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, a receiving system comprising:a first amplifier disposed along a first path, corresponding to a first frequency band, between an input of the receiving system and an output of the receiving system; a second amplifier disposed along a second path, corresponding to a second frequency band, between the input of the receiving system and the output of the receiving system; a third amplifier disposed along a third path, corresponding to a third frequency band, between the input of the receiving system and the output of the receiving system; a first impedance matching circuit with a fixed impedance coupled to the first amplifier and disposed along the first path, the first impedance matching circuit configured to reduce a noise figure for the second frequency band and the third frequency band and to reduce an in-band metric for the first frequency band, the in-band metric comprising an in-band noise figure minus an in-band gain; a second impedance matching circuit with a fixed impedance coupled to the second amplifier and disposed along the second path, the second impedance matching circuit configured to reduce a noise figure for the first frequency band and the third frequency band; and a third impedance matching circuit with a fixed impedance coupled to the third amplifier and disposed along the third path, the third impedance matching circuit configured to reduce a noise figure for the first frequency band and the second frequency band. In accordance with an aspect, a radio-frequency (RF) module comprising a packaging substrate configured to receive a plurality of components; a receiving system implemented on the packaging substrate, the receiving system including a first amplifier disposed along a first path, corresponding to a first frequency band, between an input of the receiving system and an output of the receiving system; the receiving system further including a second amplifier disposed along a second path, corresponding to a second frequency band, between the input of the receiving system and the output of the receiving system; the receiving system further including a third amplifier disposed along a third path, corresponding to a third frequency band, between the input of the receiving system and the output of

the receiving system; the receiving system further including a first impedance matching circuit with a fixed impedance coupled to the first amplifier and disposed along the first path, the first impedance matching circuit configured to reduce a noise figure for the second frequency band and the third frequency band and to reduce an in-band metric for the first frequency band, the in-band metric comprising an in-band noise figure minus an in-band gain; the receiving system further including a second impedance matching circuit with a fixed impedance coupled to the second amplifier and disposed along the second path, the second impedance matching circuit configured to reduce a noise figure for the first frequency band and the third frequency band; and the receiving system further including a third impedance matching circuit with a fixed impedance coupled to the third amplifier and disposed along the third path, the third impedance matching circuit configured to reduce a noise figure for the first frequency band and the second frequency band. A wireless device comprising:

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

a front-end module (FEM) in communication with the first antenna, the FEM including a packaging substrate configured to receive a plurality of components, the FEM further including a receiving system implemented on the packaging substrate, the receiving system including a first amplifier disposed along a first path, corresponding to a first frequency band, between an input of the receiving system and an output of the receiving system; the receiving system further including a second amplifier disposed along a second path, corresponding to a second frequency band, between the input of the receiving system and the output of the receiving system; the receiving system further including a third amplifier disposed along a third path, corresponding to a third frequency band, between the input of the receiving system and the output of the receiving system; the receiving system further including a first impedance matching circuit with a fixed impedance coupled to the first amplifier and disposed along the first path, the first impedance matching circuit configured to reduce a noise figure for the second frequency band and the third frequency band and to reduce an in-band metric for the first frequency band, the in-band metric comprising an in-band noise figure minus an in-band gain; the receiving system further including a second

impedance matching circuit with a fixed impedance coupled to the second amplifier and disposed along the second path, the second impedance matching circuit configured to reduce a noise figure for the first frequency band and the third frequency band; and the receiving system further including a third impedance matching circuit with a fixed impedance coupled to the third amplifier and disposed along the third path, the third impedance matching circuit configured to reduce a noise figure for the first frequency band and the second frequency band; and a transceiver configured to receive a processed version of the RF signal from the output of the FEM via a transmission line and to generate data bits based on the processed version of the first RF signal.

In accordance with the present disclosure, there is provided a 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

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.

[0006]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 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 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.

[0007] The present disclosure further provides a wireless device comprising

Claims

1. A receiving system comprising:

a first amplifier disposed along a first path, corresponding to a first frequency band, between an input of the receiving system and an output of the receiving system;

a second amplifier disposed along a second path, corresponding to a second frequency band, between the input of the receiving system and the output of the receiving system;

a third amplifier disposed along a third path, corresponding to a third frequency band, between the input of the receiving system and the output of the receiving system;

a first impedance matching circuit with a fixed impedance coupled to the first amplifier and disposed along the first path, the first impedance matching circuit configured to reduce a noise figure for the second frequency band and the third frequency band and to reduce an in-band metric for the first frequency band, the in-band metric comprising an in-band noise figure minus an in-band gain;

a second impedance matching circuit with a fixed impedance coupled to the second amplifier and disposed along the second path, the second impedance matching circuit configured to reduce a noise figure for the first frequency band and the third frequency band; and

a third impedance matching circuit with a fixed impedance coupled to the third amplifier and disposed along the third path, the third impedance matching circuit configured to reduce a noise figure for the first frequency band and the second frequency band.

2. The receiving system of claim 1 wherein the in-band metric is reduced to within a threshold amount of an in-band metric minimum, the in-band metric minimum being a minimum possible in-band metric subject to any constraints.

3. The receiving system of claim 1 wherein the second impedance matching circuit is further configured to reduce the in-band metric for the second frequency band.

