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

Submission Title: [Meiji University UWB PHY Proposal for Body Area Network]
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Re: [This document is a response of Meiji University to the Call For Proposal from the IEEE P802.15 Task Group 6 on BAN.]

Abstract: [This document describes preliminary PHY proposal with UWB-IR]

Purpose: [This document is intended as a preliminary proposal for consideration in IEEE 802.15.6.]

Meiji University UWB PHY Proposal: Flexible UWB-IR PHY Proposal for Body Area Network

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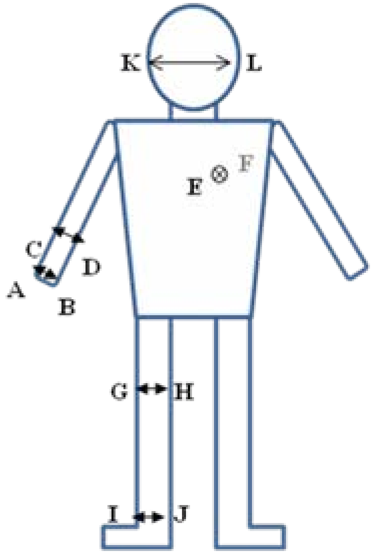
Presentation summary: UWB-IR with flexibilities

- Preliminary proposal for PHY only
- UWB-IR PPM-SS (TBD)
- Scalable data rate
- Non-coherent detection
- Tx power can be reduced. Tx power may be less than -41.3dBm/MHz at short range, e.g. on-body to on-body
- Bandwidth, center frequency and pulse shape of both Tx and Rx are flexible, for coexistence or avoiding interferences

On-body to on-body link may be kept with less transmitting power than on-body to external



Link	Description
A - B	Through the hand
C - D	Through the wrist
E - F	Torso, front to back
G - H	Through the thigh
I - J	Through the ankle
K - L	Left ear to right ear
M – N	Glucose sensor to Glucose pump

Why should we transmit maximal Tx power of -41.3dBm/MHz in shorter and lower data rate operation?

Can we reduce Tx power to coexist with other systems? YES!

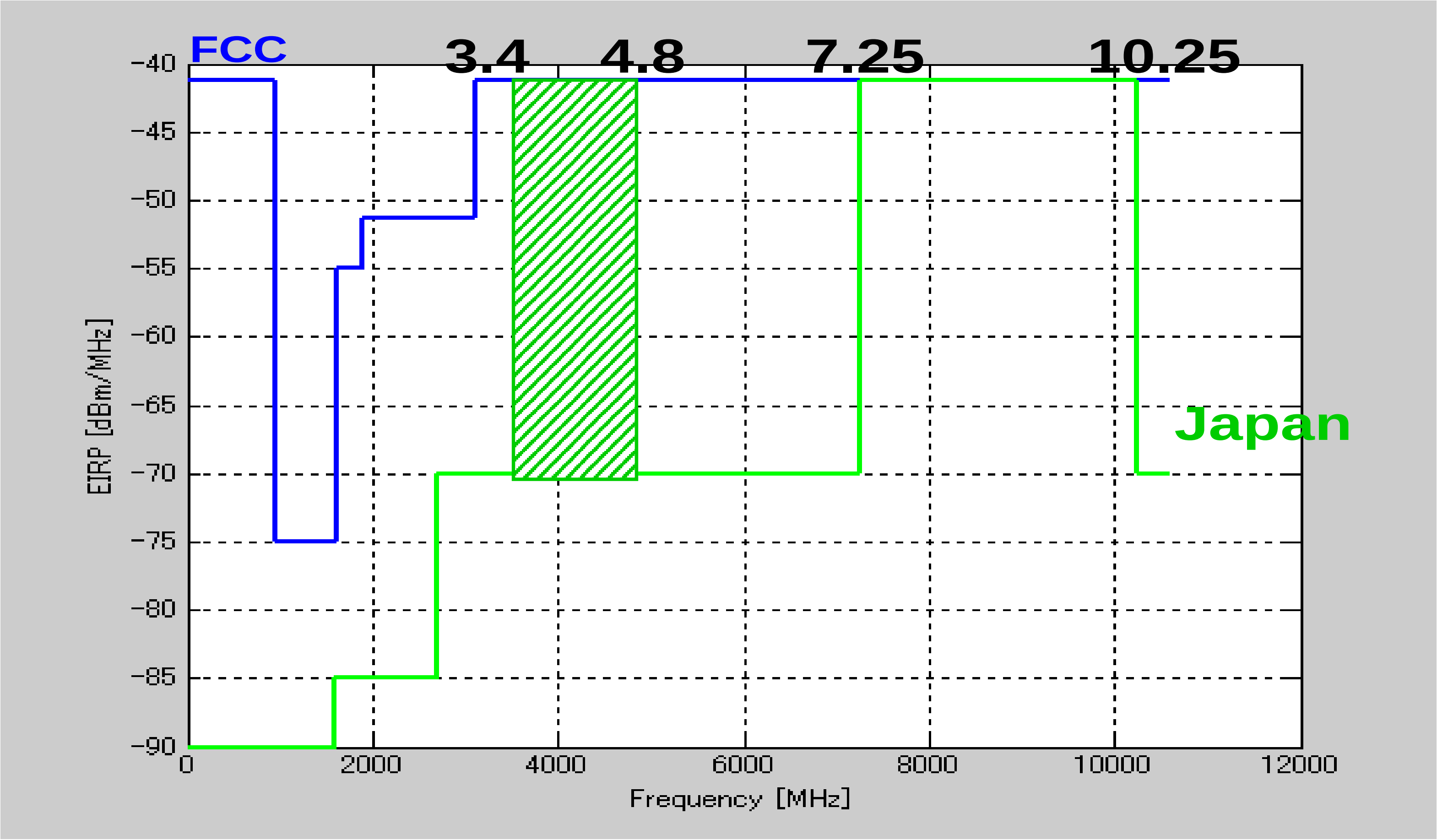
Radio Regulation for Reduced Tx Power UWB

