DYNAMIC BAND STEERING FILTER BANK DIE

Field of the Disclosure

[0001] The present disclosure relates in general to radio frequency processing. In particular, the present disclosure relates to filter bank modules.

Background

[0002] To support the newly released Wireless Fidelity (Wi-Fi) spectrum at 6 GHz while supporting the existing Wi-Fi bands at 2.4 GHz and 5 GHz, customers use complex banks of filters, along with switches, diplexers, and an assortment of surface-mount technology matching components. As such, filter bank modules incorporating these components are relatively large in size and have relatively high cost and relatively poor performance. What is needed is a new type of filter bank module having a substantial reduction in size and cost while also substantially improving performance.

Summary

[0003] Disclosed is a filter bank die having a first acoustic wave (AW) filter having a first antenna terminal and a first filter terminal, and a second AW filter configured to pass frequencies of a passband that are different from the frequencies of the first passband of the first AW filter. The first AW filter is configured as a bandpass filter to pass a first passband with a filter skirt having a first falling slope that spans between a 100 MHz and a 160 MHz gap between adjacent passbands and a first rising slope that spans a gap less than the gap of the first falling slope. The second AW filter has a second antenna terminal coupled to the first antenna terminal and a second filter terminal to diplex signals that pass through the first AW filter and the second AW filter. The second AW filter is configured to pass the frequencies of the second passband with a second filter skirt having a second rising slope that spans another gap between 100 MHz and 160 MHz.

[0004] In some exemplary embodiments, at least one switch such as a single-pole double-throw switch or a multi-pole multi-throw switch is integrated within a filter bank module with the filter bank die. Also, in some exemplary embodiments, a low-noise amplifier is integrated with the switch and the filter bank die within the filter bank module. In further exemplary embodiments, a power amplifier is integrated with the low-noise amplifier, the switch, and the filter bank die within the filter bank module. Moreover, passive filters such as

Claims

1. A filter bank die comprising:
   - a first acoustic wave (AW) filter having a first antenna terminal and a first filter terminal, wherein the first AW filter is configured as a bandpass filter to pass a first passband with a filter skirt having a first that spans between a 100 MHz and a 160 MHz gap between adjacent passbands and a first rising slope that spans a gap less than the gap of the first falling slope; and
   - a second AW filter configured to pass frequencies of a passband that are different from the frequencies of the first passband of the first AW filter, wherein the second AW filter has a second antenna terminal coupled to the first antenna terminal and a second filter terminal to diplex signals that pass through the first AW filter and the second AW filter; and
   - wherein the second AW filter is configured to pass the frequencies of the second passband with a second filter skirt having a second rising slope that spans another gap between 100 MHz and 160 MHz.

2. The filter bank die of claim 1 wherein the first AW filter is configured to have a filter skirt with a slope that spans at least a 100 MHz gap between adjacent passbands.

3. The filter bank die of claim 1 wherein the second AW filter is configured to have a filter skirt with a slope that spans at least a 100 MHz gap between adjacent passbands.

4. The filter bank die of claim 1 wherein the second AW filter is configured as a bandpass filter to pass a UNII-2c to UNII-3 passband with a filter skirt having a rising slope that spans up to a 160 MHz gap between adjacent passbands.

5. The filter bank die of claim 1 wherein the first AW filter is configured as a bandpass filter to pass a UNII-1 to UNII-2a passband with a filter skirt having a

falling slope that spans up to a 160 MHz gap between adjacent passbands and the second AW filter is configured as a bandpass filter to pass a UNII-2c to UNII-3 passband with a filter skirt having a rising slope that spans up to a 160 MHz gap between adjacent passbands.

6. The filter bank die of claim 1 wherein the first AW filter is configured as a bandpass filter to pass a UNII-2c to UNII-4 passband with a filter skirt having a rising slope that spans up to a 160 MHz gap between adjacent passbands.

7. The filter bank die of claim 1 wherein the second AW filter is configured to pass a UNII-5 to UNII-8 passband while rejecting the UNII-2c to UNII-4 passband.

