

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 | 876 | 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 |
|------------------------|-----------------------|-------------------|-------------------|-------------------|
| 920.5-924.5 (China) | Data Rate (kbps) | 50 | 100 | 150 |
| | Modulation | 2-FSK | 2-FSK | 2-FSK |
| | Modulation Index | 1.0 | 0.5 | 0.5 |
| | Channel spacing (kHz) | 200 | 200 | 200 |
| 870 – 876 (Europe) | Data Rate (kbps) | 50 | 100 | 150 |
| | Modulation | 2-FSK | 2-FSK | 2-FSK |
| | Modulation Index | 0.5 | 0.5 | 0.5 |
| | Channel spacing (kHz) | 100 | 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 – 921 (Europe) 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 (Mode# 1, 3: 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) |
|----------------------|------------------------------------|-------------------|--------------|-----------------------|
| 870-876 | 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 870-876 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 |
|----------------------|---------------------|-----|------------------|
| 870-876 | 100 | yes | $(32,1)_0$ -DSSS |

| Frequency band (MHz) | Chip rate (kchip/s) | BDE | rate $\frac{1}{2}$ FEC + interleaver | Spreading |
|----------------------|---------------------|-----|--------------------------------------|---------------------|
| 870-876 | 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>