

CLAIMS

WHAT IS CLAIMED IS:

1. A method of wireless communication by a base station, comprising:
determining to change from a first beam to a second beam;
generating a beam change instruction to indicate the determination to change from the first beam to the second beam;
transmitting, to a user equipment (UE), the beam change instruction in a downlink control information (DCI); and
determining whether or not the beam change instruction is detected by the UE.
2. The method of claim 1, wherein the first beam and the second beam are transmit beams or receive beams.
3. The method of claim 1, further comprising:
changing from the first beam to the second beam upon determining that the beam change instruction is detected by the UE.
4. The method of claim 1, wherein the DCI is transmitted for a downlink (DL) grant.
5. The method of claim 1, wherein the DCI is transmitted for an uplink (UL) grant.
6. The method of claim 5, wherein the determining whether or not the beam change instruction is detected further comprises:
receiving an uplink transmission indicating that the UE has detected the beam change instruction, and
decoding the uplink transmission to determine whether or not the beam change instruction is detected.
7. The method of claim 5, wherein the determining whether or not the beam change instruction is detected further comprises:

receiving an uplink transmission indicating that the UE has detected the beam change instruction, and

detecting an energy of the uplink transmission to determine whether or not the beam change instruction is detected.

8. The method of claim 7, wherein the base station determines that the beam change instruction is detected if the detected energy of the uplink transmission is greater than an energy threshold.

9. The method of claim 5, wherein the determining whether or not the beam change instruction is detected further comprises:

receiving an uplink transmission indicating that the UE has detected the beam change instruction, and

decoding a demodulation reference signal (DMRS) included in the uplink transmission, the DMRS indicating that the beam change instruction is detected.

10. The method of claim 1, where the DCI is a semi-persistent scheduling (SPS) DCI transmitted via SPS.

11. The method of claim 10, wherein the SPS DCI is independent from a physical downlink shared channel (PDSCH).

12. The method of claim 10, wherein the SPS DCI has a different bit pattern than other DCIs.

13. The method of claim 10, wherein the determining whether or not the beam change instruction is detected comprises:

receiving from the UE, an acknowledgement (ACK) indicating that the SPS DCI is received by the UE or a negative acknowledgement (NACK) indicating that the SPS DCI is not received by the UE.

14. The method of claim 1, wherein the transmitting the beam change instruction comprises:

transmitting a physical downlink control channel (PDCCH) including the DCI that is for an uplink grant or for a downlink grant, or is communicated via semi-persistent scheduling (SPS).

15. The method of claim 4, wherein the determining whether or not the beam change instruction is detected comprises:

receiving an indication that the beam change instruction is detected,

wherein the determining whether or not the beam change instruction is detected is based on the indication.

16. The method of claim 15, wherein the indication is received via a physical uplink control channel (PUCCH), the PUCCH being associated with the DCI for the DL grant.

17. The method of claim 16, wherein the indication comprises:

the PUCCH scrambled with a beam change scrambling code indicating that the beam change instruction is detected by the UE.

18. The method of claim 17, wherein the beam change scrambling code is different from a scrambling code used by the UE to transmit a PUCCH if the beam change instruction is not detected in the DCI.

19. The method of claim 16, wherein the indication comprises:

the PUCCH including a beam change demodulation reference signal (DMRS) sequence indicating that the beam change instruction is detected by the UE.

20. The method of claim 19, where the beam change DMRS sequence is different from a DMRS sequence used by the UE to transmit a PUCCH if the beam change instruction is not detected in the DCI.

21. The method of claim 16, wherein the indication comprises:

a DCI bit included in the PUCCH to indicate whether the DCI is successfully decoded.

22. The method of claim 15, wherein the indication comprises a tri-state indicator indicating one of:

successful decoding of the DCI and failure of a cyclic redundancy check (CRC) for a physical downlink shared channel (PDSCH) when the DCI is successfully decoded and the CRC for the PDSCH fails,

successful decoding of the DCI and a pass of the CRC for the PDSCH when the DCI is successfully decoded and the CRC for the PDSCH passes, and

unsuccessful decoding of the DCI when the DCI is not successfully decoded.

