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Multi-antenna switch control in 5G

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ABSTRACT

A mobile device typically has multiple antenna elements to enable antenna diversity and to accommodate multiple protocols, e.g., 4G, 5G, SRS, etc. When different antenna elements transmit or receive simultaneously, intermodulation products from one can reduce the sensitivity of another. This disclosure describes techniques to allocate antenna elements across protocols and antenna diversity schemes such that intermodulation desensing is minimized and transceiver-antenna connectivity is continuously maintained.

KEYWORDS

- Antenna switched diversity (ASDiv)
- Switched diversity
- Intermodulation
- Desensing
- LTE
- 5G-NR
- Sounding reference signal (SRS)
- Resource allocation
- Antenna allocation

BACKGROUND

A mobile device typically has multiple antenna elements to enable antenna diversity and to accommodate multiple protocols, e.g., LTE, 5G, NR, SRS, etc. When different antenna elements transmit or receive simultaneously, intermodulation products from one can reduce the sensitivity of another.

In the context of this disclosure, the terms LTE (long-term evolution) and E-UTRA (evolved universal terrestrial radio access) are each synonymous with fourth-generation mobile radio (4G). The term NR (new radio) is synonymous with fifth-generation mobile radio (5G). LTE and NR may operate out of the same mobile device; such operation is referred to as E-UTRA-NR dual connectivity (eN-DC), or simply, dual connectivity. Under dual connectivity, the LTE and NR transceivers may operate on the same or on different bands. If they operate on the same band, then the NR transceiver may be anchored on the LTE transceiver. To optimize diversity, each transceiver may deploy antenna switched diversity (ASDiv) techniques, e.g., each transceiver may continuously or periodically switch antennas based on the antenna(s) that have the best signal strength.

DESCRIPTION

The techniques to minimize intermodulation desensing are described below using example cases.

Example 1: LTE-NR dual connectivity, with each transceiver deploying ASDiv

In this case, the available set of antennas is split into disjoint subsets such that signals from each transceiver are coupled to different antenna subsets. Intermodulation desensing is reduced by having signals from different transceivers traverse different paths to their respective antennas.

For example, if there are four antennas on the mobile device labeled 0, 1, 2, and 3, then the LTE transceiver can be assigned antennas 2 and 3, while the NR transceiver can be assigned antennas 0 and 1. In executing antenna switched diversity, the LTE transceiver is constrained to switch between antennas 2 and 3, while the NR transceiver is constrained to switch between antennas 0 and 1. Antenna switched diversity can be turned off by assigning a single antenna to each transceiver. For example, assigning antenna-2 to LTE and assigning antenna-0 to NR causes each transceiver to be parked at the one antenna assigned to it.

If the LTE and NR transceiver operate on different bands, intermodulation desensing can be further reduced by leveraging the dependence of intermodulation products on band combination. For example, if LTE is in band X1 and NR is in band Y1 then the antenna mapping can be set to LTE: {2,3} and NR: {0,1}. On the other hand, if LTE is in band X2, different from band X1, and NR is in band Y2, then the antenna mapping can be set to LTE: {0,2} and NR: {1,3}. If no band-combination dependent antenna mapping is specified, then the transceivers default to a fixed, e.g., band-combination independent, antenna mapping.

The technique of splitting the set of antennas into band-combination dependent disjoint subsets applies also to cases where UL-CA (uplink carrier aggregation) and UL-MIMO (uplink multiple input multiple output) technologies are applied.

Example 2: LTE-NR dual connectivity, with each transceiver deploying ASDiv under SRS

An SRS (sounding reference signal) is a known uplink signal transmitted by a mobile device antenna to enable a base station to determine the channel between itself and each of the mobile-device antennas. SRS and ASDiv compete for the same antenna resources. An SRS event can override the currently programmed RF paths for the LTE transceiver depending on the state of the NR transceiver. When an SRS event occurs, the LTE transceiver can thus potentially lose its connectivity to its antenna. Per the techniques of this disclosure, during an SRS event, switch-paths between the transceivers and the antennas are reprogrammed in real-time such that the LTE and NR receivers stay connected to their respective, disjoint antenna subsets. Upon completion of the SRS event, the LTE and NR transceivers go back to their originally programmed antenna mappings.

