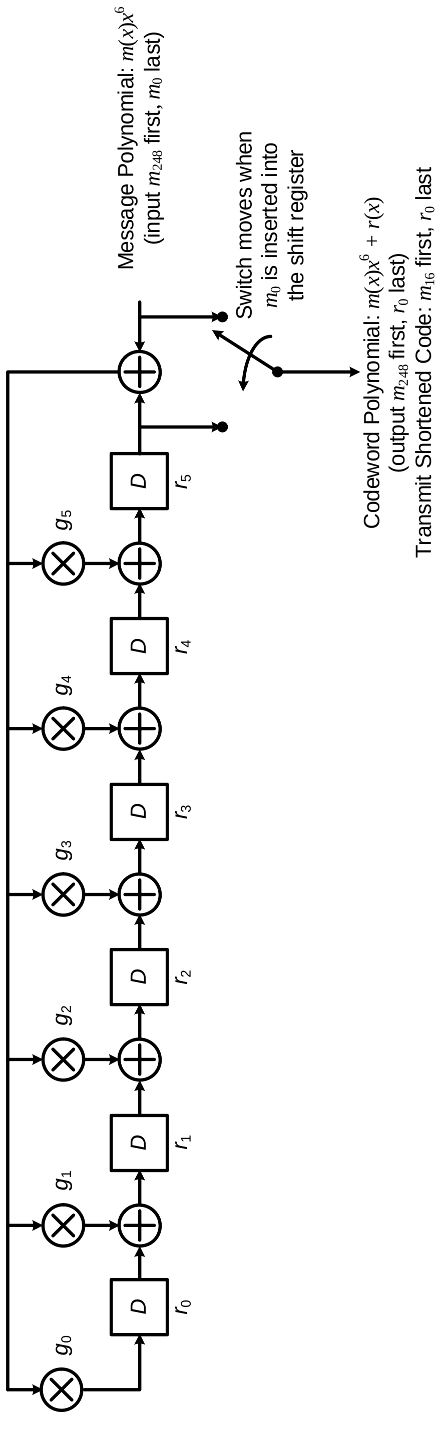

Fig. 6-9. Shift-register implementation of systematic Reed-Solomon encoder

6.3.3 Header Check Sequence

The combination of PHY header and the MAC header shall be protected with a 2 octet CCITT CRC-16 header check sequence (HCS). The CCITT CRC-16 HCS shall be the ones complement of the remainder generated by the modulo-2 division of the combined PHY and MAC headers by the polynomial: $x^{16} + x^{12} + x^{5} + 1$. The HCS bits shall be processed in the transmit order. All HCS calculations shall be made prior to data scrambling. A schematic of the processing order is shown in Fig. 6-10. The registers shall be initialized to all ones.

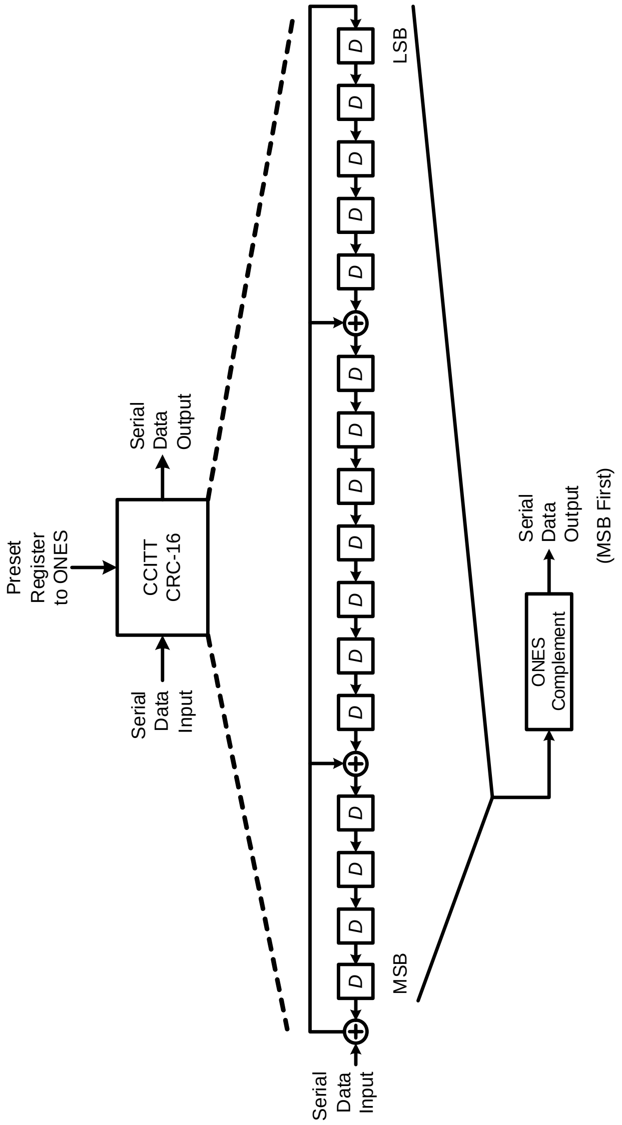

Fig. 6-10. CCITT CRC-16 block diagram

6.4 PSDU

The PSDU is the last major component of the PPDU and shall be constructed as shown in Fig. 6-11:

1. Form the non-scrambled PSDU by appending the frame payload with the 4-octet FCS, N_{tail} tail bits, and a sufficient number of pad bits (see Section 6.4.1) in order to ensure that the PSDU is aligned on the interleaver boundary for data rates that use CC, and on the LDPC codeword boundary for data rates that use LDPC.
2. The resulting combination is scrambled according to Section 6.5.
3. For data rates that use CC the N_{tail} tail bits in the PSDU shall be produced by replacing the N_{tail} scrambled “zero” bits with N_{tail} non-scrambled “zero” bits (see Section 6.6).

For data rates that use CC the resulting scrambled PSDU is encoded, as shown in Fig. 6-11, using a $R = 1/3$, $K = 7$ convolutional code and punctured to achieve the appropriate coding rate (see Section 6.7), interleaved using a bit interleaver (see Section 6.8), and mapped onto either a QPSK or DCM constellation (see Section 6.9).

For data rates that use LDPC the resulting scrambled PSDU shall be encoded by means of an LDPC code of the appropriate coding rate as described in Section 6.11. The resulting coded bits shall be mapped onto either a QPSK or a DCM or an MDCM constellation (see Section 6.9).

Finally, the resulting complex values are loaded onto the data subcarriers of the OFDM symbol (see Section 6.10) in order to create the real or complex baseband signal, depending on the desired data rate.

Tone nulling (see Section 5.2), if implemented, is then applied.

When the PLCP length field (i.e., the length of the frame payload) is zero, the length of the PSDU shall also be zero.

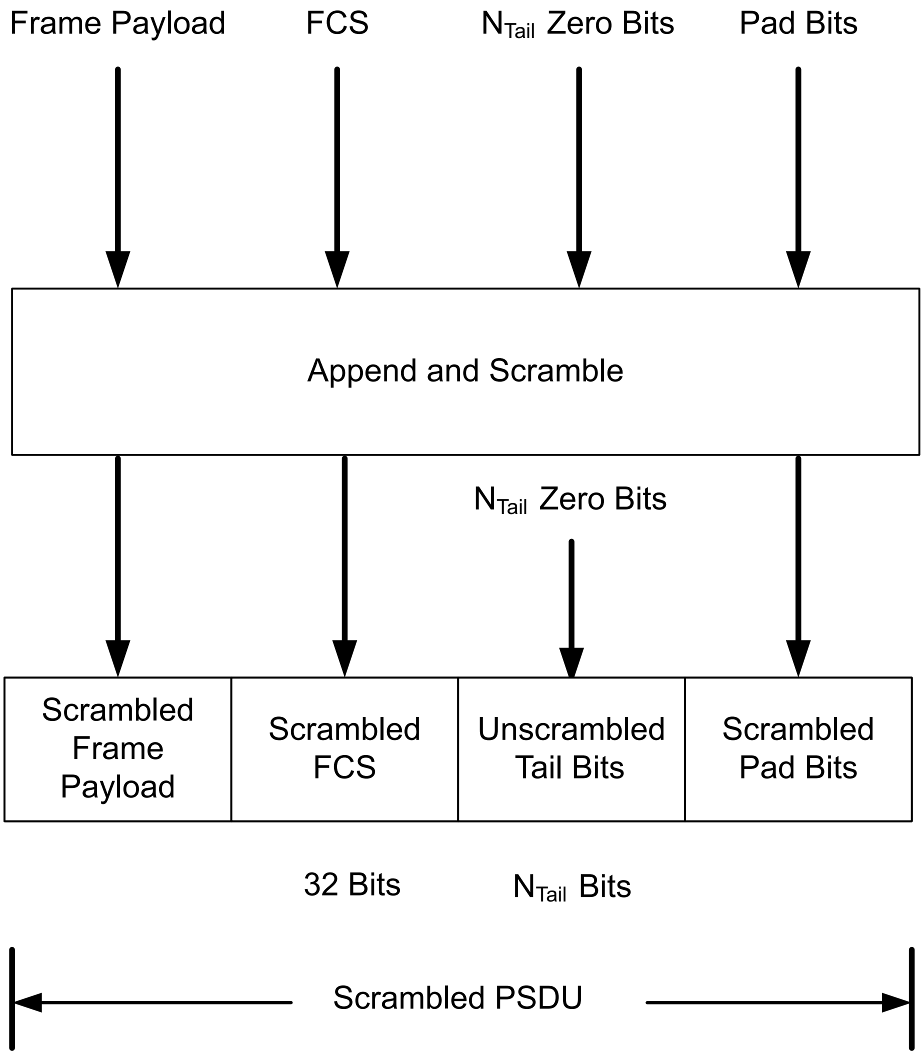

Fig. 6-11. Block diagram of PSDU construction

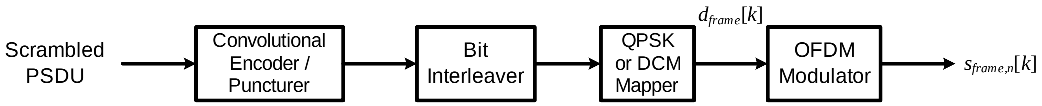

Fig. 6-12. Block diagram of the encoding process for the scrambled PSDU

6.4.1 Pad bits

For data rates that use CC N_{pad} pad bits shall be appended after the tail bits prior to scrambling and encoding in order to ensure that the resulting PSDU is aligned with the boundaries of the bit interleaver defined in Section 6.8.

For data rates that use LDPC N_{pad} pad bits shall be appended after the 32 FCS bits prior to scrambling and encoding in order to ensure that the resulting PSDU is aligned with the boundaries of an LDPC codeword.

The appended pad bits shall be set to "zeros" and scrambled with the rest of the PSDU.

6.5 Data Scrambler

A side-stream scrambler shall be used to whiten only portions of the PLCP header, i.e., the MAC header and HCS and the entire PSDU. In addition, the scrambler shall be initialized to a seed value specified by the MAC at the beginning of the MAC header and then re-initialized to the same seed value at the beginning of the PSDU.

The polynomial generator, $g(D)$, for the pseudo-random binary sequence (PRBS) generator shall be: $g(D) = 1 + D^{14} + D^{15}$, where D is a single bit delay element. Using this generator polynomial, the corresponding PRBS, $x[n]$, is generated as:

$$x[n] = x[n-14] \oplus x[n-15],\ n = 0, 1, 2, \ldots \qquad (6\text{-}9)$$

where "⊕" denotes modulo-2 addition. The following sequence defines the initialization vector, x_{init}, which is specified by the parameter "seed value" in Table 6-22:

$$x_{init} = \begin{bmatrix} x_i[-1] & x_i[-2] & \ldots & x_i[-14] & x_i[-15] \end{bmatrix}, \qquad (6\text{-}10)$$

where $x_i[-k]$ represents the binary initial value at the output of the k^{th} delay element. The scrambled data bits, v_m, are obtained as shown in Fig. 6-13:

$$v[m] = s[m] \oplus x[m],\ m = 0, 1, 2, \ldots \qquad (6\text{-}11)$$

where $s[m]$ represents the non-scrambled data bits. The side-stream de-scrambler at the receiver shall be initialized with the same initialization vector, x_{init}, used in the transmitter scrambler. The initialization vector is determined from the seed identifier contained in the PLCP header of the received frame.

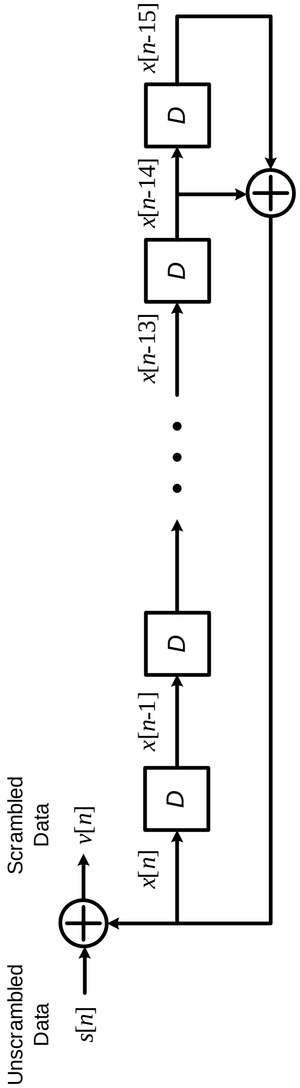

Fig. 6-13. Block diagram of the side-stream scrambler

The 15-bit initialization vector or seed value shall correspond to the seed identifier as shown in Table 6-22. The MAC shall set the seed identifier value to 00 when the PHY is initialized and this value shall be incremented in a 2-bit rollover counter for *each* frame sent by the PHY.

All consecutive packets, including retransmissions, shall be sent with a different initial seed value.

TABLE 6-22. Scrambler seed selection

Seed Identifier (S1, S2)	Seed Value $x_{init} = x_i[-1]\ x_i[-2] \ldots x_i[-15]$	PRBS Output First 16 bits $x[0]\ x[1] \ldots x[15]$
00	0011 1111 1111 111	0000 0000 0000 1000
01	0111 1111 1111 111	0000 0000 0000 0100
10	1011 1111 1111 111	0000 0000 0000 1110
11	1111 1111 1111 111	0000 0000 0000 0010

6.6 Tail bits

For data rates that use CC the tail bit fields are required to return the convolutional encoder to the zero state. This procedure reduces the error probability of the convolutional decoder, which relies on the future bits when decoding the message stream. The tail bit fields after the PHY header and the HCS shall consist of six non-scrambled zeros, and the tail bit field after the Reed-Solomon parity bit field shall be a punctured tail bit sequence consisting of four non-scrambled zeros.

The tail bit field following the scrambled frame check sequence shall be produced by replacing the six scrambled zero bits with six non-scrambled zero bits.

6.7 Convolutional Encoder

The convolutional encoder shall use the rate $R = 1/3$ code with generator polynomials, $g_0 = 133_8$, $g_1 = 165_8$, and $g_2 = 171_8$, as shown in Fig. 6-14. The bit denoted as “A” shall be the first bit generated by the encoder, followed by the bit denoted as “B”, and finally, by the bit denoted as “C”. Additional coding rates are derived from the “mother” rate $R = 1/3$ convolutional code by employing “puncturing”. Puncturing is a procedure for omitting some of the encoded bits at the transmitter (thus reducing the number of transmitted bits and increasing the coding rate) and inserting a dummy “zero” metric into the decoder at the receiver in place of the omitted bits. The puncturing patterns are illustrated in Fig. 6-15 through Fig. 6-17. In each of these cases, the tables shall be filled in with encoder output bits from left to right. For the last block of bits, the process shall be stopped at the point at which encoder output bits are exhausted, and the puncturing pattern applied to the partially filled block.

The PLCP header shall be encoded using a coding rate of $R = 1/3$. The encoder shall start from the all-”zero state”. After the encoding process for the PLCP header has been completed, the encoder shall be reset to the all-”zero state” before the encoding starts for the PSDU; in other words, the encoding of the PSDU shall also start from the all-”zero state”. The PSDU shall be encoded using the appropriate coding rate of $R = 1/3$, $1/2$, $5/8$, or $3/4$.

Decoding by the Viterbi algorithm is recommended.

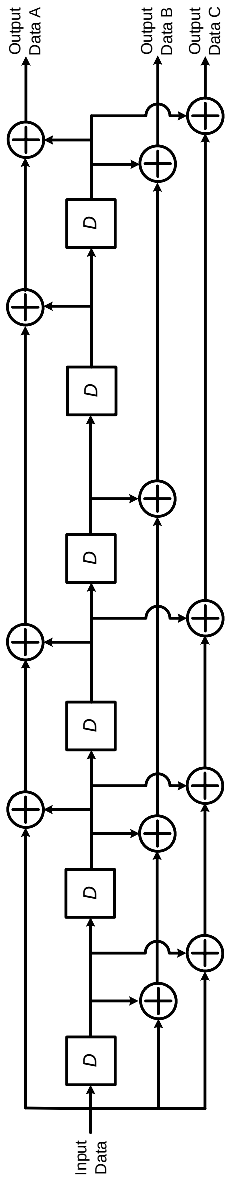

Fig. 6-14. Convolutional encoder: rate $R = 1/3$, constraint length $K = 7$

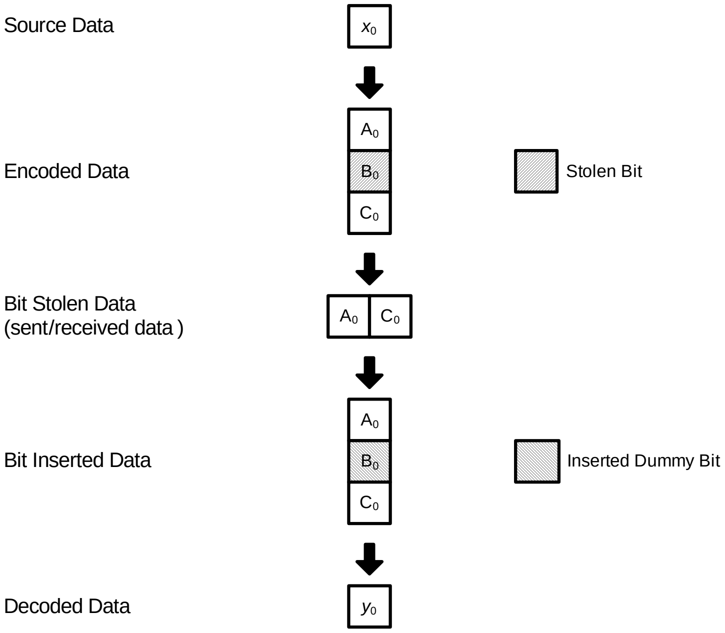

Fig. 6-15. An example of bit-stealing and bit-insertion for $R = 1/2$ code

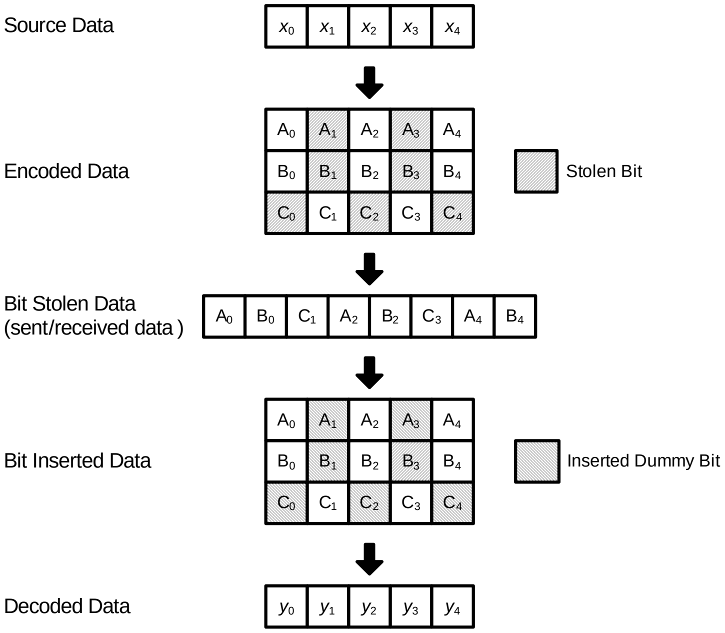

Fig. 6-16. An example of bit-stealing and bit-insertion for $R = 5/8$ code

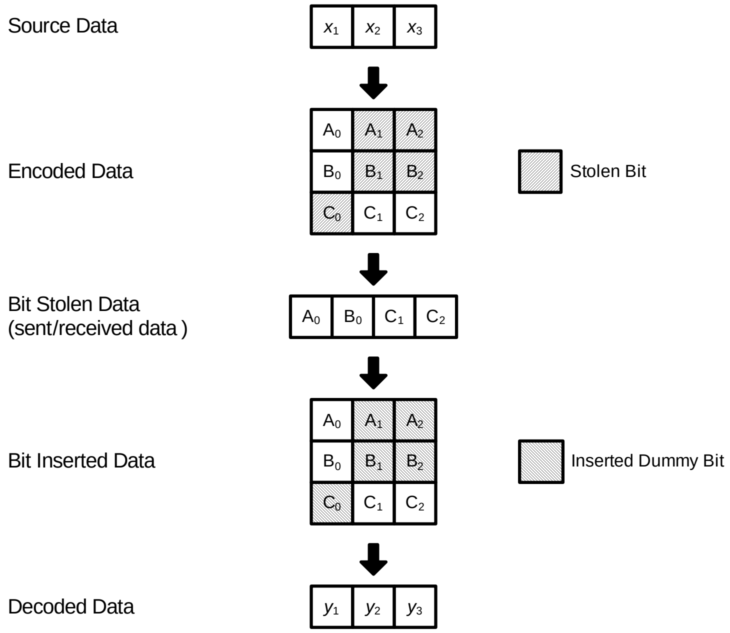

Fig. 6-17. An example of bit-stealing and bit-insertion for $R = 3/4$ code

6.8 Bit interleaving

For data rates that use CC the coded and padded bit stream shall be interleaved prior to modulation to provide robustness against burst errors. The bit interleaving operation is performed in three distinct stages, as shown in Fig. 6-18:

1. Symbol interleaving, which permutes the bits across 6 consecutive OFDM symbols, enables the PHY to exploit frequency diversity within a band group.
2. Intra-symbol tone interleaving, which permutes the bits across the data subcarriers within an OFDM symbol, exploits frequency diversity across subcarriers and provides robustness against narrow-band interferers.
3. Intra-symbol cyclic shifts, which cyclically shift the bits in successive OFDM symbols by deterministic amounts, enables modes that employ time-domain spreading and the fixed frequency interleaving (FFI) modes to better exploit frequency diversity.

The additional parameters needed by the interleaver are listed in Table 6-23 as a function of the data rate.

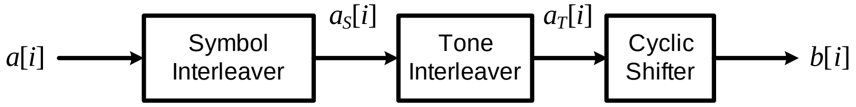

Fig. 6-18. A block diagram of the various stages of the bit interleaver

TABLE 6-23. Parameters for the interleaver

Data Rate (Mb/s)	TDS Factor (N_{TDS})	Coded Bits / OFDM Symbol (N_{CBPS})	Tone Interleaver Block Size (N_{Tint})	Cyclic Interleaver Shift (N_{cyc})
53.3	2	100	10	33
80	2	100	10	33
106.7	2	200	20	66
160	2	200	20	66
200	2	200	20	66
320	1	200	20	33
400	1	200	20	33
480	1	200	20	33

The symbol interleaving operation is performed by first grouping the coded bits into blocks of N_{CBP6S} bits (corresponding to six “on-air” OFDM symbols) and then using a block interleaver of size N_{CBPS} by $6/N_{TDS}$ to permute the coded bits. Let the sequences $a[i]$ and $a_S[i]$, where $i = 0, \ldots, N_{CBP6S} - 1$, represent the input and output bits of the symbol block interleaver, respectively. The output of the symbol block interleaver is given by the following relationship:

$$a_S[i] = a\left[\left\lfloor \frac{i}{N_{CBPS}} \right\rfloor + \left(\frac{6}{N_{TDS}}\right) \times \mathrm{mod}(i, N_{CBPS})\right] , \qquad \text{(6-12)}$$

where $\lfloor\cdot\rfloor$ is the floor function, which returns the largest integer value less than or equal to its argument value, and mod(a,b) is the modulus operator, which returns the non-negative integer remainder when a is divided by b.

The output of the symbol interleaver, which is grouped together into blocks of N_{CBPS} bits, is then permuted using a regular block intra-symbol interleaver of size $N_{Tint} \times 10$. Let the sequences $a_S[j]$ and $a_T[j]$, where $j = 0, \ldots, N_{CBPS} - 1$, represent the input and output bits of the tone interleaver, respectively. The output of the tone interleaver is given by the following relationship:

$$a_T[j] = a_S\left[\left\lfloor\frac{j}{N_{Tint}}\right\rfloor + 10 \times \mathrm{mod}(j, N_{Tint})\right] \quad . \tag{6-13}$$

The output of the tone interleaver is then passed through an intra-symbol cyclic shifter, which consists of a different cyclic shift for each block of N_{CBPS} bits within the span of the symbol interleaver. Let the sequences $a_T[i]$ and $b[i]$, where $i = 0, \ldots, N_{CBP6S} - 1$, represent the input and output bits of the cyclic shifter, respectively. The output of the cyclic shifter is given by the following relationship:

$$b[i] = a_T\left[m(i) \times N_{CBPS} + \mathrm{mod}(i + m(i) \times N_{cyc}, N_{CBPS})\right] \quad , \tag{6-14}$$

where $m(i) = \lfloor i / N_{CBPS} \rfloor$, where $i = 0, \ldots, N_{CBP6S} - 1$.

6.9 Constellation Mapping

The section describes the techniques for constellation mapping. For rates that use CC the input to constellation mapping is the coded and interleaved binary serial data $b[i]$ as described in Section 6.8. For rates that use LDPC the input to the constellation mapping is the coded binary serial data $b[i]$ as described in Section 6.11. For data rates 200 Mb/s and lower, the binary data shall be mapped onto a QPSK constellation. For data rates 320, 400 and 480 Mb/s, the binary data shall be mapped onto a four-dimensional constellation using a dual-carrier modulation (DCM) technique. For data rates 640 Mb/s and higher the binary data shall be mapped onto a four-dimensional constellation using a modified dual-carrier modulation (MDCM) technique.

6.9.1 QPSK

The input data, $b[i]$ where $i = 0, 1, 2, \ldots$, shall be divided into groups of two bits and converted into a complex number representing one of the four QPSK constellation points. The conversion shall be performed according to the Gray-coded constellation mapping, illustrated in Fig. 6-19, with the input bit, $b[2k]$ where $k = 0, 1, 2, \ldots$, being the earliest of the two in the stream. The output values, $d[k]$ where $k = 0, 1, 2, \ldots$, are formed by multiplying $(2\times b[2k]-1) + j(2\times b[2k+1]-1)$ value by a normalization factor of K_{MOD}, as described in the following equation:

$$d[k] = K_{MOD} \times \left[(2\times b[2k]-1) + j(2\times b[2k+1]-1)\right], \text{ where } k = 0, 1, 2, \ldots, \tag{6-15}$$

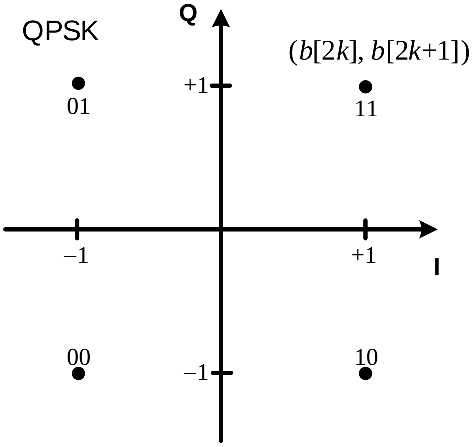

Fig. 6-19. QPSK constellation bit encoding

The normalization factor $K_{MOD} = 1/\sqrt{2}$ for a QPSK constellation. In practical implementations, an approximate value of the normalization factor can be used, as long as the device conforms to the modulation accuracy requirements. For QPSK, $b[2k]$ determines the I value, and $b[2k+1]$ determines the Q value, as illustrated in Table 6-24.

TABLE 6-24. QPSK encoding table

Input Bit ($b[2k]$, $b[2k+1]$)	*I*-out	*Q*-out
00	–1	–1
01	–1	1
10	1	–1
11	1	1

6.9.2 Dual-carrier modulation (DCM)

The input data, $b[i]$ where $i = 0, 1, 2, \ldots$, shall be divided into groups of 200 bits and converted into 100 complex numbers using a technique called dual-carrier modulation. The conversion shall be performed as follows:

1. The 200 coded bits are grouped into 50 groups of 4 bits. Each group is represented as $(b[g(k)], b[g(k)+1], b[g(k) + 50], b[g(k) + 51])$, where $k \in [0, 49]$ and

$$g(k) = \begin{cases} 2k & k \in [0, 24] \\ 2k + 50 & k \in [25, 49] \end{cases} . \qquad (6\text{-}16)$$

2. Each group of 4 bits ($b[g(k)]$, $b[g(k)+1]$, $b[g(k) + 50]$, $b[g(k) + 51]$) shall be mapped onto a four-dimensional constellation, as shown in Fig. 6-20, and converted into two complex numbers ($d[k]$, $d[k + 50]$). The mapping between bits and constellation is enumerated in Table 6-26.
3. The complex numbers shall be normalized using a normalization factor K_{MOD}.

The normalization factor $K_{MOD} = 1/\sqrt{10}$ is used for the dual-carrier modulation. In practical implementations, an approximate value of the normalization factor can be used, as long as the device conforms to the modulation accuracy requirements.

6.9.3 Modified dual-carrier modulation (MDCM)

The LDPC coded binary serial input data, $b[i]$ where i = 0, 1, 2, ..., shall be divided into groups of 400 bits and converted into 100 complex numbers using a technique called modified dual-carrier modulation.
The conversion shall be performed as follows:

1. The 400 bits are grouped into 50 groups of 8 bits. Each group is represented as $b[8 \times k], b[8 \times k + 1], \ldots, b[8 \times k + 7]$ where $k \in [0, 49]$.
2. Each group of 8 bits shall be converted into two complex numbers $(d[k], d[k + 50])$. These values are generated by means of two intermediate values x_a and x_b which are determined by the values in Table 6-25. The value x_a is generated using the input bits $b[8 \times k], \ldots, b[8 \times k + 3]$. The x_b value is generated using the input bits $b[8 \times k + 4], \ldots, b[8 \times k + 7]$. The values $d[k]$ and $d[k + 50]$ are then created by the formula:

$$\begin{bmatrix} d[k] \\ d[k+50] \end{bmatrix} = \begin{bmatrix} 4 & 1 \\ 1 & -4 \end{bmatrix} \begin{bmatrix} x_a \\ x_b \end{bmatrix} \tag{6-17}$$

TABLE 6-25. Modified dual-carrier modulation intermediate value encoding table

input bits	I-out	Q-out	input bits	I-out	Q-out
0000	-3	-3	1000	3	-3
0001	-3	-1	1001	3	-1
0010	-3	3	1010	3	3
0011	-3	1	1011	3	1
0100	-1	-3	1100	1	-3
0101	-1	-1	1101	1	-1
0110	-1	3	1110	1	3
0111	-1	1	1111	1	1

As an example, if the bits $b[8 \times k], b[8 \times k + 1], \ldots, b[8 \times k + 7]$ are 11001010 then x_a and x_b are $(1 - 3j)$ and $(3 + 3j)$ respectively; and $d[k]$ and $d[k + 50]$ are $(7 - 9j)$ and $(-11 - 15j)$ respectively.

3. The complex numbers $d[k]$ and $d[k + 50]$ shall be normalized using the normalization factor K_{MOD}.

The normalization factor $K_{MOD} = 1/\sqrt{170}$ is used for the modified dual-carrier modulation. In practical implementations, an approximate value of the normalization factor can be used, as long as the device conforms to the modulation accuracy requirements.

The LDPC coded extension parity data, $b_G[i]$ where i = 0, 1, 2, ... shall be divided into groups of 40 bits and converted into 10 complex numbers using the same technique.

1. The 40 bits are grouped into 5 groups of 8 bits. Each group is represented as $b[8 \times k], b[8 \times k + 1], \ldots, b[8 \times k + 7]$ where $k \in [0, 4]$.
2. Each group of 8 bits shall be converted into two complex numbers $(d_G[k], d_G[k + 5])$ using the process described above.

