DIVERSITY RECEIVER FRONT END SYSTEM WITH SWITCHING NETWORK

CROSS-REFERENCE TO RELATED APPLICATION(S)

[0001] This application claims priority to U.S. Provisional Application No. 62/073,043 filed October 31, 2014, entitled DIVERSITY RECEIVER FRONT END SYSTEM, U.S. Provisional Application No. 62/073,041, filed October 31, 2014, entitled ADAPTIVE MULTIBAND LNA FOR CARRIER AGGREGATION, U.S. Application No. 14/727,739, filed June 1, 2015, entitled DIVERSITY FRONT END SYSTEM WITH VARIABLE-GAIN AMPLIFIERS, and U.S. Application No. 14/734,746, filed June 9, 2015, entitled DIVERSITY RECEIVER FRONT END SYSTEM WITH SWITCHING NETWORK, the disclosure of each of which is hereby expressly incorporated by reference herein in its entirety.

BACKGROUND

Field

[0002] The present disclosure generally relates to wireless communication systems having one or more diversity receiving antennas.

Description of the Related Art

[0003] In wireless communication applications, size, cost, and performance are examples of factors that can be important for a given product. For example, to increase performance, wireless components such as a diversity receive antenna and associated circuitry are becoming more popular.

[0004] 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

[0005] In accordance with the present disclosure, there is provided a receiving system comprising:

a first amplifier disposed along first path between an input of the receiving system and an output of the receiving system and configured to amplify a signal received at the first amplifier; a second amplifier disposed along a second path between the input of the receiving system and the output of the receiving system and configured to amplify a signal received at the second amplifier; a single-pole/single-throw (SPST) switch disposed between the first path and the second path and configured to couple the first path and the second path; and a controller configured to receive a band select signal and, based on the band select signal, enable one of the first amplifier or the second amplifier and control the SPST switch.

~~a plurality of amplifiers, each one of the plurality of amplifiers disposed along a corresponding one of a plurality of paths between an input of the receiving system and an output of the receiving system and configured to amplify a signal received at the amplifier;~~

~~a switching network including one or more single-pole/single-throw switches, each one of the switches coupling two of the plurality of paths; and~~

~~a controller configured to receive a band select signal and, based on the band select signal, enable one of the plurality of amplifiers and control the switching network.~~

[0005A] The present disclosure also provides 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 first amplifier disposed along a first path between an input of the RF module and an output of the RF module and configured to amplify a signal received at the first amplifier, a second amplifier disposed along a second path between the input of the RF module and the output of the RF module, a single-pole/single-throw switch disposed between the first path and the second path and configured to couple the first path and the second path, and a controller configured to receive a band select signal and, based on the band select signal, enable one of the first amplifier or

the second amplifier and control the switch.~~plurality of amplifiers, each one of the plurality of amplifiers disposed along a corresponding one of a plurality of paths between an input of the receiving system and an output of the receiving system and configured to amplify a signal received at the amplifier, a switching network including one or more single-pole/single-throw switches, each one of the switches coupling two of the plurality of paths, and a controller configured to receive a band select signal and, based on the band select signal, enable one of the plurality of amplifiers and control the switching network.~~

[0005B] The present disclosure still further provides a wireless device comprising:

a first antenna configured to receive a first radio-frequency (RF) signal;

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 first amplifier disposed along a first path between an input of the FEM module and an output of the FEM module and configured to amplify a signal received at the first amplifier, a second amplifier disposed along a second path between the input of the FEM module and the output of the FEM module and configured to amplifier a signal received at the second amplifier, a single-pole/single-throw switch disposed between the first path and the second path and configured to couple the first path and the second path, and a controller configured to receive a band select signal and, based on the band select signal, enable one of the first amplifier or the second amplifier and control the switch; and a transceiver configured to receive a processed version of the first RF signal from the output via a cable and generate data bits based on the processed version of the first RF signal.

~~a plurality of amplifiers, each one of the plurality of amplifiers disposed along a corresponding one of a plurality of paths~~

~~between an input of the receiving system and an output of the receiving system and configured to amplify a signal received at the amplifier, a switching network including one or more single-pole/single-throw switches, each one of the switches coupling two of the plurality of paths, and a controller configured to receive a band select signal and, based on the band select signal, enable one of the plurality of amplifiers and control the switching network; and~~

~~a transceiver configured to receive a processed version of the first RF signal from the output via a cable and generate data bits based on the processed version of the first RF signal.~~

The present disclosure still provides a receiving system comprising:

a plurality of amplifiers, each one of the plurality of amplifiers disposed along a corresponding one of a plurality of paths between an input of the receiving system and an output of the receiving system and configured to amplify a signal received at the amplifier; a switching network including one or more single-pole/single-throw (SPST) switches, each one of the switches corresponding to a respective pair of the plurality of paths and configured to couple the pair of the plurality of paths; and a controller configured to receive a band select signal and, based on the band select signal, enable one of the plurality of amplifiers and control the switching network

[0005C] In some implementations, the present disclosure relates to a receiving system comprising a plurality of amplifiers. Each one of the plurality of amplifiers is disposed along a corresponding one of a

WHAT IS CLAIMED IS:

1. A receiving system comprising:

a plurality of amplifiers, each one of the plurality of amplifiers disposed along a corresponding one of a plurality of paths between an input of the receiving system and an output of the receiving system and configured to amplify a signal received at the amplifier;

a switching network including one or more single-pole/single-throw switches, each one of the switches coupling two of the plurality of paths; and

a controller configured to receive a band select signal and, based on the band select signal, enable one of the plurality of amplifiers and control the switching network.

