**IEEE P802.15**

**Wireless Personal Area Networks**

|  |  |  |
| --- | --- | --- |
| Project | IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs) | |
| Title |  | |
| Date Submitted | [21 Dec 2011] | |
| Source | [Xiang Wang, ] [WSNIRI, ] | Voice: [ ] Fax: [ ] E-mail: [wilsonwangxiang@gmail.com] |
| Re: | [802.15.4k LECIM DSSS PHY draft text] | |
| Abstract | [Work in progress] | |
| Purpose | [For incorporation into 802.15.4k draft text ] | |
| Notice | This document has been prepared to assist the IEEE P802.15. It is offered as a basis for discussion and is not binding on the contributing individual(s) or organization(s). The material in this document is subject to change in form and content after further study. The contributor(s) reserve(s) the right to add, amend or withdraw material contained herein. | |
| Release | The contributor acknowledges and accepts that this contribution becomes the property of IEEE and may be made publicly available by P802.15. | |

IEEE P™/D  
Draft for

Sponsor

**Committee**of the **IEEE <Society Name> Society**

Approved <XX MONTH 20XX>

**IEEE-SA Standards Board**

Copyright © 201X by the Institute of Electrical and Electronics Engineers, Inc.

Three Park Avenue

New York, New York 10016-5997, USA

All rights reserved.

This document is an unapproved draft of a proposed IEEE Standard. As such, this document is subject to change. USE AT YOUR OWN RISK! Because this is an unapproved draft, this document must not be utilized for any conformance/compliance purposes. Permission is hereby granted for IEEE Standards Committee participants to reproduce this document for purposes of international standardization consideration. Prior to adoption of this document, in whole or in part, by another standards development organization, permission must first be obtained from the IEEE Standards Association Department (stds.ipr@ieee.org). Other entities seeking permission to reproduce this document, in whole or in part, must also obtain permission from the IEEE Standards Association Department.

IEEE Standards Association Department

445 Hoes Lane

Piscataway, NJ 08854, USA

Abstract: <Select this text and type or paste Abstract—contents of the Scope may be used>

Keywords: <Select this text and type or paste keywords>

[[1]](#footnote-1)•

**IEEE Standards** documents are developed within the IEEE Societies and the Standards Coordinating Committees of the IEEE Standards Association (IEEE-SA) Standards Board. The IEEE develops its standards through a consensus development process, approved by the American National Standards Institute, which brings together volunteers representing varied viewpoints and interests to achieve the final product. Volunteers are not necessarily members of the Institute and serve without compensation. While the IEEE administers the process and establishes rules to promote fairness in the consensus development process, the IEEE does not independently evaluate, test, or verify the accuracy of any of the information or the soundness of any judgments contained in its standards.

Use of an IEEE Standard is wholly voluntary. The IEEE disclaims liability for any personal injury, property or other damage, of any nature whatsoever, whether special, indirect, consequential, or compensatory, directly or indirectly resulting from the publication, use of, or reliance upon this, or any other IEEE Standard document.

The IEEE does not warrant or represent the accuracy or content of the material contained herein, and expressly disclaims any express or implied warranty, including any implied warranty of merchantability or fitness for a specific purpose, or that the use of the material contained herein is free from patent infringement. IEEE Standards documents are supplied “**AS IS**.”

The existence of an IEEE Standard does not imply that there are no other ways to produce, test, measure, purchase, market, or provide other goods and services related to the scope of the IEEE Standard. Furthermore, the viewpoint expressed at the time a standard is approved and issued is subject to change brought about through developments in the state of the art and comments received from users of the standard. Every IEEE Standard is subjected to review at least every five years for revision or reaffirmation, or every ten years for stabilization. When a document is more than five years old and has not been reaffirmed, or more than ten years old and has not been stabilized, it is reasonable to conclude that its contents, although still of some value, do not wholly reflect the present state of the art. Users are cautioned to check to determine that they have the latest edition of any IEEE Standard.

