[0004] The two common designs for the waveform used to generate the WUS are ON-OFF keying (OOK) and Frequency Shift Keying (FSK). OOK is adopted in IEEE 802.11ba. In OOK, the waveform includes ON and OFF patterns in time domain and a specific pattern is used to convey information. For example, (ON OFF) may be conveyed by bit "1", while (OFF ON) may be conveyed by bit "0". In FSK, the frequency of the waveform conveys information. For example, if a pulse is transmitted on or around frequency f0, bit "0" is conveyed, and if the pulse is transmitted on or around frequency f1, bit 1 is conveyed.

SUMMARY

[0005] According to examples, systems and methods are provided for generating an orthogonal frequency-division multiplexing (OFDM)-based Frequency Shift Keying (FSK) waveform.

[0006] According to an aspect, a method of generating a wake up signal, the method performed by at least one processor, is provided. The method includes receiving a plurality of input samples, performing, on the plurality of input samples, subcarrier mapping that maps the plurality of input samples to a set of subcarriers, thereby generating a subcarrier mapper output, generating a first orthogonal frequency-division multiplexing (OFDM) signal by mapping at least a portion of the subcarrier mapper output to a first frequency band, wherein the first frequency band corresponds to a first wake up signal symbol, generating a second OFDM signal by mapping at least a portion of the subcarrier mapper output to a second frequency band, wherein the second frequency band corresponds to a second wake up signal symbol, and generating a wake up signal comprising at least a portion of the first OFDM signal to represent the first wake up signal symbol and at least a portion of the second OFDM signal to represent the second wake up signal symbol, wherein the at least a portion of the first OFDM signal comprises n selected samples of the first OFDM signal, and the at least a portion of the second OFDM signal comprises n selected samples of the second OFDM signal, wherein n is smaller than a total number of samples N of the first and second OFDM signals.

[0007] Mapping at least a portion of the subcarrier mapper output to the first frequency band may also include performing, on the subcarrier mapper output, a first inverse discrete Fourier transform (IDFT), and mapping at least a portion of the subcarrier mapper output to the second frequency band may also include performing, on the subcarrier mapper output, a second IDFT.

[0008] According to an aspect, a wake-up signal waveform generator is provided, including: at least one memory configured to store computer program code; and at least one processor configured to access the at least one memory and operate as instructed by the computer program code, wherein the computer program code includes: receiving code configured to cause the at least one processor to receive a plurality of input samples; a performing code configured to cause the at least one processor to perform, on the plurality of input samples, subcarrier mapping that maps the plurality of input samples to a set of subcarriers, thereby generating a subcarrier mapper output; a first generating code configured to cause the at least one processor to generate first orthogonal frequency-division multiplexing (OFDM) signal by mapping at least a portion of the subcarrier mapper output to a first frequency band, wherein the first frequency band corresponds to a first wake up signal symbol; a second generating code configured to cause the at least one process to generate a second OFDM signal by mapping at least a portion of the subcarrier mapper output to a second frequency band, wherein the second frequency band corresponds to a second wake up signal symbol; and a third generating code configured to cause the at least one process to generate a wake up signal comprising at least a portion of the first OFDM signal to represent the first wake up signal symbol and at least a portion of the second OFDM signal to represent the second wake up signal symbol, wherein the at least a portion of the first OFDM signal comprises n selected samples of the first OFDM signal, and the at least a portion of the second OFDM signal comprises n selected samples of the second OFDM signal, wherein n is smaller than a total number of samples N of the first and second OFDM signals.

[0009] According to an aspect, a non-transitory computer readable medium having instructions stored therein is provided, which when executed by a processor in wake-up signal waveform generator cause the processor to execute a method including: receiving plurality of input samples; performing, on the plurality of input samples, subcarrier mapping that maps the plurality of input samples to a set of subcarriers, thereby generating a subcarrier mapper output; generating a first orthogonal frequency-division multiplexing (OFDM) signal by mapping at least a portion of the subcarrier mapper output to a first frequency band, wherein the first frequency band corresponds to a first wake up signal symbol; generating a second OFDM signal by mapping at least a portion of the subcarrier mapper output to a second frequency band, wherein the second frequency band corresponds to a second wake up signal symbol; and generating a wake up signal comprising at least a portion of the first OFDM signal to represent the first wake up signal symbol and at least a portion of the second OFDM signal to represent the second wake up signal symbol, wherein the at least a portion of the first OFDM signal comprises n selected samples of the first OFDM signal, and the at least a portion of the second OFDM signal comprises n selected samples of the second OFDM signal, wherein n is smaller than a total number of samples N of the first and second OFDM signals.

