

CLAIMS

1. A wireless communication device, comprising:
a transceiver;
a memory; and
a processor communicatively coupled to the transceiver and the memory, the processor configured to:
generate a time-based scrambling sequence according to a time parameter associated with one of a wake-up signal (WUS) or a paging occasion (PO), the time-based scrambling sequence facilitating a phase shift in time;
generate a scrambled WUS, the scrambled WUS generated by multiplying a WUS base sequence by the time-based scrambling sequence; and
transmit, via the transceiver, the scrambled WUS to at least one scheduled entity.
2. The wireless communication device of claim 1, wherein the time parameter is at least one of a subframe, a frame, a slot index, or a symbol index.
3. The wireless communication device of claim 1, wherein the processor configured to generate the time-based scrambling sequence comprises the processor configured to:
match a length of the time-based scrambling sequence with a length of a total number of resource elements (REs) in a single WUS subframe.
4. The wireless communication device of claim 1, wherein the processor configured to generate the time-based scrambling sequence comprises the processor configured to:
match a length of the time-based scrambling sequence with a length of a total number of resource elements (REs) of all WUS subframes.
5. The wireless communication device of claim 4, wherein:
the processor configured to generate the time-based scrambling sequence comprises the processor configured to generate the time-base scrambling sequence

according to a Gold sequence $c_{n_f, n_s}(j)$, $j = 0, \dots, 2L - 1$ with L as the length of the WUS sequence, initialized at a start of a first WUS subframe based on a first frame n_{f_start} and first slot n_{s_start} of the first PO to which the WUS is associated and a cell ID with $c_{init_WUS} = (N_{ID}^{N_{cell}} + 1) \left(\left(10n_{f_start} + \left\lfloor \frac{n_{s_start}}{2} \right\rfloor \right) \bmod 2048 + 1 \right) 2^9 + N_{ID}^{N_{cell}}$; and

the processor configured to generate the scrambled WUS comprises the processor configured to scramble the WUS according to

$$b(n) = \begin{cases} 1, & \text{if } c_{n_f, n_s}(2i) = 0 \text{ and } c_{n_f, n_s}(2i + 1) = 0 \\ -1, & \text{if } c_{n_f, n_s}(2i) = 0 \text{ and } c_{n_f, n_s}(2i + 1) = 1 \\ j, & \text{if } c_{n_f, n_s}(2i) = 1 \text{ and } c_{n_f, n_s}(2i + 1) = 0 \\ -j, & \text{if } c_{n_f, n_s}(2i) = 1 \text{ and } c_{n_f, n_s}(2i + 1) = 1 \end{cases}$$

6. The wireless communication device of claim 1, wherein the processor is further configured to:

generate a frequency-based scrambling sequence, wherein the frequency-based scrambling sequence facilitates a phase shift in frequency; and

generate the scrambled WUS by multiplying the WUS base sequence by the time-based scrambling sequence and further by the frequency-based scrambling sequence.

7. The wireless communication device of claim 6, wherein:

the processor configured to generate the frequency-based scrambling sequence comprises the processor configured to generate the frequency-based scrambling sequence based on a time parameter of a starting point of a WUS transmission or a starting point of a PO transmission; and

the processor configured to generate the time-based scrambling sequence comprises the processor configured to generate the time-based scrambling sequence based on a time parameter of a current WUS transmission.

8. The wireless communication device of claim 7, wherein the processor configured to generate the frequency-based scrambling sequence comprises the processor configured to:

match a length of the frequency-based scrambling sequence with a length of a total number of resource elements of a single WUS subframe;

match a length of the time-based scrambling sequence with a length of a total number of resource elements (REs) in a single WUS subframe; or

match a length of the time-based scrambling sequence with a length of a total number of resource elements (REs) of all WUS subframes.

9. The wireless communication device of claim 1, wherein the processor configured to generate the scrambled WUS comprises the processor configured to:
generate the scrambled WUS based on a UE group identifier.

