Project: IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs)

Submission Title: [PHY proposal for FANE]
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Abstract: [PHY proposal for supporting up to 2.4Mb/s data rates and long range in 15.4]

Purpose: [To be considered in the PHY amendment as part of 802.15.4x]

Background

- **Scope of the project:**

"This amendment defines enhancements to the IEEE Std 802.15.4 SUN Orthogonal Frequency-Division Multiplexing (OFDM) PHYs enabling the support for data rates up to 2.4Mb/s. This amendment also defines additional channel plans, as needed, to support emerging applications."

Purpose and Objective

- Higher data rate
  - OFDM 800 kbps, 1.2 Mbps, 2.4 Mbps
  - Compliment to lower rate (bandwidth) OFDM, OQPSK and FSK
  - Builds on what is working now
- Longer range modes support
  - SUN-OQPSK rate modes 0-3 at 100 k/chips per second
  - Channel plan is not defined for most market regions including North America
- Specify operational PHY parameters for existing 15.4 regions

Updates to SUN OFDM PHY

- 21.3 Data rates for SUN OFDM

Table 21-9—Data Rates for SUN OFDM PHY

Parameter	OFDM Option 1	OFDM Option 2	OFDM Option 3	OFDM Option 4
Nominal bandwidth (kHz)	1094	552	281	156
Channel spacing (kHz)	1200	800	400	200
DFT size	128	64	32	16
Active tones	104	52	26	14
# Pilot tones	8	4	2	2
# Data tones	96	48	24	12
MCS0 (kb/s) (BPSK rate 1/2 with 4x frequency repetition)	100	50	—	—
MCS1 (kb/s) (BPSK rate 1/2 with 2x frequency repetition)	200	100	50	—
MCS2 (kb/s) (QPSK rate 1/2 and 2x frequency repetition)	400	200	100	50
MCS3 (kb/s) (QPSK rate 1/2)	800	400	200	100
MCS4 (kb/s) (QPSK rate 3/4)	—	600	300	150
MCS5 (kb/s) (16-QAM rate 1/2)	—	800	400	200
MCS6 (kb/s) (16-QAM rate 3/4)	—	—	600	300

Table 21.9 - Data Rate for SUN OFDM PHY

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Nominal bandwidth (kHz)	1094	552	281	156
Channel spacing (kHz)	1200	880	400	200
DFT size	128	64	32	16
Active tones	104	52	26	14
# Pilot tones	8	4	2	2
# Data tones	96	48	24	12
MCS0 (kb/s) (BPSK rate 1/2 with 4x frequency repetition)	100	50	-	-
MCS1 (kb/s) (BPSK rate 1/2 with 2x frequency repetition)	200	100	50	-
MCS2 (kb/s) (QPSK rate 1/2 with 2x frequency repetition)	400	200	100	50
MCS3 (kb/s) (QPSK rate 1/2)	800	400	200	100
MCS4 (kb/s) (QPSK rate 3/4)	1200	600	300	150
MCS5 (kb/s) (16-QAM rate 1/2)	1600	800	400	200
MCS6 (kb/s) (16-QAM rate 3/4)	2400	1200	600	300

PHY symbol per octet

Table 21-11—*phySymbolsPerOctet* values for SUN OFDM PHY

	OFDM Option			
MCS level	**1**	**2**	**3**	**4**
MCS0 (BPSK 1/2 rate coded and 4x frequency repetition)	2/3	4/3	—	—
MCS1 (BPSK 1/2 rate coded and 2x frequency repetition)	1/3	2/3	4/3	—
MCS2 (QPSK 1/2 rate coded and 2x frequency repetition)	1/6	1/3	2/3	4/3
MCS3 (QPSK 1/2 rate coded)	1/12	1/6	1/3	2/3
MCS4 (QPSK 3/4 rate coded)	—	1/9	2/9	4/9
MCS5 (16-QAM 1/2 rate coded)	—	1/12	1/6	1/3
MCS6 (16-QAM 3/4 rate coded)	—	—	1/9	2/9

PHY symbol per octet

- Update Table 21-11 as shown below

	OFDM Option			
MCS level	1	2	3	4
MCS0 (BPSK 1/2 rate coded and 4x frequency repetition)	2/3	4/3	—	—
MCS1 (BPSK 1/2 rate coded and 2x frequency repetition)	1/3	2/3	4/3	—
MCS2 (QPSK 1/2 rate coded and 2x frequency repetition)	1/6	1/3	2/3	4/3
MCS3 (QPSK 1/2 rate coded)	1/12	1/6	1/3	2/3
MCS4 (QPSK 3/4 rate coded)	1/18	1/9	2/9	4/9
MCS5 (16-QAM 1/2 rate coded)	1/24	1/12	1/6	1/3
MCS6 (16-QAM 3/4 rate coded)	1/36	1/18	1/9	2/9

