## SUMMARY

**[0005]** 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 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.

**[0005A]** In accordance with the present disclosure, there is also provided 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 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.

**[0005B]** In accordance with the present disclosure, there is further provided 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 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 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; and

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

**[0005C]** In some implementations, the present disclosure relates to a 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 includes a plurality of amplifiers. Each one of the plurality of amplifiers is disposed along a corresponding one of the plurality of paths and is configured to amplify a signal received at the amplifier. The receiving system further includes a plurality of impedance matching components. Each one of the plurality of impedance matching components is disposed along a corresponding one of the plurality of paths and is 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]** In some embodiments, a first impedance matching component of the plurality of impedance matching components disposed along a first path of the plurality of paths corresponding to a first frequency band can be configured to reduce at least one of an out-of-band noise figure or an out-of-band gain for a second frequency band corresponding to a second path of the plurality of paths.

**[0007]** In some embodiments, a second impedance matching component of the plurality of impedance matching components disposed along the second path can be configured to reduce at least one of an out-of-band noise

figure or an out-of-band gain for the first frequency band. In some embodiments, the first impedance matching component can be further configured to reduce at least one of an out-of-band noise figure or an out-of-band gain for a third frequency band corresponding to a third path of the plurality of paths.

**[0008]** In some embodiments, the first impedance matching component can be further configured to reduce at least one of an in-band noise figure or increase an in-band gain for the first frequency band. In some embodiments, the first impedance matching component can be configured to reduce an in-band metric of the in-band noise figure minus the in-band gain to within a threshold amount of an in-band metric minimum. In some embodiments, the first impedance matching component can be configured to reduce an out-of-band metric of the out-of-band noise figure plus the out-of-band gain to an in-band-constrained out-of-band minimum.

## SUMMARY

**[0005]** 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 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 plurality of phase-shift components including a first phase-shift component disposed along a first path of the plurality of paths corresponding to a first frequency band and configured to phase-shift a second frequency band of a signal passing through the first phase-shift component such that a second initial signal propagated along a second path of the plurality of paths corresponding to the second frequency band and a second reflected signal propagated along the first path are at least partially in-phase.

**[0005A]** In accordance with the present disclosure, there is also provided 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 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 plurality of phase-shift components includes a first phase-shift component disposed along a first path of the plurality of paths corresponding to a first frequency band and configured to phase-shift a second frequency band of a signal passing through the first phase-shift component such that a second initial signal propagated along a second path of the plurality of paths corresponding to the second frequency band and a second reflected signal propagated along the first path are at least partially in-phase.

**[0005B]** In accordance with the present disclosure, there is further provided 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 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 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, a first phase-shift component of the plurality of phase-shift components disposed along a first path of the plurality of paths corresponding to a first frequency band being configured to phase-shift a second frequency band of a signal passing through the first phase-shift component such that a second initial signal propagated along a second path of the plurality of paths corresponding to the second frequency band and a second reflected signal propagated along the first path are at least partially in-phase; and

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

**[0005C]** In some implementations, the present disclosure relates to a 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 includes a plurality of amplifiers. Each one of the plurality of amplifiers is disposed along a corresponding one of the plurality of paths and is configured to amplify a signal received at the amplifier. The receiving system further includes a plurality of impedance matching components. Each one of the plurality of impedance matching components is disposed along a corresponding one of the plurality of paths and is 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]** In some embodiments, a first impedance matching component of the plurality of impedance matching components disposed along a first path of the plurality of paths corresponding to a first frequency band can be configured to reduce at least one of an out-of-band noise figure or an out-of-band gain for a second frequency band corresponding to a second path of the plurality of paths.

**[0007]** In some embodiments, a second impedance matching component of the plurality of impedance matching components disposed along the second path can be configured to reduce at least one of an out-of-band noise figure or an out-of-band gain for the first frequency band. In some embodiments, the first impedance matching component can be further configured to reduce at least one of an out-of-band noise figure or an out-of-band gain for a third frequency band corresponding to a third path of the plurality of paths.

**[0008]** In some embodiments, the first impedance matching component can be further configured to reduce at least one of an in-band noise figure or increase an in-band gain for the first frequency band. In some embodiments, the first impedance matching component can be configured to reduce an in-band metric of the in-band noise figure minus the in-band gain to within a threshold amount of an in-band metric minimum. In some embodiments, the first impedance matching component can be configured to reduce an out-of-band

metric of the out-of-band noise figure plus the out-of-band gain to an in-band-constrained out-of-band minimum.

