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(54) **SYSTEM AND METHOD TO GENERATE A WAVEFORM IN A COMMUNICATION NETWORK**

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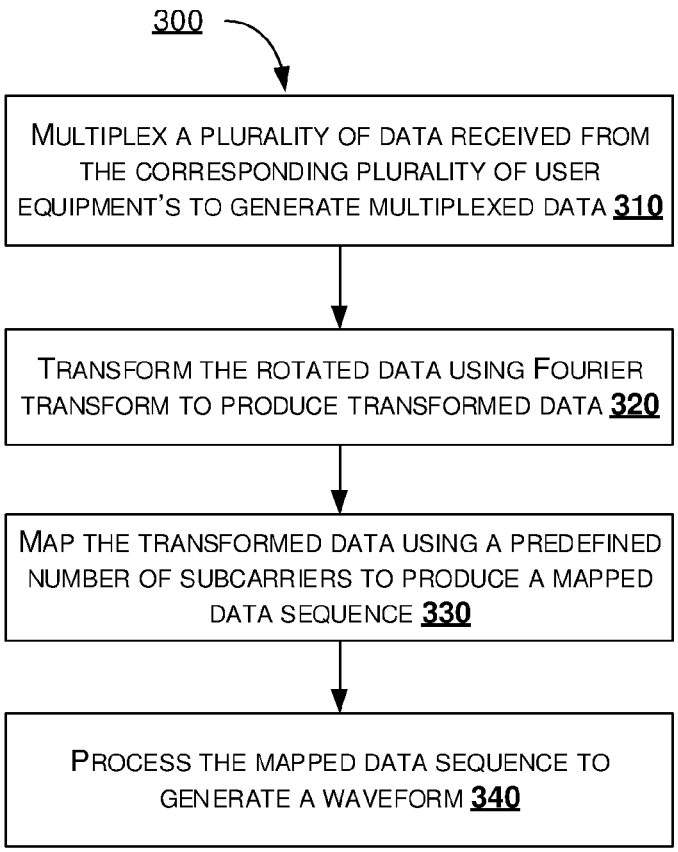
(57) **ABSTRACT**

Embodiments of the present disclosure relate to a communication system to generate a waveform by multiplexing multiple user data. The system comprises at least one transceiver, a multiplexer and a processor. The at least one transceiver configured to perform at least one of receiving a plurality of data from a transmitter, and transmitting a generated waveform to a destination. The multiplexer configured to multiplex a plurality of data associated with a plurality of users, to generate multiplexed data. The processor is configured to perform a rotation operation on the multiplexed data to produce a rotated data. Also, the processor is configured to transform the rotated data using Fourier transform to produce transformed data. Further, the processor is configured to map the transformed data using a predefined number of subcarriers to produce a mapped data sequence and thereafter, process the mapped data sequence to generate the waveform.



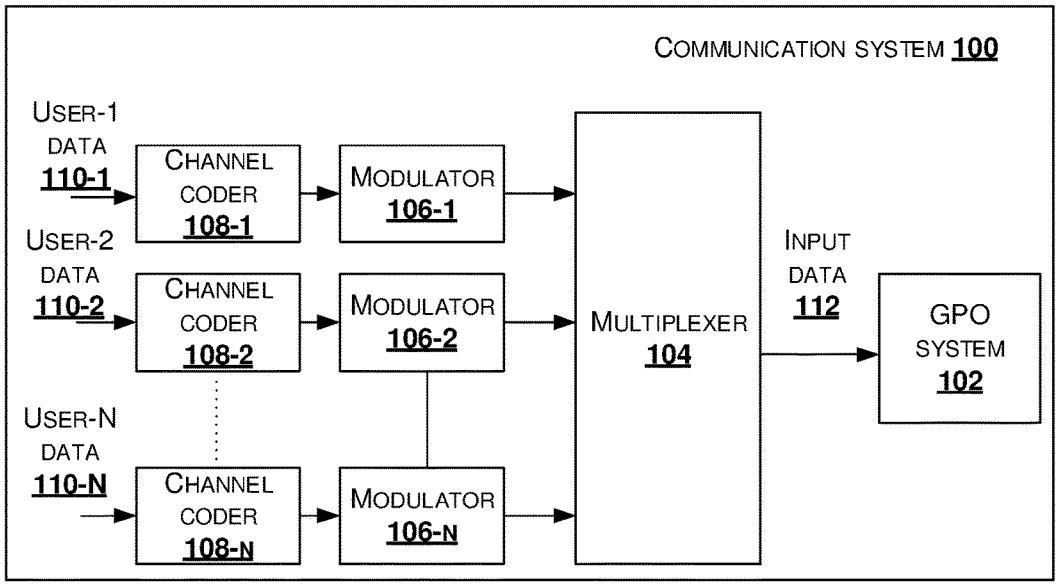

COMMUNICATION SYSTEM 100
USER-1 DATA 110-1
USER-2 DATA 110-2
USER-N DATA 110-N
CHANNEL CODER 108-1
CHANNEL CODER 108-2
CHANNEL CODER 108-N
MODULATOR 106-1
MODULATOR 106-2
MODULATOR 106-N
MULTIPLEXER 104
INPUT DATA 112
GPO SYSTEM 102