[0010] Additional aspects will be set forth in part in the description that follows and, in part, will be apparent from the description, or may be realized by practice of the presented embodiments of the disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] Features, aspects and advantages of certain exemplary embodiments of the disclosure will be described below with reference to the accompanying drawings, in which like reference numerals denote like elements, and wherein:

[0012] FIG. 1 illustrates a WUS generation using an OFDM transmitter according to an embodiment;

CLAIMS:

What is claimed is:

1. A method of generating a wake up signal, the method performed by at least one processor and comprising:

receiving a plurality of input samples;

performing, on the plurality of input samples, subcarrier mapping that maps the plurality of input samples to a set of subcarriers, thereby generating a subcarrier mapper output;

generating a first orthogonal frequency-division multiplexing (OFDM) signal by mapping at least a portion of the subcarrier mapper output to a first frequency band, wherein the first frequency band corresponds to a first wake up signal symbol;

generating a second OFDM signal by mapping at least a portion of the subcarrier mapper output to a second frequency band, wherein the second frequency band corresponds to a second wake up signal symbol; and

generating a wake up signal comprising at least a portion of the first OFDM signal to represent the first wake up signal symbol and at least a portion of the second OFDM signal to represent the second wake up signal symbol, wherein the at least a portion of the first OFDM signal comprises n selected samples of the first OFDM signal, and the at least a portion of the second OFDM signal comprises n selected samples of the second OFDM signal, wherein n is smaller than a total number of samples N of the first and second OFDM signals.

2. The method of claim 1, wherein mapping at least a portion of the subcarrier mapper output to the first frequency band comprises performing, on the subcarrier mapper output, a first inverse discrete Fourier transform (IDFT), and mapping at least a portion of the subcarrier mapper

output to the second frequency band comprises performing, on the subcarrier mapper output, a second IDFT.

3. The method of claim 2, wherein generating the first OFDM signal further comprises prepending at least one of a cyclic prefix (CP) and a guard interval to an output of the first IDFT, and generating the second OFDM signal further comprises prepending at least one of a cyclic prefix (CP) and a guard interval to an output of the second IDFT.

4. The method of claim 3, further comprising:

modulating the wake up signal to a carrier frequency;

processing the wake up signal using a digital-to-analog converter; and

transmitting the modulated analog wake up signal.

5. The method of claim 1, wherein the plurality of input samples comprise at least one of symbols of binary phase shift keying (BPSK) modulation and symbols of quadrature phase shift keying (QPSK) modulation.

6. The method of claim 1, further comprising:

processing the plurality of input samples using a frequency domain window prior to performing subcarrier mapping.

7. The method of claim 6, further comprising:

performing a phase change operation on the plurality of input samples prior to performing subcarrier mapping.

8. A wake-up signal waveform generator, comprising:

at least one memory configured to store computer program code; and

at least one processor configured to access the at least one memory and operate as instructed by the computer program code, the computer program code including:

receiving code configured to cause the at least one processor to receive a plurality of input samples;

a performing code configured to cause the at least one processor to perform, on the plurality of input samples, subcarrier mapping that maps the plurality of input samples to a set of subcarriers, thereby generating a subcarrier mapper output;

a first generating code configured to cause the at least one processor to generate first orthogonal frequency-division multiplexing (OFDM) signal by mapping at least a portion of the subcarrier mapper output to a first frequency band, wherein the first frequency band corresponds to a first wake up signal symbol;

a second generating code configured to cause the at least one process to generate a second OFDM signal by mapping at least a portion of the subcarrier mapper output to a second frequency band, wherein the second frequency band corresponds to a second wake up signal symbol; and

a third generating code configured to cause the at least one process to generate a wake up signal comprising at least a portion of the first OFDM signal to represent the first wake up signal symbol and at least a portion of the second OFDM signal to represent the second wake up signal symbol, wherein the at least a portion of the first OFDM signal comprises n selected samples of the first OFDM signal, and the at least a portion of the second OFDM signal comprises n selected samples of the second OFDM signal, wherein n is smaller than a total number of samples N of the first and second OFDM signals.