10. The wireless communication device of claim 9, wherein the processor configured to generate the scrambled WUS further comprises the processor configured to:

place the UE group identifier in a most significant bit (MSB) of the scrambled WUS; or

place the UE group identifier in a least significant bit (LSB) of the scrambled WUS; or

multiply the UE group identifier with a most significant bit (MSB) of the scrambled WUS.

11. A method of wireless communication, comprising:

generating a time-based scrambling sequence, the time-based scrambling sequence facilitating a phase shift in time and generated according to a time parameter associated with a wake-up signal (WUS) or a paging occasion (PO);

generating a scrambled WUS, the scrambled WUS generated by multiplying a WUS base sequence by the time-based scrambling sequence; and

transmitting the scrambled WUS to at least one scheduled entity.

12. The method of claim 11, wherein the time parameter is at least one of a subframe, a frame, a slot index, or a symbol index.

13. The method of claim 11, wherein generating the time-based scrambling sequence comprises one of:

matching a length of the time-based scrambling sequence with a length of a total number of resource elements (REs) in a single WUS subframe; or

matching a length of the time-based scrambling sequence with a length of a total number of resource elements (REs) of all WUS subframes.

14. The method of claim 13, wherein:

generating the time-based scrambling sequence comprises generating the time-base scrambling sequence according to a Gold sequence $c_{n_f, n_s}(j)$, $j = 0, \dots, 2L - 1$ with L as the length of the WUS sequence, initialized at a start of a first WUS subframe based on a first frame n_{f_start} and first slot n_{s_start} of the first PO to which the WUS is associated and a cell ID with

$$c_{init_WUS} = (N_{ID}^{N_{cell}} + 1) \left(\left(10n_{f_start} + \left\lfloor \frac{n_{s_start}}{2} \right\rfloor \right) \bmod 2048 + 1 \right) 2^9 + N_{ID}^{N_{cell}}, \text{ and}$$

generating the scrambled WUS comprises generating the scrambled WUS according to

$$b(n) = \begin{cases} 1, & \text{if } c_{n_f, n_s}(2i) = 0 \text{ and } c_{n_f, n_s}(2i + 1) = 0 \\ -1, & \text{if } c_{n_f, n_s}(2i) = 0 \text{ and } c_{n_f, n_s}(2i + 1) = 1 \\ j, & \text{if } c_{n_f, n_s}(2i) = 1 \text{ and } c_{n_f, n_s}(2i + 1) = 0 \\ -j, & \text{if } c_{n_f, n_s}(2i) = 1 \text{ and } c_{n_f, n_s}(2i + 1) = 1 \end{cases}.$$

15. The method of claim 11, further comprising:

generating a frequency-based scrambling sequence, wherein the frequency-based scrambling sequence facilitates a phase shift in frequency; and

wherein generating the scrambled WUS further comprises multiplying the WUS base sequence by the frequency-based scrambling sequence.

16. The method of claim 15, wherein:

generating the frequency-based scrambling sequence comprises generating the frequency-based scrambling sequence based on a time parameter of a starting point of a WUS transmission or a starting point of a PO transmission; and

generating the time-based scrambling sequence comprises generating the time-based scrambling sequence based on a time parameter of a current WUS transmission.

17. The method of claim 16, wherein generating the frequency-based scrambling sequence comprises one of:

matching a length of the frequency-based scrambling sequence with a length of a total number of resource elements of a single WUS subframe;

matching a length of the time-based scrambling sequence with a length of a total number of resource elements (REs) in a single WUS subframe; or

matching a length of the time-based scrambling sequence with a length of a total number of resource elements (REs) of all WUS subframes.

18. The method of claim 11, wherein generating the scrambled WUS further comprises:

generating the scrambled WUS based on a UE group identifier.

19. The method of claim 18, wherein generating the scrambled WUS further comprises one of:

placing the UE group identifier in a most significant bit (MSB) of the scrambled WUS;

placing the UE group identifier in a least significant bit (LSB) of the scrambled WUS; or

multiplying the UE group identifier with a most significant bit (MSB) of the scrambled WUS.