In publishing and making this document available, the IEEE is not suggesting or rendering professional or other services for, or on behalf of, any person or entity. Nor is the IEEE undertaking to perform any duty owed by any other person or entity to another. Any person utilizing this, and any other IEEE Standards document, should rely upon his or her independent judgment in the exercise of reasonable care in any given circumstances or, as appropriate, seek the advice of a competent professional in determining the appropriateness of a given IEEE standard.

Interpretations: Occasionally questions may arise regarding the meaning of portions of standards as they relate to specific applications. When the need for interpretations is brought to the attention of IEEE, the Institute will initiate action to prepare appropriate responses. Since IEEE Standards represent a consensus of concerned interests, it is important to ensure that any interpretation has also received the concurrence of a balance of interests. For this reason, IEEE and the members of its societies and Standards Coordinating Committees are not able to provide an instant response to interpretation requests except in those cases where the matter has previously received formal consideration. A statement, written or oral, that is not processed in accordance with the IEEE-SA Standards Board Operations Manual shall not be considered the official position of IEEE or any of its committees and shall not be considered to be, nor be relied upon as, a formal interpretation of the IEEE. At lectures, symposia, seminars, or educational courses, an individual presenting information on IEEE standards shall make it clear that his or her views should be considered the personal views of that individual rather than the formal position, explanation, or interpretation of the IEEE.

Comments for revision of IEEE Standards are welcome from any interested party, regardless of membership affiliation with IEEE. Suggestions for changes in documents should be in the form of a proposed change of text, together with appropriate supporting comments. Recommendations to change the status of a stabilized standard should include a rationale as to why a revision or withdrawal is required. Comments and recommendations on standards, and requests for interpretations should be addressed to:

Secretary, IEEE-SA Standards Board

445 Hoes Lane

Piscataway, NJ 08854

USA

Authorization to photocopy portions of any individual standard for internal or personal use is granted by The Institute of Electrical and Electronics Engineers, Inc., provided that the appropriate fee is paid to Copyright Clearance Center. To arrange for payment of licensing fee, please contact Copyright Clearance Center, Customer Service, 222 Rosewood Drive, Danvers, MA 01923 USA; +1 978 750 8400. Permission to photocopy portions of any individual standard for educational classroom use can also be obtained through the Copyright Clearance Center.

Introduction

This introduction is not part of IEEE P/D<draft\_number>, Draft<opt\_Trial-Use><Gde./Rec. Prac./Std.> for .

<Select this text and type or paste introduction text>

Notice to users

Laws and regulations

Users of these documents should consult all applicable laws and regulations. Compliance with the provisions of this standard does not imply compliance to any applicable regulatory requirements. Implementers of the standard are responsible for observing or referring to the applicable regulatory requirements. IEEE does not, by the publication of its standards, intend to urge action that is not in compliance with applicable laws, and these documents may not be construed as doing so.

Copyrights

This document is copyrighted by the IEEE. It is made available for a wide variety of both public and private uses. These include both use, by reference, in laws and regulations, and use in private self-regulation, standardization, and the promotion of engineering practices and methods. By making this document available for use and adoption by public authorities and private users, the IEEE does not waive any rights in copyright to this document.

Updating of IEEE documents

Users of IEEE standards should be aware that these documents may be superseded at any time by the issuance of new editions or may be amended from time to time through the issuance of amendments, corrigenda, or errata. An official IEEE document at any point in time consists of the current edition of the document together with any amendments, corrigenda, or errata then in effect. In order to determine whether a given document is the current edition and whether it has been amended through the issuance of amendments, corrigenda, or errata, visit the IEEE Standards Association web site at <http://ieeexplore.ieee.org/xpl/standards.jsp>, or contact the IEEE at the address listed previously.

For more information about the IEEE Standards Association or the IEEE standards development process, visit the IEEE-SA web site at <http://standards.ieee.org>.

Errata

Errata, if any, for this and all other standards can be accessed at the following URL:   
<http://standards.ieee.org/findstds/errata/index.html>. Users are encouraged to check this URL for errata periodically.

Interpretations

Current interpretations can be accessed at the following URL: <http://standards.ieee.org/findstds/interps/index.html>.

