

WHAT IS CLAIMED IS:

1. A method for radio frequency (RF) sensing using space-time-frequency multiplexing (STFM):
 - performing a transmit sequence comprising:
 - wirelessly transmitting, using a first frequency, a first sequence of a first complementary pair of sequences;
 - subsequent to wirelessly transmitting the first sequence of the first complementary pair of sequences, wirelessly transmitting, using a second frequency, a first sequence of a second complementary pair of sequences;
 - subsequent to wirelessly transmitting the first sequence of the second complementary pair of sequences, wirelessly transmitting, using the first frequency, a second sequence of the first complementary pair of sequences; and
 - subsequent to wirelessly transmitting the second sequence of the first complementary pair of sequences, wirelessly transmitting, using the second frequency, a second sequence of the second complementary pair of sequences;
 - performing a receive sequence comprising:
 - receiving the first complementary pair of sequences, and
 - receiving the second complementary pair of sequences; and
 - determining a distance of an object based on the received first complementary pair of sequences and the received second complementary pair of sequences.
2. The method of claim 1, wherein the first complementary pair of sequences is the same as the second complementary pair of sequences.
3. The method of claim 1, wherein the first complementary pair of sequences is wirelessly transmitted in a first direction, and the second complementary pair of sequences is wirelessly transmitted in a second direction.
4. The method of claim 3, further comprising performing the transmit sequence and receive sequence a plurality of times in succession.
5. The method of claim 3, wherein performing the transmit sequence further comprises:

wirelessly transmitting, in a third direction using the first frequency, a first sequence of a third complementary pair of sequences;
subsequent to wirelessly transmitting the first sequence of the third complementary pair of sequences, wirelessly transmitting, in a fourth direction using the second frequency, a first sequence of a fourth complementary pair of sequences;
subsequent to wirelessly transmitting the first sequence of the fourth complementary pair of sequences, wirelessly transmitting, in the third direction using the first frequency, a second sequence of the third complementary pair of sequences; and
subsequent to wirelessly transmitting the second sequence of the third complementary pair of sequences, wirelessly transmitting, in the fourth direction using the second frequency, a second sequence of the fourth complementary pair of sequences.

6. The method of claim 3, wherein performing the transmit sequence further comprises:

wirelessly transmitting a third complementary pair of sequences using a third frequency, and
wirelessly transmitting a fourth complementary pair of sequences using a fourth frequency; and
wherein wirelessly transmitting a first sequence of the third complementary pair of sequences and wirelessly transmitting a first sequence of the fourth complementary pair sequences occurs subsequent to wirelessly transmitting the first sequence of the second complementary pair of sequences and prior to wirelessly transmitting the second sequence of the first complementary pair of sequences.

7. The method of claim 1, wherein the transmit sequence is performed with transmit circuitry having a single Digital-to-Analog Converter (DAC).

8. The method of claim 1, wherein the receive sequence is performed with a receive circuitry having a single Analog-to-Digital Converter (ADC).

9. A radar system for performing radio frequency (RF) sensing using space-time-frequency multiplexing (STFM):

transmit circuitry configured to perform a transmit sequence comprising:
wirelessly transmitting, using a first frequency, a first sequence of a first complementary pair of sequences;
subsequent to wirelessly transmitting the first sequence of the first complementary pair of sequences, wirelessly transmitting, using a second frequency, a first sequence of a second complementary pair of sequences;
subsequent to wirelessly transmitting the first sequence of the second complementary pair of sequences, wirelessly transmitting, using the first frequency, a second sequence of the first complementary pair of sequences; and
subsequent to wirelessly transmitting the second sequence of the first complementary pair of sequences, wirelessly transmitting, using the second frequency, a second sequence of the second complementary pair of sequences;
receive circuitry configured to perform a receive sequence comprising:
receiving the first complementary pair of sequences, and
receiving the second complementary pair of sequences; and
processing circuitry communicatively coupled with the transmit circuitry and the receive circuitry, wherein the processing circuitry is configured to determine a distance of an object based on the received first complementary pair of sequences and the received second complementary pair of sequences.

