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

Submission Title: [Continuous Spectrum (CS) UWB signal]

Date Submitted: [July 21, 2005]

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Abstract: [Continuous Spectrum (CS) UWB signal is presented.]

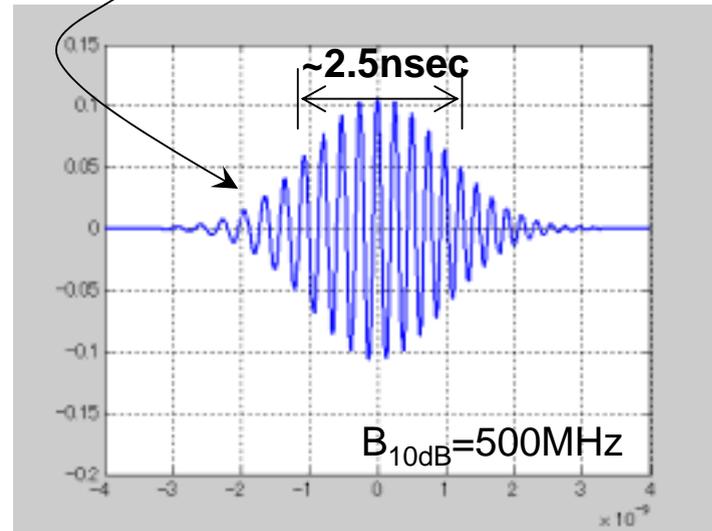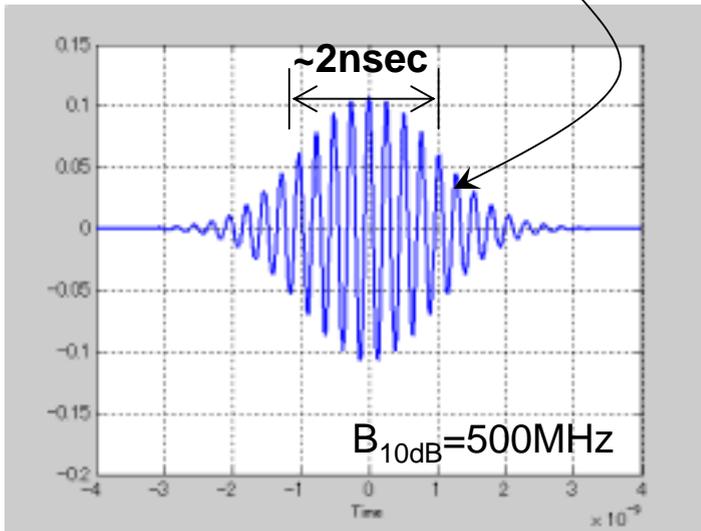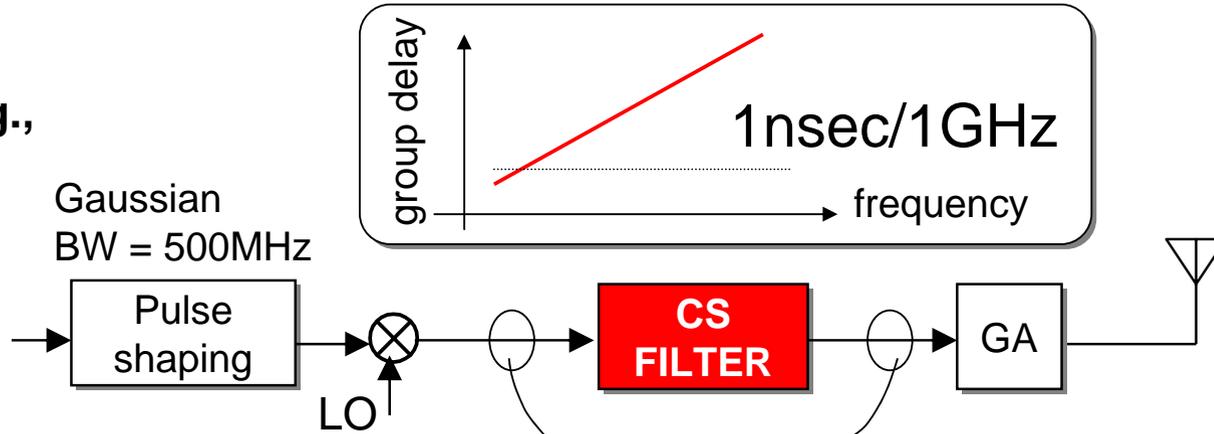**Purpose:** [To forward the discussion within 15.4a group]

- This presentation gives the answer for the question to the NICT's presentation (15-05-0440-00-004a).

