

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

**Submission Title:** [Final Proposal for 802.15.4d from OKI]

**Date Submitted:** [17-March-2008]

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**Re:** [802.15.4d]

**Abstract:** [Final proposal for 802.15.4d, that is for the low cost and low power consumption WPAN.]

**Purpose:** [To explain our proposal and discussion in 802.15.4d.]

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# Summary

- **OKI proposes low cost and low power consumption PHY**
  - Modulation method: GFSK
  - Number of channels
    - 1mW: 10 channels + 2 optional channels
    - 10mW: 2 channels
  - Data rate: 100kbps
  -
- GFSK specification and performance
  -
- GFSK's CCA-SD

# OKI's proposal

# Modulation parameters

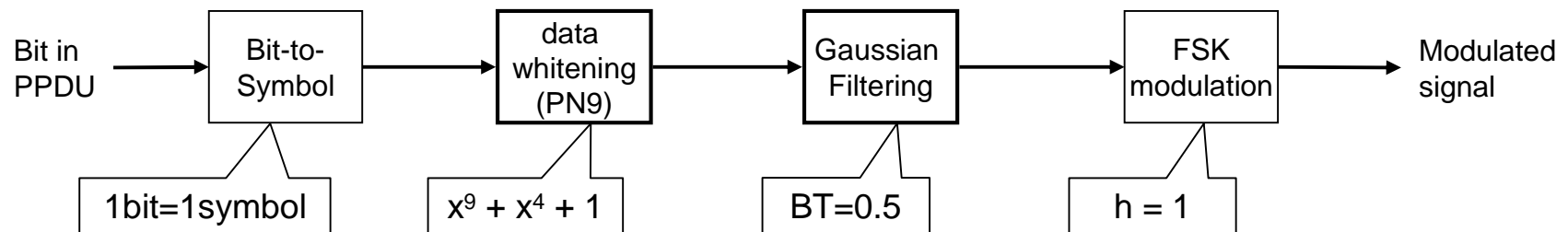
Modulation parameters					
Channel spacing	Bit Rate (kbit/s)	Symbol Rate (k sym/s)	Modulation type*	BT	Modulation Index (h)
400kHz	100	100	GFSK	0.5	1

(\*Our proposal does not use spread spectrum technology)



## Modulation polarity

“1” is transmitted by shifting the frequency higher than the channel center, “0” is transmitted by shifting the frequency lower than the channel center.

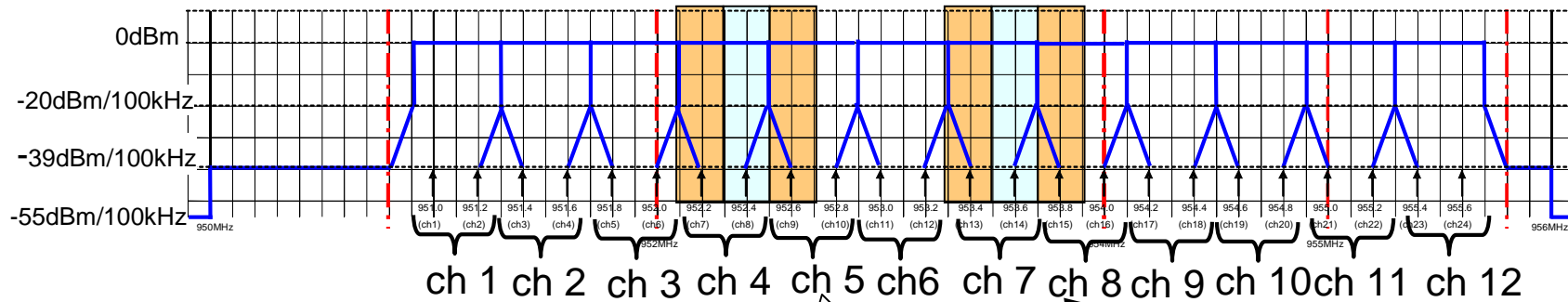
## Transmitter functions



# Channel plan

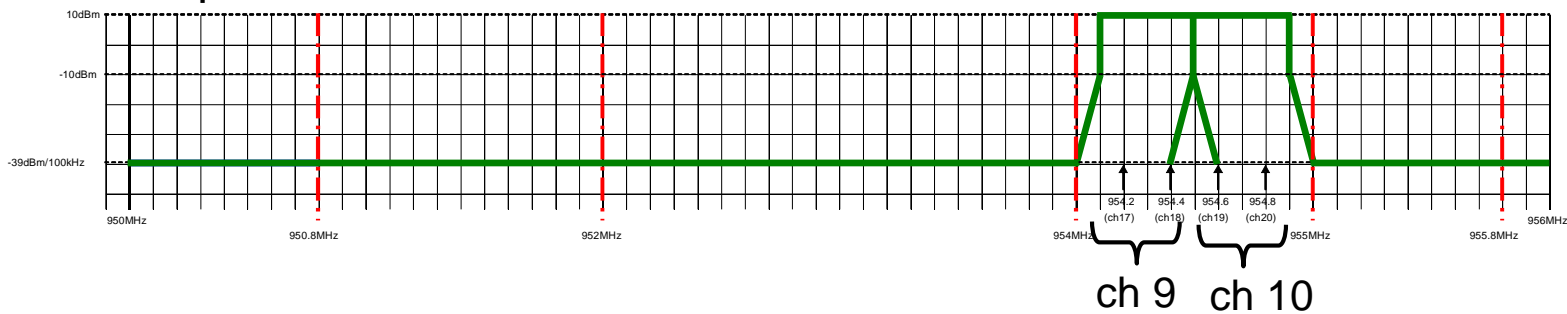
-  Reader channel of Miller sub-carrier RFID
-  Response channel of Miller sub-carrier RFID