- In some regions, Tx power of lower than -41.3dBm/MHz UWB relaxes radio regulation in certain frequency band usages
- Examples: (P802.15-08-0034r10)

3.1-6GHz for -70dBm/MHz or
8.5-10.6GHz for -65dBm/MHz in EU,
3.4-4.8GHz for -70dBm/MHz in Japan,
can operate without DAA function

DAA: Detection and Avoidance

UWB Spectrum Mask



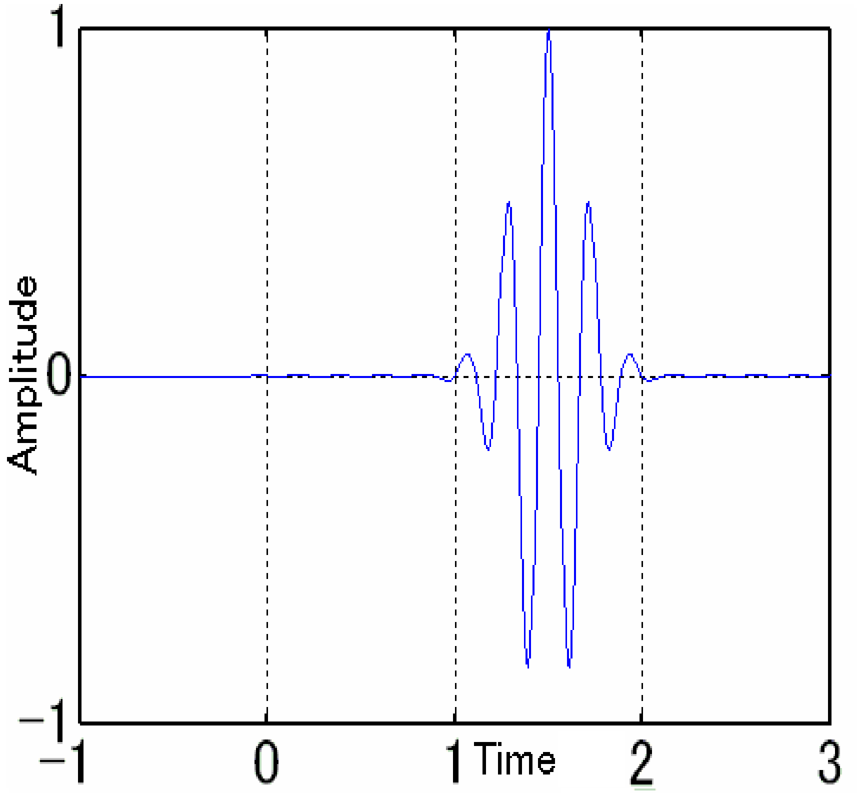
Japanese spectrum mask P802.15-08-0034r10