Fig. 1A

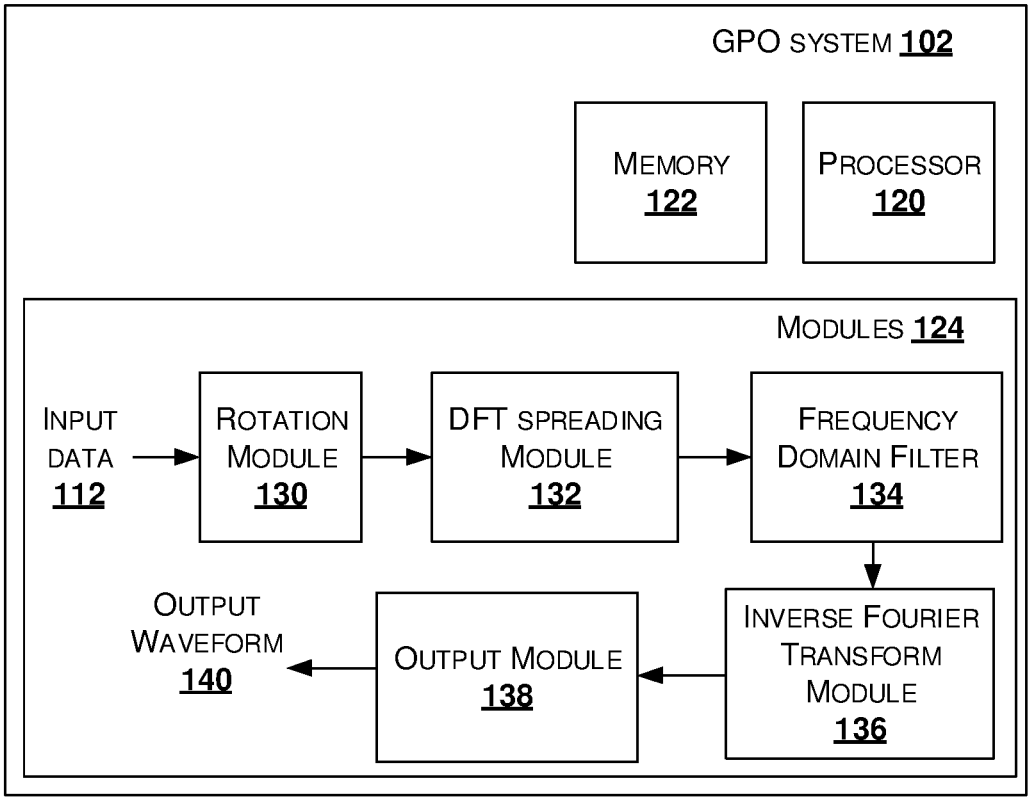

GPO SYSTEM 102
MEMORY 122
PROCESSOR 120
MODULES 124
INPUT DATA 112
ROTATION MODULE 130
DFT SPREADING MODULE 132
FREQUENCY DOMAIN FILTER 134
INVERSE FOURIER TRANSFORM MODULE 136
OUTPUT MODULE 138
OUTPUT WAVEFORM 140

