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

Submission Title: [Latest Japanese Spectrum Mask for UWB]

Date Submitted: [September 22, 2005]

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Abstract: [A draft of spectrum mask for UWB in 3-10GHz has been announced in Japanese regulator MIC on August 25, 2005. Although this mask is still a draft and should be revised to be approved in Japanese radio regulation, it is important for IEEE P802.15 standard to be compliant in a world as well as other nations' masks.]

Purpose: [Suggestion to modify specifications such as a band plan, sequence, FEC, MAC and additional requirement for IEEEP802.15 in microwave band to be world-wide compliant.]

Latest Japanese Spectrum Mask for UWB

Ryuji Kohno
National Institute of Information and Communications Technology (NICT),
Yokohama National University (YNU)

Liaison with Japanese Regulator (MIC)

Japanese UWB radio regulation Context

- Japanese regulator MIC established **UWB Radio Systems Regulatory Committee ,** November 22, 2002.
- MIC reported intermediate draft spectral masks , February 2, 2004.
- MIC mandated MMAC Forum in ARIB to test interference to victim systems during March-August, 2005
- MIC reported latest draft spectral mask on August 25, 2005.
- China, Japan, and Korea (CJK) Workshop on UWB will be held in Seoul on Sept.27, 2005
- MIC will submit the draft with possible revision to ITU-R TG1/8 during Oct.12-20, 2005

UWB Radio Systems Regulatory Committee in MIC(*MPHPT*) Telecommunications Council

> Four working groups were set up to investigate compatibility between UWB and other radio communication systems in Nov. 2002:

WG1: Compatibility Model Working Group,
WG2: Fixed-Broadcasting systems Working Group,
WG3: Radar-Aviation and Maritime systems Working Group
WG4: Satellite-Low Power systems Working Group

> Comments were invited on the Draft Interim Report
22 submissions received in the period 2 – 27 February 2004

Basic principles of compatibility model in Japan

(1) Radio spectrum is a finite resource. As such, radio spectrum usage should adhere to international systems of rules and should be carefully designed to avoid future problems.

(2) As yet, **UWB stations do not belong to any designated service and the UWB format is not based on the Radio Regulations (RR) allocations**. As such, it is not considered in compliance with stipulations.

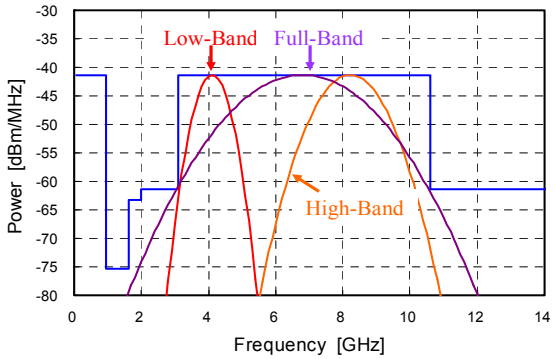
(3) **The study of compatibility conditions is predicated on radio regulations (RR) Section 4.4 concerning interference.**

[Radio Regulations. Section 4.4]
Administrations of the Member States shall not assign to a station any frequency in derogation of either the Table of Frequency Allocations in this Chapter or the other provisions of these Regulations, except on the express condition that such a station, when using such a frequency assignment, shall not cause harmful interference to, and shall not claim protection from harmful interference caused by, a station operating in accordance with the provisions of the Constitution, the Convention and these Regulations.

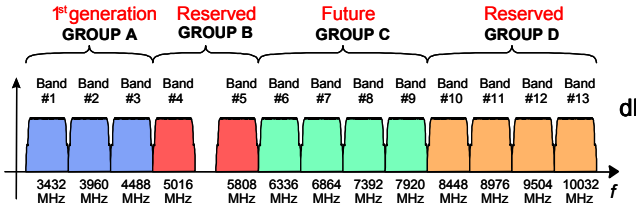
UWB Models and Spectral Mask in Japan

Different types of UWB radio systems under consideration

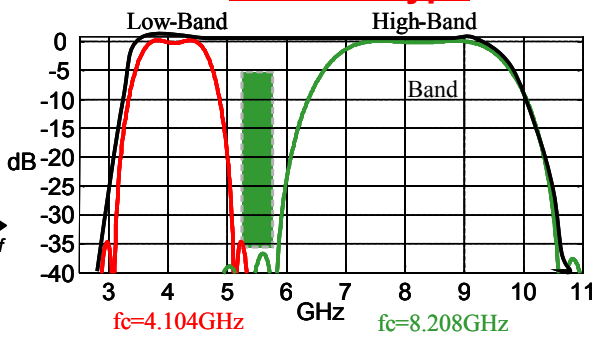
Impulse Radio type



MB-OFDM type



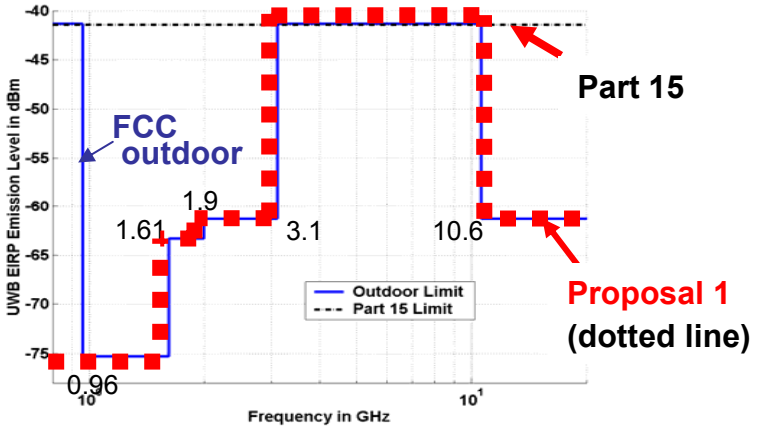
DS-UWB type



Draft Proposals for emission power spectral mask (Feb.2, 2004)

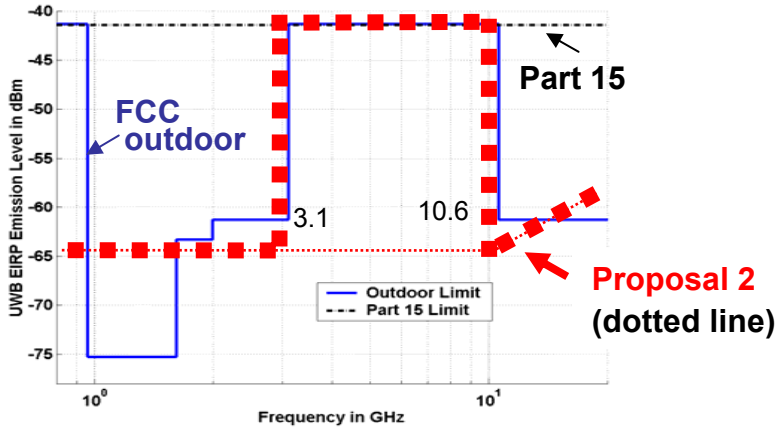
<Proposal 1>

Based on FCC Outdoor specifications



< Proposal 2>

Standards for Extreme Low Power Stations in Japan applied to portion of spectrum outside the range 3.1 – 10.6 GHz



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UWB Interference Measurement Report of

MMAC Forum, Japan

UWB Demonstration Experiments Task Force

(Over 30 companies joined during March-August 2005)

Victim systems are categorized to 5 groups to test

① Fixed Micro systems
② Broadcasting (Analog FPU, Digital FPU)
③ Satellite • Base station (GPS, Mobile BC, FSS)
④ Cellular phones (1xEV-DO, PDC, WCDMA)
⑤ Wireless Access (WLAN IEEE802.11a, 11j)

The common UWB interference signal sources are as follows.

