For example, to increase performance, wireless components such as a diversity receive antenna and associated circuitry are becoming more popular.

[0009] In many radio-frequency (RF) applications, a diversity receive antenna is placed physically far from a primary antenna. When both antennas are used at once, a transceiver can process signals from both antennas in order to increase data throughput.

SUMMARY

[0009a] In accordance with an aspect, a radio frequency (RF) receiving system comprising a controller configured to selectively activate one or more of a plurality of paths between an input of the receiving system and an output of the receiving system; a plurality of amplifiers, each one of the plurality of amplifiers disposed along a corresponding one of the plurality of paths and configured to amplify a signal received at the amplifier; and at least a first feature and a second feature, at least the second feature and a third feature, at least the second feature and a fourth feature, at least the second feature and a fifth feature, at least the second feature and a sixth feature, at least the first feature and the fifth feature, at least the first feature and the sixth feature, at least the third feature and the fifth feature, at least the third feature and the sixth feature, at least the fourth feature and the fifth feature, at least the fourth feature and the sixth feature, or at least the fifth feature and the sixth feature, implemented for the RF receiving system, the first feature including a plurality of bandpass filters, each one of the plurality of bandpass filters disposed along a corresponding one of the plurality of paths and configured to filter a signal received at the bandpass filter to a respective frequency band, and at least some of the plurality of amplifiers implemented as a plurality of variable-gain amplifiers (VGAs), each one of the plurality of VGAs configured to amplify the corresponding signal with a gain controlled by an amplifier control signal received from the controller; the second feature including a plurality of phase-shift components, each one of the plurality of phase-shift components disposed along a corresponding one of the plurality of paths and configured to phase-shift a signal passing through the phase-shift component; the third feature including a plurality of impedance matching components, each one of the plurality of impedance matching components disposed

along a corresponding one of the plurality of paths and configured to reduce at least one of an out-of-band noise figure or an out-of-band gain of the one of the plurality of paths; the fourth feature including a plurality of post-amplifier bandpass filters, each one of the plurality of post-amplifier bandpass filters disposed along a corresponding one of the plurality of paths at an output of a corresponding one of the plurality of amplifiers and configured to filter a signal to a respective frequency band; the fifth feature including a switching network having one or more single-pole/single-throw switches, each one of the switches coupling two of the plurality of paths, the switching network configured to be controlled by the controller based on a band select signal; the sixth feature including an input multiplexer configured to receive one or more RF signals at one or more input multiplexer inputs and to output each of the one or more RF signals to one or more of a plurality of input multiplexer outputs to propagate along a respective one or more of the plurality of paths, and an output multiplexer configured to receive one or more amplified RF signals propagating along the respective one or more of the plurality of paths at one or more respective output multiplexer inputs and to output each of the one or more amplified RF signals to a selected one of a plurality of output multiplexer outputs.

[0009b] In accordance with an aspect, a radio-frequency (RF) module comprising a packaging substrate configured to receive a plurality of components; and a receiving system implemented on the packaging substrate, the receiving system including a controller configured to selectively activate one or more of a plurality of paths between an input of the receiving system and an output of the receiving system, the receiving system further including a plurality of amplifiers, each one of the plurality of amplifiers disposed along a corresponding one of the plurality of paths and configured to amplify a signal received at the amplifier, the receiving system further including at least a first feature and a second feature, at least the second feature and a third feature, at least the second feature and a fourth feature, at least the second feature and a fifth feature, at least the second feature and a sixth feature, at least the first feature and the fifth feature, at least the first feature and the sixth feature, at least the third feature and the fifth feature, at least the third feature and

