**IEEE P802.15**

**Wireless Personal Area Networks**

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At this time, there is one approved standard for operation in this band: IEEE 802.15.4-2012 (specifically the 15.4g amendment). However, in the US this is a licensed band under CFR 47 (US FCC) Part 90 rules, and so any usages shall be controlled by the licensee and the frequency coordinator for that band segment. Therefore, it is highly improbable that the licensee shall choose to put to mutually interfering systems on the same channel. 12

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(B2) IEEE Std. 802.15.2 – 2003, IEEE Recommended Practice for Information Technology – Telecommunications and Information exchange between systems – Local and metropolitan area networks – Specific requirements – Part 15.2: Coexistence of Wireless Personal Area Networks with Other Wireless Devices Operating in Unlicensed Frequency Bands.

(B3) IEEE Std. 802.15.3 – 2003, IEEE Standard for Information Technology – Telecommunications and Information exchange between systems – Local and metropolitan area networks – Specific requirements – Part 15.3: Wireless Medium Access Control (MAC) and Physical Layer (PHY) Specifications for High Rate Wireless Personal Area Networks (WPANs).

(B4) IEEE Std. 802.15.4 – 2011, IEEE Standard for Information Technology – Telecommunications and Information exchange between systems – Local and metropolitan area networks – Specific requirements – Part 15.4: Wireless Medium Access Control (MAC) and Physical Layer (PHY) Specifications for Low-Rate Wireless Personal Area Networks (WPANs).

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(B6) IEEE Std. 802.15.4p/D6 – 2012, IEEE Draft Standard for Information Technology –Telecommunications and Information exchange between systems – Local and metropolitan area networks – Specific requirements – Part 15.4: Wireless Medium Access Control (MAC) and Physical Layer (PHY) Specifications for Low-Rate Wireless Personal Area Networks (WPANs) – Amendment x: Physical Layer Specifications for Low Energy, Critical Infrastructure

Monitoring Networks

(B7) IEEE Std. 802.15.4g - 2012, IEEE Standard for Information Technology – Telecommunications and Information exchange between systems – Local and metropolitan area networks – Specific requirements – Part 15.4: Wireless Medium Access Control (MAC) and Physical Layer (PHY) Specifications for Low-Rate Wireless Personal Area Networks (WPANs) – Amendment 3: Physical Layer Specifications for Low Data Rate Wireless Smart Metering

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(B8) IEEE Std. 802.15.4f – 2012, IEEE Standard for Information Technology – Telecommunications and Information exchange between systems – Local and metropolitan area networks – Specific requirements – Part 15.4: Wireless Medium Access Control (MAC) and Physical Layer (PHY) Specifications for Low-Rate Wireless Personal Area Networks (WPANs) – Amendment 2: Active Radio Frequency Identification (RFID) System Physical Layer (PHY)

(B9) IEEE Std. 802.11 – 2011 IEEE Standard for Information Technology – Telecommunications and Information exchange between systems – Local and metropolitan area networks – Specific requirements – Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications.

(B10) IEEE Std. 802.15.4g TG4 Coexistence Assurance Document (IEEE 802.15-10-00668-05-004g)

(B11) IEEE Std. 802.15.4 Coexistence analysis of IEEE Std. 802.15.4 with other IEEE standards and proposed standards (IEEE 802.15.10-0808-00)

(B12) IEEE Std. 802.15.4p TG4p PAR (IEEE 802.15.12-0nnn-nn-0SGp)

# 2 Overview

The overview of 802.15.4p is summarized in Section 5.2 Scope of TG4p PAR (Bnn).