Proposal PHY

UWB-IR PPM-SS (TBD)

- Non-coherent detection
- Center freq.: UWB band(3.1GHz to 10.6GHz)
- Tx Bandwidth: ~500MHz, ~1GHz, (~2GHz and wider)
- Scalable data rate: 10kbps to 10Mbps
- Multiple piconets with SS codes
- Tx power may be reduced for short range. Tx power may be less than -41.3dBm/MHz at short range, e.g. on-body to on-body ~ -70dBm/MHz
- Bandwidth, center frequency and pulse shape of both Tx and Rx are flexible, for coexistence or avoiding interferences

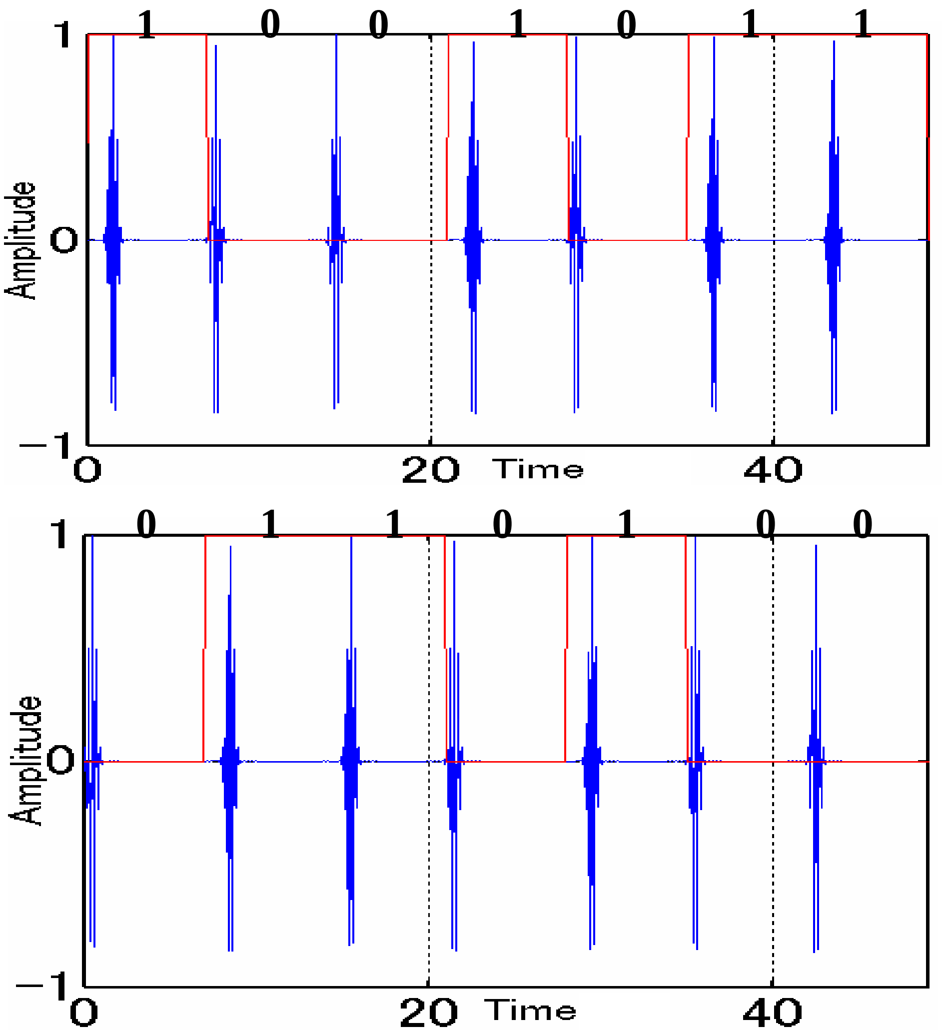
BPPM-UWB in principle



Time domain

unit pulses are shifted based on data “0” and “1”

