

CLAIMS

1. A method of wireless communication, comprising:
modulating uplink control information (UCI) comprising a plurality of control information types, to generate a plurality of modulated UCI symbols;
mapping the plurality of modulated UCI symbols to a plurality of resource elements (REs) of a physical uplink shared channel (PUSCH) such that the modulated UCI symbols of each control information type are distributed according to a predetermined step size among the REs of one or more corresponding orthogonal frequency division multiplexing (OFDM) symbols of the PUSCH; and
transmitting data in the PUSCH including the UCI.
2. The method of claim 1,
wherein the UCI comprises a hybrid automatic repeat request acknowledgment (HARQ-ACK), a first portion of control state information (CSI), and a second portion of CSI; and
wherein the mapping comprises:
mapping the HARQ-ACK to a first set of the REs;
mapping the first portion of CSI to a second set of the REs; and
mapping the second portion of CSI to a third set of the REs.
3. The method of claim 2, wherein two or more of the first set of the REs, the second set of the REs, and the third set of the REs, are multiplexed in a frequency domain in each of the OFDM symbols.
4. The method of claim 3, wherein the mapping comprises:
interleaving two or more of the REs of the HARQ-ACK, the REs of the first portion of CSI, and the REs of the second portion of CSI, in an OFDM symbol.
5. The method of claim 2, wherein the mapping comprises:
mapping the HARQ-ACK to one or more OFDM symbols of the PUSCH earlier in a time domain than the first portion of CSI and the second portion of CSI; or
mapping the first portion of CSI to one or more OFDM symbols of the PUSCH earlier in a time domain than the HARQ-ACK.

6. The method of claim 2, wherein the mapping comprises:
mapping the HARQ-ACK, the first portion of CSI, and the second portion of CSI to the OFDM symbols of the PUSCH in a predetermined order in a time domain;
and

for each OFDM symbol, evenly distributing modulated symbols of one or more of the HARQ-ACK, the first portion of CSI, and the second portion of CSI mapped to the OFDM symbols, in a frequency domain.

7. The method of claim 1,
wherein the mapping comprises:
dividing the modulated UCI symbols into a first partition and a second partition; and

mapping the first partition to REs of a first frequency band and the second partition to REs of a second frequency band; and

wherein the transmitting comprises transmitting the data including the modulated UCI symbols in the PUSCH using frequency hopping across the first frequency band and the second frequency band.

8. The method of claim 1,
wherein the PUSCH further comprises a first demodulation reference signal (DMRS) and a second DMRS, and

wherein the mapping further comprises:
dividing the modulated UCI symbols of each control information type into a plurality of groups; and

mapping each group of the modulated UCI symbols to one or more OFDM symbols starting at an OFDM symbol adjacent to the first DMRS or the second DMRS.

9. The method of claim 8,
wherein the first DMRS is front-loaded in the PUSCH, and the first DMRS and the second DMRS are separated by one or more OFDM symbols; and

wherein the mapping further comprises:

mapping a first group of the UCI symbols to OFDM symbols adjacent to the first DMRS;

mapping a second group of the UCI symbols to OFDM symbols adjacent to and earlier in time than the second DMRS; and

mapping a third group of the UCI symbols to OFDM symbols adjacent to and later in time than the second DMRS.

10. An apparatus comprising:

a communication interface configured for wireless communication; and

a communication circuit configured to:

modulate uplink control information (UCI) comprising a plurality of control information types, to generate a plurality of modulated UCI symbols;

map the plurality of modulated UCI symbols to a plurality of resource elements (REs) of a physical uplink shared channel (PUSCH) such that the modulated UCI symbols of each control information type are distributed according to a predetermined step size among the REs of one or more corresponding orthogonal frequency division multiplexing (OFDM) symbols of the PUSCH; and

transmit data in the PUSCH including the UCI using the communication interface.

11. The apparatus of claim 10,

wherein the UCI comprises a hybrid automatic repeat request acknowledgment (HARQ-ACK), a first portion of control state information (CSI), and a second portion of CSI; and

wherein the communication circuit is further configured to:

map the HARQ-ACK to a first set of the REs;

map the first portion of CSI to a second set of the REs; and

map the second portion of CSI to a third set of the REs.

12. The apparatus of claim 11, wherein two or more of the first set of the REs, the second set of the REs, and the third set of the REs, are multiplexed in a frequency domain in each of the OFDM symbols.

