

CLAIMS

1. A front-end module (FEM) comprising:

a first section including

a first node,

a second node,

a first filter,

a first switch coupled to the first node, a transmit path, and a receive path, the first switch being configured to selectively couple the first node to only one of the transmit path or receive path at a time; and

a first noise cancellation circuit, the first filter and the first noise cancellation circuit being coupled in parallel with one-another between the first node and the second node, the first node being configured to provide a first electrical signal to the first filter and the first noise cancellation circuit, the first filter being configured to produce a first conditioned signal based on the first electrical signal, the first noise cancellation circuit being configured to produce a first cancellation signal based on the first electrical signal, and the second node being configured to receive the first conditioned signal and the first cancellation signal.

2. The FEM of claim 1 wherein the FEM further comprises a second section

including:

a third node;

a fourth node;

a second filter; and

a second noise cancellation circuit, the second filter and the second noise cancellation circuit being coupled in parallel with one-another between the third node and the fourth node, the third node being configured to provide a second electrical signal to the second filter and the second noise cancellation circuit, the second filter being configured to produce a second conditioned signal based on the second electrical signal, the second noise cancellation circuit being configured to produce a second cancellation signal based on the second electrical signal, and the fourth node being configured to receive the second conditioned signal and the second cancellation signal.

3. The FEM of claim 2 wherein the first electrical signal corresponds to a first frequency band and the second electrical signal corresponds to a second frequency band.

5 4. The FEM of claim 2 wherein the first electrical signal corresponds to a 6GHz frequency band, and the second electrical signal corresponds to a 5GHz frequency band.

5. The FEM of claim 1 wherein the first noise cancellation circuit includes a plurality of dynamically programmable taps configured to determine the first cancellation signal.

10 6. The FEM of claim 1 wherein the first electrical signal has frequency components in a first frequency band and a second frequency band, and the first noise cancellation circuit produces the first electrical signal such that the first cancellation signal attenuates at least a portion of the frequency components in the second frequency band when summed together in the
15 second node with the first conditioned signal.

7. The FEM of claim 1 further comprising:
an antenna coupled to one of the first node or the second node; and
a switch coupled to a different one of the first node or the second node than is coupled to
20 the antenna.

8. The FEM of claim 7 wherein the first switch has a first terminal coupled to the receive path, a second terminal coupled to the transmit path, and a third terminal configured to be selectively coupled to only one of the first terminal and the second terminal at a time.

25 9. The FEM of claim 1 wherein the first electrical signal overlaps includes frequency components that overlap with a frequency band of a second electrical signal.

10. The FEM of claim 9 wherein the first noise cancellation circuit produces the first
30 cancellation signal such that the first cancellation signal attenuates the frequency components that overlap with the frequency band of the second signal near an edge of the frequency band.

11. A front-end module comprising:

an input configured to transmit and receive wireless telecommunication signals;

a filter coupled between the input and a transmit node and a receive node and configured

5 to filter one or more of the wireless telecommunication signals;

a noise cancellation circuit configured to provide noise cancellation to one or more of the wireless telecommunication signals, the noise cancellation circuit being coupled in parallel with the filter between the input and the transmit or receive node, and including a plurality of dynamically programmable taps that can be dynamically programmed to determine one or more frequency bands for which the noise cancellation circuit provides noise cancellation dependent upon whether the FEM is operating in a transmit mode of operation or a receive mode of operation, and further based on a proximity of the one or more frequency bands for which the noise cancellation circuit provides noise cancellation to a frequency band associated with the transmit mode of operation or the receive mode of operation;

15 a first switch coupled between the transmit or receive node and a parallel combination of the noise cancellation circuit and the filter, the first switch being configured to selectively couple the parallel combination to only one of the transmit node or the receive node at a time; and

a summing node coupled to the filter and the noise cancellation circuit, the summing node configured to sum an output of the filter and an output of the noise cancellation circuit.

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12. The FEM of claim 11 wherein the FEM has a plurality of modes of operation including the transmit mode of operation and the receive mode of operation.

13. The FEM of claim 12 further comprising a controller configured to set one or more values of the dynamically programmable taps of the plurality of dynamically programmable taps.

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14. The FEM of claim 13 wherein the controller is configured to set the one or more values of the dynamically programmable taps to a first set of values in the transmit mode of operation.

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15. The FEM of claim 14 wherein setting the dynamically programmable taps to the first set of values corresponds to setting the noise cancellation circuit to cancel at least a portion of at least one signal occupying a subset of frequencies near an edge of the frequency band associated with the transmit mode of operation.

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16. The FEM of claim 14 wherein the controller is configured to set the one or more values of the dynamically programmable taps to a second set of values in the receive mode of operation.

10 17. The FEM of claim 16 wherein setting the dynamically programmable taps to the second set of values corresponds to setting the noise cancellation circuit to cancel at least a portion of at least one signal occupying a subset of frequencies across the frequency band associated with the receive mode of operation.

15 18. A method of filtering signals in a wireless telecommunications device using time domain duplexing (TDD) comprising:

transmitting, from a first front-end module ("first FEM"), a first signal on a first frequency band;

receiving, at a second FEM, the first signal, the first signal having frequency components
20 extending into a second frequency band;

receiving, at the second FEM, a second signal on the second frequency band, and combining the second signal and the first signal to produce a combined signal;

providing the combined signal to a filter of the second FEM, the filter configured to condition the combined signal to produce a conditioned signal;

25 providing at least a portion of the combined signal to a noise cancellation circuit of the second FEM, the noise cancellation circuit having a plurality of dynamically programmable taps, the noise cancellation circuit being configured to adjust the at least a portion of the combined signal to produce an adjusted signal;

dynamically programming the dynamically programmable taps to have values corresponding to a frequency of the first frequency band based on a proximity of the frequency of the at least a portion of the combined signal to the second frequency band; and summing the conditioned signal and the adjusted signal.

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19. The method of claim 18 wherein providing the at least a portion of the combined signal to the noise cancellation circuit includes the at least a portion of the combined signal being within a first range of frequencies, the first range of frequencies being a subset of the frequencies of the first signal.

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20. The method of claim 18 wherein adjusting the at least a portion of the combined signal includes at least one of altering the phase of the at least a portion of the combined signal or altering the amplitude of the at least a portion of the combined signal.

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