

CLAIMS

What is claimed is:

1. A method for mapping an enhanced physical downlink control channel (ePDCCH) to physical resource blocks in a radio frame, comprising:
 - 5 mapping modulated symbols in the ePDCCH to at least one control channel element;
 - mapping the at least one control channel element to at least one of:
 - 10 resource elements located in a plurality of distributed physical resource blocks in a subframe, wherein each resource block is separated by at least one additional resource block in the subframe; and
 - resource elements distributed in a single resource block in the subframe, wherein the control channel element is mapped to be distributed in frequency and time relative to other mapped resource elements in the single resource block; and
 - 15 applying the mapping to control data to form an ePDCCH configured to be communicated from an enhanced Node B (eNB) to a user equipment (UE).
2. The method of claim 1, further comprising mapping the at least one control channel element to the resource elements located in the plurality of physical resource blocks in the subframe, wherein each resource block is separated from another resource block by a frequency that is at least two times a coherent bandwidth of the ePDCCH carrier frequency.
3. The method of claim 1, further comprising mapping the at least one control channel element to resource elements to a single resource block pair in the subframe wherein the control channel element is mapped in frequency and time to the resource elements in the single resource block pair.
4. The method of claim 3, further comprising mapping the modulated symbols in the ePDCCH to the single resource block pair, wherein the control channel element is mapped across a slot boundary in the physical resource block pair.

5. The method of claim 1, further comprising mapping the at least one control channel element to resource elements located in the plurality of physical resource blocks in the subframe, wherein each resource block is contiguous in frequency.
- 5 6. The method of claim 1, further comprising mapping the at least one control channel element to the resource elements located in the plurality of physical resource blocks in the subframe and to the single resource block in the subframe, wherein the single resource block contains both contiguous resource elements and resource elements distributed in frequency and time to which the at least one control channel element is mapped.
- 10 7. The method of claim 1, further comprising:
mapping symbols in a localized ePDCCH to a plurality of control channel elements; and
15 mapping the plurality of control channel elements to physical resource blocks that are contiguous in frequency in the subframe.
8. The method of claim 1, further comprising mapping the at least one control channel element to the resource elements located in the plurality of physical resource blocks in the subframe, wherein the resource elements are grouped into a plurality of resource element groups, with each resource element group consisting of four resource elements that are contiguous in at least one of time and frequency.
- 20 9. The method of claim 1, further comprising forming distributed resource element groups in one of the plurality of physical resource blocks and the single resource block, wherein each distributed resource element group consists of four resource elements distributed in time and frequency.
- 25 10. The method of claim 1, further comprising forming an individual index of the at least one control channel elements that are mapped to the resource elements in the resource blocks in the subframe.
- 30 11. The method of claim 1, further comprising forming a global index of the at least one control channel elements that are mapped to the resource elements in the resource blocks in each subframe of the radio frame.
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12. The method of claim 1, further comprising configuring reference signal ports to be located in resource elements in the at least one resource block, wherein the reference signal is selected from the group consisting of a cell specific reference signal (CRS), a demodulation reference signal (DMRS), and a channel state information reference signal (CSIRS).

13. The method of claim 1, further comprising defining a search space, wherein a ePDCCH candidate $m = 0, 1, \dots, M(\Lambda) - 1$ at aggregation level Λ comprises a CCE numbered with $n_{cce}^{PDCCH} = (\Lambda \times m + i) \bmod N_{CCE}^{PDCCH}$, where N_{CCE}^{PDCCH} is the total number of CCEs for the selected category, $i = 0, 1, \dots, \Lambda - 1$ and $M(\Lambda)$ is a number of ePDCCH candidates based on the aggregation level Λ .

14. An article, comprising a non-transitory computer-readable storage medium containing instructions that if executed by a processor enable a system to:

apply mapping to control data operable to form an extended physical downlink control channel (ePDCCH) configured to be communicated from an enhanced Node B (eNB) to a user equipment (UE) in a radio frame, wherein the mapping is formed by:

mapping modulated symbols in the ePDCCH to at least one of at least one localized control channel element and at least one distributed control channel element, wherein:

the at least one localized control channel element is mapped within a physical resource block or multiple physical resource blocks that are contiguous in the frequency domain on a subframe of the radio frame; and

the at least one distributed control channel element is mapped to distributed resource elements in at least one physical resource block in the subframe of the radio frame.

15. The article of claim 14, further comprising instructions that when executed by a processor enable the system to:

apply mapping to control data operable to form the ePDCCH configured to be communicated from the eNB to the UE in the radio frame, wherein the mapping is formed by:

mapping the modulated symbols in the ePDCCH to the at least one distributed control channel element that is mapped to multiple localized physical resource blocks that are distributed in frequency in the subframe.

5 16. The article of claim 14, further comprising instructions that when executed by a processor enable the system to:

apply mapping to control data operable to form the ePDCCH configured to be communicated from the eNB to the UE in the radio frame, wherein the mapping is formed by:

10 mapping the at least one localized control channel element and the at least one distributed control channel element to physical resource blocks in the subframe of the radio frame, wherein the subframe includes at least one of the mapped localized control channel element and the at least one mapped distributed control channel element.