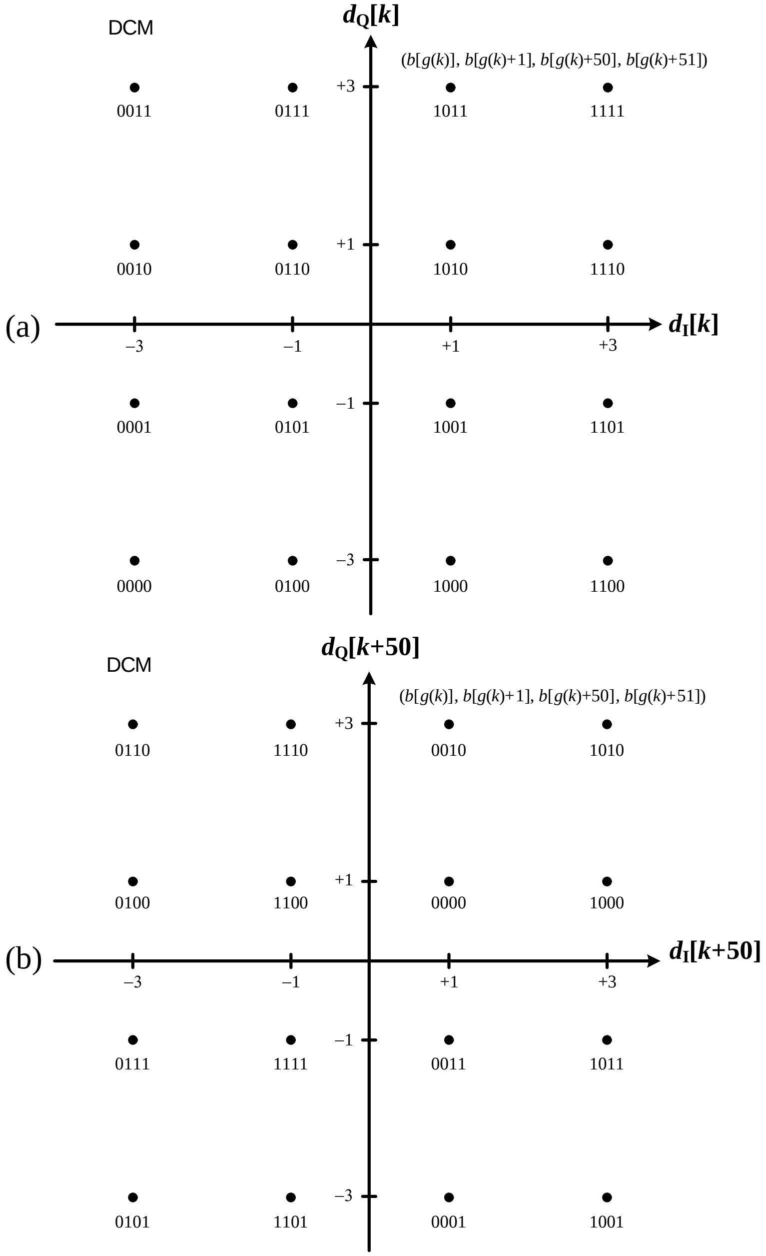

Fig. 6-20. DCM encoding: (a) mapping for $d[k]$; (b) mapping for $d[k+50]$

TABLE 6-26. Dual-carrier modulation encoding table

Input Bit ($b[g(k)]$, ($b[g(k)+1]$, ($b[g(k)+50]$), ($b[g(k)+51]$)	$d[k]$ *I*-out	$d[k]$ *Q*-out	$d[k+50]$ *I*-out	$d[k+50]$ *Q*-out
0000	-3	-3	1	1
0001	-3	-1	1	-3
0010	-3	1	1	3
0011	-3	3	1	-1
0100	-1	-3	-3	1
0101	-1	-1	-3	-3
0110	-1	1	-3	3
0111	-1	3	-3	-1
1000	1	-3	3	1
1001	1	-1	3	-3
1010	1	1	3	3
1011	1	3	3	-1
1100	3	-3	-1	1
1101	3	-1	-1	-3
1110	3	1	-1	3
1111	3	3	-1	-1

6.10 OFDM Modulation

The discrete-time signal, $s_n[k]$, shall be created by taking the IDFT of the stream of complex values as follows:

$$s_n[k] = \frac{1}{\sqrt{N_{FFT}}}\left[\sum_{l=0}^{N_D} C_{D,n}[l]\exp(j2\pi M_D[l]k/N_{FFT}) + \right.$$

$$\left.\sum_{l=0}^{N_G} C_{G,n}[l]\exp(j2\pi M_G[l]k/N_{FFT}) + \sum_{l=0}^{N_P} C_{P,n}[l]\exp(j2\pi M_P[l]k/N_{FFT})\right], \qquad (6\text{-}18)$$

where $k \in [0, N_{FFT} - 1]$, $n \in [N_{sync}, N_{packet} - 1]$, N_D is the number of data subcarriers, N_G is the number of guard subcarriers, N_P is the number of pilot subcarriers, N_{FFT} is the number of total subcarriers, and $C_{D,n}[l]$, $C_{G,n}[l]$, $C_{P,n}[l]$ are the complex numbers placed on the l^{th}

data, guard, and pilot subcarriers of the n^{th} OFDM symbol, respectively. The relationship between $C_{D,n}[l]$ and $C_{G,n}[l]$, and the stream of complex values is defined in Section 6.10.2 and Section 6.10.3. The values for $C_{P,n}[l]$ are defined in Section 6.10.4. Functions $M_D[l]$, $M_G[l]$ and $M_P[l]$ define a mapping from indices $[0, N_D - 1]$, $[0, N_G - 1]$ and $[0, N_P - 1]$ to logical frequency subcarriers $[-N_T/2, N_T/2]$ excluding 0, respectively. The exact definitions for the mapping functions $M_D[l]$, $M_G[l]$, and $M_P[l]$ are given below:

$$M_D[l] = \begin{cases} l - 56 & l = 0 \\ l - 55 & 1 \le l \le 9 \\ l - 54 & 10 \le l \le 18 \\ l - 53 & 19 \le l \le 27 \\ l - 52 & 28 \le l \le 36 \\ l - 51 & 37 \le l \le 45 \\ l - 50 & 46 \le l \le 49 \\ l - 49 & 50 \le l \le 53 \\ l - 48 & 54 \le l \le 62 \\ l - 47 & 63 \le l \le 71 \\ l - 46 & 72 \le l \le 80 \\ l - 45 & 81 \le l \le 89 \\ l - 44 & 90 \le l \le 98 \\ l - 43 & l = 99 \end{cases} , \tag{6-19}$$

$$M_G[l] = \begin{cases} -61 + l & l \in \left[0, \dfrac{N_G}{2} - 1\right] \\ 52 + l & l \in \left[\dfrac{N_G}{2}, N_G - 1\right] \end{cases} , \tag{6-20}$$

$$M_P[l] = \quad -55 + 10l \qquad l \in [0, N_P - 1] \quad . \tag{6-21}$$

The mapping of the data, pilot and guard subcarriers within an OFDM symbol is illustrated in Fig. 6-21.

Finally, the discrete-time signals for the PLCP header, $s_{hdr,n}[k]$, and the PSDU, $s_{frame,n}[k]$, shall be created as follows by appending a zero-padded suffix (ZPS) to every IDFT output:

$$s_{hdr,n}[k] = \begin{cases} s_n[k] & k \in [0, N_{FFT} - 1] \\ 0 & k \in [N_{FFT}, N_{SYM} - 1] \end{cases} , \tag{6-22}$$

for $n \in [N_{sync}, N_{sync} + N_{hdr} - 1]$, and

$$s_{frame,n}[k] = \begin{cases} s_n[k] & k \in [0, N_{FFT} - 1] \\ 0 & k \in [N_{FFT}, N_{SYM} - 1] \end{cases} , \qquad (6\text{-}23)$$

for $n \in [N_{sync} + N_{hdr}, N_{packet} - 1]$. The zero-padded suffix is typically used to mitigate the effects of multi-path as well as to provide a time window or guard interval to allow the transmitter and receiver sufficient time to switch between the different center frequencies.

Within the OFDM modulation process, frequency-domain spreading within a symbol and time-domain spreading across two consecutive symbols is used to obtain further bandwidth expansion, beyond that provided by the forward error correction code and the time-frequency codes. Frequency-domain spreading entails transmitting the same information (complex number) on two separate subcarriers within the same OFDM symbol. Time-domain spreading involves transmitting the same information across two consecutive OFDM symbols. This technique is used to maximize frequency-diversity and to improve the performance in the presence of other non-coordinated devices.

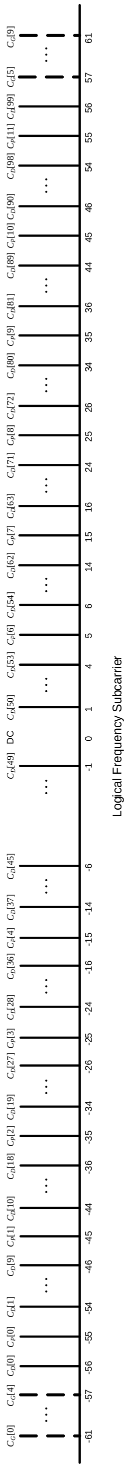

Fig. 6-21. Mapping from data, guard and pilot subcarriers to logical frequency subcarriers

6.10.1 Implementation Considerations

A common way to implement an inverse discrete Fourier transform is by using an inverse Fast Fourier Transform (IFFT) algorithm. In this example, the logical frequency subcarriers $[-N_T/2, N_T/2]$ shall be mapped according to Fig. 6-22. The logical frequency subcarriers 1 to 61 are mapped to the same numbered IFFT inputs, while the logical frequency subcarriers –61 to –1 are mapped into IFFT inputs 67 to 127, respectively. The rest of the inputs, 62 to 66 and the 0 (DC) input, are set to zero. The subcarrier falling at DC (0^{th} subcarrier) is not used to avoid difficulties in DAC and ADC offsets and carrier feed-through in the RF chain. In Fig. 6-22, d_n indicates logical frequency subcarrier n.

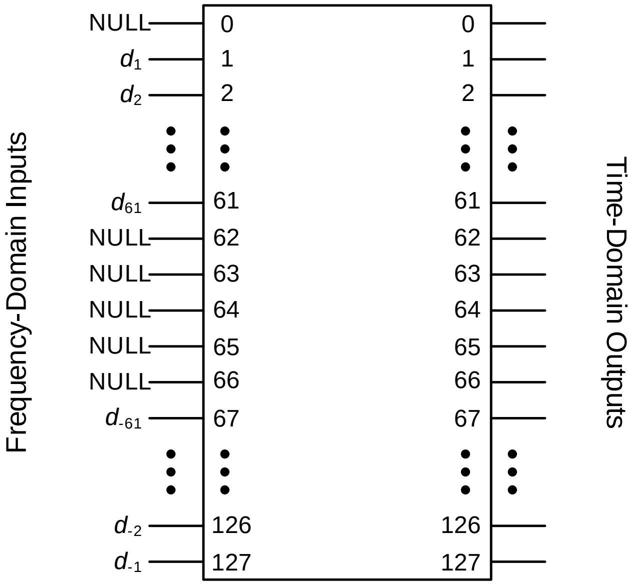

Fig. 6-22. Input and outputs relationship of the IFFT.

6.10.2 Data Subcarriers

The mapping between the stream of complex values and the data subcarriers is dependent on the portion of the PPDU and the data rate. In the following subsections, a detailed mapping between the stream of complex values and the data subcarriers is provided.

6.10.2.1 Mapping for PLCP Header

Both frequency-domain and time-domain spreading techniques shall be used for the PLCP header. For this case, the stream of complex values, $d_{hdr}[k]$, where $k = 0, 1, 2, \ldots,$

shall be the sequence $d[k]$ defined in Section 6.9.1 for the PLCP Header data. The stream $d_{hdr}[k]$ shall be grouped into sets of $N_D/2 = 50$ complex numbers. This group of complex values shall be mapped onto the l^{th} data subcarrier of the n^{th} OFDM symbol, $C_{D,n}[l]$, as follows:

$$C_{D,\,2n}[l] \;=\; d_{hdr}\left[\frac{N_D}{4}\times(2n-N_{sync})+l\right] \;, \tag{6-24}$$

$$C_{D,\,2n}\left[l+\frac{N_D}{2}\right] \;=\; d_{hdr}^{\;*}\left[\frac{N_D}{4}\times(2n-N_{sync})+\left(\frac{N_D}{2}-1-l\right)\right] \;, \tag{6-25}$$

$$C_{D,\,2n+1}[l] \;= p_{spread}[n]\times\; d_{hdr}\left[\frac{N_D}{4}\times(2n-N_{sync})+l\right] \;, \tag{6-26}$$

$$C_{D,\,2n+1}\left[l+\frac{N_D}{2}\right] \;= p_{spread}[n]\times\; d_{hdr}^{\;*}\left[\frac{N_D}{4}\times(2n-N_{sync})+\left(\frac{N_D}{2}-1-l\right)\right] \;, \tag{6-27}$$

where

$$p_{spread}[n] = \; p\left[\mathrm{mod}\left(n-\frac{N_{sync}}{2}+6,\, N_{FFT}-1\right)\right] \;, \tag{6-28}$$

and where $p[n]$ is a length 127 pseudo-random sequence, whose values are defined in Table 6-27, $l \in \left[0, \frac{N_D}{2}-1\right]$, $n \in \left[\frac{N_{sync}}{2}, \frac{N_{sync}+N_{hdr}}{2}-1\right]$, N_D is the number of data subcarriers, N_{sync} is the number of symbols in the PLCP preamble and N_{hdr} is the number of symbols in the PLCP header.

TABLE 6-27. Length 127 pseudo-random sequence

n	$p[n]$	n	$p[n]$	n	$p[n]$	n	$p[n]$
0	1	32	1	64	-1	96	-1
1	1	33	1	65	-1	97	-1
2	1	34	-1	66	1	98	-1
3	1	35	1	67	-1	99	-1
4	-1	36	1	68	1	100	-1
5	-1	37	-1	69	-1	101	1
6	-1	38	-1	70	1	102	-1
7	1	39	1	71	1	103	1
8	-1	40	1	72	-1	104	1
9	-1	41	1	73	-1	105	-1

TABLE 6-27. Length 127 pseudo-random sequence

10	-1	42	-1	74	-1	106	1
11	-1	43	1	75	1	107	-1
12	1	44	-1	76	1	108	1
13	1	45	-1	77	-1	109	1
14	-1	46	-1	78	-1	110	1
15	1	47	1	79	-1	111	-1
16	-1	48	-1	80	-1	112	-1
17	-1	49	1	81	1	113	1
18	1	50	-1	82	-1	114	-1
19	1	51	-1	83	-1	115	-1
20	-1	52	1	84	1	116	-1
21	1	53	-1	85	-1	117	1
22	1	54	-1	86	1	118	1
23	-1	55	1	87	1	119	1
24	1	56	1	88	1	120	-1
25	1	57	1	89	1	121	-1
26	1	58	1	90	-1	122	-1
27	1	59	1	91	1	123	-1
28	1	60	-1	92	-1	124	-1
29	1	61	-1	93	1	125	-1
30	-1	62	1	94	-1	126	-1
31	1	63	1	95	1		

6.10.2.2 Mapping for Data Rates of 53.3 and 80 Mb/s

Both frequency-domain and time-domain spreading techniques shall be used when the PSDU is encoded at a data rate of 53.3 or 80 Mb/s. For this case, the stream of complex values, $d_{frame}[k]$, where $k = 0, 1, 2, \ldots$, shall be the sequence $d[k]$ defined in Section 6.9.1 for the PSDU. The stream $d_{frame}[k]$ shall be grouped into sets of $N_D/2 = 50$ complex numbers. This group of complex values shall be mapped onto the l^{th} data subcarrier of the n^{th} OFDM symbol, $C_{D,n}[l]$, as follows:

$$C_{D,2n}[l] = d_{frame}\left[\frac{N_D}{4} \times (2n - N_{sync} - N_{hdr}) + l\right] \quad , \tag{6-29}$$

$$C_{D,2n}\left[l + \frac{N_D}{2}\right] = d_{frame}^{*}\left[\frac{N_D}{4} \times (2n - N_{sync} - N_{hdr}) + \left(\frac{N_D}{2} - 1 - l\right)\right] \quad , \tag{6-30}$$

$$C_{D,\,2n+1}[l] \;=\; p_{spread}[n] \times \quad d_{frame}\left[\frac{N_D}{4} \times (2n - N_{sync} - N_{hdr}) + l\right] \quad , \tag{6-31}$$

$$C_{D,\,2n+1}\left[l + \frac{N_D}{2}\right] \;=\; p_{spread}[n] \times \quad d_{frame}{}^{*}\left[\frac{N_D}{4} \times (2n - N_{sync} - N_{hdr}) + \left(\frac{N_D}{2} - 1 - l\right)\right] \quad , \tag{6-32}$$

where $p_{spread}[n]$ is defined in (6-28), $p[n]$ is defined in Table 6-27, $l \in \left[0, \frac{N_D}{2} - 1\right]$, $n \in \left[\frac{N_{sync} + N_{hdr}}{2}, \frac{N_{packet}}{2} - 1\right]$, N_D is the number of data subcarriers, N_{sync} is the number of symbols in the PLCP preamble, N_{hdr} is the number of symbols in the PLCP header and N_{packet} is the total number of symbols in the packet.

6.10.2.3 Mapping for Data Rates of 106.7, 160 and 200 Mb/s

Only time-domain spreading techniques shall be used when the PSDU is encoded at a data rate of 106.7, 160 or 200 Mb/s. For this case, the stream of complex values, $d_{frame}[k]$, where $k = 0, 1, 2, \ldots$, shall be the sequence $d[k]$ defined in Section 6.9.1 for the PSDU. The stream $d_{frame}[k]$ shall be grouped into sets of $N_D = 100$ complex numbers. This group of complex values shall be mapped onto the l^{th} data subcarrier of the n^{th} OFDM symbol, $C_{D,n}[l]$, as follows:

$$C_{D,\,2n}[l] \;=\; d_{frame}\left[\frac{N_D}{2} \times (2n - N_{sync} - N_{hdr}) + l\right] \quad , \tag{6-33}$$

$$\begin{aligned} C_{D,\,2n+1}[l] \;=\; p_{spread}[n] \times \quad & \left\{ imag\left(d_{frame}\left[\frac{N_D}{2} \times (2n - N_{sync} - N_{hdr}) + (N_D - 1 - l)\right]\right) \right. \\ & \left. + j \quad real\left(d_{frame}\left[\frac{N_D}{2} \times (2n - N_{sync} - N_{hdr}) + (N_D - 1 - l)\right]\right) \right\} \quad , \end{aligned} \tag{6-34}$$

where $p_{spread}[n]$ is defined in (6-28), $p[n]$ is defined in Table 6-27, $l \in [0, N_D - 1]$, $n \in \left[\frac{N_{sync} + N_{hdr}}{2}, \frac{N_{packet}}{2} - 1\right]$, N_D is the number of data subcarriers, N_{sync} is the number of symbols in the PLCP preamble, N_{hdr} is the number of symbols in the PLCP header and N_{packet} is the total number of symbols in the packet.

6.10.2.4 Mapping for Data Rates of 320, 400 and 480 Mb/s

No spreading techniques shall be used when the PSDU is encoded at a data rate of 320, 400 or 480 Mb/s. For this case, the stream of complex values, $d_{frame}[k]$, where $k = 0, 1, 2, \ldots$, shall be the sequence $d[k]$ defined in Section 6.9.2 for the PSDU. The stream $d_{frame}[k]$ shall be grouped into sets of $N_D = 100$ complex numbers. This group of complex values shall be mapped onto the l^{th} data subcarrier of the n^{th} OFDM symbol, $C_{D,n}[l]$, as follows:

$$C_{D,n}[l] = d_{frame}[N_D \times (n - N_{sync} - N_{hdr}) + l] \quad , \tag{6-35}$$

where $l \in [0, N_D - 1]$, $n \in [N_{sync} + N_{hdr}, N_{packet} - 1]$, N_D is the number of data subcarriers, N_{sync} is the number of symbols in the PLCP preamble, N_{hdr} is the number of symbols in the PLCP header and N_{packet} is the total number of symbols in the packet.

6.10.3 Guard Subcarriers

For each OFDM symbol, starting with the channel estimation sequence within the PLCP preamble, there shall be ten subcarriers, 5 on each edge of the occupied frequency band, allocated as guard subcarriers.

Individual implementations may exploit the guard subcarriers for various purposes, including relaxing the specs on analog transmit and analog receive filters, and possibly improving performance.

The relationship between the power levels of the guard subcarriers and that of the data subcarriers shall be implementation dependent. This relationship shall remain constant within a packet, i.e., from the start of the channel estimation sequence to the end of the packet. In addition, the power levels for the guard subcarriers shall be chosen in such a way as to ensure that the transmitted signal meets the local regulatory requirements of minimum occupied bandwidth and any other necessary regulatory conditions.

The 10 guard subcarriers are located on either edge of the OFDM symbol; at logical frequency subcarriers -61, -60, …, -57, and 57, 58, …, 61.

6.10.3.1 Mapping for PLCP Header & Data Rates of 480 Mb/s or Less

The data on these carriers shall be created by copying over the five outermost data-bearing subcarriers from the nearest edge of the OFDM symbol as shown below:

$$C_{G,n}[l] = \begin{cases} C_{D,n}[l] & l \in \left[0, \frac{N_G}{2} - 1\right] \\ C_{D,n}[l + 90] & l \in \left[\frac{N_G}{2}, N_G - 1\right] \end{cases}, \qquad (6\text{-}36)$$

where $C_{G,n}[l]$ is the l^{th} guard subcarrier of the n^{th} OFDM symbol, $n \in [N_{sync}, N_{packet}-1]$, N_{sync} is the number of symbols in the PLCP preamble and N_{packet} is the total number of symbols in the packet.

6.10.3.2 Mapping for Data Rates of 640 Mb/s and Higher

The data on these carriers shall be created from the stream of complex values, $d_{G,frame}[k]$, where $k = 0, 1, 2, \ldots$, shall be the sequence $d_G[k]$ defined in Section 6.9.3. for the PSDU. The stream $d_{G,frame}[k]$ shall be grouped into sets of $N_G = 10$ complex numbers. This group of complex values shall be mapped onto the l^{th} guard subcarrier of the n^{th} OFDM symbol, $C_{G,n}[l]$, as follows:

$$C_{G,n}[l] = d_{G,frame}[N_G \times (n - N_{sync} - N_{hdr}) + l]$$

where $l \in [0, N_G - 1]$, $n \in [N_{sync} + N_{hdr}, N_{packet} - 1]$, N_G is the number of guard subcarriers, N_{sync} is the number of symbols in the PLCP preamble, N_{hdr} is the number of symbols in the PLCP header and N_{packet} is the total number of symbols in the packet.

6.10.4 Pilot Subcarriers

In all of the OFDM symbols following the PLCP preamble, twelve of the subcarriers shall be dedicated to pilot signals in order to allow for coherent detection and to provide robustness against frequency offsets and phase noise. These pilot signals shall be placed in logical frequency subcarriers -55, -45, -35, -25, -15, -5, 5, 15, 25, 35, 45 and 55. The mapping between actual pilot sequence and the pilot subcarriers is dependent on the data portion of the PPDU and the information data rate. In the following subsections, a detailed mapping between the stream of complex values and the data subcarriers is provided.

6.10.4.1 Mapping for PLCP Header

During the PLCP header portion of the PPDU, the information for the l^{th} pilot subcarrier of the n^{th} OFDM symbol shall be defined as follows:

$$C_{P,2n}[l] = p\left[\mathrm{mod}\left(n - \frac{N_{sync}}{2}, N_{FFT} - 1\right)\right] \times d_{pilot,cs}[l], \tag{6-37}$$

$$C_{P,2n+1}[l] = p\left[\mathrm{mod}\left(n - \frac{N_{sync}}{2}, N_{FFT} - 1\right)\right] \times p_{spread}[n] \times d_{pilot,cs}[l], \tag{6-38}$$

where

$$d_{pilot,cs}[l] = \begin{cases} \frac{1-j}{\sqrt{2}} & l = 0, 3 \\ \frac{-1+j}{\sqrt{2}} & l = 1, 2, 4, 5 \\ \frac{1+j}{\sqrt{2}} & l = 8, 11 \\ \frac{-1-j}{\sqrt{2}} & l = 6, 7, 9, 10 \end{cases}, \tag{6-39}$$

and where $p[n]$ is defined in Table 6-27, $p_{spread}[n]$ is defined in (6-28), $n \in \left[\frac{N_{sync}}{2}, \frac{N_{sync} + N_{hdr}}{2} - 1\right]$, N_{sync} is the number of symbols in the PLCP preamble and N_{hdr} is the number of symbols in the PLCP header.

6.10.4.2 Mapping for Data Rates of 53.3 and 80 Mb/s

When the PPDU is encoded at a data rate of 53.3 or 80 Mb/s, the information for the l^{th} pilot subcarrier of the n^{th} OFDM symbol shall be defined as follows:

$$C_{P,2n}[l] = p\left[\mathrm{mod}\left(n - \frac{N_{sync}}{2}, N_{FFT} - 1\right)\right] \times d_{pilot,cs}[l], \tag{6-40}$$

$$C_{P,2n+1}[l] = p\left[\mathrm{mod}\left(n - \frac{N_{sync}}{2}, N_{FFT} - 1\right)\right] \times p_{spread}[n] \times d_{pilot,cs}[l], \tag{6-41}$$

where $d_{pilot,cs}[l]$ is defined in (6-39), $p[n]$ is defined in Table 6-27, $p_{spread}[n]$ is defined in (6-28), $n \in \left[\frac{N_{sync} + N_{hdr}}{2}, \frac{N_{packet}}{2} - 1\right]$, N_{sync} is the number of symbols in the PLCP preamble, N_{hdr} is the number of symbols in the PLCP header and N_{packet} is the total number of symbols in the packet.

6.10.4.3 Mapping for Data Rates of 106.7, 160 and 200 Mb/s

When the PPDU is encoded at a data rate of 106.7, 160 or 200 Mb/s, the information for the l^{th} pilot subcarrier of the n^{th} OFDM symbol shall be defined as follows:

$$C_{P,\,2n}[l] \;=\; p\left[\operatorname{mod}\left(n - \frac{N_{sync}}{2},\, N_{FFT} - 1\right)\right] \;\times d_{pilot,ncs}[l], \tag{6-42}$$

$$C_{P,\,2n+1}[l] \;=\; p\left[\operatorname{mod}\left(n - \frac{N_{sync}}{2},\, N_{FFT} - 1\right)\right] \;\times p_{spread}[n] \times d_{pilot,ncs}[l], \tag{6-43}$$

where

$$d_{pilot,ncs}[l] = \begin{cases} \dfrac{1+j}{\sqrt{2}} & l = 0, 3, 8, 11 \\ \dfrac{-1-j}{\sqrt{2}} & l = 1, 2, 4, 5, 6, 7, 9, 10 \end{cases} \quad , \tag{6-44}$$

and where $p[n]$ is defined in Table 6-27, $p_{spread}[n]$ is defined in (6-28), $n \in \left[\frac{N_{sync} + N_{hdr}}{2}, \frac{N_{packet}}{2} - 1\right]$, N_{sync} is the number of symbols in the PLCP preamble, N_{hdr} is the number of symbols in the PLCP header and N_{packet} is the total number of symbols in the packet.

6.10.4.4 Mapping for Data Rates of 320, 400 and 480 Mb/s

When the PPDU is encoded at a data rate of 320, 400 or 480 Mb/s, the information for the l^{th} pilot subcarrier of the n^{th} OFDM symbol shall be defined as follows:

$$C_{P,\,n}[l] \;=\; p\left[\operatorname{mod}\left(n - N_{sync} - \frac{N_{hdr}}{2},\, N_{FFT} - 1\right)\right] \;\times d_{pilot,ncs}[l], \tag{6-45}$$

where $d_{pilot,ncs}[l]$ is defined in (6-44), $p[n]$ is defined in Table 6-27, $n \in [N_{sync} + N_{hdr}, N_{packet} - 1]$, N_{sync} is the number of symbols in the PLCP preamble, N_{hdr} is the number of symbols in the PLCP header and N_{packet} is the total number of symbols in the packet.

6.11 LDPC Coding

The LDPC code is composed of a set of fundamental LDPC codes with block length 1200 bits. Each of the codes is a systematic linear block code, of rates 0.5, 0.625, 0.75 and 0.8. Each of these codes is expanded to a code of lower rate by adding an extra 120 parity bits, by expanding the parity-check matrix of the fundamental code as defined below. The extra parity bits are transmitted on the guard tones by data rates of 640 Mb/s and above. Utilizing the extra parity bits in the decoder is optional at the receiver side. Each LDPC code is defined by a parity-check matrix H of size $m \times n$, where n is the length of the code and m is the number of parity check bits in the code. The number of systematic bits is $k = n - m$.

The matrix **H** is defined as

$$H = \begin{bmatrix} P_{0,0} & P_{0,1} & P_{0,2} & \cdots & P_{0,n_b-1} \\ P_{1,0} & P_{1,1} & P_{1,2} & \cdots & P_{1,n_b-1} \\ P_{2,0} & P_{2,1} & P_{2,2} & \cdots & P_{2,n_b-1} \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ P_{m_b-1,0} & P_{m_b-1,1} & P_{m_b-1,2} & \cdots & P_{m_b-1,n_b-1} \end{bmatrix} \qquad (6\text{-}46)$$

where $P_{i,j}$ is one of a set of $z \times z$ permutation matrices or a $z \times z$ zero matrix, and $z = 30$. Each permutation matrix is a cyclically right shifted identity matrix, denoted as I^S for shift S, where S is an integer between 0 and $z-1$. Thus, the matrix **H** is composed of m_b block rows and n_b block columns, where $n = z \times n_b$ and $m = z \times m_b$. Hence, it can be concisely described by an $m_b \times n_b$ matrix where entry (*i,j*) contains either 0 if $P_{i,j} = 0$ or $1 + S$ if $P_{i,j} = I^S$. The matrix **H** for the coding rates 1/2, 5/8, 3/4, 4/5 are provided in tables 6-29 thru 6-32. Each table provides the **H** matrix in its $m_b \times n_b$ format.
Use Table 6-1 to match this coding rate to each data rate.

The values of m_b and n_b for the different fundamental code rates and their expanded versions are given in Table 6-28.

TABLE 6-28. Block parity-check matrix size for fundamental codes and their expansions

Parity-check matrix size Fundamental code rate	Fundamental matrix		Expanded matrix	
	m_b	n_b	m_b	n_b
0.5	20	40	24	44
0.625	15	40	19	44
0.75	10	40	14	44
0.8	8	40	12	44

The input to the LDPC encoder is the scrambled payload as described by section 6.5.

The output of the LDPC encoder $c[i]$ is separated into two different bit streams:

$b[i] = c[1320 \cdot \lfloor i/1200 \rfloor + mod(i, 1200)]$ are mapped onto complex constellations as described in section 6.9 and these are used to create the data subcarrier values as described in section 6.10.2.

For data rates of 640 Mb/s and above bits $b_G[i] = c[1320 \cdot \lfloor i/120 \rfloor + 1200 + mod(i, 120)]$ are mapped onto complex constellations as described in section 6.9 and these are used to create the guard tones as described in section 6.10.3.2. For data rates of 480 Mb/s and below that use LDPC the bits b_G are unused and the guard tones are generated as defined in Section 6.10.3.1.