10. The radar system of claim 9, wherein the transmit circuitry comprises a multiband pulse generator, a digital-to-analog converter (DAC), a mixer, an amplifier, a phase shift array, and one or more antennas.

11. The radar system of claim 9, wherein the transmit circuitry is further configured to:
wirelessly transmit the first complementary pair of sequences in a first direction, and
wirelessly transmit the second complementary pair of sequences in a second direction.

12. The radar system of claim 11, wherein the transmit circuitry and the receive circuitry are configured to perform the transmit sequence and receive sequence a plurality of times in succession.

13. The radar system of claim 11, wherein the transmit circuitry is further configured to:

wirelessly transmit, in a third direction using the first frequency, a first sequence of a third complementary pair of sequences;

wirelessly transmit, subsequent to wirelessly transmitting the first sequence of the third complementary pair of sequences, a first sequence of a fourth complementary pair of sequences in a fourth direction using the second frequency;

wirelessly transmit, subsequent to wirelessly transmitting the first sequence of the fourth complementary pair of sequences, a second sequence of the third complementary pair of sequences in the third direction using the first frequency; and

wirelessly transmit, subsequent to wirelessly transmit the second sequence of the third complementary pair of sequences, a second sequence of the fourth complementary pair of sequences in the fourth direction using the second frequency.

14. A radar system of claim 11, wherein the transmit circuitry is further configured to:

transmit a third complementary pair of sequences using a third frequency, and

transmit a fourth complementary pair of sequences using a fourth frequency; and

wherein, the transmit circuitry is further configured to wirelessly transmit a first sequence of the third complementary pair of sequences and to wirelessly transmit a first sequence of the fourth complementary pair sequences subsequent to wirelessly transmitting the first sequence of the second complementary pair of sequences and prior to wirelessly transmitting the second sequence of the first complementary pair of sequences.

15. A radar system of claim 10, wherein the receive circuitry comprises one or more antennas, a phase shifter array, an amplifier, a mixer, an analog-to-digital converter (ADC), and a band pass filter bank.

16. A radar system of claim 15, wherein processing circuitry comprises:

a correlator for each sequence of the first complementary pair of sequences and each sequence of the second complementary pair of sequences,
a summation module for each of the first complementary pair of sequences and the second complementary pair of sequences, and
a processing unit.

17. A device for radio frequency (RF) sensing using space-time-frequency multiplexing (STFM):

means for performing a transmit sequence comprising:

means for wirelessly transmitting, using a first frequency, a first sequence of a first complementary pair of sequences;

means for wirelessly transmitting, subsequent to wirelessly transmitting the first sequence of the first complementary pair of sequences, a first sequence of a second complementary pair of sequences using a second frequency;

means for wirelessly transmitting, subsequent to wirelessly transmitting the first sequence of the second complementary pair of sequences, a second sequence of the first complementary pair of sequences using the first frequency; and

means for wirelessly transmitting, subsequent to wirelessly transmitting the second sequence of the first complementary pair of sequences, a second sequence of the second complementary pair of sequences using the second frequency;

means for performing a receive sequence comprising:

means for receiving the first complementary pair of sequences,
and

means for receiving the second complementary pair of sequences;
and

means for determining a distance of an object based on the received first complementary pair and the received second complementary pair.

18. The device of claim 17, further comprising means for wirelessly transmitting the first complementary pair of sequences in a first direction, and means for wirelessly transmitting the second complementary pair of sequences in a second direction.

19. The device of claim 18, further comprising means for causing the device to perform the transmit sequence and receive sequence a plurality of times in succession.