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17. The article of claim 14, further comprising instructions that when executed by a processor enable the system to:

20 apply mapping to control data operable to form the ePDCCH configured to be communicated from the eNB to the UE in the radio frame, wherein the mapping is formed by:

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mapping the at least one localized control channel element and the at least one distributed control channel element to a physical resource block in the subframe of the radio frame, wherein the at physical resource block includes at least one of the mapped localized control channel elements and at least one of the mapped distributed control channel elements.

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18. An apparatus, comprising:

an enhanced Node B (eNB) operable to apply mapping to control data operable to form an extended physical downlink control channel (ePDCCH) configured to be communicated to a user equipment (UE) in a radio frame, wherein the mapping is formed by:

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mapping modulated symbols in the ePDCCH to at least one of at least one localized control channel element and at least one distributed control channel element, wherein:

the at least one localized control channel element is mapped within a physical resource block or multiple physical resource blocks that are contiguous in the frequency domain on a subframe of the radio frame; and

the at least one distributed control channel element is mapped to distributed resource elements in at least one physical resource block in the subframe of the radio frame.

19. The apparatus of claim 18, wherein the eNB is further configured to:

apply mapping to control data operable to form the ePDCCH configured to be communicated from the eNB to the UE in the radio frame, wherein the mapping is formed by:

mapping the modulated symbols in the ePDCCH to the at least one distributed control channel element that is mapped to multiple localized physical resource blocks that are distributed in frequency in the subframe.

20. The apparatus of claim 18, wherein the eNB is further configured to:

apply mapping to control data operable to form the ePDCCH configured to be communicated from the eNB to the UE in the radio frame, wherein the mapping is formed by:

mapping the at least one localized control channel element and the at least one distributed control channel element to physical resource blocks in the subframe of the radio frame, wherein the subframe includes at least one of the mapped localized control channel element and the mapped distributed control channel element.

21. The apparatus of claim 18, wherein the eNB is further configured to:

apply mapping to control data operable to form the ePDCCH configured to be communicated from the eNB to the UE in the radio frame, wherein the mapping is formed by:

mapping the at least one localized control channel element and the at least one distributed control channel element to a physical resource block in the subframe of the radio frame, wherein the physical resource block includes at least one of the mapped localized control channel elements and at least one of the mapped distributed control channel elements.

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What is claimed is:

1. A method for mapping an enhanced physical downlink control channel (ePDCCH) to physical resource blocks in a radio frame at an enhanced Node B (eNB), comprising: mapping modulated symbols at the eNB in the ePDCCH to at least one control channel element (CCE);

mapping the at least one CCE to resource elements located in a plurality of distributed physical resource blocks in a subframe; and

applying the mapping to control data for scheduling to form an ePDCCH configured to be communicated from the eNB to a user equipment (UE).

2. The method of claim 1, further comprising mapping the modulated symbols in the ePDCCH to at least one consecutive CCE.

3. The method of claim 1, further comprising mapping the at least one CCE to resource elements located in a plurality of distributed physical resource blocks, wherein each resource block is separated by at least one additional resource block in the subframe.

4. The method of claim 1, further comprising mapping the at least one control channel element to resource elements located in the plurality of physical resource blocks in the subframe, wherein each physical resource block is contiguous in frequency.

5. The method of claim 1, further comprising mapping the at least one control channel element to the resource elements located in the plurality of physical resource blocks in the subframe and to a single physical resource block in the subframe, wherein the single physical resource block contains both contiguous resource elements and resource elements distributed in frequency and time to which the at least one control

channel element is mapped.

6. The method of claim 1, further comprising forming an individual index of the at least one control channel elements that are mapped to the resource elements in the physical resource blocks in the subframe.
7. The method of claim 1, further comprising forming distributed resource element groups in one of the plurality of physical resource blocks, wherein each distributed resource element group consists of resource elements distributed in time and frequency.
8. The method of claim 1, further comprising applying the mapping to the control data for scheduling to form the ePDCCH configured to be communicated from the eNB to the UE, wherein the UE includes a microphone, an audio speaker, a liquid crystal display (LCD) screen, an organic light emitting display screen (OLED), a touch sensitive screen, or a non-volatile memory port.
9. A enhanced Node B (eNB) operable to apply mapping to control data operable to form an enhanced physical downlink control channel (ePDCCH) configured to be communicated to a user equipment (UE) in a radio frame, wherein the mapping comprises:
mapping modulated symbols in the ePDCCH to at least one control channel element (CCE);
mapping the at least one CCE to resource elements in a single physical resource block in the subframe; and
applying the mapping to control data for scheduling to form an ePDCCH configured to be communicated from the eNB to a user equipment UE.
10. The eNB of claim 9, wherein the modulated symbols in the ePDCCH are mapped to at least one consecutive CCE.