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Continuous spectrum (CS) UWB signal

e.g.,

group delay

1nsec/1GHz

frequency

Gaussian
BW = 500MHz

Pulse
shaping

LO

CS FILTER

GA

~2nsec

B_{10dB}=500MHz

~2.5nsec

B_{10dB}=500MHz

CS: Continuous Spectrum   Slide   3   Hara, Takizawa, Ikegami, Kohno (NICT)
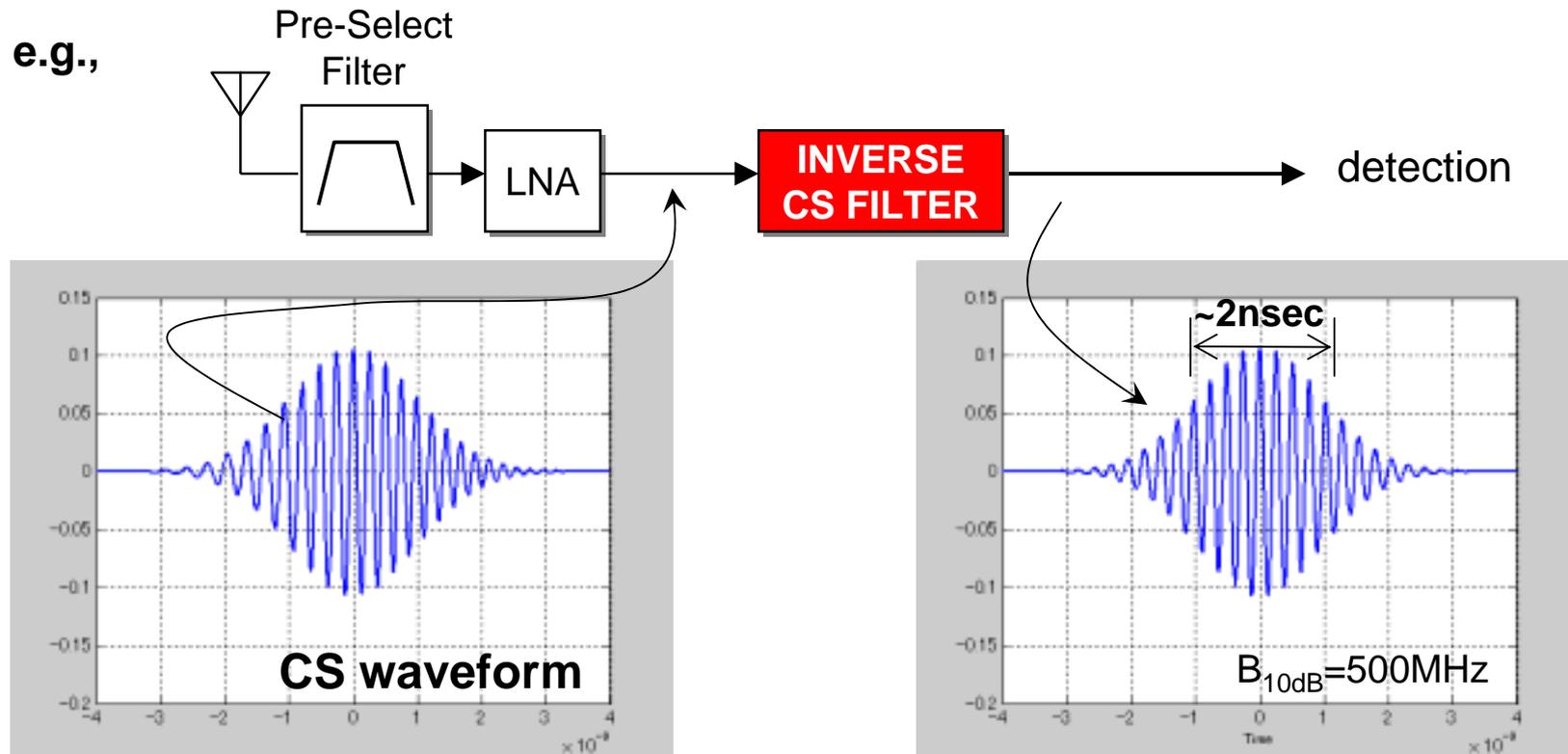
What is the difference between input signal and output signal ?