the sixth feature, at least the fourth feature and the fifth feature, at least the fourth feature and the sixth feature, or at least the fifth feature and the sixth feature, implemented for the RF receiving system, the first feature including a plurality of bandpass filters, each one of the plurality of bandpass filters disposed along a corresponding one of the plurality of paths and configured to filter a signal received at the bandpass filter to a respective frequency band, and at least some of the plurality of amplifiers implemented as a plurality of variable-gain amplifiers (VGAs), each one of the plurality of VGAs configured to amplify the corresponding signal with a gain controlled by an amplifier control signal received from the controller; the second feature including a plurality of phase-shift components, each one of the plurality of phase-shift components disposed along a corresponding one of the plurality of paths and configured to phase-shift a signal passing through the phase-shift component; the third feature including a plurality of impedance matching components, each one of the plurality of impedance matching components disposed along a corresponding one of the plurality of paths and configured to reduce at least one of an out-of-band noise figure or an out-of-band gain of the one of the plurality of paths; the fourth feature including a plurality of post-amplifier bandpass filters, each one of the plurality of post-amplifier bandpass filters disposed along a corresponding one of the plurality of paths at an output of a corresponding one of the plurality of amplifiers and configured to filter a signal to a respective frequency band; the fifth feature including a switching network having one or more single-pole/single-throw switches, each one of the switches coupling two of the plurality of paths, the switching network configured to be controlled by the controller based on a band select signal; the sixth feature including an input multiplexer configured to receive one or more RF signals at one or more input multiplexer inputs and to output each of the one or more RF signals to one or more of a plurality of input multiplexer outputs to propagate along a respective one or more of the plurality of paths, and an output multiplexer configured to receive one or more amplified RF signals propagating along the respective one or more of the plurality of paths at one or more respective output multiplexer inputs and to output each of the one or more amplified RF signals to a selected one of a plurality of output multiplexer outputs.

[0009c] In accordance with an aspect, a wireless device comprising a first antenna configured to receive one or more radio-frequency (RF) signals; a first front-end module (FEM) in communication with the first antenna, the first FEM including a packaging substrate configured to receive a plurality of components, the first FEM further including a receiving system implemented on the packaging substrate, the receiving system including a controller configured to selectively activate one or more of a plurality of paths between an input of the receiving system and an output of the receiving system, the receiving system further including a plurality of amplifiers, each one of the plurality of amplifiers disposed along a corresponding one of the plurality of paths and configured to amplify a signal received at the amplifier, the receiving system further including at least a first feature and a second feature, at least the second feature and a third feature, at least the second feature and a fourth feature, at least the second feature and a fifth feature, at least the second feature and a sixth feature, at least the first feature and the fifth feature, at least the first feature and the sixth feature, at least the third feature and the fifth feature, at least the third feature and the sixth feature, at least the fourth feature and the fifth feature, at least the fourth feature and the sixth feature, or at least the fifth feature and the sixth feature, implemented for the RF receiving system, the first feature including a plurality of bandpass filters, each one of the plurality of bandpass filters disposed along a corresponding one of the plurality of paths and configured to filter a signal received at the bandpass filter to a respective frequency band, and at least some of the plurality of amplifiers implemented as a plurality of variable-gain amplifiers (VGAs), each one of the plurality of VGAs configured to amplify the corresponding signal with a gain controlled by an amplifier control signal received from the controller; the second feature including a plurality of phase-shift components, each one of the plurality of phase-shift components disposed along a corresponding one of the plurality of paths and configured to phase-shift a signal passing through the phase-shift component; the third feature including a plurality of impedance matching components, each one of the plurality of impedance matching components disposed along a corresponding one of the

plurality of paths and configured to reduce at least one of an out-of-band noise figure or an out-of-band gain of the one of the plurality of paths; the fourth feature including a plurality of post-amplifier bandpass filters, each one of the plurality of post-amplifier bandpass filters disposed along a corresponding one of the plurality of paths at an output of a corresponding one of the plurality of amplifiers and configured to filter a signal to a respective frequency band; the fifth feature including a switching network having one or more single-pole/single-throw switches, each one of the switches coupling two of the plurality of paths, the switching network configured to be controlled by the controller based on a band select signal; the sixth feature including an input multiplexer configured to receive one or more RF signals at one or more input multiplexer inputs and to output each of the one or more RF signals to one or more of a plurality of input multiplexer outputs to propagate along a respective one or more of the plurality of paths, and an output multiplexer configured to receive one or more amplified RF signals propagating along the respective one or more of the plurality of paths at one or more respective output multiplexer inputs and to output each of the one or more amplified RF signals to a selected one of a plurality of output multiplexer outputs; and a transceiver configured to receive a processed version of the one or more RF signals from the receiving system and generate data bits based on the processed version of the one or more RF signals.