23. A method of wireless communication by a base station, comprising:

transmitting a beam change instruction in a downlink control information (DCI) using a first beam;

receiving a first sample signal using the first beam;

receiving a second sample signal using a second beam indicated by the beam change instruction; and

selecting one of the first beam and the second beam based on the first sample signal and the second sample signal.

24. The method of claim 23, wherein the first sample signal and the second sample signal are received in a subframe specified to the UE in the DCI.

25. A method of wireless communication by a user equipment (UE), comprising:

receiving a downlink control information (DCI) from a base station;

determining whether a beam change instruction is detected in the DCI;

indicating via an uplink transmission which is associated with the DCI whether the beam change instruction is detected, the uplink transmission including at least one of a physical uplink control channel (PUCCH) or a physical uplink shared channel (PUSCH); and

transmitting the uplink transmission to the base station.

26. The method of claim 25, wherein the PUCCH includes an acknowledgement (ACK) to indicate successful decoding of the DCI or a negative acknowledgement (NACK) to indicate unsuccessful decoding of the DCI.

27. The method of claim 25, wherein the indicating via the uplink transmission comprises:

scrambling the PUCCH with a beam change scrambling code indicating that the beam change instruction is detected.

28. The method of claim 27, wherein the beam change scrambling code is different from a scrambling sequence used by the UE to transmit a PUCCH if the beam change instruction is not detected in the DCI.

29. The method of claim 25, wherein the indicating via the uplink transmission comprises;

including a beam change demodulation reference signal (DMRS) sequence in the PUCCH indicating that the beam change instruction is detected.

30. The method of claim 29, where the beam change DMRS sequence is different from a DMRS sequence used by the UE to transmit a PUCCH if the beam change instruction is not detected in the DCI.

31. The method of claim 25, wherein the indicating via the uplink transmission comprises including a tri-state indicator in the uplink transmission to indicate one of:

successful decoding of the DCI and failure of a cyclic redundancy check (CRC) for a physical downlink shared channel (PDSCH) when the DCI is successfully decoded and the CRC for the PDSCH fails;

successful decoding of the DCI and a pass of the CRC for the PDSCH when the DCI is successfully decoded and the CRC for the PDSCH passes, and
unsuccessful decoding of the DCI when the DCI is not successfully decoded.

32. The method of claim 25, wherein the indicating via the uplink transmission comprises:

including a DCI bit in the PUCCH to indicate whether the DCI is successfully decoded.

33. The method of claim 25, wherein the receiving the DCI comprises:

receiving at least one of a DCI for an uplink grant including the beam change instruction, a DCI for a downlink grant including the beam change instruction, or a semi-persistent scheduling (SPS) DCI including the beam change instruction.

34. The method of claim 33, wherein the transmitting the uplink transmission comprises:

transmitting an acknowledgement (ACK) indicating that the beam change instruction is detected or a negative acknowledgment (NACK) indicating that the beam change instruction is not detected when the SPS DCI grant is received.

35. The method of claim 33, wherein the receiving at least one of the DCI for the uplink grant, the DCI for the downlink grant, or the SPS DCI comprises:

receiving a physical downlink control channel (PDCCH) including at least one of the DCI for uplink grant, the DCI for downlink grant, or the SPS DCI.

36. The method of claim 34, wherein the SPS DCI is independent from a physical downlink shared channel (PDSCH).

37. A base station for wireless communication, comprising:

means for determining to change from a first beam to a second beam;

means for generating a beam change instruction to indicate the determination to change from the first beam to the second beam;

means for transmitting, to a user equipment (UE), the beam change instruction in a downlink control information (DCI); and

means for determining whether or not the beam change instruction is detected by the UE.

38. The base station of claim 37, wherein the first beam and the second beam are transmit beams or receive beams.

39. The base station of claim 37, further comprising:

means for changing from the first beam to the second beam upon determining that the beam change instruction is detected by the UE.