13. The apparatus of claim 12, wherein the communication circuit is further configured to:

interleave two or more of the REs of the HARQ-ACK, the REs of the first portion of CSI, and the REs of the second portion of CSI, in an OFDM symbol.

14. The apparatus of claim 11, wherein the communication circuit is further configured to:

map the HARQ-ACK to one or more OFDM symbols of the PUSCH earlier in a time domain than the first portion of CSI and the second portion of CSI; or

map the first portion of CSI to one or more OFDM symbols of the PUSCH earlier in a time domain than the HARQ-ACK.

15. The apparatus of claim 11, wherein the communication circuit is further configured to:

map the HARQ-ACK, the first portion of CSI, and the second portion of CSI to the OFDM symbols of the PUSCH in a predetermined order in a time domain; and

for each OFDM symbol, evenly distribute modulated symbols of one or more of the HARQ-ACK, the first portion of CSI, and the second portion of CSI mapped to the OFDM symbols, in a frequency domain.

16. The apparatus of claim 10, wherein the communication circuit is further configured to:

divide the modulated UCI symbols into a first partition and a second partition; and

map the first partition to REs of a first frequency band and the second partition to REs of a second frequency band; and

transmit the data including the modulated UCI symbols in the PUSCH using frequency hopping across the first frequency band and the second frequency band.

17. The apparatus of claim 10, wherein the PUSCH further comprises a first demodulation reference signal (DMRS) and a second DMRS, and

wherein the communication circuit is further configured to:

divide the modulated UCI symbols of each control information type into a plurality of groups; and

map each group of the modulated UCI symbols to one or more OFDM symbols starting at an OFDM symbol adjacent to the first DMRS or the second DMRS.

18. The apparatus of claim 17,

wherein the first DMRS is front-loaded in the PUSCH, and the first DMRS and the second DMRS are separated by one or more OFDM symbols; and

wherein the communication circuit is further configured to:

map a first group of the UCI symbols to OFDM symbols adjacent to the first DMRS;

map a second group of the UCI symbols to OFDM symbols adjacent to and earlier in time than the second DMRS; and

map a third group of the UCI symbols to OFDM symbols adjacent to and later in time than the second DMRS.

19. A wireless communication apparatus comprising:

means for modulating uplink control information (UCI) comprising a plurality of control information types, to generate a plurality of modulated UCI symbols;

means for mapping the plurality of modulated UCI symbols to a plurality of resource elements (REs) of a physical uplink shared channel (PUSCH) such that the modulated UCI symbols of each control information type are distributed according to a predetermined step size among the REs of one or more corresponding orthogonal frequency division multiplexing (OFDM) symbols of the PUSCH; and

means for transmitting data in the PUSCH including the UCI.

20. The wireless communication apparatus of claim 19,

wherein the UCI comprises a hybrid automatic repeat request acknowledgment (HARQ-ACK), a first portion of control state information (CSI), and a second portion of CSI; and

wherein the means for mapping is configured to:

map the HARQ-ACK to a first set of the REs;

map the first portion of CSI to a second set of the REs; and

map the second portion of CSI to a third set of the REs.

21. The wireless communication apparatus of claim 20, wherein two or more of the first set of the REs, the second set of the REs, and the third set of the REs, are multiplexed in a frequency domain in each of the OFDM symbols.

22. The wireless communication apparatus of claim 21, wherein the means for mapping is configured to:

interleave two or more of the REs of the HARQ-ACK, the REs of the first portion of CSI, and the REs of the second portion of CSI, in an OFDM symbol.

23. The wireless communication apparatus of claim 20, wherein the means for mapping is configured to:

map the HARQ-ACK to one or more OFDM symbols of the PUSCH earlier in a time domain than the first portion of CSI and the second portion of CSI; or

map the first portion of CSI to one or more OFDM symbols of the PUSCH earlier in a time domain than the HARQ-ACK.

24. The wireless communication apparatus of claim 20, wherein the means for mapping is configured to:

map the HARQ-ACK, the first portion of CSI, and the second portion of CSI to the OFDM symbols of the PUSCH in a predetermined order in a time domain; and

for each OFDM symbol, evenly distribute modulated symbols of one or more of the HARQ-ACK, the first portion of CSI, and the second portion of CSI mapped to the OFDM symbols, in a frequency domain.

25. The wireless communication apparatus of claim 19, wherein the means for mapping is configured to:

divide the modulated UCI symbols into a first partition and a second partition; and

map the first partition to REs of a first frequency band and the second partition to REs of a second frequency band; and

wherein the means for transmitting is configured to transmit the data including the modulated UCI symbols in the PUSCH using frequency hopping across the first frequency band and the second frequency band.