**Only the time-frequency distribution of signal energy is different**

Gaussian waveform

time

input

frequency

~2nsec

CS FILTER

CS waveform

time

output

frequency

~2.5nsec

Ordinary chirp

>10nsec

Inverse CS filter

e.g.,

Pre-Select Filter

LNA

INVERSE CS FILTER

detection

~2nsec

CS waveform

B_{10dB}=500MHz
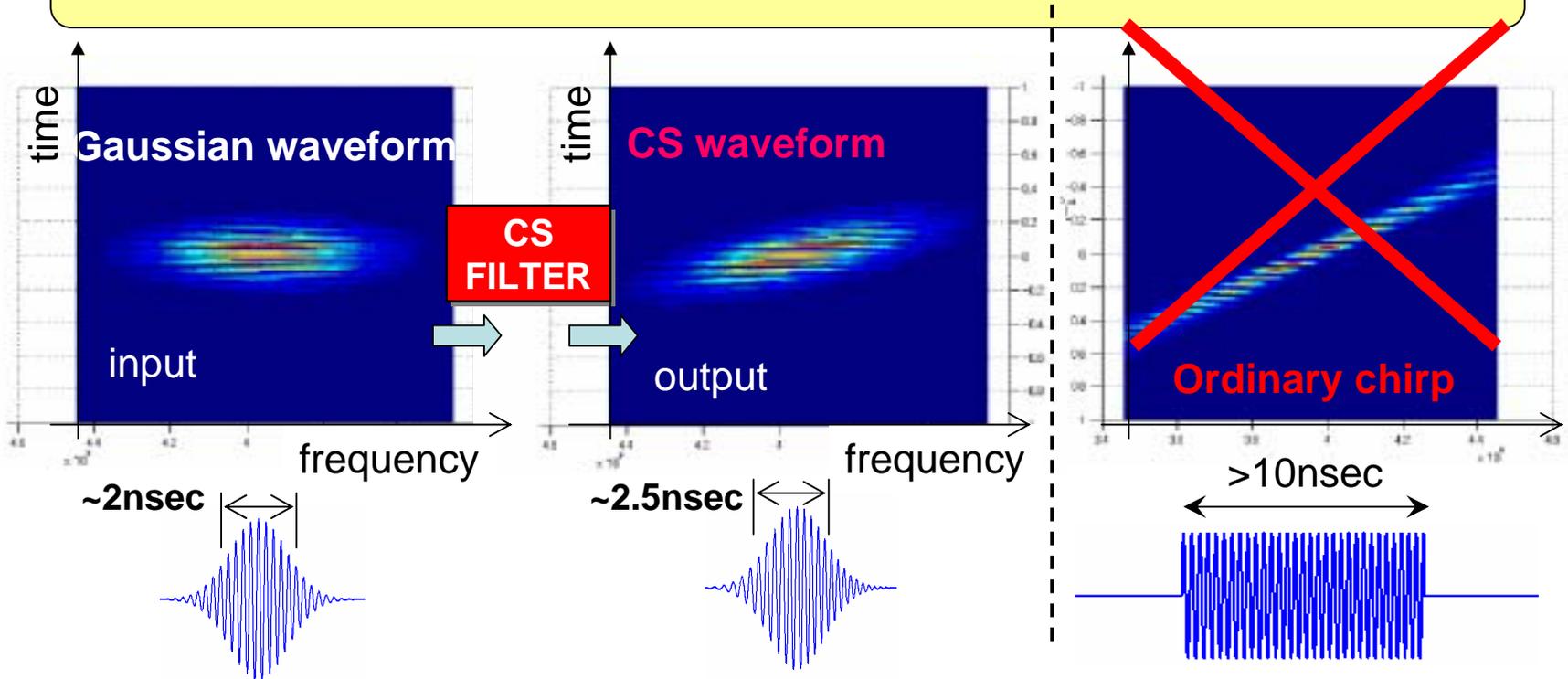
CS waveform is inversed to the input signal before the CS filter at TX

Soft-Spectrum Adaptation* UWB waveforms

➤ Design a proper pulse waveform with high frequency efficiency corresponding to any frequency mask.