① MB-OFDM (made by Wisair , offered by Ti/Intel)
② DS-UWB (made and offered by FSL)
③ IR (PRF =1M& 10MHz) (made and offered by NICT)
④ AWGN

UWB Interference Measurement Report of

MMAC Forum, Japan

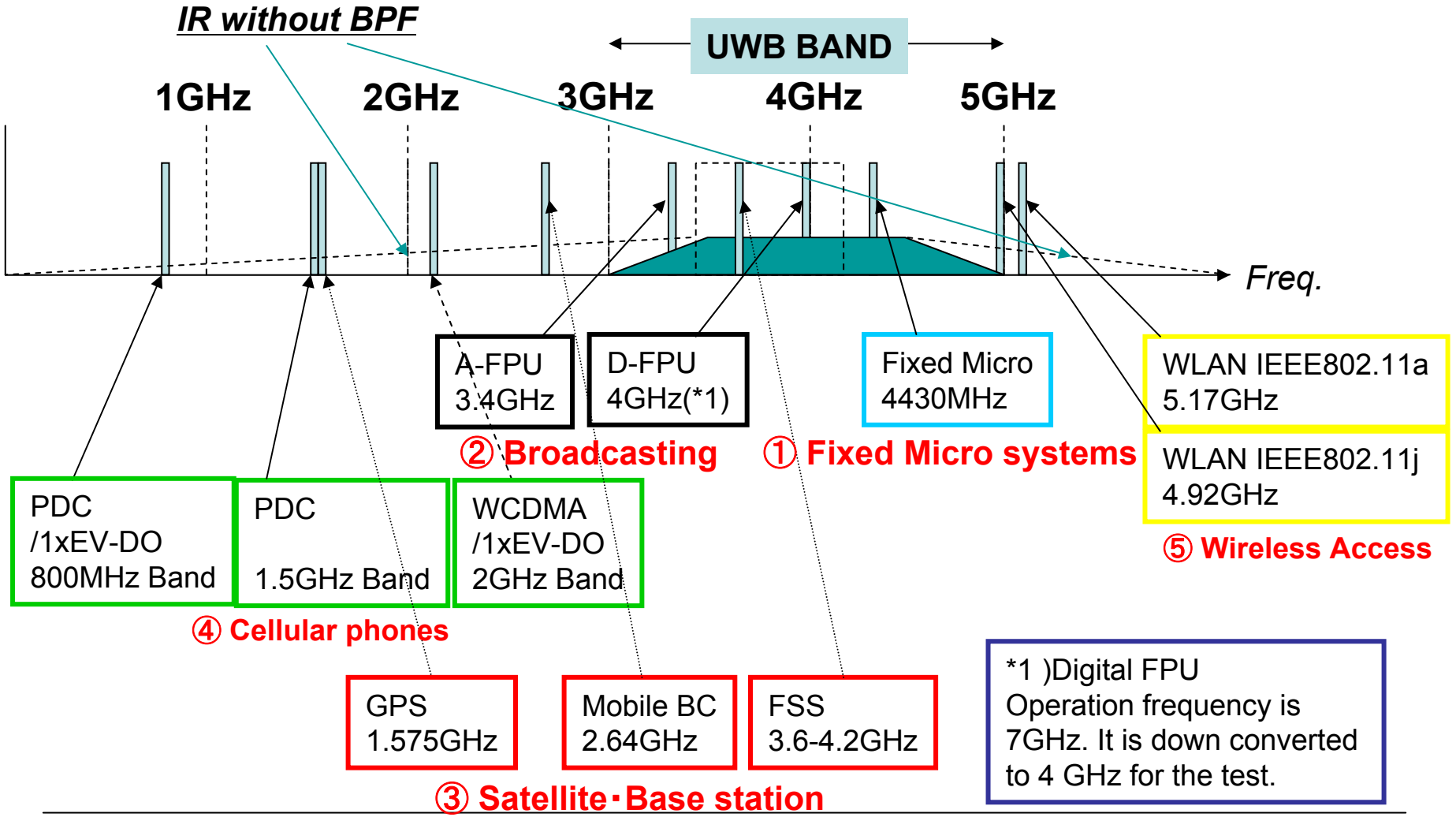
http://www.arib.or.jp/mmac/e/index.htm

UWB Demonstration Experiments Task Force

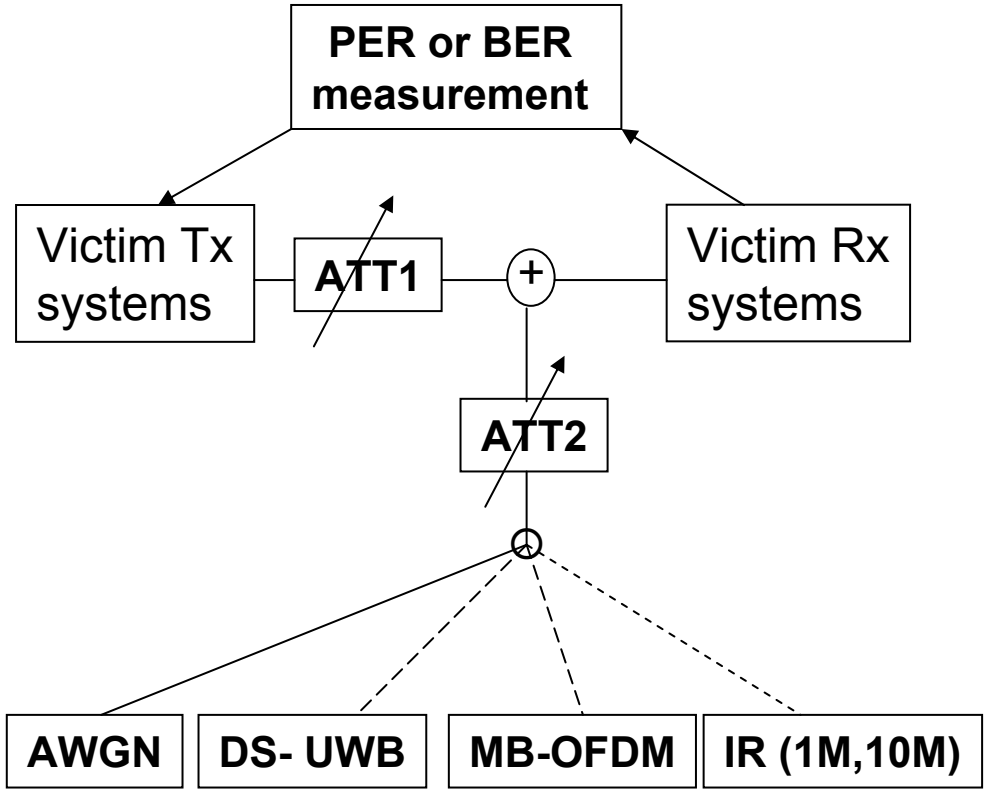
Over 30 companies joined

Intel
Willcom
Space Communication Corporation
NEC TOSHIBA Space Systems, Ltd.
NHK Science & Technical Research Laboratories
NTTDoCoMo
FM Tokyo
KDDI
JSAT
NICT
Advanced Space Business Corporation
SONY
TDK
TV Asahi
TV Tokyo
TOKYO ELECTIRC POWER,
TBS
Japan TI
NTV
NTT
NAB (The National Association of Broadcasters in Japan)
JRC
Hitachi
Fujitsu
Fuji TV
FSL
Furuno Systems
Nippon Cultural Broadcasting
Matsushita
Mitsubishi
Mobile Broadcasting
YOKOGAWA Electric