Antenna power = 1mW



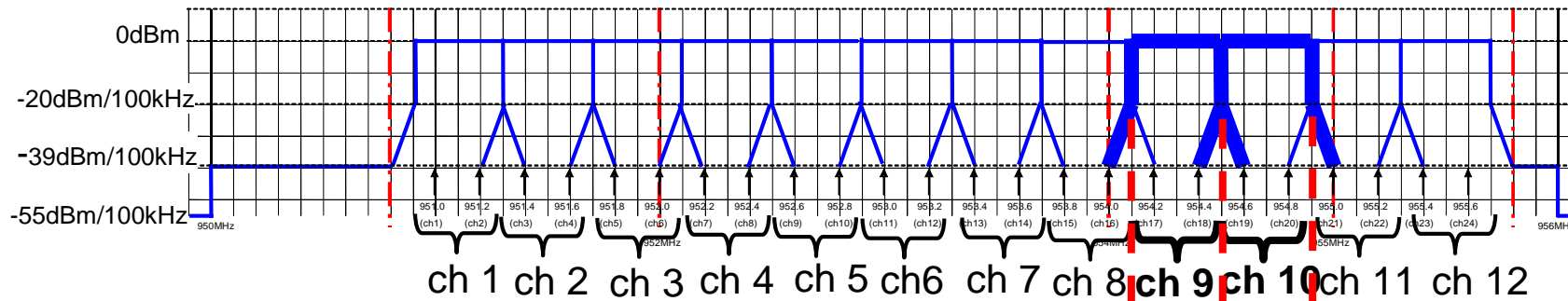
When to use ch 5 and ch 8, it have to do additional carrier sense on ch 4 and ch 7 respectively.  
**So, ch 5 and ch 8 should be made optional.**

Antenna power = 10mW

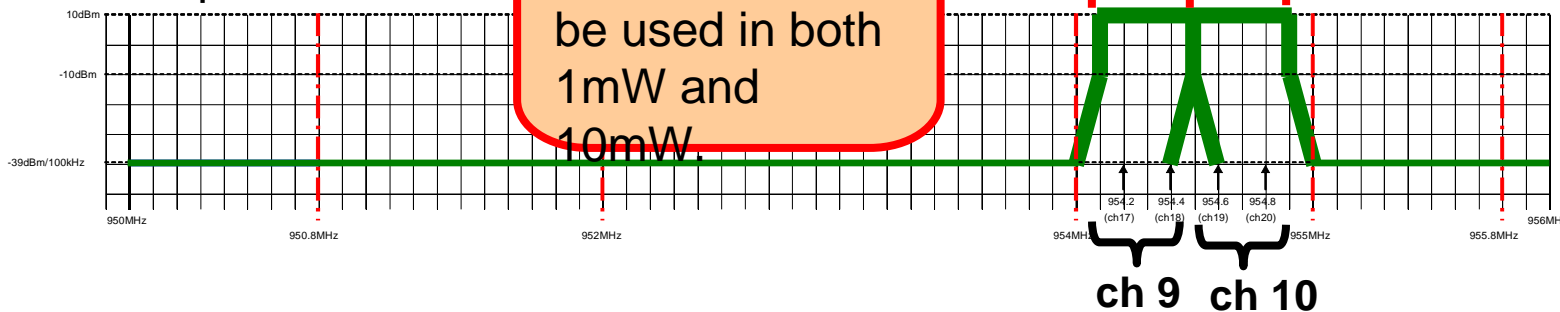


# Channel plan

Antenna power = 1mW

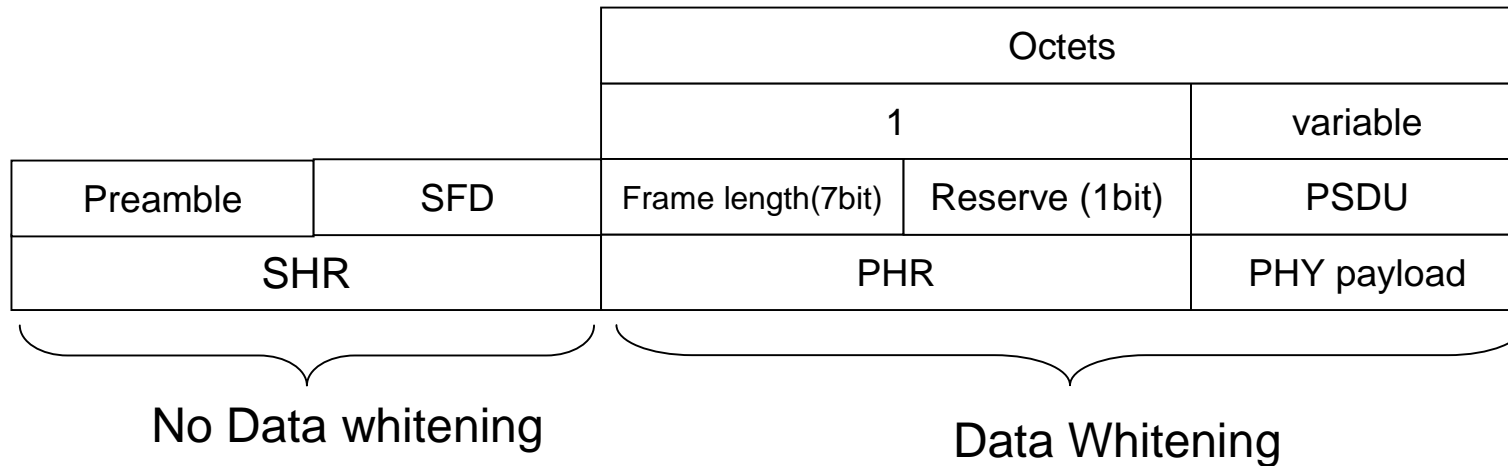


Antenna power = 10mW



Same channel allocation can be used in both 1mW and 10mW.