[0010] In accordance with some implementations, the present disclosure relates to a radio-frequency (RF) receiving system that includes a controller configured to selectively activate one or more of a plurality of paths between an input of the receiving system and an output of the receiving system. The RF receiving system further includes a plurality of amplifiers, with each one of the plurality of amplifiers being disposed along a corresponding one of the plurality of paths and configured to amplify a signal received at the amplifier. The RF receiving system further includes two or more of a first feature, a second feature, a third feature, a fourth feature, a fifth feature, and a sixth feature, implemented for the RF receiving system.

[0011] The first feature includes a plurality of bandpass filters, with each one of the plurality of bandpass filters being disposed along a corresponding one of the

plurality of paths and configured to filter a signal received at the bandpass filter to a respective frequency band. At least some of the plurality of amplifiers are implemented as a plurality of variable-gain amplifiers (VGAs), with each one of the plurality of VGAs being configured to amplify the corresponding signal with a gain controlled by an amplifier control signal received from the controller.

[0012] The second feature includes a plurality of phase-shift components, with each one of the plurality of phase-shift components being disposed along a corresponding one of the plurality of paths and configured to phase-shift a signal passing through the phase-shift component.

[0013] The third feature includes a plurality of impedance matching components, with each one of the plurality of impedance matching components being disposed along a corresponding one of the plurality of paths and configured

WHAT IS CLAIMED IS:

1. A radio-frequency (RF) receiving system comprising:

a controller configured to selectively activate one or more of a plurality of paths between an input of the receiving system and an output of the receiving system;

a plurality of amplifiers, each one of the plurality of amplifiers disposed along a corresponding one of the plurality of paths and configured to amplify a signal received at the amplifier; and

at least a first feature and a second feature, at least the second feature and a third feature, at least the second feature and a fourth feature, at least the second feature and a fifth feature, at least the second feature and a sixth feature, at least the first feature and the fifth feature, at least the first feature and the sixth feature, at least the third feature and the fifth feature, at least the third feature and the sixth feature, at least the fourth feature and the fifth feature, at least the fourth feature and the sixth feature, or at least the fifth feature and the sixth feature, implemented for the RF receiving system, the first feature including a plurality of bandpass filters, each one of the plurality of bandpass filters disposed along a corresponding one of the plurality of paths and configured to filter a signal received at the bandpass filter to a respective frequency band, and at least some of the plurality of amplifiers implemented as a plurality of variable-gain amplifiers (VGAs), each one of the plurality of VGAs configured to amplify the corresponding signal with a gain controlled by an amplifier control signal received from the controller; the second feature including a plurality of phase-shift components, each one of the plurality of phase-shift components disposed along a corresponding one of the plurality of paths and configured to phase-shift a signal passing through the phase-shift component; the third feature including a plurality of impedance matching components, each one of the plurality of impedance matching components disposed along a corresponding one of the plurality of paths and configured to reduce at

least one of an out-of-band noise figure or an out-of-band gain of the one of the plurality of paths; the fourth feature including a plurality of post-amplifier bandpass filters, each one of the plurality of post-amplifier bandpass filters disposed along a corresponding one of the plurality of paths at an output of a corresponding one of the plurality of amplifiers and configured to filter a signal to a respective frequency band; the fifth feature including a switching network having one or more single-pole/single-throw switches, each one of the switches coupling two of the

plurality of paths, the switching network configured to be controlled by the controller based on a band select signal; the sixth feature including an input multiplexer configured to receive one or more RF signals at one or more input multiplexer inputs and to output each of the one or more RF signals to one or more of a plurality of input multiplexer outputs to propagate along a respective one or more of the plurality of paths, and an output multiplexer configured to receive one or more amplified RF signals propagating along the respective one or more of the plurality of paths at one or more respective output multiplexer inputs and to output each of the one or more amplified RF signals to a selected one of a plurality of output multiplexer outputs.