20. The device of claim 18, further comprising:
means for wirelessly transmitting a first sequence of a third complementary pair of sequences in a third direction using the first frequency;
means for wirelessly transmitting a first sequence of a fourth complementary pair of sequences in a fourth direction using the second frequency, subsequent to wirelessly transmitting the first sequence of the third complementary pair of sequences;
means for wirelessly transmitting a second sequence of the third complementary pair of sequences in the third direction using the first frequency, subsequent to wirelessly transmitting the first sequence of the fourth complementary pair of sequences; and
means for wirelessly transmitting a second sequence of the fourth complementary pair of sequences in the fourth direction using the second frequency, subsequent to wirelessly transmitting the second sequence of the third complementary pair of sequences.

21. The device of claim 18, further comprising:
means for wirelessly transmitting a third complementary pair of sequences using a third frequency and wirelessly transmitting a fourth complementary pair of sequences using a fourth frequency, such that a first sequence of the third complementary pair of sequences and a first sequence of the fourth complementary pair of sequences are wirelessly transmitted subsequent to wirelessly transmitting the first sequence of the second complementary pair of sequences and prior to wirelessly transmitting the second sequence of the first complementary pair of sequences.

22. The device of claim 17, wherein the means for performing the transmit sequence comprises a single Digital-to-Analog Converter (DAC).

23. The device of claim 17, wherein the means for performing a receive sequence comprises a single Analog-to-Digital Converter (ADC).

24. A non-transitory computer-readable medium having instructions stored thereby for performing radio frequency (RF) sensing using space-time-frequency multiplexing (STFM), wherein the instructions, when executed by one or more processing units, cause the one or processing units to:

perform a transmit sequence comprising:

wirelessly transmitting, using a first frequency, a first sequence of a first complementary pair of sequences;

wirelessly transmitting, subsequent to wirelessly transmitting the first sequence of the first complementary pair of sequences, a first sequence of a second complementary pair of sequences using a second frequency;

wirelessly transmitting, subsequent to wirelessly transmitting the first sequence of the second complementary pair of sequences, a second sequence of the first complementary pair of sequences using the first frequency; and

wirelessly transmitting, subsequent to wirelessly transmitting the second sequence of the first complementary pair of sequences, a second sequence of the second complementary pair of sequences using the second frequency;

perform a receive sequence comprising:

receiving the first complementary pair of sequences, and

receiving the second complementary pair of sequences; and

determine a distance of an object based on the received first complementary pair of sequences and the received second complementary pair of sequences.

25. The non-transitory computer-readable medium of claim 24, wherein the instructions further comprise instructions for causing the one or processing units to wirelessly transmit the first complementary pair of sequences in a first direction,

and wirelessly transmit the second complementary pair of sequences in a second direction.

26. The non-transitory computer-readable medium of claim 25, wherein the instructions further comprise instructions for causing the one or processing units to perform the transmit sequence and receive sequence a plurality of times in succession.

27. The non-transitory computer-readable medium of claim 25, wherein the instructions further comprise instructions for causing the one or processing units to:

wirelessly transmit a first sequence of a third complementary pair of sequences in a third direction using the first frequency;

wirelessly transmit a first sequence of a fourth complementary pair of sequences in a fourth direction using the second frequency, subsequent to wirelessly transmitting the first sequence of the third complementary pair of sequences;

wirelessly transmit a second sequence of the third complementary pair of sequences in the third direction using the first frequency, subsequent to wirelessly transmitting the first sequence of the fourth complementary pair of sequences; and

wirelessly transmit a second sequence of the fourth complementary pair of sequences in the fourth direction using the second frequency, subsequent to wirelessly transmitting the second sequence of the third complementary pair of sequences.

28. The non-transitory computer-readable medium of claim 25, wherein the instructions further comprise instructions for causing the one or processing units to:

wirelessly transmit a third complementary pair of sequences using a third frequency and wirelessly transmit a fourth complementary pair of sequences using a fourth frequency, such that a first sequence of the third complementary pair of sequences and a first sequence of the fourth complementary pair sequences are wirelessly transmitted subsequent to wirelessly transmitting the first sequence of the

second complementary pair of sequences and prior to wirelessly transmitting the second sequence of the first complementary pair of sequences.