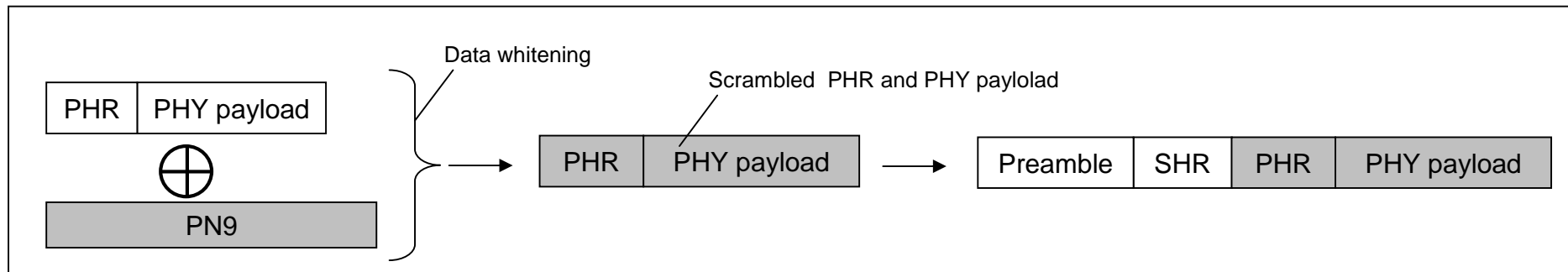
# Preamble & SFD



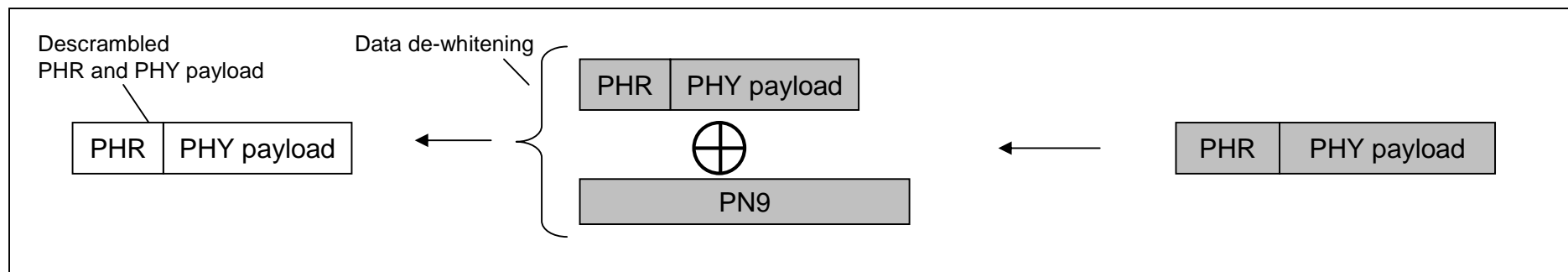
- Preamble length and SFD are compatible with 802.15.4b
  - Preamble size; 4 bytes
  - SFD; 1byte(11100101b)
- Preamble character is modified from 802.15.4b
  - Preamble character; 0xAA

# Data whitening

## Transmitter



## Receiver





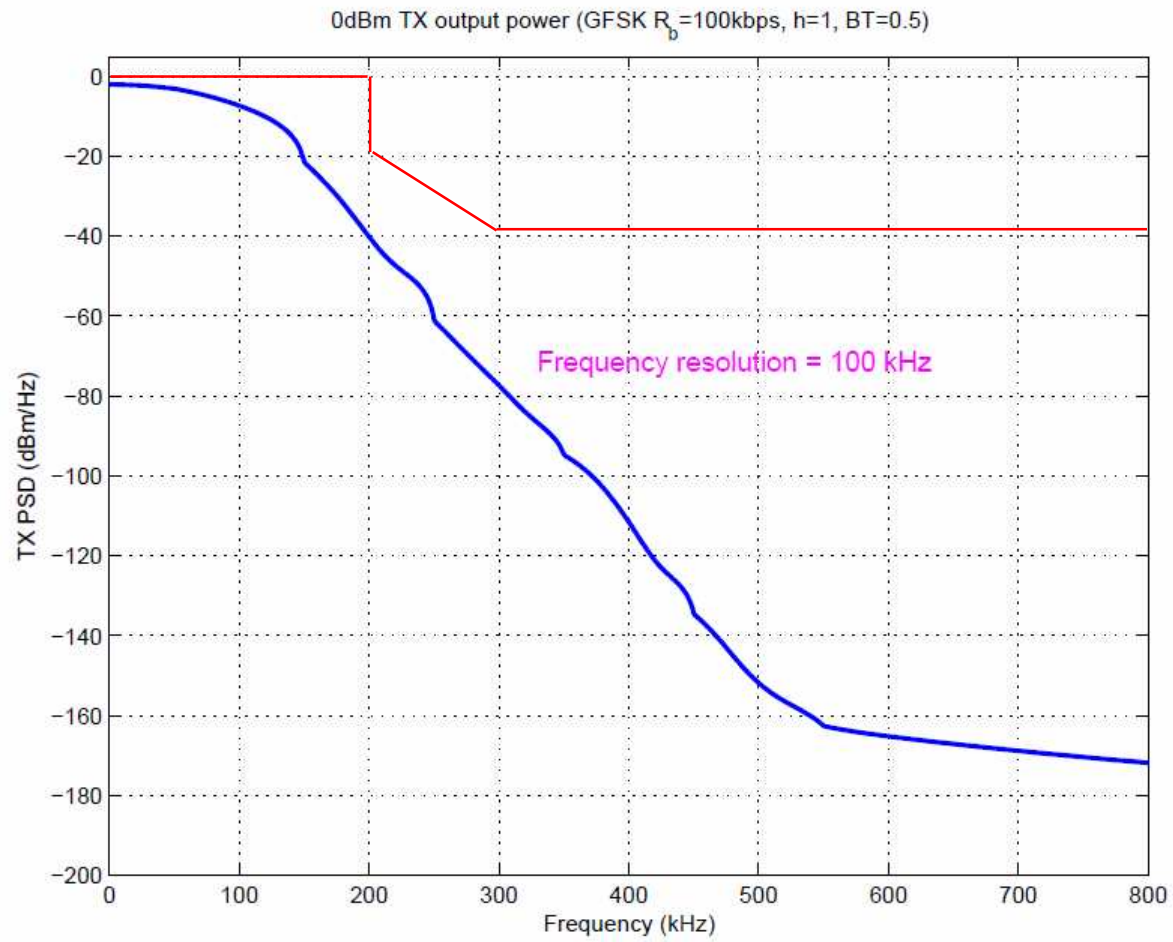
# Advantages of proposed GFSK PHY?

