

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

**Submission Title:** [Proposals for Amendments to the FSK PHY of LECIM draft 15-12-0089-02-004k ]

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**Re:** []

**Abstract:** []

**Purpose:** [To assist with the definition of the 15.4k FSK PHY of the LECIM draft standard]

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## FSK PHY Amendments

- Add PHY bands for Australia / New Zealand
- Delete 2.4 GHz band from FSK PHY
  - Very limited analysis /data for FSK systems at 2.4 GHz
  - 200 kHz channel raster for 83 MHz of available spectrum is not best use of spectrum
- Proposals for FSK PHY amendments to ensure regulatory compliance and to assist with good spectral efficiency and improved receiver selectivity
- Add MAC mechanism for adaptive data rate

- Section 8.1.1 Frequency Bands and Data Rates
- Amend Table 66 as follows:
  - GFSK modulation
    - Definition of Gaussian FSK is well defined (802.15.4-2011, 802.1...)
  - BT as required to meet local regulatory transmit spectral masks
  - GFSK provides additional margin at channel edge
  - Tighten TX spectrum mask will allow tighter RX specification
    - Can specify “like” modulation for ACR / AACR
- Add the following PHY for Australia / New Zealand

PHY (MHZ)	Frequency Band (MHz)	Spreading		Data Parameters		
		Chip Rate (kchips/s)	Modulation	Bit Rate (kb/s)	Symbol Rate (kb/s)	Symbols
921.5	915 - 928	-	GFSK	37.5	37.5	Binary
		-	GFSK	25	25	Binary
		-	GFSK	12.5	12.5	Binary

- Section 8.1.2 Channel Assignment
- Add to Table 1

<b>Frequency Band (MHz)</b>	<b>Modulation (Uplink/Downlink)</b>	<b>ChanSpacing (MHz)</b>	<b>TotalNumChan</b>	<b>ChanCenterFreq<sub>0</sub> (MHz)</b>
915 - 928	GFSK	0.2	63	915.2

- Add to Table 2

<b>Frequency Band (MHz)</b>	<b>Modulation (Uplink/Downlink)</b>	<b>ChanSpacing (MHz)</b>	<b>TotalNumChan</b>	<b>ChanCenterFreq<sub>0</sub> (MHz)</b>
915 - 928	GFSK	0.1	128	915.1

– References:

- *AS / NZS 4628: 2003*
- *Radiocommunications Regulations (General User Radio Licence for Short Range Devices) Notice 2011*

- Section 19.2 FSK PHY Specification
- 19.2.2 Modulation and coding for FSK
- Amend Table 78 as follows:
  - Modulation: GFSK / P-GFSK
- Add to Table 78:

<b>Frequency Band (MHz)</b>	<b>Parameter</b>	<b>37.5 kb/s</b>	<b>25 kb/s</b>	<b>12.5 kb/s</b>
915 – 928 (AUS / NZ)	Modulation	GFSK / P-GFSK	GFSK / P-GFSK	GFSK / P-GFSK
	Modulation Index	0.5	1.0	2.0
	Channel spacing (kHz)	200	200	200

- Section 19.2 FSK PHY Specification
- 19.2.2 Modulation and coding for FSK
- Amend Table 79 as follows:
  - Modulation: GFSK / P-GFSK
- Add to Table 79:

Frequency Band (MHz)	Parameter	37.5 kb/s	25 kb/s	12.5 kb/s
915 – 928 (AUS / NZ)	End device to coordinator	GFSK / P-GFSK	GFSK / P-GFSK	GFSK / P-GFSK
	Modulation Index	0.5	1.0	2.0
	Channel spacing (kHz)	100	100	100

- Section 19.2.4 FSK PHY RF Requirements
- 19.2.4.6 Receiver sensitivity
  - Under the conditions specified in 8.1.7, a compliant PHY device shall be capable of achieving a sensitivity of at least:
    - $S_0 = (P_{TX} - 120)$  (dBm)
      - $S_0$  = minimum sensitivity level at the minimum defined BR for the FSK PHY (dBm)
      - $P_{TX}$  = stated transmitted output power of the device (dBm)
    - $S = [S_0 + 10 \cdot \log(R/R_0)]$  (dBm)
      - $S$  = required minimum sensitivity level (dBm)
      - $R_0$  = symbol rate at minimum BR for the FSK PHY (kb/s)
      - $R$  = symbol rate (kb/s)
  - Spreading and / or FEC may be implemented to meet sensitivity limit
  - Refer to 8.1.7 for additional information on receiver sensitivity