TABLE 6-29. The H Matrix for the 0.5 codeword

0	0	0	0	21	0	0	24	0	1	0	0	0	0	0	0	0	4	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	20	19	0	18	0	0	0	0	0	0	0	14	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	23	14	20	0	0	0	0	0	0	0	0	0	0	0	13	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	14	0	0	0	0	0	0	0	0	29	17	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	4	11	0	0	0	0	2	0	0	0	0	12	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	11	0	11	14	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	13	0	14	0	7	0	0	20	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	6	0	28	0	9	0	0	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	24	0	0	0	0	0	0	0	0	0	15	0	0	15	23	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	3	0	0	0	0	16	29	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	14	0	0	0	0	18	0	0	0	0	0	0	0	0	0	0	19	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	2	0	0	2	2	21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0
0	7	0	0	0	0	0	0	0	0	0	1	23	0	0	0	22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	26	26	0	11	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
8	0	11	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0
0	20	5	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	27	0	17	0	0	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
0	0	0	0	0	4	0	0	0	18	25	0	0	0	0	0	0	0	22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0
0	24	0	0	0	0	0	0	0	0	0	0	16	0	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
0	0	0	0	0	0	0	7	0	0	20	0	0	0	0	26	0	5	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
0	0	0	0	0	0	13	0	0	0	0	20	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	21	0	0	0	0	0	0	0	0	0	0	0	0	2	1	0	0
0	0	0	0	0	0	0	0	0	12	0	0	0	0	0	0	0	0	0	10	0	0	0	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0
0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	5	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
19	0	0	0	0	0	0	0	16	0	0	0	26	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	1

TABLE 6-30. The H matrix for the expanded 0.625 codeword:

0	0	0	0	13	0	0	0	0	18	11	0	14	0	9	0	0	0	20	0	0	0	0	22	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	20	24	4	24	0	8	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	23	0	0	0	1	11	29	17	27	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	7	18	0	0	0	21	0	0	0	22	0	0	0	29	0	0	0	1	0	26	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	19	1	0	0	0	0	0	0	0	0	0	0	22	0	24	0	0	0	0	0	15	0	6	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
26	3	8	0	0	16	9	0	0	0	0	0	0	0	28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	12	22	0	18	0	0	0	9	7	0	0	27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0
0	12	0	0	1	0	0	0	0	0	0	0	21	0	0	17	0	0	0	0	4	0	0	4	0	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
0	0	0	8	0	0	0	0	28	0	8	21	0	0	0	4	0	0	0	0	0	0	12	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	7	26	0	0	0	23	0	0	0	0	0	0	0	9	3	28	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	30	29	0	0	0	0	10	0	0	0	17	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0
0	0	0	0	8	0	0	0	0	0	0	0	8	0	0	0	12	0	0	0	2	0	0	14	12	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
0	0	6	20	17	0	0	2	0	0	0	17	0	0	0	26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0
0	6	0	0	0	30	30	0	0	0	0	0	0	0	0	0	24	0	0	0	24	0	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
0	0	0	0	0	0	0	0	0	6	0	30	0	5	0	0	0	27	0	21	0	1	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	9	0	0	0	0	0	26	0	2	25	14	0	0	6	0	0	2	1	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0	0	0	0	0	0	0	0	9	15	0	0	29	13	0	0	29	0	0	0	0	0	0	1	1	1	0
18	0	0	0	0	22	0	17	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	22	0	2	10	0	0	0	0	0	0	0	0	0	0	0	0	1	1
0	0	0	0	0	0	0	0	0	8	0	29	0	0	0	0	0	0	17	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	19	17	2	0	0	1

TABLE 6-31. The H matrix for the expanded 0.75 codeword

2	0	0	0	0	0	0	0	0	0	29	6	0	0	0	0	0	28	3	28	8	0	0	0	12	20	0	0	0	20	2	1	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	7	9	0	16	0	5	0	0	24	0	0	0	0	17	0	0	0	27	0	0	0	0	0	0	8	3	0	1	1	0	0	0	0	0	0	0	0	0	0	0
0	22	0	23	11	22	0	0	25	12	0	0	0	0	0	0	21	0	0	0	0	0	0	0	0	0	16	2	22	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
0	25	7	0	0	0	1	0	14	0	0	0	0	0	27	16	23	0	27	0	0	0	0	27	0	30	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
0	19	0	3	0	12	0	0	30	0	0	0	0	0	0	28	0	0	28	0	0	0	28	0	0	22	0	0	0	29	1	0	0	0	1	1	0	0	0	0	0	0	0	0
0	0	9	0	0	0	0	4	0	0	0	0	22	21	4	9	29	0	0	0	0	0	7	14	0	0	0	15	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	12	25	28	29	30	0	0	0	0	18	20	13	0	11	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
0	29	0	0	0	4	6	0	25	6	0	0	0	0	0	0	0	0	0	11	0	29	0	0	5	0	12	0	7	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0
0	0	28	0	0	0	28	0	0	0	10	0	0	28	0	0	10	0	0	14	2	0	0	0	22	0	14	8	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
0	0	0	7	19	0	0	22	0	0	6	4	0	0	0	0	0	7	0	0	5	0	20	0	0	0	0	5	0	8	2	0	0	0	0	0	0	0	0	1	0	0	0	0
0	0	0	9	0	0	0	0	0	0	0	27	0	0	12	0	0	0	0	0	0	0	21	0	0	0	0	0	0	0	0	0	0	14	0	0	17	22	0	0	2	1	0	0
27	0	0	0	0	0	0	0	0	0	0	0	15	21	0	0	0	0	18	0	0	0	0	0	0	24	0	0	0	0	0	18	12	0	0	11	0	0	0	0	1	1	1	0
0	0	0	0	0	0	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	26	30	0	0	0	0	17	0	0	1	1
0	0	0	0	8	0	0	0	0	1	0	0	0	0	0	0	0	11	0	0	0	0	0	0	12	0	0	0	13	0	0	0	0	0	0	0	0	0	12	0	2	0	0	1

TABLE 6-32. The H matrix for the expanded 0.8 codeword

0	0	0	23	0	0	0	0	12	25	12	24	0	0	0	0	23	0	0	0	3	13	0	13	0	28	0	15	11	0	0	29	2	1	0	0	0	0	0	0	0	0	0	0
0	0	21	0	0	14	0	25	0	0	0	14	0	0	14	14	27	0	0	1	0	19	7	0	28	0	0	0	0	8	8	0	0	1	1	0	0	0	0	0	0	0	0	0
19	0	16	0	0	5	0	18	0	0	0	0	6	2	0	17	0	0	14	20	0	0	25	0	13	0	4	0	0	6	0	0	0	0	1	1	0	0	0	0	0	0	0	0
24	1	0	20	29	0	30	0	14	0	28	0	0	0	0	0	0	2	20	0	0	0	0	17	0	0	0	0	22	0	0	6	1	0	0	1	1	0	0	0	0	0	0	0
15	11	11	0	23	27	14	0	0	0	0	0	0	9	15	0	0	30	0	0	0	0	13	0	2	0	27	0	0	0	7	0	0	0	0	0	1	1	0	0	0	0	0	0
0	0	10	0	0	0	0	20	0	14	0	22	9	14	0	28	0	0	0	17	0	0	0	0	19	19	8	2	0	15	0	0	0	0	0	0	0	1	1	0	0	0	0	0
0	0	0	0	0	0	0	0	23	18	2	0	23	0	0	0	0	0	13	0	13	0	0	0	0	13	0	3	2	0	0	3	0	0	0	0	0	0	1	1	0	0	0	0
0	19	0	9	6	0	20	0	0	0	19	0	0	0	27	0	24	17	0	0	12	9	0	12	0	0	0	0	6	0	10	0	2	0	0	0	0	0	0	1	0	0	0	0
0	0	0	11	14	0	0	0	0	0	0	0	0	29	0	0	0	0	0	0	0	0	0	4	0	0	13	0	0	0	0	0	2	0	0	11	28	25	0	0	2	1	0	0
0	0	0	0	0	25	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	23	0	0	0	0	0	0	0	0	0	0	19	23	0	0	0	0	2	1	1	1	0
0	0	0	0	0	0	0	0	28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	3	8	5	0	0	0	1	1
0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	6	0	0	19	16	0	0	0	0	0	0	0	0	0	6	0	0	0	0	18	7	0	0	17	9	2	0	0	1

7. GENERAL REQUIREMENTS

7.1 Operating Band Frequencies

7.1.1 Operating Frequency Range

This PHY operates in the 3100-10600 MHz UWB band.

7.1.2 Band Numbering

The relationship between center frequency, f_c, and BAND_ID number, n_b, is given by the following equation:

$$f_c(n_b) = \quad 2904 + 528 \times n_b \ \ (\text{MHz}) \qquad n_b = 1, \ldots, 14 \quad . \tag{7-1}$$

This definition provides a unique numbering system for all channels that have a spacing of 528 MHz and lie within the band 3100-10600 MHz. As shown in Fig. 7-1, six band groups are defined. Band groups 1 to 4 consist of 3 bands each, spanning the bands 1 to 12. Band group 5 contains the two bands 13 and 14. Band group 6 contains the bands 9, 10 and 11. The band allocation is summarized in Table 7-1.

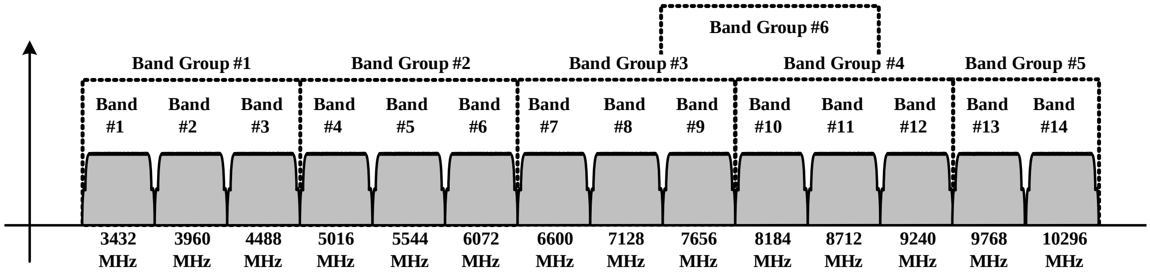

Fig. 7-1. Diagram of the band group allocation

TABLE 7-1. Band group allocation

Band Group	BAND_ID (n_b)	Lower Frequency (MHz)	Center Frequency (MHz)	Upper Frequency (MHz)
1	1	3168	3432	3696
	2	3696	3960	4224
	3	4224	4488	4752
2	4	4752	5016	5280
	5	5280	5544	5808
	6	5808	6072	6336
3	7	6336	6600	6864
	8	6864	7128	7392
	9	7392	7656	7920
4	10	7920	8184	8448
	11	8448	8712	8976
	12	8976	9240	9504
5	13	9504	9768	10032
	14	10032	10296	10560
6	9	7392	7656	7920
	10	7920	8184	8448
	11	8448	8712	8976

7.2 Channelization

Unique logical channels are defined by using up to ten different time-frequency codes for each band group. The TFCs and the associated base sequences (and corresponding preambles) for band group 1 are defined in Table 7-2 as a function of BAND_ID values. Similarly, the definitions for the TFCs and the associated base sequences (and corresponding preambles) for band groups 2, 3, 4, 5 and 6 are enumerated in Table 7-3 through Table 7-7.

TABLE 7-2. Time-Frequency codes and preamble patterns for band group 1

TFC Number	Base Sequence / Preamble	BAND_ID (n_b) for TFC					
1	1	1	2	3	1	2	3
2	2	1	3	2	1	3	2
3	3	1	1	2	2	3	3
4	4	1	1	3	3	2	2
5	5	1	1	1	1	1	1
6	6	2	2	2	2	2	2
7	7	3	3	3	3	3	3
8	8	1	2	1	2	1	2
9	9	1	3	1	3	1	3
10	10	2	3	2	3	2	3

TABLE 7-3. Time-Frequency codes and preamble patterns for band group 2

TFC Number	Base Sequence / Preamble	BAND_ID (n_b) for TFC					
1	1	4	5	6	4	5	6
2	2	4	6	5	4	6	5
3	3	4	4	5	5	6	6
4	4	4	4	6	6	5	5
5	5	4	4	4	4	4	4
6	6	5	5	5	5	5	5
7	7	6	6	6	6	6	6
8	8	4	5	4	5	4	5
9	9	4	6	4	6	4	6
10	10	5	6	5	6	5	6

TABLE 7-4. Time-Frequency codes and preamble patterns for band group 3

TFC Number	Base Sequence / Preamble	BAND_ID (n_b) for TFC					
1	1	7	8	9	7	8	9
2	2	7	9	8	7	9	8
3	3	7	7	8	8	9	9
4	4	7	7	9	9	8	8
5	5	7	7	7	7	7	7
6	6	8	8	8	8	8	8
7	7	9	9	9	9	9	9
8	8	7	8	7	8	7	8
9	9	7	9	7	9	7	9
10	10	8	9	8	9	8	9

TABLE 7-5. Time-Frequency codes and preamble patterns for band group 4

TFC Number	Base Sequence / Preamble	BAND_ID (n_b) for TFC					
1	1	10	11	12	10	11	12
2	2	10	12	11	10	12	11
3	3	10	10	11	11	12	12
4	4	10	10	12	12	11	11
5	5	10	10	10	10	10	10
6	6	11	11	11	11	11	11
7	7	12	12	12	12	12	12
8	8	10	11	10	11	10	11
9	9	10	12	10	12	10	12
10	10	11	12	11	12	11	12

TABLE 7-6. Time-Frequency codes and preamble patterns for band group 5

TFC Number	Base Sequence / Preamble	BAND_ID (n_b) for TFC					
5	5	13	13	13	13	13	13
6	6	14	14	14	14	14	14
8	8	13	14	13	14	13	14

TABLE 7-7. Time-Frequency codes and preamble patterns for band group 6

MAC TFC Number	MAC Band Group	PHY TFC number	PHY Band Group	Base Sequence / Preamble	BAND_ID (n_b) for TFC					
1	6	1	6	3	9	10	11	9	10	11
2	6	2	6	4	9	11	10	9	11	10
3	6	3	6	1	9	9	10	10	11	11
4	6	4	6	2	9	9	11	11	10	10
5	6	7	3	7	9	9	9	9	9	9
6	6	5	4	5	10	10	10	10	10	10
7	6	6	4	6	11	11	11	11	11	11
8	6	9	6	9	9	10	9	10	9	10
9	6	10	6	10	9	11	9	11	9	11
10	6	8	4	8	10	11	10	11	10	11

Band group 6 requires special consideration due to overlap with band groups 3 and 4. Referring to Table 7-7, the MAC TFC number and MAC BG are the ones used by the MAC when selecting the current channel. If the MAC-PHY Interface is implemented then the MAC TFC number and MAC BG are used in the TXCHAN and RXCHAN registers (see WiMedia MAC-PHY Interface Specification 1.2 for definitions of these registers). The MAC TFC number also indicates the hopping pattern and cover sequence to be used. The PHY TFC number and the PHY BG are the values encoded in the PHY header, TXVECTOR and RXVECTOR. The mapping in Table 7-7 ensures that fully overlapping channels appear identical over the air.

The PHY layer channelization scheme is based on the definition of band groups, as defined in Table 7-1, and the definition of TFCs, as defined in Table 7-2 through Table 7-7, and is summarized in Table 7-8. The PHY channels are identified by channel numbers as shown in this table. The channel number takes on values from 0-255 (decimal). The values not defined in Table 7-8 are reserved for future use. Channels using TFCs 1-4 are also referred to as time-frequency interleaved (TFI) channels, and those using TFCs 5-7 are also referred to as fixed-frequency interleaved (FFI) channels. Channels using TFCs 8-10 are referred to as two-band time-frequency interleaved (TFI2) channels.

TABLE 7-8. Mapping of channel number to band group and time-frequency code

Channel Number (decimal)	Channel Number (octal)	(Band Group, TFC)	Mandatory / Optional
9 - 15	011 - 017	(1, 1 - 7)	Optional[1]
17 - 23	021 - 027	(2, 1 - 7)	Optional[1]
25 - 31	031 - 037	(3, 1 - 7)	Optional[1]
33 - 39	041 - 047	(4, 1 - 7)	Optional[1]
45 - 46	055 - 056	(5, 5 - 6)	Optional[1]
49 - 55	061 - 067	(6, 1 - 7)	Optional[1]
72 - 74	110 - 112	(1, 8-10)	Optional[1]
80 - 82	120 - 122	(2, 8-10)	Optional[1]
88 - 90	130 - 132	(3, 8-10)	Optional[1]
96 - 98	140 - 142	(4, 8-10)	Optional[1]
104	150	(5, 8)	Optional[1]
112 - 114	160 - 162	(6, 8-10)	Optional[1]

[1] At least one of the six band groups shall be implemented. A band group is supported if all channels in the band group are supported.

For band group 6, the Band Group and TFC in Table 7-8 indicate the MAC Band Group and MAC TFC.

The current channel number for transmit or receive indicates an intended band group, which in turn indicates the use of bits in the Tone Nulling mask.

7.3 PHY Layer Timing

The values for the PHY layer timing parameters are defined in Table 7-9.

TABLE 7-9. PHY layer timing parameters

PHY Parameter	Value
pMIFSTime	$6 \times T_{SYM} = 1.875$ µs
pSIFSTime	$32 \times T_{SYM} = 10.0$ µs
pCCADetectTime	$18 \times T_{SYM} = 5.625$ µs
pBandSwitchTime	9.47 ns

7.3.1 Interframe Spacing

The interframe spacing parameters are given in Table 7-10.

TABLE 7-10. Interframe spacing parameters

MAC Parameter	Value
MIFS	pMIFSTime
SIFS	pSIFSTime

7.3.2 Receive-to-Transmit Turnaround Time

The RX-to-TX turnaround time shall not be greater than pSIFSTime. This turnaround time shall be measured at the air interface. The time elapsed from the leading edge of the last received symbol, where a symbol is composed of the OFDM symbol (IFFT output) and a zero-padded suffix, to the leading edge of the first transmitted symbol of the PLCP preamble for the next frame shall not be greater than pSIFSTime + T_{SYM}.

7.3.3 Transmit-to-Receive Turnaround Time

The TX-to-RX turnaround time shall not be greater than pSIFSTime. This turnaround time shall be measured at the air interface. The time elapsed from the leading edge of the last transmitted symbol until the receiver is ready to begin the reception of the next PHY frame shall not be greater than pSIFSTime + T_{SYM}.

7.3.4 Time Between Successive Transmissions

For uninterrupted successive transmissions by a device in standard mode, the interframe spacing after the packet shall be pSIFSTime if PLCP length field is zero, and shall not be less than pMIFSTime if the PLCP length field is nonzero. The interframe spacing time shall be measured at the air interface. When the PLCP length field is zero, the time elapsed from the leading edge of the last transmitted symbol to the leading edge of the first transmitted symbol of the PLCP preamble for the following packet shall be equal to pSIFSTime + T_{SYM}. When the PLCP length field is nonzero, the time elapsed from the leading edge of the last transmitted symbol to the leading edge of the first transmitted symbol of the PLCP preamble for the following packet shall not be less than pMIFSTime + T_{SYM}.

For burst mode transmissions, the interframe spacing between uninterrupted successive transmissions by a device shall be fixed to pMIFSTime ±1 ns. The interframe spacing time shall be measured at the air interface. The time elapsed from the leading edge of the last transmitted symbol to the leading edge of the first transmitted symbol of the PLCP preamble for the following packet shall be fixed to pMIFSTime + T_{SYM} ±1 ns.

See Section 6.3.1.4 for details on LENGTH constraints for burst mode.

7.3.5 Band Frequency Switch Time

The band frequency switch time is defined as the interval from when the PHY receives the last valid sample of a symbol on one band frequency until it is ready to receive the next symbol on a new band frequency. It is required that the switching time between band frequencies not exceed pBandSwitchTime to obtain the best performance.

8. TRANSMITTER SPECIFICATIONS

8.1 Transmit PSD Mask

The transmitted spectral mask shall have the following break points: an emissions level of 0 dBr (dB relative to the maximum spectral density of the signal) from -260 MHz to 260 MHz around the center frequency, -12 dBr at 285 MHz frequency offset, and -20 dBr at 330 MHz frequency offset and above. For all other intermediate frequencies, the emissions level is assumed to be linear in the dB scale. The transmitted spectral density of the transmitted signal shall fall within the spectral mask, as shown in Fig. 8-1.

Dependent on local regulations, additional limitations on the permitted transmissions and on the absolute transmit power levels may apply. These regulations are not described in this standard.

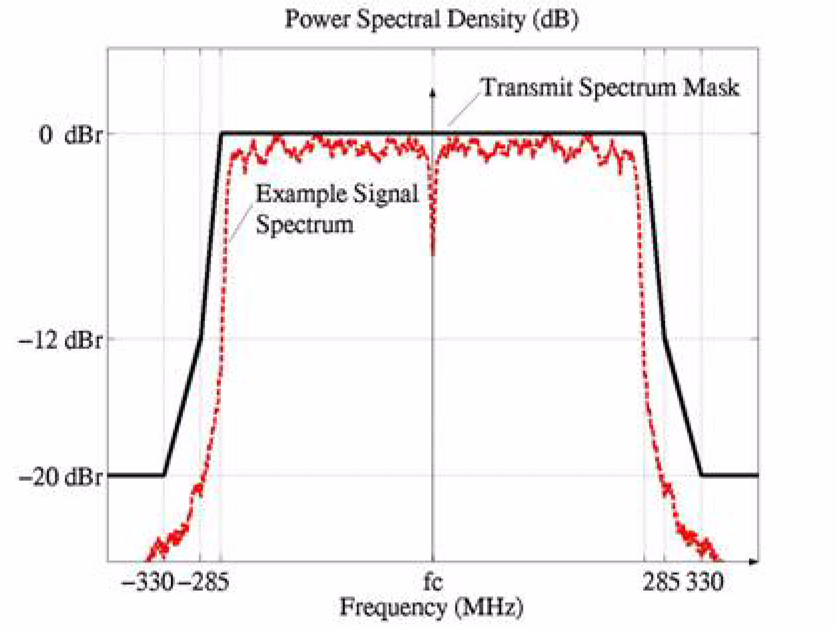

Fig. 8-1. Transmit power spectral density mask

8.2 Transmit Center Frequency Tolerance

The transmitted center frequency tolerance shall be ±20 ppm maximum.

8.3 Symbol Clock Frequency Tolerance

The symbol clock frequency tolerance shall be ±20 ppm maximum.

8.4 Clock Synchronization

The transmit center frequencies and the symbol clock frequency shall be derived from the same reference oscillator.

8.5 Phase Coherence

The transmit carrier frequencies shall be phase coherent within a single band over the duration of a single packet. Lack of phase coherence may contribute to Transmitter Constellation Error as described in Section 8.7.

Phase coherence in TFI mode or TFI2 mode means that the phase of the LO is coherent when it returns to the same frequency. For example, let ω_k = radian frequency and θ_k=phase, k={1,2,3}. The LO can be represented as $\sin(\omega_k t + \theta_k)$. Let the hopping pattern be 1,2,3,1,2,3,... Frequency hops occur when t = NT, T=symbol duration. Thus at the hopping points, the LO is $\sin(\omega_1 T + \theta_1)$, $\sin(\omega_2 2T + \theta_2)$, $\sin(\omega_3 3T + \theta_3)$, $\sin(\omega_1 4T + \theta_1)$, $\sin(\omega_2 5T + \theta_2)$, $\sin(\omega_3 6T + \theta_3)$,... which is phase coherent by definition since the LO returns to the same phase θ_1 for N=1,4,...; θ_2 for N=2,5,...; θ_3 for N=3,6,...

8.6 Transmit Power Control

A device shall provide support for transmit power control (TPC). The objective of a power control algorithm is to minimize the transmit power spectral density, while still providing a reliable link for the transfer of information.

When the device is using time-frequency interleaving, the monotonic dynamic range for the attenuation of the transmit power shall be 0 – 12 dB, with a step size granularity of 2 dB. When the device is using time-frequency interleaving over 2 bands, the monotonic dynamic range for the attenuation of transmit power shall be 0 - 10 dB, with a step size granularity of 2 dB. When the device is using fixed-frequency interleaving, the monotonic dynamic range for the attenuation of the transmit power shall be 0 – 8 dB, with a step size granularity of 2 dB. Table 8-1 summaries the mapping between the TXPWR_LEVEL and the associated transmit power attenuation.

TABLE 8-1. Mapping between TXPWR_LEVEL and transmit power attenuation

TXPWR_LEVEL	TX Power Attenuation for TFI Modes	TX Power Attenuation for TFI2 Modes	TX Power Attenuation for FFI Modes
0	0 dB	0 dB	0 dB
1	2 dB	2 dB	2 dB
2	4 dB	4 dB	4 dB
3	6 dB	6 dB	6 dB
4	8 dB	8 dB	8 dB
5	10 dB	10 dB	RESERVED
6	12 dB	RESERVED	RESERVED
7	RESERVED	RESERVED	RESERVED

In either case, the relative accuracy of change in transmit power attentuation shall be the maximum of ±1 dB or ±20% of the change in the attenuation (in the dB scale). As an example, for an attenuation change of 4 dB and an attenuation change of 8 dB, the allowed relative accuracy is ±1.0 dB and ±1.6 dB, respectively.

Finally, the device shall support a value for the signal-to-carrier leakage at transmitter output port of at least 20 dB and shall satisfy all necessary rules as defined by regulatory bodies where the device is intended to be deployed.

8.7 Transmitter Constellation Error

The relative constellation RMS error, averaged over all data and pilot subcarriers of the OFDM symbols and over all of the frames, shall not exceed the values given in Table 8-2. Note that the relative constellation error values are a function of the transmit power attenuation. Relative constellation error values are based on a multi-path margin of 2.5 dB for data rates of 200 Mb/s and lower and 3.6 dB for data rates 320 Mb/s and higher, and an implementation loss of 2.5 dB. In addition, it is assumed that the degradation due to the relative constellation error can be no more than 0.5 dB for data rates of 200 Mb/s and lower, and 1.0 dB for data rates of 320 Mb/s and higher.

TABLE 8-2. Permissible relative constellation error for device transmitting at full power

	Relative Constellation RMS Error		
Data Rate (Mb/s)	No TX Attenuation	TX Attenuation of 2, 4, 6 dB (All TFCs)	TX Attenuation of 8, 10, 12 dB (All TFCs)
53.3, 80, 106.7, 160, 200	-17.0 dB	-15.5 dB	-14.5 dB
320, 400, 480	-19.5 dB	-18.0 dB	-17.0 dB
640, 800, 960, 1024	-20.5 dB	-19.0 dB	-18.0 dB

The relative constellation RMS error calculation shall be performed using a device capable of converting the transmitted signal into a stream of complex samples at 528 Msample/s or more, with sufficient accuracy in the I/Q imbalance, DC offset, phase noise, etc. The sampled signal shall then be processed in a manner similar to that of an ideal receiver including adding the first 32 samples of the zero-padded suffix to the received OFDM symbol via the overlap-and-add method. An example of the minimum steps necessary for receiver processing is listed below:

1. Detect the start of the packet and frame boundary.
2. Estimate the correct sampling time and frequency offset. Correct as needed.
3. Estimate the channel frequency response.
4. For each symbol estimate the common phase error (CPE) from the pilot subcarriers, then filter the sequence of CPE estimates using a single-pole low-pass filter with a 3 dB cut-off frequency as defined in Table 8-3. De-rotate each OFDM symbol with the filtered phase estimate.

TABLE 8-3. CPE measurement 3 dB cut-off frequency

3 dB cutoff frequency (radians/filter update rate)	**TFC number**
$\pi/4$	1, 2, 3, 4
$\pi/12$	5, 6, 7
$\pi/6$	8, 9, 10

2π corresponds to the filter update rate of F_{SYM} for FFI Modes, $F_{SYM}/3$ for TFI Modes and $F_{SYM}/2$ for TFI2 Modes. The value for F_{SYM} is defined in Table 6-2.

5. Equalize the channel with the estimated channel frequency response.

6. For each of the data and pilot subcarriers, find the closest constellation point and compute the Euclidean distance.
7. Compute the RMS error, averaged over all the data and pilot subcarriers and over all frames, as follows:

$$RMS_{error} = \frac{1}{N_f}\sum_{i=1}^{N_f}\sqrt{\sum_{n=1+N_{sync}+N_{hdr}}^{N_{packet}}\left[\frac{\sum_{k=1}^{N_D}\left|R_{D,n}[k]-C_{D,n}[k]\right|^2+\sum_{k=1}^{N_P}\left|R_{P,n}[k]-C_{P,n}[k]\right|^2}{(N_D+N_p+N_{TN,n})N_{frame}P_0}\right]} \quad (8\text{-}1)$$

where N_f is the number of packets under test, N_{packet} is the number of symbols in the packet, N_{sync} is the number of symbols in the PLCP preamble, N_{hdr} is the number of symbols in the PLCP header, $N_{frame} = N_{packet} - N_{sync} - N_{hdr}$ is the number of symbols in the PSDU, N_D is the number of data subcarriers, N_P is the number of pilot subcarriers, P_0 is the average power over all payload symbols of the data and pilot constellations, $C_{D,n}[k]$ and $C_{P,n}[k]$ are the transmitted k^{th} data subcarrier and k^{th} pilot subcarrier for the n^{th} OFDM symbol, respectively, and $R_{D,n}[k]$ and $R_{P,n}[k]$ are the observed k^{th} data subcarrier and k^{th} pilot subcarrier for the n^{th} OFDM symbol, respectively. The values for N_D and N_P are defined in Table 6-2, while the values for N_{sync}, N_{hdr}, N_{frame}, and N_{packet} are defined in Table 6-3. The RMS error shall be computed over the payload portion of the packet only. P_0 is re-computed for each packet.

The test shall be performed over a minimum of $N_f = 100$ packets, where the PSDU of each packet is at least 30 symbols in length and is generated from random data.

The RMS error shall be measured without any tone nulling applied as a mandatory test. If a device is declared to support tone nulling, testing with tone nulling in effect shall also be conducted with the following modified definition applied to RMS error:

$N_{TN,n}$ is the number of data or pilot tones nulled in symbol n. If a data tone k is nulled (i.e., the corresponding tone nulling element is set to zero according to a valid tone nulling mask) in symbol n then $R_{D,n[k]}$ and $C_{D,n[k]}$ are replaced with zero. If pilot tone k is nulled in symbol n then $R_{P,n[k]}$ and $C_{P,n[k]}$ are replaced with zero. See Section 5.2 on Tone Nulling.

9. RECEIVER SPECIFICATION

9.1 Receiver Sensitivity

For a PSDU of 1024 octets, the minimum receiver sensitivity numbers in AWGN for the different data rates are listed in Table 9-1, where a noise figure of 6.6 dB (referenced at the antenna), an implementation loss of 2.5 dB, and a margin of 3 dB have been assumed. For band groups 2 - 6 an additional 1 - 2 dB noise figure degradation can be expected. In addition, the sensitivity numbers are subject to variations in noise figure over process, voltage and temperature.

TABLE 9-1. Minimum Receiver Sensitivity for band group

Data Rate (Mb/s)	Packet Error Rate (PER) (%)	Minimum Receiver Sensitivity (dBm)
53.3	8	-80.8
80	8	-78.9
106.7	8	-77.8
160	8	-75.9
200	8	-74.5
320	8	-72.8
400	8	-71.5
480	8	-70.4
640	1	-67.6
800	1	-66.2
960	1	-64.3
1024	1	-63.5

9.2 Receiver CCA Performance

The start of a valid OFDM transmission at a receiver level equal to or greater than the minimum sensitivity for a 53.3 Mb/s transmission (-80.8 dBm) shall cause CCA to indicate that the channel is busy with a probability > 90% within pCCADetectTime.

9.3 Link Quality Indicator

A device shall be capable of estimating the link quality of the received channel, where the link quality shall be defined as an estimate of the SNR available after the FFT and will included all implementation losses associated with that particular receiver architecture (quantization noise, channel estimation errors, etc.). Devices capable only of data rates up to 200Mbps shall be capable of estimating values in the range from –2 dB to +7 dB. Devices capable of data rates above 200Mbps shall be capable of estimating values in the range from –2 dB to +12 dB. Estimating values below –2 dB or above +12 dB is optional. All estimated values, when measured under static channel conditions, shall be monotonically increasing with signal strength over the entire reporting range. Note that the estimates may exhibit saturation behavior at values higher than +12 dB. Finally, the link quality estimates shall be made on a packet-by-packet basis.

When reporting the estimates of the link quality, the device shall quantize these values to the nearest dB in the range from –6 dB to +24 dB and report them as the link quality estimate (LQE). The accuracy of the LQE is defined as the standard deviation of the packet-by-packet estimates for a static AWGN channel and a fixed SNR value. Table 9-2 enumerates the allowed standard deviation of the estimates as a function of the reporting range. Even though the reported estimates should be nominally equal to the SNR after the FFT, no bounds on absolute accuracy with respect to an external reference plane are intended or implied by this specification.

TABLE 9-2. Allowed Standard Deviation for the LQE with a payload of 1024 Bytes

Link Quality Estimate (LQE)	Standard Deviation for Estimate (σ)
–6 dB, …, –4 dB	1.3 dB
–3 dB, …, 0 dB	1.1 dB
1 dB, …, 6 dB	0.9 dB
7 dB, …, 24 dB	0.7 dB

The mapping between LQE and the Link Quality Indicator (LQI) is summarized in Table 9-3. A standard encoding is used to report the estimates in the range from –6 dB (0000 0001) to +24 dB (0001 1111). The all-zero bit representation implies that reporting of LQE is not supported by the device, or that LQE is too small to be measured accurately. Additionally, the range from 1000 0000 to 1011 1111 and the range from 1100 0000 to 1111 1111 are defined to allow vendors to report additional link quality information. All other bit representations are reserved for future use.

The test for the accuracy of the link quality estimate shall be performed over a minimum of N_f = 1000 packets, where the PSDU of each packet is at least 1024 bytes in length and is generated from random data.

TABLE 9-3. Encoding for the Link Quality Estimates

LQI	Description
0000 0000	Link Quality is too low to be measured
0000 0001 – 0001 1111	LQI = (LQE + 7) dB
0010 0000 – 0111 1111	Reserved

TABLE 9-3. Encoding for the Link Quality Estimates

LQI	Description
1000 0000 – 1011 1111	Vendor specific Link Quality encoding
1100 0000 – 1111 1111	Vendor specific Link Quality encoding

9.4 Receive Signal Strength Indicator

A device may indicate the strength in decibels of the incoming signal. The RSSI is a monotonically increasing function of the energy received at the antenna. It is a value between 0 and RSSIMaximum. RSSIMaximum is implementation defined, up to 255.

10. RANGING AND LOCATION AWARENESS

A device may support the capability to determine the relative location of one device with respect to another. The distance or range between the devices can be estimated by multiplying the speed of light by the measured propagation delay between the devices. The following resources are included to support range detection and calculation in the MAC.

10.1 Ranging requirements

If ranging is supported, all devices shall support ranging capabilities with an accuracy and precision of ±60 cm or better.

10.2 Ranging reference signal

The propagation delay between two devices should be measured with respect to a ranging reference signal. The reference point is defined as the beginning of the first channel estimation symbol in the PLCP preamble, i.e., the first sample of the first channel estimation sequence $s_{sync,N_{pf}}[0]$ (see Section 6.2, Fig. 6-2, Fig. 6-3 and (6-2)).

10.3 PHY ranging resources

If ranging is supported, the PHY shall contain a MIB attribute pRangingTimer to capture the time of generation or detection of the ranging reference signal. This attribute represents a ranging timer, which is nominally a 32-bit value [31:0], with bit 0 clocked at 4224 MHz. This represents timing uncertainty of 7.1 cm.

In the minimum implementation, pRangingTimer is 15 bits of counter [17:3]; bits [31:18] and [2:0] = 0. Bit 3 is clocked at 528 MHz for 56.8 cm ranging uncertainty. To provide increasing precision, optional implementations may clock bit 2 at 1056 MHz (28.4 cm), bit 1 at 2112 MHz (14.2 cm), or clock bit 0 at 4224 MHz (7.1 cm). To support MAC algorithms that use multiple ranging transactions to correct for frequency offset between two stations, longer counters may be provided in PHY hardware or in MAC logic. If supported in the PHY, more of the bits [31:18] will be active. For a list of valid timer configurations see Table 11-8.

10.4 PHY ranging operation

If ranging is supported, the PHY shall control when the counter pRangingTimer shall start, stop and reset. The value of the counter pRangingTimer shall be captured in a register exposed to the MAC when one of two events occurs:

- PHY is in transmit mode, and the PHY generates the ranging reference signal.

- PHY is in receive mode, and the PHY detects the ranging reference signal.

10.5 Ranging Calibration Constants

If ranging is supported, the PHY shall provide to the MAC two constants in order to support ranging calculations in the MAC (e.g. in the PHY device specifications):

1. RANGING_TRANSMIT_DELAY = the time from the generation of the reference signal (see Section 10.2), triggering the pRangingTimer capture, to the time this signal reaches its own antenna,

2. RANGING_RECEIVE_DELAY = the time from the arrival of the reference signal at the antenna to the time this signal is first detected in the PHY, triggering the pRangingTimer clock capture.

These constants are 16-bit unsigned integer values, in units of 4224 MHz clock periods. These values allow the MAC to correct the pRangingTimer values for delays in the PHY and associated circuits.