- **Low current consumption**
  - A high efficient non-linear amplifier can be used
  - Low complexity modem
  -
- **Low cost LSI**
  - Low complexity modem
  - Small area of LSI
  -
- **Low emission outside the 400kHz channel**
  - Meets Japanese Regulations at both 10 and 0dBm output power

## Why 400kHz channel spacing?

- Two 10mW channels available
  - Only one single channel available when 600kHz bandwidth is used
  -
- Both 1mW and 10mW can use identical channel allocation
  -
- Max data rate in 200kHz is too low
  -
- When 200kHz channel spacing is used the Phase Noise of the LO needs to be very low in order to meet Japanese Regulations"
  - Will increase power consumption of LSI

# Power spectrum



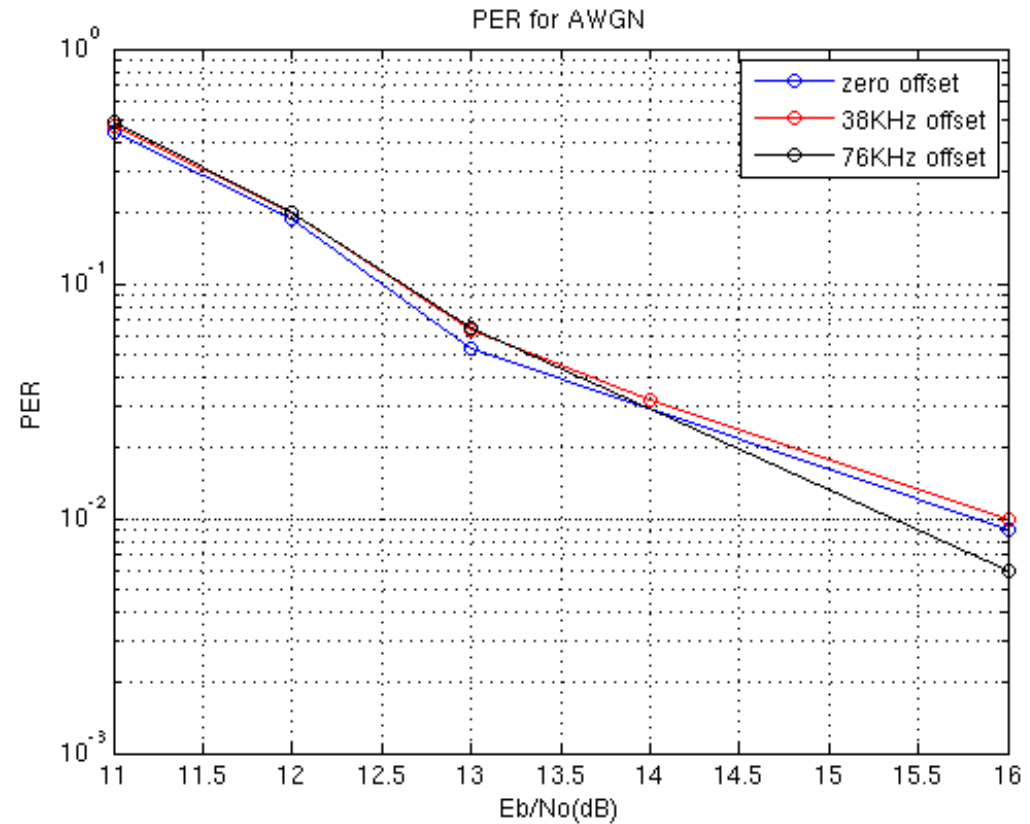
# Power emission

- In channel power is defined as integrated power over + and – 200kHz around the channel center.
- Adjacent channel power is defined as integrated power over + and – 100kHz around an offset of 300kHz away from the channel center.
- Out of channel power is defined as integrated power over + and – 50kHz around an offset of 350kHz away from the channel center.