## 2.1 Regulatory Information

The available US and European frequency bands for 802.15.4p are given as below:

(a) 160.170 – 161.580 MHz

(b) 216 - 217 MHz

(c) 217 - 220 MHz

(d) 220 - 222 MHz

(e) 450 – 470 MHz

(f) 769 - 775 MHz

(g) 799 - 805 MHz

(h) 806 – 821 / 851 - 866 MHz

(i) 863 – 870 MHz (Europe)

(j) 896 – 901 / 935 – 940 MHz

(k) 901 – 902 MHz

(l) 902 – 928 MHz

(m) 928 - 952 MHz

(n) 2400 – 2483.5 MHz

(o) 4940 – 4990 MHz

(p) 5250 – 5350 MHz

(q) 5470 – 5725 MHz

(r) 5650 – 5925 MHz

(o) 5725 – 5850 MHz

From the above list, bands (e) and (j) – (n) may be occupied by different 802.15.4p PHYs. These are listed in Table 1, below.

Table 1 Frequency Bands for 802.15.4p PHYs

|  |  |  |  |
| --- | --- | --- | --- |
| Frequency Band (MHz) | IEEE 802.15.4p PHYs | | |
| RCC LMR | RCC DSSS BPSK | RCC Ranging |
| 160.170 – 161.580 | X |  |  |
| 216 – 217 | X |  |  |
| 217 – 220 | X |  |  |
| 220 – 222 | X |  |  |
| 450 – 470 | X |  |  |
| 769 – 775 | X |  |  |
| 799 – 805 | X |  |  |
| 806 – 821 / 851 – 866 | X |  |  |
| 863 – 870 | X |  |  |
| 896 – 901 / 935 – 940 | X |  |  |
| 901 – 902 | X |  |  |
| 902 – 928 | X | X | X |
| 928 – 952 | X |  |  |
| 4940 – 4990 | X | X |  |
| 5250 – 5350 | X | X | X |
| 5470 – 5725 | X | X | X |
| 5650 – 5925 | X | X | X |
| 5725 - 5850 | X | X | X |

## 2.2 Overview of Coexistence Mechanisms in 802.15.4 and 802.15.4p

The importance of a coexistence mechanism in 15.4p is manifold. 15.4p specifies three alternative PHYs that shall be able to coexist with each other if operating co-located in the same frequency band. 15.4p also has to share multiple frequency bands and coexist with dissimilar 802 systems.

The coexistence mechanisms specified in 802.15.4 and subsequent amendments are applicable to both homogeneous (among different 15.4p PHYs) and heterogeneous (across other 802 systems) coexistence.

# 3 Dissimilar Systems Sharing the Same Frequency Bands with 802.15.4p

This clause presents an overview on other 802 systems which are specified to operate in some of the same frequency bands that are also specified for 802.15.4p. The following sub-clauses present collocated dissimilar systems with reference to respective frequency bands which are shared by dissimilar 802.15.4 systems.

The frequency bands of interest are the 160.170 – 161.580 MHz band, 216 - 217 MHz band, 217 – 220 MHz band, 220 – 222 MHz band, 450 - 470 MHz band, 769 – 775 MHz band, 799 – 805 MHz band, 806 – 821 / 851 – 866 MHz band (paired), 863 – 870 MHz band, 896 – 901 / 935 – 940 MHz band (paired), 902 – 902 MHz band, 902 – 928 MHz band, 938 – 952 MHz band, 2400 – 2483.5 MHz band, 4940 – 4990 MHz band, 5250 – 5350 MHz band, 5470 – 5725 MHz band, 5650 – 5925 MHz band, and 5725 – 2825 MHz band.

In this and following clauses, each frequency band is discussed referring to a table listing all the coexisting systems from other standard specifications. The contents of the tables are formatted as below:

1. Standard specification: the name of the 802 system with which 802.15.4p system is coexisting.
2. PHY specification: the PHY design of the above 802 system specification
3. Receiver bandwidth: the receiver bandwidth of the above 802 system specification
4. Transmit power: the transmit power of the above 802 system specification
5. Receiver sensitivity: the receiver sensitivity of the above 802 system specification.
6. Involved 802.15.4p system: the particular PHY in 802.15.4p that is coexisting with the above 802 system specification

Note: The data rate modes, including receiver bandwidth, transmit power and receiver sensitivity listed in the columns of the following tables, are only a part of the complete list from the respective standard specifications. These data rate modes are chosen for the purpose of coexistence analysis in this document.