10.6 Example Range Measurement (Informative)

Fig. 10-1 shows a pair of ranging frames being exchanged between two devices. R_{M1} is designated as the initial ranging measurement frame transmitted by device #1, whereas R_{M2} is designated as the reply ranging measurement frame transmitted by device #2. Each device must take two measurements: one when the ranging measurement frame is sent (T_i, where $i = 1, 2$), and one when the ranging measurement frame is received (R_i, where $i = 1, 2$). Next, each device must apply the calibration constants (see Section 10.5) to account for signal processing delays through the transmit and receive chains:

$$T_{ic} = T_i + \mathrm{RANGING\_TRANSMIT\_DELAY}, \qquad (10\text{-}1)$$

$$R_{ic} = R_i - \mathrm{RANGING\_RECEIVE\_DELAY}, \qquad (10\text{-}2)$$

where $i = 1, 2$, and where T_{ic} and R_{ic} are the calibrated time measurements. Finally, device #2 must deliver the measurement values T_{2c} and R_{2c} to device #1.

Given the four compensated time measurements, a simple range estimate, D, can be calculated as follows:

$$D = c \times \left[\frac{(R_{2c} - T_{1c}) - (T_{2c} - R_{1c})}{2} \right], \qquad (10\text{-}3)$$

where c is the speed of light.

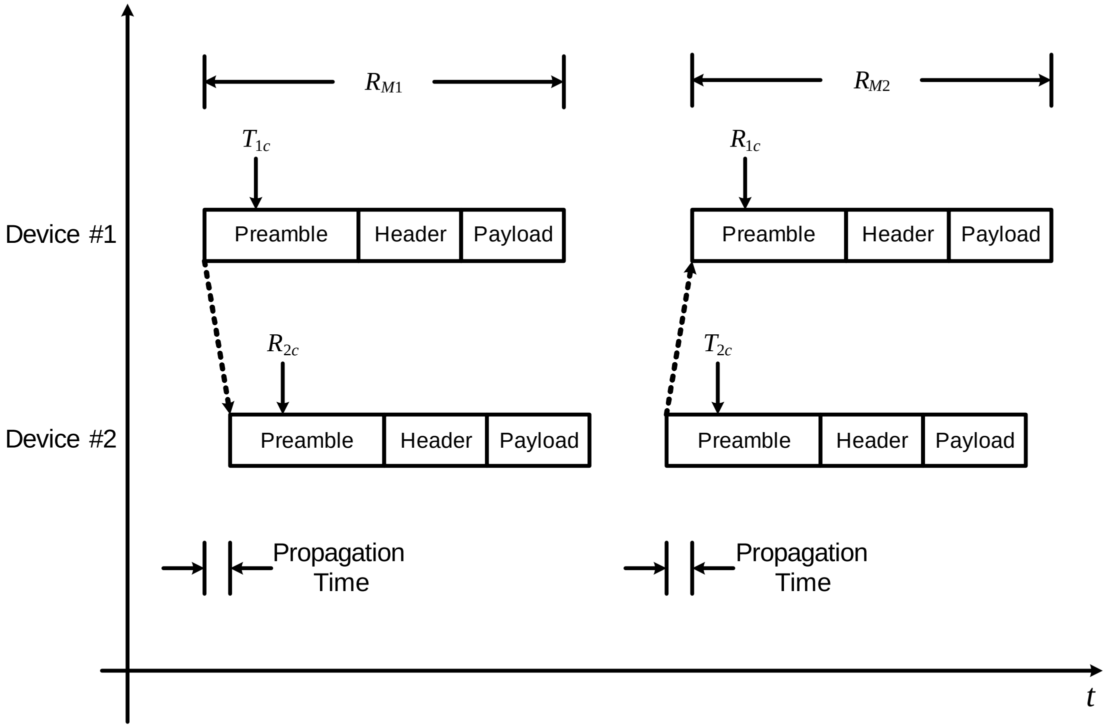

Fig. 10-1. Example ranging measurement frame pair

11. PHY SERVICE AND MANAGEMENT

The physical layer (PHY) provides data services to the medium access control (MAC) sublayer through the PHY service access point (SAP). These services are described in this clause in terms of PHY primitives exchanged between the MAC and the PHY via the PHY SAP.

To facilitate such data services, the MAC sublayer management entity (MLME) in turn provides management to the PHY layer management entity (PLME) on behalf of itself or the device management entity (ME). Management information is exchanged across the PLME SAP, and is expressed through the PLME primitives defined in this clause.

Both the PHY SAP and PLME SAP referenced in this specification are logical interfaces and do not necessarily imply a particular implementation or an exposed interface.

11.1 PHY SAP Interface

Table 11-1 lists the PHY SAP primitives for peer-to-peer interactions. Table 11-2 lists the PHY SAP primitives for sublayer-to-sublayer interactions only.

TABLE 11-1. PHY-SAP peer-to-peer service primitives

Primitive	Request	Indication	Response	Confirm
PHY-DATA	×	×	×	×

TABLE 11-2. PHY-SAP sublayer-to-sublayer service primitives

Primitive	Request	Indication	Response	Confirm
PHY-TX-START	×			×
PHY-TX-END	×			×
PHY-CCA-START	×			×
PHY-CCA-END	×			×
PHY-RX-START	×	×		×
PHY-RX-END	×	×		×

The remainder of this subclause describes the services provided using these PHY primitives.

11.1.1 Data Transfer

This mechanism supports the procedure of transferring an octet of data from the MAC entity to the PHY entity or vice versa. Table 11-3 lists the parameters that appear in the primitives of this subclause.

TABLE 11-3. PHY-DATA primitive parameters

Name	Type	Valid Range	Description
DATA	Bit String	0×00 - 0×FF	Appears in PHY-DATA.request and PHY-DATA.indication; specifies an octet of bit string for transfer from the MAC to the PHY or vice versa.

11.1.1.1 PHY-DATA.request

This primitive requests the transfer of an octet of data from the MAC to the PHY. The semantics of the primitive are as follows:

PHY-DATA.request(DATA)

11.1.1.1.1 When Generated

This primitive is generated by the MAC to request the transfer of a single octet of data from the MAC to the PHY. It may only be issued following a transmit initialization confirmation (PHY-TX-START.confirm) from the PHY.

11.1.1.1.2 Effect of Receipt

The PHY transfers a single octet of data from the MAC. It subsequently issues a PHY-DATA.confirm to the MAC.

11.1.1.2 PHY-DATA.confirm

This primitive reports the transfer of an octet of data from the MAC to the PHY. The semantics of the primitive are as follows:

PHY-DATA.confirm

11.1.1.2.1 When Generated

The primitive is generated by the PHY following the transfer of an octet of data from the MAC to the PHY.

11.1.1.2.2 Effect of Receipt

The MAC generates the next PHY-DATA.request to transfer the next octet of data to the PHY, if applicable.

11.1.1.3 PHY-DATA.indication

This primitive indicates a transfer of an octet of data from the PHY to the MAC. The semantics of the primitive are as follows:

PHY-DATA.indication(DATA)

11.1.1.3.1 When Generated

This primitive is generated by a receiving PHY entity to transfer an octet of available data to the local MAC entity. It may only be issued following a receive initialization confirmation (PHY-RX-START.confirm) from the PHY.

11.1.1.3.2 Effect of Receipt

The MAC transfers a single octet of data from the PHY. It subsequently issues a PHY-DATA.response to the PHY.

11.1.1.4 PHY-DATA.response

This primitive responds to the transfer of an octet of data from the PHY to the MAC. The semantics of the primitive are as follows:

PHY-DATA.response

11.1.1.4.1 When Generated

The primitive is generated by the MAC to respond to the PHY after an octet of data has been transferred from the PHY to the MAC.

11.1.1.4.2 Effect of Receipt

The PHY will generate the next PHY-DATA.indication for the transfer of the next available octet of data to the MAC, if applicable.

11.1.2 PHY Transmission Control

This mechanism supports the procedure of controlling the start or end of a PHY transmission. Table 11-4 lists the parameters that appear in the primitives of this subclause via TXVECTOR.

TABLE 11-4. TXVECTOR parameters

Name	Type	Valid Range	Description
LENGTH	Integer	0 .. pMaxFramePayloadSize for standard mode; 1 .. pMaxFramePayloadSize for burst mode	Specifies the number of octets in the frame payload (which does not include the FCS, tail bits, and pad bits) that the MAC is requesting the PHY to transmit.
DATARATE	Bit String	5 bits	Specifies the data rate at which the frame body is to be transmitted (see Table 6-17).
BURST_MODE	Enumeration	0 = standard mode; 1 = burst mode	Indicates whether the transmission is in the middle of a burst, i.e., whether the current PPDU will be followed by another PPDU transmitted by this device with a MIFS separation.
PREAMBLE_TYPE	Enumeration	0 = standard preamble; 1 = burst preamble	Specifies the type of preamble for the next PPDU when BM is set to 1; Reserved when BM is set to 0.
SCRAMBLER_INIT	Bit String	2 bits	Provides a 2-bit value to initialize the scrambler for the current PPDU transmission (see Table 6-22).
TXPWR_LEVEL	Integer	0-7	Specifies the transmit power attenuation for the current PPDU transmission (see Table 8-1)
TX_TFC	Bit String	4 bits	Specifies the TFC code used for transmission of the current packet (see Table 6-20).
BG	Bit String	3 bits	Specifies the band group used for transmission of the current packet (see Table 6-21).
MAC_HEADER	Octet String	10 octets	Provides the MAC header for the current PPDU for transmission.
TN	Bit String	384 bits	Specifies nulled frequency carriers (see Section 5.2)

11.1.2.1 PHY-TX-START.request

This primitive requests the local PHY entity to start the transmission of a PPDU onto the wireless medium. The semantics of the primitive are as follows:

PHY-TX-START.request(TXVECTOR)

11.1.2.1.1 When Generated

The primitive is generated by the MAC sublayer to initiate the transmission of a PPDU by the local PHY entity onto the wireless medium.

11.1.2.1.2 Effect of Receipt

The PHY begins transmitting a PLCP preamble. It subsequently issues a PHY-TX-START.confirm to the MAC.

11.1.2.2 PHY-TX-START.confirm

This primitive reports the start of the PLCP preamble transmission by the PHY. The semantics of the primitive are as follows:

PHY-TX-START.confirm

11.1.2.2.1 When Generated

This primitive is generated by the PHY to indicate to the MAC the start of transmission of the PPDU onto the wireless medium.

11.1.2.2.2 Effect of Receipt

The MAC proceeds to issue PHY-DATA.request primitives to transfer the TXVECTOR and frame body, if any, to the PHY when they are available, or to issue a PHY-TX-END.request primitive to end PHY’s transmission.

11.1.2.3 PHY-TX-END.request

This primitive requests the local PHY entity to end the transmission. The semantics of the primitive are as follows:

PHY-TX-END.request

11.1.2.3.1 When Generated

This primitive is generated by the MAC following reception of the last PHY-DATA.confirm from the PHY for the current MPDU transfer.

11.1.2.3.2 Effect of Receipt

The PHY stops the transmission and subsequently issues a PHY-TX-END.confirm to the MAC.

11.1.2.4 PHY-TX-END.confirm

This primitive reports the PHY’s exit from the transmission. The semantics of the primitive are as follows:

PHY-TX-END.confirm

11.1.2.4.1 When Generated

This primitive is generated by the PHY upon stopping the local transmission.

11.1.2.4.2 Effect of Receipt

The MAC is in a position to initiate the next transmit, receiver, or power management operation.

11.1.3 PHY Reception Control

This mechanism supports the procedure of controlling the start or end of a PHY reception. Table 11-5 lists the parameters that appear in the primitives of this subclause via RXVECTOR.

TABLE 11-5. RXVECTOR parameters

Name	Type	Valid Range	Description
LENGTH	Integer	0 .. pMaxFramePayloadSize for standard mode; 1 .. pMaxFramePayloadSize for burst mode;	Specifies the number of octets in the frame payload (which does not include the FCS, tail bits, and pad bits) that the PHY will be transferring to the MAC.
DATARATE	Bit String	5 bits	Specifies the data rate at which the frame body is received (see Table 6-17).
BURST_MODE	Enumeration	0 = standard mode; 1 = burst mode	Indicates whether the reception is in the middle of a burst, i.e., whether the current PPDU will be followed by another PPDU transmitted by the same device with a MIFS separation.
PREAMBLE_TYPE	Enumeration	0 = standard preamble; 1 = burst preamble	Specifies the type of preamble for the next PPDU when BM is set to 1; Reserved when BM is set to 0.
TX_TFC	Bit String	4 bits	Specifies the TFC code used for transmission of the current packet (see Table 6-20).
BG	Bit String	3 bits	Specifies the band group used for transmission of the current packet (see Table 6-21).
MAC_HEADER	Octet String	10 Octets	Provides the MAC header for the received PPDU.
HEADER_ERROR	Integer	0-255	Value = 0: HCS and all fields valid Bit 4 = 1: HCS invalid Bit 3 = 1: Unsupported data rate Bit 2 = 1: wrong channel
RSSI	Integer	0 .. RSSIMaximum	Provides the receive signal strength indication, in decibels, a measure of the energy observed at the antenna used to receive the PLCP preamble of the current PPDU, and a monotonically increasing function of the received power.
LQI	Bit String	8 bits	Provides a monotonically increasing measure of the link quality as assessed by the PHY (see Table 9-3).

11.1.3.1 PHY-RX-START.request

This primitive requests the local PHY entity to start reception. The semantics of the primitive are as follows:

PHY-RX-START.request

11.1.3.1.1 When Generated

The primitive is generated by the MAC sublayer to initiate or continue the acquisition of a PLCP preamble by the local PHY entity for an anticipated PPDU reception.

11.1.3.1.2 Effect of Receipt

The PHY begins PLCP preamble acquisition. It subsequently issues a PHY-RX-START.confirm to the MAC.

11.1.3.2 PHY-RX-START.indication

This primitive indicates acquisition of a PLCP preamble by the local PHY entity. The semantics of the primitive are as follows:

PHY-RX-START.indication

11.1.3.2.1 When Generated

This primitive is generated by a receiving PHY entity upon detecting the end of the synchronization sequence of a PLCP preamble.

11.1.3.2.2 Effect of Receipt

The MAC is provided with a reference time for determining the start of the received frame on the local air interface.

11.1.3.3 PHY-RX-START.confirm

This primitive reports reception of the PLCP header by the PHY. The semantics of the primitive are as follows:

PHY-RX-START.confirm(RXVECTOR)

11.1.3.3.1 When Generated

This primitive is generated by the PHY following complete reception of the PLCP header or a timeout.

11.1.3.3.2 Effect of Receipt

If the value of HEADER_ERROR is zero and the value of LENGTH is non-zero then the MAC is in a position to receive PHY-DATA.request primitives for the transfer of the RXVECTOR and frame body, if any, or issue a PHY-RX-END.request to abort the receive operation.

11.1.3.4 PHY-RX-END.request

This primitive requests the local PHY entity to end the reception. The semantics of the primitive are as follows:

PHY-RX-END.request

11.1.3.4.1 When Generated

This primitive is generated by the MAC following reception of the last PHY-DATA.indication from the PHY for the anticipated receive MPDU transfer.

11.1.3.4.2 Effect of Receipt

The PHY stops the reception and issues a PHY-TX-END.confirm to the MAC.

11.1.3.5 PHY-RX-END.indication

This primitive indicates completion of a PPDU reception from the wireless medium. The semantics of the primitive are as follows:

PHY-RX-END.indication

11.1.3.5.1 When Generated

This primitive is generated by a receiving PHY entity upon receiving the complete PPDU from the wireless medium.

11.1.3.5.2 Effect of Receipt

The MAC is provided with a reference time for determining the end of the received frame on the local air interface.

11.1.3.6 PHY-RX-END.confirm

This primitive reports the PHY’s exit from the reception. The semantics of the primitive are as follows:

PHY-RX-END.confirm

11.1.3.6.1 When Generated

This primitive is generated by the PHY upon stopping the reception.

11.1.3.6.2 Effect of Receipt

The MAC is in a position to initiate the next transmit, receiver, or power management operation.

11.1.4 PHY CCA Control

This mechanism supports the procedure of controlling the start or end of a PHY CCA. There are no parameters that appear in the primitives of this subclause.

11.1.4.1 PHY-CCA-START.request

This primitive requests the local PHY entity to start its CCA operation. The semantics of the primitive are as follows:

PHY-CCA-START.request

11.1.4.1.1 When Generated

This primitive is generated by the MAC sublayer to initiate the CCA by the PHY entity.

11.1.4.1.2 Effect of Receipt

The PHY starts its CCA operation and reports the CCA result in the PHY MIB pCCA-Status attribute. It subsequently issues a PHY-CCA-START.confirm to the MAC. The PHY updates the CCAStatus value whenever the CCA result is changed, until a subsequent PHY-CCA-END.request is issued by the MAC.

11.1.4.2 PHY-CCA-START.confirm

This primitive reports the start of the CCA operation by the PHY. The semantics of the primitive are as follows:

PHY-CCA-START.confirm

11.1.4.2.1 When Generated

This primitive is generated by the PHY to indicate to the MAC the start of the CCA.

11.1.4.2.2 Effect of Receipt

The MAC/MLME may proceed to issue generic management primitives PLME-GET (CCAStatus) to obtain and update the CCA result.

11.1.4.3 PHY-CCA-END.request

This primitive requests the local PHY entity to end the CCA operation. The semantics of the primitive are as follows:

PHY-CCA-END.request

11.1.4.3.1 When Generated

This primitive is generated by the MAC whenever CCA is no longer needed.

11.1.4.3.2 Effect of Receipt

The PHY stops the CCA operation.

11.1.4.4 PHY-CCA-END.confirm

This primitive reports the end of the CCA operation by the PHY. The semantics of the primitive are as follows:

PHY-CCA-END.confirm

11.1.4.4.1 When Generated

This primitive is generated by the PHY upon stopping the CCA operation.

11.1.4.4.2 Effect of Receipt

The MAC stops issuing generic management primitives PLME-GET (pCCAStatus) to obtain the CCA result.

11.2 PLME SAP Interface

The PHY management service is provided using the generic management service primitives PLME-GET and PLME-SET operating on PHY MIB attributes defined in Table 11-6 and Table 11-7, and the management service primitives operating on no specific PHY MIB attributes as listed in Table 11-9.

TABLE 11-6. PHY MIB attributes

Name	Type	Valid Range	Description
pMaxFramePayloadSize	Integer	16383	Specifies the maximum allowed length of the frame payload (which does not include an FCS) in any MPDU.
pPowerState	Enumeration	SLEEP, STANDBY, READY	Specifies the power state of the PHY.
pCCAStatus	Enumeration	CHANNEL_BUSY, CHANNEL_CLEAR	Indicates the medium activity of the channel

TABLE 11-7. PHY MIB ranging attributes

Name	Type	Valid Range	Description
pRCLKOptions	Integer	See Table 11-8	Specifies the ranging support capabilities. Value set to 0 if ranging is not supported. bit 0: set if ranging is supported; bit 1: set if a 528 MHz timer is used; bit 2: set if a 1056 MHz timer is used; bit 3: set if a 2112 MHz timer is used; bit 4: set if a 4224 MHz timer is used; bit 5: set if pRangingTimer bits [23:18] are active; bit 6: set if pRangingTimer bits [31:24] are active
pRCLKTolerance	Integer	0 - 255	Specifies the PHY ranging timer accuracy in PPM.
pRangingTimer	Integer	0 - (2^{31}-1)	Specifies the ranging timer value via a 32-bit unsigned integer. If bit 4 of pRCLKOptions is 0, Timer[0] = 0. If bit 3 of pRCLKOptions is 0, Timer[1] = 0. If bit 2 of pRCLKOptions is 0, Timer[2] = 0. If bit 5 of pRCLKOptions is 0, Timer[23:18] = 0×00. If bit 6 of pRCLKOptions is 0, Timer[31:24] = 0×00.

TABLE 11-8. Ranging pRCLKOptions valid values

Value (Hex)	Active Timer Bits	Clock Frequency (MHz)	Timer Span
00	N/A	N/A	N/A
03	[17:3]	528	62.1 μs
05	[17:2]	1056	62.1 μs
09	[17:1]	2112	62.1 μs
11	[17:0]	4224	62.1 μs
23	[23:3]	528	3.97 ms
25	[23:2]	1056	3.97 ms
29	[23:1]	2112	3.97 ms
31	[23:0]	4224	3.97 ms
63	[31:3]	528	1.02 s
65	[31:2]	1056	1.02 s
69	[31:1]	2112	1.02 s
71	[31:0]	4224	1.02 s

TABLE 11-9. PLME-SAP service primitives

Primitive	Request	Indicate	Response	Confirm
PLME-RESET	×			×
PLME-RANGING-TIMER-START	×			×
PLME-RANGING-TIMER-END	×			×

11.2.1 PHY Reset

This mechanism supports the procedure of resetting the PHY layer and its management entity. Table 11-10 lists the parameters that appear in the primitives of this subclause.

TABLE 11-10. PLME-RESET primitive parameters

Name	Type	Valid Range	Description
ResetResultCode	Enumeration	SUCCESS, FAILED	Indicates the result of the PHY reset procedure.

11.2.1.1 PLME-RESET.request

This primitive requests to reset the PHY data path and its management entity and MIB. The semantics of the primitive are as follows:

PLME-RESET.request

11.2.1.1.1 When Generated

This primitive is generated by the MLME on behalf of itself or the DME whenever the PHY needs to be reset.

11.2.1.1.2 Effect of Receipt

The PHY resets both transmission and reception, the CCA operation, and its management entity and MIB. The PHY enters the STANDBY state. The PLME subsequently issues a PHY-RESET.confirm to the MLME.

11.2.1.2 PLME-RESET.confirm

This primitive reports the results of a reset procedure. The semantics of the primitive are as follows:

PLME-RESET.confirm(ResetResultCode)

11.2.1.2.1 When Generated

This primitive is generated by the PLME as a result of a PLME-RESET.request.

11.2.1.2.2 Effect of Receipt

The DME or MLME is notified of the results of the PHY reset procedure.

11.2.2 PHY Ranging Timer Control

This mechanism supports the procedure of enabling or disabling the PHY ranging timer. There are no parameters that appear in the primitives of this subclause.

11.2.2.1 PLME-RANGING-TIMER-START.request

This primitive requests to enable the PHY ranging timer. The semantics of the primitive are as follows:

PLME-RANGING-TIMER-START.request

11.2.2.1.1 When Generated

This primitive is generated by the MLME on behalf of itself or the DME to enable the PHY ranging timer.

11.2.2.1.2 Effect of Receipt

The PLME enables the PHY ranging timer. The PHY captures the value of the ranging timer in the MIB attribute pRangingTimer. It subsequently issues a PHY-RANGING-TIMER-START.confirm to the MLME.

11.2.2.2 PLME-RANGING-TIMER-START.confirm

This primitive reports the enabling of the PHY ranging timer. The semantics of the primitive are as follows:

PLME-RANGING-TIMER-START.confirm

11.2.2.2.1 When Generated

This primitive is generated by the PLME as a result of a PLME-RANGING-TIMER-START.request.

11.2.2.2.2 Effect of Receipt

The DME or MLME is notified of the enabling of the PHY ranging timer.

11.2.2.3 PLME-RANGING-TIMER-END.request

This primitive requests to disable the PHY ranging timer. The semantics of the primitive are as follows:

PLME-RANGING-TIMER-END.request

11.2.2.3.1 When Generated

This primitive is generated by the MLME on behalf of itself or the DME to disable the PHY ranging timer.

11.2.2.3.2 Effect of Receipt

The PLME disables the PHY ranging timer. It subsequently issues a PHY-RANGING-TIMER-END.confirm to the MLME.

11.2.2.4 PLME-RANGING-TIMER-END.confirm

This primitive reports the disabling of the PHY ranging timer. The semantics of the primitive are as follows:

PLME-RANGING-TIMER-END.confirm

11.2.2.4.1 When Generated

This primitive is generated by the PLME as a result of a PLME-RANGING-TIMER-START.request.

11.2.2.4.2 Effect of Receipt

The DME or MLME is notified of the disabling of the PHY ranging timer. The DME or MLME ceases to get the value of the MIB attribute pRangingTimer.

ANNEX A - EXAMPLE ENCODING OF A PHY PACKET

A.1 Introduction

In this Annex, an example test vector for a 40-octet payload transmitted at 200 Mb/s is provided. Note that in this example some of the intermediate data has been excluded for purposes of clarity, but the entire packet at the output of the transmitter is shown in Appendix A.4. The packet shall be created as shown in Fig. 6-1, where the standard PLCP preamble is created as shown in Fig. 6-2 and Fig. 6-3, the PLCP header is created as shown in Fig. 6-6 and Fig. 6-7, and the PSDU is created as shown in Fig. 6-11 and Fig. 6-12.

A.2 Example Device Parameters

The device parameters for this example are enumerated in Table A-1.

A.2.1 PHY Header

The PHY header is a non-scrambled 5-octet field as defined in Section 6.3.1. Based on the parameters listed in Table A-1, the PHY header is described in bits as:

phyHeader = [0 0 0
0 0 1 0 0 (Data Rate)
0 0 0 1 0 1 0 0 0 0 0 0 (Length in Octets)
0 0
0 1 (Scrambler Seed)
0 0
1 (Burst Mode)
0 (Preamble Type)
1 0 0 (TX_TFC[T1..T3])
1 (BG_LSB)
0 0
0 (TX_TFC[T4])
0 0 0 0 0], (11-1)

or, equivalently in octets as 20 28 80 94 00.

TABLE A-1. Example device parameters

Parameter	Value
Time Frequency Code (TFC)	1
Band Group	1
Preamble Mode	Standard
Data Rate	200 Mb/s
Modulation	QPSK
Coding Rate	5/8
FDS	NO
TDS	YES
RATE Bits (R1-R5)	00100
LENGTH	40 bytes
SCRAMBLER (S1-S2)	01
Preamble Type (PT) Bit	0
Burst Mode (BM) Bit	1

A.2.2 MAC Header

The MAC header is a 10-octet field and for this example is given by:

D3 C2 36 8C 8F 36 0D BB ED BA (11-2)

The bit representation for the MAC Header is shown in Table A-2.

A.2.3 Generation of the HCS

The HCS is computed over the PHY and the MAC header using a 16-bit CRC as described in Section 6.3.3. HCS is calculated without the tail bits inserted between the PHY and MAC header. The resulting HCS is given in bit representation as:

1 1 0 1 1 1 0 0 0 0 1 0 1 0 1 1 (11-3)

The resulting 2 octets are appended to the end of the MAC header.

TABLE A-2. MAC header in bits

Bit #	Value	Bit #	Value	Bit #	Value	Bit #	Value
1	1	21	1	41	0	61	1
2	1	22	1	42	1	62	1
3	0	23	0	43	1	63	0
4	0	24	0	44	0	64	1
5	1	25	0	45	1	65	1
6	0	26	0	46	1	66	0
7	1	27	1	47	0	67	1
8	1	28	1	48	0	68	1
9	0	29	0	49	1	69	0
10	1	30	0	50	0	70	1
11	0	31	0	51	1	71	1
12	0	32	1	52	1	72	1
13	0	33	1	53	0	73	0
14	0	34	1	54	0	74	1
15	1	35	1	55	0	75	0
16	1	36	1	56	0	76	1
17	0	37	0	57	1	77	1
18	1	38	0	58	1	78	1
19	1	39	0	59	0	79	0
20	0	40	1	60	1	80	1

A.2.4 PLCP Header

The PHY header and a scrambled version of the MAC header and HCS are encoded using a shortened Reed-Solomon (23,17) code as defined in Section 6.3.2. The Reed-Solomon message octets are given in Table A-3. The resulting Reed-Solomon parity octets are listed in Table A-4.

TABLE A-3. Reed-Solomon message octets

m_i	Octet Value
m_{16}	20
m_{15}	28
m_{14}	80
m_{13}	94
m_{12}	00
m_{11}	D3
m_{10}	E2
m_9	36
m_8	94
m_7	8F
m_6	3C
m_5	8D
m_4	BC
m_3	CD
m_2	B8
m_1	A3
m_0	D5

TABLE A-4. Reed-Solomon parity octets

r_i	Octet Value
r_5	BC
r_4	6E
r_3	DF
r_2	A9
r_1	5E
r_0	BD

A.3 Frame Payload Transmission

The frame payload that is transmitted in this example is given in Table A-5.

TABLE A-5. 40-octet payload

#		#		#		#	
1	7B	11	2B	21	92	31	FB
2	B1	12	D5	22	DD	32	56
3	C0	13	6E	23	11	33	78
4	0A	14	E7	24	9E	34	E5
5	AB	15	02	25	B2	35	DC
6	87	16	E2	26	BA	36	29
7	44	17	F6	27	AE	37	F5
8	71	18	EA	28	59	38	CC
9	33	19	0E	29	A4	39	00
10	C1	20	A5	30	08	40	3C

The FCS for the 40-octet message is given below in octet format

DE 89 E6 B2 (11-4)

The FCS along with the tail bits and potentially pad bits are then appended to the frame payload to create the PSDU.

A.4 Complete Transmitted Packet

The symbol structure for the entire transmitted packet transmission is shown in Table A-6, where selected symbols of the packet are shown in Table A-7 through Table A-26. Each table describes exactly one symbol (165 complex values). Note that the length of this packet is exactly 48 symbols.

TABLE A-6. Symbol structure for entire packet

Symbol 1	1st Packet/Frame Synchronization Sequence (samples 1-165)
Symbols 2-24	Modulated version of Symbol 1: modulation depends on Cover Sequence (symbols not shown)
Symbol 25	Channel Estimation Sequence (samples 3961-4125)
Symbols 26-30	Same as Symbol 25 (symbols not shown)
Symbols 31-42	PLCP Header (samples 4951-6930)
Symbols 43-end	Payload (samples 6931-7913)

TABLE A-7. Time-domain sequence for symbol #1

#	Real	Imag	#	Real	Imag	#	Real	Imag
1	7.2502	0	56	13.9370	0	111	4.2370	0
2	-15.1001	0	57	6.5985	0	112	-12.6823	0
3	-10.9990	0	58	-12.1234	0	113	-0.3899	0
4	-15.4425	0	59	-10.7979	0	114	-7.4523	0
5	9.3676	0	60	-11.0255	0	115	-12.8712	0
6	12.0306	0	61	9.9044	0	116	-9.8260	0
7	-9.5222	0	62	19.4840	0	117	2.6664	0
8	12.7154	0	63	-11.2784	0	118	1.2813	0
9	10.6058	0	64	18.6810	0	119	-7.7174	0
10	-15.0007	0	65	-2.3140	0	120	5.2808	0
11	-9.2273	0	66	12.8568	0	121	2.0114	0
12	-14.6340	0	67	13.6233	0	122	-11.7876	0
13	12.1101	0	68	16.9414	0	123	-10.6875	0
14	14.7279	0	69	-9.7685	0	124	-13.6090	0
15	-8.1493	0	70	-4.2602	0	125	5.5260	0
16	14.9830	0	71	8.5381	0	126	8.1946	0
17	10.3396	0	72	-10.7736	0	127	-9.8679	0
18	-9.0705	0	73	-2.5570	0	128	9.2682	0
19	-2.9403	0	74	6.1622	0	129	0	0
20	-7.5837	0	75	4.4568	0	130	0	0
21	9.3190	0	76	4.6921	0	131	0	0
22	12.4117	0	77	-3.7101	0	132	0	0
23	-3.6063	0	78	-10.9504	0	133	0	0
24	11.6098	0	79	6.5996	0	134	0	0
25	8.7557	0	80	-9.2869	0	135	0	0
26	-3.7146	0	81	3.9620	0	136	0	0
27	-1.4823	0	82	-10.6080	0	137	0	0
28	-1.7076	0	83	-11.0476	0	138	0	0
29	7.6820	0	84	-12.8524	0	139	0	0
30	11.7169	0	85	10.5925	0	140	0	0
31	-1.7673	0	86	7.8831	0	141	0	0
32	10.4290	0	87	-7.4843	0	142	0	0
33	-0.9322	0	88	10.8510	0	143	0	0
34	13.2257	0	89	-6.0241	0	144	0	0
35	13.5427	0	90	12.1742	0	145	0	0
36	15.9064	0	91	18.2083	0	146	0	0
37	-6.6140	0	92	14.6981	0	147	0	0
38	-5.1637	0	93	-14.1955	0	148	0	0

TABLE A-7. Time-domain sequence for symbol #1

39	9.4106	0	94	-13.9823	0	149	0	0
40	-9.8547	0	95	10.4213	0	150	0	0
41	-6.1887	0	96	-18.5661	0	151	0	0
42	13.1285	0	97	4.6744	0	152	0	0
43	12.2913	0	98	-14.0099	0	153	0	0
44	11.9654	0	99	-20.0484	0	154	0	0
45	-10.0215	0	100	-16.3792	0	155	0	0
46	-17.9233	0	101	11.3789	0	156	0	0
47	11.0597	0	102	10.4036	0	157	0	0
48	-17.7466	0	103	-12.6712	0	158	0	0
49	3.7112	0	104	16.4112	0	159	0	0
50	-14.5092	0	105	-7.5042	0	160	0	0
51	-15.9572	0	106	10.5737	0	161	0	0
52	-19.0400	0	107	11.9367	0	162	0	0
53	11.3624	0	108	12.6414	0	163	0	0
54	6.7377	0	109	-13.5990	0	164	0	0
55	-10.2026	0	110	-7.3374	0	165	0	0