➤ Adjust transmitted signal's spectra in flexible so as to minimize interference with coexisting systems.
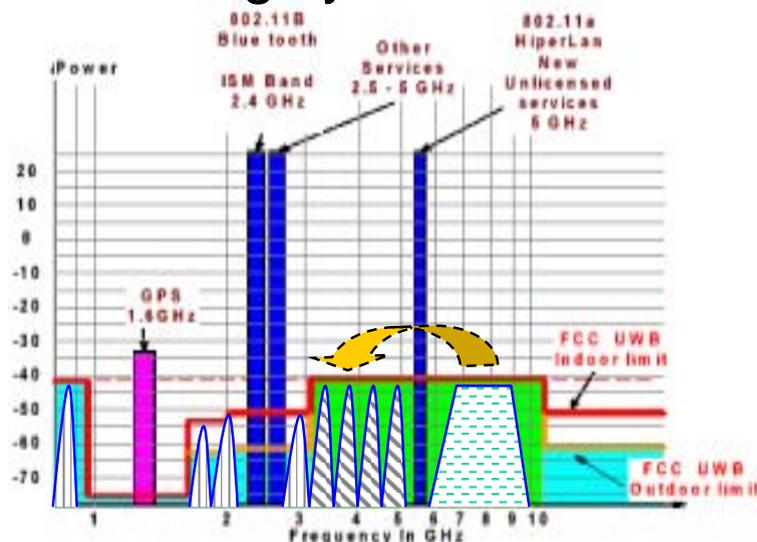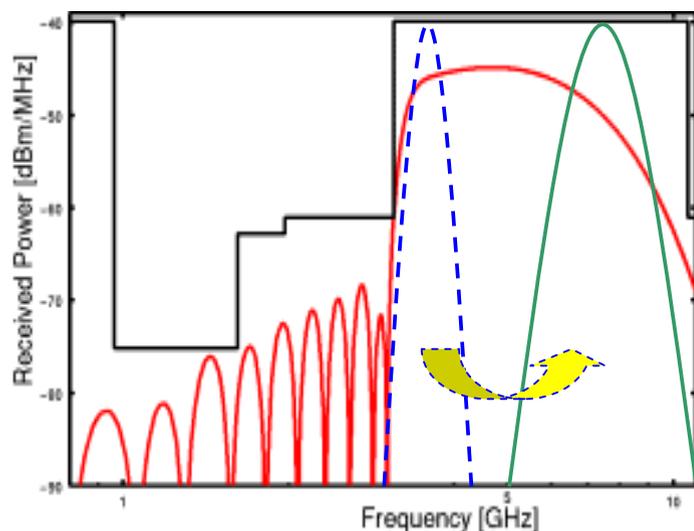
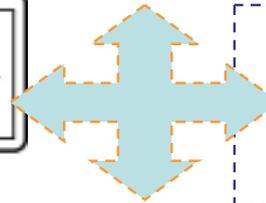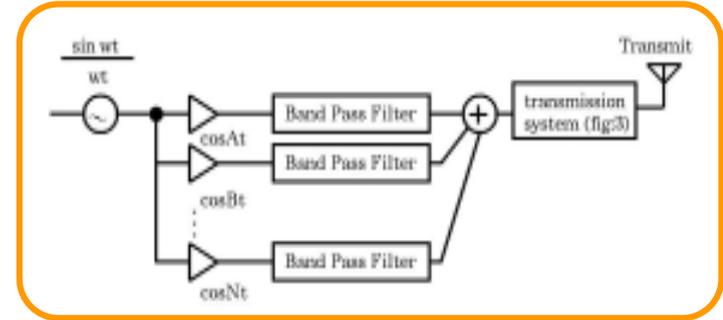
Soft-Spectrum Adaptation (SSA) ***:03097r5P802-15_TG3a**