2. The RF receiving system of claim 1 wherein the RF receiving system includes the first feature and the second feature.

3. The RF receiving system of claim 1 wherein the RF receiving system includes the second feature and the third feature.

4. The RF receiving system of claim 1 wherein the RF receiving system includes the second feature and the fourth feature.

5. The RF receiving system of claim 1 wherein the RF receiving system includes the first feature, the second feature and the third feature.

6. The RF receiving system of claim 1 wherein the RF receiving system includes the first feature, the second feature and the fourth feature.

7. The RF receiving system of claim 1 wherein the RF receiving system includes the second feature, the third feature and the fourth feature.

8. The RF receiving system of claim 1 wherein the RF receiving system includes the first feature, the second feature, the third feature and the fourth feature.

9. The RF receiving system of claim 1 wherein the RF receiving system includes the first feature, the second feature and the fifth feature.

10. The RF receiving system of claim 1 wherein the RF receiving system includes the first feature, the third feature and the fifth feature.

11. The RF receiving system of claim 1 wherein the RF receiving system includes the first feature, the fourth feature and the fifth feature.

12. The RF receiving system of claim 1 wherein the RF receiving system includes the second feature, the third feature and the fifth feature.

13. The RF receiving system of claim 1 wherein the RF receiving system includes the the second feature, the fourth feature and the fifth feature.

14. The RF receiving system of claim 1 wherein the RF receiving system includes the third feature, the fourth feature and the fifth feature.

15. The RF receiving system of claim 1 wherein the RF receiving system includes the first feature, the second feature, the third feature and the fifth feature

16. The RF receiving system of claim 1 wherein the RF receiving system includes the first feature, the second feature, the fourth feature and the fifth feature.

17. The RF receiving system of claim 1 wherein the RF receiving system includes the first feature, the third feature, the fourth feature and the fifth feature.

18. The RF receiving system of claim 1 wherein the RF receiving system includes the second feature, the third feature, the fourth feature and the fifth feature.

19. The RF receiving system of claim 1 wherein the RF receiving system includes the first feature, the second feature, the third feature, the fourth feature and the fifth feature.

20. The RF receiving system of claim 1 wherein the RF receiving system includes the first feature, the second feature and the sixth feature.

21. The RF receiving system of claim 1 wherein the RF receiving system includes the first feature, the third feature and the sixth feature.

22. The RF receiving system of claim 1 wherein the RF receiving system includes the first feature, the fourth feature and the sixth feature.

23. The RF receiving system of claim 1 wherein the RF receiving system includes the second feature, the third feature and the sixth feature.

24. The RF receiving system of claim 1 wherein the RF receiving system includes the second feature, the fourth feature and the sixth feature.

25. The RF receiving system of claim 1 wherein the RF receiving system includes the third feature, the fourth feature and the sixth feature.

26. The RF receiving system of claim 1 wherein the RF receiving system includes the first feature, the second feature, the third feature and the sixth feature.

27. The RF receiving system of claim 1 wherein the RF receiving system includes the first feature, the second feature, the fourth feature and the sixth feature.

28. The RF receiving system of claim 1 wherein the RF receiving system includes the first feature, the third feature, the fourth feature and the sixth feature.

29. The RF receiving system of claim 1 wherein the RF receiving system includes the second feature, the third feature, the fourth feature and the sixth feature.

30. The RF receiving system of claim 1 wherein the RF receiving system includes the first feature, the second feature, the third feature, the fourth feature and the sixth feature.

31. The RF receiving system of claim 1 wherein the RF receiving system includes the first feature, the second feature, the fifth feature and the sixth feature.

32. The RF receiving system of claim 1 wherein the RF receiving system includes the first feature, the third feature, the fifth feature and the sixth feature.

33. The RF receiving system of claim 1 wherein the RF receiving system includes the first feature, the fourth feature, the fifth feature and the sixth feature.

34. The RF receiving system of claim 1 wherein the RF receiving system includes the second feature, the third feature, the fifth feature and the sixth feature.