Spectral Allocation of Tested Victim Systems



Simplified Common Experiment Scheme ~ Always Wired~



General test flow

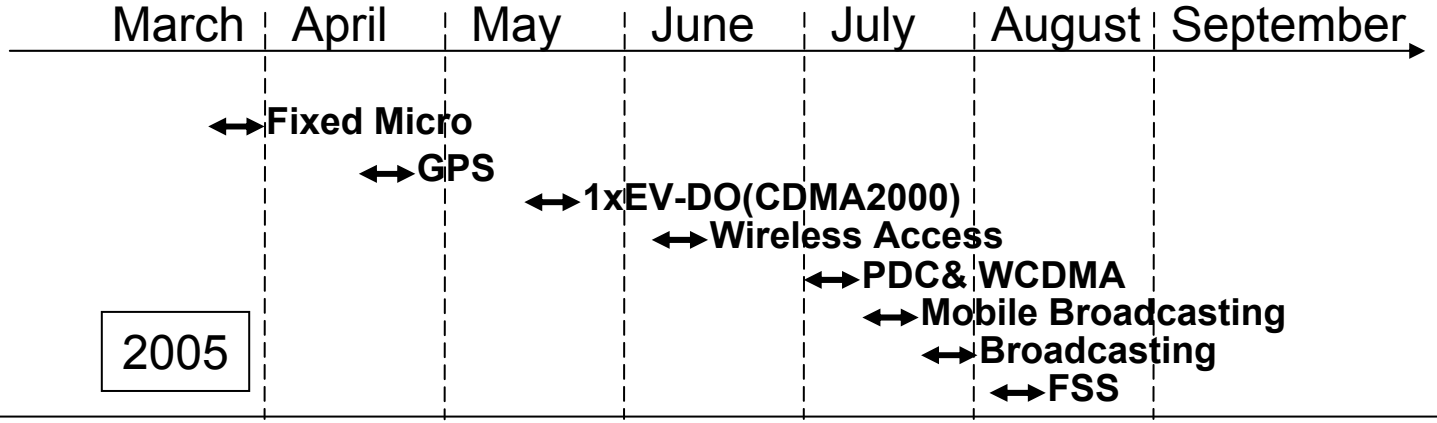
1. 'Minimum sensitivity' is measured by desired signal only

2. Set desired signal to a certain level from 'Minimum sensitivity', and
3. Measure PER/BER by adding various level of interference signals

4. The output is C/N vs. BER (PER)

TEST TIME TABLE

Group	Tested system	Test Done at	Reported to Telecommunication council
Fixed Micro systems	Fixed Micro	Mar.22-24	Done at August 25th. Therefore, the report is open to the public.
Broadcasting	Digital FPU Analog FPU	July 19-20	
Cellular phones	1xEV-DO	May 23-26	
	PDC&WDCMA	July 4-6	
Satellite・Base station (Common test done April 11th)	GPS	April 19-20	
	Mobile Broadcasting	July 11-12	Not open yet as of Sep. 7th
	FSS	August 2-5	Not open yet as of Sep. 7th
Wireless Access	11a, 11j	June 7-9	Not open yet as of Sep. 7th



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Spectral Mask of CEPT(1/2)

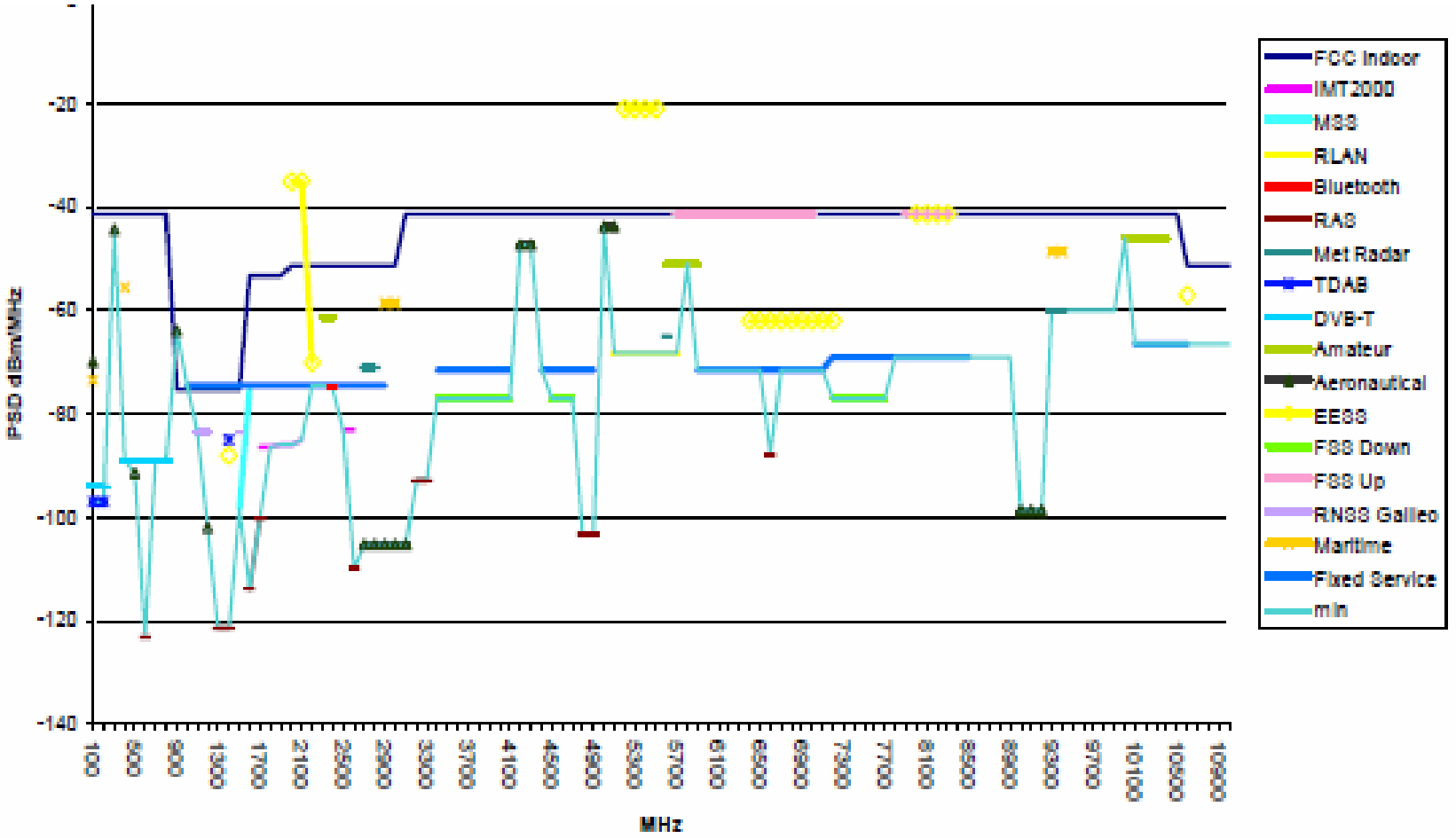


Fig. 1 Comparison between CEPT and FCC Mask

Spectral Mask of CEPT(2/2)