Freq. Offset (kHz)	In channel power (dBm)	Adj. channel power (dBm)	Regulation limit adj. channel (dBm)	Out of channel power (dBm)	Regulation limit Out of channel (dBm)
0	0	-68.63	-26	-101.04	-39
	10	-58.63	-18	-91.04	-39
38	0	-56.23	-26	-89.76	-39
	10	-46.23	-18	-79.76	-39

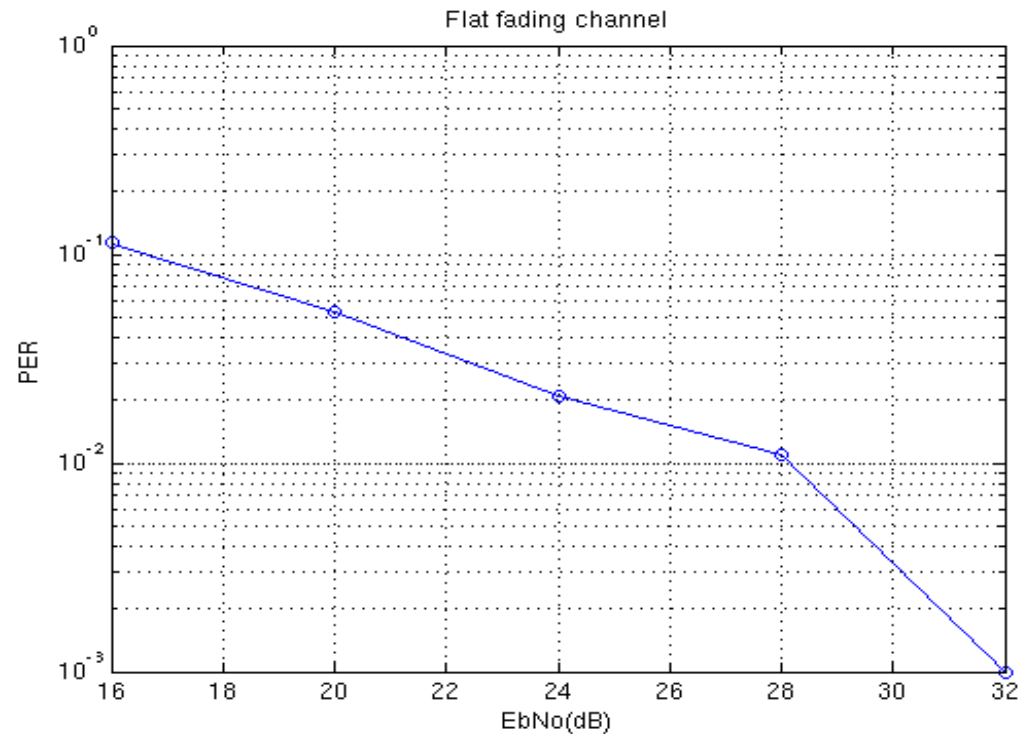
# PER vs Eb/No in AWGN channel

- 1000 packets per data point
- GFSK,  $h=1$ ,  $BT=0.5$ ,  $R_b=100\text{kbps}$
- frequency offset (0, 40 & 80ppm)
- Modem includes
  - AFC (Automatic Frequency Control)
  - Bit clock recovery
  - Sync word detection
- Robust against frequency error



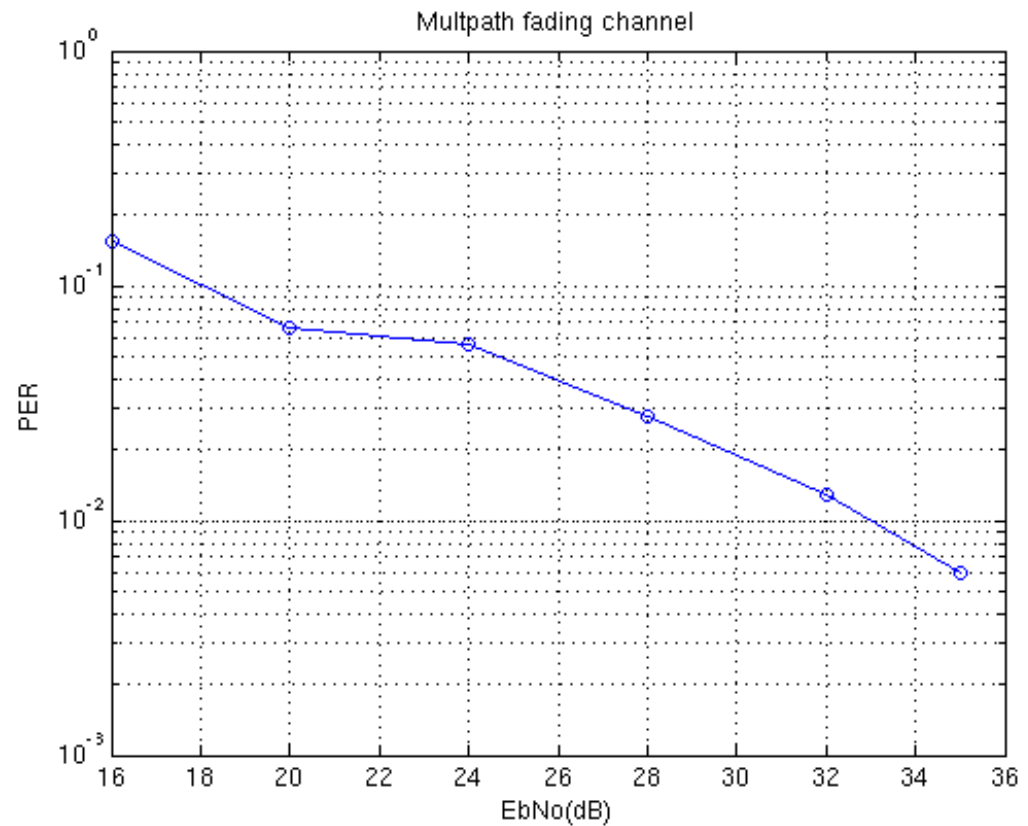
# PER vs Eb/No in Flat Fading channel

- 1000 packets per data point
- GFSK,  $h=1$ ,  $BT=0.5$ ,  $R_b=100\text{kbps}$
- Flat fading according to:
  - doc 15-04-585-00-004b
  - No frequency error
- Modem includes
  - AFC (Automatic Frequency Control)
  - Bit clock recovery
  - Sync word detection