## 3.1 Coexisting Systems in 160.170 – 161.580 MHz Band

No existing 802 systems share the 160.170 - 161.580 MHz band with 802.15.4p PHYs.

## 3.2 Coexisting Systems in 216 - 217 MHz Band

No existing 802 systems share the 216 – 217 MHz band with 802.15.4p PHYs.

## 3.3 Coexisting Systems in 217 - 220 MHz Band

No existing 802 systems share the 217 – 220 MHz band with 802.15.4p PHYs.

## 3.4 Coexisting Systems in 220 - 222 MHz Band

No existing 802 systems share the 220 – 222 MHz band with 802.15.4p PHYs.

## 3.5 Coexisting Systems in 450 - 470 MHz Band

At this time, there is one approved standard for operation in this band: IEEE 802.15.4-2012 (specifically the 15.4g amendment). However, in the US this is a licensed band under CFR 47 (US FCC) Part 90 rules, and so any usages shall be controlled by the licensee and the frequency coordinator for that band segment. Therefore, it is highly improbable that the licensee shall choose to put to mutually interfering systems on the same channel.

## 3.6 Coexisting Systems in 769 - 775 MHz Band

No existing 802 systems share the 769 – 775 MHz band with 802.15.4p PHYs.

## 3.7 Coexisting Systems in 799 - 805 MHz Band

No existing 802 systems share the 799 – 805 MHz band with 802.15.4p PHYs.

## 3.8 Coexisting Systems in 806 – 821 / 851 – 866 MHz Band

No existing 802 systems share the 806 – 821 / 851 – 866 MHz band with 802.15.4p PHYs.

## 3.9 Coexisting Systems in 863 – 870 MHz Band

Table 2 shows other 802 systems that share the 863 – 870 MHz band with 802.15.4p PHYs.

Table 2 Dissimilar Systems Coexisting with 802.15.4p within 863 - 870 MHz Band

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Standard | Standard PHY | Involved 802.15.4p PHY | | |
| RCC LMR | RCC DSSS BPSK | RCC Ranging |
| 802.15.4 | BPSK | X | X | X |
| ASK | X | X | X |
| O-QPSK | X | X | X |
| MR-FSK | X | X | X |
| MR-OFDM | X | X | X |
| MR-O-QPSK | X | X | X |

## 3.11 Coexisting Systems in 896 – 901 / 935 – 940 MHz Paired Bands

At this time, there is one approved standard for operation in this band: IEEE 802.15.4-2012 (specifically the 15.4g amendment). However, in the US this is a licensed band under CFR 47 (US FCC) Part 90 rules, and so any usages shall be controlled by the licensee. Therefore, it is highly improbable that the licensee shall choose to put to mutually interfering systems on the same channel.

## 3.12 Coexisting Systems in 901 – 902 MHz Band

At this time, there is one approved standard for operation in this band: IEEE 802.15.4-2012 (specifically the 15.4g amendment). However, in the US this is a licensed band under CFR 47 (US FCC) Part 24 rules, and so any usages shall be controlled by the licensee. Therefore, it is highly improbable that the licensee shall choose to put to mutually interfering systems on the same channel.

## 3.13 Coexisting Systems in 902 – 928 MHz Band

Table 2 shows other 802 systems that share the 902 – 928 MHz band with 802.15.4p PHYs.

Table 3 Dissimilar Systems Coexisting with 802.15.4p in the 902 – 928 MHz Band

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Standard | Standard PHY | Involved 802.15.4p PHY | | |
| RCC LMR | RCC DSSS BPSK | RCC Ranging |
| 802.15.4 | BPSK | X | X | X |
| ASK | X | X | X |
| O-QPSK | X | X | X |
| MR-FSK | X | X | X |
| MR-OFDM | X | X | X |
| MR-O-QPSK | X | X | X |

## 3.14 Coexisting Systems in 928 – 952 MHz Band

Table 3 shows other 802 systems that share the 928 - 952 MHz band with 802.15.4p PHYs.