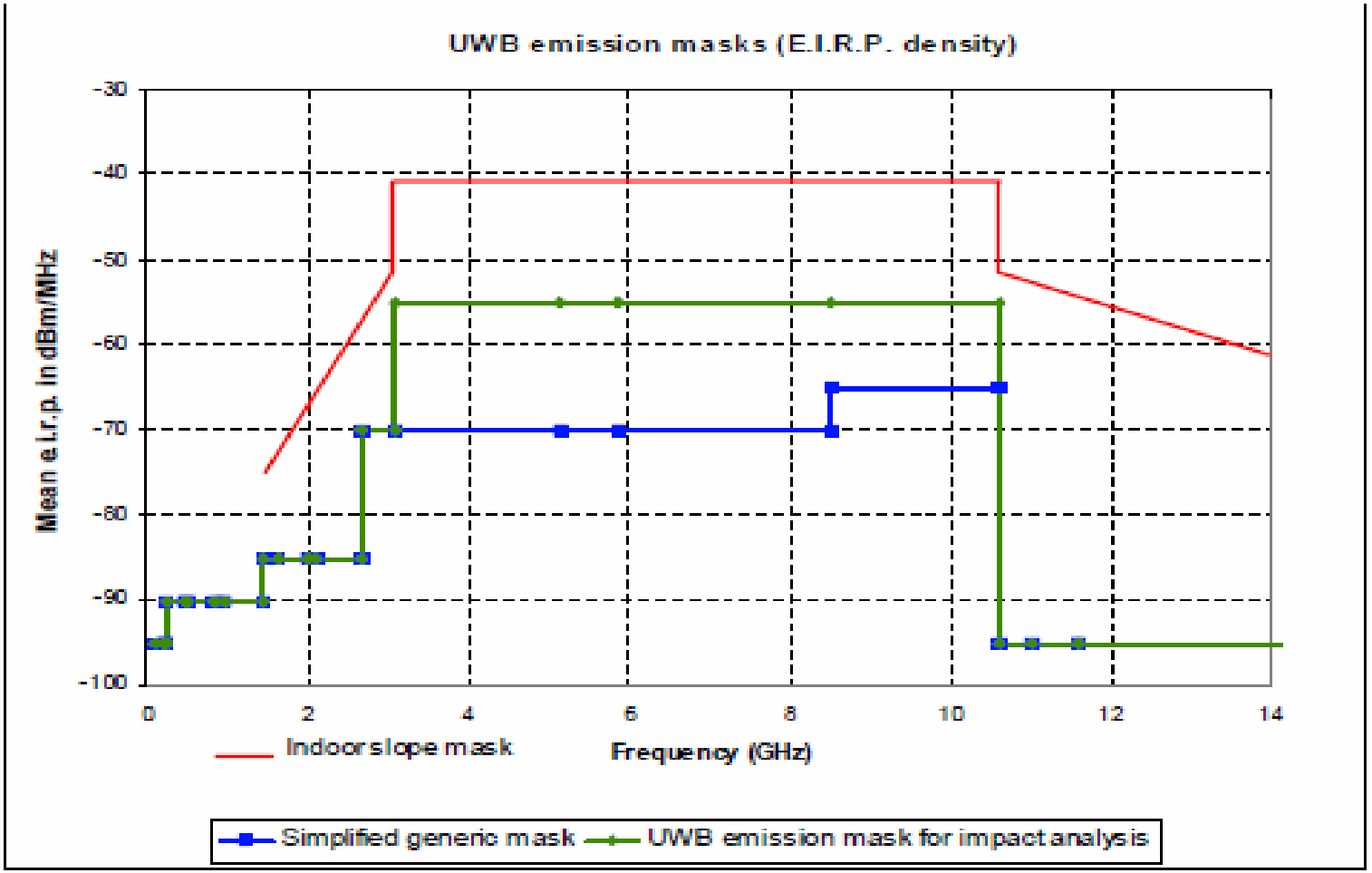
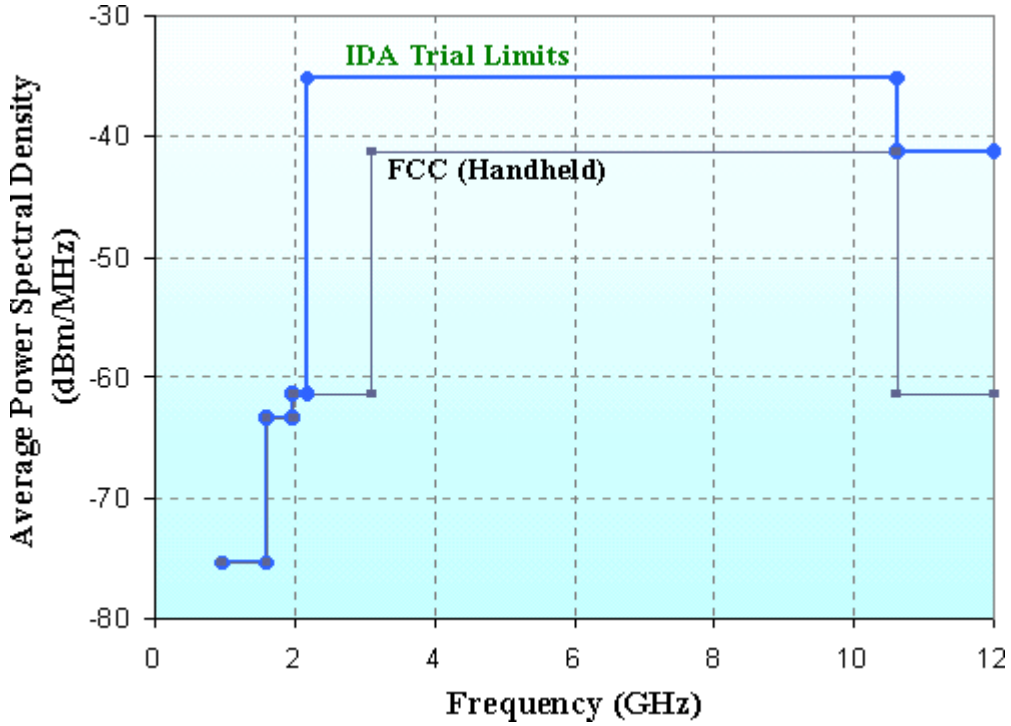