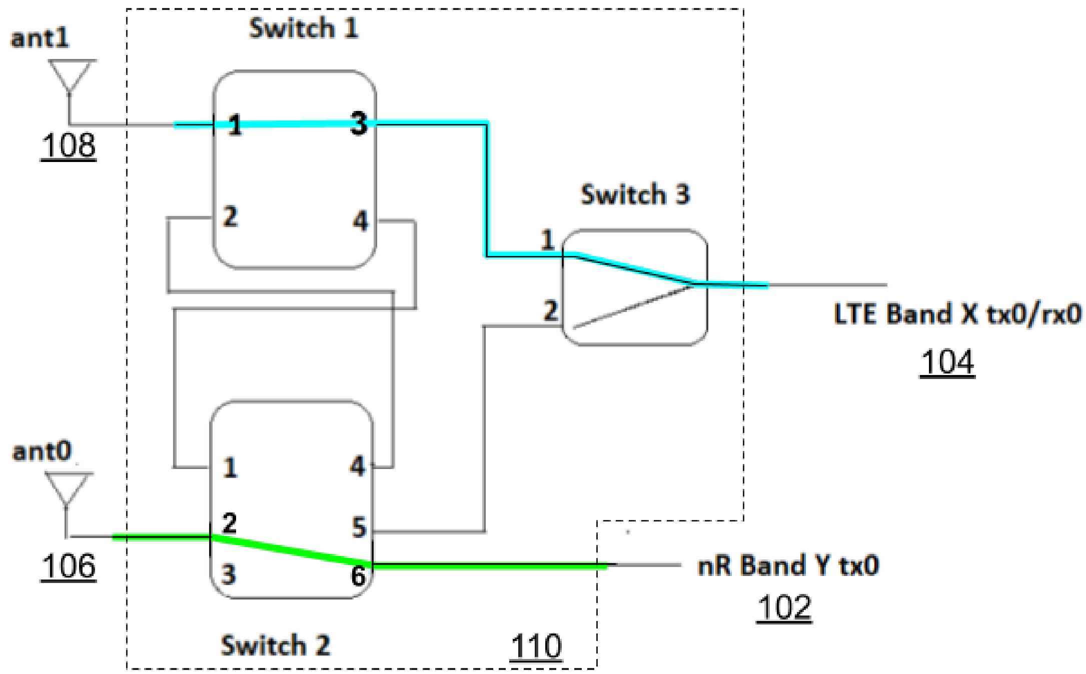

Fig. 1: Switch paths to maintain transceiver-antenna connectivity during an SRS event

Fig. 1 illustrates programming switch paths to maintain transceiver-antenna connectivity during an SRS event. In the example of Fig. 1, an NR transmitter (102) and an LTE transceiver (104) are shown that can be connected to one or both of two antennas (106, 108) via a switch network (110). Switches in the switch network are programmable, e.g., the input-output mapping of a switch can be programmatically changed. During an SRS event, if the NR transmitter is connected to antenna-0 via the green switch path, then the LTE transceiver is re-programmed to be connected to antenna-1 via the blue switch path. The green switch path is activated by turning on the following connections: Switch 2: port 6 to port 2. The blue switch path is activated by turning on the following connections: Switch 1: port 3 to port 1. Other antennas that are used for the purposes of ASDiv or SRS, either for reception or transmission, are similarly connected to their respective transceivers via the switch network.