Table 4 Dissimilar Systems coexisting with 802.15.4p within 928 - 952 MHz band

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Standard | Standard PHY | Involved 802.15.4p PHY | | |
| RCC LMR | RCC DSSS BPSK | RCC Ranging |
| 802.15.4 | BPSK | X | X | X |
| ASK | X | X | X |
| O-QPSK | X | X | X |
| MR-FSK | X | X | X |
| MR-OFDM | X | X | X |
| MR-O-QPSK | X | X | X |

## 3.15 Coexisting Systems in 2400 – 2483.5 MHz Band

Table 2 shows other 802 systems that share the 2400 – 2483.5 MHz band with 802.15.4p PHYs.

Table 5 Dissimilar Systems coexisting with 802.15.4p within 2400 - 2483.5 MHz Band

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Standard | Standard PHY | Involved 802.15.4p PHY | | |
| RCC LMR | RCC DSSS BPSK | RCC Ranging |
| 802.15.1 | FHSS GFSK | X | X | X |
| 802.15.3 | SC D-QPSK | X | X | X |
| 802.15.4 | O-QPSK | X | X | X |
| 802.15.4 | CSSS | X | X | X |
| 802.11b | DSSS | X | X | X |
| 802.11g | DSSS | X | X | X |
| 802.11g | OFDM | X | X | X |
| 802.11n | OFDM | X | X | X |

## 3.16 Coexisting Systems in 4940 - 4990 MHz Band

At this time, there is one approved standard for operation in this band: IEEE 802.15.11-2011. However, this band is separated into 1 MHz wide channels that are not comingled with the aggregable 5 MHz channels. The 802.15.4p usage is restricted to the 1 MHz wide channels that are at both band edges. Thus, there is no potential for co-channel interference.

## 3.17 Coexisting Systems in 5250 - 5350 MHz Band

In the 5250 - 5350 MHz band, IEEE 802.11-2011 is the only other 802 system sharing this band with the proposed 802.15.4p PHYs. In the US under 47 CFR 15 UNII band rules, all subject users are required to meet the same TX power output rules. The primary difference between 802.11 and 802.15.4p systems in this band is occupied bandwidth. As the proposed 802.15.4p systems have a significantly narrower bandwidth than most of the 802.11 systems used in this band, the primary impact with co-channel use will be interference to the 802.11 system.

Table 6 Dissimilar Systems coexisting with 802.15.4p within 5250 - 5350 MHz band

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Standard | Standard PHY | Involved 802.15.4p PHY | | |
| RCC LMR | RCC DSSS BPSK | RCC Ranging |
| 802.11a | OFDM | X | X | X |
| 802.11n | OFDM | X | X | X |

## 3.18 Coexisting Systems in 5470 - 5725 MHz Band

Table 7 shows other 802 systems that share 5470 - 5725 MHz band with 802.15.4p PHYs

Table 7 Dissimilar Systems coexisting with 802.15.4p within 5470 - 5725 MHz band

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Standard | Standard PHY | Involved 802.15.4p PHY | | |
| RCC LMR | RCC DSSS BPSK | RCC Ranging |
| 802.11a | OFDM | X | X | X |
| 802.11n | OFDM | X | X | X |

## 3.19 Coexisting Systems in 5650 - 5925 MHz Band

Table 8 shows other 802 systems that share the 5650 - 5925 MHz band with 802.15.4p PHYs

Table 8 Dissimilar Systems coexisting with 802.15.4p within 5650 - 5925 MHz band

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Standard | Standard PHY | Involved 802.15.4p PHY | | |
| RCC LMR | RCC DSSS BPSK | RCC Ranging |
| 802.11a | OFDM | X | X | X |
| 802.11n | OFDM | X | X | X |

## 3.20 Coexisting Systems in 5725 - 5850 MHz Band

Table 9 shows other 802 systems that share the 5725 - 5850 MHz band with 802.15.4p PHYs

Table 9 Dissimilar Systems coexisting with 802.15.4p within 5725 - 5850 MHz band

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Standard | Standard PHY | Involved 802.15.4p PHY | | |
| RCC LMR | RCC DSSS BPSK | RCC Ranging |
| 802.11a | OFDM | X | X | X |
| 802.11n | OFDM | X | X | X |

# 4 Coexistence Scenario and Analysis

## 4.1 PHY Modes in the 802.15.4p System

### 4.1.1 Parameters of the 802.15.4p PHY Modes

The PHY modes selected from both the FSK and DSSS DPSK PHYs, along with their corresponding parameters are tabulated in Table 9.

