THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A radio frequency transponder, including:

a substrate; and

a plurality of planar antennas on said substrate, each antenna having a shape determining a corresponding resonant frequency of the antenna and said antenna causes a phase difference between backscattered signals generated in response to excitation of said antenna by orthogonally polarised interrogation signals at said resonant frequency, said phase difference representing a code of said antenna and

wherein the antennas have respective different resonant frequencies, and the codes determined from the phase differences between the backscattered signals at each of the resonant frequencies are used to generate a unique code for the transponder.

2. A radio frequency transponder as claimed in claim 1, wherein the shape of said antenna determines said phase difference.

3. A radio frequency transponder as claimed in claim 2, wherein said antenna includes a load element to control a value represented by said code.

4. A radio frequency transponder as claimed in claim 3, wherein said shape is a polygon with equal sides.

5. A radio frequency transponder as claimed in claim 4, wherein said shape is square.

6. A radio frequency transponder as claimed in claim 5, wherein said load element is a stub of said antenna, said stub having a length which determines the value of said code.

7. A radio frequency transponder as claimed in claim 6, including a conductive ground plane, and said substrate is on said ground plane.

8. A radio frequency transponder as claimed in any one of claims 1 to 7, wherein said antenna is printed using electrically conductive ink on said substrate which is dielectric.

9. A radio frequency transponder as claimed in claim 1, including arrays of antennas with the same resonant frequency and having a symmetrical layout.

10. A radio frequency transponder as claimed in claim 9, wherein each array represents a frequency signature with one of a number of phase signatures determined from the phase difference of the backscattered signals at the resonant frequency for the array, and said phase signature represents a value of the code.

11. A radio frequency transponder as claimed in claim 10, wherein the layout of the arrays is symmetrical to cancel mutual coupling effects of the non-radiating antennas and provide a symmetrical response at each resonant frequency.

12. A radio frequency transponder as claimed in claim 11, including a first layer of the layout with arrays of higher resonant frequencies than arrays of a second layer of the layout surrounding the first layer.

13. A radio-frequency identification transponder, including:

a dielectric substrate;

a plurality of antennas on said substrate for generating backscattered radiation at different resonant frequencies for different polarisations; and

load elements of said antennas which each determine a phase difference of the different polarisations of said backscattered radiation, said phase difference representing a value of a code of said transponder.

14. A radio frequency transponder as claimed in any one of claims 1 to 13, wherein said transponder is passive and chipless.

15. A radio frequency transponder system, including:

a transponder as claimed in any one of claims 1 to 14; and

a reader for generating the interrogation signals and reading the backscattered signals to extract said code.

16. A radio frequency reader for interrogating a radio frequency transponder, including:

a frequency interface unit for transmitting polarised interrogation signals and receiving backscattered signals from the transponder in response; and

a signal processing unit for determining a code of the transponder from phase difference of said backscattered signals.

17. A radio frequency reader, as claimed in claim 16, wherein:

the frequency interface unit includes a phased array antenna transmitting and receiving frequency modulated continuous wave signals with frequency and polarisation diversity to read multiple transponders; and

the signal processing unit processes the received signals using a direction of arrival and phase difference detection process.

18. A radio frequency transponder as claimed in claim 16 or 17, wherein the interrogation signals are orthogonally polarised and the phase difference is the phase difference of the orthogonal components of the backscattered signals.

19. A radio frequency process, including:

transmitting polarised interrogation signals;

receiving backscattered signals including orthogonal components from a transponder in response; and

determining a code of the transponder from phase difference between the orthogonal components of said backscattered signals.

THE CLAIMS:

1. A radio frequency transponder, including:

a substrate; and

a plurality of planar antennas on said substrate, each antenna having a shape determining a corresponding resonant frequency of the antenna and said antenna causes a phase difference between backscattered signals in two orthogonal planes generated in response to excitation of said antenna by orthogonally polarised interrogation signals at said resonant frequency, said phase difference between the backscattered signals in two orthogonal planes representing a code of said antenna and

wherein the antennas have respective different resonant frequencies, and the codes determined from the phase differences between the backscattered signals at each of the resonant frequencies are used to generate a unique code for the transponder.

2. A radio frequency transponder as claimed in claim 1, wherein the shape of said antenna determines said phase difference.

3. A radio frequency transponder as claimed in claim 2, wherein said antenna includes a load element to control a value represented by said code.

4. A radio frequency transponder as claimed in claim 3, wherein said shape is a polygon with equal sides.

5. A radio frequency transponder as claimed in claim 4, wherein said shape is square.

6. A radio frequency transponder as claimed in claim 5, wherein said load element is a stub of said antenna, said stub having a length which determines the value of said code.

7. A radio frequency transponder as claimed in claim 6, including a conductive ground plane, and said substrate is on said ground plane.

8. A radio frequency transponder as claimed in any one of claims 1 to 7, wherein said antenna is printed using electrically conductive ink on said substrate which is dielectric.

9. A radio frequency transponder as claimed in claim 1, including arrays of antennas with the same resonant frequency and having a symmetrical layout.

10. A radio frequency transponder as claimed in claim 9, wherein each array represents a frequency signature with one of a number of phase signatures determined from the phase difference of the backscattered signals at the resonant frequency for the array, and said phase signature represents a value of the code.

11. A radio frequency transponder as claimed in claim 10, wherein the layout of the arrays is symmetrical to cancel mutual coupling effects of the non-radiating antennas and provide a symmetrical response at each resonant frequency.

12. A radio frequency transponder as claimed in claim 11, including a first layer of the layout with arrays of higher resonant frequencies than arrays of a second layer of the layout surrounding the first layer.

13. A radio-frequency identification transponder as claimed in claim 1, wherein said substrate is dielectric, and said antennas each include load elements which each determine said phase difference.

14. A radio frequency transponder as claimed in any one of claims 1 to 13, wherein said transponder is passive and chipless.

15. A radio frequency transponder system, including:

a transponder as claimed in any one of claims 1 to 14; and

a reader for generating the interrogation signals and reading the backscattered signals to extract said code.

16. A radio frequency reader for interrogating a radio frequency transponder as claimed in any one of claims 1 to 14, including:

a frequency interface unit for transmitting orthogonally polarised interrogation signals and receiving backscattered signals from the transponder in response; and

a signal processing unit for determining a code of the transponder from phase difference of the orthogonal components of said backscattered signals.

17. A radio frequency reader, as claimed in claim 16, wherein:

the frequency interface unit includes a phased array antenna transmitting and receiving frequency modulated continuous wave signals with frequency and polarisation diversity to read multiple transponders; and

the signal processing unit processes the received signals using a direction of arrival and phase difference detection process.

18. A radio frequency reader process, including:

transmitting polarised interrogation signals to a transponder as claimed in any one of claims 1 to 14;

receiving backscattered signals including components in two orthogonal planes from the transponder in response; and

determining a code of the transponder from phase difference between the orthogonal components of said backscattered signals.

19. A radio frequency transponder, reader or process substantially as hereinbefore described with reference to the accompanying drawings.