UNIFIED SOUNDING REFERENCE SIGNAL INPUT/OUTPUT FUNCTIONALITY

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims priority to U.S. Provisional Application Serial No. 63/142,264, titled "UNIFIED SOUNDING REFERENCE SIGNAL INPUT/OUTPUT FUNCTIONALITY," filed on January 27, 2021, which is hereby incorporated by reference in its entirety.

BACKGROUND

The present disclosure relates generally to front-end modules (FEM). Some examples relate to systems and methods for improving sounding reference signal functionality in FEM architectures.

SUMMARY

According to at least one aspect of the present disclosure, a front-end module for a wireless device is provided comprising at least one transmit path configured to provide a first sounding reference signal, at least one transmit/receive path coupled to at least one antenna port, a sounding-reference-signal port configured to provide the first sounding reference signal and to receive a second sounding reference signal, an antenna switching module coupled between the at least one transmit path, the at least one transmit/receive path, and the sounding-reference-signal port, the antenna switching module being configured to provide the first sounding reference signal from the transmit path to the at least one transmit/receive path and the sounding-reference-signal port and to provide the second sounding reference signal received at the sounding-reference-signal port to the at least one transmit/receive path, wherein the first sounding reference signal is provided from the sounding-reference-signal port to a second front-end module included in the wireless device, and the second sounding reference signal is received from the second front-end module.

In some examples, the first sounding reference signal and the second sounding reference signal are provided to the at least one transmit/receive path to be transmitted by one or more antennas coupled to the at least one antenna port. In at least one example, the first sounding reference signal and the second sounding reference signal are transmitted to at least one base station to characterize an uplink channel between the wireless device and the base station. In various examples, the first sounding reference signal is provided from the sounding-reference-signal port to a second front-end module included in the wireless device. In some examples, the second sounding reference signal is received from the second front-end module.

configured to route the first sounding reference signal from the second sounding-reference-signal port to the at least one second transmit/receive path.

In various examples, the first sounding reference signal is provided to the at least one first antenna port to be transmitted by one or more first antennas coupled to the at least one first antenna port, and the second sounding reference signal is provided to the at least one second antenna port to be transmitted by one or more second antennas coupled to the at least one second antenna port. In some examples, the first sounding reference signal and the second sounding reference signal are transmitted to at least one base station to characterize an uplink channel between the mobile-communications-device system and the at least one base station. In at least one example, the first antenna switch module includes a single pin connection configured to be coupled to the first sounding-reference-signal port and the second antenna switch module includes a single pin connection configured to be coupled to the second sounding-reference-signal port.

According to at least one aspect of the disclosure, a non-transitory computer-readable medium storing thereon sequences of computer-executable instructions for controlling a front-end module for a wireless device comprising a sounding-reference-signal port, at least one transmit path, at least one transmit/receive path coupled to at least one antenna port, and an antenna switching module coupled between the sounding-reference-signal port, the at least one transmit path, and the at least one transmit/receive path is provided, the sequences of computer-executable instructions including instructions that instruct at least one processor to control the antenna switching module to route a first sounding reference signal from the at least one transmit path to the sounding-reference-signal port, and control the antenna switching module to route a second sounding reference signal from the sounding-reference-signal port to the at least one transmit/receive port, wherein the first sounding reference signal is provided from the sounding-reference-signal port to a second front-end module included in the wireless device, and the second sounding reference signal is received from the second front-end module.

In some examples, the instructions instruct the at least one processor to route the first sounding reference signal and the second sounding reference signal to the at least one transmit/receive path to be transmitted by one or more antennas coupled to the at least one antenna port. In at least one example, the wireless device includes a transceiver, and the instructions instruct the at least one processor to route the first sounding reference signal from the transceiver and to route the second sounding reference signal to the transceiver. In various examples, the instructions instruct the at least one processor to provide the first sounding

CLAIMS

1. A front-end module for a wireless device comprising:

at least one transmit path configured to provide a first sounding reference signal;

at least one transmit/receive path coupled to at least one antenna port;

a sounding-reference-signal port configured to provide the first sounding reference signal and to receive a second sounding reference signal;

an antenna switching module coupled between the at least one transmit path, the at least one transmit/receive path, and the sounding-reference-signal port, the antenna switching module being configured to provide the first sounding reference signal from the transmit path to the at least one transmit/receive path and the sounding-reference-signal port and to provide the second sounding reference signal received at the sounding-reference-signal port to the at least one transmit/receive path, wherein the first sounding reference signal is provided from the sounding-reference-signal port to a second front-end module included in the wireless device, and the second sounding reference signal is received from the second front-end module.

2. The front-end module of claim 1 wherein the first sounding reference signal and the second sounding reference signal are provided to the at least one transmit/receive path to be transmitted by one or more antennas coupled to the at least one antenna port.