Patents

***[If the IEEE has not received letters of assurance prior to the time of publication, the following notice shall appear:]***

Attention is called to the possibility that implementation of this<opt\_trial-use><gde./rec. prac./std.> may require use of subject matter covered by patent rights. By publication of this<opt\_trial-use><gde./rec. prac./std.>, no position is taken with respect to the existence or validity of any patent rights in connection therewith. The IEEE is not responsible for identifying Essential Patent Claims for which a license may be required, for conducting inquiries into the legal validity or scope of Patents Claims or determining whether any licensing terms or conditions provided in connection with submission of a Letter of Assurance, if any, or in any licensing agreements are reasonable or non-discriminatory. Users of this<opt\_trial-use><gde./rec. prac./std.> are expressly advised that determination of the validity of any patent rights, and the risk of infringement of such rights, is entirely their own responsibility. Further information may be obtained from the IEEE Standards Association.

***[The following notice shall appear when the IEEE receives assurance from a known patent holder or patent applicant prior to the time of publication that a license will be made available to all applicants either without compensation or under reasonable rates, terms, and conditions that are demonstrably free of any unfair discrimination.]***

Attention is called to the possibility that implementation of this<opt\_trial-use><gde./rec. prac./std.> may require use of subject matter covered by patent rights. By publication of this<opt\_trial-use><gde./rec. prac./std.>, no position is taken with respect to the existence or validity of any patent rights in connection therewith. A patent holder or patent applicant has filed a statement of assurance that it will grant licenses under these rights without compensation or under reasonable rates, with reasonable terms and conditions that are demonstrably free of any unfair discrimination to applicants desiring to obtain such licenses. Other Essential Patent Claims may exist for which a statement of assurance has not been received. The IEEE is not responsible for identifying Essential Patent Claims for which a license may be required, for conducting inquiries into the legal validity or scope of Patents Claims, or determining whether any licensing terms or conditions provided in connection with submission of a Letter of Assurance, if any, or in any licensing agreements are reasonable or non-discriminatory. Users of this<opt\_trial-use><gde./rec. prac./std.> are expressly advised that determination of the validity of any patent rights, and the risk of infringement of such rights, is entirely their own responsibility. Further information may be obtained from the IEEE Standards Association.

Participants

At the time this draft<opt\_trial-use><gde./rec. prac./std.> was submitted to the IEEE-SA Standards Board for approval, the Working Group had the following membership:

, *Chair*

, *Vice Chair*

Participant1

Participant2

Participant3

Participant4

Participant5

Participant6

Participant7

Participant8

Participant9

The following members of the <individual/entity> balloting committee voted on this<opt\_trial-use><gde./rec. prac./std.>. Balloters may have voted for approval, disapproval, or abstention.

***(to be supplied by IEEE)***

Balloter1

Balloter2

Balloter3

Balloter4

Balloter5

Balloter6

Balloter7

Balloter8

Balloter9

When the IEEE-SA Standards Board approved this<opt\_trial-use><gde./rec. prac./std.> on <XX MONTH 20XX>, it had the following membership:

***(to be supplied by IEEE)***

**<Name>,** *Chair*

**<Name>,** *Vice Chair*

**<Name>,** *Past Chair*

**<Name>,** *Secretary*

SBMember1

SBMember2

SBMember3

SBMember4

SBMember5

SBMember6

SBMember7

SBMember8

SBMember9

\*Member Emeritus

Also included are the following nonvoting IEEE-SA Standards Board liaisons:

<Name>, *NRC Representative*

<Name>, *DOE Representative*

<Name>, *NIST Representative*

<Name>

*IEEE Standards Program Manager, Document Development*

<Name>

*IEEE Standards Program Manager, Technical Program Development*

Contents

<After draft body is complete, select this text and click Insert Special->Add (Table of) Contents>

Draft for

***IMPORTANT NOTICE: This standard is not intended to ensure safety, security, health, or environmental protection. Implementers of the standard are responsible for determining appropriate safety, security, environmental, and health practices or regulatory requirements.***