TABLE A-8. Time-domain sequence for symbol #25

#	Real	Imag	#	Real	Imag	#	Real	Imag
3961	9.8995	0	4016	13.5986	0	4071	0.7116	0
3962	-7.2562	0	4017	3.7818	0	4072	12.0037	0
3963	-8.4976	0	4018	9.4041	0	4073	13.1716	0
3964	7.0257	0	4019	-8.8197	0	4074	0.3003	0
3965	0.3928	0	4020	-2.2902	0	4075	5.7548	0
3966	17.7030	0	4021	19.9806	0	4076	12.1077	0
3967	-11.7901	0	4022	-2.0604	0	4077	9.3034	0
3968	12.3091	0	4023	-6.1139	0	4078	-8.2817	0
3969	-11.7563	0	4024	-10.8551	0	4079	14.3560	0
3970	5.3317	0	4025	-9.8995	0	4080	-16.5921	0
3971	7.2923	0	4026	3.8499	0	4081	12.7035	0
3972	-2.5968	0	4027	5.9205	0	4082	-2.2428	0
3973	16.7493	0	4028	16.2487	0	4083	6.7585	0
3974	-3.8235	0	4029	4.9132	0	4084	8.7422	0
3975	-2.2717	0	4030	-15.2805	0	4085	-7.6215	0
3976	-0.0808	0	4031	11.6706	0	4086	-0.0991	0
3977	6.0000	0	4032	6.5789	0	4087	-9.9805	0
3978	-12.8722	0	4033	4.9279	0	4088	13.4091	0
3979	-12.9997	0	4034	6.7958	0	4089	0	0
3980	-7.5541	0	4035	-2.8129	0	4090	0	0
3981	17.4249	0	4036	-15.6939	0	4091	0	0
3982	-12.2915	0	4037	-18.2254	0	4092	0	0
3983	-3.9802	0	4038	-13.4653	0	4093	0	0
3984	17.4186	0	4039	-15.8214	0	4094	0	0
3985	0.5597	0	4040	-12.9716	0	4095	0	0
3986	-11.3055	0	4041	-6.0000	0	4096	0	0
3987	-20.2687	0	4042	13.9538	0	4097	0	0
3988	-12.5852	0	4043	-4.0309	0	4098	0	0
3989	-0.7328	0	4044	-16.5369	0	4099	0	0
3990	18.6881	0	4045	9.0572	0	4100	0	0
3991	1.3508	0	4046	-7.5991	0	4101	0	0
3992	-10.9864	0	4047	7.5677	0	4102	0	0
3993	18.3848	0	4048	0.7103	0	4103	0	0
3994	-3.4662	0	4049	-0.0744	0	4104	0	0
3995	-0.9163	0	4050	15.7589	0	4105	0	0
3996	2.0911	0	4051	-16.7636	0	4106	0	0
3997	-13.9331	0	4052	-5.4543	0	4107	0	0
3998	-18.0095	0	4053	10.0305	0	4108	0	0

TABLE A-8. Time-domain sequence for symbol #25

3999	5.9530	0	4054	13.8226	0	4109	0	0
4000	8.2221	0	4055	-1.7224	0	4110	0	0
4001	-15.8583	0	4056	16.1963	0	4111	0	0
4002	5.5459	0	4057	-1.4142	0	4112	0	0
4003	-14.4491	0	4058	-9.2484	0	4113	0	0
4004	-2.2933	0	4059	17.3049	0	4114	0	0
4005	-9.6066	0	4060	-5.8931	0	4115	0	0
4006	-14.0188	0	4061	-17.7161	0	4116	0	0
4007	13.1612	0	4062	-11.7285	0	4117	0	0
4008	-8.9657	0	4063	1.0413	0	4118	0	0
4009	-18.8284	0	4064	14.6324	0	4119	0	0
4010	-10.1388	0	4065	17.0299	0	4120	0	0
4011	-4.4768	0	4066	4.9622	0	4121	0	0
4012	0.0705	0	4067	-16.8781	0	4122	0	0
4013	1.8713	0	4068	15.2393	0	4123	0	0
4014	15.9283	0	4069	0.7395	0	4124	0	0
4015	18.4954	0	4070	-14.1115	0	4125	0	0

TABLE A-9. Time-domain sequence for symbol #31

#	Real	Imag	#	Real	Imag	#	Real	Imag
4951	-24.0416	0	5006	4.9458	0	5061	5.1465	0
4952	17.0934	0	5007	-1.3721	0	5062	4.0559	0
4953	-10.1885	0	5008	-0.3136	0	5063	2.0000	0
4954	-3.7917	0	5009	0.8293	0	5064	-10.8757	0
4955	6.1113	0	5010	-21.8677	0	5065	26.8015	0
4956	3.1685	0	5011	23.8626	0	5066	11.9007	0
4957	-4.3795	0	5012	19.1469	0	5067	-5.9224	0
4958	-18.1249	0	5013	-9.9532	0	5068	4.8359	0
4959	0.8659	0	5014	11.0442	0	5069	22.8651	0
4960	17.0610	0	5015	-4.2426	0	5070	-5.8629	0
4961	5.4753	0	5016	-28.1502	0	5071	-3.7995	0
4962	6.8694	0	5017	-10.9862	0	5072	-0.7381	0
4963	8.7059	0	5018	-0.5257	0	5073	8.6174	0
4964	5.6139	0	5019	-9.9625	0	5074	-4.6997	0
4965	16.4724	0	5020	-1.5968	0	5075	-11.5808	0
4966	-11.3538	0	5021	4.7904	0	5076	-20.1242	0
4967	5.1716	0	5022	6.0344	0	5077	-13.1194	0
4968	0.8281	0	5023	-0.6649	0	5078	10.0394	0
4969	-13.3243	0	5024	-16.6432	0	5079	0	0
4970	12.7665	0	5025	6.4458	0	5080	0	0
4971	-8.5005	0	5026	7.9961	0	5081	0	0
4972	0.2355	0	5027	8.1933	0	5082	0	0
4973	14.9466	0	5028	-2.7742	0	5083	0	0
4974	1.9262	0	5029	-9.2911	0	5084	0	0
4975	-2.7422	0	5030	-4.1074	0	5085	0	0
4976	12.6604	0	5031	-10.8284	0	5086	0	0
4977	21.4445	0	5032	17.5945	0	5087	0	0
4978	14.5548	0	5033	-0.2063	0	5088	0	0
4979	23.8425	0	5034	3.0344	0	5089	0	0
4980	-7.1320	0	5035	4.9369	0	5090	0	0
4981	3.1928	0	5036	-23.9435	0	5091	0	0
4982	-11.7240	0	5037	1.5958	0	5092	0	0
4983	9.8995	0	5038	-4.2665	0	5093	0	0
4984	12.0012	0	5039	13.5706	0	5094	0	0
4985	-5.6722	0	5040	8.6342	0	5095	0	0
4986	0.8512	0	5041	7.3411	0	5096	0	0
4987	-4.4057	0	5042	10.4947	0	5097	0	0
4988	-4.2563	0	5043	0.1600	0	5098	0	0

TABLE A-9. Time-domain sequence for symbol #31

4989	12.5905	0	5044	-5.0297	0	5099	0	0
4990	15.0799	0	5045	-21.8209	0	5100	0	0
4991	-21.7473	0	5046	-7.1065	0	5101	0	0
4992	-6.8287	0	5047	-9.8995	0	5102	0	0
4993	-10.0805	0	5048	9.3736	0	5103	0	0
4994	7.1849	0	5049	-2.6079	0	5104	0	0
4995	0.4041	0	5050	-5.5876	0	5105	0	0
4996	-6.5773	0	5051	-0.7136	0	5106	0	0
4997	8.6865	0	5052	8.6168	0	5107	0	0
4998	4.4659	0	5053	-4.3333	0	5108	0	0
4999	-2.0000	0	5054	-4.4183	0	5109	0	0
5000	-13.1786	0	5055	-18.0517	0	5110	0	0
5001	-4.5024	0	5056	-9.1457	0	5111	0	0
5002	8.6659	0	5057	3.2409	0	5112	0	0
5003	-15.4846	0	5058	6.7812	0	5113	0	0
5004	-14.3738	0	5059	2.9810	0	5114	0	0
5005	-4.7619	0	5060	-10.4372	0	5115	0	0

TABLE A-10. Time-domain sequence for symbol #32

#	Real	Imag	#	Real	Imag	#	Real	Imag
5116	24.0416	0	5171	-4.9458	0	5226	-5.1465	0
5117	-17.0934	0	5172	1.3721	0	5227	-4.0559	0
5118	10.1885	0	5173	0.3136	0	5228	-2.0000	0
5119	3.7917	0	5174	-0.8293	0	5229	10.8757	0
5120	-6.1113	0	5175	21.8677	0	5230	-26.8015	0
5121	-3.1685	0	5176	-23.8626	0	5231	-11.9007	0
5122	4.3795	0	5177	-19.1469	0	5232	5.9224	0
5123	18.1249	0	5178	9.9532	0	5233	-4.8359	0
5124	-0.8659	0	5179	-11.0442	0	5234	-22.8651	0
5125	-17.0610	0	5180	4.2426	0	5235	5.8629	0
5126	-5.4753	0	5181	28.1502	0	5236	3.7995	0
5127	-6.8694	0	5182	10.9862	0	5237	0.7381	0
5128	-8.7059	0	5183	0.5257	0	5238	-8.6174	0
5129	-5.6139	0	5184	9.9625	0	5239	4.6997	0
5130	-16.4724	0	5185	1.5968	0	5240	11.5808	0
5131	11.3538	0	5186	-4.7904	0	5241	20.1242	0
5132	-5.1716	0	5187	-6.0344	0	5242	13.1194	0
5133	-0.8281	0	5188	0.6649	0	5243	-10.0394	0
5134	13.3243	0	5189	16.6432	0	5244	0	0
5135	-12.7665	0	5190	-6.4458	0	5245	0	0
5136	8.5005	0	5191	-7.9961	0	5246	0	0
5137	-0.2355	0	5192	-8.1933	0	5247	0	0
5138	-14.9466	0	5193	2.7742	0	5248	0	0
5139	-1.9262	0	5194	9.2911	0	5249	0	0
5140	2.7422	0	5195	4.1074	0	5250	0	0
5141	-12.6604	0	5196	10.8284	0	5251	0	0
5142	-21.4445	0	5197	-17.5945	0	5252	0	0
5143	-14.5548	0	5198	0.2063	0	5253	0	0
5144	-23.8425	0	5199	-3.0344	0	5254	0	0
5145	7.1320	0	5200	-4.9369	0	5255	0	0
5146	-3.1928	0	5201	23.9435	0	5256	0	0
5147	11.7240	0	5202	-1.5958	0	5257	0	0
5148	-9.8995	0	5203	4.2665	0	5258	0	0
5149	-12.0012	0	5204	-13.5706	0	5259	0	0
5150	5.6722	0	5205	-8.6342	0	5260	0	0
5151	-0.8512	0	5206	-7.3411	0	5261	0	0
5152	4.4057	0	5207	-10.4947	0	5262	0	0
5153	4.2563	0	5208	-0.1600	0	5263	0	0

TABLE A-10. Time-domain sequence for symbol #32

5154	-12.5905	0	5209	5.0297	0	5264	0	0
5155	-15.0799	0	5210	21.8209	0	5265	0	0
5156	21.7473	0	5211	7.1065	0	5266	0	0
5157	6.8287	0	5212	9.8995	0	5267	0	0
5158	10.0805	0	5213	-9.3736	0	5268	0	0
5159	-7.1849	0	5214	2.6079	0	5269	0	0
5160	-0.4041	0	5215	5.5876	0	5270	0	0
5161	6.5773	0	5216	0.7136	0	5271	0	0
5162	-8.6865	0	5217	-8.6168	0	5272	0	0
5163	-4.4659	0	5218	4.3333	0	5273	0	0
5164	2.0000	0	5219	4.4183	0	5274	0	0
5165	13.1786	0	5220	18.0517	0	5275	0	0
5166	4.5024	0	5221	9.1457	0	5276	0	0
5167	-8.6659	0	5222	-3.2409	0	5277	0	0
5168	15.4846	0	5223	-6.7812	0	5278	0	0
5169	14.3738	0	5224	-2.9810	0	5279	0	0
5170	4.7619	0	5225	10.4372	0	5280	0	0

TABLE A-11. Time-domain sequence for symbol #33

#	Real	Imag	#	Real	Imag	#	Real	Imag
5281	4.2426	0	5336	18.5388	0	5391	5.9604	0
5282	-13.1537	0	5337	1.9820	0	5392	-7.1869	0
5283	-17.1802	0	5338	3.4892	0	5393	4.0000	0
5284	-10.9092	0	5339	22.1600	0	5394	-6.2479	0
5285	-0.1366	0	5340	9.9179	0	5395	-6.4936	0
5286	-2.7590	0	5341	18.8865	0	5396	5.7625	0
5287	-0.5540	0	5342	32.0170	0	5397	2.8239	0
5288	11.1969	0	5343	-5.2683	0	5398	-12.9276	0
5289	-5.2620	0	5344	-3.5078	0	5399	-2.5922	0
5290	-15.1817	0	5345	-9.8995	0	5400	-1.3835	0
5291	-3.2615	0	5346	-3.5444	0	5401	-16.1242	0
5292	14.6765	0	5347	14.8763	0	5402	-16.6353	0
5293	12.5016	0	5348	0.4054	0	5403	3.0835	0
5294	1.3575	0	5349	6.6606	0	5404	20.5041	0
5295	-4.8180	0	5350	-9.7213	0	5405	3.9251	0
5296	-4.8701	0	5351	4.6199	0	5406	3.5259	0
5297	-0.1421	0	5352	27.4419	0	5407	22.7779	0
5298	-7.9815	0	5353	-1.5665	0	5408	2.1000	0
5299	0.5341	0	5354	-7.0722	0	5409	0	0
5300	-3.7717	0	5355	-12.8162	0	5410	0	0
5301	17.3607	0	5356	-19.5550	0	5411	0	0
5302	12.6644	0	5357	-9.6481	0	5412	0	0
5303	-15.2406	0	5358	-6.7917	0	5413	0	0
5304	-2.9655	0	5359	-2.1632	0	5414	0	0
5305	-18.4746	0	5360	3.5409	0	5415	0	0
5306	6.0360	0	5361	-28.1421	0	5416	0	0
5307	7.1150	0	5362	18.3975	0	5417	0	0
5308	0.9319	0	5363	0.6840	0	5418	0	0
5309	-0.9734	0	5364	-16.2015	0	5419	0	0
5310	-2.4154	0	5365	-13.0015	0	5420	0	0
5311	-1.1355	0	5366	11.1119	0	5421	0	0
5312	0.4057	0	5367	11.8478	0	5422	0	0
5313	-4.2426	0	5368	-8.7904	0	5423	0	0
5314	-3.3064	0	5369	4.3325	0	5424	0	0
5315	13.8805	0	5370	-4.8574	0	5425	0	0
5316	-4.7961	0	5371	23.7675	0	5426	0	0
5317	-8.5115	0	5372	-11.3327	0	5427	0	0
5318	7.2995	0	5373	-0.1815	0	5428	0	0

TABLE A-11. Time-domain sequence for symbol #33

5319	13.5124	0	5374	-13.4025	0	5429	0	0
5320	-1.7741	0	5375	-10.7172	0	5430	0	0
5321	-0.1796	0	5376	6.4914	0	5431	0	0
5322	6.2154	0	5377	4.2426	0	5432	0	0
5323	-16.8899	0	5378	-2.1451	0	5433	0	0
5324	11.9162	0	5379	-2.3329	0	5434	0	0
5325	1.7221	0	5380	-21.4181	0	5435	0	0
5326	-14.0809	0	5381	7.6444	0	5436	0	0
5327	6.6777	0	5382	-4.0902	0	5437	0	0
5328	5.8488	0	5383	-11.9214	0	5438	0	0
5329	-4.0000	0	5384	9.5413	0	5439	0	0
5330	-9.3321	0	5385	1.3512	0	5440	0	0
5331	7.3456	0	5386	0.6923	0	5441	0	0
5332	-12.8859	0	5387	-11.8448	0	5442	0	0
5333	-1.5262	0	5388	27.3831	0	5443	0	0
5334	3.1087	0	5389	-14.9188	0	5444	0	0
5335	11.6419	0	5390	4.4764	0	5445	0	0

TABLE A-12. Time-domain sequence for symbol #34

#	Real	Imag	#	Real	Imag	#	Real	Imag
5446	4.2426	0	5501	18.5388	0	5556	5.9604	0
5447	-13.1537	0	5502	1.9820	0	5557	-7.1869	0
5448	-17.1802	0	5503	3.4892	0	5558	4.0000	0
5449	-10.9092	0	5504	22.1600	0	5559	-6.2479	0
5450	-0.1366	0	5505	9.9179	0	5560	-6.4936	0
5451	-2.7590	0	5506	18.8865	0	5561	5.7625	0
5452	-0.5540	0	5507	32.0170	0	5562	2.8239	0
5453	11.1969	0	5508	-5.2683	0	5563	-12.9276	0
5454	-5.2620	0	5509	-3.5078	0	5564	-2.5922	0
5455	-15.1817	0	5510	-9.8995	0	5565	-1.3835	0
5456	-3.2615	0	5511	-3.5444	0	5566	-16.1242	0
5457	14.6765	0	5512	14.8763	0	5567	-16.6353	0
5458	12.5016	0	5513	0.4054	0	5568	3.0835	0
5459	1.3575	0	5514	6.6606	0	5569	20.5041	0
5460	-4.8180	0	5515	-9.7213	0	5570	3.9251	0
5461	-4.8701	0	5516	4.6199	0	5571	3.5259	0
5462	-0.1421	0	5517	27.4419	0	5572	22.7779	0
5463	-7.9815	0	5518	-1.5665	0	5573	2.1000	0
5464	0.5341	0	5519	-7.0722	0	5574	0	0
5465	-3.7717	0	5520	-12.8162	0	5575	0	0
5466	17.3607	0	5521	-19.5550	0	5576	0	0
5467	12.6644	0	5522	-9.6481	0	5577	0	0
5468	-15.2406	0	5523	-6.7917	0	5578	0	0
5469	-2.9655	0	5524	-2.1632	0	5579	0	0
5470	-18.4746	0	5525	3.5409	0	5580	0	0
5471	6.0360	0	5526	-28.1421	0	5581	0	0
5472	7.1150	0	5527	18.3975	0	5582	0	0
5473	0.9319	0	5528	0.6840	0	5583	0	0
5474	-0.9734	0	5529	-16.2015	0	5584	0	0
5475	-2.4154	0	5530	-13.0015	0	5585	0	0
5476	-1.1355	0	5531	11.1119	0	5586	0	0
5477	0.4057	0	5532	11.8478	0	5587	0	0
5478	-4.2426	0	5533	-8.7904	0	5588	0	0
5479	-3.3064	0	5534	4.3325	0	5589	0	0
5480	13.8805	0	5535	-4.8574	0	5590	0	0
5481	-4.7961	0	5536	23.7675	0	5591	0	0
5482	-8.5115	0	5537	-11.3327	0	5592	0	0
5483	7.2995	0	5538	-0.1815	0	5593	0	0

TABLE A-12. Time-domain sequence for symbol #34

5484	13.5124	0	5539	-13.4025	0	5594	0	0
5485	-1.7741	0	5540	-10.7172	0	5595	0	0
5486	-0.1796	0	5541	6.4914	0	5596	0	0
5487	6.2154	0	5542	4.2426	0	5597	0	0
5488	-16.8899	0	5543	-2.1451	0	5598	0	0
5489	11.9162	0	5544	-2.3329	0	5599	0	0
5490	1.7221	0	5545	-21.4181	0	5600	0	0
5491	-14.0809	0	5546	7.6444	0	5601	0	0
5492	6.6777	0	5547	-4.0902	0	5602	0	0
5493	5.8488	0	5548	-11.9214	0	5603	0	0
5494	-4.0000	0	5549	9.5413	0	5604	0	0
5495	-9.3321	0	5550	1.3512	0	5605	0	0
5496	7.3456	0	5551	0.6923	0	5606	0	0
5497	-12.8859	0	5552	-11.8448	0	5607	0	0
5498	-1.5262	0	5553	27.3831	0	5608	0	0
5499	3.1087	0	5554	-14.9188	0	5609	0	0
5500	11.6419	0	5555	4.4764	0	5610	0	0

TABLE A-13. Time-domain sequence for symbol #35

#	Real	Imag	#	Real	Imag	#	Real	Imag
5611	-24.0416	0	5666	-2.9050	0	5721	-17.7167	0
5612	1.2285	0	5667	22.4537	0	5722	12.1590	0
5613	6.2281	0	5668	-1.7791	0	5723	6.8284	0
5614	-2.4405	0	5669	1.3932	0	5724	-8.1108	0
5615	-16.6922	0	5670	5.2041	0	5725	7.9329	0
5616	12.5876	0	5671	4.5919	0	5726	7.1087	0
5617	-2.7848	0	5672	7.8750	0	5727	9.1810	0
5618	20.5619	0	5673	14.4637	0	5728	2.5262	0
5619	-6.7767	0	5674	3.6928	0	5729	0.1477	0
5620	-5.3672	0	5675	-15.5563	0	5730	-0.4629	0
5621	1.3931	0	5676	-18.4535	0	5731	-4.3116	0
5622	-8.7222	0	5677	-17.8908	0	5732	-3.9144	0
5623	5.5412	0	5678	-4.7247	0	5733	5.0427	0
5624	8.2742	0	5679	2.6761	0	5734	-14.0415	0
5625	-11.1326	0	5680	5.2050	0	5735	5.3231	0
5626	13.6553	0	5681	-16.3751	0	5736	-10.8456	0
5627	14.9706	0	5682	-20.1239	0	5737	21.9483	0
5628	-7.3539	0	5683	-3.0812	0	5738	14.2813	0
5629	4.3129	0	5684	-22.4182	0	5739	0	0
5630	3.5615	0	5685	-12.5504	0	5740	0	0
5631	12.5790	0	5686	-12.9163	0	5741	0	0
5632	-5.1377	0	5687	-3.3050	0	5742	0	0
5633	-0.9516	0	5688	-4.2879	0	5743	0	0
5634	-11.6666	0	5689	-16.9968	0	5744	0	0
5635	4.1200	0	5690	0.9189	0	5745	0	0
5636	-6.5941	0	5691	18.9706	0	5746	0	0
5637	-1.0811	0	5692	19.6647	0	5747	0	0
5638	-4.5680	0	5693	9.9963	0	5748	0	0
5639	-4.9643	0	5694	-8.3693	0	5749	0	0
5640	12.1569	0	5695	-13.3688	0	5750	0	0
5641	19.5146	0	5696	-4.5933	0	5751	0	0
5642	-0.9429	0	5697	15.2973	0	5752	0	0
5643	1.4142	0	5698	-9.8130	0	5753	0	0
5644	-7.0567	0	5699	6.0221	0	5754	0	0
5645	-8.0593	0	5700	16.2300	0	5755	0	0
5646	5.0362	0	5701	-9.2183	0	5756	0	0
5647	-4.1482	0	5702	2.1858	0	5757	0	0
5648	16.5043	0	5703	-7.2938	0	5758	0	0

TABLE A-13. Time-domain sequence for symbol #35

5649	-20.0347	0	5704	6.6777	0	5759	0	0
5650	-9.1876	0	5705	-11.6898	0	5760	0	0
5651	18.3057	0	5706	-3.1900	0	5761	0	0
5652	22.8762	0	5707	9.8995	0	5762	0	0
5653	-8.8941	0	5708	12.5315	0	5763	0	0
5654	-2.7532	0	5709	-11.1695	0	5764	0	0
5655	18.4753	0	5710	-0.6615	0	5765	0	0
5656	2.0806	0	5711	-6.8063	0	5766	0	0
5657	22.2955	0	5712	-9.5438	0	5767	0	0
5658	5.9221	0	5713	-5.1607	0	5768	0	0
5659	-1.1716	0	5714	-3.5267	0	5769	0	0
5660	2.8639	0	5715	19.8364	0	5770	0	0
5661	-2.6644	0	5716	-3.7194	0	5771	0	0
5662	-9.5058	0	5717	12.6011	0	5772	0	0
5663	-17.3618	0	5718	-9.0206	0	5773	0	0
5664	9.7653	0	5719	-7.0547	0	5774	0	0
5665	-13.4519	0	5720	5.3828	0	5775	0	0

TABLE A-14. Time-domain sequence for symbol #36

#	Real	Imag	#	Real	Imag	#	Real	Imag
5776	24.0416	0	5831	2.9050	0	5886	17.7167	0
5777	-1.2285	0	5832	-22.4537	0	5887	-12.1590	0
5778	-6.2281	0	5833	1.7791	0	5888	-6.8284	0
5779	2.4405	0	5834	-1.3932	0	5889	8.1108	0
5780	16.6922	0	5835	-5.2041	0	5890	-7.9329	0
5781	-12.5876	0	5836	-4.5919	0	5891	-7.1087	0
5782	2.7848	0	5837	-7.8750	0	5892	-9.1810	0
5783	-20.5619	0	5838	-14.4637	0	5893	-2.5262	0
5784	6.7767	0	5839	-3.6928	0	5894	-0.1477	0
5785	5.3672	0	5840	15.5563	0	5895	0.4629	0
5786	-1.3931	0	5841	18.4535	0	5896	4.3116	0
5787	8.7222	0	5842	17.8908	0	5897	3.9144	0
5788	-5.5412	0	5843	4.7247	0	5898	-5.0427	0
5789	-8.2742	0	5844	-2.6761	0	5899	14.0415	0
5790	11.1326	0	5845	-5.2050	0	5900	-5.3231	0
5791	-13.6553	0	5846	16.3751	0	5901	10.8456	0
5792	-14.9706	0	5847	20.1239	0	5902	-21.9483	0
5793	7.3539	0	5848	3.0812	0	5903	-14.2813	0
5794	-4.3129	0	5849	22.4182	0	5904	0	0
5795	-3.5615	0	5850	12.5504	0	5905	0	0
5796	-12.5790	0	5851	12.9163	0	5906	0	0
5797	5.1377	0	5852	3.3050	0	5907	0	0
5798	0.9516	0	5853	4.2879	0	5908	0	0
5799	11.6666	0	5854	16.9968	0	5909	0	0
5800	-4.1200	0	5855	-0.9189	0	5910	0	0
5801	6.5941	0	5856	-18.9706	0	5911	0	0
5802	1.0811	0	5857	-19.6647	0	5912	0	0
5803	4.5680	0	5858	-9.9963	0	5913	0	0
5804	4.9643	0	5859	8.3693	0	5914	0	0
5805	-12.1569	0	5860	13.3688	0	5915	0	0
5806	-19.5146	0	5861	4.5933	0	5916	0	0
5807	0.9429	0	5862	-15.2973	0	5917	0	0
5808	-1.4142	0	5863	9.8130	0	5918	0	0
5809	7.0567	0	5864	-6.0221	0	5919	0	0
5810	8.0593	0	5865	-16.2300	0	5920	0	0
5811	-5.0362	0	5866	9.2183	0	5921	0	0
5812	4.1482	0	5867	-2.1858	0	5922	0	0
5813	-16.5043	0	5868	7.2938	0	5923	0	0

TABLE A-14. Time-domain sequence for symbol #36

5814	20.0347	0	5869	-6.6777	0	5924	0	0
5815	9.1876	0	5870	11.6898	0	5925	0	0
5816	-18.3057	0	5871	3.1900	0	5926	0	0
5817	-22.8762	0	5872	-9.8995	0	5927	0	0
5818	8.8941	0	5873	-12.5315	0	5928	0	0
5819	2.7532	0	5874	11.1695	0	5929	0	0
5820	-18.4753	0	5875	0.6615	0	5930	0	0
5821	-2.0806	0	5876	6.8063	0	5931	0	0
5822	-22.2955	0	5877	9.5438	0	5932	0	0
5823	-5.9221	0	5878	5.1607	0	5933	0	0
5824	1.1716	0	5879	3.5267	0	5934	0	0
5825	-2.8639	0	5880	-19.8364	0	5935	0	0
5826	2.6644	0	5881	3.7194	0	5936	0	0
5827	9.5058	0	5882	-12.6011	0	5937	0	0
5828	17.3618	0	5883	9.0206	0	5938	0	0
5829	-9.7653	0	5884	7.0547	0	5939	0	0
5830	13.4519	0	5885	-5.3828	0	5940	0	0

TABLE A-15. Time-domain sequence for symbol #37

#	Real	Imag	#	Real	Imag	#	Real	Imag
5941	4.2426	0	5996	-4.3089	0	6051	-13.5796	0
5942	-1.8468	0	5997	10.8565	0	6052	19.3353	0
5943	-15.1061	0	5998	-11.0905	0	6053	-8.8284	0
5944	2.7413	0	5999	-14.0788	0	6054	-10.1153	0
5945	12.4704	0	6000	20.2929	0	6055	-16.2659	0
5946	10.3586	0	6001	11.9481	0	6056	0.8329	0
5947	20.5888	0	6002	4.3048	0	6057	5.7774	0
5948	10.9830	0	6003	-5.7093	0	6058	0.6510	0
5949	-3.2115	0	6004	-7.3066	0	6059	23.2530	0
5950	6.5708	0	6005	18.3848	0	6060	9.7423	0
5951	17.3275	0	6006	1.9790	0	6061	-19.3417	0
5952	23.2973	0	6007	4.5623	0	6062	5.8509	0
5953	-3.0369	0	6008	9.5259	0	6063	-0.6105	0
5954	-8.2836	0	6009	6.5196	0	6064	8.7611	0
5955	13.5021	0	6010	-19.1521	0	6065	-0.5866	0
5956	-4.2381	0	6011	-7.6440	0	6066	-18.0597	0
5957	-15.3137	0	6012	-0.0769	0	6067	-0.3860	0
5958	-10.0926	0	6013	10.0399	0	6068	-9.0988	0
5959	8.8508	0	6014	-1.6119	0	6069	0	0
5960	-1.5965	0	6015	-5.4914	0	6070	0	0
5961	-7.5391	0	6016	-6.5538	0	6071	0	0
5962	-1.3772	0	6017	-21.0010	0	6072	0	0
5963	-5.0895	0	6018	9.3804	0	6073	0	0
5964	-6.7737	0	6019	2.2762	0	6074	0	0
5965	6.3412	0	6020	-16.0339	0	6075	0	0
5966	-10.3550	0	6021	-7.3137	0	6076	0	0
5967	-1.2634	0	6022	13.0858	0	6077	0	0
5968	18.0168	0	6023	-13.8978	0	6078	0	0
5969	3.4930	0	6024	-14.0688	0	6079	0	0
5970	8.5356	0	6025	-20.5407	0	6080	0	0
5971	6.1278	0	6026	-16.7484	0	6081	0	0
5972	-4.4886	0	6027	9.8334	0	6082	0	0
5973	-7.0711	0	6028	6.0345	0	6083	0	0
5974	-11.1013	0	6029	-14.8265	0	6084	0	0
5975	-1.0020	0	6030	-3.2709	0	6085	0	0
5976	11.8188	0	6031	-5.0617	0	6086	0	0
5977	-11.3586	0	6032	-3.4572	0	6087	0	0
5978	3.5484	0	6033	-12.5113	0	6088	0	0

TABLE A-15. Time-domain sequence for symbol #37

5979	8.0844	0	6034	-0.3660	0	6089	0	0
5980	3.3981	0	6035	5.2678	0	6090	0	0
5981	-5.4950	0	6036	7.8317	0	6091	0	0
5982	-1.0818	0	6037	1.4142	0	6092	0	0
5983	7.6612	0	6038	8.0314	0	6093	0	0
5984	-9.3134	0	6039	2.8777	0	6094	0	0
5985	5.2879	0	6040	-2.5007	0	6095	0	0
5986	10.7782	0	6041	10.7117	0	6096	0	0
5987	-5.5576	0	6042	-22.3685	0	6097	0	0
5988	-2.9331	0	6043	1.4888	0	6098	0	0
5989	3.1716	0	6044	-11.4387	0	6099	0	0
5990	-5.0080	0	6045	4.3234	0	6100	0	0
5991	-13.3326	0	6046	-24.5712	0	6101	0	0
5992	-9.0034	0	6047	22.2033	0	6102	0	0
5993	-7.3545	0	6048	5.8341	0	6103	0	0
5994	20.2103	0	6049	5.0932	0	6104	0	0
5995	15.4262	0	6050	27.9607	0	6105	0	0

TABLE A-16. Time-domain sequence for symbol #38

#	Real	Imag	#	Real	Imag	#	Real	Imag
6106	-4.2426	0	6161	4.3089	0	6216	13.5796	0
6107	1.8468	0	6162	-10.8565	0	6217	-19.3353	0
6108	15.1061	0	6163	11.0905	0	6218	8.8284	0
6109	-2.7413	0	6164	14.0788	0	6219	10.1153	0
6110	-12.4704	0	6165	-20.2929	0	6220	16.2659	0
6111	-10.3586	0	6166	-11.9481	0	6221	-0.8329	0
6112	-20.5888	0	6167	-4.3048	0	6222	-5.7774	0
6113	-10.9830	0	6168	5.7093	0	6223	-0.6510	0
6114	3.2115	0	6169	7.3066	0	6224	-23.2530	0
6115	-6.5708	0	6170	-18.3848	0	6225	-9.7423	0
6116	-17.3275	0	6171	-1.9790	0	6226	19.3417	0
6117	-23.2973	0	6172	-4.5623	0	6227	-5.8509	0
6118	3.0369	0	6173	-9.5259	0	6228	0.6105	0
6119	8.2836	0	6174	-6.5196	0	6229	-8.7611	0
6120	-13.5021	0	6175	19.1521	0	6230	0.5866	0
6121	4.2381	0	6176	7.6440	0	6231	18.0597	0
6122	15.3137	0	6177	0.0769	0	6232	0.3860	0
6123	10.0926	0	6178	-10.0399	0	6233	9.0988	0
6124	-8.8508	0	6179	1.6119	0	6234	0	0
6125	1.5965	0	6180	5.4914	0	6235	0	0
6126	7.5391	0	6181	6.5538	0	6236	0	0
6127	1.3772	0	6182	21.0010	0	6237	0	0
6128	5.0895	0	6183	-9.3804	0	6238	0	0
6129	6.7737	0	6184	-2.2762	0	6239	0	0
6130	-6.3412	0	6185	16.0339	0	6240	0	0
6131	10.3550	0	6186	7.3137	0	6241	0	0
6132	1.2634	0	6187	-13.0858	0	6242	0	0
6133	-18.0168	0	6188	13.8978	0	6243	0	0
6134	-3.4930	0	6189	14.0688	0	6244	0	0
6135	-8.5356	0	6190	20.5407	0	6245	0	0
6136	-6.1278	0	6191	16.7484	0	6246	0	0
6137	4.4886	0	6192	-9.8334	0	6247	0	0
6138	7.0711	0	6193	-6.0345	0	6248	0	0
6139	11.1013	0	6194	14.8265	0	6249	0	0
6140	1.0020	0	6195	3.2709	0	6250	0	0
6141	-11.8188	0	6196	5.0617	0	6251	0	0
6142	11.3586	0	6197	3.4572	0	6252	0	0
6143	-3.5484	0	6198	12.5113	0	6253	0	0