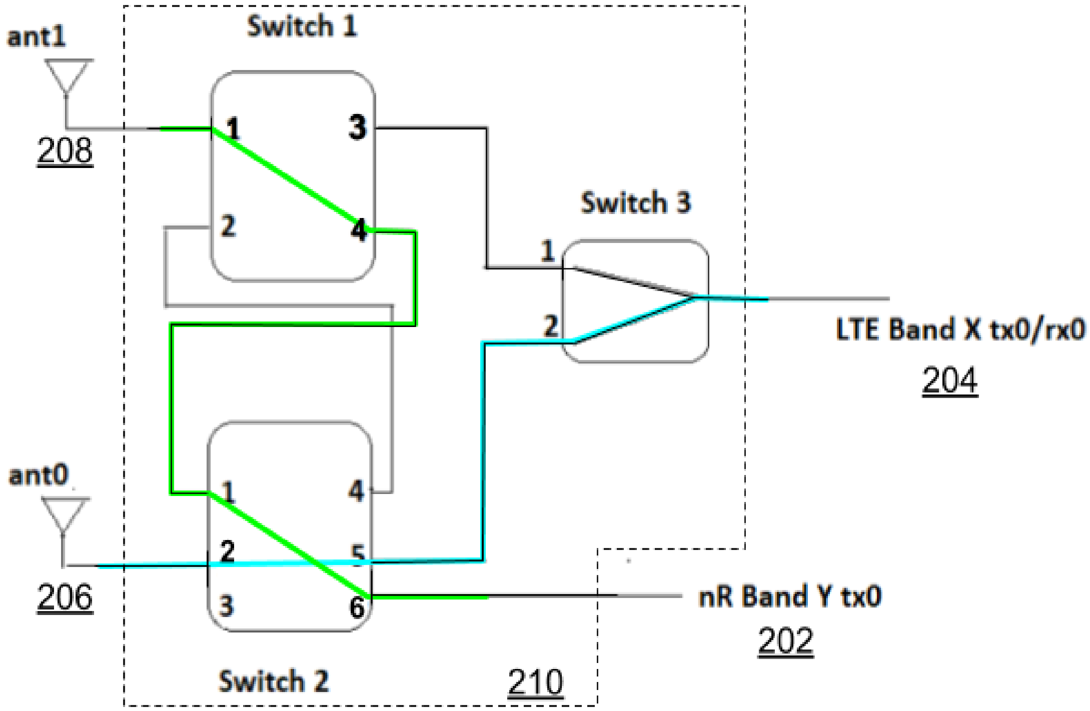

Fig. 2: Switch paths to maintain transceiver-antenna connectivity during an SRS event

Fig. 2 illustrates another example of programming switch paths to maintain transceiver-antenna connectivity during an SRS event. In this example, an NR transmitter (202) and an LTE transceiver (204) can be connected to one or both of two antennas (206, 208) via a switch network (210). During an SRS event, if the NR transmitter is connected to antenna-1 via the green switch path, then the LTE transceiver is re-programmed to be connected to antenna-0 via the blue switch path. The green switch path is activated by turning on the following connections: Switch 2: port 6 to port 1, and switch 1: port 4 to port 1. The blue switch path is activated by turning on the following connections: Switch 2: port 5 to port 2. Other antennas that are used for the purposes of ASDiv or SRS, either for reception or transmission, are similarly connected to their respective transceivers via the switch network.