11. The eNB of claim 9, wherein the at least one control channel element is mapped to resource elements in a single physical resource block pair in the subframe, wherein the control channel element is mapped in frequency and time to the resource elements in the single physical resource block pair.
12. The eNB of claim 11, wherein the modulated symbols in the ePDCCH are mapped to the single physical resource block pair, wherein the control channel element is mapped across a slot boundary in the physical resource block pair.
13. The eNB of claim 9, wherein the at least one control channel element is mapped to resource elements located in a plurality of physical resource blocks in the subframe and to the single physical resource block in the subframe, wherein the single physical resource block contains both contiguous resource elements and resource elements distributed in frequency and time to which the at least one control channel element is mapped.
14. The eNB of claim 9, further comprising an individual index of the at least one control channel elements that are mapped to the resource elements in the physical resource block in the subframe.
15. The eNB of claim 9, wherein the ePDCCH is configured to be communicated from the eNB to the UE, wherein the UE includes a microphone, an audio speaker, a liquid crystal display (LCD) screen, an organic light emitting display screen (OLED), a touch sensitive screen, or a non-volatile memory port.
16. An article, comprising a non-transitory computer-readable storage medium containing instructions that if executed by a processor, enable a system to:

apply mapping to control data operable to form an enhanced physical downlink control channel (ePDCCH) configured to be communicated from an enhanced Node B (eNB) to a user equipment (UE) in a radio frame, wherein the mapping is formed by:

mapping modulated symbols in the ePDCCH to at least one of at least one localized control channel element and at least one distributed control channel element, wherein:

the at least one localized control channel element is mapped within a physical resource block or multiple physical resource blocks that are contiguous in the frequency domain on a subframe of the radio frame; and

the at least one distributed control channel element is mapped to distributed resource elements in at least one physical resource block in the subframe of the radio frame.

17. The article of claim 16, further comprising instructions that when executed by a processor enable the system to:

apply mapping to control data operable to form the ePDCCH configured to be communicated from the eNB to the UE in the radio frame, wherein the mapping is formed by:

mapping the modulated symbols in the ePDCCH to the at least one distributed control channel element that is mapped to multiple localized physical resource blocks that are distributed in frequency in the subframe.

18. The article of claim 16, further comprising instructions that when executed by a processor enable the system to:

apply mapping to control data operable to form the ePDCCH configured to be communicated from the eNB to the UE in the radio frame, wherein the mapping is formed by:

mapping the at least one localized control channel element and the at least one distributed control channel element to physical resource blocks in the subframe of the radio frame, wherein the subframe includes at least one of the mapped localized control channel element and the at

least one mapped distributed control channel element.

19. The article of claim 16, further comprising instructions that when executed by a processor enable the system to:
apply mapping to control data operable to form the ePDCCH configured to be communicated from the eNB to the UE in the radio frame, wherein the mapping is formed by:
mapping the at least one localized control channel element and the at least one distributed control channel element to a physical resource block in the subframe of the radio frame, wherein the at physical resource block includes at least one of the mapped localized control channel elements and at least one of the mapped distributed control channel elements.

20. An apparatus, comprising:
an enhanced Node B (eNB) operable to apply mapping to control data operable to form an enhanced physical downlink control channel (ePDCCH) configured to be communicated to a user equipment (UE) in a radio frame, wherein the mapping is formed by:
mapping modulated symbols in the ePDCCH to at least one of at least one localized control channel element and at least one distributed control channel element, wherein:
the at least one localized control channel element is mapped within a physical resource block or multiple physical resource blocks that are contiguous in the frequency domain on a subframe of the radio frame; and
the at least one distributed control channel element is mapped to distributed resource elements in at least one physical resource block in the subframe of the radio frame.

21. The apparatus of claim 20, wherein the eNB is further configured to:
apply mapping to control data operable to form the ePDCCH configured to be communicated from the eNB to the UE in the radio frame, wherein the mapping is formed by:

mapping the modulated symbols in the ePDCCH to the at least one distributed control channel element that is mapped to multiple localized physical resource blocks that are distributed in frequency in the subframe.

22. The apparatus of claim 20, wherein the eNB is further configured to:
apply mapping to control data operable to form the ePDCCH configured to be communicated from the eNB to the UE in the radio frame, wherein the mapping is formed by:

mapping the at least one localized control channel element and the at least one distributed control channel element to physical resource blocks in the subframe of the radio frame, wherein the subframe includes at least one of the mapped localized control channel element and the mapped distributed control channel element.

23. The apparatus of claim 20, wherein the eNB is further configured to:
apply mapping to control data operable to form the ePDCCH configured to be communicated from the eNB to the UE in the radio frame, wherein the mapping is formed by:

mapping the at least one localized control channel element and the at least one distributed control channel element to a physical resource block in the subframe of the radio frame, wherein the physical resource block includes at least one of the mapped localized control channel elements and at least one of the mapped distributed control channel elements.