9. The wake-up signal waveform generator of claim 8,

wherein the first generating code further comprises code configured to cause the at least one processor to perform, on at least a portion of the subcarrier mapper output, a first inverse discrete Fourier transform (IDFT), and

wherein the second generating code further comprises code configured to cause the at least one processor to perform, on at least a portion of the subcarrier mapper output, a second IDFT.

10. The wake-up signal waveform generator of claim 9,

wherein the first generating code further comprises code configured to cause the at least one processor to prepend at least one of a cyclic prefix (CP) and a guard interval to an output of the first IDFT, and

wherein the second generating code further comprises code configured to cause the at least one processor to prepend at least one of a cyclic prefix (CP) and a guard interval to an output of the second IDFT.

11. The wake-up signal waveform generator of claim 10, further comprising a transmitter, wherein the computer program code further includes:

modulation code configured to cause the at least one processor to modulate the wake up signal to a carrier frequency;

conversion code configured to cause the at least one processor to convert the wake up signal from a digital signal to an analog signal; and

transmitting code configured to cause the at least one processor to transmit the modulated analog wake up signal to be transmitted by the transmitter.

12. The wake-up signal waveform generator of claim 8, wherein the plurality of input samples comprise at least one of symbols of binary phase shift keying (BPSK) modulation and quadrature phase shift keying (QPSK) modulation.

13. The wake-up signal waveform generator of claim 8, wherein the computer program code further includes processing code configured to cause the at least one processor to process the plurality of input samples using a frequency domain window prior to performing subcarrier mapping.

14. The wake-up signal waveform generator of claim 13, wherein the computer program code further includes phase change code configured to cause the at least one processor to perform a phase change operation on the plurality of input samples prior to performing subcarrier mapping.

15. A non-transitory computer readable medium having instructions stored therein, which when executed by a processor in wake-up signal waveform generator cause the processor to execute a method comprising:

receiving plurality of input samples;

performing, on the plurality of input samples, subcarrier mapping that maps the plurality of input samples to a set of subcarriers, thereby generating a subcarrier mapper output;

generating a first orthogonal frequency-division multiplexing (OFDM) signal by mapping at least a portion of the subcarrier mapper output to a first frequency band, wherein the first frequency band corresponds to a first wake up signal symbol;

generating a second OFDM signal by mapping at least a portion of the subcarrier mapper output to a second frequency band, wherein the second frequency band corresponds to a second wake up signal symbol; and

generating a wake up signal comprising at least a portion of the first OFDM signal to represent the first wake up signal symbol and at least a portion of the second OFDM signal to represent the second wake up signal symbol, wherein the at least a portion of the first OFDM signal comprises n selected samples of the first OFDM signal, and the at least a portion of the second OFDM signal comprises n selected samples of the second OFDM signal, wherein n is smaller than a total number of samples N of the first and second OFDM signals.

16. The non-transitory computer readable medium of claim 15, wherein mapping at least a portion of the subcarrier mapper output to the first frequency band comprises performing, on the subcarrier mapper output, a first inverse discrete Fourier transform (IDFT), and mapping at least a portion of the subcarrier mapper output to the second frequency band comprises performing, on the subcarrier mapper output, a second IDFT.

17. The non-transitory computer readable medium of claim 16, wherein generating the first OFDM signal further comprises prepending at least one of a cyclic prefix (CP) and a guard interval to an output of the first IDFT, and generating the second OFDM signal further comprises prepending at least one of a cyclic prefix (CP) and a guard interval to an output of the second IDFT.

18. The non-transitory computer readable medium of claim 17, wherein the method further comprises:

modulating the wake up signal to a carrier frequency;

processing the wake up signal using a digital-to-analog converter; and

transmitting the modulated analog wake up signal.

19. The non-transitory computer readable medium of claim 15, wherein the plurality of input samples comprise at least one of symbols of binary phase shift keying (BPSK) modulation and symbols of quadrature phase shift keying (QPSK) modulation.

20. The non-transitory computer readable medium of claim 15, wherein the method further comprises:

processing the plurality of input samples using a frequency domain window prior to performing subcarrier mapping; and

performing a phase change operation on the plurality of input samples prior to performing subcarrier mapping.