***This IEEE document is made available for use subject to important notices and legal disclaimers.   
These notices and disclaimers appear in all publications containing this document and may   
be found under the heading “Important Notice” or “Important Notices and Disclaimers   
Concerning IEEE Documents.” They can also be obtained on request from IEEE or viewed at*** [***http://standards.ieee.org/IPR/disclaimers.html***](http://standards.ieee.org/IPR/disclaimers.html)***.***

1. Overview
   1. General
   2. Scope
   3. Purpose
2. Normative references

The following referenced documents are indispensable for the application of this document (i.e., they must be understood and used, so each referenced document is cited in text and its relationship to this document is explained). For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

1. Definitions, acronyms, and abbreviations

For the purposes of this document, the following terms and definitions apply. The *IEEE Standards Dictionary: Glossary of Terms & Definitions* should be consulted for terms not defined in this clause.[[2]](#footnote-2)

1. General description
2. MAC protocol
3. MAC services
4. Security
5. General PHY requirements
6. PHY Services
7. O-QPSK PHY
8. Binary phase-shift keying (BPSK) PHY
9. Amplitude shift keying (ASK) PHY
10. Chirp spread spectrum (CSS) PHY
11. UWB PHY
12. GFSK PHY
13. SUN PHYs
14. LECIM PHYs
    1. DSSS PHY specification
       1. LECIM DSSS PPDU format

For convenience, the PPDU structure is presented so that the leftmost field as written in this standard shall be transmitted or received first. All multiple octet fields shall be transmitted or received least significant octet first, and each octet shall be transmitted or received least significant bit (LSB) first.

The PPDU shall be formatted as illustrated in .



Figure PPDU Format

* + - 1. SHR

The SHR or Synchronization Header is a field which may be used for obtaining frequency, symbol, and frame synchronization. It consists of two sub-fields, the preamble and the start of frame delimiter (SFD). It is possible to recover a fixed length frame without the use of a SFD, or SHR.

* + - * 1. Preamble

The preamble is a sub-field which may be used to obtain symbol timing and frequency offset. A preamble length of 0, 2, 4 octets may be commissioned.

Preamble16 = [1 1 0 0 0 0 0 1 0 1 0 0 1 1 0]

Preamble32 = [ T.B.D. ]

* + - * 1. SFD

The SFD or start frame delimiter is a sub-field which may be used to indicate the beginning of the frame.

SFD = [ T.B.D. ]

* + - 1. PHR

The PHR or PHY Header is a field used to indicate the length of a variable length PHY payload. When the PHY payload is commissioned to a fixed size, the PHR is elided. For variable length PHY payloads of up to 128 octets, the PHR is a one octet and represents a payload of n+1 octets where n = 0..127. For variable length PHY payloads of 129-2048 octets, the PHR is two octets as illustrated in .

* + 1. Modulation and spreading
       1. Data Rate
       2. Reference modulator diagram

The functional block diagram in Figure 2 is provided as a reference for specifying the LECIM DSSS PHY modulation. All binary data contained in the SHR, PHR, and PSDU shall be encoded using the modulation shown in Figure 2.



Figure Reference modulator diagram

* + - 1. Convolutional FEC encoding

Same as 802.15.4-2011 UWB PHY section 14.3.3.2?

* + - 1. Interleaver

TBD

* + - 1. Differential encoding

Same as 802.15.4-2011 BPSK PHY section 11.2.3?

* + - 1. Bit-to-symbol and symbol-to-chip encoding

The bit-to-symbol mapper converts bits into binary symbols through the mapping:

These binary symbols are then spread to chip-rate with spreading factor SF. This process is illustrated explicitly in Figure 3 below where SF = 8. The symbols are first up-sampled SF times and interpolated using a scaled boxcar filter, i.e. the symbol is repeated SF times at chip-rate. Note that this is a mathematical representation of the direct sequence spreading operation. This process can be implemented in an alternative manner that is mathematically equivalent. The up-sampled symbols are multiplied by a specified Gold Code to create the spread signal.