40. The base station of claim 37, wherein the DCI is transmitted for a downlink (DL) grant.

41. The base station of claim 37, wherein the DCI is transmitted for an uplink (UL) grant.

42. The base station of claim 41, wherein the means for determining whether or not the beam change instruction is detected is further configured to:

receive an uplink transmission indicating that the UE has detected the beam change instruction, and

decode the uplink transmission to determine whether or not the beam change instruction is detected.

43. The base station of claim 41, wherein the means for determining whether or not the beam change instruction is detected is further configured to:

receive an uplink transmission indicating that the UE has detected the beam change instruction, and

detect an energy of the uplink transmission to determine whether or not the beam change instruction is detected.

44. The base station of claim 43, wherein the means for determining whether or not the beam change instruction is detected is configured to determine that the beam change instruction is detected if the detected energy of the uplink transmission is greater than an energy threshold.

45. The base station of claim 41, wherein the means for determining whether or not the beam change instruction is detected is further configured to

receive an uplink transmission indicating that the UE has detected the beam change instruction, and

decode a demodulation reference signal (DMRS) included in the uplink transmission, the demodulation reference signal indicating that the beam change instruction is detected.

46. The base station of claim 37, wherein the DCI is a semi-persistent scheduling (SPS) DCI transmitted via SPS.

47. The base station of claim 46, wherein the SPS DCI is independent from a physical downlink shared channel (PDSCH).

48. The base station of claim 46, wherein the SPS DCI has a different bit pattern than other DCIs.

49. The base station of claim 46, wherein the means for determining whether or not the beam change instruction is detected is configured to:

receive from the UE, an acknowledgement (ACK) indicating that the SPS DCI is received by the UE or a negative acknowledgement (NACK) indicating that the SPS DCI is not received by the UE.

50. The base station of claim 37, wherein the means for transmitting the beam change instruction is configured to:

transmit a physical downlink control channel (PDCCH) including the DCI that is for uplink grant or downlink grant or is communicated via semi-persistent scheduling (SPS).

51. The base station of claim 40, wherein the means for determining whether or not the beam change instruction is detected is configured to:

receive an indication that the beam change instruction is detected,

wherein the determining whether or not the beam change instruction is detected is based on the indication.

52. The base station of claim 51, wherein the indication is received via a physical uplink control channel (PUCCH), the PUCCH being associated with the DCI for the DL grant.

53. The base station of claim 52, wherein the indication comprises:
the PUCCH scrambled with a beam change scrambling code indicating that the beam change instruction is detected by the UE.
54. The base station of claim 53, wherein the beam change scrambling code is different from a scrambling code used by the UE to transmit a PUCCH if the beam change instruction is not detected in the DCI.
55. The base station of claim 52, wherein the indication comprises:
the PUCCH including a beam change demodulation reference signal (DMRS) sequence indicating that the beam change instruction is detected by the UE.
56. The base station of claim 55, where the beam change DMRS sequence is different from a DMRS sequence used by the UE to transmit a PUCCH if the beam change instruction is not detected in the DCI.
57. The base station of claim 52, wherein the indication comprises:
a DCI bit included in the PUCCH to indicate whether the DCI is successfully decoded.
58. The base station of claim 51, wherein the indication comprises a tri-state indicator indicating one of:
successful decoding of the DCI and failure of a cyclic redundancy check (CRC) for a physical downlink shared channel (PDSCH) when the DCI is successfully decoded and the CRC for the PDSCH fails,
successful decoding of the DCI and a pass of the CRC for the PDSCH when the DCI is successfully decoded and the CRC for the PDSCH passes, and
unsuccessful decoding of the DCI when the DCI is not successfully decoded.
59. A base station for wireless communication, comprising:

means for transmitting a beam change instruction in a downlink control information (DCI) using a first beam;

means for receiving a first sample signal using the first beam;

means for receiving a second sample signal using a second beam indicated by the beam change instruction; and

means for selecting one of the first beam and the second beam based on the first sample signal and the second sample signal.