Fig. 1B

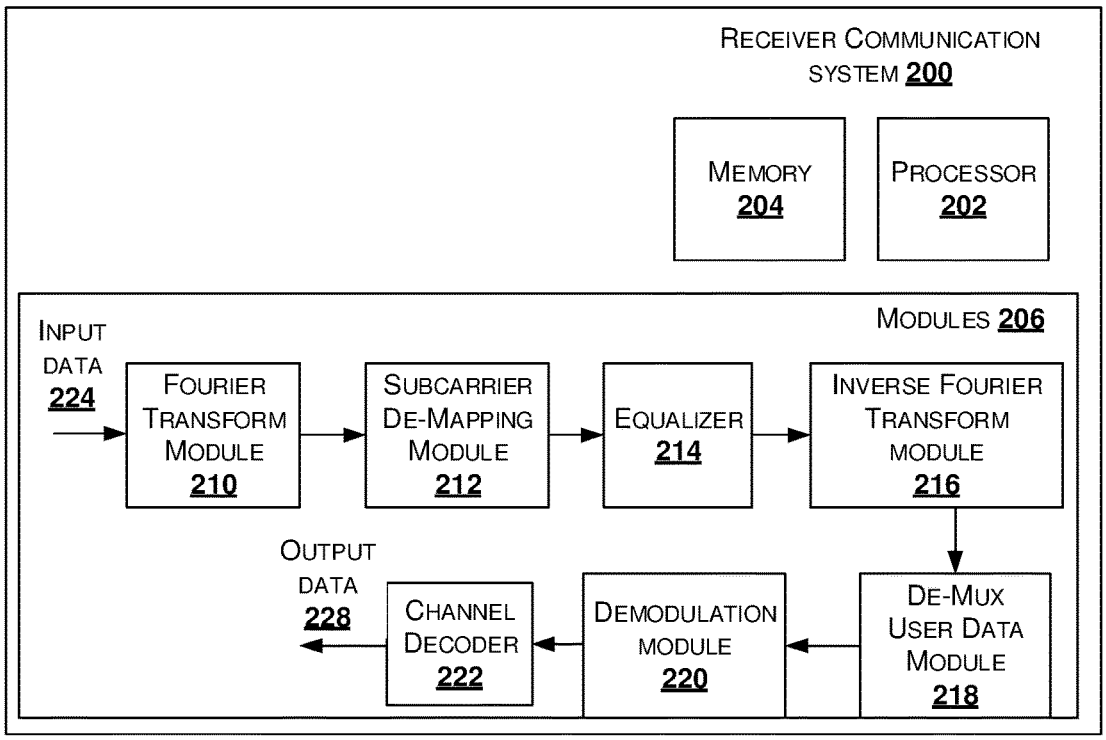

RECEIVER COMMUNICATION SYSTEM 200
MEMORY 204
PROCESSOR 202
MODULES 206
INPUT DATA 224
FOURIER TRANSFORM MODULE 210
SUBCARRIER DE-MAPPING MODULE 212
EQUALIZER 214
INVERSE FOURIER TRANSFORM MODULE 216
DE-MUX USER DATA MODULE 218
DEMODULATION MODULE 220
CHANNEL DECODER 222
OUTPUT DATA 228

Fig. 2

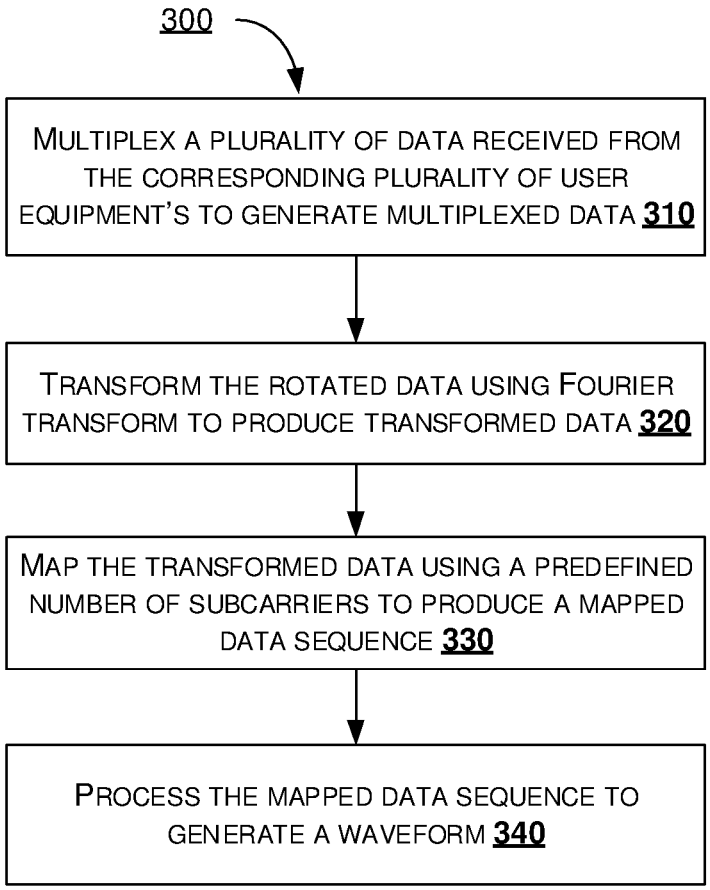

300
MULTIPLEX A PLURALITY OF DATA RECEIVED FROM THE CORRESPONDING PLURALITY OF USER EQUIPMENT'S TO GENERATE MULTIPLEXED DATA 310
TRANSFORM THE ROTATED DATA USING FOURIER TRANSFORM TO PRODUCE TRANSFORMED DATA 320
MAP THE TRANSFORMED DATA USING A PREDEFINED NUMBER OF SUBCARRIERS TO PRODUCE A MAPPED DATA SEQUENCE 330
PROCESS THE MAPPED DATA SEQUENCE TO GENERATE A WAVEFORM 340

Fig. 3

# SYSTEM AND METHOD TO GENERATE A WAVEFORM IN A COMMUNICATION NETWORK

## TECHNICAL FIELD

**[0001]** Embodiments of the present disclosure are related, in general to communication, but exclusively relate to system and method for multiplexing multiple user data using one of a single waveform and multiple waveforms.

## BACKGROUND

**[0002]** Orthogonal Frequency Division Multiplexing (OFDM) is widely used in many wireless systems for both modulation and multiple access. The OFDM waveform has high peak-to-average-power-ratio (PAPR), and therefore requires a high-power amplifier back-off during transmission. Discrete Fourier Transform pre-coded OFDM (DFT pre-coded OFDM) was suggested in the uplink of LTE (Long-Term-Evolution) standards to reduce the PAPR. While OFDM exhibits close to 9 dB PAPR, DFT pre-coded OFDM has PAPR in the range of 5.0-6.0 dB for QPSK (Quadrature-Phase-Shift-Keying) modulation. However, it is inherently power inefficient modulation.

**[0003]** Hence, there is a need of a solution for a method and system to multiplex data of a multiple users and generate a pre-coded waveform with low PAPR.

## SUMMARY

**[0004]** The shortcomings of the prior art are overcome and additional advantages are provided through the provision of method of the present disclosure.

**[0005]** Additional features and advantages are realized through the techniques of the present disclosure. Other embodiments and aspects of the disclosure are described in detail herein and are considered a part of the claimed disclosure.