Table 9: Major Parameters of 802.15.4p PHY Modes9

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Parameters and values | 802.15.4p LMR PHY | 802.15.4p LMR PHY | 802.15.4p LMR PHY | 802.15.4p LMR PHY | 802.15.4p LMR PHY |
| Operation mode | MSK | C4FM | QPSK | Pi/4 DQPSK | DSSS DQPSK |
| Data Rate (Kbps) | 9.6 / 19.2 | 9.6 / 19.2 / 38.4 | 16 / 32 | 16 / 32 / 36 | various |
| Chip Rate (Mcps) | n.a. | n.a. | n.a. | n.a. | 1 |
| Spreading factor | n.a. | n.a. | n.a. | n.a. | 11 |
| FEC | disabled | disabled | disabled | disabled | disabled |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |

### 4.1.2 BER / FER Calculations for 802.15.4p PHY Modes

As defined in TG4g Coexistence Assurance Document section 4.1.2 (B10), the BER and FER are modeled in MatLab with uncoded AWGN channel without interference for 802.15.4p PHY modes. The receiver bandwidth is assumed to be equal to the equivalent noise bandwidth of the PHY mode. The BER and FER plots of the 802.15.4p PHY modes are illustrated in Figure 1 and Figure 2. The BER and FER plots are simulated with matched filter receiver and coherent demodulator for all modulation modes except that frequency discriminator is used for C4FM. The FEC is disabled for the simulations. The frame length is set to 125 octects.

Figure 1: BER vs. SNR for 802.15.4p MSK, C4FM, QPSK, pi/4 DQPSK and DSSS DQPSK

Figure 2: FER vs. SNR for 802.15.4p MSK, C4FM, QPSK, pi/4 DQPSK and DSSS DQPSK

## 4.2 Interference Modeling

802.15.4g’s interference model, described in section 4.2 of TG4g Coexistence Assurance Document (B10), is adopted for 802.15.4p’s coexistence simulation modeling.

* In the coexistence model, the transmitting power and distance between the victim’s transmitter and receiver are fixed, thus the received signal strength is fixed. The interference at the victim’s receiver is injected accordingly vs. the distance from the interferer’s transmitter to the victim’s receiver.
* Hata channel model (large scale urban) is used for the interference calculation. No AWGN noise is included in the channel to limit the factors affecting the system’s performance to interference only. Therefore the coexistence performance analysis herein is mainly focused on the interference caused by the interferer’s transmitter.
* There is no frequency offset between the interferer’s center frequency and the victim’s center frequency in the spectrum. This assumes the worst case.
* Antenna gain is assumed 0dBi.

## 4.7 863 – 870 MHz Band Coexistence Performance

This sub-clause presents the coexistence performance of the systems coexisting in the 863 - 870 MHz frequency band. In order to understand the impact of the generated interference, 802.15.4p systems and other coexisting 802 systems in this frequency band are set as both the victim and interferer source.

### 4.7.1 Parameters for Coexistence Quantification

The following sub-clauses present the parameters involved in quantification of coexistence analysis amongst the participating systems.