Fig. 2 Switzerland Proposed Mask to ITU-R TG1/8

Present Regulations for UWB in Singapore

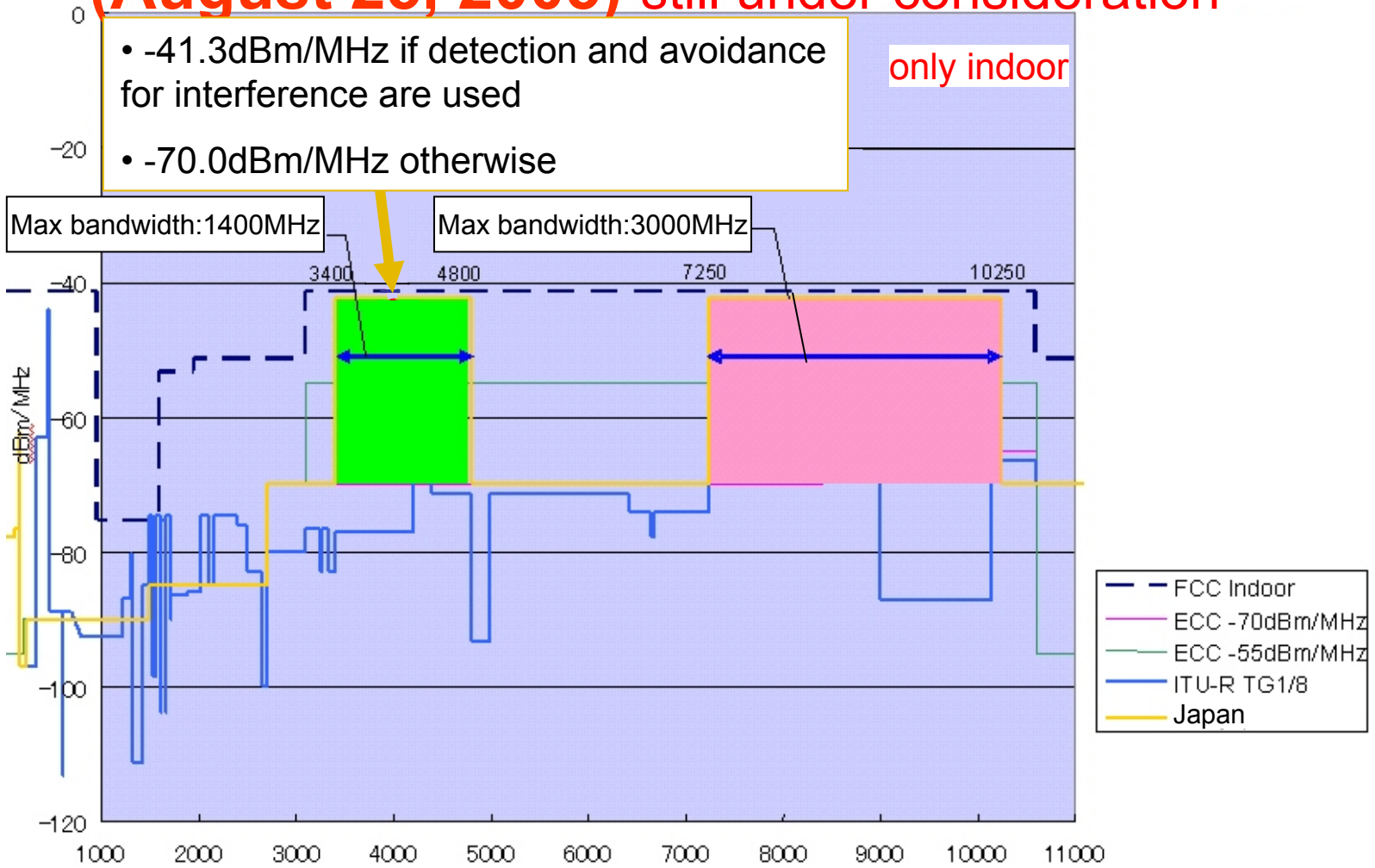
- Impose slightly less stringet emission limits to encourage experimentation and innovation
- UWB operation is permitted for demonstration or trial purpose
  - FCC's Limits applicable to demo use
  - IDA's trial emission mask applicable to trial use



Reference:
http://www.ida.gov.sg/idaweb/techdev/infopage.jsp?infopagecategory=18:techdev&versionid=4&infopageid=I2107

Draft Spectrum Mask in Japan (MIC)

(August 25, 2005) still under consideration



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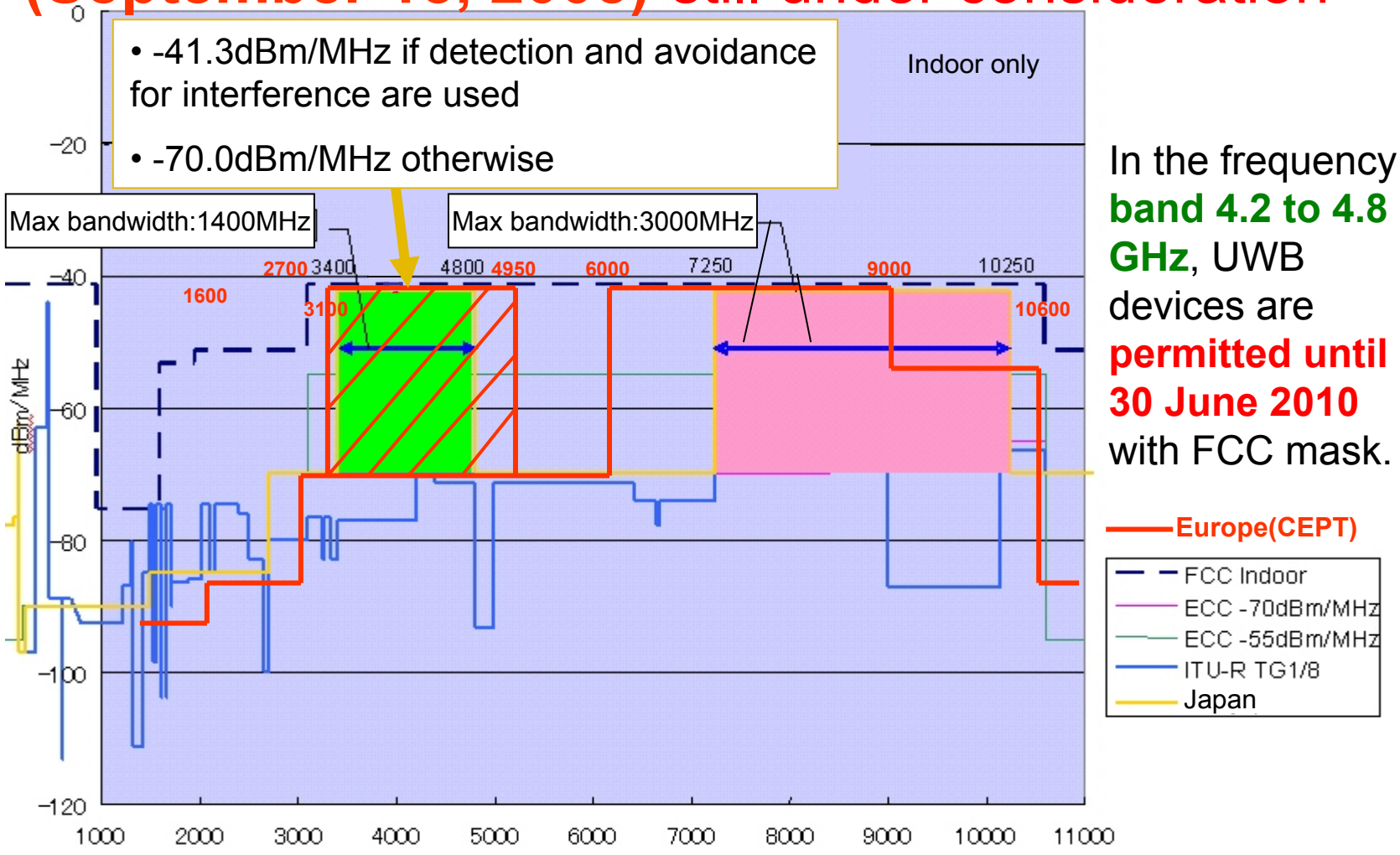
Last EU Regulatory News (Sept.15, 2005)