**[0006]** In an aspect of the present disclosure, method of generating a waveform in a communication network is provided. The method comprises multiplexing, by a communication system, a plurality of data associated with a plurality of users, to generate multiplexed data. Also, the method comprises performing a rotation operation on the multiplexed data to produce a rotated data and transforming the rotated data using Fourier transform to produce transformed data. Further, the method comprises mapping the transformed data using a predefined number of subcarriers to produce a mapped data sequence and processing the mapped data sequence to generate the waveform.

**[0007]** Another aspect of the present disclosure is a communication system to generate a waveform in a communication network. The system comprises at least one transceiver, a multiplexer and a processor. The at least one transceiver configured to perform at least one of receiving a plurality of data from a transmitter, and transmitting a generated waveform to a destination. The multiplexer configured to multiplex a plurality of data associated with a plurality of users, to generate multiplexed data. The processor is configured to perform a rotation operation on the multiplexed data to produce a rotated data. Also, the processor is configured to transform the rotated data using Fourier transform to produce transformed data. Further, the processor is configured to map the transformed data using a predefined number of subcarriers to produce a mapped data sequence and thereafter, process the mapped data sequence to generate the waveform.

**[0008]** The foregoing summary is illustrative only and is not intended to be in any way limiting. In addition to the illustrative aspects, embodiments, and features described above, further aspects, embodiments, and features will become apparent by reference to the drawings and the following detailed description.

## BRIEF DESCRIPTION OF THE ACCOMPANYING DRAWINGS

**[0009]** The accompanying drawings, which are incorporated in and constitute a part of this disclosure, illustrate exemplary embodiments and, together with the description, serve to explain the disclosed principles. In the figures, the left-most digit(s) of a reference number identifies the figure in which the reference number first appears. The same numbers are used throughout the figures to reference like features and components. Some embodiments of device or system and/or methods in accordance with embodiments of the present subject matter are now described, by way of example only, and with reference to the accompanying figures, in which:

**[0010]** FIG. **1**A shows an illustration of a communication system to generate a waveform by multiplexing multi-user data, in accordance with some embodiments of the present disclosure.

**[0011]** FIG. **1**B shows an illustration of a generalized precoded OFDM (Orthogonal frequency-division multiplexing) (GPO) system to generate a waveform, in accordance with some embodiments of the present disclosure;

**[0012]** FIG. **2** illustrates a block diagram of GPO receiver, in accordance with some embodiment of the present disclosure; and

**[0013]** FIG. **3** shows a flowchart illustrating a method of generating a waveform using communication system as shown in FIG. **1**, in accordance with some embodiments of the present disclosure.

## DETAILED DESCRIPTION

**[0014]** In the present document, the word "exemplary" is used herein to mean "serving as an example, instance, or illustration." Any embodiment or implementation of the present subject matter described herein as "exemplary" is not necessarily to be construed as preferred or advantageous over other embodiments.

**[0015]** While the disclosure is susceptible to various modifications and alternative forms, specific embodiment thereof has been shown by way of example in the drawings and will be described in detail below. It should be understood, however that it is not intended to limit the disclosure to the particular forms disclosed, but on the contrary, the disclosure is to cover all modifications, equivalents, and alternative falling within the spirit and the scope of the disclosure.

**[0016]** The terms "comprises", "comprising", or any other variations thereof, are intended to cover a non-exclusive inclusion, such that a setup, device or method that comprises a list of components or steps does not include only those components or steps but may include other components or steps not expressly listed or inherent to such setup or device or method. In other words, one or more elements in a device or system or apparatus proceeded by "comprises . . . a" does

not, without more constraints, preclude the existence of other elements or additional elements in the device or system or apparatus.

**[0017]** The present disclosure relates to a system and method of generating a waveform in a communication network. The system comprises a multiplexing module to multiplex a plurality of data associated with a plurality of users and generate multiplexed data. Also, the system is configured to perform a rotation operation on the multiplexed data to produce a rotated data and transform the rotated data using Fourier transform to produce a transformed data. Further, the system maps the transformed data using a predefined number of subcarriers to produce a mapped data sequence. Thereafter, the system processes the mapped data sequence to generate a waveform.

**[0018]** In the following detailed description of the embodiments of the disclosure, reference is made to the accompanying drawings that form a part hereof, and in which are shown by way of illustration specific embodiments in which the disclosure may be practiced. These embodiments are described in sufficient detail to enable those skilled in the art to practice the disclosure, and it is to be understood that other embodiments may be utilized and that changes may be made without departing from the scope of the present disclosure. The following description is, therefore, not to be taken in a limiting sense.

**[0019]** FIG. **1**A shows an illustration of a communication system **100** to generate a waveform by multiplexing multi-user data, in accordance with some embodiments of the present disclosure.

**[0020]** As shown in FIG. **1**A, the communication system **100** includes a generalized pre-coded OFDM (Orthogonal frequency-division multiplexing) (GPO) system **102**, a multiplexer **104**, a plurality of modulators **106-1**, **106-2**, . . . **106**-N, and a plurality of channel coders **108-1**, **108-2**, . . . **108**-N. The communication system **100** is also referred as a base station (BS), transmitter system, transmitter, generalized pre-coded (Orthogonal Frequency Division Multiple Access) OFDM (GPO) transmitter or GPO system. The communication system **100** is configured to generate waveform, also referred as data or signals, for multi-users by multiplexing data in downlink, in accordance with some embodiments of the present disclosure.