Example Modulation: PPM-SS-UWB



Pulse train
[1 0 0 1 0 1 1]
corresponds data “0”

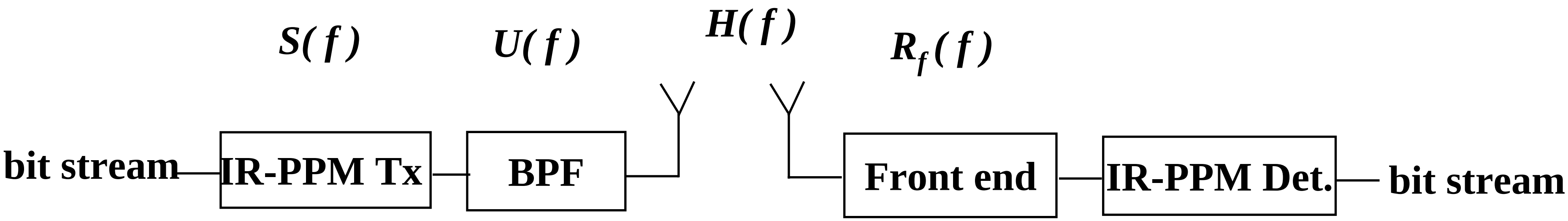
Pulse train
[0 1 1 0 1 0 0]
corresponds data “1”

Ikebe et.al, IWUWBT2005

UWB-IR : Bandwidth, center frequency and pulse shape of both Tx and Rx are flexible in principle

- When PPM with energy detection of pulse is employed,
- As long as correlation output of Rx produce a certain level for PPM detection, transfer function of Rx front-end or template waveform at correlator does not have to match the transmitted one.

Advantage of IR-PPM with Energy Detection



S(f)**: Tx UWB-IR PPM Pulse**

U(f)**: Tx BPF,and Antenna**

X(f)= S(f) U(f)**: Tx Signal**

H(f)**: Channel including Rx Antenna**

$R_f(f)$: Rx BPF, Template, etc.

$R_f(f)$ does not have to match transmitted signal $H(f)X(f)$

We allow Tx-Rx mismatched filter. This eases UWB-IR design

- If we allow mismatch loss, receiver front end transfer function $R_f(f)$ does not have to match transmitted signal $H(f)X(f)$. $R_f(f)$ can be designed based on interference resistant manner [Ikegami, IWUWBS2003, Ohno, IEEE MTT2006].
- $H(f)$: transfer function of channel including Rx antenna
- $X(f)=S(f)U(f)$
- $X(f)$: transmitted signal
- $S(f)$: transmitting UWB pulse
- $U(f)$: transfer function of Tx filter and antenna

Link Budget Analyses 1 (3m distance, Rx NF 6dB)

	Free Sp	CM3	Low PSD	Missmatch	Upper B	Lower B
Center [MHz}	6350	6350	6350	6350	8125	4000
TX BPF BW [MHz]	7500	7500	7500	7500	1250	1700
RX BPF BW [MHz]	7500	7500	7500	6000	1250	1700
TX PSD[dBm/MHz]	-41.3	-41.3	-70	-70	-70	-70
EIRP[dBm]	-2.5	-2.5	-31.2	-31.2	-39.0	-37.7
Free space path loss[dB]	58.0	58.0	58.0	58.0	60.2	54.0
CM3 Excess Path loss[dB]	0.0	16.0	16.0	16.0	16.0	16.0
Total path loss [dB]	58.0	74.0	74.0	74.0	76.2	72.0
N0[dBm/Hz]	-169.1	-169.1	-169.1	-169.1	-169.1	-169.1
C[dBm]	-60.6	-76.6	-105.3	-106.3	-115.2	-91.7
C/No[dBHz]	108.5	92.5	63.8	62.8	53.9	77.4
Bit Rate [Mbps]	10	100	0.15	0.15	0.016	0.064
Eb/No[dB]	38.5	12.5	12.0	11.1	11.8	11.3
Req. Eb/No[dB]	11.0	11.0	11.0	11.0	11.0	11.0
margin [dB]	27.5	1.5	1.0	0.1	0.8	0.3

