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

Submission Title: [Continuous Spectrum (CS) UWB signal]  
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Source: [Kenichi Takizawa, Shinsuke Hara, Tetsushi Ikegami, Ryuji Kohno; NICT]  
Contact: Ryuji Kohno  
Voice: [E-Mail: kohno@nict.go.jp]  
Abstract: [Continuous Spectrum (CS) UWB signal is presented.]  
Purpose: [To forward the discussion within 15.4a group]  
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• This presentation gives the answer for the question to the NICT’s presentation (15-05-0440-00-004a).
Continuous spectrum (CS) UWB signal

**e.g.,**

Gaussian

BW = 500MHz

Pulse shaping

CS FILTER

GA

LO

~2nsec

~2.5nsec

B_{10dB}=500MHz

B_{10dB}=500MHz
What is the difference between input signal and output signal?

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

- Input: Gaussian waveform
  - Time: ~2 nsec
  - Frequency: ~2.5 nsec

- Output: CS waveform
  - Time: ~2 nsec
  - Frequency: ~2.5 nsec

- Ordinary chirp: >10 nsec

CS: Continuous Spectrum
Inverse CS filter

e.g.,

Pre-Select Filter

LNA

INVERSE CS FILTER

detection

CS waveform

CS waveform is inversed to the input signal before the CS filter at TX

CS: Continuous Spectrum
**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.
**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**

**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*
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

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

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
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.
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**

**SSA type**

- Geometrical
- Free-verse

**Kernel function**

- Sinusoidal
- Adaptive
- Gaussian
- Hermitian

**SSA type**

- *Multiband with carrier*
- *Multi-carrier*
- *Single/Dual-band*

**SSA type**

- *Time-Frequency Hopping*
- *Time-Frequency coding*
- *TI: OFDM*
- *Intel, Wisair, etc.*
- *GA, Philips*
- *ST Microelectronics*
- *Mitsubishi (5th derivation)*
- *CRL*
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.