(FBMC), filtered OFDM, discrete Fourier transform spread OFDM (DFT spread OFDM), and the like. Sparsity of codewords helps to reduce the complexity of joint detection of multiplexed SCMA layers by using message passing algorithm (MPA). In general, each layer of SCMA signal has its specific codebook set. Low density spreading (LDS) is a special case of SCMA. LDS as a form of multi-carrier CDMA (MC-CDMA) is used for multiplexing different layers of data. As opposed to SCMA with multi-dimensional codewords, LDS uses repetitions of the same (QAM) symbol on layer-specific nonzero position in time or frequency. As an example, in LDS-orthogonal frequency division multiplexing (LDS-OFDM) a constellation point is repeated (with some possible phase rotations) over nonzero frequency tones of a LDS block. The shaping gain and coding gain of multi-dimensional constellations is one of the advantages of SCMA over LDS. The gain is potentially high for higher order modulations where the repetition coding of LDS shows a large loss and poor performance.

[0029] SCMA is an encoding technique that encodes data streams, such as binary data streams, or in general, M-ary data streams, where M is an integer number greater than or equal to 1 into multidimensional codewords. SCMA directly encodes the data stream into multidimensional codewords and circumvents quadrature amplitude modulation (QAM) symbol mapping, which may lead to coding gain over conventional CDMA (and LDS) encoding. Notably, SCMA encoding techniques convey data streams using a multidimensional codeword rather than a QAM symbol. SCMA uses a SCMA codebook to encode the data stream into multidimensional codewords, the SCMA codebook is an example of a spread constellation. The spread constellation, which may also be referred to as a spread modulation map, is achieved by applying a spreading sequence to a constellation. The constellation may also be referred to as a modulation map. The spreading sequence may also be referred to as a signature.

[0030] Additionally, SCMA encoding provides multiple access through the use of different codebooks for different multiplexed layers, as opposed to the use of different spreading sequences for ~~difference~~ different multiplexed layers, e.g., a LDS signatures in LDS, as is common in conventional CDMA encoding. Furthermore, SCMA encoding typically uses codebooks with sparse codewords that enable receivers to use low complexity algorithms, such as message passing algorithms (MPA), to detect respective codewords from combined codewords received by the receiver, thereby reducing processing complexity in the receivers.

[0031] CDMA is a multiple access technique in which data symbols are spread out over orthogonal and/or near orthogonal code sequences. Traditional CDMA encoding is a two-step process in which a binary code is mapped to a quadrature amplitude modulation (QAM) symbol before a spreading sequence is applied. While traditional CDMA encoding can provide relatively

WHAT IS CLAIMED IS:

1. A method for transmitting a waveform, the method comprising:

adjusting, by a transmitting device, first multiplexing parameters of a first multi-carrier waveform to meet communications requirements of a communications system;

generating, by the transmitting device, a first signal in accordance with a first input bit block and a first modulation map;

placing, by the transmitting device, the first signal in a first subband, wherein the first subband is specified in accordance with the first adjusted multiplexing parameters; and

transmitting, by the transmitting device, the first subband.

2. The method of claim 1, wherein the first multiplexing parameters comprises first frequency division multiplexing (FDM) parameters.

3. The method of claim 1, wherein the first signal is a first sparse code multiple access (SCMA) signal, and wherein the first modulation map is in correspondence with a first SCMA codebook.

4. The method of claim 1, wherein the communications requirements comprises at least one of data rate, symbol duration, subcarrier spacing, and cyclic prefix (CP) length.

5. The method of claim 1, wherein the first multiplexing parameters comprises at least one of a first subcarrier spacing, a first symbol duration, and a first CP length.

6. The method of claim 1, wherein the first multi-carrier waveform comprises an orthogonal frequency division multiplexing waveform.

7. The method of claim 1, wherein the first multi-carrier waveform comprises one of a single carrier frequency division multiple access (SC-FDMA) waveform, a multi-carrier code division multiple access (MC-CDMA) waveform, a filter bank multicarrier (FBMC) waveform, a discrete Fourier transform spread OFDM (DFT spread OFDM) waveform, and a filtered OFDM waveform.

8. The method of claim 1, wherein the first signal comprises N components and the first subband comprises M subcarriers, where N and M are integer values and M is greater than or equal to N.

9. The method of claim 1, further comprising:

filtering the first subband with a first filter prior to transmitting the first subband.

10. The method of claim 1, further comprising:

adjusting, by a transmitting device, second multiplexing parameters of a second multi-carrier waveform to meet the communications requirements;

generating, by the transmitting device, a second signal in accordance with a second input bit block and a second modulation map;

placing, by the transmitting device, the second signal in a second subband, wherein the second subband is specified in accordance with the second adjusted multiplexing parameters; and

transmitting, by the transmitting device, the second subband.