100Mbps OK 150kbps OK 150kbps OK 16kbps OK 64kbps OK

Link Budget Analyses 2 (1m distance, Rx NF6dB)

	Free Sp	CM3	Low PSD	10kbps	Mismatch	8GHz
Center Freq [MHz}	4000	4000	4000	4000	4000	8000
TX BPF BW [MHz]	500	500	500	500	500	500
RX BPF BW [MHz]	500	500	500	500	100	500
TX PSD[dBm/MHz]	-41.3	-41.3	-70	-70	-70	-70
EIRP[dBm]	-14.3	-14.3	-43.0	-43.0	-43.0	-43.0
Free space path loss[dB]	44.5	44.5	44.5	44.5	44.5	50.5
CM3 Excess Path loss[dB]	0.0	16.0	16.0	16.0	16.0	16.0
Total path loss [dB]	44.5	60.5	60.5	60.5	60.5	66.5
N0[dBm/Hz]	-169.1	-169.1	-169.1	-169.1	-169.1	-169.1
C[dBm]	-58.8	-74.8	-103.5	-103.5	-110.5	-109.5
C/No[dBHz]	110.3	94.3	65.6	65.6	58.6	59.6
Bit Rate [Mbps]	10	10	0.15	0.01	0.01	0.01
Eb/No[dB]	40.3	24.3	13.8	25.6	18.6	19.6
Req. Eb/No[dB]	11.0	11.0	11.0	11.0	11.0	11.0
margin [dB]	29.3	13.3	2.8	14.6	7.6	8.6

10Mbps OK 150kbps OK margin 14.6dB 7.6dB 6.6dB

Simpler is better!

- Non-coherent UWB-IR
- Flexible Tx power
- Flexible Rx bandwidth

UWB PHY, Rx is subject to interference, robust receiver design will be key (may be out of scope TG6 spec.)

- Interference detection and rejection type receiver design
- Interference rejection by BPF or notch filter [Ikegami, IEEE IWUWBS2003]
- Interference rejection by receiver template waveform processing [Ohno, IEEE MTT 2006]
- UWB-IR type IEEE802.15.4a signal can be detected by simpler energy detector [Hasegawa, IEEE ICUWB2008]
- Use of chirp template to detect interferences [Ohno, IEEE ICUWB2008]

Conclusion: UWB-IR with flexibilities

- UWB-IR PPM-SS
- Scalable data rate
- Non-coherent detection
- Tx power can be reduced. Tx power may be less than -41.3dBm/MHz.
- Bandwidth, center frequency and pulse shape of Tx or Rx template are flexible, for coexistence or avoiding interferences.

References

- Tetsushi Ikegami, Kohei Ohno “Effect of interference from other radio system to UWB impulse radio,” IEEE Proc. IWUWBS2003 June 2003.
- Takanori Ikebe, Kohei Ohno, Tetsushi Ikegami, “Interference Study for UWB using Envelope Detection,” Proc. IWUWBT2005, Dec. 2005.
- Kohei Ohno, Tetsushi Ikegami, ”Interference Mitigation Study for UWB Radio by Using Template Waveform Processing,” IEEE Transactions on Microwave Theory and Techniques, MTT, vol.54, 4, pp.1782-1792, 2006.
- Makoto Hasegawa, Masaki Kumazawa, Tetsushi Ikegami, Kenichi Takizawa,”A Study for possibility of detecting IEEE802.15.4a signals,” IEEE ICUWB2008, vol.1, pp.217-220, Sept. 2008.

Thank you for your attention.