20. An apparatus for wireless communication, comprising:

means for generating a time-based scrambling sequence, the time-based scrambling sequence facilitating a phase shift in time and generated according to a time parameter associated with a wake-up signal (WUS) or a paging occasion (PO);

means for generating a scrambled WUS, the scrambled WUS generated by multiplying a WUS base sequence by the time-based scrambling sequence; and

means for transmitting the scrambled WUS to at least one scheduled entity.

21. The apparatus of claim 20, further comprising:

means for generating a frequency-based scrambling sequence, wherein the frequency-based scrambling sequence facilitates a phase shift in frequency; and

means for generating the scrambled WUS by multiplying the WUS base sequence by the frequency-based scrambling sequence.

22. The apparatus of claim 21, wherein:

generating the frequency-based scrambling sequence comprises generating the frequency-based scrambling sequence based on a time parameter of a starting point of a WUS transmission or a starting point of a PO transmission; and

generating the time-based scrambling sequence comprises generating the time-based scrambling sequence based on a time parameter of a current WUS transmission.

23. The apparatus of claim 20, wherein generating the scrambled WUS further comprises:

generating the scrambled WUS based on a UE group identifier.

24. The apparatus of claim 20, wherein:

generating the time-based scrambling sequence comprises generating the time-base scrambling sequence according to a Gold sequence $c_{n_f, n_s}(j)$, $j = 0, \dots, 2L - 1$ with L as the length of the WUS sequence, initialized at a start of a first WUS subframe based on a first frame n_{f_start} and first slot n_{s_start} of the first PO to which the WUS is associated and a cell ID with

$$c_{init_WUS} = (N_{ID}^{Ncell} + 1) \left(\left(10n_{f_start} + \left\lfloor \frac{n_{s_start}}{2} \right\rfloor \right) \bmod 2048 + 1 \right) 2^9 + N_{ID}^{Ncell}; \text{ and}$$

generating the scrambled WUS comprises generating the scrambled WUS according to

$$b(n) = \begin{cases} 1, & \text{if } c_{n_f, n_s}(2i) = 0 \text{ and } c_{n_f, n_s}(2i + 1) = 0 \\ -1, & \text{if } c_{n_f, n_s}(2i) = 0 \text{ and } c_{n_f, n_s}(2i + 1) = 1 \\ j, & \text{if } c_{n_f, n_s}(2i) = 1 \text{ and } c_{n_f, n_s}(2i + 1) = 0 \\ -j, & \text{if } c_{n_f, n_s}(2i) = 1 \text{ and } c_{n_f, n_s}(2i + 1) = 1 \end{cases}$$

25. A non-transitory processor-readable storage medium storing processor-executable programming for causing a processing circuit to:

generate a time-based scrambling sequence, the time-based scrambling sequence facilitating a phase shift in time and generated according to a time parameter associated with a wake-up signal (WUS) or a paging occasion (PO);

generate a scrambled WUS, the scrambled WUS generated by multiplying a WUS base sequence by the time-based scrambling sequence; and

transmit the scrambled WUS to at least one scheduled entity.

26. The processor-readable storage medium of claim 25, further comprising processor-executable programming for causing a processing circuit to:

- generate a frequency-based scrambling sequence, wherein the frequency-based scrambling sequence facilitates a phase shift in frequency; and
- generate the scrambled WUS by multiplying the WUS base sequence by the frequency-based scrambling sequence.

27. The processor-readable storage medium of claim 26, wherein:

- the processor-executable programming for causing a processing circuit to generate the frequency-based scrambling sequence comprises the processor-executable programming for causing a processing circuit to generate the frequency-based scrambling sequence based on a time parameter of a starting point of a WUS transmission or a starting point of a PO transmission; and
- the processor-executable programming for causing a processing circuit to generate the time-based scrambling sequence comprises the processor-executable programming for causing a processing circuit to generate the time-based scrambling sequence based on a time parameter of a current WUS transmission.

