CLAIMS

1. A multimode antenna structure for transmitting and receiving electromagnetic signals in a communications device, the communications device including circuitry for processing signals communicated to and from the antenna structure, the antenna structure configured for optimal operation in a given frequency range, the antenna structure comprising:

a plurality of antenna ports operatively coupled to the circuitry;

a plurality of antenna elements, each operatively coupled to a different one of the antenna ports, each of said plurality of antenna elements being configured to have an electrical length selected to provide optimal operation within said given frequency range; and

one or more connecting elements electrically connecting the antenna elements such that electrical currents on one antenna element flow to a connected neighboring antenna element and generally bypass the antenna port coupled to the neighboring antenna element, the electrical currents flowing through the one antenna element and the neighboring antenna element being generally equal in magnitude, such that an antenna mode excited by one antenna port is generally electrically isolated from a mode excited by another antenna port at a given desired signal frequency range without the use of a decoupling network connected to said antenna ports, and the antenna structure generates diverse antenna patterns.

2. The multimode antenna structure of claim 1 wherein said given frequency range is about 2300 to 2400 MHz.

3. The multimode antenna structure of claim 1 wherein said given frequency range is about 2300 to 6000 MHz.

4. The multimode antenna structure of claim 1 wherein each of said plurality of antenna elements has a tortuous configuration to provide said electrical length.

5. The multimode antenna structure of claim 4 wherein said tortuous configuration comprises a meandered configuration, helical coils, or loops.

6. The multimode antenna structure of claim 1 wherein each of said plurality of antenna elements includes at least one slot to provide said electrical length.

7. The multimode antenna structure of claim 1 wherein said antenna structure is configured for use in a WiMAX or ExpressCard product.

8. The multimode antenna structure of claim 1 wherein said antenna structure is configured for use in a WiMAX USB dongle.

9. The multimode antenna structure of claim 1 wherein said plurality of antenna elements and said one or more connecting elements comprise a printed circuit.

10. The multimode antenna structure of claim 9 wherein said printed circuit comprises copper.

11. The multimode antenna structure of claim 9 wherein said printed circuit is mounted on a plastic carrier.

12. The multimode antenna structure of claim 11 wherein said printed circuit extends from a top surface of the plastic carrier, over one or more sides of the plastic carrier, to an opposite bottom surface of the plastic carrier, wherein said antenna elements have a meandered configuration and are located substantially on the top surface of the plastic carrier, and the one or more connecting elements have a meandered configuration and are located substantially on the bottom surface of the plastic carrier.

13. The multimode antenna structure of claim 1 wherein said plurality of antenna elements and said one or more connecting elements comprise a stamped metal part.

14. The multimode antenna structure of claim 13 wherein the stamped metal part is fabricated from a copper alloy sheet having a thickness of about 0.2 mm.

15. The multimode antenna structure of claim 13 wherein said stamped metal part

includes a pickup feature at the center of mass of the part for use in an automated pick and place assembly process.

16. The multimode antenna structure of claim 13 wherein each antenna element comprises integrally formed first and second portions, wherein the first portion includes a feed point at one end thereof, and the second portion extends generally perpendicularly from the first portion, each of the first and second portions including a slot at opposite ends thereof to provide a meandered configuration, wherein the one or more connecting elements electrically connects respective first portions of the antenna elements, at least one of said one or more connecting elements including a pickup feature.

17. The multimode antenna structure of claim 1 wherein the communications device is a cellular handset, PDA, wireless networking device, or a data card for PC.

18. The multimode antenna structure of claim 1 further comprising a matching network to provide an input impedance match for the antenna elements at the desired signal frequency range.

19. The multimode antenna structure of claim 1 wherein the multimode antenna structure comprises a flexible printed circuit mounted on a plastic carrier.

20. The multimode antenna structure of claim 1 further comprising an antenna pattern control mechanism operatively coupled to the plurality of antenna ports for adjusting the relative phase between signals fed to neighboring antenna ports such that a signal fed to the one antenna port has a different phase than a signal fed to the neighboring antenna port to provide antenna pattern control.

21. A multimode antenna structure for transmitting and receiving electromagnetic signals in a communications device, the communications device including circuitry for processing signals communicated to and from the antenna structure, the antenna structure comprising:

a plurality of antenna ports operatively coupled to the circuitry;

a plurality of antenna elements, each operatively coupled to a different one of the

antenna ports;

one or more connecting elements electrically connecting the antenna elements such that electrical currents on one antenna element flow to a connected neighboring antenna element and generally bypass the antenna port coupled to the neighboring antenna element, the electrical currents flowing through the one antenna element and the neighboring antenna element being generally equal in magnitude, such that an antenna mode excited by one antenna port is generally electrically isolated from a mode excited by another antenna port at a given desired signal frequency range and the antenna structure generates diverse antenna patterns; and

an antenna pattern control mechanism operatively coupled to the plurality of antenna ports for adjusting the relative phase between signals fed to neighboring antenna ports such that a signal fed to the one antenna port has a different phase than a signal fed to the neighboring antenna port to provide antenna pattern control.

22. The multimode antenna structure of claim 21 wherein the antenna pattern control mechanism comprises an electrically controlled phase shift device.

23. The multimode antenna structure of claim 21 wherein the antenna pattern control mechanism comprises a phase shift network.

24. The multimode antenna structure of claim 21 wherein the antenna pattern control mechanism controls the phase of a carrier signal provided at each of said plurality of antenna ports.