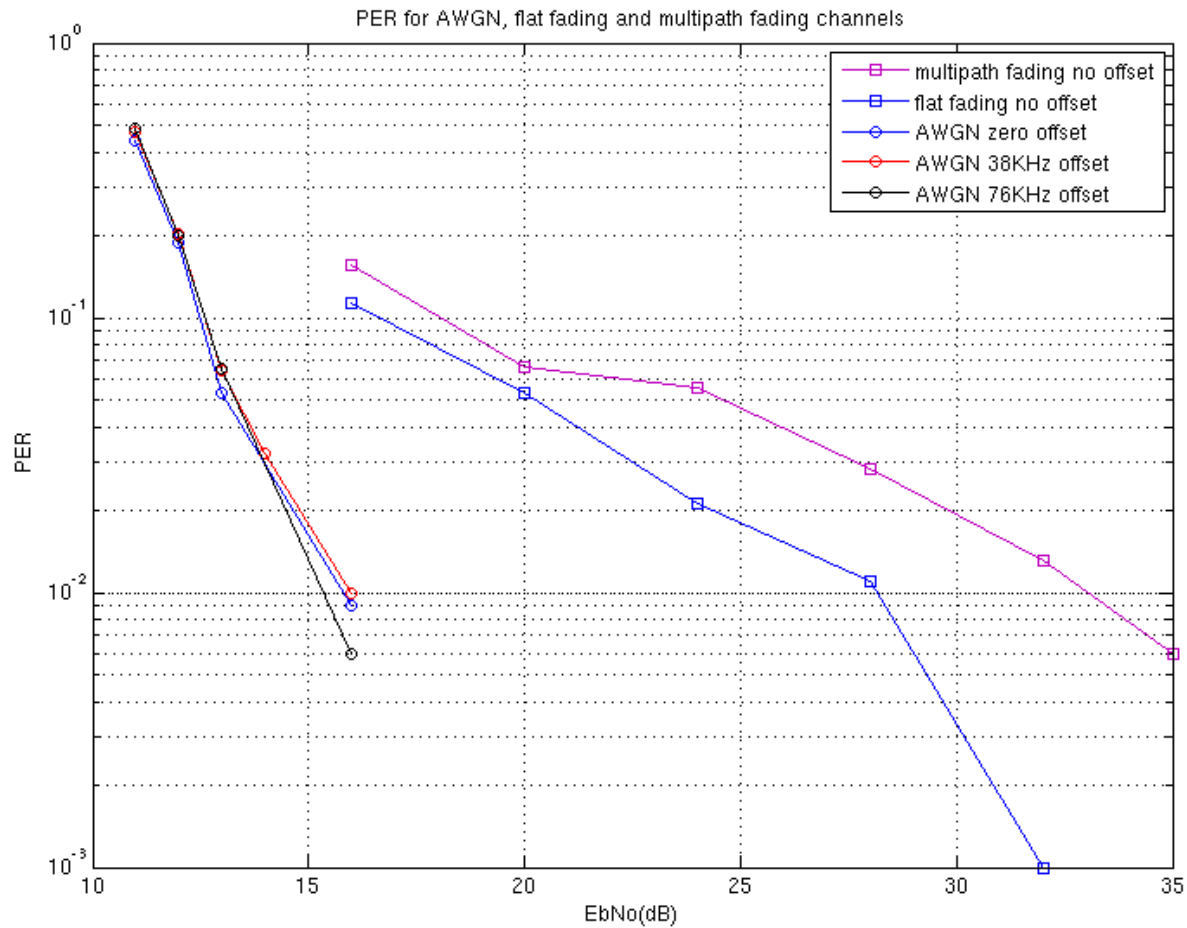


# PER vs Eb/No in Delay Spread channel

- 1000 packets per data point
- GFSK,  $h=1$ ,  $BT=0.5$ ,  $R_b=100\text{kbps}$
- Flat fading according to:
  - doc 15-04-585-00-004b
  - RMS delay spread = 250ns
  - No frequency error
- Modem includes
  - AFC (Automatic Frequency Control)
  - Bit clock recovery
  - Sync word detection



# PER vs Eb/No all cases





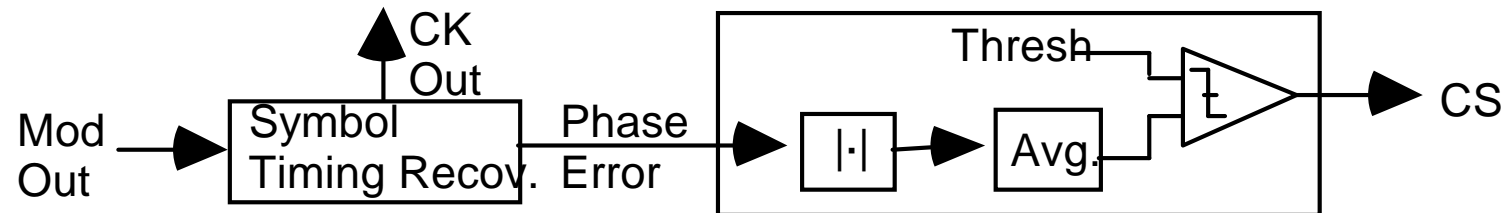
# Susceptibility for RFID interference

- Measurements and simulation show:
  - CW co-channel immunity = -8.5dB
  - It means that CW interferer needs to be at least 8.5dB below the desired channel power for BER < 1E-3.