#### 4.7.1.1 PHY Mode Parameters of Coexisting Standards

Table 14 shows the PHY mode parameters of coexisting standards within the frequency band

Table 14: Major Parameters of Coexisting 802 Systems in the 863 - 870 MHz Band

|  |  |  |  |
| --- | --- | --- | --- |
| Parameters and values | 802.15.4 PHY | 802.15.4 PHY | 802.15.4p LMR PHY |
| Operation mode | MR-FSK | BPSK | DSSS DQPSK |
| Data Rate (Kbps) | 200 | 40 | 181 |
| Chip Rate (Mcps) | n.a. | 0.6 | 1 |
| Spreading factor | n.a. | 15 | 11 |
| FEC | disabled | disabled | disabled |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |

#### 4.7.1.2 BER / FER for PHY Modes of Coexisting 802 Standards

In this sub-clause, the BER / FER performance corresponding to SNR for all the 802 standards within the frequency band are presented. The BER and FER curves are illustrated Figure 24.

<to be added by Meng>

Figure 24: BER and FER vs. SNR for 802.15.4 & 4g Systems (863 - 870MHz band)

### 4.7.2 Coexistence Simulation Results

#### 4.7.2.1 802.15.4p PHY Mode as Victim Receiver

Figure 25 and Figure 26 show the BER/FER performances of the 802.15.4p PHY mode victim receiver corresponding to the distance from the interferer to the 802.15.4p victim receiver.

<to be added by Meng>

Figure 25: Victim (802.15.4p DSSS DPSK) BER/FER vs. Distance from Interferer Tx(802.15.4 MR-FSK) to Victim Rx

<to be added by Meng>

Figure 26: Victim (802.15.4p DSSS DPSK) BER/FER vs. Distance from Interferer Tx (802.15.4 BPSK) to Victim Rx

#### 4.7.2.2 802.15.4/4g PHY Modes as Victim Receiver

Figure 28 and Figure 29 show the BER/FER performances of the 802.15.4 victim receivers corresponding to the distance from the 802.15.4p interferer to the TX 802.15.4/4g victim receivers.

<to be added by Meng>

Figure 28: Victim (802.15.4 MR-FSK) BER/FER vs. Distance from Interferer Tx (802.15.4p DSSS DPSK) to Victim Rx

<to be added by Meng>

Figure 29: Victim(802.15.4 BPSK) BER/FER vs. Distance from Interferer Tx (802.15.4p DSSS DPSK) to 802.15.4 Victim Rx

## 4.8 902 – 928 MHz Bands Coexistence Performance

This sub-clause presents the coexistence performance of the systems coexisting in the 902 - 928 MHz frequency bands. In order to understand the impact of the generated interference, 802.15.4p systems and other coexisting 802 systems in this frequency band are set as both the victim and interferer source.

### 4.8.1 Parameters for Coexistence Quantification

The following sub-clauses present the parameters involved in quantification of coexistence analysis amongst the participating systems.

#### 4.8.1.1 PHY Mode Parameters of Coexisting Standards

Table 15 shows the PHY mode parameters of coexisting standards within the frequency band

Table 15: Major Parameters of Coexisting 802 Systems in the 902 - 928 MHz Band

|  |  |  |  |
| --- | --- | --- | --- |
| Parameters and values | 802.15.4 PHY | 802.15.4 PHY | 802.15.4p LMR PHY |
| Operation mode | MR-FSK | BPSK | DSSS DQPSK |
| Data Rate (Kbps) | 200 | 40 | 181 |
| Chip Rate (Mcps) | n.a. | 0.6 | 1 |
| Spreading factor | n.a. | 15 | 11 |
| FEC | disabled | disabled | disabled |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |

#### 4.8.1.2 BER / FER for PHY Modes of Coexisting 802 Standards

In this sub-clause, the BER / FER performances corresponding to SNR for all the 802 standards within the frequency band are presented. The BER and FER curves are illustrated Figure 30.

<To be added by Meng>

Figure 30: BER and FER vs. SINR for 802.15.4 & 4g Systems (902 - 928 MHz band)

### 4.8.2 Coexistence Simulation Results

#### 4.8.2.1 802.15.4p PHY Mode as Victim Receiver

Figure 31 and Figure 32 show the BER/FER performances of the 802.15.4p PHY mode victim receivers corresponding to the distance from the interferer to 802.15.4p victim receivers.