TABLE A-16. Time-domain sequence for symbol #38

6144	-8.0844	0	6199	0.3660	0	6254	0	0
6145	-3.3981	0	6200	-5.2678	0	6255	0	0
6146	5.4950	0	6201	-7.8317	0	6256	0	0
6147	1.0818	0	6202	-1.4142	0	6257	0	0
6148	-7.6612	0	6203	-8.0314	0	6258	0	0
6149	9.3134	0	6204	-2.8777	0	6259	0	0
6150	-5.2879	0	6205	2.5007	0	6260	0	0
6151	-10.7782	0	6206	-10.7117	0	6261	0	0
6152	5.5576	0	6207	22.3685	0	6262	0	0
6153	2.9331	0	6208	-1.4888	0	6263	0	0
6154	-3.1716	0	6209	11.4387	0	6264	0	0
6155	5.0080	0	6210	-4.3234	0	6265	0	0
6156	13.3326	0	6211	24.5712	0	6266	0	0
6157	9.0034	0	6212	-22.2033	0	6267	0	0
6158	7.3545	0	6213	-5.8341	0	6268	0	0
6159	-20.2103	0	6214	-5.0932	0	6269	0	0
6160	-15.4262	0	6215	-27.9607	0	6270	0	0

TABLE A-17. Time-domain sequence for symbol #39

#	Real	Imag	#	Real	Imag	#	Real	Imag
6271	26.8701	0	6326	-8.3688	0	6381	9.1614	0
6272	-10.7431	0	6327	-3.6002	0	6382	-5.9404	0
6273	-18.3894	0	6328	18.7576	0	6383	-2.8284	0
6274	-7.0754	0	6329	10.7848	0	6384	14.4913	0
6275	-1.5203	0	6330	15.3808	0	6385	-7.6184	0
6276	1.4489	0	6331	-3.4561	0	6386	1.4148	0
6277	0.0681	0	6332	-12.7662	0	6387	-8.1464	0
6278	13.3719	0	6333	0.4346	0	6388	-7.3790	0
6279	0.7927	0	6334	5.1090	0	6389	-4.6623	0
6280	5.3528	0	6335	-9.8995	0	6390	4.0859	0
6281	-8.2045	0	6336	-14.9101	0	6391	7.1149	0
6282	-7.0861	0	6337	-0.6692	0	6392	8.8677	0
6283	-9.6901	0	6338	9.2635	0	6393	-6.0197	0
6284	-4.4190	0	6339	11.6910	0	6394	2.6793	0
6285	-1.9052	0	6340	-2.7168	0	6395	25.2282	0
6286	-10.9489	0	6341	3.4763	0	6396	14.3283	0
6287	-27.6569	0	6342	6.2512	0	6397	12.6888	0
6288	10.5007	0	6343	-5.9643	0	6398	-17.7742	0
6289	-1.5164	0	6344	14.6145	0	6399	0	0
6290	-14.3487	0	6345	16.9253	0	6400	0	0
6291	-7.7967	0	6346	3.9017	0	6401	0	0
6292	-14.3702	0	6347	13.9901	0	6402	0	0
6293	3.9170	0	6348	0.4787	0	6403	0	0
6294	8.8099	0	6349	9.2451	0	6404	0	0
6295	2.6917	0	6350	-7.4253	0	6405	0	0
6296	-5.9424	0	6351	16.3431	0	6406	0	0
6297	-5.8326	0	6352	-0.6619	0	6407	0	0
6298	-1.8318	0	6353	-2.1854	0	6408	0	0
6299	-21.3049	0	6354	-3.9771	0	6409	0	0
6300	-8.6065	0	6355	-11.9180	0	6410	0	0
6301	-8.2873	0	6356	1.8453	0	6411	0	0
6302	1.6414	0	6357	-10.0586	0	6412	0	0
6303	18.3848	0	6358	13.5421	0	6413	0	0
6304	-8.5055	0	6359	-23.1770	0	6414	0	0
6305	-10.0740	0	6360	-23.2615	0	6415	0	0
6306	3.6550	0	6361	2.7515	0	6416	0	0
6307	-6.4324	0	6362	15.4696	0	6417	0	0
6308	5.8417	0	6363	-6.1240	0	6418	0	0

TABLE A-17. Time-domain sequence for symbol #39

6309	26.8974	0	6364	-5.8123	0	6419	0	0
6310	7.2349	0	6365	24.3804	0	6420	0	0
6311	2.4841	0	6366	-2.5350	0	6421	0	0
6312	-25.2955	0	6367	15.5563	0	6422	0	0
6313	12.4199	0	6368	7.9985	0	6423	0	0
6314	0.8516	0	6369	-13.4292	0	6424	0	0
6315	5.0465	0	6370	2.7688	0	6425	0	0
6316	7.5167	0	6371	-16.0225	0	6426	0	0
6317	-11.7766	0	6372	-5.4199	0	6427	0	0
6318	7.3772	0	6373	16.0929	0	6428	0	0
6319	-2.8284	0	6374	8.1966	0	6429	0	0
6320	-9.4836	0	6375	8.3444	0	6430	0	0
6321	10.5684	0	6376	-4.4070	0	6431	0	0
6322	2.2946	0	6377	-2.1384	0	6432	0	0
6323	-16.4232	0	6378	-0.7330	0	6433	0	0
6324	9.4363	0	6379	-15.0033	0	6434	0	0
6325	-1.7897	0	6380	-2.0334	0	6435	0	0

TABLE A-18. Time-domain sequence for symbol #40

#	Real	Imag	#	Real	Imag	#	Real	Imag
6436	-26.8701	0	6491	8.3688	0	6546	-9.1614	0
6437	10.7431	0	6492	3.6002	0	6547	5.9404	0
6438	18.3894	0	6493	-18.7576	0	6548	2.8284	0
6439	7.0754	0	6494	-10.7848	0	6549	-14.4913	0
6440	1.5203	0	6495	-15.3808	0	6550	7.6184	0
6441	-1.4489	0	6496	3.4561	0	6551	-1.4148	0
6442	-0.0681	0	6497	12.7662	0	6552	8.1464	0
6443	-13.3719	0	6498	-0.4346	0	6553	7.3790	0
6444	-0.7927	0	6499	-5.1090	0	6554	4.6623	0
6445	-5.3528	0	6500	9.8995	0	6555	-4.0859	0
6446	8.2045	0	6501	14.9101	0	6556	-7.1149	0
6447	7.0861	0	6502	0.6692	0	6557	-8.8677	0
6448	9.6901	0	6503	-9.2635	0	6558	6.0197	0
6449	4.4190	0	6504	-11.6910	0	6559	-2.6793	0
6450	1.9052	0	6505	2.7168	0	6560	-25.2282	0
6451	10.9489	0	6506	-3.4763	0	6561	-14.3283	0
6452	27.6569	0	6507	-6.2512	0	6562	-12.6888	0
6453	-10.5007	0	6508	5.9643	0	6563	17.7742	0
6454	1.5164	0	6509	-14.6145	0	6564	0	0
6455	14.3487	0	6510	-16.9253	0	6565	0	0
6456	7.7967	0	6511	-3.9017	0	6566	0	0
6457	14.3702	0	6512	-13.9901	0	6567	0	0
6458	-3.9170	0	6513	-0.4787	0	6568	0	0
6459	-8.8099	0	6514	-9.2451	0	6569	0	0
6460	-2.6917	0	6515	7.4253	0	6570	0	0
6461	5.9424	0	6516	-16.3431	0	6571	0	0
6462	5.8326	0	6517	0.6619	0	6572	0	0
6463	1.8318	0	6518	2.1854	0	6573	0	0
6464	21.3049	0	6519	3.9771	0	6574	0	0
6465	8.6065	0	6520	11.9180	0	6575	0	0
6466	8.2873	0	6521	-1.8453	0	6576	0	0
6467	-1.6414	0	6522	10.0586	0	6577	0	0
6468	-18.3848	0	6523	-13.5421	0	6578	0	0
6469	8.5055	0	6524	23.1770	0	6579	0	0
6470	10.0740	0	6525	23.2615	0	6580	0	0
6471	-3.6550	0	6526	-2.7515	0	6581	0	0
6472	6.4324	0	6527	-15.4696	0	6582	0	0
6473	-5.8417	0	6528	6.1240	0	6583	0	0

TABLE A-18. Time-domain sequence for symbol #40

6474	-26.8974	0	6529	5.8123	0	6584	0	0
6475	-7.2349	0	6530	-24.3804	0	6585	0	0
6476	-2.4841	0	6531	2.5350	0	6586	0	0
6477	25.2955	0	6532	-15.5563	0	6587	0	0
6478	-12.4199	0	6533	-7.9985	0	6588	0	0
6479	-0.8516	0	6534	13.4292	0	6589	0	0
6480	-5.0465	0	6535	-2.7688	0	6590	0	0
6481	-7.5167	0	6536	16.0225	0	6591	0	0
6482	11.7766	0	6537	5.4199	0	6592	0	0
6483	-7.3772	0	6538	-16.0929	0	6593	0	0
6484	2.8284	0	6539	-8.1966	0	6594	0	0
6485	9.4836	0	6540	-8.3444	0	6595	0	0
6486	-10.5684	0	6541	4.4070	0	6596	0	0
6487	-2.2946	0	6542	2.1384	0	6597	0	0
6488	16.4232	0	6543	0.7330	0	6598	0	0
6489	-9.4363	0	6544	15.0033	0	6599	0	0
6490	1.7897	0	6545	2.0334	0	6600	0	0

TABLE A-19. Time-domain sequence for symbol #41

#	Real	Imag	#	Real	Imag	#	Real	Imag
6601	21.2132	0	6656	-29.1176	0	6711	13.4834	0
6602	-19.2759	0	6657	-17.4814	0	6712	8.0450	0
6603	-13.0178	0	6658	4.4509	0	6713	-16.8284	0
6604	11.3705	0	6659	9.3295	0	6714	1.3748	0
6605	10.1838	0	6660	-0.3226	0	6715	-19.3215	0
6606	17.7854	0	6661	-6.3761	0	6716	-16.3364	0
6607	9.1938	0	6662	8.4122	0	6717	-1.7305	0
6608	6.6528	0	6663	27.2959	0	6718	3.2442	0
6609	7.7490	0	6664	-7.4088	0	6719	-0.0653	0
6610	-5.0398	0	6665	-21.2132	0	6720	10.7310	0
6611	2.3687	0	6666	-4.9547	0	6721	0.9962	0
6612	4.6466	0	6667	-26.6757	0	6722	8.1854	0
6613	12.0147	0	6668	1.5377	0	6723	3.4585	0
6614	13.6126	0	6669	8.8062	0	6724	-5.0708	0
6615	-8.4246	0	6670	1.4625	0	6725	7.2014	0
6616	6.0367	0	6671	-11.5579	0	6726	2.5851	0
6617	15.3137	0	6672	-8.0684	0	6727	2.6914	0
6618	9.2860	0	6673	-4.2343	0	6728	-7.9982	0
6619	13.2957	0	6674	1.8951	0	6729	0	0
6620	-8.0570	0	6675	-6.5136	0	6730	0	0
6621	-18.7755	0	6676	19.2543	0	6731	0	0
6622	11.8976	0	6677	7.6344	0	6732	0	0
6623	6.2117	0	6678	7.2191	0	6733	0	0
6624	9.9430	0	6679	9.4739	0	6734	0	0
6625	-4.0695	0	6680	5.7438	0	6735	0	0
6626	-5.8465	0	6681	7.3137	0	6736	0	0
6627	-0.0574	0	6682	-6.6956	0	6737	0	0
6628	-14.0676	0	6683	6.5434	0	6738	0	0
6629	-9.3718	0	6684	-7.8110	0	6739	0	0
6630	11.0560	0	6685	-9.3042	0	6740	0	0
6631	3.2374	0	6686	8.8269	0	6741	0	0
6632	-4.2206	0	6687	-8.0733	0	6742	0	0
6633	-12.7279	0	6688	-25.4963	0	6743	0	0
6634	-3.3156	0	6689	3.5842	0	6744	0	0
6635	13.5657	0	6690	-0.8877	0	6745	0	0
6636	-7.5897	0	6691	-9.8120	0	6746	0	0
6637	0.1368	0	6692	8.8656	0	6747	0	0
6638	-12.3638	0	6693	-5.1103	0	6748	0	0

TABLE A-19. Time-domain sequence for symbol #41

6639	11.9640	0	6694	-22.1330	0	6749	0	0
6640	-12.8865	0	6695	2.1984	0	6750	0	0
6641	-14.2552	0	6696	-2.9995	0	6751	0	0
6642	9.3610	0	6697	7.0711	0	6752	0	0
6643	-10.1759	0	6698	3.6542	0	6753	0	0
6644	30.0969	0	6699	9.3593	0	6754	0	0
6645	-9.4119	0	6700	5.8059	0	6755	0	0
6646	-0.1784	0	6701	-0.7837	0	6756	0	0
6647	-0.0147	0	6702	4.8168	0	6757	0	0
6648	13.7112	0	6703	3.7003	0	6758	0	0
6649	11.1716	0	6704	-17.2949	0	6759	0	0
6650	-5.6646	0	6705	-6.2301	0	6760	0	0
6651	20.9372	0	6706	4.1003	0	6761	0	0
6652	-7.3846	0	6707	-15.9115	0	6762	0	0
6653	0.1534	0	6708	-5.5652	0	6763	0	0
6654	0.3033	0	6709	-7.8941	0	6764	0	0
6655	6.5679	0	6710	-1.9190	0	6765	0	0

TABLE A-20. Time-domain sequence for symbol #42

#	Real	Imag	#	Real	Imag	#	Real	Imag
6766	-21.2132	0	6821	29.1176	0	6876	-13.4834	0
6767	19.2759	0	6822	17.4814	0	6877	-8.0450	0
6768	13.0178	0	6823	-4.4509	0	6878	16.8284	0
6769	-11.3705	0	6824	-9.3295	0	6879	-1.3748	0
6770	-10.1838	0	6825	0.3226	0	6880	19.3215	0
6771	-17.7854	0	6826	6.3761	0	6881	16.3364	0
6772	-9.1938	0	6827	-8.4122	0	6882	1.7305	0
6773	-6.6528	0	6828	-27.2959	0	6883	-3.2442	0
6774	-7.7490	0	6829	7.4088	0	6884	0.0653	0
6775	5.0398	0	6830	21.2132	0	6885	-10.7310	0
6776	-2.3687	0	6831	4.9547	0	6886	-0.9962	0
6777	-4.6466	0	6832	26.6757	0	6887	-8.1854	0
6778	-12.0147	0	6833	-1.5377	0	6888	-3.4585	0
6779	-13.6126	0	6834	-8.8062	0	6889	5.0708	0
6780	8.4246	0	6835	-1.4625	0	6890	-7.2014	0
6781	-6.0367	0	6836	11.5579	0	6891	-2.5851	0
6782	-15.3137	0	6837	8.0684	0	6892	-2.6914	0
6783	-9.2860	0	6838	4.2343	0	6893	7.9982	0
6784	-13.2957	0	6839	-1.8951	0	6894	0	0
6785	8.0570	0	6840	6.5136	0	6895	0	0
6786	18.7755	0	6841	-19.2543	0	6896	0	0
6787	-11.8976	0	6842	-7.6344	0	6897	0	0
6788	-6.2117	0	6843	-7.2191	0	6898	0	0
6789	-9.9430	0	6844	-9.4739	0	6899	0	0
6790	4.0695	0	6845	-5.7438	0	6900	0	0
6791	5.8465	0	6846	-7.3137	0	6901	0	0
6792	0.0574	0	6847	6.6956	0	6902	0	0
6793	14.0676	0	6848	-6.5434	0	6903	0	0
6794	9.3718	0	6849	7.8110	0	6904	0	0
6795	-11.0560	0	6850	9.3042	0	6905	0	0
6796	-3.2374	0	6851	-8.8269	0	6906	0	0
6797	4.2206	0	6852	8.0733	0	6907	0	0
6798	12.7279	0	6853	25.4963	0	6908	0	0
6799	3.3156	0	6854	-3.5842	0	6909	0	0
6800	-13.5657	0	6855	0.8877	0	6910	0	0
6801	7.5897	0	6856	9.8120	0	6911	0	0
6802	-0.1368	0	6857	-8.8656	0	6912	0	0
6803	12.3638	0	6858	5.1103	0	6913	0	0

TABLE A-20. Time-domain sequence for symbol #42

6804	-11.9640	0	6859	22.1330	0	6914	0	0
6805	12.8865	0	6860	-2.1984	0	6915	0	0
6806	14.2552	0	6861	2.9995	0	6916	0	0
6807	-9.3610	0	6862	-7.0711	0	6917	0	0
6808	10.1759	0	6863	-3.6542	0	6918	0	0
6809	-30.0969	0	6864	-9.3593	0	6919	0	0
6810	9.4119	0	6865	-5.8059	0	6920	0	0
6811	0.1784	0	6866	0.7837	0	6921	0	0
6812	0.0147	0	6867	-4.8168	0	6922	0	0
6813	-13.7112	0	6868	-3.7003	0	6923	0	0
6814	-11.1716	0	6869	17.2949	0	6924	0	0
6815	5.6646	0	6870	6.2301	0	6925	0	0
6816	-20.9372	0	6871	-4.1003	0	6926	0	0
6817	7.3846	0	6872	15.9115	0	6927	0	0
6818	-0.1534	0	6873	5.5652	0	6928	0	0
6819	-0.3033	0	6874	7.8941	0	6929	0	0
6820	-6.5679	0	6875	1.9190	0	6930	0	0

TABLE A-21. Time-domain sequence for symbol #43

#	Real	Imag	#	Real	Imag	#	Real	Imag
6931	5.6569	-15.5563	6986	4.5972	9.2839	7041	8.1378	4.8784
6932	-7.3256	-5.8859	6987	10.0968	2.7119	7042	1.7870	-1.6942
6933	-3.4562	8.0375	6988	8.5499	7.9283	7043	0.0000	-5.1716
6934	-2.1729	-3.4839	6989	-7.9708	-5.9453	7044	8.9829	14.1947
6935	3.1765	0.6753	6990	-2.4135	12.9526	7045	5.4362	-1.9039
6936	0.2959	6.3641	6991	-13.7910	-2.2408	7046	2.1940	-16.1145
6937	4.7368	9.7582	6992	7.3309	-2.7881	7047	-8.6025	-3.1296
6938	-4.9815	7.4272	6993	-5.7758	17.8872	7048	1.6272	-4.7230
6939	10.8796	2.0273	6994	-4.9856	1.3084	7049	-0.7598	-5.3260
6940	-0.9253	-1.4276	6995	5.6569	-12.7279	7050	-9.4105	10.1188
6941	-11.7830	-1.9553	6996	-24.5126	-11.9274	7051	-2.7831	5.7734
6942	-8.6512	-8.4905	6997	3.3019	14.1191	7052	6.0694	-2.9262
6943	-7.6180	3.8784	6998	-14.6726	-6.6855	7053	-1.6380	-1.1872
6944	-3.1359	-2.1070	6999	-4.4027	12.9101	7054	-11.3373	-2.0241
6945	2.5044	-9.5182	7000	4.4330	-0.3948	7055	-4.4831	10.9295
6946	-5.5661	3.7362	7001	-1.5017	-9.0949	7056	17.6827	0.5902
6947	-5.6569	-3.6569	7002	10.0538	6.3784	7057	1.5137	-4.9642
6948	5.2865	-0.2268	7003	-4.5365	-3.1989	7058	-10.4545	3.2112
6949	10.5334	19.4120	7004	9.0527	-3.2487	7059	0	0
6950	0.1996	16.8985	7005	-0.9686	-0.8514	7060	0	0
6951	-7.8014	-1.1601	7006	2.3481	1.4031	7061	0	0
6952	4.2362	6.4591	7007	2.8578	-7.8070	7062	0	0
6953	-7.9485	2.1321	7008	3.1287	-6.3080	7063	0	0
6954	0.0994	13.2728	7009	4.3057	-0.1872	7064	0	0
6955	-2.6643	7.9382	7010	14.7856	-2.7287	7065	0	0
6956	7.2059	3.6947	7011	-5.6569	-7.6569	7066	0	0
6957	-0.6246	2.3534	7012	2.8560	6.9983	7067	0	0
6958	2.0810	-5.0736	7013	-9.5841	-6.7473	7068	0	0
6959	-1.5367	2.5028	7014	-8.9301	13.5903	7069	0	0
6960	-2.0227	-6.0615	7015	5.9662	-5.8718	7070	0	0
6961	-5.2936	-7.0084	7016	7.4282	1.3332	7071	0	0
6962	3.6447	-1.7857	7017	-2.7779	11.3060	7072	0	0
6963	8.4853	-4.2426	7018	-0.2445	-8.3119	7073	0	0
6964	4.0458	-3.6770	7019	17.9780	0.5471	7074	0	0
6965	6.3857	-0.7584	7020	-19.6581	-18.2471	7075	0	0
6966	-7.8420	-12.3965	7021	-7.4235	-2.4253	7076	0	0
6967	-4.9671	-3.8454	7022	2.0931	0.4803	7077	0	0
6968	-4.2232	-7.5612	7023	8.4971	-5.5347	7078	0	0

TABLE A-21. Time-domain sequence for symbol #43

6969	2.4266	4.1413	7024	3.8439	-8.9789	7079	0	0
6970	-5.3201	4.9082	7025	14.8830	10.5244	7080	0	0
6971	-1.3061	2.3318	7026	-2.2545	4.3930	7081	0	0
6972	-9.2108	-6.1741	7027	2.8284	-7.0711	7082	0	0
6973	-5.8050	-23.6260	7028	8.1303	-11.1961	7083	0	0
6974	27.1735	-0.4131	7029	0.1118	-19.3846	7084	0	0
6975	0.4294	11.3002	7030	-0.9545	-6.5142	7085	0	0
6976	-6.5053	7.5784	7031	14.1934	3.9169	7086	0	0
6977	-0.9615	-8.2982	7032	13.9534	1.7256	7087	0	0
6978	-10.0636	-4.3610	7033	6.4476	-1.2708	7088	0	0
6979	0.0000	10.8284	7034	-4.3143	9.4710	7089	0	0
6980	-12.6022	4.7360	7035	-16.3508	4.4966	7090	0	0
6981	-0.0423	-0.0882	7036	4.6826	4.7574	7091	0	0
6982	-4.3698	11.8128	7037	0.8997	-1.6766	7092	0	0
6983	2.4377	7.8184	7038	2.6272	-5.3143	7093	0	0
6984	3.8926	-4.0643	7039	-6.9830	-1.7148	7094	0	0
6985	2.6905	7.6677	7040	2.6619	-3.6913	7095	0	0

TABLE A-22. Time-domain sequence for symbol #44

#	Real	Imag	#	Real	Imag	#	Real	Imag
7096	-15.5563	5.6569	7151	9.2839	4.5972	7206	4.8784	8.1378
7097	-5.8859	-7.3256	7152	2.7119	10.0968	7207	-1.6942	1.7870
7098	8.0375	-3.4562	7153	7.9283	8.5499	7208	-5.1716	0.0000
7099	-3.4839	-2.1729	7154	-5.9453	-7.9708	7209	14.1947	8.9829
7100	0.6753	3.1765	7155	12.9526	-2.4135	7210	-1.9039	5.4362
7101	6.3641	0.2959	7156	-2.2408	-13.7910	7211	-16.1145	2.1940
7102	9.7582	4.7368	7157	-2.7881	7.3309	7212	-3.1296	-8.6025
7103	7.4272	-4.9815	7158	17.8872	-5.7758	7213	-4.7230	1.6272
7104	2.0273	10.8796	7159	1.3084	-4.9856	7214	-5.3260	-0.7598
7105	-1.4276	-0.9253	7160	-12.7279	5.6569	7215	10.1188	-9.4105
7106	-1.9553	-11.7830	7161	-11.9274	-24.5126	7216	5.7734	-2.7831
7107	-8.4905	-8.6512	7162	14.1191	3.3019	7217	-2.9262	6.0694
7108	3.8784	-7.6180	7163	-6.6855	-14.6726	7218	-1.1872	-1.6380
7109	-2.1070	-3.1359	7164	12.9101	-4.4027	7219	-2.0241	-11.3373
7110	-9.5182	2.5044	7165	-0.3948	4.4330	7220	10.9295	-4.4831
7111	3.7362	-5.5661	7166	-9.0949	-1.5017	7221	0.5902	17.6827
7112	-3.6569	-5.6569	7167	6.3784	10.0538	7222	-4.9642	1.5137
7113	-0.2268	5.2865	7168	-3.1989	-4.5365	7223	3.2112	-10.4545
7114	19.4120	10.5334	7169	-3.2487	9.0527	7224	0	0
7115	16.8985	0.1996	7170	-0.8514	-0.9686	7225	0	0
7116	-1.1601	-7.8014	7171	1.4031	2.3481	7226	0	0
7117	6.4591	4.2362	7172	-7.8070	2.8578	7227	0	0
7118	2.1321	-7.9485	7173	-6.3080	3.1287	7228	0	0
7119	13.2728	0.0994	7174	-0.1872	4.3057	7229	0	0
7120	7.9382	-2.6643	7175	-2.7287	14.7856	7230	0	0
7121	3.6947	7.2059	7176	-7.6569	-5.6569	7231	0	0
7122	2.3534	-0.6246	7177	6.9983	2.8560	7232	0	0
7123	-5.0736	2.0810	7178	-6.7473	-9.5841	7233	0	0
7124	2.5028	-1.5367	7179	13.5903	-8.9301	7234	0	0
7125	-6.0615	-2.0227	7180	-5.8718	5.9662	7235	0	0
7126	-7.0084	-5.2936	7181	1.3332	7.4282	7236	0	0
7127	-1.7857	3.6447	7182	11.3060	-2.7779	7237	0	0
7128	-4.2426	8.4853	7183	-8.3119	-0.2445	7238	0	0
7129	-3.6770	4.0458	7184	0.5471	17.9780	7239	0	0
7130	-0.7584	6.3857	7185	-18.2471	-19.6581	7240	0	0
7131	-12.3965	-7.8420	7186	-2.4253	-7.4235	7241	0	0
7132	-3.8454	-4.9671	7187	0.4803	2.0931	7242	0	0
7133	-7.5612	-4.2232	7188	-5.5347	8.4971	7243	0	0

TABLE A-22. Time-domain sequence for symbol #44

7134	4.1413	2.4266	7189	-8.9789	3.8439	7244	0	0
7135	4.9082	-5.3201	7190	10.5244	14.8830	7245	0	0
7136	2.3318	-1.3061	7191	4.3930	-2.2545	7246	0	0
7137	-6.1741	-9.2108	7192	-7.0711	2.8284	7247	0	0
7138	-23.6260	-5.8050	7193	-11.1961	8.1303	7248	0	0
7139	-0.4131	27.1735	7194	-19.3846	0.1118	7249	0	0
7140	11.3002	0.4294	7195	-6.5142	-0.9545	7250	0	0
7141	7.5784	-6.5053	7196	3.9169	14.1934	7251	0	0
7142	-8.2982	-0.9615	7197	1.7256	13.9534	7252	0	0
7143	-4.3610	-10.0636	7198	-1.2708	6.4476	7253	0	0
7144	10.8284	0.0000	7199	9.4710	-4.3143	7254	0	0
7145	4.7360	-12.6022	7200	4.4966	-16.3508	7255	0	0
7146	-0.0882	-0.0423	7201	4.7574	4.6826	7256	0	0
7147	11.8128	-4.3698	7202	-1.6766	0.8997	7257	0	0
7148	7.8184	2.4377	7203	-5.3143	2.6272	7258	0	0
7149	-4.0643	3.8926	7204	-1.7148	-6.9830	7259	0	0
7150	7.6677	2.6905	7205	-3.6913	2.6619	7260	0	0

TABLE A-23. Time-domain sequence for symbol #45

#	Real	Imag	#	Real	Imag	#	Real	Imag
7261	4.2426	1.4142	7316	-3.7965	-3.8348	7371	1.0272	9.7552
7262	-9.0284	-6.4358	7317	10.0479	1.0744	7372	-6.0192	8.8716
7263	9.9329	5.4955	7318	5.8456	-5.3574	7373	0.5858	6.0000
7264	-15.6100	-19.1940	7319	5.6773	8.0844	7374	1.3770	-8.0634
7265	6.4262	-3.9811	7320	-4.5314	-9.4594	7375	-10.6254	-0.1091
7266	8.6776	2.7611	7321	4.1378	-11.2395	7376	8.6844	12.7212
7267	1.6156	8.6983	7322	11.9433	9.8801	7377	-5.0839	-0.3012
7268	0.6804	11.9387	7323	-8.9144	-2.3267	7378	-20.5265	3.3287
7269	-2.3869	6.2620	7324	-5.2063	1.5669	7379	-4.7078	7.8844
7270	-9.2055	0.5013	7325	1.4142	-4.2426	7380	5.2643	-1.0267
7271	-5.9799	12.0769	7326	-5.1850	7.3146	7381	-4.7342	0.4403
7272	8.6424	12.2814	7327	-4.7431	-5.5691	7382	5.2284	5.4375
7273	11.0325	5.9058	7328	1.9036	2.3519	7383	-15.9664	-9.1970
7274	0.8695	-3.4337	7329	-2.9460	-2.4286	7384	2.5172	16.1653
7275	3.3488	2.5280	7330	9.4621	-16.4579	7385	-2.5701	0.9309
7276	13.9412	9.1555	7331	19.6582	-3.2065	7386	10.1756	-1.6611
7277	1.4142	4.8284	7332	-0.9931	-1.0878	7387	-6.4483	-20.4933
7278	-1.3303	-4.8535	7333	-7.6131	2.5665	7388	-11.0273	0.3051
7279	-1.9441	2.7731	7334	-3.6724	-7.2341	7389	0	0
7280	2.8071	-8.2579	7335	-16.2091	-2.9789	7390	0	0
7281	1.1122	13.0724	7336	-4.6108	9.2346	7391	0	0
7282	2.5126	-4.3936	7337	2.8397	-1.4574	7392	0	0
7283	-7.2980	0.4676	7338	10.5571	-1.2599	7393	0	0
7284	-2.0863	13.9107	7339	-3.1598	11.2551	7394	0	0
7285	11.7183	-4.7818	7340	6.8204	8.5555	7395	0	0
7286	-15.1614	5.2562	7341	1.4142	0.8284	7396	0	0
7287	-4.9963	-5.8573	7342	6.4053	4.5493	7397	0	0
7288	-8.7059	-0.7558	7343	14.5286	7.1405	7398	0	0
7289	-6.0637	-6.8116	7344	5.0887	-4.8862	7399	0	0
7290	8.9261	1.4829	7345	-3.4922	-6.8898	7400	0	0
7291	-1.1142	3.6990	7346	-10.2580	-4.5815	7401	0	0
7292	5.3707	8.5904	7347	16.5492	2.7190	7402	0	0
7293	-1.4142	-4.2426	7348	-1.5320	-5.9925	7403	0	0
7294	-15.7666	0.5872	7349	5.5954	-13.7035	7404	0	0
7295	-6.9068	-7.3585	7350	11.5529	16.8321	7405	0	0
7296	3.6025	-0.9987	7351	5.0196	1.2358	7406	0	0
7297	-3.6364	-6.4725	7352	13.4144	-1.6963	7407	0	0
7298	-1.6752	-1.5960	7353	5.4665	9.1202	7408	0	0

TABLE A-23. Time-domain sequence for symbol #45

7299	-13.8144	3.8826	7354	7.2999	2.0320	7409	0	0
7300	0.6665	-4.3316	7355	-11.0236	2.9343	7410	0	0
7301	3.9176	-0.8204	7356	-14.7595	-7.6027	7411	0	0
7302	6.0209	2.3768	7357	-4.2426	-9.8995	7412	0	0
7303	3.5727	2.8193	7358	-0.9229	11.6744	7413	0	0
7304	15.1533	-18.2266	7359	11.1216	14.0275	7414	0	0
7305	12.8255	10.1401	7360	4.3153	-9.8931	7415	0	0
7306	3.0603	7.8972	7361	-5.5007	-6.4315	7416	0	0
7307	6.9705	-4.0379	7362	0.0886	-4.9611	7417	0	0
7308	-0.7904	5.6695	7363	-10.3844	-0.9855	7418	0	0
7309	-3.4142	-6.0000	7364	-18.5329	-12.6878	7419	0	0
7310	-4.5378	-7.8844	7365	6.0824	-2.3512	7420	0	0
7311	1.3226	2.9139	7366	-3.6198	17.2992	7421	0	0
7312	-5.2441	-4.4187	7367	-6.4316	-2.8694	7422	0	0
7313	1.8071	-9.1950	7368	4.5733	-6.9678	7423	0	0
7314	-3.6387	-6.6753	7369	6.2729	-6.5884	7424	0	0
7315	-4.9321	-0.1460	7370	-5.4742	-14.3621	7425	0	0