Figure Bit-to-chip diagram



Figure Boxcar filter

* + - * 1. Gold code generator

Gold Code sequences are a large family of easily parameterized PN sequences with good periodic cross-correlation and off-peak auto-correlation properties. A Gold Code sequence is derived from the binary addition (XOR) of two Maximum Length Sequences (m-sequences, or MLS) as illustrated in . The m-sequences are generated using Fibonacci Linear Feedback Shift Registers (LFSR). Each LFSR is constructed from primitive (or prime) polynomials over Galois Field 2 (GF[2]). The resulting sequences thus constitute segments of a set of Gold sequences. The specific m-sequences listed below are the preferred pair as described in the 3rd Generation Partnership Project (3GPP) Technical Specification 25.213. The Gold Sequence can be parameterized by setting the Initialization Vector of LFSR2 to different values (LFSR1 is always initialized to 0x1).

* m = 25 (Length of LSFR)
* n = 2m-1 = 33,554,431 (Length of Gold Code)
* n+2 = 33,554,433 (Total Gold Sequences) = {a, b, a\*b, a\*Tb, a\*T2b, …}

LFSR (MLS) generator polynomials:

* p1(x) = x25 + x3 + 1
* p2(x) = x25 + x3 + x2 + x + 1



Figure 5 Gold code generator

* + - 1. BPSK/O-QPSK modulation
         1. BPSK modulation

Same as 802.15.4-2011 BPSK PHY section 11.2.5?

Pulse shape

Same as 802.15.4-2011 BPSK PHY section 11.2.5.1?

Chip transmission order

Same as 802.15.4-2011 BPSK PHY section 11.2.5.2?

* + - * 1. O-QPSK modulation

The chip sequences representing each data symbol are modulated onto the carrier using O-QPSK with pulse shaping. For even-indexed symbol, the even-indexed chips are modulated onto the in-phase (I) carrier, and odd-indexed chips are modulated onto the quadrature-phase (Q) carrier. For odd-indexed symbol, even-indexed chips are modulated onto the quadrature-phase (Q) carrier, and odd-indexed chips are modulated onto the in-phase (I) carrier. To form the offset between I-phase and Q-phase chip modulation, the Q-phase chips shall be delayed by Tc with respect to the I-phase chips, as illustrated in , where Tc is the inverse of the chip rate.

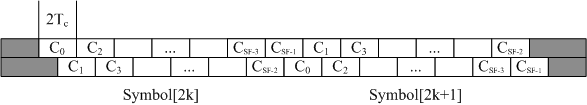


Figure 6 O-QPSK chip modulation

##### 17.1.2.7.2.1 Pulse shape

Same as 802.15.4-2011 BPSK PHY section 10.2.6?

Chip transmission order

Same as 802.15.4-2011 BPSK PHY section 10.2.7?

* 1. FSK PHY specification

# (informative) Bibliography

1. The Institute of Electrical and Electronics Engineers, Inc.

   3 Park Avenue, New York, NY 10016-5997, USA

   Copyright © 20XX by the Institute of Electrical and Electronics Engineers, Inc.

   All rights reserved. Published <XX MONTH 20XX>. Printed in the United States of America.

   IEEE is a registered trademark in the U.S. Patent & Trademark Office, owned by the Institute of Electrical and Electronics   
   Engineers, Incorporated.

   **PDF: ISBN 978-0-XXXX-XXXX-X STDXXXXX**

   **Print: ISBN 978-0-XXXX-XXXX-X STDPDXXXXX**

   *IEEE prohibits discrimination, harassment and bullying. For more information, visit* [*http://www.ieee.org/web/aboutus/whatis/policies/p9-26.html*](http://www.ieee.org/web/aboutus/whatis/policies/p9-26.html)*.*

   *No part of this publication may be reproduced in any form, in an electronic retrieval system or otherwise, without the prior written permission of the publisher.*  [↑](#footnote-ref-1)
2. *The* *IEEE Standards Dictionary: Glossary of Terms & Definitions* is available at <http://shop.ieee.org/>. [↑](#footnote-ref-2)