Basic Formulation

$$f(t) = \sum_{k=1}^{N} f_k(t)$$
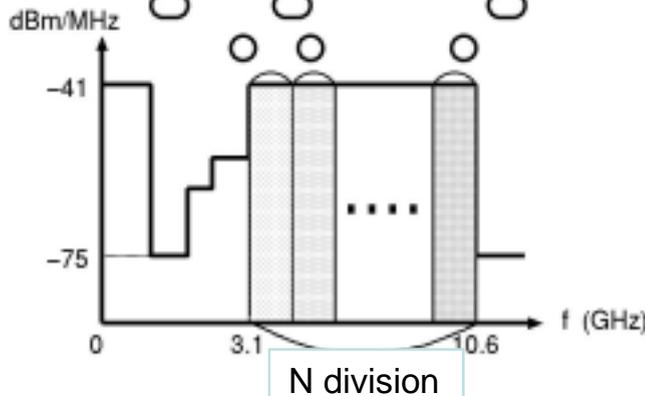
Synthesize a proper pulse waveform

In case of multiband, a kernel function is a sinusoidal function.
In case of impulse radio, a kernel function is a Gaussian, Hermitian pulse function etc.
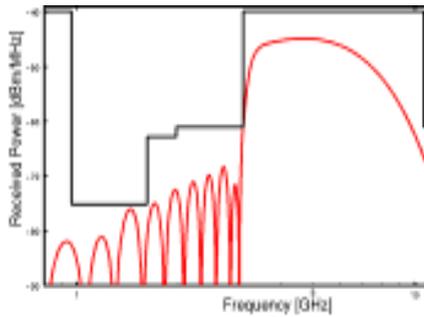
Example of Pulse Generator

N division

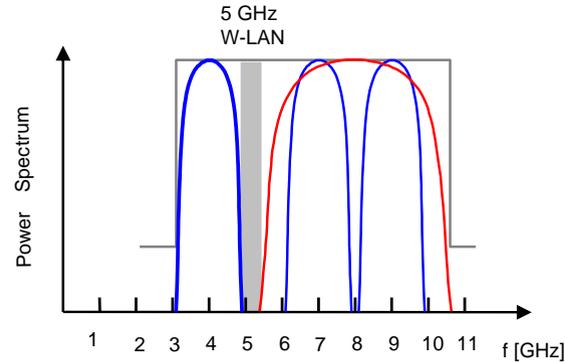## Feasible Solution: Pulse design satisfying Spectrum Mask

➢ Divide (spread-and-shrink) the whole bandwidth into several sub-bands →
Soft Spectrum (spectrum matching)
➢ Pulse synthesized by several pulses that have different spectra →
Soft Spectrum, *M*-ary signaling

Soft-Spectrum Adaptation (SSA) with Flexible Band Plan
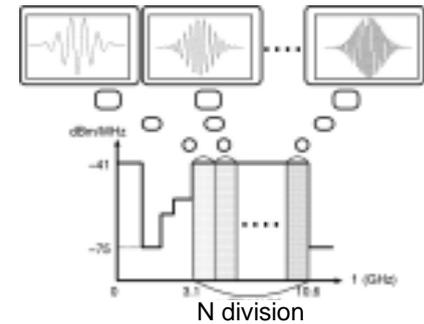
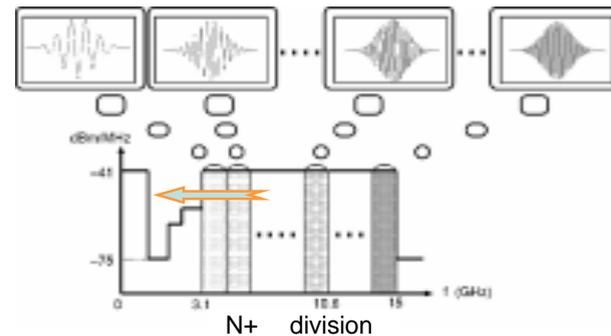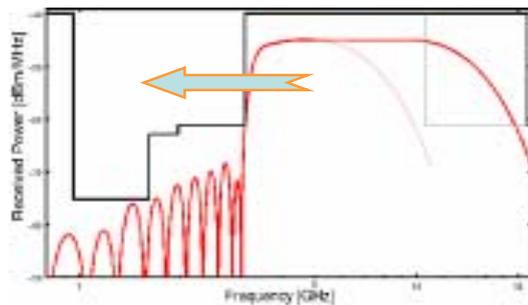Single-band   Dual- or Triple-band   Multi-band

In the future, if the restricting ruggedness of regional spectral mask (e.g. FCC mask) is eased, band allocation can be extended below 3.1 GHz or above 10.6 GHz.