28. The processor-readable storage medium of claim 25, wherein the processor-executable programming for causing a processing circuit to generate the scrambled WUS comprises processor-executable programming for causing a processing circuit to:

- generate the scrambled WUS based on a UE group identifier.

29. The processor-readable storage medium of claim 25, wherein:

- the processor-executable programming for causing a processing circuit to generate the time-based scrambling sequence comprises processor-executable programming for causing a processing circuit to generate the time-base scrambling sequence according to a Gold sequence $c_{n_f, n_s}(j)$, $j = 0, \dots, 2L - 1$ with L as the length of the WUS sequence, initialized at a start of a first WUS subframe based on a first frame n_{f_start} and first slot n_{s_start} of the first PO to which the WUS is associated and a cell ID with

$$c_{init_WUS} = (N_{ID}^{N_{cell}} + 1) \left(\left(10n_{f_start} + \left\lfloor \frac{n_{s_start}}{2} \right\rfloor \right) \bmod 2048 + 1 \right) 2^9 + N_{ID}^{N_{cell}}, \text{ and}$$

the processor-executable programming for causing a processing circuit to generate the scrambled WUS comprises processor-executable programming for causing a processing circuit to scramble the WUS according to

$$b(n) = \begin{cases} 1, & \text{if } c_{n_f, n_s}(2i) = 0 \text{ and } c_{n_f, n_s}(2i + 1) = 0 \\ -1, & \text{if } c_{n_f, n_s}(2i) = 0 \text{ and } c_{n_f, n_s}(2i + 1) = 1 \\ j, & \text{if } c_{n_f, n_s}(2i) = 1 \text{ and } c_{n_f, n_s}(2i + 1) = 0 \\ -j, & \text{if } c_{n_f, n_s}(2i) = 1 \text{ and } c_{n_f, n_s}(2i + 1) = 1 \end{cases}$$

30. A wireless communication device, comprising:

a transceiver;

a memory; and

a processor communicatively coupled to the transceiver and the memory, the processor configured to:

receive a scrambled wake-up signal (WUS) from a scheduling entity;

identify a time-based scrambling sequence associated with the WUS, the time-based scrambling sequence facilitating a phase shift in time and corresponding to a time parameter associated with a WUS or a paging occasion (PO); and

descramble the WUS according to the time-based scrambling sequence.

31. The wireless communication device of claim 30, wherein the time parameter is at least one of a subframe, a frame, a slot index, or a symbol index.

32. The wireless communication device of claim 30, wherein the processor configured to identify the time-based scrambling sequence comprises the processor configured to:

match a length of the time-based scrambling sequence with a length of a total number of resource elements (REs) in a single WUS subframe; or

match a length of the time-based scrambling sequence with a length of a total number of resource elements (REs) of all WUS subframes.

33. The wireless communication device of claim 30, the processor further configured to:

identify a frequency-based scrambling sequence, wherein the frequency-based scrambling sequence facilitates a phase shift in frequency; and
descramble the WUS according to the frequency-based scrambling sequence.

34. The wireless communication device of claim 33, wherein:
the processor configured to identify the frequency-based scrambling sequence comprises the processor configured to identify the frequency-based scrambling sequence based on a time parameter of a starting point of a WUS transmission or a starting point of a PO transmission; and
the processor configured to identify the time-based scrambling sequence comprises the processor configured to identify the time-based scrambling sequence based on a time parameter of a current WUS transmission.

35. The wireless communication device of claim 34, wherein the processor configured to identify the frequency-based scrambling sequence comprises the processor configured to:
match a length of the frequency-based scrambling sequence with a length of a total number of resource elements of a single WUS subframe; or
match a length of the time-based scrambling sequence with a length of a total number of resource elements (REs) in a single WUS subframe; or
match a length of the time-based scrambling sequence with a length of a total number of resource elements (REs) of all WUS subframes.