	General Devices witout Mitigation (Indoor)				Detect and Avoid (DAA)		Low Duty Circly Devices	
Agreed			No Mitigation		Mitigation+Indoor		5% / Sec AND 0,5% / Hour	
Frequency	GHz		Average	Peak	Average	Peak	Average	Peak
below	1,6		-90	-50				
1,6	2,7		-85	-45				
2,7	3,1		-70	-30	Agreed		Proposed (To be finalised in Nov. 2005)	
3,1	4,95		-70	-30	-41,3	0	-41,3	0
4,95	6		-70	-30				
6	9		-41,3	0				
9	10,6		-65	-25				
avove	10,6		-85	-45				
			dB/MHz	dB/50MHz	dB/MHz	dB/50MHz	dB/MHz	dB/50MHz
		4,2-4,8 FCC until 2010 to allow USA devices on Europe Market in 2006						

DRAFT for DECISSION ,
Still NOT FINAL

Draft Spectrum Mask in Europe (CEPT)

(September 15, 2005) still under consideration



In the frequency **band 4.2 to 4.8 GHz**, UWB devices are **permitted until 30 June 2010** with FCC mask.

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Issues for IEEE802.15.4a Corresponding to These Spectral Masks

- Although IEEE802.15.4a is primarily US standard, it should be world-wide compliant for a world trade.
- Specification in TG4a has been mostly decided and should be finalized as soon as possible within this year or before next March for marketing.
- The regulators need to know feasibility of implementing 3a & 4a devices compliant to the masks including DAA (Detection and Avoidance of interference to 4G etc) before finalizing the regulation for UWB by the same deadline as well.
- What shall we modify specification to make it world-wide compliant?

What shall we modify 4a's specification to make it world-wide compliant?

Suggested minor modification in specification:

- Band plan: 3-5GHz with DAA, 6-10GHz without DAA
- Modulation: Sequence, PRF, Pulse Shape, FEC
- MAC: Carrier and Energy Sensing for other radios
- Ranging: interference from coexisting radios
- CSS: compliance in 2.4GHz band
- Extra Functions: DAA

Suggested minor modification in specification (2/3)

- Band plan: 3-5GHz with DAA, 6-10GHz without DAA
  - **6-10GHz should be involved as well as 3-5GHz.**
  - Common subbands allocation for European and Japanese masks as well as FCC's one.
- Modulation: Sequence, Pulse Shape, PRF, FEC
  - **To shape UWB signal spectrum for avoiding interference to victim radios**, e.g. 4G, **sequence and pulse shape can be designed to make notches in spectral shape.** PRF should be also high enough for low interference.
  - **To protect UWB devices against interference from strong coexisting radios, e.g. 4G**, **FEC should be designed with enough error-correcting capability so as to match with error features like error burst statistics.** Super-orthogonal convolutional (SOC) codes with low encoding and decoding complexity and others are suggested.

Suggested minor modification in specification (3/3)

- MAC: carrier and energy sensing other radios as well
  - To achieve DAA adaptively, we need to sense a victim radio's signal like cognitive radio concept.
  - DAA may need modification of MAC as well as PHY. CBP (Contention-Base Protocol) requested by FCC could be introduced to 4a as well.
- Ranging: interference from coexisting radios
  - Investigate ranging performance degradation due to interference from coexisting radios.
  - Make ranging more secure and robust against jamming and the interference.
- CSS: compliance in 2.4GHz band
- Extra Functions: DAA

Feasible Implementation of DAA for IEEE802.15.4a

Adaptive interference avoiding techniques by SSA

Soft-Spectrum Adaptation (SSA)

Adaptive band eliminating filter

- Analog Implementation
- Digital Implementation or hybrid

Adapative pulse shaping

- Pulse shaping by high-speed DAC
- Pulse shaping by combining an wavelet

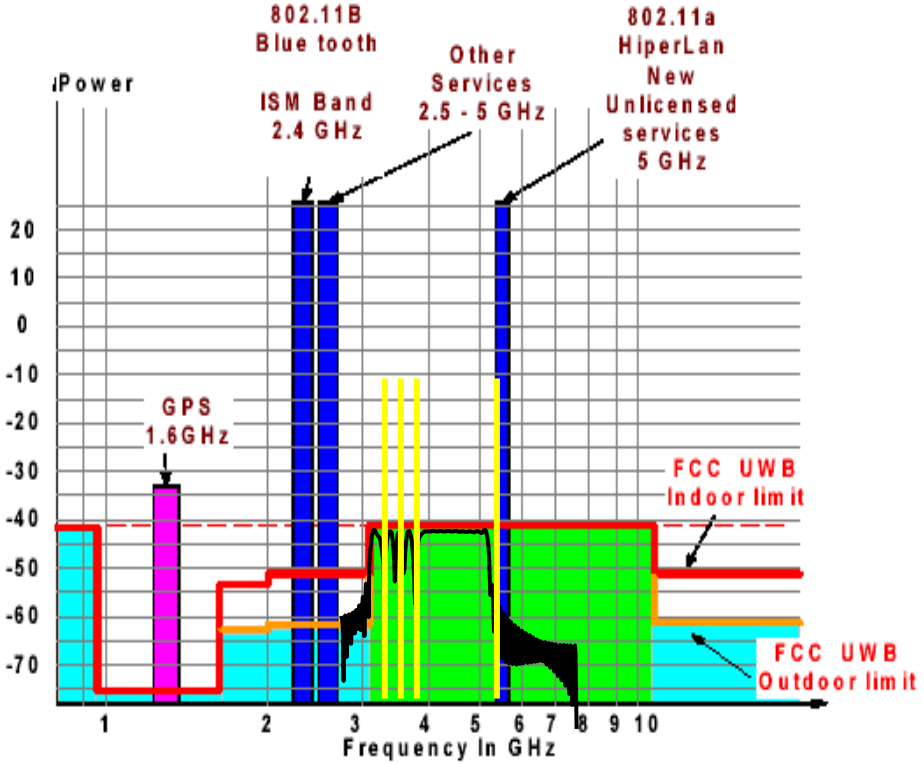
Ref. Modified pulse shapes based on SSA for interference mitigation and systems coexistence (update), Doc: IEEE 802.15-03-0457-00-003a

