

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

Submission Title: [PHY proposal for the Sub 1-GHz frequency bands]

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Abstract: [PHY proposal to support Sub 1-GHz band]

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

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Background

- **Scope of the project:**

“This amendment defines changes to the IEEE Std 802.15.4-2015 PHY clauses enabling the use of the 870-876 MHz & 915-921 MHz bands in Europe, the 902-928 MHz band in Mexico, the 902-907.5 MHz & 915-928 MHz bands in Brazil, the 915-928 MHz band in Australia/ New Zealand and Asian regional frequency bands that are not in IEEE Std 802.15.4-2015. This amendment also changes the channel parameters for the 470-510 MHz band in China and the 863-870 MHz band in Europe for SUN PHYs, and aligns these channel parameters with regional requirements. The amendment includes channel access and/or timing changes to the MAC necessary for conformance to regional requirements for these bands.”

Purpose and Objective

- No Sub-GHz band suitable on a global basis
- Different Sub-GHz frequency bands used in different countries have different rules
- New spectrum is available and have been opened up after 802.15.4g amendment for Smart Utility Networks and Smart Cities

Overview of Frequency Bands

ISM and Sub-GHz frequency bands identified

Country	MHz		Country	MHz	
China	920.5	924.5	Philippines	915	918
Europe	870	875.6	Malaysia	919	923
Mexico	902	928	Hong Kong	920	925
Brazil	902 915	907.5 928	Singapore	920	925
Europe	915	921	Thailand	920	925
Australia/ New Zealand	915	928	Vietnam	920	925

Regional Spectrum Rules

- China
 - Channels requires ≤ 250 kHz widths
- Europe
 - Channels require ≤ 200 kHz widths
- Other Asian Frequency Bands
 - Limited spectrum available (4 to 5 MHz)

Modulation and Channel Parameters (SUN FSK)

Frequency band (MHz)	Parameter	Operating Mode #1	Operating Mode #2	Operating Mode #3	Operating Mode #4
920.5-924.5 (China)	Data Rate (kbps)	50	100	150	200
	Modulation	2-FSK	2-FSK	2-FSK	4-FSK
	Modulation Index	1.0	0.5	0.5	0.33
	Channel spacing (kHz)	200	200	200	200
870 – 875.6 and 915 - 921 (Europe)	Data Rate (kbps)	50	100	150	200
	Modulation	2-FSK	2-FSK	2-FSK	4-FSK
	Modulation Index	0.5	0.5	0.5	0.33
	Channel spacing (kHz)	100	200	200	200

Modulation and Channel Parameters (SUN FSK)

Frequency band (MHz)	Parameter	Operating Mode #1	Operating Mode #2	Operating Mode #3	Operating Mode #4	Operating Mode #5
902 – 928 (Mexico) 902-907.5 & 915-928 (Brazil) 915-928 (Australia/ New Zealand) 915-918 (Philippines) 919-923 (Malaysia) 920-925 (Hong Kong) 920-925 (Singapore) 920-925 (Thailand) 920-925 (Vietnam)	Data Rate (kbps)	50	100	150	200	300
	Modulation	2-FSK	2-FSK	2-FSK	2-FSK	2-FSK
	Modulation Index	1.0	0.5	0.5	0.5	0.5
	Channel spacing (kHz)	200	200	400	400	400

Modulation and Channel Parameters for Chinese and European band

Modulation	Support for OFDM Option 4 as per sub-clause 21 (SUN OFDM PHY)
SUN OFDM Optional Mode	Data rates supported (kb/s): 50, 100, 150, 200, 300 Channel Spacing (kHz): 200 Nominal bandwidth (kHz): 156

Modulation	Support for SUN O-QPSK
SUN O-QPSK Optional Mode	Rate Mode: 0,1,2,3 Data rates supported (kb/s): 6.25, 12.5, 25, 50 Channel Spacing (kHz): 200 Chip rate (kchip/s): 100

Modulation and Channel Parameters (Contd..)

- Summary
 - SUN FSK (Mandatory Mode)
 - 100 kbps (Mode#2: Mandatory data rate for Chinese and European bands)
 - 50 kbps, 150 kbps and 100 kbps (Mode# 1, 3, 4: Optional data rate for Chinese and European bands)
 - 50 kbps (Mode# 1: Mandatory for all other frequency bands)
 - 100 kbps, 150 kbps, 200 kbps and 300 kbps (Mode# 2,3,4, 5: Optional for all other frequency bands per slide 7)
 - SUN OFDM 4 (Optional Mode – only for Chinese and European band)
 - 50, 100, 150, 200, and 300 kbps (Optional data rates)
 - SUN OFDM (Optional Mode – For all other frequency bands per slide 7)
 - SUN O-QPSK (Optional Mode – only for Chinese and European band)
 - 6.25, 12.5, 25 and 50 kbps
 - SUN O-QPSK (Optional Mode – For all other frequency bands per slide 7)
- All additional PHY parameters shall be as per existing SUN FSK, SUN OFDM and SUN O-QPSK

Proposed changes to existing 15.4 (For European band) (Based on 802.15.4-2015)

- 7.4.4.10: Include a new row in Table 7-19
- 10.1.1.: Include the frequency band in Table 10-1
- 10.1.2.8: Insert the following row to Table 10-10

Frequency band (MHz)	Modulation	ChanSpacing (MHz)	TotalNumChan	ChanCenterFreq0 (MHz)
870-875.6	SUN FSK operating mode #1, #3 & #4	0.2	27	870.2
	SUN FSK operating mode #2	0.1	54	870.1
	SUN OFDM Option 4	0.2	27	870.2
	SUN O-QPSK	0.2	27	870.2

- 20.1: Insert a new row in Table 20-1 for symbol period
- 20.3: Include 870 MHz band in the second paragraph and add new row in Table 20-6 as shown in slide 6
- 21.5.1: Include 870-875.6 MHz in the list of bands

Proposed changes to existing 15.4 (Contd..)

- 22.2.1.1: Include 870 MHz in the second sentence
- 22.2.2: Include the 870 MHz in the second paragraph, last sentence
- 22.3.2 and 22.3.3: Include the band in the Table 22-2 and 22-3 as shown below,

Frequency band (MHz)	Chip rate (kchip/s)	BDE	Spreading
870-875.6	100	yes	$(32,1)_0$ -DSSS

Frequency band (MHz)	Chip rate (kchip/s)	BDE	rate $\frac{1}{2}$ FEC + interleaver	Spreading
870-875.6	100	yes	yes	$(8,1)_{0/1}$ -DSSS

- 22.3.4 and 22.3.5: Include the band in Table 22-4 for O-QPSK PHY
- 22.5.1: Include the 870 MHz band in the list of bands

Note: Need to includes details for other freq bands

Proposed changes to existing 15.4 (Contd..)

- 22.5.3: Include receiver sensitivity for 870 MHz band in Table 22-21 and Table 22-22
- 22.5.4: Include ACR for 870 MHz band in Table 22-23
- 22.5.13: Include CCA time for 870 MHz band in Table 22-24

Note: Need to includes details for other freq bands

Reference

- IEEE Std. 802.15.4-2015, Part 15.4: Low-Rate Wireless Personal Area Networks (LR-WPANs)
- IEEE Std. 802.15.4g-2012, Part 15.4: Low-Rate Wireless Personal Area Networks (LR-WPANs) - Amendment 3: Physical Layer (PHY) Specifications for Low-Data-Rate, Wireless, Smart Metering Utility Networks, March 2012.
 - <https://standards.ieee.org/findstds/standard/802.15.4g-2012.html>