- Section 19.2.4 FSK PHY RF Requirements
- 19.2.4.7 Receiver selectivity
- 19.2.4.7.1 Receiver interference rejection
- Amend Table 84 as follows:

CHANNEL SPACING (kHz)	ADJACENT CHANNEL REJECTION (dB)	ALTERNATE CHANNEL REJECTION (dB)
100	25	35
200	30	40

- 169 MHz / 50 kHz single channel PHY. No ACR / AACR interferer
- Amend from line 52 as follows:
  - The adjacent channel rejection shall be measured as follows. The interfering signal shall be a compliant GFSK signal, as defined by 19.2.2, of pseudo-random data of length at least 512 bits. The desired signal is input to the receiver at a level 3 dB greater than the minimum allowed receiver sensitivity given in 19.2.4.6.
- Insert after line 54 on page 80:
  - Spreading and / or FEC may be implemented to meet sensitivity limit



- Section 19.2 FSK PHY RF Requirements
- 19.2.4.7 Receiver selectivity
- 19.2.4.7.1 Receiver co-channel rejection
  - Add the following text:
    - The minimum receiver co-channel rejection level shall be -10 dB.
    - The co-channel rejection shall be measured as follows. The unwanted signal shall be an un-modulated carrier. The desired signal is input to the receiver at a level 3 dB greater than the minimum allowed receiver sensitivity given in 19.2.4.6.
    - Spreading and / or FEC may be implemented to meet sensitivity limit

- Section 19.2 FSK PHY RF Requirements
- 19.2.4.7 Receiver selectivity
- 19.2.4.7.1 Receiver blocking immunity
  - Add the following text:
    - The minimum receiver blocking immunity levels are given in Table XX.

- **Table XX**

<b>FREQUENCY OFFSET (MHz)</b>	<b>BLOCKING IMMUNITY (dB)</b>
1	50
2	55
10	65

- The blocking immunity shall be measured as follows. The unwanted signal shall be an un-modulated carrier. The desired signal is input to the receiver at a level 3 dB greater than the minimum allowed receiver sensitivity given in 19.2.4.6.
- Spreading and / or FEC may be implemented to meet sensitivity limit

# References:

- 15-12-0089-02-004k “Preliminary draft for 4k” (Brown)
- 15-12-0014-03-004k “Radio Specification Analysis of Draft FSK PHY” (Jillings)
- 15-11-0027-00-004g “Consideration for Radio Specification Comments” (Jillings)

# Aus / NZ Path Loss Analysis:

- Maximum ERP = 1 W (+30 dBm)
- Minimum sensitivity = -90 dBm
- Aus / NZ PHY amendment is suitable for LECIM

Channel Model Parameters		Notes
Frequency (MHz)	921.5	Valid Range 150-2400 MHz
Collector Antenna Height (m)	10	Hata Valid Range 30-200 m, including terrain. Erceg Valid Range 10-80m, including terrain
Endpoint Antenna Height (m)	2	Hata Valid Range 1-10 m, Erceg Fixed to 2m.
Distance (km)	1	Valid Range Hata 1-20 km, Valid Range Erceg 100m-8km
Downlink Path Loss Calculation		Notes
Collector Tx Power (dBm)	30	Subject to Tx Power Regulations
Collector Tx Antenna Gain (dBi)	0	Subject to Tx Power Regulations
Path Loss (dB)	-122.23	Must reference the right path loss from the Hata or Erceg worksheet
Shadowing Margin (dB)	-16	To buffer against variable shadowing loss
Penetration Loss (dB)	-10	For underground vaults, etc.
Endpoint Rx Antenna Gain (dBi)	0	If using same antenna for Tx, must be same as in Uplink Table
Endpoint Interference (dB)	1	Rise over Thermal Interference
Rx Power at Endpoint (dBm)	-117.23	Compare against Rx sensitivity
Uplink Path Loss Calculation		Notes
Endpoint Tx Power (dBm)	30	Subject to Tx Power Regulations. Can be different from Collector
Endpoint Tx Antenna Gain (dBi)	0	Subject to Tx Power Regulations
Penetration Loss (dB)	-10	For underground vaults, etc.
Path Loss (dB)	-122.23	Same as Downlink
Shadowing Margin (dB)	-16	Same as Downlink
Collector Rx Antenna Gain (dBi)	0	If using same antenna for Tx, must be same as in Downlink Table
Collector Interference (dB)	2	Rise over Thermal Interference
Rx Power at Collector (dBm)	-116.23	Compare against Rx sensitivity