60. The base station of claim 59, wherein the first sample signal and the second sample signal are received in a subframe specified to the UE in the DCI.

61. A user equipment (UE) for wireless communication, comprising:

means for receiving a downlink control information (DCI) from a base station;

means for determining whether a beam change instruction is detected in the DCI;

means for indicating via an uplink transmission which is associated with the DCI whether the beam change instruction is detected, the uplink transmission including at least one of a physical uplink control channel (PUCCH) or a physical uplink shared channel (PUSCH); and

means for transmitting the uplink transmission to the base station.

62. The UE of claim 61, wherein the PUCCH includes an acknowledgement (ACK) to indicate successful decoding of the DCI or a negative acknowledgement (NACK) to indicate unsuccessful decoding of the DCI.

63. The UE of claim 61, wherein the means for indicating via the uplink transmission is configured to:

scramble the PUCCH with a beam change scrambling code indicating that the beam change instruction is detected.

64. The UE of claim 63, wherein the beam change scrambling code is different from a scrambling sequence used by the UE to transmit a PUCCH if the beam change instruction is not detected in the DCI.

65. The UE of claim 61, wherein the means for indicating via the uplink transmission is configured to:

include a beam change demodulation reference signal (DMRS) sequence in the PUCCH indicating that the beam change instruction is detected.

66. The UE of claim 65, where the beam change DMRS sequence is different from a DMRS sequence used by the UE to transmit a PUCCH if the beam change instruction is not detected in the DCI.

67. The UE of claim 61, wherein the means for indicating via the uplink transmission is configured to include a tri-state indicator in the uplink transmission to indicate one of:

successful decoding of the DCI and failure of a cyclic redundancy check (CRC) for a physical downlink shared channel (PDSCH) when the DCI is successfully decoded and the CRC for the PDSCH fails;

successful decoding of the DCI and a pass of the CRC for the PDSCH when the DCI is successfully decoded and the CRC for the PDSCH passes, and
unsuccessful decoding of the DCI when the DCI is not successfully decoded.

68. The UE of claim 61, wherein the means for indicating via the uplink transmission is configured to:

include a DCI bit in the PUCCH to indicate whether the DCI is successfully decoded.

69. The UE of claim 61, wherein the means for receiving the DCI comprises:

means for receiving at least one of a DCI for an uplink grant including the beam change instruction without using a DCI for downlink grant, a DCI for a downlink grant including the beam change instruction, or semi-persistent scheduling (SPS) DCI including the beam change instruction.

70. The UE of claim 69, wherein the means for transmitting the uplink transmission is configured to:

transmit an acknowledgement (ACK) indicating that the beam change instruction is detected or a negative acknowledgment (NACK) indicating that the beam change instruction is not detected when the SPS DCI grant is received.

71. The UE of claim 69, wherein the means for receiving at least one of the DCI for the uplink grant, the DCI for the downlink grant, or the SPS DCI is configured to:

receive a physical downlink control channel (PDCCH) including at least one of the DCI for uplink grant, the DCI for downlink grant, or the SPS DCI.

72. The UE of claim 70, wherein the SPS DCI is independent from a physical downlink shared channel (PDSCH).

73. A base station for wireless communication, comprising:
a memory; and

at least one processor coupled to the memory and configured to:

determine to change from a first beam to a second beam;

generate a beam change instruction to indicate the determination to change from the first beam to the second beam;

transmit, to a user equipment (UE), the beam change instruction in a downlink control information (DCI); and

determine whether or not the beam change instruction is detected by the UE.

74. The base station of claim 73, wherein the first beam and the second beam are transmit beams or receive beams.

75. The base station of claim 73, wherein the at least one processor is further configured to:

change from the first beam to the second beam upon determining that the beam change instruction is detected by the UE.

76. The base station of claim 73, wherein the DCI is transmitted for a downlink (DL) grant.

77. The base station of claim 73, wherein the DCI is transmitted for an uplink (UL) grant.

78. The base station of claim 77, wherein the at least one processor configured to determine whether or not the beam change instruction is detected is further configured to:

receive an uplink transmission indicating that the UE has detected the beam change instruction, and

decode the uplink transmission to determine whether or not the beam change instruction is detected.