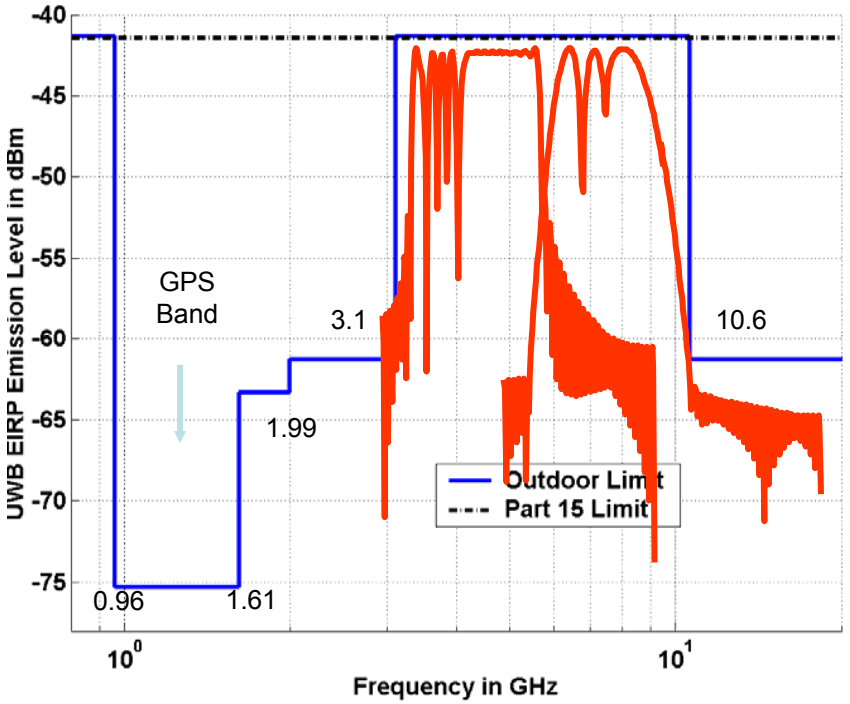
Adaptive spreading sequence

- Spectrum null coding

Ref. Alternative Spreading Code and Channel Code for IEEE802.15.4a, Doc: IEEE 802.15-05-0462-01-004a

Global harmonization and compliance utilizing optimized SSA-UWB pulse wavelets





Ref. Modified pulse shapes based on SSA for interference mitigation and systems coexistence (update), Doc: IEEE 802.15-03-0457-00-003a

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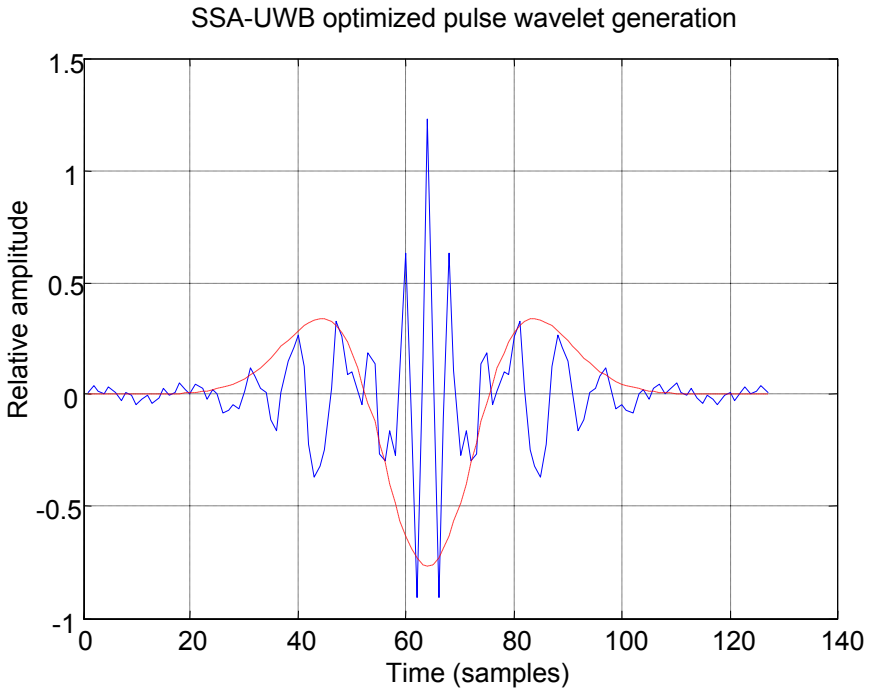
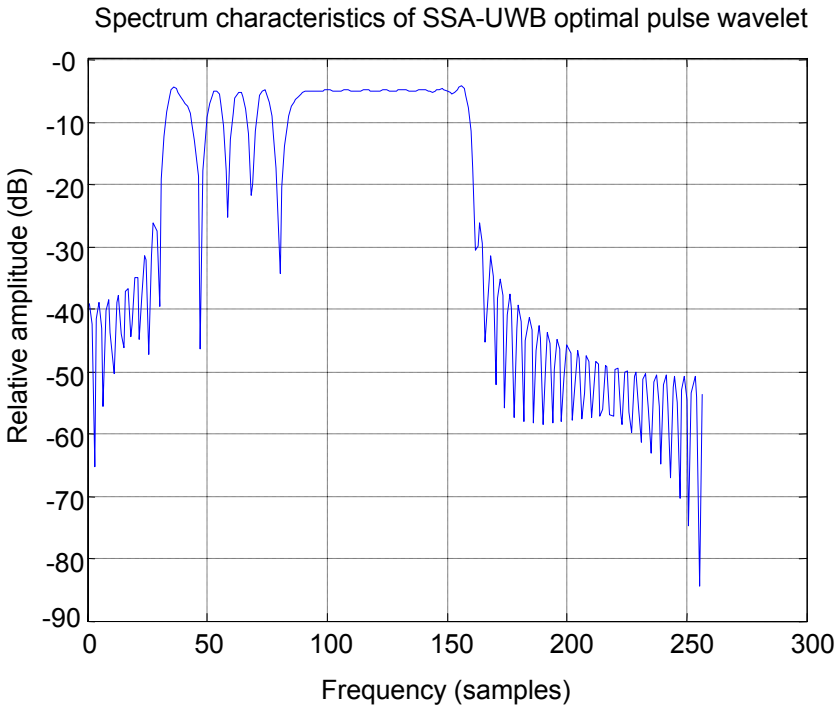
Optimized SSA-UWB pulse wavelet with adaptive spectral notches achieving coexistence, flexibility and efficient power transmission





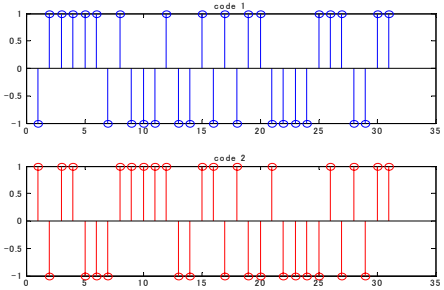
Ref. Modified pulse shapes based on SSA for interference mitigation and systems coexistence (update), Doc: IEEE 802.15-03-0457-00-003a

Matched spectral null coding

Case 0: [1 0 1 1 0 1] → [1 0 0 1 1 1 0 0 0 1 1 0]

Case 1: 4 successive bits are encoded into 1 symbol.