35. The RF receiving system of claim 1 wherein the RF receiving system includes the second feature, the fourth feature, the fifth feature and the sixth feature.

36. The RF receiving system of claim 1 wherein the RF receiving system includes the third feature, the fourth feature, the fifth feature and the sixth feature.

37. The RF receiving system of claim 1 wherein the RF receiving system includes the first feature, the second feature, the third feature, the fifth feature and the sixth feature.

38. The RF receiving system of claim 1 wherein the RF receiving system includes the first feature, the second feature, the fourth feature, the fifth feature and the sixth feature.

39. The RF receiving system of claim 1 wherein the RF receiving system includes the first feature, the third feature, the fourth feature, the fifth feature and the sixth feature.

40. The RF receiving system of claim 1 wherein the RF receiving system includes the second feature, the third feature, the fourth feature, the fifth feature and the sixth feature.

41. The RF receiving system of claim 1 wherein the RF receiving system includes the first feature, the second feature, the third feature, the fourth feature, the fifth feature and the sixth feature.

42. The RF receiving system of claim 1 wherein the RF receiving system includes the first feature and the fifth feature.

43. The RF receiving system of claim 1 wherein the RF receiving system includes the second feature and the fifth feature.

44. The RF receiving system of claim 1 wherein the RF receiving system includes the third feature and the fifth feature.

45. The RF receiving system of claim 1 wherein the RF receiving system includes the fourth feature and the fifth feature.

46. The RF receiving system of claim 1 wherein the RF receiving system includes the first feature and the sixth feature.

47. The RF receiving system of claim 1 wherein the RF receiving system includes the second feature and the sixth feature.

48. The RF receiving system of claim 1 wherein the RF receiving system includes the third feature and the sixth feature.

49. The RF receiving system of claim 1 wherein the RF receiving system includes the fourth feature and the sixth feature.

50. The RF receiving system of claim 1 wherein the RF receiving system includes the fifth feature and the sixth feature.

51. The RF receiving system of claim 1 wherein the RF receiving system includes the first feature, the fifth feature and the sixth feature.

52. The RF receiving system of claim 1 wherein the RF receiving system includes the second feature, the fifth feature and the sixth feature.

53. The RF receiving system of claim 1 wherein the RF receiving system includes the third feature, the fifth feature and the sixth feature.

54. The RF receiving system of claim 1 wherein the RF receiving system includes the fourth feature, the fifth feature and the sixth feature.

55. A radio-frequency (RF) module comprising:

a packaging substrate configured to receive a plurality of components; and

a receiving system implemented on the packaging substrate, the receiving system including a controller configured to selectively activate one or more of a plurality of paths between an input of the receiving system and an output of the receiving system, the receiving system further including a plurality of amplifiers, each one of the plurality of amplifiers disposed along a corresponding one of the plurality of paths and configured to amplify a signal received at the amplifier, the receiving system further including at least a first feature and a second feature, at least the second feature and a third feature, at least the second feature and a fourth feature, at least the second feature and a fifth feature, at least the second feature and a sixth feature, at least the first feature and the fifth feature, at least the first feature and the sixth feature, at least the third feature and the fifth feature, at least the third feature and the sixth feature, at least the fourth feature and the fifth feature, at least the fourth feature and the sixth feature, or at least the fifth feature and the sixth feature, implemented for the RF receiving system, the first feature including a plurality of bandpass filters, each one of the plurality of bandpass filters disposed along a corresponding one of the plurality of paths and configured to filter a signal received at the bandpass filter to a respective frequency band, and at least some of the plurality of amplifiers implemented as a plurality of variable-gain amplifiers (VGAs), each one of the plurality of VGAs configured to amplify the corresponding signal with a gain controlled by an amplifier control signal received from the controller; the second feature including a plurality of phase-shift components, each one of the plurality of phase-shift components disposed along a corresponding one of the plurality of paths and configured to phase-shift a signal passing through the phase-shift