36. The wireless communication device of claim 30, wherein the scrambled WUS is based on a UE group identifier.

37. The wireless communication device of claim 36, wherein the scrambled WUS includes one of
the UE group identifier in a most significant bit (MSB) of the scrambled WUS,
the UE group identifier in a least significant bit (LSB) of the scrambled WUS, or
a multiplying of the UE group identifier with a most significant bit (MSB) of the scrambled WUS.

38. A method of wireless communication, comprising:

receiving a scrambled wake-up signal (WUS) from a scheduling entity;
identifying a time-based scrambling sequence associated with the WUS, the time-based scrambling sequence facilitating a phase shift in time and corresponding to a time parameter associated with a WUS or a paging occasion (PO); and
descrambling the WUS according to the time-based scrambling sequence.

39. The method of claim 38, wherein the time parameter is at least one of a subframe, a frame, a slot index, or a symbol index.

40. The method of claim 38, wherein identifying the time-based scrambling sequence comprises one of:

matching a length of the time-based scrambling sequence with a length of a total number of resource elements (REs) in a single WUS subframe; or

matching a length of the time-based scrambling sequence with a length of a total number of resource elements (REs) of all WUS subframes.

41. The method of claim 38, further comprising:

identifying a frequency-based scrambling sequence, wherein the frequency-based scrambling sequence facilitates a phase shift in frequency; and
descrambling the WUS according to the frequency-based scrambling sequence.

42. The method of claim 41, wherein:

identifying the frequency-based scrambling sequence comprises identifying the frequency-based scrambling sequence based on a time parameter of a starting point of a WUS transmission or a starting point of a PO transmission; and

identifying the time-based scrambling sequence comprises identifying the time-based scrambling sequence based on a time parameter of a current WUS transmission.

43. The method of claim 42, wherein identifying the frequency-based scrambling sequence comprises one of:

matching a length of the frequency-based scrambling sequence with a length of a total number of resource elements of a single WUS subframe;

matching a length of the time-based scrambling sequence with a length of a total number of resource elements (REs) in a single WUS subframe; or

matching a length of the time-based scrambling sequence with a length of a total number of resource elements (REs) of all WUS subframes.

44. The method of claim 38, wherein the scrambled WUS is based on a UE group identifier.

45. The method of claim 44, wherein the scrambled WUS includes one of the UE group identifier in a most significant bit (MSB) of the scrambled WUS, the UE group identifier in a least significant bit (LSB) of the scrambled WUS, or a multiplying of the UE group identifier with a most significant bit (MSB) of the scrambled WUS.

46. An apparatus for wireless communication, comprising:
means for receiving a scrambled wake-up signal (WUS) from a scheduling entity;
means for identifying a time-based scrambling sequence associated with the WUS, the time-based scrambling sequence facilitating a phase shift in time and corresponding to a time parameter associated with a WUS or a paging occasion (PO);
and
means for descrambling the WUS according to the time-based scrambling sequence.

47. The apparatus of claim 46, further comprising:
means for identifying a frequency-based scrambling sequence, wherein the frequency-based scrambling sequence facilitates a phase shift in frequency; and
means for descrambling the WUS according to the frequency-based scrambling sequence.

48. The apparatus of claim 46, wherein the scrambled WUS is based on a UE group identifier.

49. A non-transitory processor-readable storage medium storing processor-executable programming for causing a processing circuit to:
receive a scrambled wake-up signal (WUS) from a scheduling entity;

identify a time-based scrambling sequence associated with the WUS, the time-based scrambling sequence facilitating a phase shift in time and corresponding to a time parameter associated with a WUS or a paging occasion (PO); and
descramble the WUS according to the time-based scrambling sequence.

50. The processor-readable storage medium of claim 49, further comprising processor-executable programming for causing a processing circuit to:
identify a frequency-based scrambling sequence, wherein the frequency-based scrambling sequence facilitates a phase shift in frequency; and
descramble the WUS according to the frequency-based scrambling sequence.

51. The processor-readable storage medium of claim 49, wherein the scrambled WUS is based on a UE group identifier.