2. The receiving system of claim 1 wherein the controller is configured to, in response to receiving a band select signal indicating a single frequency band, enable one of the plurality of amplifiers corresponding the single frequency band and control the switching network to open all of the one or more switches.

3. The receiving system of claim 1 wherein the controller is configured to, in response to receiving a band select signal indicating multiple frequency bands, enable one of the plurality of amplifiers corresponding to one of the multiple frequency bands and control the switching network to close at least one of the one or more switches between paths corresponding to the multiple frequency bands.

4. The receiving system of claim 1 further comprising 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 to increase the impedance for the frequency band corresponding to another one of the plurality of paths.

5. The receiving system of claim 4 wherein each one of the plurality of phase-shift components is disposed between the switching network and the input.

6. The receiving system of claim 4 wherein at least one of the plurality of phase-shift components includes a tunable phase-shift component configured to phase-shift a signal passing through the tunable phase-shift component an amount controlled by a phase-shift tuning signal received from the controller.

7. The receiving system of claim 6 wherein the controller is configured to generate the phase-shift tuning signal based on the band select signal.

8. The receiving system of claim 1 further comprising 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 decrease a noise figure of the one of the plurality of paths.

9. The receiving system of claim 7 wherein each one of the plurality of impedance matching components is disposed between the switching network and a corresponding one of the plurality of amplifiers.

10. The receiving system of claim 7 wherein at least one of the plurality of impedance matching components includes a tunable impedance matching component configured to present an impedance controlled by a impedance tuning signal received from the controller.

11. The receiving system of claim 7 wherein the controller is configured to generate the impedance tuning signal based on the band select signal.

12. The receiving system of claim 1 further comprising a multiplexer configured to split an input signal received at the input into a plurality of signals at a respective plurality of frequency bands propagated along the plurality of paths.

13. The receiving system of claim 1 wherein at least one of the plurality of amplifiers includes a dual-stage amplifier.

14. The receiving system of claim 1 wherein the controller is further configured to disable the others of the plurality of amplifiers.

15. 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 plurality of amplifiers, each one of the plurality of amplifiers disposed along a corresponding one of a plurality of paths between an input of the receiving system and an output of the receiving system and configured to amplify a signal received at the amplifier, a switching network including one or more single-pole/single-throw switches, each one of the switches coupling two of the plurality of paths, and a controller configured to receive a band select signal and, based on the band select signal, enable one of the plurality of amplifiers and control the switching network.

16. The RF module of claim 15 wherein the RF module is a diversity receiver front-end module (FEM).

17. The RF module of claim 15 wherein the receiving system further includes 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 to increase the impedance for the frequency band corresponding to another one of the plurality of paths.

18. A wireless device comprising:

a first antenna configured to receive a first radio-frequency (RF) signal;

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 plurality of amplifiers, each one of the plurality of amplifiers disposed along a corresponding one of a plurality of paths between an input of the receiving system and an output of the receiving system and configured to amplify a signal received at the amplifier, a switching network including one or more single-pole/single-throw switches, each one of the switches coupling two of the plurality of paths, and a controller configured to receive a band select signal and, based on the band select signal, enable one of the plurality of amplifiers and control the switching network; and

a transceiver configured to receive a processed version of the first RF signal from the output via a cable and generate data bits based on the processed version of the first RF signal.

19. The wireless device of claim 18 further comprising a second antenna configured to receive a second radio-frequency (RF) signal and a second FEM in communication with the first antenna, the transceiver being configured to receive a processed version of the second RF signal from an output of the second FEM and generate the data bits based on the processed version of the second RF signal.

20. The wireless device of claim 18 wherein the receiving system further includes 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 to increase the impedance for the frequency band corresponding to another one of the plurality of paths.

WHAT IS CLAIMED IS:

1. A receiving system comprising: a first amplifier disposed along first path between an input of the receiving system and an output of the receiving system and configured to amplify a signal received at the first amplifier; a second amplifier disposed along a second path between the input of the receiving system and the output of the receiving system and configured to amplify a signal received at the second amplifier; a single-pole/single-throw (SPST) switch disposed between the first path and the second path and configured to couple the first path and the second path; and a controller configured to receive a band select signal and, based on the band select signal, enable one of the first amplifier or the second amplifier and control the SPST switch.

2. The receiving system of claim 1 wherein the controller is configured to, in response to receiving a band select signal indicating a single frequency band, enable one of the first amplifier or the second amplifier corresponding the single frequency band and open the SPST switch.