**[0021]** Also, as shown in FIG. **1**A, a plurality of data, also referred as user data i.e. user-**1** data **110-1**, user-**2** data **110-2**, . . . , user-N data **110**-N, is associated with a plurality of users, are multiplexed in time domain using the multiplexer **104** before feeding the data to the GPO system **102**. The plurality of data is collectively referred as plurality of user data **110**. For example, the plurality of data **110-1**, **110-2**, . . . , **110**-N belongs to multiple cell edge users (not shown in Fig.) may be multiplexed using one of BPSK or QPSK modulation. Each of the plurality of user data (**110-1**, **110-2**, . . . , **110**-N) is coded by a corresponding channel coder **108-1**, **108-2**, . . . **108**-N. For the case of BPSK, it is preferable that all users share the same BPSK modulation so that GPO generates a signal with low PAPR. Each user can apply its own code rate, encoding method for BPSK. Further, the length of the data between the users may be unequal.

**[0022]** FIG. **1**B shows an illustration of a generalized precoded OFDM (Orthogonal frequency-division multiplexing) (GPO) system to generate a waveform, in accordance with some embodiments of the present disclosure.

**[0023]** As shown in FIG. **1**B, the GPO system **102** includes a processor **120** and a memory **122**. The memory **122** may be communicatively coupled to the processor **120**. The processor **120** may be configured to perform one or more functions of the GPO system **102** for generating a waveform, using a plurality of data associated with a plurality of users. In one implementation, the GPO system **100** may comprise modules **124** for performing various operations in accordance with the embodiments of the present disclosure.

**[0024]** In an embodiment, the GPO system **102** receives input data from the multiplexer **104**, whose input is the plurality of data associated with the plurality of users. The plurality of data is also referred as input data **112**.

**[0025]** In some embodiment, the input data **112** may be processed by one or more modules **124** of the GPO system **102**. In some implementation, the one or more modules **124** may be stored with the memory **122**. In another implementation, the one or more modules **124** may be communicatively coupled to the processor **120** for performing one or more functions of the GPO system **102**. The modules **124** may include, without limiting to, a rotation module **130**, a Discrete Fourier Transform (DFT) spreading module **132**, a frequency domain filter **134**, an inverse Fourier Transform module **136** and an output module **138**.

**[0026]** The rotation module **130** performs constellation rotation on input data **112** to produce a rotated data. The constellation rotation operation performed rotates the input data **112** by **180**/Q degrees between consecutive data symbols, where Q is size of modulation alphabet. The input data **112** is one of a Binary Phase Shift Keying (BPSK) sequence and Quadrature Phase Shift Keying (QPSK) sequence. In one embodiment, the input data is binary phase-shift keying (BPSK), of predefined length and the phase difference between consecutive data symbols is 90-degrees.

**[0027]** The DFT spreading module **132** transforms the rotated data into frequency domain using an M-point DFT (Discrete Fourier Transform) to produce a transformed date, also referred as a DFT output data sequence or transformed output data sequence, wherein M is length of data sequence. In an embodiment, the DFT size is predefined. The DFT module may further spread the DFT output by repeatedly concatenating the transformed output data sequence 's' times where 's' is an oversampling factor. The value of "s" may be greater than or equal to 1.

**[0028]** The frequency domain filter **134**, also referred as subcarrier filter or subcarrier mapper, performs the frequency domain pulse shaping or subcarrier level filtering on the output of DFT spreading module **132**, which is followed by mapping of frequency domain pulse shaped data to subcarriers. The frequency domain filter **134** uses one of contiguous subcarrier mapping, interleaved subcanier mapping, distributed subcarrier mapping. For the uplink operation, the frequency domain pulse shaping and mapping is a user specific operation. Different users may use different mapping rules. In some embodiments, the frequency domain pulse shaping and mapping rule are fixed operations. The user specific frequency shift or offset used by the subcarrier mapping operation determines whether users use frequency orthogonal, i.e. non-overlapping subcarriers of users, or frequency non-orthogonal i.e. partially or fully overlapping subcarriers among users.

**[0029]** The inverse Fourier transform module **136**, also referred as inverse DFT module or inverse fast Fourier

transform (IFFT) performs the inverse transform on the output of the frequency domain filter **134** output, to generate a time domain signal.

**[0030]** The output module **138** performs at least one of addition of cyclic prefix, cyclic suffix, windowing, windowing with overlap and adding operation, and frequency shifting on the time domain signal to generate a waveform, also referred as an output or output waveform **140**. Also, the output waveform **140** is fed to a digital to analog converter (DAC) to generate analog precoded waveform.

**[0031]** In one embodiment, the output module **138** uses a predefined number of samples (Ncp) of the time domain sequence, output of inverse Fourier transform module **136**, to append the Ncp sample at the beginning of the time domain data sequence to obtain CP (cyclic prefix) time domain sequence. In another embodiment, a multiplicative windowing operation is performed by the output module **138** on the CP time domain sequence to obtain windowed CP time domain sequence. The window function may be chosen such that the window takes zero value during the beginning of the CP time domain sequence and raises to unit value during the portion of the CP. Also, the window starts decaying at some point towards the end of the CP time domain sequence and decays to zero at the edge of the CP time domain sequence. The window function is preferably chosen to be symmetric function.