WHAT IS CLAIMED IS:

1. 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 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~~.~~,

~~2. The receiving system of claim 1 wherein a first phase-shift component of~~ the plurality of phase-shift components including a first phase-shift component disposed along a first path of the plurality of paths corresponding to a first frequency band ~~is~~ and configured to phase-shift a second frequency band of a signal passing through the first phase-shift component such that a second initial signal propagated along a second path of the plurality of paths corresponding to the second frequency band and a second reflected signal propagated along the first path are at least partially in-phase.

~~3.~~2. The receiving system of claim ~~2~~ 1 wherein ~~a second phase-shift component of~~ the plurality of phase-shift components includes a second phase-shift component disposed along the second path ~~is~~ and configured to phase-shift the first frequency band of a signal passing through the second phase-shift component such that a first initial signal propagated along the first path and a first reflected signal propagated along the second path are at least partially in-phase.

~~4.~~3. The receiving system of claim ~~2~~ 1 wherein the first phase-shift component is further configured to phase-shift a third frequency band of a signal passing through the first phase-shift component such that a third initial signal

propagated along a third path of the plurality of paths corresponding to the third frequency band and a third reflected signal propagated along the first path are at least partially in-phase.

~~5.~~4. The receiving system of claim ~~2~~ 1 wherein the first phase-shift component is configured to phase-shift the second frequency band of a signal passing through the first phase-shift component such that the second initial signal and the second reflected signal have a phase difference of an integer multiple of 360 degrees.

~~6.~~5. 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.

~~7.~~6. The receiving system of claim 1 further comprising a signal combiner configured to combine signals propagating along the plurality of paths.

~~8.~~7. The receiving system of claim ~~7~~ 6 further comprising a post-combiner amplifier disposed between the signal combiner and the output, the post-combiner amplifier configured to amplify a signal received at the post-combiner amplifier.

~~9.~~8. The receiving system of claim ~~7~~ 6 wherein each one of the plurality of phase-shift components is disposed between the signal combiner and a respective one of the plurality of amplifiers.

~~10.~~9. The receiving system of claim 1 wherein at least one of the plurality of amplifiers includes a dual-stage amplifier.

~~11.~~10. The receiving system of claim 1 wherein at least one of the plurality of phase-shift components is a passive circuit.

~~12.~~11. The receiving system of claim 1 wherein at least one of the plurality of phase-shift components is an LC circuit.

~~13.~~12. The receiving system of claim 1 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.

13. The receiving system of claim 12 wherein the phase-shift tuning signal is based on a band select signal.

14. The receiving system of claim 1 further comprising a plurality of impedance matching components, each one of the impedance matching components disposed along a corresponding one of the plurality of paths and configured to decrease at least one of an out-of-band noise figure or an out-of-band gain of the corresponding one of the plurality of paths.

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 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 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~~.~~

~~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 a first phase-shift component of~~, the plurality of phase-shift components includes a first

phase-shift component disposed along a first path of the plurality of paths corresponding to a first frequency band ~~is~~ and configured to phase-shift ~~the~~ a second frequency band of a signal passing through the first phase-shift component such that a second initial signal propagated along a second path of

the plurality of paths corresponding to the second frequency band and a second reflected signal propagated along the first path are at least partially in-phase.

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 plurality of phase-shift components includes a second phase-shift component disposed along the second path and configured to phase-shift the first frequency band of a signal passing through the second phase-shift component such that a first initial signal propagated along the first path and a first reflected signal propagated along the second path are at least partially in-phase.

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 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 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, a first phase-shift component of the plurality of phase-shift components disposed along a first path of the plurality of paths corresponding to a first frequency band being configured to phase-shift a second frequency band of a signal passing through the first phase-shift component such that a second initial signal propagated along a second

path of the plurality of paths corresponding to the second frequency band and a second reflected signal propagated along the first path are at least partially in-phase; and

a transceiver configured to receive a processed version of the first RF signal from the output via a transmission line 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~~ second 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 plurality of phase-shift components includes a second phase-shift component disposed along the second path and configured to phase-shift the first frequency band of a signal passing through the second phase-shift component such that a first initial signal propagated along the first path and a first reflected signal propagated along the second path are at least partially in-phase. ~~The wireless device of claim 18 wherein a first phase-shift component of the plurality of phase-shift components disposed along a first path of the plurality of paths corresponding to a first frequency band is configured to phase-shift the second frequency band of a signal passing through the first~~

~~phase-shift component such that a second initial signal propagated along a second path of the plurality of paths corresponding to the second frequency band and a second reflected signal propagated along the first path are at least partially in-phase.~~