Figure 31: Victim (802.15.4p DSSS DPSK) BER/FER vs. Distance from Interferer Tx (802.15.4 MR-FSK) to Victim Rx



Figure 32: Victim (802.15.4p DSSS DPSK) BER/FER vs. Distance from Interferer Tx (802.15.4 BPSK) to Victim Rx

#### 4.8.2.2 802.15.4PHY Modes as Victim Receiver

Figure 34 and Figure 35 show the BER/FER performances of the 802.15.4victim receivers corresponding to the distance from the 802.15.4p interferer TX to the 802.15.4/4g victim receiver.



Figure 34: Victim (802.15.4 MR-FSK) BER/FER vs. Distance from Interferer Tx (802.15.4p DSSS DPSK) to Victim Rx



Figure 35: Victim BER/FER vs. Distance from Interferer Tx to 802.15.4 & 4g Victim Rx

## 4.9 2400 – 2483.5 MHz Band Coexistence Performance

This sub-clause presents the coexistence performance of the systems coexisting in the 2400 – 2483.5 MHz frequency band. In order to understand the impact of the generated interference, 802.15.4p systems and other coexisting 802 systems in this frequency band MHz band are set as both the victim and interferer source.

### 4.9.1 Parameters for Coexistence Quantification

The following sub-clauses present the parameters involved in quantification of coexistence analysis amongst the participating systems.

#### 4.9.1.1 PHY Mode Parameters of Coexisting Standards

Table 17 shows the PHY mode parameters of coexisting standards within the frequency band

Table 17: Major Parameters of Coexisting 802 Systems in the 2400 – 2483.5 MHz band

|  |  |  |
| --- | --- | --- |
| Parameters and values | 802.11g PHY | 802.15.4p LMR PHY |
| Operation mode | OFDM | DSSS DQPSK |
| Data Rate (Kbps) | 6000 | 181 |
| Chip Rate (Mcps) | n.a. | 1 |
| Spreading factor | n.a. | 11 |
| FEC | Rate ½ convolutional code | disabled |
|  |  |  |
|  |  |  |
|  |  |  |

#### 4.9.1.2 BER / FER for PHY Modes of Coexisting 802 Standards

In this sub-clause, the BER / FER performance corresponding to SNR for the all the 802 standards within the frequency band are presented. The BER and FER curves are illustrated in Figure 36 and Figure 37.

<To be added by Meng>

Figure 36: BER and FER for 802.11 & 802.15 Systems (2400 – 2483.5MHz band)

### 4.9.2 Coexistence Simulation Results

#### 4.9.2.1 802.15.4p PHY Mode as Victim Receiver

Figure 38 shows the BER/FER performances of the 802.15.4p PHY mode victim receivers corresponding to the distance from the 802.11 interferers to the 802.15.4p victim receiver.

<To be added by Meng>

Figure 38: Victim BER vs. Distance from Interferer Tx to 802.15.4p DSSS Victim Rx

### 4.9.2.2 802.11 PHY Modes as Victim Receiver

Figure 42, Figure 43, and Figure 44 show the BER/FER performances of the 802.11 victim receivers corresponding to the distance from the 802.15.4p interferer to the 802.11 victim receiver at different interferer’s transmitting power levels.

<To be added by Meng>

Figure 40: Victim BER/FER vs. Distance from Interferer Tx to 802.11 Victim Rx

# 5 Interference Avoidance and Mitigation Techniques

802.15.4p adopts the interference avoidance and mitigation techniques outlined in 802.15.4g coexistence document (B10).

# 6 Conclusions

As a victim, 802.15.4p FSK has comparable BER performance with the other 802 FSK systems; 802.15.4p DSSS has much better BER performance than the other 802 DSSS systems due to the high spreading factor values.

As an interferer, either 802.15.4p FSK or 802.15.4p DSSS has similar performance impact to the other 802 systems at the same transmitting power level. However the performance degradation to the other systems can become significant as the transmitting power is increased up to the possible maximum 30dBm. This requires more physical distance from other 802 systems if an 802.15.4p system is designed to operate at a high transmitting power level.