**[0032]** In one embodiment, the output module **138** is configured with both CP and cyclic post fix (CS). CS refers to addition of first Ncs samples of the time domain sequence and appends Ncs samples to the beginning of the time domain data sequence to obtain CP and CS time domain sequence. In an embodiment, the value of Ncs may exceed the CP value. Also, the output module **138** performs time domain filtering on the output from the inverse Fourier transform module **136**, using windowing and overlap add operation to reduce the OBE.

**[0033]** In an embodiment, the GPO system **102** generates a waveform is any of two operational modes, i.e. GPO with excess bandwidth (BW) mode and GPO without excess BW. For the GPO system **102** with the excess BW mode, the frequency domain filter **134** is configured with a frequency domain pulse shaping filter (FDPSF) that occupies certain excess bandwidth (BW). The data from plurality of users is multiplexed with M-subcarrier spacing, M-being the number of occupied subcarriers for each user, so that excess BW does not cause a loss in bandwidth efficiency. The excess BW may cause mutual interference between users that are frequency multiplexed in adjacent resources. The amount of interference caused by the FDPSF is low, such that there is no significant reduction in bit error rate (BER). In an embodiment, a linearized Gaussian minimum shift keying (GMSK) pulse is oversampled with an oversampling factor "os", which provides the FDPSF an excess BW of "os times M" i.e. "os" times the number of occupied subcarriers.

**[0034]** For example, when BW=infinity, and os=3, then the output of the frequency domain filter **134** is a minimum shift keying (MSK) signal with near constant envelope and smooth phase trajectories within one OFDM symbol. In another example, when BT=0.3, and os=2, a signal similar to that of linearized GMSK is obtained by the frequency domain filter **134**.

**[0035]** For example, for the GPO without excess BW mode, let os=1 and the FDPSF do not use excess BW. Then, this mode leads to a frequency orthogonal user multiplexing i.e. the PAPR of the signal generated using os=1 is generally higher than for the case of os>1.

**[0036]** In one example embodiment, let a base station (BS) frequency multiplexes a number of users in the uplink, here the BS is the communication system **100**. Therefore, number of subcarriers of the users occupied is less than the total number of subcarriers. However, the user may use a large IFFT size in the inverse Fourier transform module **136**, with sufficient number of zeros added for null subcarriers, to generate a signal at a high sampling rate. The IFFT size is dependent on total number of subcarriers, used by the frequency domain filter **134** configured in the communication system **100**. The output module **138** is configured to add a cyclic prefix (CP) before transmission of the generated output waveform **140**. Length of the CP added is same for all users and is designed to handle the delay spread for full band allocation.

**[0037]** In another embodiment, the number of allocated subcarriers is kept to a fixed maximum value so that the user transmits a signal that occupies a sub-band. In this case, the user may use an IFFT size such that the user generates a narrow band signal. In this case, the user generates the signal at a lower sampling rate using a smaller FFT size. After digital-to-analog conversion (ADC), the signal is up converted to a desired carrier frequency that is typically the center of the sub-band.

**[0038]** In an embodiment of the present disclosure, the GPO system **102** is configured with millimeter wave (mmwave) having low PAPR, in the downlink. Also, for GPO output waveform, the plurality of data **110** associated with the plurality of users is multiplexed in time domain either within OFDM symbols or over multiple distinct OFDM symbols.

**[0039]** In an embodiment, the communication system **100** performs multiplexing of different waveforms from different users, in downlink. The communication system **100** is configured with GPO system **102** with BPSK to be applied to one group of users to enhance coverage. For other users, the GPO system **102** with QPSK, may be applied. In an embodiment, for users who are in close to the vicinity of the communication system or BS **100**, OFDM may be used. The plurality of user's data, also referred as frame, is split into multiple zones, where a different waveform may be applied in each zone. The zones may be configured in at least one of statically and dynamically. The communication system **100** may inform the users about the zone configuration in a broadcast channel. The different zones may use same or different numerology, such as but not limited to subcarrier width, CP length, and the like.

**[0040]** FIG. **2** illustrates a block diagram of a receiver communication system **200**, in accordance with some embodiment of the present disclosure.

**[0041]** As shown in FIG. **2**, the receiver communication system **200**, is also referred as a receiver system or receiver. The receiver **200** includes a processor **202**, memory **204** and modules **206**. The memory **204** may be communicatively coupled to the processor **202**. The processor **202** may be configured to perform one or more functions of the receiver **200** for receiving the data. In one implementation, the receiver **200** may comprise modules **206** for performing various operations in accordance with the embodiments of the present disclosure.

**[0042]** The modules **206** includes a Fourier transform (FT) module **210**, subcarrier de-mapping module **212**, an equal-

izer **214**, an inverse Fourier transform (IFT) module **216**, de-mux user data module **218**, demodulation module **220** and a channel decoder **222**.