Soft-Spectrum Adaptation (SSA) can correspond freely

# *Soft-Spectrum* Adaptation(SSA) Classification

(1) Free-Verse Type of SSA

→ A kernel function is non-sinusoidal, e.g. Gaussian, Hermitian pulse etc.

→ Single band, Impulse radio

(2) **Geometrical Type of SSA**

→ A kernel function is sinusoidal with different frequency.

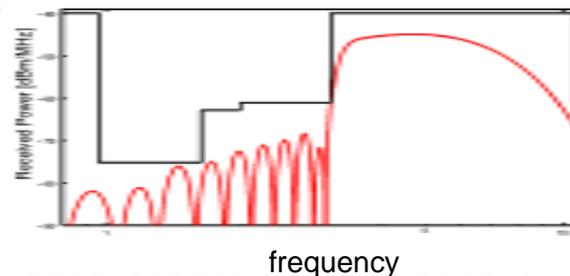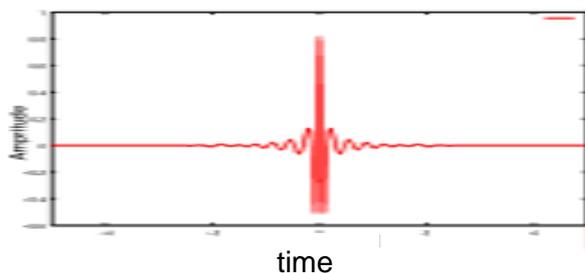→ Multiband with carriers and Multi-carrier

→ **Continuous spectrum (CS)** UWB

(1) Free-verse Type Soft-Spectrum Adaptation

→ Freely design pulse waveforms by synthesizing pulses, e.g. overlapping and shifting

time   frequency
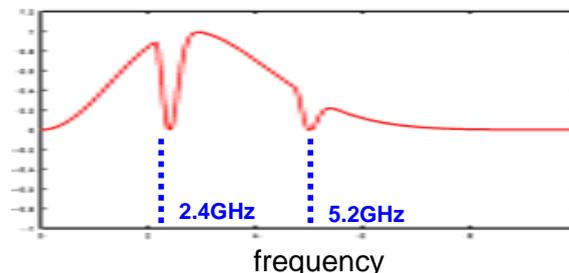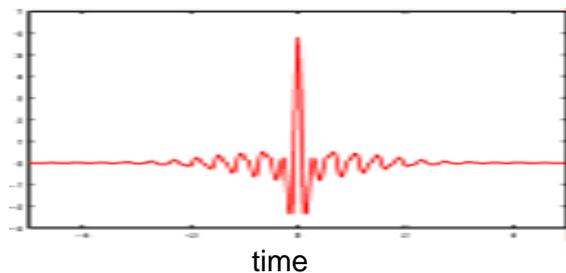
K-3 Free-verse *Soft-Spectrum* Adaptation pulse
(Note: band notches *clearly* happen at 2.4 and 5.2 GHz as well)

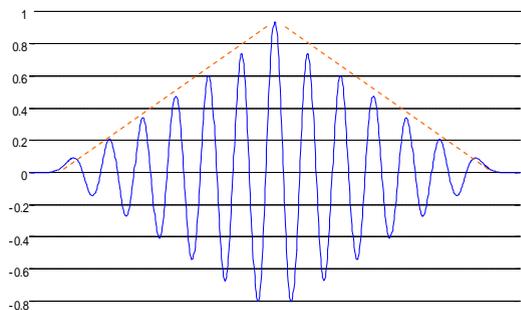time   frequency
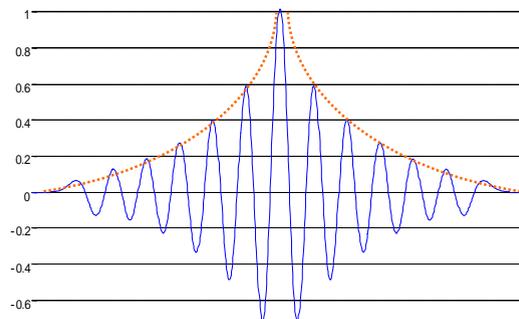
K-4 Free-verse *Soft-Spectrum* Adaptation pulse
(Note: pulse waveform has more freedom)
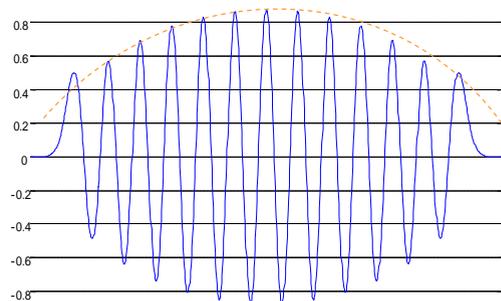
(2) Geometrical Type Soft-Spectrum Adaptation