8. The filter bank die of claim 1 wherein the first AW filter is configured as a bandpass filter to pass a UNII-2c to UNII-4 passband with a filter skirt having a rising slope that spans up to a 160 MHz gap between adjacent passbands and the second AW filter is configured to pass a UNII-5 to UNII-8 passband while rejecting the UNII-2c to UNII-4 passband.

9. The filter bank die of any one of the preceding claims, wherein the first antenna terminal and the second antenna terminal are directly coupled together.

10. A filter bank module comprising:
the filter bank die of any one of the preceding claims; and
a single-pole double-throw switch having a first throw terminal coupled to the first filter terminal and a second throw terminal coupled to the second filter terminal and a single pole terminal.

11. A filter bank module comprising:
the filter bank die of any one of claims 1 to 9; and

a double-pole double-throw switch having a first throw terminal coupled to the first filter terminal and a second throw terminal coupled to the second filter terminal, a transmit pole terminal, and a receive pole terminal.

12. The filter bank module of claim 11 wherein the double-pole double-throw switch is configured to selectively couple the receive pole terminal between the first throw terminal and the second throw terminal.

13. The filter bank module of claim 11 wherein the double-pole double-throw switch is configured to selectively couple the transmit pole terminal between the first throw terminal and the second throw terminal.

14. The filter bank module of claim 11 wherein the filter bank module further comprises a low-noise amplifier (LNA) having an LNA input terminal coupled to the receive pole terminal and an LNA output terminal.

15. The filter bank module of claim 14 wherein the filter bank module further comprises a power amplifier (PA) having a PA output coupled to the transmit pole terminal and a PA input.

16. A filter bank module comprising:
the filter bank die of any one of claims 1 to 9,
wherein the filter bank module further comprises a passive filter having a third antenna terminal coupled to an antenna port and a third filter terminal.

17. The filter bank module of claim 16 wherein the passive filter comprises at least one inductor and at least one capacitor.

18. The filter bank module of claim 16 wherein the third antenna terminal is coupled directly to both the first antenna terminal and the second antenna terminal.

19. The filter bank module of claim 16 wherein the filter bank module further comprises a single-pole double-throw switch having a first throw terminal coupled to the first filter terminal and a second throw terminal coupled to the second filter terminal and a single pole terminal.

20. The filter bank module of claim 16 wherein the filter bank module further comprises a double-pole double-throw switch having a first throw terminal coupled to the first filter terminal and a second throw terminal coupled to the second filter terminal, a transmit pole terminal, and a receive pole terminal.

21. The filter bank module of claim 20 wherein the double-pole double-throw switch is configured to selectively couple the receive pole terminal between the first throw terminal and the second throw terminal.

22. The filter bank module of claim 20 wherein the double-pole double-throw switch is configured to selectively couple the transmit pole terminal between the first throw terminal and the second throw terminal.

23. The filter bank module of claim 20 wherein the filter bank module further comprises a low-noise amplifier (LNA) having an LNA input terminal coupled to the receive pole terminal and an LNA output terminal.

24. The filter bank module of claim 23 wherein the filter bank module further comprises a power amplifier (PA) having a PA output coupled to the transmit pole terminal and a PA input.

25. The filter bank module of claim 20 wherein an insertion loss between either of the transmit pole terminal or the receive pole terminal and the antenna port minus an insertion loss of either the first AW filter or the second AW filter is no greater than 1.2 decibels.

26. The filter bank module of claim 20 wherein a real estate area of the filter bank module is no greater than 2.56 square millimeters.

27. The filter bank module of claim 20 wherein a real estate area of the filter bank module is no greater than 4 square millimeters.

28. The filter bank die of claim 1 wherein the second filter skirt has a falling slope that is less than the gap of the second rising slope.

29. The filter bank die of claim 1 wherein the second filter skirt has a falling slope that is equal to the gap of the second rising slope.