component; the third feature including a plurality of impedance matching components, each one of the plurality of impedance matching components disposed along a corresponding one of the plurality of paths and configured to reduce at least one of an out-of-band noise figure or an out-of-band gain of the one of the plurality of paths; the fourth feature including a plurality of post-amplifier bandpass filters, each one of the plurality of post-amplifier bandpass filters disposed along a corresponding one of the plurality of

paths at an output of a corresponding one of the plurality of amplifiers and configured to filter a signal to a respective frequency band; the fifth feature including a switching network having one or more single-pole/single-throw switches, each one of the switches coupling two of the plurality of paths, the switching network configured to be controlled by the controller based on a band select signal; the sixth feature including an input multiplexer configured to receive one or more RF signals at one or more input multiplexer inputs and to output each of the one or more RF signals to one or more of a plurality of input multiplexer outputs to propagate along a respective one or more of the plurality of paths, and an output multiplexer configured to receive one or more amplified RF signals propagating along the respective one or more of the plurality of paths at one or more respective output multiplexer inputs and to output each of the one or more amplified RF signals to a selected one of a plurality of output multiplexer outputs.

56. The RF module of claim 55 wherein the RF module is a diversity receiver front-end module (FEM).

57. A wireless device comprising:

a first antenna configured to receive one or more radio-frequency (RF) signals;

a first front-end module (FEM) in communication with the first antenna, the first FEM including a packaging substrate configured to receive a plurality of components, the first FEM further including a receiving system implemented on the packaging substrate, the receiving system including a controller configured to selectively activate one or more of a plurality of paths between an input of the receiving system and an output of the receiving system, the receiving system further including a plurality of amplifiers, each one of the plurality of amplifiers disposed along a corresponding one of the plurality of paths and configured to amplify a signal received at the amplifier, the receiving system further including at least a first feature and a second

feature, at least the second feature and a third feature, at least the second feature and a fourth feature, at least the second feature and a fifth feature, at least the second feature and a sixth feature, at least the first feature and the fifth feature, at least the first feature and the sixth feature, at least the third feature and the fifth feature, at least the third feature and the sixth feature, at least the fourth feature and the fifth feature, at least the fourth feature and the sixth feature, or at least the fifth feature and the sixth feature, implemented for the RF receiving

system, the first feature including a plurality of bandpass filters, each one of the plurality of bandpass filters disposed along a corresponding one of the plurality of paths and configured to filter a signal received at the bandpass filter to a respective frequency band, and at least some of the plurality of amplifiers implemented as a plurality of variable-gain amplifiers (VGAs), each one of the plurality of VGAs configured to amplify the corresponding signal with a gain controlled by an amplifier control signal received from the controller; the second feature including a plurality of phase-shift components, each one of the plurality of phase-shift components disposed along a corresponding one of the plurality of paths and configured to phase-shift a signal passing through the phase-shift component; the third feature including a plurality of impedance matching components, each one of the plurality of impedance matching components disposed along a corresponding one of the plurality of paths and configured to reduce at least one of an out-of-band noise figure or an out-of-band gain of the one of the plurality of paths; the fourth feature including a plurality of post-amplifier bandpass filters, each one of the plurality of post-amplifier bandpass filters disposed along a corresponding one of the plurality of paths at an output of a corresponding one of the plurality of amplifiers and configured to filter a signal to a respective frequency band; the fifth feature including a switching network having one or more single-pole/single-throw switches, each one of the switches coupling two of the plurality of paths, the switching network configured to be controlled by the controller based on a band select signal; the sixth feature including an input multiplexer configured to receive one or more RF signals at one or more input multiplexer inputs and to output each of the one or more RF signals to one or more of a plurality of input multiplexer outputs to propagate along a respective one or more of the plurality of paths, and an output multiplexer configured to receive one or more amplified RF signals propagating along the respective one or more of the plurality of paths at one or more respective output multiplexer inputs and to output each of the one or more amplified RF signals to a selected one of a plurality of output multiplexer outputs; and

a transceiver configured to receive a processed version of the one or more RF signals from the receiving system and generate data bits based on the processed version of the one or more RF signals.

58. The wireless device of claim 57 wherein the wireless device is a cellular phone.