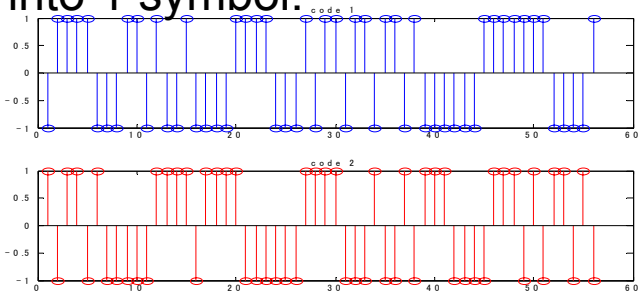
Case 2: 6 successive bits are encoded into 1 symbol.



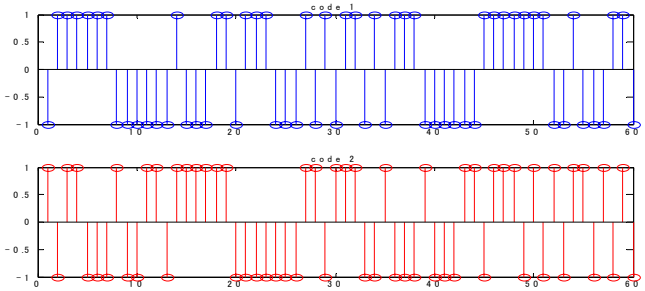
PBTSs
(energy detection)

Matched spectral null coding

Case 1

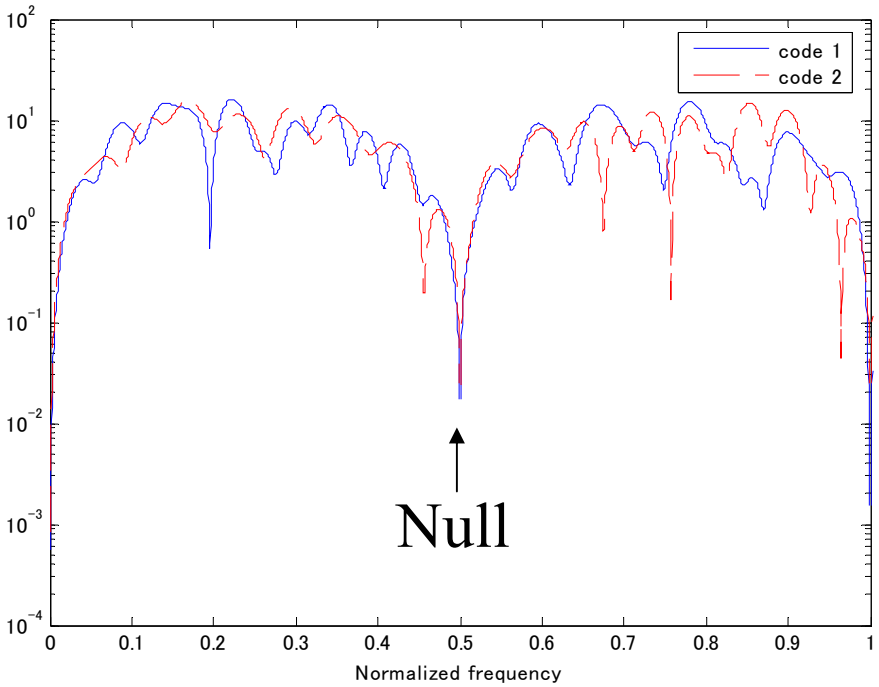


Case 2

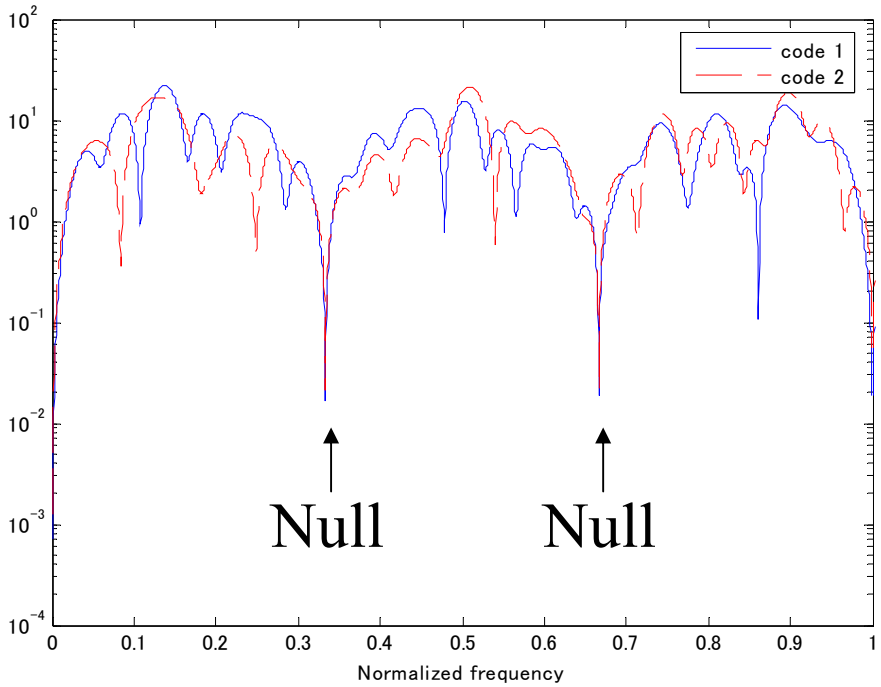


Ref. Alternative Spreading Code and Channel Code for IEEE802.15.4a,
Doc: IEEE 802.15-05-0462-01-004a

Spectra of Matched spectral null coded PBTS



Case 1



Case 2

Ref. Alternative Spreading Code and Channel Code for IEEE802.15.4a, Doc: IEEE 802.15-05-0462-01-004a

Concluding Remark

- Although a global single regulation for UWB may not be agreed soon, UWB business will soon start or has already started if regional regulation is not much different. Regional and international consensus are important for a world trade.
- If DAA (detection and avoidance) of interference to coexisting systems is implemented with reasonable cost, then a lower band(3-5GHz) for UWB will be available. Otherwise, a higher band(7-10GHz) will be first applied. However, this is not the best solution but we need effort for a better solution.
- Manufactures developing both 4G and UWB systems should focus on reasonable solution to succeed both businesses while common carrier operators make better business model for integrated services of 4G and UWB.
- IEEEP802.15 can contribute a fewer spectral masks in a world.