→ Freely design pulse waveforms using various geometrical type envelopes

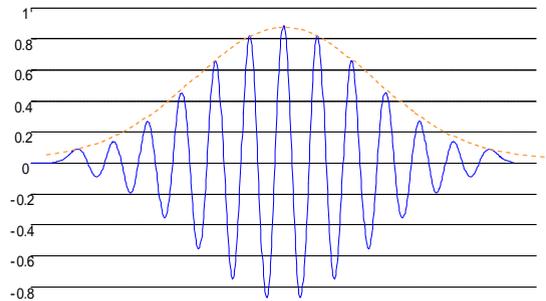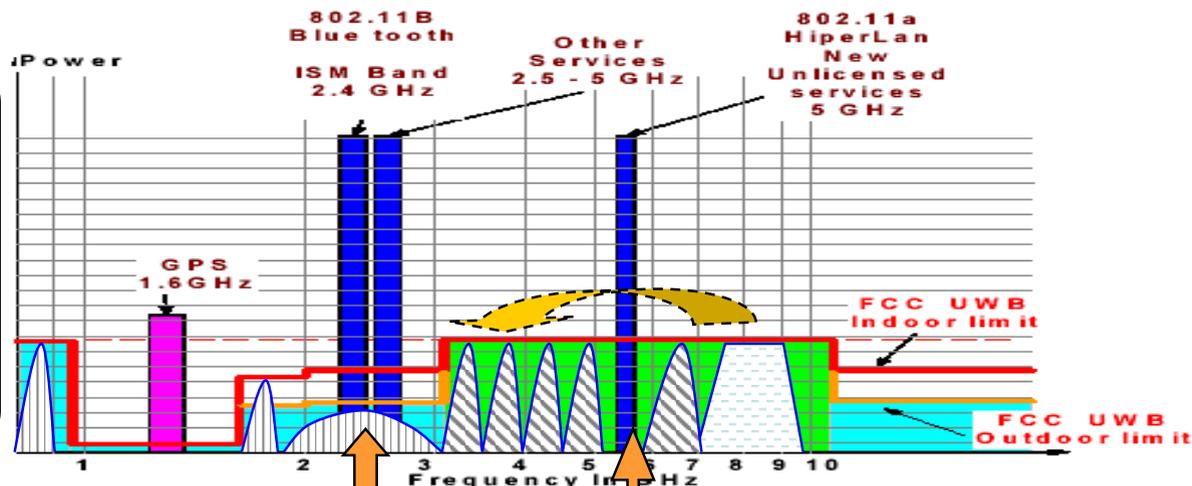Triangular-type envelope

Exponential-type envelope

Cosine-type envelope

Gaussian-type envelope

Global Coexistence with other Potential Interferences

➢Multiband/OFDM:
Only (b) is available
➢*SSA:*
Both (a) and (b) are
available

(a) Use of frequency band having low
emission limit, but the same pulse energy is
available by using wider bandwidth.

(b) Simply eliminate the
band if other services
exist.

➢ If more potential interferer should be considered, (b)
does not work because it simply reduce the signal energy.

➢ *Soft-Spectrum Adaptation* (SSA) approach provides more
option to overcome future potential coexistence issue.

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Features of *Soft-Spectrum* Adaptation (SSA)

➢ *Soft-Spectrum Adaptation* (SSA) with flexible pulse waveform and frequency band can perform single and multiband UWB by
  → *Free-verse type* pulse waveform shaping and
  → *Geometrical type* pulse waveform shaping, respectively.
➢ Interference avoidance for co-existence, harmonization for various proposals, and global implementation can be carried out by *SSA*.
  → *SSA* can flexibly adjust UWB signal spectrum so as to match with spectral restriction in transmission power, i.e. spectrum masks in both cases of *single* and *multiple* bands.
➢ Scalable, adaptive performance improvement
➢ Smooth system version-up similar to *Software Defined Radio* (SDR).