**[0043]** The Fourier transform module **210**, also referred as a Discrete Fourier Transform (DFT) module or fast Fourier transform (FFT) module, is configured to receive an input data **224** from a transmitter, and transform the received input data from time domain into frequency domain, to obtain a transformed data.

**[0044]** The subcarrier de-mapping module **212** is configured to perform the de-mapping operation on the transformed data, to obtain de-mapped data and collect allocated subcarriers. Also, the subcarrier de-mapping module **212** is configured with an optional constellation de-rotation block to perform constellation de-rotation on the de-mapped data.

**[0045]** The equalizer **214** is configured to use time domain processing and equalizing the de-mapped data and frequency domain input, applied with frequency domain equalization to generate equalized samples of data. For example, when the modulation of the user data is BPSK modulation that uses real-valued modulation, then the equalizer **214** uses a widely linear (WL) equalizer, that filters the signal and its complex-conjugate suppress the inter symbol interference (ISI). The IFT module **216** performs inverse Fourier transformation of equalized data to generate time domain signal.

**[0046]** The de-mux user data module **218**, is also referred as demultiplexing module, is configured to demultiplex the time domain signal to produce de-multiplex data. The demodulation module **220**, is configured to perform demodulation on the demultiplexed data and generate demodulated data. The demodulation may be one of BPSK demodulation and QPSK demodulation.

**[0047]** For QPSK modulation, the demodulation module **220** is configured with sequence estimation methods to mitigate the ISI and to reduce the performance loss caused by the ISI and generate demodulated data. Also, for QPSK modulation, the equalizer **214** may be configured with a minimum mean-squared-error decision-feedback equalizer (MMSE-DFE) pre-filter, the De-Mux user data module **218** may be inactive or disabled and the data demodulation may be performed jointly for all the user's data, using sequence estimation.

**[0048]** The channel decoder **222**, also referred as decoder, is configured to receive demodulated data from the demodulation module **220**, to perform decoding and produce an output data **228**, also referred as decoded data, associated with a user. Also, the decoder **222** may be configured to perform least squares (LS) channel estimates on the demodulated data.

**[0049]** FIG. **3** shows a flowchart illustrating a method of generating a waveform using communication system **100** as shown in FIG. **1**, in accordance with some embodiments of the present disclosure.

**[0050]** As illustrated in FIG. **3**, the method **300** comprises one or more blocks for generating a waveform in a communication network. The method **300** may be described in the general context of computer executable instructions. Generally, computer executable instructions can include routines, programs, objects, components, data structures, procedures, modules, and functions, which perform functions or implement abstract data types.

**[0051]** The order in which the method **300** is described is not intended to be construed as a limitation, and any number of the described method blocks can be combined in any order to implement the method. Additionally, individual blocks may be deleted from the methods without departing from the spirit and scope of the subject matter described herein. Furthermore, the method can be implemented in any suitable hardware, software, firmware, or combination thereof.

**[0052]** At block **310**, multiplexing is performed, by the communication system **100**, on a plurality of data **110**, associated with the plurality of users to generate multiplexed data. Each of the plurality of data **110** is one of a binary phase shift keying (BPSK) sequence and quadrature phase shift keying (QPSK) sequence. In an embodiment, each of the plurality of data **110** is modulated using a binary phase shift keying (BPSK) modulation, wherein the generated waveform by the communication system **100** may have an optimized peak to average power ratio (PAPR).

**[0053]** In an embodiment, each of the plurality of data **110**, associated with the plurality of users, is modulated using a quadrature phase shift keying (QPSK) modulation, wherein the generated waveform by the communication system **100** may have an optimized peak to average power ratio (PAPR). In an embodiment, the communication system **100** is configured such that each of the plurality of data **110**, associated with the plurality of users, is modulated using one of binary phase shift keying (BPSK) and quadrature phase shift keying (QPSK) modulation.

**[0054]** At block **320**, performing a rotation operation, by the rotation module **130**, configured in the communication system **100**, on the multiplexed data to produce a rotated data. The rotation module **130** performs a constellation rotation, to rotate each of the plurality of data by 90 degrees. The constellation rotation operation performed on each of the plurality of input data produces a corresponding phase difference between each successive data associated with the plurality of data.

**[0055]** At block **330**, transforming the rotated data by the DFT spreading module **132**, configured in the communication system **100**, using Fourier transform to produce transformed data.

**[0056]** At block **340**, mapping of the transformed data is performed by the frequency domain filter **134**, which is configured with subcarrier mapping which uses a predefined number of subcarriers to produce a mapped data sequence.

**[0057]** At block **350**, processing the mapped data sequence to generate the waveform. The processing is performed by the inverse Fourier transform module **136** on the mapped data sequence, to produce time domain signal. Further, the output module **138** performs at least one of addition of cyclic prefix, cyclic suffix, windowing, windowing with overlap and adding operation, and frequency shifting on the time domain signal to generate a waveform. In an embodiment, the output waveform **140** may be fed to a digital to analog converter to generate analog precoded waveform.

**[0058]** In an embodiment, the communication system **100** has applications such as multiplexing of multiple user data in coverage limited systems or in systems where high-power amplifier (PA) efficiency is required. Also, other applications include, but not limited to, mmwave systems, cellular base stations that need very large coverage, cellular base stations that may run on solar power that need high PA efficiency. Also, the communication system **100** may be used for low cost base stations that needs a lower cost PA.