TABLE A-24. Time-domain sequence for symbol #46

#	Real	Imag	#	Real	Imag	#	Real	Imag
7426	1.4142	4.2426	7481	-3.8348	-3.7965	7536	9.7552	1.0272
7427	-6.4358	-9.0284	7482	1.0744	10.0479	7537	8.8716	-6.0192
7428	5.4955	9.9329	7483	-5.3574	5.8456	7538	6.0000	0.5858
7429	-19.1940	-15.6100	7484	8.0844	5.6773	7539	-8.0634	1.3770
7430	-3.9811	6.4262	7485	-9.4594	-4.5314	7540	-0.1091	-10.6254
7431	2.7611	8.6776	7486	-11.2395	4.1378	7541	12.7212	8.6844
7432	8.6983	1.6156	7487	9.8801	11.9433	7542	-0.3012	-5.0839
7433	11.9387	0.6804	7488	-2.3267	-8.9144	7543	3.3287	-20.5265
7434	6.2620	-2.3869	7489	1.5669	-5.2063	7544	7.8844	-4.7078
7435	0.5013	-9.2055	7490	-4.2426	1.4142	7545	-1.0267	5.2643
7436	12.0769	-5.9799	7491	7.3146	-5.1850	7546	0.4403	-4.7342
7437	12.2814	8.6424	7492	-5.5691	-4.7431	7547	5.4375	5.2284
7438	5.9058	11.0325	7493	2.3519	1.9036	7548	-9.1970	-15.9664
7439	-3.4337	0.8695	7494	-2.4286	-2.9460	7549	16.1653	2.5172
7440	2.5280	3.3488	7495	-16.4579	9.4621	7550	0.9309	-2.5701
7441	9.1555	13.9412	7496	-3.2065	19.6582	7551	-1.6611	10.1756
7442	4.8284	1.4142	7497	-1.0878	-0.9931	7552	-20.4933	-6.4483
7443	-4.8535	-1.3303	7498	2.5665	-7.6131	7553	0.3051	-11.0273
7444	2.7731	-1.9441	7499	-7.2341	-3.6724	7554	0	0
7445	-8.2579	2.8071	7500	-2.9789	-16.2091	7555	0	0
7446	13.0724	1.1122	7501	9.2346	-4.6108	7556	0	0
7447	-4.3936	2.5126	7502	-1.4574	2.8397	7557	0	0
7448	0.4676	-7.2980	7503	-1.2599	10.5571	7558	0	0
7449	13.9107	-2.0863	7504	11.2551	-3.1598	7559	0	0
7450	-4.7818	11.7183	7505	8.5555	6.8204	7560	0	0
7451	5.2562	-15.1614	7506	0.8284	1.4142	7561	0	0
7452	-5.8573	-4.9963	7507	4.5493	6.4053	7562	0	0
7453	-0.7558	-8.7059	7508	7.1405	14.5286	7563	0	0
7454	-6.8116	-6.0637	7509	-4.8862	5.0887	7564	0	0
7455	1.4829	8.9261	7510	-6.8898	-3.4922	7565	0	0
7456	3.6990	-1.1142	7511	-4.5815	-10.2580	7566	0	0
7457	8.5904	5.3707	7512	2.7190	16.5492	7567	0	0
7458	-4.2426	-1.4142	7513	-5.9925	-1.5320	7568	0	0
7459	0.5872	-15.7666	7514	-13.7035	5.5954	7569	0	0
7460	-7.3585	-6.9068	7515	16.8321	11.5529	7570	0	0
7461	-0.9987	3.6025	7516	1.2358	5.0196	7571	0	0
7462	-6.4725	-3.6364	7517	-1.6963	13.4144	7572	0	0
7463	-1.5960	-1.6752	7518	9.1202	5.4665	7573	0	0

TABLE A-24. Time-domain sequence for symbol #46

7464	3.8826	-13.8144	7519	2.0320	7.2999	7574	0	0
7465	-4.3316	0.6665	7520	2.9343	-11.0236	7575	0	0
7466	-0.8204	3.9176	7521	-7.6027	-14.7595	7576	0	0
7467	2.3768	6.0209	7522	-9.8995	-4.2426	7577	0	0
7468	2.8193	3.5727	7523	11.6744	-0.9229	7578	0	0
7469	-18.2266	15.1533	7524	14.0275	11.1216	7579	0	0
7470	10.1401	12.8255	7525	-9.8931	4.3153	7580	0	0
7471	7.8972	3.0603	7526	-6.4315	-5.5007	7581	0	0
7472	-4.0379	6.9705	7527	-4.9611	0.0886	7582	0	0
7473	5.6695	-0.7904	7528	-0.9855	-10.3844	7583	0	0
7474	-6.0000	-3.4142	7529	-12.6878	-18.5329	7584	0	0
7475	-7.8844	-4.5378	7530	-2.3512	6.0824	7585	0	0
7476	2.9139	1.3226	7531	17.2992	-3.6198	7586	0	0
7477	-4.4187	-5.2441	7532	-2.8694	-6.4316	7587	0	0
7478	-9.1950	1.8071	7533	-6.9678	4.5733	7588	0	0
7479	-6.6753	-3.6387	7534	-6.5884	6.2729	7589	0	0
7480	-0.1460	-4.9321	7535	-14.3621	-5.4742	7590	0	0

TABLE A-25. Time-domain sequence for symbol #47

#	Real	Imag	#	Real	Imag	#	Real	Imag
7591	-2.8284	7.0711	7646	9.4126	-3.0015	7701	2.7923	6.6644
7592	13.9421	15.9959	7647	-3.8268	-13.2745	7702	-2.6903	3.6856
7593	-3.7703	7.2471	7648	10.3114	4.9883	7703	-2.8284	-7.6569
7594	-8.6675	4.3944	7649	4.2137	0.6988	7704	5.8013	-7.7852
7595	1.0182	-8.4175	7650	-3.3219	-0.6549	7705	-3.2658	-6.0507
7596	-15.3914	-10.5005	7651	-0.0032	-0.1500	7706	-5.7868	-7.7895
7597	-6.8927	-1.7940	7652	-8.0071	-16.0955	7707	6.3477	-4.8991
7598	7.8557	-13.8528	7653	0.1460	-0.4320	7708	0.1301	4.2344
7599	0.6006	0.9272	7654	-4.9965	-9.6813	7709	3.5516	5.1450
7600	-2.1683	-5.8756	7655	-8.4853	4.2426	7710	-1.3679	-3.5906
7601	6.9292	-10.3237	7656	-6.2649	1.4403	7711	3.8268	-1.5539
7602	8.9010	4.3986	7657	3.3303	-0.0537	7712	1.2239	-1.9365
7603	-8.3112	-4.3839	7658	-22.4698	4.9352	7713	-7.7590	1.6254
7604	-11.8377	-14.3747	7659	-14.1762	-0.3587	7714	-15.7783	-9.6889
7605	2.6927	-3.4803	7660	19.1651	1.1810	7715	1.3396	-1.1696
7606	1.1823	-13.4777	7661	-9.3186	6.8608	7716	-9.4345	0.6938
7607	-8.0000	-6.3431	7662	-2.0123	15.2532	7717	-3.1315	-3.7000
7608	12.7148	-4.1065	7663	3.3994	9.2149	7718	11.1439	6.9109
7609	-1.3977	4.7058	7664	-4.1535	-0.3888	7719	0	0
7610	6.0659	6.6030	7665	14.6364	-1.2104	7720	0	0
7611	-6.8543	-27.5782	7666	6.2109	-5.9018	7721	0	0
7612	-14.1040	-5.1843	7667	-1.7435	-5.5865	7722	0	0
7613	8.1044	-9.1837	7668	-4.6282	-11.0184	7723	0	0
7614	8.9777	15.2762	7669	1.6434	3.7524	7724	0	0
7615	9.2388	-2.1712	7670	-0.8793	6.6448	7725	0	0
7616	4.2990	1.1415	7671	8.0000	17.6569	7726	0	0
7617	6.5188	1.1778	7672	-1.0481	-5.3588	7727	0	0
7618	-8.8306	-7.2690	7673	9.2416	-2.5985	7728	0	0
7619	0.2538	10.9253	7674	-3.8724	9.9821	7729	0	0
7620	13.0311	12.9525	7675	-0.4267	-1.4857	7730	0	0
7621	9.5764	6.1682	7676	13.8860	16.6384	7731	0	0
7622	-4.7108	-6.8444	7677	-7.5032	-3.5767	7732	0	0
7623	-2.8284	7.0711	7678	-7.2244	0.3915	7733	0	0
7624	-3.4868	0.6474	7679	-9.2388	11.3428	7734	0	0
7625	-7.9269	6.7388	7680	6.1916	5.3634	7735	0	0
7626	-9.6788	-3.5997	7681	2.6750	-5.3372	7736	0	0
7627	-4.1829	-0.1412	7682	-4.2841	4.9974	7737	0	0
7628	1.9907	-8.0221	7683	-3.2470	16.0511	7738	0	0

TABLE A-25. Time-domain sequence for symbol #47

7629	1.9794	3.1843	7684	1.0061	5.1601	7739	0	0
7630	1.3870	-10.5432	7685	13.2307	-5.1395	7740	0	0
7631	-9.0740	13.8490	7686	4.9801	-6.7891	7741	0	0
7632	2.8425	-5.6272	7687	-2.8284	4.2426	7742	0	0
7633	24.5997	1.3490	7688	-0.4633	5.5202	7743	0	0
7634	-1.9499	12.1128	7689	-9.9344	-4.7059	7744	0	0
7635	-2.9158	-3.0863	7690	1.1803	-4.3625	7745	0	0
7636	14.1004	4.5271	7691	-0.3159	-7.3669	7746	0	0
7637	8.3636	-11.8332	7692	-0.3946	9.4537	7747	0	0
7638	-9.7956	15.2216	7693	2.6625	8.3662	7748	0	0
7639	-2.8284	-3.6569	7694	-1.8895	4.3969	7749	0	0
7640	-4.3340	-2.0237	7695	5.0740	4.2932	7750	0	0
7641	-14.9631	2.7171	7696	19.2196	-1.9946	7751	0	0
7642	11.5858	0.2895	7697	-0.5002	4.0203	7752	0	0
7643	7.2764	-6.3213	7698	-3.9311	-8.4467	7753	0	0
7644	-5.6386	2.6519	7699	3.3136	-1.2864	7754	0	0
7645	-5.2697	-1.0019	7700	-3.2461	7.7026	7755	0	0

TABLE A-26. Time-domain sequence for symbol #48

#	Real	Imag	#	Real	Imag	#	Real	Imag
7756	-7.0711	2.8284	7811	3.0015	-9.4126	7866	-6.6644	-2.7923
7757	-15.9959	-13.9421	7812	13.2745	3.8268	7867	-3.6856	2.6903
7758	-7.2471	3.7703	7813	-4.9883	-10.3114	7868	7.6569	2.8284
7759	-4.3944	8.6675	7814	-0.6988	-4.2137	7869	7.7852	-5.8013
7760	8.4175	-1.0182	7815	0.6549	3.3219	7870	6.0507	3.2658
7761	10.5005	15.3914	7816	0.1500	0.0032	7871	7.7895	5.7868
7762	1.7940	6.8927	7817	16.0955	8.0071	7872	4.8991	-6.3477
7763	13.8528	-7.8557	7818	0.4320	-0.1460	7873	-4.2344	-0.1301
7764	-0.9272	-0.6006	7819	9.6813	4.9965	7874	-5.1450	-3.5516
7765	5.8756	2.1683	7820	-4.2426	8.4853	7875	3.5906	1.3679
7766	10.3237	-6.9292	7821	-1.4403	6.2649	7876	1.5539	-3.8268
7767	-4.3986	-8.9010	7822	0.0537	-3.3303	7877	1.9365	-1.2239
7768	4.3839	8.3112	7823	-4.9352	22.4698	7878	-1.6254	7.7590
7769	14.3747	11.8377	7824	0.3587	14.1762	7879	9.6889	15.7783
7770	3.4803	-2.6927	7825	-1.1810	-19.1651	7880	1.1696	-1.3396
7771	13.4777	-1.1823	7826	-6.8608	9.3186	7881	-0.6938	9.4345
7772	6.3431	8.0000	7827	-15.2532	2.0123	7882	3.7000	3.1315
7773	4.1065	-12.7148	7828	-9.2149	-3.3994	7883	-6.9109	-11.1439
7774	-4.7058	1.3977	7829	0.3888	4.1535	7884	0	0
7775	-6.6030	-6.0659	7830	1.2104	-14.6364	7885	0	0
7776	27.5782	6.8543	7831	5.9018	-6.2109	7886	0	0
7777	5.1843	14.1040	7832	5.5865	1.7435	7887	0	0
7778	9.1837	-8.1044	7833	11.0184	4.6282	7888	0	0
7779	-15.2762	-8.9777	7834	-3.7524	-1.6434	7889	0	0
7780	2.1712	-9.2388	7835	-6.6448	0.8793	7890	0	0
7781	-1.1415	-4.2990	7836	-17.6569	-8.0000	7891	0	0
7782	-1.1778	-6.5188	7837	5.3588	1.0481	7892	0	0
7783	7.2690	8.8306	7838	2.5985	-9.2416	7893	0	0
7784	-10.9253	-0.2538	7839	-9.9821	3.8724	7894	0	0
7785	-12.9525	-13.0311	7840	1.4857	0.4267	7895	0	0
7786	-6.1682	-9.5764	7841	-16.6384	-13.8860	7896	0	0
7787	6.8444	4.7108	7842	3.5767	7.5032	7897	0	0
7788	-7.0711	2.8284	7843	-0.3915	7.2244	7898	0	0
7789	-0.6474	3.4868	7844	-11.3428	9.2388	7899	0	0
7790	-6.7388	7.9269	7845	-5.3634	-6.1916	7900	0	0
7791	3.5997	9.6788	7846	5.3372	-2.6750	7901	0	0
7792	0.1412	4.1829	7847	-4.9974	4.2841	7902	0	0
7793	8.0221	-1.9907	7848	-16.0511	3.2470	7903	0	0

TABLE A-26. Time-domain sequence for symbol #48

7794	-3.1843	-1.9794	7849	-5.1601	-1.0061	7904	0	0
7795	10.5432	-1.3870	7850	5.1395	-13.2307	7905	0	0
7796	-13.8490	9.0740	7851	6.7891	-4.9801	7906	0	0
7797	5.6272	-2.8425	7852	-4.2426	2.8284	7907	0	0
7798	-1.3490	-24.5997	7853	-5.5202	0.4633	7908	0	0
7799	-12.1128	1.9499	7854	4.7059	9.9344	7909	0	0
7800	3.0863	2.9158	7855	4.3625	-1.1803	7910	0	0
7801	-4.5271	-14.1004	7856	7.3669	0.3159	7911	0	0
7802	11.8332	-8.3636	7857	-9.4537	0.3946	7912	0	0
7803	-15.2216	9.7956	7858	-8.3662	-2.6625	7913	0	0
7804	3.6569	2.8284	7859	-4.3969	1.8895	7914	0	0
7805	2.0237	4.3340	7860	-4.2932	-5.0740	7915	0	0
7806	-2.7171	14.9631	7861	1.9946	-19.2196	7916	0	0
7807	-0.2895	-11.5858	7862	-4.0203	0.5002	7917	0	0
7808	6.3213	-7.2764	7863	8.4467	3.9311	7918	0	0
7809	-2.6519	5.6386	7864	1.2864	-3.3136	7919	0	0
7810	1.0019	5.2697	7865	-7.7026	3.2461	7920	0	0

Page Intentionally Left Blank.

ANNEX B - RECOMMENDED OUT-OF-BAND EMISSIONS LIMITS

Table B-1 defines recommended out-of-band emissions limits when close proximity between UWB devices, and cellular phones and GPS downlink devices is required. The emission limits are specified for average power and exclude possible narrowband spectrum spikes or spurs. The following parameters were assumed in the derivation of the limits recommended in this section:

1. Device separation of 60 cm.
2. Noise figure 7 dB for cellular and 3.5 dB for GPS, respectively.
3. Allowed noise increase 1 dB for cellular and 0.5 dB for GPS, respectively.
4. Victim antenna gain of -3 dBi.
5. Free space path loss model (*f* equals to lower limit of the victim receiver band).

TABLE B-1. Recommended emissions limits

Frequency Band (MHz)	Recommended limit (dBm/MHz)
869-894	-83.3
925-960	-82.5
1570-1581	-84.7
1805-1880	-76.8
1930-1990	-76.2
2110-2170	-75.4

Page Intentionally Left Blank.

ANNEX C - PROTOCOL IMPLEMENTATION CONFORMANCE STATEMENT (PICS) PROFORMA

In the ‘Status’ column M indicates Mandatory; O indicates Optional; C indicates Conditional as described in a footnote; and any other value indicates than an identical choice shall be made to an earlier optional item.

TABLE C-1. PICS Proforma

Item	Feature	Reference	Status	Support
TXRX: OFDM PHY Transmitter and Receiver capabilities				
R0	PLCP header RATE = 0 (53Mb/s)	6.3.1.1	M	Yes[ ] No[ ]
R1	PLCP header RATE = 1 (80Mb/s)	6.3.1.1	O	Yes[ ] No[ ]
R2	PLCP header RATE = 2 (106.7Mb/s)	6.3.1.1	M	Yes[ ] No[ ]
R3	PLCP header RATE = 3 (160Mb/s)	6.3.1.1	O	Yes[ ] No[ ]
R4	PLCP header RATE = 4 (200Mb/s)	6.3.1.1	M	Yes[ ] No[ ]
R5	PLCP header RATE = 5 (320Mb/s)	6.3.1.1	O	Yes[ ] No[ ]
R6	PLCP header RATE = 6 (400Mb/s)	6.3.1.1	O	Yes[ ] No[ ]
R7	PLCP header RATE = 7 (480Mb/s)	6.3.1.1	O	Yes[ ] No[ ]
R8	PLCP header RATE = 8 (640Mb/s)	6.3.1.1	O	Yes[ ] No[ ]
R9	PLCP header RATE = 9 (800Mb/s)	6.3.1.1	O	Yes[ ] No[ ]
R10	PLCP header RATE = 10 (960Mb/s)	6.3.1.1	O	Yes[ ] No[ ]
R11	PLCP header RATE = 11 (1024Mb/s)	6.3.1.1	O	Yes[ ] No[ ]
R19	PLCP header RATE = 19 (160Mb/s using LDPC)	6.3.1.1	O	Yes[ ] No[ ]
R20	PLCP header RATE = 20 (200Mb/s using LDPC)	6.3.1.1	O	Yes[ ] No[ ]
R21	PLCP header RATE = 21 (320Mb/s using LDPC)	6.3.1.1	O	Yes[ ] No[ ]
R22	PLCP header RATE = 22 (400Mb/s using LDPC)	6.3.1.1	O	Yes[ ] No[ ]

TABLE C-1. PICS Proforma

Item	Feature	Reference	Status	Support
R23	PLCP header RATE = 23 (480Mb/s using LDPC)	6.3.1.1	O	Yes[ ] No[ ]
LEN	any LENGTH payload in 0..16383	6.3.1.2	M	Yes[ ] No[ ]
SEED	any SEED value in 0..3	6.3.1.3	M	Yes[ ] No[ ]
BM	BM values in {0,1}	6.3.1.4	M	Yes[ ] No[ ]
PT0	PT value 0 for RATE in 0..4	6.3.1.5	M	Yes[ ] No[ ]
PT5	PT value in {0,1} for RATE = 5	6.3.1.5	R5	Yes[ ] No[ ]
PT6	PT value in {0,1} for RATE = 6	6.3.1.5	R6	Yes[ ] No[ ]
PT7	PT value in {0,1} for RATE = 7	6.3.1.5	R7	Yes[ ] No[ ]
TFC	TX_TFC values in 1..10	6.3.1.6	M	Yes[ ] No[ ]
LSB	BG_LSB value	6.3.1.7	M	Yes[ ] No[ ]
HCS	Header Check Sequence	6.3.3	M	Yes[ ] No[ ]
PSDU	PSDU if LENGTH != 0	6.4, 6.5, 6.6, 6.7, 6.8, 6.9, 6.10	M	Yes[ ] No[ ]
BG1	all channels in band group 1	7.2	C[a]	Yes[ ] No[ ]
BG2	all channels in band group 2	7.2	C[a]	Yes[ ] No[ ]
BG3	all channels in band group 3	7.2	C[a]	Yes[ ] No[ ]
BG4	all channels in band group 4	7.2	C[a]	Yes[ ] No[ ]
BG5	all channels in band group 5	7.2	C[a]	Yes[ ] No[ ]
BG6	all channels in band group 6	7.2	C[a]	Yes[ ] No[ ]
RLA	Ranging and Location Awareness	10	O	Yes[ ] No[ ]
TX: OFDM PHY Transmitter				
RS	Reed-Solomon Outer Code	6.3.2	M	Yes[ ] No[ ]
PSD	signal is within PSD mask	8.1	M	Yes[ ] No[ ]
TPC	transmit power control	8.6	M	Yes[ ] No[ ]
EVM	constellation error within stated limits	8.7	M	Yes[ ] No[ ]

TABLE C-1. PICS Proforma

Item	Feature	Reference	Status	Support
TN	transmit signal under control of TN tone nulling mask	5.2	O	Yes[ ] No[ ]
RX: OFDM PHY Receiver				
CCA	CCA indication	9.2	M	Yes[ ] No[ ]
LQI	Link Quality Indication	9.3	M	Yes[ ] No[ ]
RSSI	Received Signal Strength Indicator	9.4	O	Yes[ ] No[ ]

a. At least one of the six band groups shall be implemented. A band group is supported if all channels in the band group are supported.

ANNEX D - ALTERNATE BASE TIME DOMAIN SEQUENCES

The time domain sequences for TFCs 8-10 have been flattened for a 1 MHz resolution bandwidth while the sequences for TFCs 1-7 have been flattened to a 4.125 MHz resolution bandwidth. TFCs 1-7 may also be flattened further for minimizing spectral ripple. This Annex contains TFCs 1-7 flattened for a 1MHz resolution. The use of these values for TFCs 1-7 in place of the values in Table 6-4 to Table 6-10 is an implementation choice.

TABLE D-1. Alternate base time-domain sequence for TFC 1

l	*sbase[l]*	*l*	*sbase[l]*	*l*	*sbase[l]*	*l*	*sbase[l]*
0	0.7205	32	0.0545	64	-0.2273	96	0.3799
1	-1.5526	33	1.0485	65	1.1044	97	-1.1746
2	-1.2604	34	1.1810	66	1.1581	98	-1.7011
3	-1.5640	35	1.3583	67	1.5211	99	-1.4319
4	0.9723	36	-0.5355	68	-0.8954	100	0.9666
5	1.3664	37	-0.3663	69	-0.3523	101	0.7963
6	-1.0680	38	0.8052	70	0.7411	102	-1.0710
7	1.4281	39	-0.8357	71	-0.9267	103	1.3277
8	0.9722	40	-0.5147	72	-0.3157	104	-0.6754
9	-1.3680	41	1.1416	73	0.6667	105	0.9074
10	-0.8203	42	1.1165	74	0.4710	106	1.0699
11	-1.2975	43	1.0279	75	0.4908	107	1.0870
12	1.0359	44	-0.8800	76	-0.4106	108	-1.1956
13	1.3985	45	-1.6538	77	-1.0725	109	-0.7278
14	-0.7813	46	0.9949	78	0.6315	110	0.4270
15	1.3388	47	-1.6299	79	-0.9268	111	-1.1944
16	1.0462	48	0.2474	80	0.4670	112	0.0519
17	-1.0548	49	-1.1964	81	-1.1655	113	-0.7372
18	-0.4917	50	-1.3109	82	-1.2184	114	-1.1626
19	-0.8973	51	-1.6109	83	-1.3279	115	-0.9210
20	0.9614	52	0.9000	84	1.1136	116	0.3779
21	1.2974	53	0.4191	85	0.9531	117	0.1775
22	-0.4895	54	-0.8341	86	-0.8139	118	-0.6310
23	1.2113	55	1.0763	87	1.2429	119	0.5395
24	0.9397	56	0.4772	88	-0.4808	120	0.1006
25	-0.5617	57	-1.0323	89	1.0782	121	-0.6751
26	-0.2846	58	-0.9790	90	1.6726	122	-0.4944
27	-0.2956	59	-0.9650	91	1.3107	123	-0.7774
28	0.8050	60	0.8004	92	-1.2466	124	0.3183
29	1.2805	61	1.6412	93	-1.1728	125	0.4327
30	-0.2843	62	-1.0196	94	0.9184	126	-0.5049
31	1.0961	63	1.5773	95	-1.6176	127	0.4425

TABLE D-2. Alternate base time-domain sequence for TFC 2

l	*sbase[l]*	*l*	*sbase[l]*	*l*	*sbase[l]*	*l*	*sbase[l]*
0	0.8080	32	-1.3577	64	1.5742	96	0.5127
1	-0.8581	33	1.1041	65	-1.0144	97	-0.4183
2	0.4103	34	-1.2639	66	1.1335	98	0.1369
3	0.3750	35	-0.8292	67	1.2984	99	0.6179
4	-1.1453	36	1.5558	68	-1.5810	100	-1.1287
5	-1.2037	37	1.1352	69	-1.6241	101	-0.6492
6	-0.9100	38	1.4552	70	-1.2270	102	-0.8420
7	-0.1383	39	-0.4758	71	0.3834	103	0.1971
8	-0.9103	40	-0.9821	72	-1.2225	104	-0.9816
9	0.1211	41	1.0277	73	0.8418	105	0.6066
10	-1.0807	42	-0.4314	74	-1.3573	106	-1.1180
11	-0.7984	43	-0.7537	75	-0.8457	107	-0.4020
12	0.2775	44	1.5726	76	1.0006	108	0.3926
13	0.0534	45	1.7216	77	0.8114	109	0.4633
14	0.4419	46	1.2409	78	1.1478	110	0.5117
15	-0.8885	47	-0.2117	79	-0.5715	111	-0.3041
16	-1.4066	48	1.6262	80	-0.8117	112	-0.9156
17	0.5815	49	-0.6677	81	0.7199	113	0.5972
18	-1.3869	50	1.1157	82	-0.3213	114	-0.4376
19	-1.0994	51	1.4614	83	-0.8877	115	-0.7959
20	1.0914	52	-1.3852	84	1.5688	116	1.1879
21	0.6750	53	-1.3596	85	1.1984	117	0.9817
22	1.1587	54	-1.1632	86	1.1760	118	0.9424
23	-1.0436	55	0.8090	87	-0.2482	119	-0.3168
24	-1.3499	56	-1.2023	88	1.4695	120	1.2794
25	0.8452	57	1.0056	89	-0.8494	121	-0.8500
26	-1.3595	58	-0.8106	90	1.4534	122	1.2648
27	-0.9367	59	-0.8955	91	0.8875	123	0.6089
28	1.3111	60	1.1668	92	-0.9556	124	-0.8259
29	0.8978	61	1.6186	93	-0.9212	125	-0.9544
30	1.3377	62	0.9327	94	-1.0751	126	-0.9373
31	-0.8420	63	-0.3133	95	0.6061	127	0.3454

TABLE D-3. Alternate base time-domain sequence for TFC 3

l	*sbase[l]*	*l*	*sbase[l]*	*l*	*sbase[l]*	*l*	*sbase[l]*
0	0.4842	32	-1.0368	64	-0.7498	96	0.2922
1	0.7761	33	-1.0580	65	-1.0408	97	0.6505
2	-0.4555	34	0.7957	66	1.1121	98	-0.7238
3	0.6411	35	-0.8160	67	-0.8931	99	0.8339
4	0.2329	36	-0.8522	68	-1.0191	100	0.9231
5	-0.9210	37	1.6805	69	1.6781	101	-0.6885
6	-0.7572	38	0.9626	70	0.8397	102	-0.3690
7	-0.8154	39	1.4575	71	1.6544	103	-0.9206
8	0.3846	40	0.2535	72	0.1583	104	-0.2526
9	0.6726	41	0.9347	73	1.2150	105	-1.0998
10	-1.0270	42	-1.1676	74	-1.5377	106	1.7289
11	0.4549	43	1.1887	75	1.4870	107	-1.3642
12	0.2936	44	1.0979	76	0.9977	108	-0.9343
13	-1.3977	45	-0.7385	77	-0.7526	109	0.9489
14	-1.0209	46	-0.5662	78	-0.9302	110	1.0754
15	-1.2686	47	-1.2756	79	-1.2438	111	1.4619
16	-0.7915	48	-0.2497	80	-0.6677	112	0.4808
17	-1.5185	49	-1.0203	81	-1.3036	113	0.8230
18	1.0846	50	1.1992	82	1.7219	114	-0.9090
19	-1.9135	51	-1.2291	83	-1.7171	115	1.0902
20	-1.5172	52	-0.5531	84	-1.2599	116	0.7998
21	0.6501	53	0.2577	85	0.8846	117	-0.1884
22	0.6404	54	0.7848	86	1.0253	118	-0.3517
23	1.2470	55	0.6972	87	1.5412	119	-0.6056
24	-1.0025	56	-0.0672	88	-0.4607	120	0.6724
25	-1.3198	57	-0.6661	89	-0.8962	121	1.1874
26	0.5124	58	0.4020	90	0.8465	122	-0.8937
27	-1.3017	59	-0.7284	91	-0.9092	123	1.2342
28	-1.0581	60	-0.2438	92	-0.6700	124	0.8628
29	1.4034	61	0.5755	93	1.3787	125	-1.1059
30	0.7844	62	0.4919	94	0.9797	126	-0.8564
31	1.3761	63	0.6144	95	1.2407	127	-1.1887

TABLE D-4. Alternate base time-domain sequence for TFC 4

l	*sbase[l]*	*l*	*sbase[l]*	*l*	*sbase[l]*	*l*	*sbase[l]*
0	0.9423	32	-1.0054	64	1.3254	96	-0.9687
1	0.7879	33	-0.6722	65	0.7640	97	-0.7245
2	0.5634	34	-0.6285	66	1.4285	98	-1.0307
3	-0.5873	35	0.9481	67	-0.9865	99	0.6409
4	-1.1038	36	0.9895	68	-1.0168	100	0.9355
5	0.9961	37	-1.3717	69	0.6910	101	-0.4693
6	-0.8611	38	0.7270	70	-1.0697	102	1.0323
7	-0.1713	39	0.3640	71	-0.7707	103	0.9300
8	-0.6093	40	1.5044	72	0.7974	104	-1.4272
9	-0.3209	41	1.1055	73	0.3530	105	-0.8544
10	-0.7682	42	0.9526	74	0.2741	106	-1.4072
11	0.3301	43	-1.3038	75	-1.0728	107	1.2758
12	0.3166	44	-1.8568	76	-1.3823	108	1.5292
13	-0.1565	45	1.7911	77	0.7502	109	-0.7941
14	0.4028	46	-1.5181	78	-1.0819	110	1.5060
15	0.1909	47	-0.3908	79	-0.5354	111	1.1052
16	-1.0303	48	-1.6936	80	-1.5793	112	-0.8668
17	-0.7462	49	-0.9431	81	-1.2177	113	-0.4071
18	-0.4123	50	-1.6866	82	-1.6124	114	-0.5061
19	0.9157	51	1.0598	83	0.5221	115	1.1870
20	1.4918	52	1.0296	84	0.8529	116	1.4660
21	-1.3886	53	-1.0616	85	-1.1745	117	-0.7306
22	1.2167	54	1.0901	86	0.9935	118	1.1524
23	0.3788	55	0.6131	87	0.5091	119	0.6632
24	1.6953	56	-0.6307	88	-1.4079	120	0.8577
25	0.9116	57	-0.4583	89	-1.1649	121	0.7733
26	1.2670	58	-0.1466	90	-1.2662	122	0.9803
27	-1.2032	59	0.5464	91	0.7329	123	-0.1235
28	-1.2222	60	1.0476	92	1.3080	124	-0.3459
29	1.5847	61	-0.8735	93	-1.1769	125	0.6631
30	-1.0791	62	0.6589	94	1.2555	126	-0.5262
31	-0.6218	63	-0.0717	95	0.7580	127	-0.1395

TABLE D-5. Alternate base time-domain sequence for TFC 5

l	*sbase[l]*	*l*	*sbase[l]*	*l*	*sbase[l]*	*l*	*sbase[l]*
0	0.7805	32	0.9535	64	0.5806	96	-0.8739
1	0.5994	33	1.1545	65	-0.0483	97	-0.3697
2	1.4392	34	1.2488	66	1.0337	98	-1.3003
3	-0.0492	35	-0.5204	67	-0.7325	99	0.7253
4	-0.3062	36	-1.5769	68	-0.6604	100	0.4601
5	-0.1119	37	-0.8400	69	-0.7215	101	0.7680
6	1.1318	38	1.4982	70	0.8417	102	-1.2285
7	-0.2379	39	-1.3895	71	-0.8839	103	0.9538
8	1.0310	40	0.3206	72	-0.7507	104	0.3273
9	1.9888	41	1.5175	73	-0.3510	105	-0.0848
10	0.9969	42	-0.1612	74	-0.9048	106	0.6129
11	-0.2848	43	-0.4971	75	0.6918	107	-0.6727
12	-1.4350	44	-1.5561	76	0.8601	108	-0.4827
13	-0.7189	45	-0.8502	77	0.8933	109	-0.7870
14	1.7156	46	1.0575	78	-1.1632	110	0.7838
15	-1.3440	47	-1.4852	79	1.3227	111	-1.0522
16	0.4582	48	0.2959	80	0.8024	112	-0.5472
17	1.6358	49	0.6440	81	0.7587	113	-1.0002
18	-0.1574	50	-0.2655	82	1.2688	114	-0.6155
19	-0.1059	51	-0.6502	83	-0.4525	115	0.3780
20	-1.3783	52	-1.1060	84	-1.1533	116	1.4913
21	-0.5835	53	-0.9373	85	-0.8125	117	0.6652
22	0.9076	54	0.4525	86	1.1291	118	-0.9958
23	-1.1534	55	-1.3191	87	-1.1752	119	1.1146
24	-0.8047	56	-1.1201	88	0.3568	120	-0.4421
25	-0.1481	57	-1.2486	89	1.3055	121	-1.4213
26	-1.3498	58	-1.4279	90	0.1604	122	-0.1324
27	1.1130	59	0.7393	91	-0.5099	123	0.6943
28	0.4878	60	1.1768	92	-1.4804	124	1.7816
29	1.2275	61	1.0735	93	-0.9610	125	1.1144
30	-1.1975	62	-1.7301	94	0.9425	126	-0.8849
31	1.4616	63	1.6058	95	-1.5402	127	1.7083

TABLE D-6. Alternate base time-domain sequence for TFC 6

l	*sbase[l]*	*l*	*sbase[l]*	*l*	*sbase[l]*	*l*	*sbase[l]*
0	0.8080	32	-0.4903	64	1.0804	96	0.9080
1	-0.5116	33	0.4442	65	-1.0223	97	-1.1722
2	0.5204	34	-0.3799	66	0.7060	98	0.4431
3	0.6337	35	-0.2357	67	1.1024	99	1.3004
4	0.3671	36	-0.2953	68	0.5312	100	0.0313
5	0.0542	37	0.5327	69	-0.8263	101	-0.4697
6	-0.6887	38	-0.0394	70	-0.5653	102	-1.8346
7	-0.1875	39	0.3871	71	-0.5299	103	-0.7573
8	0.9309	40	0.7783	72	-1.1357	104	0.7693
9	-1.0289	41	-0.7641	73	1.2576	105	-1.5533
10	0.6577	42	0.5998	74	-0.9219	106	0.5018
11	0.7740	43	0.6163	75	-0.2632	107	0.6917
12	0.4785	44	0.5410	76	-0.8246	108	0.3384
13	-1.0955	45	-0.9867	77	1.4339	109	-1.6673
14	-0.4134	46	-0.0456	78	0.1602	110	-1.0056
15	-0.7238	47	-0.5465	79	0.9517	111	-1.0922
16	-1.6249	48	-1.5295	80	1.5319	112	-1.8258
17	1.3769	49	1.6055	81	-0.8680	113	0.8545
18	-1.1916	50	-1.0989	82	0.8687	114	-1.2134
19	-1.0910	51	-0.9888	83	1.9508	115	-1.5335
20	-0.9272	52	-0.8032	84	0.4189	116	-0.7312
21	1.1771	53	1.5955	85	0.2532	117	-0.0342
22	0.5549	54	0.8546	86	-1.6350	118	1.2596
23	0.9013	55	1.0364	87	-0.3212	119	0.3590
24	1.2194	56	1.9474	88	1.5882	120	-1.4037
25	-1.0155	57	-1.2483	89	-1.3376	121	1.3295
26	0.8310	58	1.3523	90	0.8771	122	-0.8977
27	1.0003	59	1.4714	91	2.1033	123	-1.3741
28	0.6429	60	0.9594	92	0.3300	124	-0.5816
29	-0.6914	61	-0.4263	93	-0.3780	125	1.1481
30	-0.6108	62	-1.1915	94	-1.9981	126	1.1815
31	-0.6029	63	-0.6151	95	-0.8172	127	0.7702

TABLE D-7. Alternate base time-domain sequence for TFC 7

l	*sbase[l]*	*l*	*sbase[l]*	*l*	*sbase[l]*	*l*	*sbase[l]*
0	0.7702	32	-0.8172	64	-0.6151	96	-0.6029
1	1.1815	33	-1.9981	65	-1.1915	97	-0.6108
2	1.1481	34	-0.3780	66	-0.4263	98	-0.6914
3	-0.5816	35	0.3300	67	0.9594	99	0.6429
4	-1.3741	36	2.1033	68	1.4714	100	1.0003
5	-0.8977	37	0.8771	69	1.3523	101	0.8310
6	1.3295	38	-1.3376	70	-1.2483	102	-1.0155
7	-1.4037	39	1.5882	71	1.9474	103	1.2194
8	0.3590	40	-0.3212	72	1.0364	104	0.9013
9	1.2596	41	-1.6350	73	0.8546	105	0.5549
10	-0.0342	42	0.2532	74	1.5955	106	1.1771
11	-0.7312	43	0.4189	75	-0.8032	107	-0.9272
12	-1.5335	44	1.9508	76	-0.9888	108	-1.0910
13	-1.2134	45	0.8687	77	-1.0989	109	-1.1916
14	0.8545	46	-0.8680	78	1.6055	110	1.3769
15	-1.8258	47	1.5319	79	-1.5295	111	-1.6249
16	-1.0922	48	0.9517	80	-0.5465	112	-0.7238
17	-1.0056	49	0.1602	81	-0.0456	113	-0.4134
18	-1.6673	50	1.4339	82	-0.9867	114	-1.0955
19	0.3384	51	-0.8246	83	0.5410	115	0.4785
20	0.6917	52	-0.2632	84	0.6163	116	0.7740
21	0.5018	53	-0.9219	85	0.5998	117	0.6577
22	-1.5533	54	1.2576	86	-0.7641	118	-1.0289
23	0.7693	55	-1.1357	87	0.7783	119	0.9309
24	-0.7573	56	-0.5299	88	0.3871	120	-0.1875
25	-1.8346	57	-0.5653	89	-0.0394	121	-0.6887
26	-0.4697	58	-0.8263	90	0.5327	122	0.0542
27	0.0313	59	0.5312	91	-0.2953	123	0.3671
28	1.3004	60	1.1024	92	-0.2357	124	0.6337
29	0.4431	61	0.7060	93	-0.3799	125	0.5204
30	-1.1722	62	-1.0223	94	0.4442	126	-0.5116
31	0.9080	63	1.0804	95	-0.4903	127	0.8080

ANNEX E - EXAMPLE ENCODING OF A PHY PACKET USING LDPC

In this Annex, example PSDU coding and MDCM modulation using the data rates that use LDPC are provided.