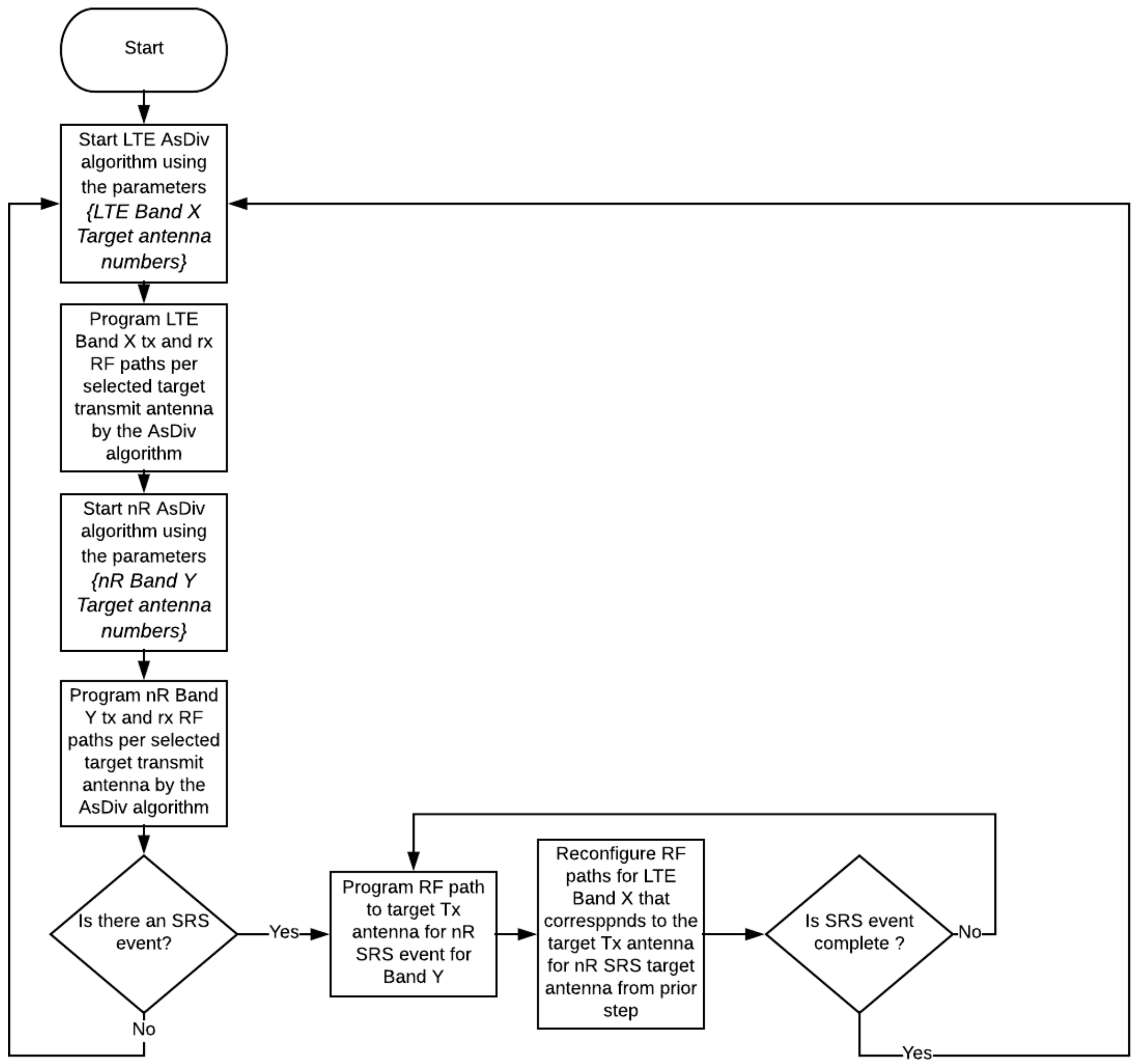

Fig. 3: Dynamic transceiver-antenna mapping for multi-protocol, ASDiv devices in the presence of SRS events

Fig. 3 illustrates the techniques of dynamic transceiver-antenna mapping for multi-protocol (LTE, NR, etc.), ASDiv devices in the presence of SRS events.

Example 3: LTE-NR dual connectivity, with prioritization of protocol, ASDiv and SRS

When multiple transceivers of differing protocol compete for the same set of antenna resources, with each transceiver deploying antenna switched diversity under the possibility of

SRS events, it can be advantageous to prioritize the protocols and SRS events. An example prioritization can be:

Priority 0 (highest): NR-SRS

Priority 1: LTE-ASDiv

Priority 2 (lowest): NR-ASDiv

Per the techniques of this disclosure, one or more antenna groupings are created. For four antennas labeled 0, 1, 2, and 3, an example grouping can be:

Group A: {0, 2}

Group B: {1, 3}

If a highest-priority protocol or event, e.g., NR-SRS, occurs, it occupies a transmit antenna resource, e.g., antenna-0. Since antenna-0 belongs to group A, a lower priority protocol, e.g., LTE-ASDiv, occupies group B antennas for the duration of the high-priority event. Within group B, the LTE-ASDiv protocol selects the best available antenna based on ASDiv selection procedures. Such priority-driven, transceiver-antenna maps are enabled by the programmable switch network between the transceivers and the antennas.

As another example, if a mid-priority protocol, e.g., LTE-ASDiv, is under operation, it occupies a transmit antenna resource, e.g., antenna-0. Since antenna-0 belongs to group A, a lower priority protocol, e.g., NR-ASDiv, occupies group B antennas. Within their respective prioritized groups, each of the LTE-ASDiv and NR-ASDiv protocols select the best antenna based on ASDiv selection procedures.

CONCLUSION

This disclosure describes techniques to allocate antenna elements across protocols and antenna diversity schemes such that intermodulation desensing is minimized and transceiver-antenna connectivity is continuously maintained.