25. The multimode antenna structure of claim 21 wherein the communications device is a cellular handset, PDA, wireless networking device, or a data card for PC.

26. The multimode antenna structure of claim 21 wherein the antenna elements comprise helical coils, wideband planer shapes, chip antennas, meandered shapes, loops, or inductively shunted forms.

27. The multimode antenna structure of claim 21 wherein the multimode antenna structure comprises a planar structure fabricated on a printed circuit board substrate.

28. The multimode antenna structure of claim 21 wherein the multimode antenna structure comprises stamped metal part including a pickup feature at the center of mass of the part for use in an automated pick and place assembly process.

29. The multimode antenna structure of claim 21 wherein the multimode antenna structure comprises a flexible printed circuit mounted on a plastic carrier.

30. The multimode antenna structure of claim 21 wherein the antenna mode excited by one antenna port is generally electrically isolated from a mode excited by another antenna port at the given desired signal frequency range without the use of a decoupling network connected to said antenna ports.

31. The multimode antenna structure of claim 21 wherein one of said plurality of antenna elements includes a slot therein defining two branch resonators wherein presence of the slot in said one of the plurality of antenna elements results in a mismatch between said one of the plurality of antenna elements and another antenna element of said multimode antenna structure at a given signal frequency range to further isolate the antenna ports.

32. A method for controlling antenna patterns of a multimode antenna structure in a communications device transmitting and receiving electromagnetic signals, the method comprising:

(a) providing a communications device including the antenna structure and circuitry for processing signals communicated to and from the antenna structure, said antenna structure comprising:

a plurality of antenna ports operatively coupled to the circuitry;

a plurality of antenna elements, each operatively coupled to a different one of the antenna ports; and

one or more connecting elements electrically connecting the antenna elements such that electrical currents on one antenna element flow to a connected neighboring antenna element and generally bypass the antenna port coupled to the neighboring

antenna element, the electrical currents flowing through the one antenna element and the neighboring antenna element being generally equal in magnitude, such that an antenna mode excited by one antenna port is generally electrically isolated from a mode excited by another antenna port at a given desired signal frequency range and the antenna structure generates diverse antenna patterns; and

(b) adjusting the relative phase between signals fed to neighboring antenna ports of the antenna structure such that a signal fed to the one antenna port has a different phase than a signal fed to the neighboring antenna port to provide antenna pattern control.

33. The method of claim 32 wherein step (b) comprises adjusting the relative phase between the signals using an electrically controlled phase shift device.

34. The method of claim 32 wherein step (b) comprises adjusting the relative phase between the signals using a phase shift network.

35. The method of claim 32 wherein step (b) comprises adjusting the relative phase between the signals by controlling the phase of a carrier signal provided at each of said plurality of antenna ports.

36. The method of claim 32 wherein the communications device is a cellular handset, PDA, wireless networking device, or a data card for PC.

37. The method of claim 32 wherein the antenna elements comprise helical coils, wideband planer shapes, chip antennas, meandered shapes, loops, or inductively shunted forms.

38. The method of claim 32 wherein the multimode antenna structure comprises a planar structure fabricated on a printed circuit board substrate.

39. The method of claim 32 wherein the multimode antenna structure comprises stamped metal part including a pickup feature at the center of mass of the part for use in an automated pick and place assembly process.

40. The method of claim 32 wherein the multimode antenna structure comprises a

flexible printed circuit mounted on a plastic carrier.

41. A multimode antenna structure for transmitting and receiving electromagnetic signals in a communications device, the communications device including circuitry for processing signals communicated to and from the antenna structure, the antenna structure comprising:

a plurality of antenna ports operatively coupled to the circuitry;

a plurality of antenna elements, each operatively coupled to a different one of the antenna ports, one of said plurality of antenna elements including a slot therein defining two branch resonators; and

one or more connecting elements electrically connecting the plurality of antenna elements such that electrical currents on one antenna element flow to a connected neighboring antenna element and generally bypass the antenna port coupled to the neighboring antenna element, the electrical currents flowing through the one antenna element and the neighboring antenna element being generally equal in magnitude, such that an antenna mode excited by one antenna port is generally electrically isolated from a mode excited by another antenna port at a given desired signal frequency range and the antenna structure generates diverse antenna patterns; and

wherein presence of the slot in said one of the plurality of antenna elements results in a mismatch between said one of the plurality of antenna elements and another antenna element of said multimode antenna structure at the given signal frequency range to further isolate the antenna ports.

42. The multimode antenna structure of claim 41 wherein the antenna mode excited by one antenna port is generally electrically isolated from a mode excited by another antenna port at the given desired signal frequency range without the use of a decoupling network connected to said antenna ports.

43. The multimode antenna structure of claim 41 wherein said plurality of antenna elements and said one or more connecting elements comprise a printed circuit.

44. The multimode antenna structure of claim 43 wherein said printed circuit comprises copper.

45. The multimode antenna structure of claim 43 wherein said printed circuit is mounted on a plastic carrier.

46. The multimode antenna structure of claim 45 wherein said printed circuit extends over a plurality of sides of the plastic carrier, and the one or more connecting elements have a meandered configuration.

47. The multimode antenna structure of claim 41 further comprising an antenna pattern control mechanism operatively coupled to the plurality of antenna ports for adjusting the relative phase between signals fed to neighboring antenna ports such that a signal fed to the one antenna port has a different phase than a signal fed to the neighboring antenna port to provide antenna pattern control.

48. The multimode antenna structure of claim 41 wherein the given signal frequency range generally comprises the GPS band.