4. The receiving system of claim 1 wherein the third impedance matching circuit is further configured to reduce the in-band metric for the third frequency band.
5. 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 at least a first signal at the first frequency band propagated along the first path, a second signal at the second frequency band propagated along the second path, and a third signal at the third frequency band propagated along the third path.

6. The receiving system of claim 1 further comprising a signal combiner configured to combine at least a first signal propagating along the first path, a second signal propagating along the second path, and a third signal propagating along the third path.

7. 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 propagated along the first path, a second signal propagated along the second path, and a third signal propagated along the third path.
8. The receiving system of claim 6 further comprising: a first band-pass filter disposed along the first path, the first band-pass filter configured to filter the first signal to the first frequency band; a second band-pass filter disposed along the second path, the second band-pass filter configured to filter the second signal to the second frequency band; and a third band-pass filter disposed along the third path, the third band-pass filter configured to filter the third signal to the third frequency band.

9. The receiving system of claim 1 further comprising a controller configured to selectively enable the first path by enabling first amplifier, to enable the second path by enabling the second amplifier, and to enable the third path by enabling the third amplifier.
10. A radio-frequency (RF) module comprising a packaging substrate configured to receive a plurality of components; a receiving system

implemented on the packaging substrate, the receiving system including a first amplifier disposed along a first path, corresponding to a first frequency band, between an input of the receiving system and an output of the receiving system; the receiving system further including a second amplifier disposed along a second path, corresponding to a second frequency band, between the input of the receiving system and the output of the receiving system; the receiving system further including a third amplifier disposed along a third path, corresponding to a third frequency band, between the input of the receiving system and the output of the receiving system; the receiving system further including a first impedance matching circuit with a fixed impedance coupled to the first amplifier and disposed along the first path, the first impedance matching circuit configured to reduce a noise figure for the second frequency band and the third frequency band and to reduce an in-band metric for the first frequency band, the in-band metric comprising an in-band noise figure minus an in-band gain; the receiving system further including a second impedance matching circuit with a fixed impedance coupled to the second amplifier and disposed along the second path, the second impedance matching circuit configured to reduce a noise figure for the first frequency band and the third frequency band; and the receiving system further including a third impedance matching circuit with a fixed impedance coupled to the third amplifier and disposed along the third path, the third impedance matching circuit configured to reduce a noise figure for the first frequency band and the second frequency band.

11. The RF module of claim 10 wherein the in-band metric is reduced to within a threshold amount of an in-band metric minimum, the in-band metric minimum being a minimum possible in-band metric subject to any constraints.

12. The RF module of claim 10 wherein the second impedance matching circuit is further configured to reduce the in-band metric for the second frequency band.

13. The RF module of claim 10 wherein the third impedance matching circuit is further configured to reduce the in-band metric for the third frequency band.

14. The RF module of claim 10 further comprising a controller configured to selectively enable the first path by enabling first amplifier, to enable the second path by enabling the second amplifier, and to enable the third path by enabling the third amplifier.

15. A wireless device comprising:

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

a front-end module (FEM) in communication with the first antenna, the FEM including a packaging substrate configured to receive a plurality of components,

the FEM further including a receiving system implemented on the packaging substrate, the receiving system including a first amplifier disposed along a first path, corresponding to a first frequency band, between an input of the receiving system and an output of the receiving system; the receiving system further including a second amplifier disposed along a second path, corresponding to a second frequency band, between the input of the receiving system and the output of the receiving system; the receiving system further including a third amplifier disposed along a third path, corresponding to a third frequency band, between the input of the receiving system and the output of the receiving system; the receiving system further including a first impedance matching circuit with a fixed impedance coupled to the first amplifier and disposed along the first path, the first impedance matching circuit configured to reduce a noise figure for the second frequency band and the third frequency band and to reduce an in-band metric for the first frequency band, the in-band metric comprising an in-band noise figure minus an in-band gain; the receiving system further including a second impedance matching circuit with a fixed impedance coupled to the second amplifier and disposed along the second path, the second impedance matching circuit configured to reduce a noise figure for the first frequency band and the third frequency band; and the receiving system further including a third impedance

matching circuit with a fixed impedance coupled to the third amplifier and disposed along the third path, the third impedance matching circuit configured to reduce a noise figure for the first frequency band and the second frequency band; and a transceiver configured to receive a processed version of the RF signal from the output of the FEM via a transmission line and to generate data bits based on the processed version of the first RF signal.

16. The wireless device of claim 15 wherein the receiving system further includes a multiplexer configured to split an input signal received at the input of the receiving system into a first signal propagated along the first path, a second signal propagated along the second path, and a third signal propagated along the third path
17. The wireless device of claim 15 further comprising a controller configured to selectively enable the first path by enabling first amplifier, to enable the second path by enabling the second amplifier, and to enable the third path by enabling the third amplifier.
18. The wireless device of claim 15 wherein the in-band metric is reduced to within a threshold amount of an in-band metric minimum, the in-band metric minimum being a minimum possible in-band metric subject to any constraints.
19. The wireless device of claim 15 wherein the second impedance matching circuit is further configured to reduce the in-band metric for the second frequency band.

20. The wireless device of claim 15 wherein the third impedance matching circuit is further configured to reduce the in-band metric for the third frequency band.