Technical Note

WipLL 2.4 GHz

Wireless IP-Based Local Loop System

Hopping Algorithms and Compliance with FCC 15.247 (a)

Connecting the World with Wireless Access Solutions

Revision Record: Hopping Compliance		
Pub/ Rev	**Date**	**Update Description**
01	Jul-03	Airspan. Author: InterDoc
02	Jul-03	Airspan. Author: InterDoc. Updating of frequency tables; average time of occupancy for Hopping and Hybrid modes.
03	Oct-03	Airspan. Author: InterDoc. Adding of pseudo-random frequencies; 1.33 Mbps.
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Contents

1. Introduction

This document provides a description of the Frequency Hopping and Hybrid systems for WipLL 2.4GHz products.

2. Hopping and Hybrid System Algorithms

- The hopping algorithm is defined by a table of ***n*** frequencies, where ***n*** is greater or equal to 75 when the system is configured for 1 Mbps, 2 Mbps and 3 Mbps, and where ***n*** is greater or equal to 39 when the system is configured for 1.33 Mbps and 4 Mbps. The hopping sequence follows cyclically the frequencies in the table, remaining in each frequency for a constant period. The frequencies in the table are all in the 2.403 to 2.481 range, with at least 1 MHz between any two frequencies in the table for systems configured for 1 Mbps, 2 Mbps, and 3 Mbps; and at least 2 MHz for systems configured for 1.33 Mbps and 4 Mbps. The order of frequencies in the table is pseudorandom.
- In Section 7, “Receiver Synchronization”, two modes (1 MHz-channel spacing and 2 MHz-channel spacing) are described in Table 1.

3. Hopping Time

The hopping time in a given is constant (typically WipLL uses 50 msec).

4. Number of Channels

The number of channels is determined by the table size ***n*** frequencies, depending on transmission speed configured for the WipLL system:

- For 1 Mbps, 2 Mbps, and 3 Mbps, ***n*** is equal to 25.
- For 1.33 Mbps and 4 Mbps, ***n*** is equal to 13.

5. Resolution

The minimum difference between any two channels is:

- 1 MHz for 1 Mbps, 2 Mbps, and 3 Mbps
- 2 MHz for 1.33 Mbps and 4 Mbps

6. Channel Distribution

Since any used channel is included once in the table, all the channels are equally used, each channel occupying ***1/n*** of the time.

7. Receiver Synchronization

The system receiver input bandwidth filter matches the hopping channel bandwidth and synchronizes with the corresponding transmitter on the hopping sequence.

Table 1: Frequency Hopping System (1, 2 and 3 Mbps) and Hybrid System (4 Mbps)

15.247 Spec.	Requirement	WipLL Capability	Comply
Spread Spectrum	FHSS or DSSS	FHSS	Yes
• Minimum channel separation at 1, 2, and 3 Mbps	• -20 dB bandwidth (1 MHz)	• -20 dB bandwidth (1 MHz	• Yes
• Minimum channel separation at 4 Mbps	• -20 dB bandwidth	• 2 MHz	• Yes
List of Freq.	Pseudo-random ordered list	Pseudo-random ordered list	Yes
Use of Freq.	Equal use of frequencies: 2.403 to 2.481	Constant hop period (50 msec) each frequency used once in a table	Yes
• Number of Frequencies at 1, 2, and 3 Mbps	• Min. 75	• 79	• Yes
• Number of frequencies at 1.33 Mbps and 4 Mbps	• ≥ 15 non-overlapping channels with total span ≥ 78 MHz	• 39	• Yes
• Occupied BW per hop at 1, 2, and 3 Mbps	• < 1 MHz at –20 dB	• < 1 MHz at –20 dB	• Yes
• Occupied BW per hop at 1.33 Mbps and 4 Mbps	• > 1 MHz	• 1 MHz < BW < 2 MHz at –20 dB	• Yes
Average time of occupancy	• Hopping mode: < 0.4 sec within 30 sec period average	• Hopping mode: 362 msec	• Yes
	• Hybrid mode: < 0.4 sec within *N**0.4 sec period average, where *N* is the number of channels	• Hybrid mode: 380 msec	• Yes

8. Frequency Hopping and Hybrid Modes

The tables below provide sequential and pseudo-random hopping frequencies for the Frequency Hopping mode and Hybrid mode.

8.1. Frequency Hopping Mode

Table 2: Frequency Hopping Mode with Pseudo-Random Hopping

Frequency Assignment	Frequency (MHz)	Frequency Assignment	Frequency (MHz)	Frequency Assignment	Frequency (MHz)
F1	2403	F35	2449	F69	2416
F2	2409	F36	2455	F70	2422
F3	2415	F37	2461	F71	2428
F4	2421	F38	2467	F72	2434
F5	2427	F39	2473	F73	2440
F6	2433	F40	2479	F74	2446
F7	2439	F41	2406	F75	2452
F8	2445	F42	2412	F76	2458
F9	2451	F43	2418	F77	2464
F10	2457	F44	2424	F78	2470
F11	2463	F45	2430	F79	2476
F12	2469	F46	2436		
F13	2475	F47	2442		
F14	2481	F48	2448		
F15	2408	F49	2454		
F16	2414	F50	2460		
F17	2420	F51	2466		
F18	2426	F52	2472		
F19	2432	F53	2478		
F20	2438	F54	2405		
F21	2444	F55	2411		
F22	2450	F56	2417		
F23	2456	F57	2423		
F24	2462	F58	2429		
F25	2468	F59	2435		
F26	2474	F60	2441		
F27	2480	F61	2447		
F28	2407	F62	2453		
F29	2413	F63	2459		
F30	2419	F64	2465		
F31	2425	F65	2471		
F32	2431	F66	2477		
F33	2437	F67	2404		
F34	2443	F68	2410		

8.2. Hybrid Mode

Table 3: Hybrid Mode with Pseudo-Random Hopping

Frequency Assignment	Frequency (MHz)	Frequency Assignment	Frequency (MHz)
F1	2475	F32	2455
F2	2423	F33	2437
F3	2407	F34	2451
F4	2471	F35	2469
F5	2445	F36	2421
F6	2411	F37	2463
F7	2443	F38	2415
F8	2457		
F9	2435		
F10	2419		
F11	2473		
F12	2405		
F13	2425		
F14	2447		
F15	2467		
F16	2403		
F17	2439		
F18	2461		
F19	2441		
F20	2417		
F21	2449		
F22	2427		
F23	2465		
F24	2431		
F25	2459		
F26	2429		
F27	2409		
F28	2477		
F29	2453		
F30	2433		
F31	2413		

9. Receiver and Transmitter Compliance

9.1. Receiver Compliance with 15.247 (a) (1) / 2.1033 (a) (10)

The system receiver has an input bandwidth that matches the hopping bandwidth of the corresponding transmitters. The receiver shifts its frequency in accordance with the same frequency hopping table and pattern as the transmitters.

9.2. Transmitter Compliance with 15.247 (g), 15.247 (h)

- **15.247 (g):**

  The equipment fully complies with the requirements of this section. In our case, each transmission employs all available hopping channels, performed according to the requirements of 15.247.

- **15.247 (h):**

  The equipment fully complies with the requirements of this section. There is no coordination between the systems to avoid simultaneous occupancy of the hopping frequencies by multiple transmitters. Each transmitter operates independently and there is no synchronization with other transmitters.