11. The method of claim 10, wherein the first multi-carrier waveform and the second multi-carrier waveform are zero peak to average power ratio (PAPR) waveforms.

12. The method of claim 1, further comprising transmitting a third subband including a non-zero PAPR waveform.

13. The method of claim 12, wherein the non-zero PAPR waveform comprises a filtered OFDM (F-OFDM) waveform.

14. A method for operating a receiving device, the method comprising:

determining, by the receiving device, multiplexing parameters;

receiving, by the receiving device, a first subband in accordance with the multiplexing parameters;

extracting, by the receiving device, a first signal from the first subband; and

processing, by the receiving device, the first signal in accordance with a first modulation map associated with the receiving device.

15. The method of claim 14, wherein the first signal comprises N components and the first subband comprises M subcarriers, where N and M are integer values and M is greater than or equal to N.

16. The method of claim 14, further comprising:

receiving a second subband in accordance with the multiplexing parameters;

extracting a second signal from the second subband; and

processing the second signal in accordance with a second modulation map associated with the receiving device.

17. The method of claim 16, wherein the first subband and the second subband include a different number of subcarriers.

18. The method of claim 16, wherein the first subband and the second subband are transmitted in different portions of a spectrum of a communications system including the receiving device.

19. The method of claim 16, wherein the first signal is a first sparse code multiple access (SCMA) signal, wherein the first modulation map is in correspondence with a zero peak to average power ratio (PAPR) SCMA codebook, wherein the second modulation map is in correspondence with a non-zero PAPR SCMA codebook.

20. The method of claim 19, wherein the second subband is transmitted in a filtered OFDM waveform.

21. A transmitting device comprising:

a processor; and

a non-transitory computer readable storage medium storing programming for execution by the processor, the programming including instructions to implement actions in a method in accordance with any one of claims 1 to 13.

22. A receiving device comprising:

a processor; and

a non-transitory computer readable storage medium storing programming for execution by the processor, the programming including instructions to implement actions in a method in accordance with any one of claims 14 to 20.

WHAT IS CLAIMED IS:

1. A METHOD COMPRISING:

encoding an input data stream to produce an encoded data stream;

applying a spreading sequence to the encoded data stream to produce a multi-dimensional codeword spread over a plurality of time-frequency resource units; and

transmitting the multi-dimensional codeword over the time-frequency resource units,

characterized in that:

the multi-dimensional codeword has only one non-zero constellation point.

2. The method of claim 1, wherein the one non-zero constellation point is transmitted on one non-zero time-frequency resource unit.

3. The method of claim 2, wherein the non-zero time-frequency resource unit is a non-zero OFDMA tone.

4. The method of claim 1, wherein the multi-dimensional codeword is a sparse codeword.

5. The method of claim 1, wherein the multi-dimensional codeword is a Sparse Code Multiple Access, SCMA, codeword selected from an SCMA codebook.

6. The method of claim 5, wherein the SCMA codebook is selected from a plurality of codebooks each assigned to a different layer.

7. The method of claim 6, wherein each of the plurality of SCMA codebooks has non-zero constellation points in different positions.

8. The method of claim 7, wherein each codebook has different non-zero constellation points for different input data streams.

9. The method of claim 1, wherein the multi-dimensional codeword has a plurality of non-zero components, and only one of the plurality of the non-zero components maps to a non-zero constellation point for each input data stream.

10. The method of claim 1, wherein each non-zero constellation point of the codeword is transmitted on a subcarrier corresponding to the non-zero constellation point.

11. The method of claim 1, wherein applying the spreading sequence is performed by encoding the input data stream directly into the multidimensional codeword.

12. A transmitting device comprising:

a processor;

a non-transitory computer readable storage medium storing programming for execution by the processor, the programming including instructions to:

encode an input data stream to produce an encoded data stream; and

apply a spreading sequence to the encoded data stream to produce a multi-dimensional codeword spread over a plurality of time-frequency resource units; and

a transmitter to transmit the multi-dimensional codeword over the time-frequency resource units,

characterized in that:

the multi-dimensional codeword has only one non-zero constellation point.

13. The method of claim 12, wherein the transmitter transmits the one non-zero constellation point on one non-zero time-frequency resource unit.

14. The method of claim 13, wherein the non-zero time-frequency resource unit is a non-zero OFDMA tone.

15. The method of claim 12, wherein the multi-dimensional codeword is a sparse codeword.