# CCA-SD for GFSK

## GFSK's CCA-SD

- GFSK's Signal detection
  - Example of implementation



From Doc:IEEE802.11/94-67

# Backup slides

## Japanese regulation overview (1/3)

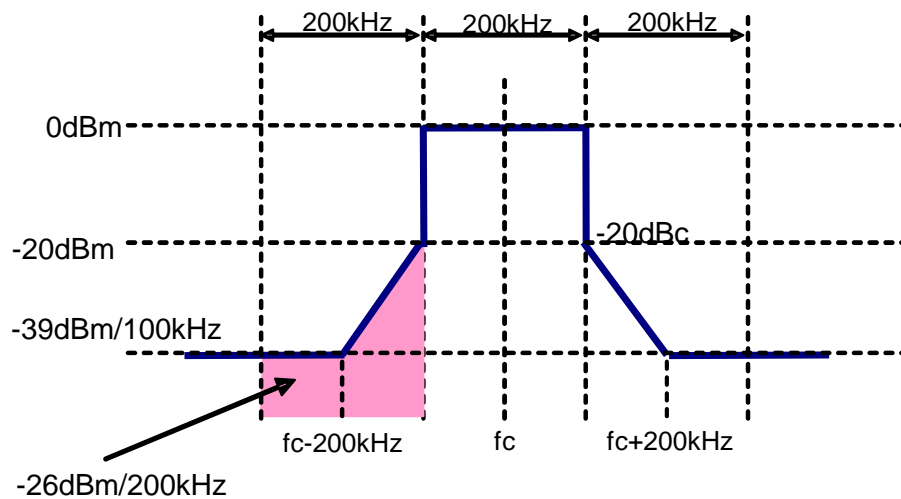
- Frequency band
  - 950.8MHz-955.8MHz (5.0MHz)
- Channel bandwidth
  - $(200 \times n)$  kHz ( $n$  is integer from 1 to 3)
- Antenna power
  - 1mW or less for all unit radio channel
  - 10mW or less for unit radio channels from 954MHz to 955MHz

# Japanese regulation overview (2/3)

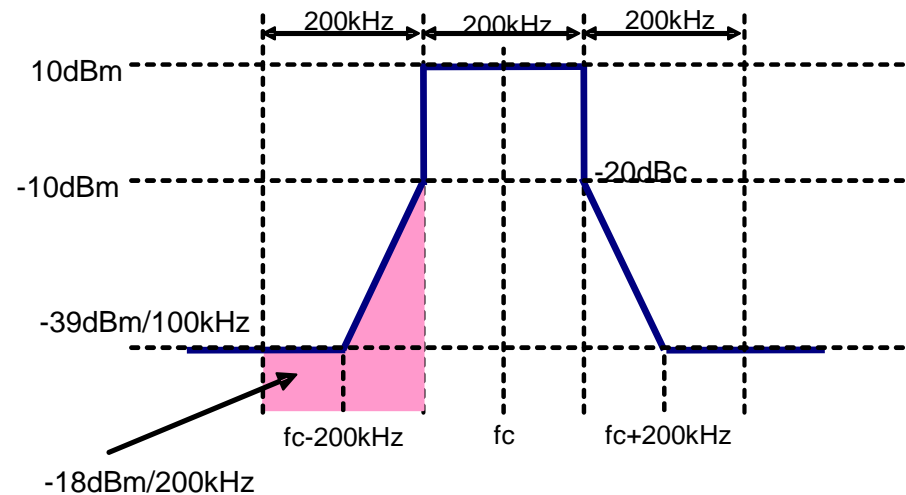
## PSD mask

- Level of channel edge: 20dBc
- Power of adjacent channel: less than -18dBm (10mW)  
less than -26dBm (1mW)