PHY Interleaver

- 21.4.5 Interleaver

Table 21-12—N_{cbps} for SUN OFDM with *phyOfdmInterleaving* = 0

MCS level	OFDM Option 1	OFDM Option 2	OFDM Option 3	OFDM Option 4
MCS0	24	12	—	—
MCS1	48	24	12	—
MCS2	96	48	24	12
MCS3	192	96	48	24
MCS4	—	96	48	24
MCS5	—	192	96	48
MCS6	—	—	96	48

PHY Interleaver

- 21.4.5 Interleaver
  - Update Table 21-12 as shown below

MCS level	OFDM Option 1	OFDM Option 2	OFDM Option 3	OFDM Option 4
MCS0	24	12	—	—
MCS1	48	24	12	—
MCS2	96	48	24	12
MCS3	192	96	48	24
MCS4	192	96	48	24
MCS5	384	192	96	48
MCS6	384	192	96	48

Receiver sensitivity

- 21.5.3 Receiver sensitivity

Table 21-20—Sensitivity requirements for OFDM options and MCS levels

	Option 1	Option 2	Option 3	Option 4
MCS0 (BPSK ½ rate coded and 4x frequency repetition)	–103 dBm	–105 dBm	—	—
MCS1 (BPSK ½ rate coded and 2x frequency repetition)	–100 dBm	–103 dBm	–105 dBm	—
MCS2 (QPSK ½ rate coded and 2x frequency repetition)	–97 dBm	–100 dBm	–103 dBm	–105 dBm
MCS3 (QPSK ½ rate coded)	–94 dBm	–97 dBm	–100 dBm	–103 dBm
MCS4 (QPSK ¾ rate coded)	—	–94 dBm	–97 dBm	–100 dBm
MCS5 (16-QAM ½ rate coded)	—	–91 dBm	–94 dBm	–97 dBm
MCS6 (16-QAM ¾ rate coded)	—	—	–91 dBm	–94 dBm

Receiver sensitivity

- 21.5.3 Receiver sensitivity
  - Update Table 21-20 as shown below

	Option 1	Option 2	Option 3	Option 4
MCS0 (BPSK ½ rate coded and 4x frequency repetition)	–103 dBm	–105 dBm	—	—
MCS1 (BPSK ½ rate coded and 2x frequency repetition)	–100 dBm	–103 dBm	–105 dBm	—
MCS2 (QPSK ½ rate coded and 2x frequency repetition)	–97 dBm	–100 dBm	–103 dBm	–105 dBm
MCS3 (QPSK ½ rate coded)	–94 dBm	–97 dBm	–100 dBm	–103 dBm
MCS4 (QPSK ¾ rate coded)	–91 dBm	–94 dBm	–97 dBm	–100 dBm
MCS5 (16-QAM ½ rate coded)	–88 dBm	–91 dBm	–94 dBm	–97 dBm
MCS6 (16-QAM ¾ rate coded)	–85 dBm	–88 dBm	–91 dBm	–94 dBm

Updates to SUN O-QPSK PHY

- 22.3.2 SHR coding and spreading

Frequency band (MHz)	Chip rate (kchip/s)	BDE	Spreading
902–928	1000	yes	(64,1)-DSSS
	100	yes	(32,1)0-DSSS

- 22.3.3 PHR coding and spreading

Frequency band (MHz)	Chip rate (kchip/s)	BDE	rate ½ FEC + interleaver	Spreading
902–928	1000	yes	yes	(16,1)0/1-DSSS
	100	yes	yes	(8,1)0/1-DSSS

Updates to SUN O-QPSK PHY

- 22.3.4 PSDU coding and spreading for DSSS
  - Addition of SUN-OQPSK rate modes 0-3 at 100 k/chips per second

Frequency band (MHz)	Chip rate (kchip/s)	RateMode	BDE	Spreading	rate ½ FEC + interleaver	Data rate (kb/s)
902–928	1000	0	yes	(16,1)0/1-DSSS	yes	31.25
		1	no	(16,4)-DSSS	yes	125
		2	no	(8,4)-DSSS	yes	250
		3	no	none	yes	500
	100	0	yes	(8,1)0/1-DSSS	yes	6.25
		1	yes	(4,1)-DSSS	yes	12.5
		2	yes	(2,1)-DSSS	yes	25
		3	no	none	yes	50

Updates to SUN O-QPSK PHY

- 22.3.11 Chip whitening

Frequency band (MHz)	RateMode
902–928*	2 and 3
	1 and 2 and 3

* Rate modes are respective to chip rate as defined in sub cluase 22.3.4

Updates to SUN O-QPSK PHY

- 22.3.12 Pilot insertion

Frequency band (MHz)	Length Np (# of chips)	Spacing Mp (# of chips)	Chip sequence $_P$p = (p0, p1, ¼, pN – 1)
902–928	64	1024	1011 0010 0010 0101 1011 0001 1101 0000 1101 0111 0011 1101 1111 0000 0010 1010
	32	512	1101 1110 1010 0010 0111 0000 0110 0101

- 22.5.3 Receiver sensitivity

Frequency band (MHz)	RateMode			
	0	1	2	3
902–928	–105	–100	–95	–90
	–110	–105	–100	–95