**[0059]** Finally, the language used in the specification has been principally selected for readability and instructional purposes, and it may not have been selected to delineate or circumscribe the inventive subject matter. It is therefore intended that the scope of the invention be limited not by this detailed description, but rather by any claims that issue on an application based here on. Accordingly, the disclosure of the embodiments of the invention is intended to be illustrative, but not limiting, of the scope of the invention, which is set forth in the following claims.

**[0060]** While various aspects and embodiments have been disclosed herein, other aspects and embodiments will be apparent to those skilled in the art. The various aspects and embodiments disclosed herein are for purposes of illustration and are not intended to be limiting, with the true scope and spirit being indicated by the following claims.

**1**. A method of generating a waveform in a communication network, the method comprising:

multiplexing, by a communication system **100**, a plurality of data associated with a plurality of users, to generate multiplexed data;

performing a rotation operation, by the communication system **100**, on the multiplexed data to produce a rotated data;

transforming, by the communication system **100**, the rotated data using Fourier transform to produce transformed data;

mapping, by the communication system **100**, the transformed data with a predefined number of subcarriers to produce a mapped data sequence; and

processing, by the communication system **100**, the mapped data sequence to generate the waveform.

**2**. The method as claimed in claim **1**, wherein each of the plurality of data is one of a binary phase shift keying (BPS K) sequence and quadrature phase shift keying (QPSK) sequence.

**3**. The method as claimed in claim **1**, wherein each of the plurality of data, associated with the plurality of users, is modulated using binary phase shift keying (BPSK) modulation, wherein the generated waveform comprises an optimized peak to average power ratio (PAPR).

**4**. The method as claimed in claim **1**, wherein each of the plurality of data, associated with the plurality of users, is modulated using quadrature phase shift keying (QPSK) modulation, wherein the generated waveform comprises an optimized peak to average power ratio (PAPR).

**5**. The method as claimed in claim **1**, wherein each of the plurality of data, associated with the plurality of users, is modulated using one of binary phase shift keying (BPSK) and quadrature phase shift keying (QPSK) modulation.

**6**. The method as claimed in claim **1**, wherein the rotation operation performed is a constellation rotation, to rotate each of the plurality of data by 90 degrees.

**7**. The method as claimed in claim **6**, wherein the constellation rotation operation on each of the plurality of input data produces a corresponding phase difference between each successive data associated with the plurality of data.

**8**. The method as claimed in claim **1**, wherein processing the mapped data sequence to generate a waveform comprising:

performing an inverse discrete Fourier transform (IDFT) on the mapped data sequence to generate mapped data sequence; and

performing at least one of transmit block selection operation, addition of cyclic prefix, addition of cyclic suffix, windowing, windowing with overlap and add operation, and frequency shifting on the mapped data sequence, to generate the waveform.

**9**. The method as claimed in claim **1**, wherein the generated waveform is converted from digital form to analog form.

**10**. A communication system **100** to generate a waveform in a communication network, the system comprising:

at least one transceiver, configured to perform at least one of receiving a plurality of data from a transmitter, and transmitting a generated waveform to a destination;

a multiplexer, coupled with the at least one transceiver, configured to multiplex a plurality of data associated with a plurality of users and generate multiplexed data;

a memory; and

a processor, communicatively coupled to a memory, configured to:

perform a rotation operation on the multiplexed data to produce a rotated data;

transform the rotated data using Fourier transform to produce transformed data;

map the transformed data using a predefined number of subcarriers to produce a mapped data sequence; and

process the mapped data sequence to generate a waveform.

**11**. The system as claimed in claim **10**, wherein each of the plurality of data is one of a Binary Phase Shift Keying (BPSK) sequence and Quadrature Phase Shift Keying (QPSK) sequence.

**12**. The system as claimed in claim **10**, wherein the processor is configured to modulate each of the plurality of data, associated with the plurality of users, using binary phase shift keying (BPSK) modulation, wherein the generated waveform comprises an optimized peak to average power ratio (PAPR).

**13**. The system as claimed in claim **10**, wherein the processor is configured to modulate each of the plurality of data, associated with the plurality of users, using quadrature phase shift keying (QPSK) modulation, wherein the generated waveform comprises an optimized peak to average power ratio (PAPR).

**14**. The system as claimed in claim **10**, wherein the processor is configured to modulate each of the plurality of data, associated with the plurality of users, using one of binary phase shift keying (BPSK) and quadrature phase shift keying (QPSK) modulation.

**15**. The system as claimed in claim **10**, wherein the processor is configured to rotate each of the plurality of data by 90 degrees using a constellation rotation.

**16**. The system as claimed in claim **10**, wherein the processor is configured to process the mapped data sequence to generate a waveform, by performing steps of:

obtaining an inverse discrete Fourier transform (IDFT) on the mapped data sequence to generate mapped data sequence; and

performing at least one of transmit block selection operation, addition of cyclic prefix, addition of cyclic suffix, windowing, windowing with overlap and add operation, and frequency shifting on the mapped data sequence, to generate the waveform.

**17**. The system as claimed in claim **10**, wherein the processor is configured to rotate each of the plurality of data by 90 degrees using a constellation rotation.

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