26. The wireless communication apparatus of claim 19,
wherein the PUSCH further comprises a first demodulation reference signal (DMRS) and a second DMRS, and
wherein the mapping further comprises:
dividing the modulated UCI symbols of each control information type into a plurality of groups; and
mapping each group of the modulated UCI symbols to one or more OFDM symbols starting at an OFDM symbol adjacent to the first DMRS or the second DMRS.

27. The wireless communication apparatus of claim 26,
wherein the first DMRS is front-loaded in the PUSCH, and the first DMRS and the second DMRS are separated by one or more OFDM symbols; and
wherein the mapping further comprises:
mapping a first group of the UCI symbols to OFDM symbols adjacent to the first DMRS;
mapping a second group of the UCI symbols to OFDM symbols adjacent to and earlier in time than the second DMRS; and
mapping a third group of the UCI symbols to OFDM symbols adjacent to and later in time than the second DMRS.

28. A computer-readable storage medium comprising executable code to cause a computer to:
modulate uplink control information (UCI) comprising a plurality of control information types, to generate a plurality of modulated UCI symbols;
map the plurality of modulated UCI symbols to a plurality of resource elements (REs) of a physical uplink shared channel (PUSCH) such that the modulated UCI symbols of each control information type are distributed according to a predetermined step size among the REs of one or more corresponding orthogonal frequency division multiplexing (OFDM) symbols of the PUSCH; and
transmit data in the PUSCH including the UCI using a communication interface.

29. The computer-readable storage medium of claim 28,

wherein the UCI comprises a hybrid automatic repeat request acknowledgment (HARQ-ACK), a first portion of control state information (CSI), and a second portion of CSI; and

wherein the computer-readable storage medium further comprising executable code to cause the computer to:

- map the HARQ-ACK to a first set of the REs;
- map the first portion of CSI to a second set of the REs; and
- map the second portion of CSI to a third set of the REs.

30. The computer-readable storage medium of claim 29, wherein two or more of the first set of the REs, the second set of the REs, and the third set of the REs, are multiplexed in a frequency domain in each of the OFDM symbols.

31. The computer-readable storage medium of claim 30, further comprising executable code to cause the computer to:

interleave two or more of the REs of the HARQ-ACK, the REs of the first portion of CSI, and the REs of the second portion of CSI, in an OFDM symbol.

32. The computer-readable storage medium of claim 29, further comprising executable code to cause the computer to:

- map the HARQ-ACK to one or more OFDM symbols of the PUSCH earlier in a time domain than the first portion of CSI and the second portion of CSI; or
- map the first portion of CSI to one or more OFDM symbols of the PUSCH earlier in a time domain than the HARQ-ACK.

33. The computer-readable storage medium of claim 29, further comprising executable code to cause the computer to:

- map the HARQ-ACK, the first portion of CSI, and the second portion of CSI to the OFDM symbols of the PUSCH in a predetermined order in a time domain; and
- for each OFDM symbol, evenly distribute modulated symbols of one or more of the HARQ-ACK, the first portion of CSI, and the second portion of CSI mapped to the OFDM symbols, in a frequency domain.

34. The computer-readable storage medium of claim 28, further comprising executable code to cause the computer to:

divide the modulated UCI symbols into a first partition and a second partition;

and

map the first partition to REs of a first frequency band and the second partition to REs of a second frequency band; and

transmit the data including the modulated UCI symbols in the PUSCH using frequency hopping across the first frequency band and the second frequency band.

35. The computer-readable storage medium of claim 28,

wherein the PUSCH further comprises a first demodulation reference signal (DMRS) and a second DMRS, and

wherein the computer-readable storage medium further comprises executable code to cause the computer to:

divide the modulated UCI symbols of each control information type into a plurality of groups; and

map each group of the modulated UCI symbols to one or more OFDM symbols starting at an OFDM symbol adjacent to the first DMRS or the second DMRS.

36. The computer-readable storage medium of claim 35,

wherein the first DMRS is front-loaded in the PUSCH, and the first DMRS and the second DMRS are separated by one or more OFDM symbols; and

wherein the computer-readable storage medium further comprises executable code to cause the computer to:

map a first group of the UCI symbols to OFDM symbols adjacent to the first DMRS;

map a second group of the UCI symbols to OFDM symbols adjacent to and earlier in time than the second DMRS; and

map a third group of the UCI symbols to OFDM symbols adjacent to and later in time than the second DMRS.