Harmonization Based on *Soft-Spectrum* Adaptation

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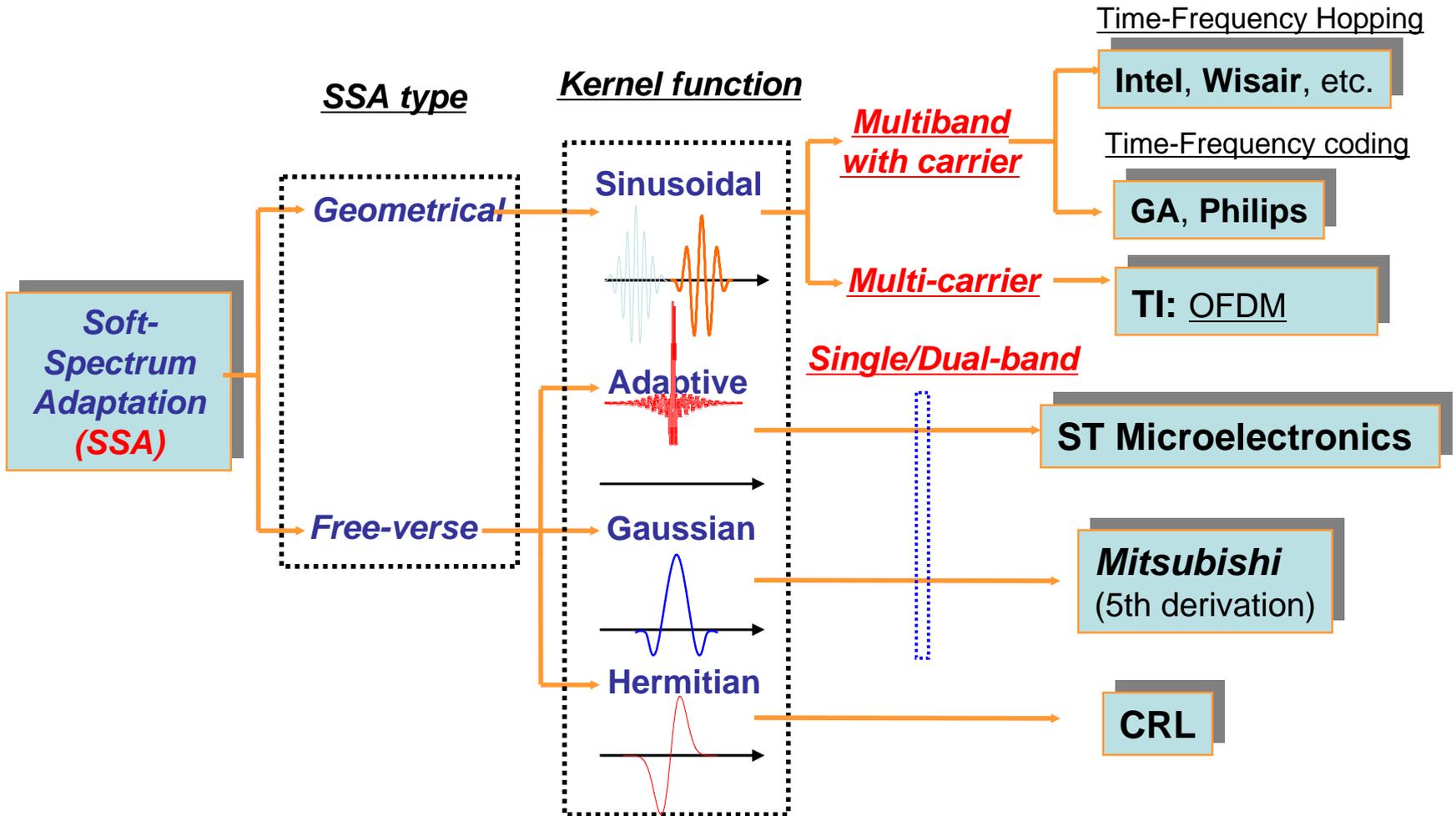
Concluding remarks

- ## Continuous Spectrum UWB
  - CS UWB signal is generated by a CS filter
  - **The difference between input and output signal of CS filter is only the time-frequency distribution of signal energy.**
  - **The time-frequency distribution of CS signals is different from that of ordinary chirp signals.**