### 1mW



### 10mW

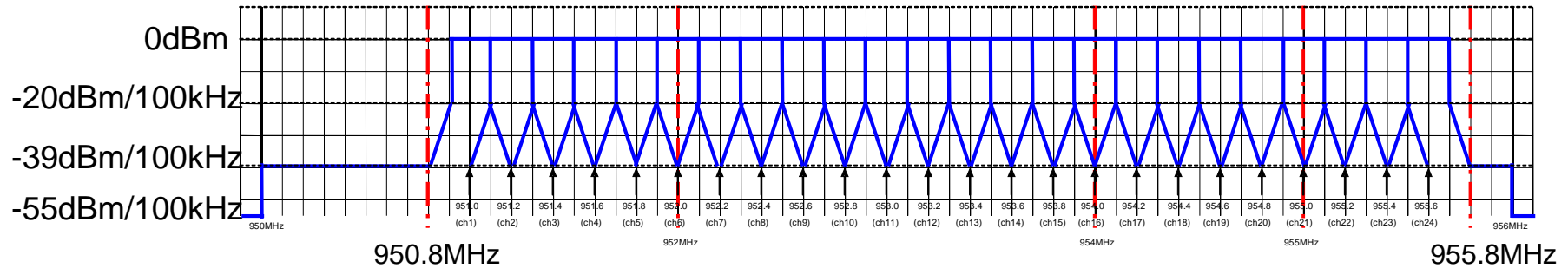


# Japanese regulation overview (3/3)

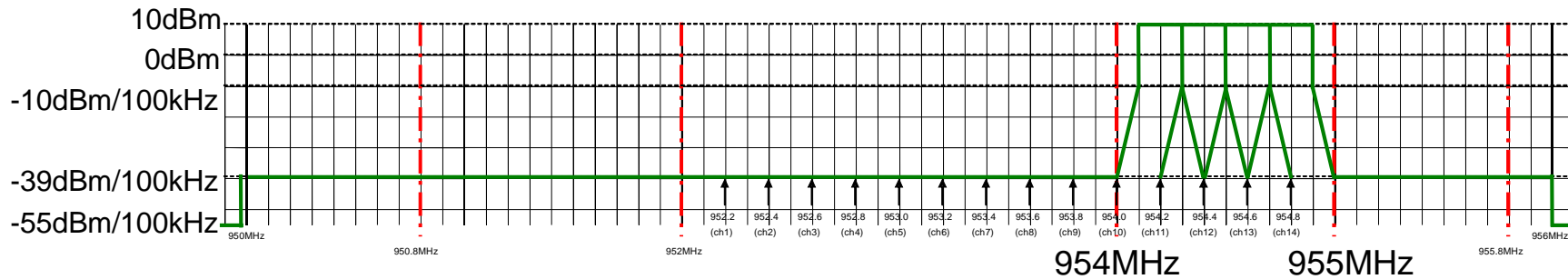
## Channel allocation

(It is 200kHz channel allocation)

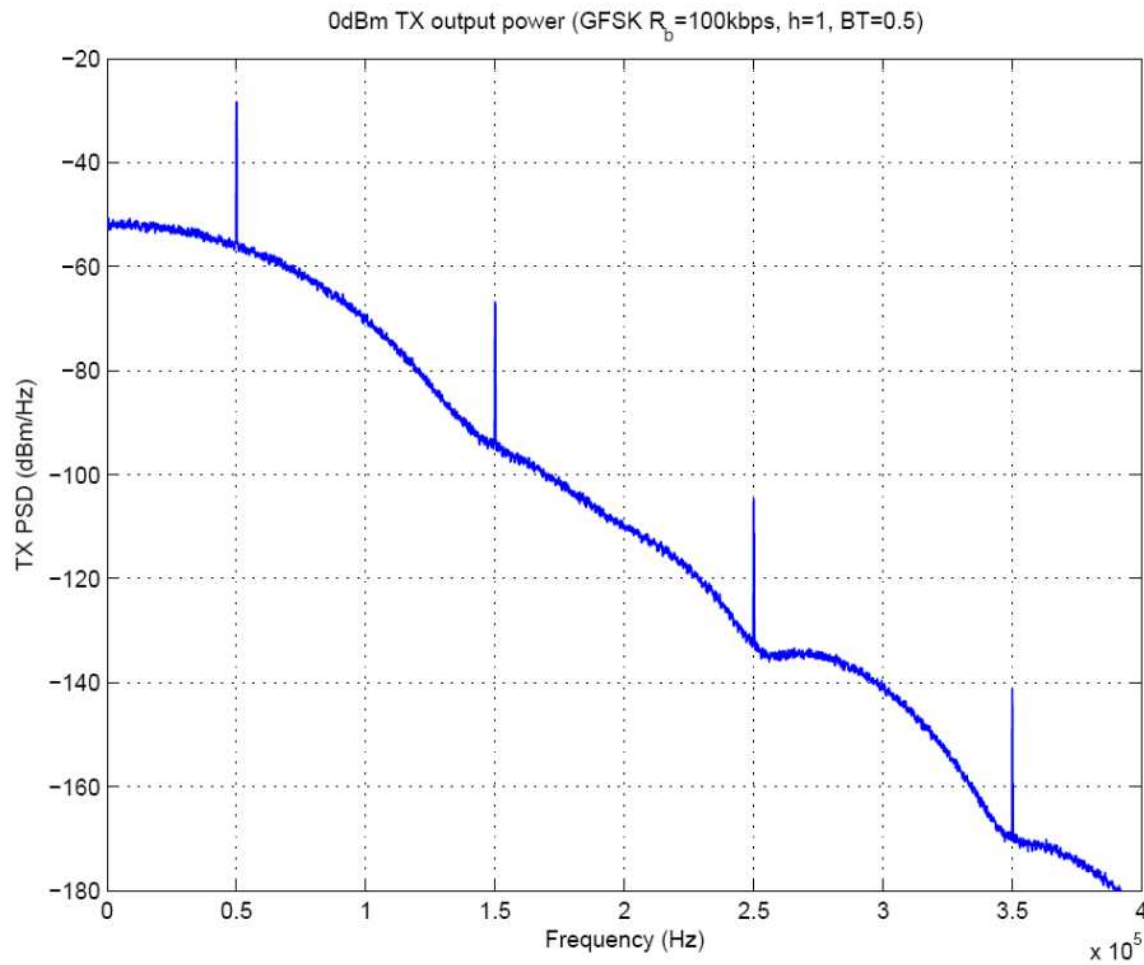
Antenna power = 1mW



Antenna power = 10mW



# Power spectrum





## Comparison between GFSK and BPSK-DSSS

	GFSK	BPSK-DSSS
Data rate	<b>High (100kbps)</b>	Low (20kbps)
Frequency efficiency	<b>1/4</b>	1/30
Complexity	<b>Low</b>	High
Power consumption	<b>Low</b>	High
CCA-CS	Easy signal detection	Easy signal detection
Market	Only JP	<b>JP and EU</b>