3. The front-end module of claim 2 wherein the first sounding reference signal and the second sounding reference signal are transmitted to at least one base station to characterize an uplink channel between the wireless device and the base station.

4. The front-end module of claim 1 wherein the at least one transmit path includes at least one power amplifier.

5. The front-end module of claim 1 wherein the at least one receive path includes at least one low-noise amplifier.

6. The front-end module of claim 1 wherein the front-end module is configured to support 5G wireless communication.

7. The front-end module of claim 1 wherein the antenna switch module includes a single pin connection configured to be coupled to the sounding-reference-signal port.

8. A mobile-communications-device system comprising:

a first front-end module including

a first sounding-reference-signal port configured to provide a first sounding reference signal and to receive a second sounding reference signal; and

a first antenna switching module coupled to the first sounding-reference-signal port, the first antenna switching module being configured to route the first sounding reference signal to the first sounding-reference-signal port and to route the second sounding reference signal from the first sounding-reference-signal port; and

a second front-end module including

a second sounding-reference-signal port configured to provide the second sounding reference signal to the first front-end module and to receive the first sounding reference signal from the first front-end module; and

a second antenna switching module coupled to the second sounding-reference-signal port, the second antenna switching module being configured to route the second sounding reference signal to the second sounding-reference-signal port and to route the first sounding reference signal from the second sounding-reference-signal port.

9. The mobile-communications-device system of claim 8 wherein

the first front-end module includes at least one first transmit path coupled to the first antenna switch module, the first antenna switch module being configured to route the first sounding reference signal from the at least one first transmit path to the first sounding-reference-signal port, and

the second front-end module includes at least one second transmit path coupled to the second antenna switch module, the second antenna switch module being configured to route the second sounding reference signal from the at least one second transmit path to the second sounding-reference-signal port.

10. The mobile-communications-device system of claim 8 wherein

the first front-end module includes at least one first transmit/receive path coupled to at least one first antenna port and coupled to the first antenna switch module, the first antenna switch module being configured to route the second sounding reference signal from the first sounding-reference-signal port to the at least one first transmit/receive path, and

the second front-end module includes at least one second transmit/receive path coupled to at least one second antenna port and coupled to the second antenna switch module, the second antenna switch module being configured to route the first sounding reference signal from the second sounding-reference-signal port to the at least one second transmit/receive path.

11. The mobile-communications-device system of claim 10 wherein

the first sounding reference signal is provided to the at least one first antenna port to be transmitted by one or more first antennas coupled to the at least one first antenna port, and

the second sounding reference signal is provided to the at least one second antenna port to be transmitted by one or more second antennas coupled to the at least one second antenna port.

12. The mobile-communications-device system of claim 11 wherein the first sounding reference signal and the second sounding reference signal are transmitted to at least one base station to characterize an uplink channel between the mobile-communications-device system and the at least one base station.

13. The mobile-communications-device system of claim 8 wherein

the first antenna switch module includes a single pin connection configured to be coupled to the first sounding-reference-signal port and

the second antenna switch module includes a single pin connection configured to be coupled to the second sounding-reference-signal port.

14. A non-transitory computer-readable medium storing thereon sequences of computer-executable instructions for controlling a front-end module for a wireless device comprising a sounding-reference-signal port, at least one transmit path, at least one transmit/receive path coupled to at least one antenna port, and an antenna switching module coupled between the sounding-reference-signal port, the at least one transmit path, and the at least one transmit/receive path, the sequences of computer-executable instructions including instructions that instruct at least one processor to:

control the antenna switching module to route a first sounding reference signal from the at least one transmit path to the sounding-reference-signal port; and

control the antenna switching module to route a second sounding reference signal from the sounding-reference-signal port to the at least one transmit/receive port, wherein the first sounding reference signal is provided from the sounding-reference-signal port to a second front-end module included in the wireless device, and the second sounding reference signal is received from the second front-end module.

15. The non-transitory computer-readable medium of claim 14 wherein the instructions instruct the at least one processor to route the first sounding reference signal and the second sounding reference signal to the at least one transmit/receive path to be transmitted by one or more antennas coupled to the at least one antenna port.

16. The non-transitory computer-readable medium of claim 14 wherein the wireless device includes a transceiver, and the instructions instruct the at least one processor to route the first sounding reference signal from the transceiver and to route the second sounding reference signal to the transceiver.

17. The non-transitory computer-readable medium of claim 14 wherein the instructions instruct the at least one processor to provide the first sounding reference signal from, and receive the second sounding reference signal at, a single pin coupled to the sounding-reference-signal port.

18. The non-transitory computer-readable medium of claim 14 wherein the instructions further instruct the at least one processor to operate the front-end module pursuant to a 5G wireless-communication standard.