79. The base station of claim 77, wherein the at least one processor configured to determine whether or not the beam change instruction is detected is further configured to:

receive an uplink transmission indicating that the UE has detected the beam change instruction, and

detect an energy of the uplink transmission to determine whether or not the beam change instruction is detected.

80. The base station of claim 79, wherein the at least one processor is configured to determine that the beam change instruction is detected if the detected energy of the uplink transmission is greater than an energy threshold.

81. The base station of claim 77, the at least one processor configured to determine whether or not the beam change instruction is detected is further configured to:

receive an uplink transmission indicating that the UE has detected the beam change instruction, and

decode a demodulation reference signal (DMRS) included in the uplink transmission, the DMRS indicating that the beam change instruction is detected.

82. The base station of claim 73, where the DCI is a semi-persistent scheduling (SPS) DCI transmitted via SPS.

83. The base station of claim 82, wherein the SPS DCI is independent from a physical downlink shared channel (PDSCH).

84. The base station of claim 82, wherein the SPS DCI has a different bit pattern than other DCIs.

85. The base station of claim 82, wherein the at least one processor configured to determine whether or not the beam change instruction is detected is configured to:

receive from the UE, an acknowledgement (ACK) indicating that the SPS DCI is received by the UE or a negative acknowledgement (NACK) indicating that the SPS DCI is not received by the UE.

86. The base station of claim 73, wherein the at least one processor configured to transmit the beam change instruction is configured to:

transmit a physical downlink control channel (PDCCH) including the DCI that is for uplink grant or downlink grant or is communicated via semi-persistent scheduling (SPS).

87. The base station of claim 76, wherein the at least one processor configured to determine whether or not the beam change instruction is detected is configured to:

receive an indication that the beam change instruction is detected,

wherein the determining whether or not the beam change instruction is detected is based on the indication.

88. The base station of claim 87, wherein the indication is received via a physical uplink control channel (PUCCH), the PUCCH being associated with the DCI for the DL grant.

89. The base station of claim 88, wherein the indication comprises:

the PUCCH scrambled with a beam change scrambling code indicating that the beam change instruction is detected by the UE.

90. The base station of claim 89, wherein the beam change scrambling code is different from a scrambling code used by the UE to transmit a PUCCH if the beam change instruction is not detected in the DCI.
91. The base station of claim 88, wherein the indication comprises:
the PUCCH including a beam change demodulation reference signal (DMRS) sequence indicating that the beam change instruction is detected by the UE.
92. The base station of claim 91, where the beam change DMRS sequence is different from a DMRS sequence used by the UE to transmit a PUCCH if the beam change instruction is not detected in the DCI.
93. The base station of claim 88, wherein the indication comprises:
a DCI bit included in the PUCCH to indicate whether the DCI is successfully decoded.
94. The base station of claim 87, wherein the indication comprises a tri-state indicator indicating one of:
successful decoding of the DCI and failure of a cyclic redundancy check (CRC) for a physical downlink shared channel (PDSCH) when the DCI is successfully decoded and the CRC for the PDSCH fails,
successful decoding of the DCI and a pass of the CRC for the PDSCH when the DCI is successfully decoded and the CRC for the PDSCH passes, and
unsuccessful decoding of the DCI when the DCI is not successfully decoded.
95. A base station for wireless communication, comprising:
a memory; and
at least one processor coupled to the memory and configured to:
transmit a beam change instruction in a downlink control information (DCI) using a first beam;
receive a first sample signal using the first beam;
receive a second sample signal using a second beam indicated by the beam change instruction; and

select one of the first beam and the second beam based on the first sample signal and the second sample signal.

96. The base station of claim 95, wherein the first sample signal and the second sample signal are received in a subframe specified to the UE in the DCI.