3. The receiving system of claim 1 wherein the controller is configured to, in response to receiving a band select signal indicating multiple frequency bands, enable one of the first amplifier or the second amplifier corresponding to one of the multiple frequency bands and to close the SPST switch.

4. The receiving system of claim 1 further comprising a first phase-shift component disposed along the first path and configured to phase-shift a signal passing through the first phase-shift component to increase the impedance for a frequency band corresponding to the second path.

5. The receiving system of claim 4 wherein the first phase-shift component is disposed between the SPST switch and the input of the receiving system.

6. The receiving system of claim 4 wherein the first phase-shift component includes a tunable phase-shift component configured to phase-shift a signal passing through the tunable phase-shift component an amount controlled by a phase-shift tuning signal received from the controller.

7. The receiving system of claim 6 wherein the controller is configured to generate the phase-shift tuning signal based on the band select signal.

8. The receiving system of claim 1 further comprising a first impedance matching component disposed along the first path and configured to decrease a noise figure of the first path.

9. The receiving system of claim 7 wherein the first impedance matching component is disposed between the SPST switch and the first amplifier.

10. The receiving system of claim 7 wherein the first impedance matching component includes a tunable impedance matching component configured to present an impedance controlled by a impedance tuning signal received from the controller.

11. The receiving system of claim 7 wherein the controller is configured to generate the impedance tuning signal based on the band select signal.

12. The receiving system of claim 1 further comprising a multiplexer configured to split an input signal received at the input of the receiving system into a first signal at a first frequency band propagated along the first path and a second signal at a second frequency band propagated along the second path.

13. The receiving system of claim 1 wherein at least one of the first amplifier or the second amplifier includes a dual-stage amplifier.

14. The receiving system of claim 1 wherein the controller is further configured to disable the other of the first amplifier or the second amplifier.

15. 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 first amplifier disposed along a first path between an input of the RF module and an output of the RF module and configured to amplify a signal received at the first amplifier, a second amplifier disposed along a second path between the input of the RF module and the output of the RF module, a single-pole/single-throw switch disposed between the first path and the second path and configured to couple the first path and the second path, and a controller configured to receive a band select signal and, based on the band select signal, enable one of the first amplifier or the second amplifier and control the switch.

16. The RF module of claim 15 wherein the RF module is a diversity receiver front-end module (FEM).

17. The RF module of claim 15 wherein the receiving system further includes a first phase-shift component disposed along the first path and configured to phase-shift a signal passing through the first phase-shift component to increase the impedance for a frequency band corresponding to the second path.

18. A wireless device comprising: a first antenna configured to receive a first radio-frequency (RF) signal; 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 first amplifier disposed along a first path between an input of the FEM module and an output of the FEM module and configured to amplify a signal received at the first amplifier, a second amplifier disposed along a second path between the input of the FEM module and the output of the FEM module and configured to amplifier a signal received at the second amplifier, a single-pole/single-throw switch disposed between the first path and the second path and configured to couple the first path and the second path, and a controller configured to receive a band select signal and, based on the band select signal, enable one of the first amplifier or the second amplifier and control the switch; and a transceiver configured to receive a processed version of the first RF signal from the output via a cable and generate data bits based on the processed version of the first RF signal.

19. The wireless device of claim 18 further comprising a second antenna configured to receive a second radio-frequency (RF) signal and a second FEM in communication with the first antenna, the transceiver being configured to receive a processed version of the second RF signal from an output of the second FEM and generate the data bits based on the processed version of the second RF signal.

20. The wireless device of claim 18 wherein the receiving system further includes a first phase-shift component disposed along a the first path and configured to phase-shift a signal passing through the first phase-shift component to increase the impedance for a frequency band corresponding to the second path.

21. The receiving system of claim 4 further comprising a second phase-shift component disposed along the second path and configured to phase-shift a signal passing through the second phase-shift component to increase the impedance for a frequency band corresponding to the first path.

22. A receiving system comprising: a plurality of amplifiers, each one of the plurality of amplifiers disposed along a corresponding one of a plurality of paths between an input of the receiving system and an output of the receiving system and configured to amplify a signal received at the amplifier; a switching network including one or more single-pole/single-throw (SPST) switches, each one of the switches corresponding to a respective pair of the plurality of paths and configured to couple the pair of the plurality of paths; and a controller configured to receive a band select signal and, based on the band select signal, enable one of the plurality of amplifiers and control the switching network.

23. The receiving system of claim 22 wherein the controller is configured to, in response to receiving a band select signal indicating a single frequency band, enable one of the plurality of amplifiers corresponding the single frequency band and control the switching network to open all of the one or more SPST switches.

24. The receiving system of claim 22 wherein the controller is configured to, in response to receiving a band select signal indicating multiple frequency bands, enable one of the plurality of amplifiers corresponding to one of the multiple frequency bands and control the switching network to couple multiple paths corresponding to the multiple frequency bands.

25. The receiving system of claim 22 further comprising 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 to increase the impedance for a frequency band corresponding to another one of the plurality of paths.