E.1 Example of Coding at 640 Mb/s

The frame payload that is transmitted in this example is given in Table A-5. The FCS for the 40-octet message is as given in section A.3. The scrambler seed value of S1=0, S2=1 is assumed.

The PLCP is transmitted as three OFDM symbols. The three symbols are as follows. In this example, the guard tones are given equal strength to the data tones, as described in Table E-1. Tables E-1, E-2, E-3 show the time domain symbols as follows:

TABLE E-1. Time-domain sequence for symbol #43

#	Real	Imag	#	Real	Imag	#	Real	Imag
6931	-12.9711	2.3682	6986	5.0611	4.2014	7041	14.2357	13.6386
6932	5.7538	-8.0101	6987	-11.2078	-3.8783	7042	0.5342	0.9034
6933	6.4449	-2.4318	6988	16.0472	-5.2410	7043	-3.1387	-2.4924
6934	-3.9390	-0.9273	6989	2.8194	0.0410	7044	10.8510	-4.6896
6935	3.7363	-0.9929	6990	4.4889	-6.2489	7045	6.7920	-10.9368
6936	-11.4042	4.2603	6991	-8.1280	9.3051	7046	-10.1198	7.0722
6937	-18.6306	6.8121	6992	-6.8987	6.3965	7047	-6.5513	1.1834
6938	-2.5011	-5.1297	6993	-6.2247	-0.7413	7048	0.3696	2.2843
6939	4.4853	-5.3125	6994	-4.0429	-7.4578	7049	-2.6291	-7.0197
6940	12.7676	8.8730	6995	9.2896	-1.4479	7050	-1.6213	-9.0668
6941	-8.3272	-0.5493	6996	-13.9790	-1.6579	7051	0.2162	9.1373
6942	0.7290	-9.8212	6997	-11.6455	2.0318	7052	-3.0686	-3.9171
6943	-12.1415	-11.6819	6998	-12.4821	2.7516	7053	21.1244	9.3870
6944	-8.5381	-2.9723	6999	-7.4794	7.6543	7054	2.2984	-5.3809
6945	5.0767	-5.3708	7000	-10.3387	-8.4506	7055	-4.6128	-16.3375
6946	-13.0154	-0.2227	7001	-6.8974	-9.8287	7056	11.0649	-3.3276
6947	15.4365	-5.1174	7002	-2.2814	15.8730	7057	-1.6023	-9.2317
6948	12.0383	-7.8922	7003	6.4883	-5.5250	7058	2.9549	1.1150
6949	9.6090	11.6224	7004	7.4393	13.0120	7059	0.0000	0.0000
6950	4.8579	4.9669	7005	0.1454	5.8112	7060	0.0000	0.0000
6951	-15.7851	-14.4732	7006	1.2395	-5.0713	7061	0.0000	0.0000

TABLE E-1. Time-domain sequence for symbol #43

6952	-5.3325	-5.3507	7007	6.1017	-11.2324	7062	0.0000	0.0000
6953	14.5837	11.9724	7008	-0.6667	6.1098	7063	0.0000	0.0000
6954	1.6491	9.6579	7009	-4.5526	7.6826	7064	0.0000	0.0000
6955	-4.1249	1.2821	7010	-5.5236	-10.2423	7065	0.0000	0.0000
6956	13.3650	9.2688	7011	1.7435	11.5599	7066	0.0000	0.0000
6957	4.8382	6.4437	7012	1.8056	-12.3970	7067	0.0000	0.0000
6958	-9.2939	0.6212	7013	1.4260	-9.1740	7068	0.0000	0.0000
6959	4.0301	-1.8811	7014	7.2630	-3.5689	7069	0.0000	0.0000
6960	5.6768	-1.0584	7015	-1.8316	3.4658	7070	0.0000	0.0000
6961	-4.7376	-4.9063	7016	2.8845	0.9224	7071	0.0000	0.0000
6962	-12.7034	-6.2035	7017	-2.4192	4.2546	7072	0.0000	0.0000
6963	2.6077	1.3805	7018	3.0198	-2.3788	7073	0.0000	0.0000
6964	3.6278	-7.8962	7019	-5.1313	-4.7004	7074	0.0000	0.0000
6965	20.0095	3.1126	7020	-11.6169	0.8281	7075	0.0000	0.0000
6966	9.3924	-3.1273	7021	-7.2634	-4.1898	7076	0.0000	0.0000
6967	-8.1930	-9.9067	7022	-5.7915	-4.7068	7077	0.0000	0.0000
6968	-0.6458	9.6905	7023	4.5519	-2.2669	7078	0.0000	0.0000
6969	1.3536	2.9268	7024	0.9985	6.9956	7079	0.0000	0.0000
6970	-7.7602	-4.2378	7025	-4.9287	20.2865	7080	0.0000	0.0000
6971	-0.8595	10.6266	7026	10.3487	14.0115	7081	0.0000	0.0000
6972	7.1675	-10.2744	7027	-0.1534	-3.5280	7082	0.0000	0.0000
6973	-8.5838	-7.3109	7028	-5.0086	-8.9989	7083	0.0000	0.0000
6974	12.3799	-2.3091	7029	1.3296	-3.3969	7084	0.0000	0.0000
6975	-1.4928	-2.3602	7030	-7.8235	22.6361	7085	0.0000	0.0000
6976	2.7596	-7.0141	7031	-0.7256	-10.8360	7086	0.0000	0.0000
6977	2.5230	-11.8382	7032	-3.0829	-1.9116	7087	0.0000	0.0000
6978	3.2793	4.4147	7033	-11.1767	3.6827	7088	0.0000	0.0000
6979	10.5015	4.6399	7034	4.4055	0.0923	7089	0.0000	0.0000
6980	2.6430	0.0242	7035	-10.7277	10.6417	7090	0.0000	0.0000
6981	-1.6747	-0.5212	7036	3.4851	2.4008	7091	0.0000	0.0000
6982	3.4668	14.3656	7037	-0.2293	4.9694	7092	0.0000	0.0000
6983	3.6968	1.8168	7038	-7.9208	7.9614	7093	0.0000	0.0000
6984	-10.1795	7.7076	7039	12.9188	4.5492	7094	0.0000	0.0000
6985	18.6635	7.1319	7040	-0.5333	-2.2569	7095	0.0000	0.0000

TABLE E-2. Time-domain sequence for Symbol #44

#	Real	Imag	#	Real	Imag	#	Real	Imag
7096	3.7675	6.5285	7151	-8.0531	-4.8646	7206	-7.5355	-12.2297
7097	-10.1067	17.8698	7152	13.4279	8.3051	7207	1.8783	0.2433
7098	2.8433	7.6437	7153	-2.6612	2.5596	7208	-3.3570	17.3130
7099	-3.5251	-19.4979	7154	0.4462	2.9271	7209	2.0711	-16.2454
7100	3.7709	7.8909	7155	10.0062	3.0230	7210	-4.1918	6.0054
7101	22.7004	-0.3006	7156	3.2402	-6.2203	7211	12.3154	-14.9540
7102	12.2617	-10.7140	7157	-3.1258	4.1583	7212	-0.3496	-5.1987
7103	0.4819	0.6677	7158	-4.6166	3.8317	7213	1.2339	-2.1876
7104	-12.7600	-4.7911	7159	17.4832	-6.5766	7214	11.5399	8.9477
7105	-10.9043	-5.9768	7160	6.3565	-1.9268	7215	-2.5478	2.6093
7106	2.5417	-0.3612	7161	-8.4471	9.5647	7216	12.2560	2.0884
7107	-0.1181	10.4376	7162	-10.6222	1.4403	7217	-1.7499	8.9920
7108	1.2570	-13.0096	7163	1.9285	-1.7328	7218	-13.4898	-0.4626
7109	-4.6068	6.4496	7164	-12.9706	1.0007	7219	14.0860	22.0906
7110	-8.4513	25.4303	7165	-0.8430	2.4444	7220	0.9105	-10.0085
7111	-3.3218	-4.3703	7166	11.2361	5.5723	7221	-14.2878	-0.7580
7112	6.0763	7.9850	7167	9.4987	7.8328	7222	6.6923	-3.2805
7113	5.8375	-12.3612	7168	9.5804	-10.3313	7223	-0.0871	0.9392
7114	-3.1486	-7.2400	7169	0.6134	-1.4752	7224	0.0000	0.0000
7115	4.0729	4.3478	7170	-6.0742	-2.5967	7225	0.0000	0.0000
7116	-4.3180	-6.9387	7171	9.0063	0.9340	7226	0.0000	0.0000
7117	-3.5909	12.9506	7172	-0.0242	-5.1111	7227	0.0000	0.0000
7118	-0.2567	11.9635	7173	-10.7537	-5.8544	7228	0.0000	0.0000
7119	-1.8618	-2.5204	7174	0.4471	-8.1108	7229	0.0000	0.0000
7120	1.9952	9.0793	7175	-3.7485	5.4631	7230	0.0000	0.0000
7121	4.8621	-19.4913	7176	-3.0084	3.6728	7231	0.0000	0.0000
7122	-8.1802	-6.3799	7177	-5.3969	-2.5161	7232	0.0000	0.0000
7123	-12.3068	5.4242	7178	-0.9155	-11.9949	7233	0.0000	0.0000
7124	-11.3762	-9.4833	7179	3.5206	-3.5597	7234	0.0000	0.0000
7125	-4.0276	-1.3739	7180	6.4289	10.6362	7235	0.0000	0.0000
7126	-1.8175	8.7054	7181	4.5134	-6.8745	7236	0.0000	0.0000
7127	5.9978	21.4558	7182	4.0213	6.6613	7237	0.0000	0.0000
7128	-3.0679	3.6814	7183	6.6316	-3.1188	7238	0.0000	0.0000

TABLE E-2. Time-domain sequence for Symbol #44

7129	-12.9888	-8.9235	7184	-1.9091	2.6158	7239	0.0000	0.0000
7130	-5.5458	0.3767	7185	-1.3031	1.8397	7240	0.0000	0.0000
7131	9.5766	13.6139	7186	3.7687	0.8959	7241	0.0000	0.0000
7132	2.8574	-5.6158	7187	-2.7257	-12.6705	7242	0.0000	0.0000
7133	15.1694	-2.7835	7188	-3.3978	-1.9423	7243	0.0000	0.0000
7134	12.3377	7.7832	7189	-7.9069	0.9218	7244	0.0000	0.0000
7135	-5.3324	16.0581	7190	-6.8842	2.5361	7245	0.0000	0.0000
7136	4.1229	-0.8264	7191	-2.3878	1.0274	7246	0.0000	0.0000
7137	3.0429	-5.0508	7192	-3.3746	-0.9204	7247	0.0000	0.0000
7138	2.9560	6.6984	7193	1.5634	1.7189	7248	0.0000	0.0000
7139	-2.1942	-2.4900	7194	9.6228	-8.3505	7249	0.0000	0.0000
7140	6.1249	-11.1277	7195	-9.7161	0.4395	7250	0.0000	0.0000
7141	1.0653	1.1345	7196	2.0910	-0.8216	7251	0.0000	0.0000
7142	-1.4372	-1.7973	7197	-4.9643	-6.3073	7252	0.0000	0.0000
7143	-2.5064	12.1147	7198	7.9081	-15.7152	7253	0.0000	0.0000
7144	2.7435	-5.6552	7199	-2.4820	1.8785	7254	0.0000	0.0000
7145	-6.8388	-16.2820	7200	-3.3976	-14.7298	7255	0.0000	0.0000
7146	0.1330	-0.0904	7201	1.5259	-6.5323	7256	0.0000	0.0000
7147	-0.4513	-11.9619	7202	-9.4122	-0.7828	7257	0.0000	0.0000
7148	-14.6900	3.9555	7203	10.8765	6.8029	7258	0.0000	0.0000
7149	-0.4976	-4.2048	7204	-4.0974	10.2713	7259	0.0000	0.0000
7150	-1.0852	2.3218	7205	-3.1915	5.8097	7260	0.0000	0.0000

TABLE E-3. Time-domain sequence for Symbol #45

#	Real	Imag	#	Real	Imag	#	Real	Imag
7261	10.8049	-16.1923	7316	-8.8153	-6.3249	7371	-3.4693	-0.2645
7262	5.2122	5.0517	7317	-9.4402	-2.0777	7372	-6.5770	3.5829
7263	-4.2145	4.8493	7318	3.9189	-7.5869	7373	7.8894	-4.2323
7264	14.5616	4.0192	7319	7.8102	5.1499	7374	-19.5129	4.5437
7265	-1.9947	3.0408	7320	5.9324	11.3531	7375	1.0947	-8.4705
7266	7.2893	10.1221	7321	-7.6709	-1.2067	7376	-10.3064	-6.1253
7267	9.3174	4.5109	7322	-19.2102	-7.2895	7377	-3.4048	1.5218
7268	-2.8886	13.0077	7323	11.9004	-2.5843	7378	1.3760	-0.2794
7269	5.8532	3.7103	7324	-4.5467	-1.7983	7379	14.5011	13.8532

TABLE E-3. Time-domain sequence for Symbol #45

7270	-4.9647	-3.0081	7325	-7.7370	-12.3388	7380	7.2826	6.2829
7271	12.2598	-4.8561	7326	0.2801	-5.0357	7381	-3.8106	-0.2432
7272	12.1063	-7.0213	7327	-1.2234	20.1255	7382	11.6278	-5.9839
7273	-9.5494	-3.9803	7328	-1.4656	-5.9589	7383	-5.1571	11.2013
7274	-3.2379	9.0119	7329	-0.5415	10.8631	7384	2.9407	-3.3162
7275	-7.1197	1.5249	7330	6.5857	7.9777	7385	-6.5605	-8.5330
7276	-3.0831	-13.1792	7331	4.9112	-6.0375	7386	1.3289	-7.3579
7277	-8.6717	-10.8083	7332	4.3132	-8.7847	7387	14.9698	2.3452
7278	4.6202	3.6507	7333	-17.1145	-2.7092	7388	9.7223	-7.4440
7279	8.1668	6.5867	7334	12.0619	2.1512	7389	0.0000	0.0000
7280	4.4781	-0.6542	7335	20.6832	-0.2832	7390	0.0000	0.0000
7281	6.8922	6.3880	7336	1.0020	7.5375	7391	0.0000	0.0000
7282	-9.9221	1.6832	7337	0.0202	3.5693	7392	0.0000	0.0000
7283	3.8522	4.0894	7338	-5.9053	2.4096	7393	0.0000	0.0000
7284	1.9863	-0.0454	7339	6.8350	6.6676	7394	0.0000	0.0000
7285	-6.3285	-18.0551	7340	-0.5422	-4.7755	7395	0.0000	0.0000
7286	-7.0700	6.4282	7341	7.1378	2.8319	7396	0.0000	0.0000
7287	-4.2925	-5.5667	7342	-1.8926	-11.9944	7397	0.0000	0.0000
7288	-0.9672	8.0967	7343	4.9522	-6.9279	7398	0.0000	0.0000
7289	4.3262	9.7796	7344	-0.0655	-1.6591	7399	0.0000	0.0000
7290	8.5212	-5.3413	7345	4.6828	-10.2805	7400	0.0000	0.0000
7291	-3.2913	2.4252	7346	5.0785	16.0346	7401	0.0000	0.0000
7292	-11.6928	-17.1420	7347	-8.3305	-11.6911	7402	0.0000	0.0000
7293	3.0679	11.6579	7348	0.1490	-1.5084	7403	0.0000	0.0000
7294	-10.3540	-4.2648	7349	-1.2821	7.4909	7404	0.0000	0.0000
7295	0.3732	4.9805	7350	-4.0130	-6.6401	7405	0.0000	0.0000
7296	5.5193	-2.1732	7351	-9.8180	-9.6079	7406	0.0000	0.0000
7297	1.3259	-5.6507	7352	6.9793	10.9720	7407	0.0000	0.0000
7298	-5.9168	-19.5409	7353	0.7325	-2.0603	7408	0.0000	0.0000
7299	-3.5740	-4.2911	7354	-13.2623	-12.3890	7409	0.0000	0.0000
7300	9.8129	-6.8056	7355	10.3650	-0.6856	7410	0.0000	0.0000
7301	-6.8134	-4.6197	7356	8.9748	3.3708	7411	0.0000	0.0000
7302	-9.8010	6.6395	7357	-1.8407	11.9647	7412	0.0000	0.0000
7303	-3.8642	-6.6534	7358	-0.2301	-0.7051	7413	0.0000	0.0000
7304	-0.9481	5.9673	7359	-14.1278	-3.8438	7414	0.0000	0.0000

TABLE E-3. Time-domain sequence for Symbol #45

7305	-0.0045	-3.9761	7360	8.0817	3.4510	7415	0.0000	0.0000
7306	-4.0005	5.0912	7361	-6.9714	1.7873	7416	0.0000	0.0000
7307	-8.6712	-7.3335	7362	1.9859	-15.2689	7417	0.0000	0.0000
7308	-5.1661	5.0901	7363	0.7206	-3.1127	7418	0.0000	0.0000
7309	-11.8777	1.1645	7364	-1.1369	6.6732	7419	0.0000	0.0000
7310	2.2688	5.1840	7365	-4.0140	-4.3580	7420	0.0000	0.0000
7311	-6.5995	2.2728	7366	2.7015	10.1322	7421	0.0000	0.0000
7312	-1.1731	16.3910	7367	3.7738	18.0406	7422	0.0000	0.0000
7313	12.2830	4.6017	7368	-0.2907	-1.2620	7423	0.0000	0.0000
7314	1.2606	4.2322	7369	6.4350	1.4990	7424	0.0000	0.0000
7315	-8.5566	3.0384	7370	-1.0015	2.5246	7425	0.0000	0.0000

E.2 Example coding at 480 Mb/s using LDPC

The frame payload that is transmitted in this example is given in Table A-5.

The FCS for the 40-octet message is as given in section A.3.

The scrambler seed value of S1=0, S2=1 is assumed.

The PLCP is transmitted as six OFDM symbols. Only the first PLCP symbol is shown here.

TABLE E-4. Time-domain sequence for symbol #43 (SPDU symbol 0)

#	Real	Imag	#	Real	Imag	#	Real	Imag
6931	7.2556	-0.3339	6986	-7.5262	-3.4844	7041	-4.4360	9.4019
6932	3.2534	5.0861	6987	-13.8309	2.8624	7042	-2.5983	-4.4111
6933	-1.8301	-6.2389	6988	7.9686	7.7119	7043	-4.9712	11.5626
6934	0.9743	1.2128	6989	-9.5075	1.4233	7044	10.4714	5.9734
6935	0.3168	5.7512	6990	18.9040	-1.6859	7045	1.5095	6.9650
6936	0.0045	-5.0403	6991	11.5276	-8.3929	7046	-6.0799	7.0473
6937	-5.9354	0.3016	6992	2.7906	-13.7971	7047	0.9519	-7.4289
6938	-5.2186	-16.1554	6993	-4.8646	8.4254	7048	-2.0899	-1.0423
6939	0.3769	-3.9002	6994	10.5081	-3.0322	7049	-6.6947	3.4149
6940	-5.2392	4.3754	6995	2.8637	-7.2556	7050	-6.1793	-4.9351

TABLE E-4. Time-domain sequence for symbol #43 (SPDU symbol 0)

#	Real	Imag	#	Real	Imag	#	Real	Imag
6941	-7.4932	5.5359	6996	-10.1525	5.4776	7051	-4.7087	5.7749
6942	3.4863	3.9462	6997	3.7725	1.4353	7052	9.6720	-4.4434
6943	-10.6137	-8.2035	6998	-1.5243	6.6377	7053	2.0830	-3.4198
6944	-8.2287	-12.2232	6999	13.4441	-15.0299	7054	-11.7511	-4.9634
6945	0.7241	-4.6580	7000	-1.6514	14.9142	7055	9.3977	-12.0876
6946	-4.0007	-3.5115	7001	-8.8327	1.6925	7056	-2.3612	7.7027
6947	-5.4951	-8.1148	7002	0.2771	-13.0561	7057	15.7979	2.7049
6948	-4.4560	10.1219	7003	-6.5743	-8.7489	7058	2.3612	4.7193
6949	-10.2375	9.8252	7004	-3.4880	2.3791	7059	0	0
6950	-9.4530	4.7773	7005	-8.4400	-3.5976	7060	0	0
6951	3.9491	-0.8445	7006	2.4123	-2.0461	7061	0	0
6952	11.7807	-12.7026	7007	0.7387	4.3487	7062	0	0
6953	1.3320	2.2340	7008	-1.3966	2.3379	7063	0	0
6954	-0.9432	15.4659	7009	9.4643	-10.7385	7064	0	0
6955	-0.3867	6.6591	7010	-3.2863	12.2080	7065	0	0
6956	6.9379	-0.2771	7011	10.5547	25.8236	7066	0	0
6957	2.2959	5.0009	7012	4.5280	-16.8103	7067	0	0
6958	7.2477	-7.3682	7013	-17.0848	3.1570	7068	0	0
6959	-10.2484	-2.8952	7014	2.4911	7.5690	7069	0	0
6960	-3.7253	-4.7412	7015	6.7862	12.0489	7070	0	0
6961	-0.3135	-22.6469	7016	4.6431	-2.5532	7071	0	0
6962	-8.9276	-5.3794	7017	0.9521	-2.8475	7072	0	0
6963	-3.7947	-2.5298	7018	1.3043	-15.5349	7073	0	0
6964	8.0876	2.3375	7019	-3.8421	-5.1772	7074	0	0
6965	5.7983	13.6740	7020	-4.3805	-6.9093	7075	0	0
6966	-17.8782	-8.6744	7021	6.0597	-8.6513	7076	0	0
6967	6.8722	-3.0486	7022	-14.0029	-3.3406	7077	0	0
6968	5.1923	7.5321	7023	0.0562	-10.7396	7078	0	0
6969	-18.5565	-2.8065	7024	2.0969	4.8458	7079	0	0
6970	8.7321	-0.9943	7025	6.6487	4.8793	7080	0	0
6971	14.9909	-9.9054	7026	1.9330	7.5329	7081	0	0
6972	-10.5967	4.7287	7027	6.3246	10.1193	7082	0	0
6973	-9.4499	-7.5254	7028	1.9079	-2.8532	7083	0	0
6974	5.1742	-3.1388	7029	2.2072	-3.2022	7084	0	0

TABLE E-4. Time-domain sequence for symbol #43 (SPDU symbol 0)

#	Real	Imag	#	Real	Imag	#	Real	Imag
6975	1.5849	2.4270	7030	10.2287	2.9803	7085	0	0
6976	-1.8147	1.1535	7031	18.9759	-5.9953	7086	0	0
6977	2.6368	7.5721	7032	4.7733	7.7833	7087	0	0
6978	-21.7735	2.5771	7033	-6.9525	-11.6336	7088	0	0
6979	7.5010	6.1462	7034	7.9440	6.5250	7089	0	0
6980	-2.6810	-4.6211	7035	3.8556	-2.7437	7090	0	0
6981	-4.3736	11.0298	7036	15.5613	-5.1218	7091	0	0
6982	4.2164	3.5389	7037	4.2135	4.9469	7092	0	0
6983	-0.6998	-0.6319	7038	-7.5287	14.9743	7093	0	0
6984	-9.5003	3.4908	7039	-2.4430	10.2450	7094	0	0
6985	-1.2087	4.5849	7040	12.5698	-4.8160	7095	0	0

ANNEX F - LDPC ENCODING PROCEDURE (INFORMATIVE)

The parity-check matrix of a fundamental code has the following structure: $\boldsymbol{H} = [\boldsymbol{A}\ \boldsymbol{B}]$, where $\mathbf{A}$ is an $m_b \times (n_b - m_b)$ block matrix corresponding to the information bits and $\mathbf{B}$ is an $m_b \times m_b$ block matrix corresponding to the parity bits. For sake of simple linear complexity encoding of the fundamental code the block matrix $\mathbf{B}$ has the dual diagonal structure:

.

$$
\mathbf{B} = \begin{bmatrix}
I^1 & I^0 & & & & \\
0 & I^0 & I^0 & & 0 & \\
\vdots & & I^0 & & & \\
I^0 & & & \ddots & & \\
\vdots & & & & I^0 & \\
0 & & 0 & & I^0 & I^0 \\
I^1 & & & & & I^0
\end{bmatrix}
$$

In the first block column of $\mathbf{B}$, the first and last block entries are I^1, block entry $\lceil m_b/2 \rceil$ is I^0 and the rest of the block entries in the column are 0.

The parity-check matrix of the expanded code has the following structure:

$$
\mathbf{H}_e = \begin{bmatrix} \mathbf{H} & 0 \\ \mathbf{C} & \mathbf{D} \end{bmatrix}
$$

where H is the $m_b \times n_b$ block parity-check matrix of the corresponding fundamental code, $\mathbf{C}$ is a $4 \times n_b$ block matrix corresponding to the fundamental codeword bits and $\mathbf{D}$ is a 4×4 block matrix corresponding to the expanded parity bits. For sake of simple linear complexity encoding of the extra parity bits of the expanded code, the block matrix $\mathbf{D}$ has the dual diagonal structure: $\mathbf{D} = \begin{bmatrix} I^1 & I^0 & 0 & 0 \\ I^0 & I^0 & I^0 & 0 \\ 0 & 0 & I^0 & I^0 \\ I^1 & 0 & 0 & I^0 \end{bmatrix}$

The encoding of a packet of a fundamental code at the transmitter generates parity bits $\mathrm{p} = (p_0, p_1, \ldots, p_{m-1})$ based on an information block $\mathbf{s} = (s_0, s_1, \ldots, s_{k-1})$, and transmits the parity bits along with the information bits over the data tones. For the expanded code the transmitter also generates the extra set of parity bits $\mathrm{p}_e = (p_{e,0}, p_{e,1}, \ldots, p_{e,m-1})$ and transmits them over the guard tones.

The encoder receives the information block $\mathbf{s} = (s_0, s_1, \ldots, s_{k-1})$ and uses the expanded matrix $\mathbf{H_e}$ in order to determine the parity bits and the extra parity-bits.

One method of encoding is to determine a generator matrix $\mathbf{G}$ from $\mathbf{H_e}$ such that $\mathbf{G}\mathbf{H}_\mathbf{e}^T = 0$. A k-bit information block $s_{1 \times k}$ can be encoded by the code generator matrix $\mathbf{G}_{k \times n}$ via the operation $\mathrm{x} = \mathbf{s}\,\mathbf{G}$ to become an n-bit codeword $\mathrm{x}_{1 \times n}$, with codeword

$$\mathbf{x} = \begin{bmatrix} \mathbf{s} \ \mathbf{p} \ \mathbf{p_e} \end{bmatrix} = [s_0, s_1, \ldots, s_{k-1}, p_0, p_1, \ldots, p_{m-1}, p_{e,0}, p_{e,1}, \ldots, p_{e,m-1}]$$

where $p_0, p_1, \ldots, p_{m-1}$ are the parity-check bits, are the extra parity-check bits and $s_0, s_1, \ldots, s_{k-1}$ are the information bits. Encoding an LDPC code from $\mathbf{G}$ has relatively high complexity (quadratic complexity in the code length *n*) since $\mathbf{G}$ is not sparse. Hence, a common method for encoding LDPC codes is to perform the encoding directly through the sparse parity-check matrix $\mathbf{H_e}$ by solving the following linear equations system: .

$$\mathbf{H}_e x^T = \begin{bmatrix} \mathbf{s} \ \mathbf{p} \ \mathbf{p_e} \end{bmatrix}^T = 0$$

By using a parity-check matrix with a lower triangular form efficient linear encoding complexity can be achieved [1]. In this case the encoding procedure is performed using a simple Gaussian elimination procedure. In order to allow such linear encoding complexity, the proposed parity-check matrices are based on a dual diagonal form which allows simple lower triangulation of the parity-check matrix. This is done by replacing the last row of $\mathbf{H}$ with a block row that is the sum of all the block rows of $\mathbf{H}$, and then set the last row to be the first one. This results in a lower triangular block matrix $\mathbf{H}_{LT}$, which defines the same fundamental code. Furthermore, the first block row of the block matrix $\begin{bmatrix}\mathbf{C} & \mathbf{D}\end{bmatrix}$ is replaced by the sum of all block rows of $\begin{bmatrix}\mathbf{C} & \mathbf{D}\end{bmatrix}$, resulting in a lower triangular matrix $\begin{bmatrix}\mathbf{C}^* & \mathbf{D}_{LT}\end{bmatrix}$. Then, the resulting matrix $\mathbf{H}_{e,LT} = \begin{bmatrix}\mathbf{H}_{LT} & 0 \\ \mathbf{C}^* & \mathbf{D}_{LT}\end{bmatrix}$ is a lower triangular matrix defining the same expanded code, which allows simple linear encoding via Gaussian elimination.

[1] T.J.Richardson and R.Urbanke, "Efficient encoding of low-density parity-check codes," *IEEE Trans. on Info. Theory*, vol.47, pp.638-656, 2001.

Page Intentionally Left Blank.