97. A user equipment (UE) for wireless communication, comprising:
a memory; and
at least one processor coupled to the memory and configured to:
receive a downlink control information (DCI) from a base station;
determine whether a beam change instruction is detected in the DCI;
indicate via an uplink transmission which is associated with the DCI whether the beam change instruction is detected, the uplink transmission including at least one of a physical uplink control channel (PUCCH) or a physical uplink shared channel (PUSCH); and
transmit the uplink transmission to the base station.

98. The UE of claim 97, wherein the PUCCH includes an acknowledgement (ACK) to indicate successful decoding of the DCI or a negative acknowledgement (NACK) to indicate unsuccessful decoding of the DCI.

99. The UE of claim 97, wherein the at least one processor configured to indicate in the PUCCH is configured to:
scramble the PUCCH with a beam change scrambling code indicating that the beam change instruction is detected.

100. The UE of claim 99, wherein the beam change scrambling code is different from a scrambling sequence used by the UE to transmit a PUCCH if the beam change instruction is not detected in the DCI.

101. The UE of claim 97, wherein the at least one processor configured to indicate in the PUCCH is configured to:

include a beam change demodulation reference signal (DMRS) sequence in the PUCCH indicating that the beam change instruction is detected.

102. The UE of claim 101, where the beam change DMRS sequence is different from a DMRS sequence used by the UE to transmit a PUCCH if the beam change instruction is not detected in the DCI.

103. The UE of claim 97, wherein the at least one processor configured to indicate in the PUCCH is configured to include a tri-state indicator in the PUCCH to indicate one of:

successful decoding of the DCI and failure of a cyclic redundancy check (CRC) for a physical downlink shared channel (PDSCH) when the DCI is successfully decoded and the CRC for the PDSCH fails,

successful decoding of the DCI and a pass of the CRC for the PDSCH when the DCI is successfully decoded and the CRC for the PDSCH passes, and

unsuccessful decoding of the DCI when the DCI is not successfully decoded.

104. The UE of claim 97, wherein the at least one processor configured to indicate in the PUCCH is configured to:

include a DCI bit in the PUCCH to indicate whether the DCI is successfully decoded.

105. The UE of claim 97, wherein the at least one processor configured to receive the DCI is configured to:

receive at least one of a DCI for an uplink grant including the beam change instruction without using a DCI for a downlink grant or semi-persistent scheduling (SPS) DCI including the beam change instruction.

106. The UE of claim 105, wherein the at least one processor configured to transmit the uplink transmission is configured to:

transmit an acknowledgement (ACK) indicating that the beam change instruction is detected or a negative acknowledgment(NACK) indicating that the beam change instruction is not detected when the SPS DCI grant is received.

107. The UE of claim 105, wherein the at least one processor configured to receive at least one of the DCI for the uplink grant, the DCI for the downlink grant, or the SPS DCI is configured to:

receive a physical downlink control channel (PDCCH) including at least one of the DCI for uplink grant or the SPS DCI.

108. The UE of claim 106, wherein the SPS DCI is independent from a physical downlink shared channel (PDSCH).

109. A computer-readable medium storing computer executable code for a base station, comprising code to:

determine to change from a first beam to a second beam;

generate a beam change instruction to indicate the determination to change from the first beam to the second beam;

transmit, to a user equipment (UE), the beam change instruction in a downlink control information (DCI); and

determine whether or not the beam change instruction is detected by the UE.

110. A computer-readable medium storing computer executable code for a base station, comprising code to:

transmit a beam change instruction in a downlink control information (DCI) using a first beam;

receive a first sample signal using the first beam;

receive a second sample signal using a second beam indicated by the beam change instruction; and

select one of the first beam and the second beam based on the first sample signal and the second sample signal.

111. A computer-readable medium storing computer executable code for a user equipment (UE), comprising code to:

receive a downlink control information (DCI) from a base station;

determine whether a beam change instruction is detected in the DCI;

indicate via an uplink transmission which is associated with the DCI whether the beam change instruction is detected, the uplink transmission including at

least one of a physical uplink control channel (PUCCH) or a physical uplink shared channel (PUSCH); and
transmit the uplink transmission to the base station.