5 GHz Wi-Fi Coexistence with 5G Cellular for Improved User Experience

The ever-increasing demand for higher data rates and reduced buffering times has driven the continuous evolution of cellular communication and transmission. 5G promises to take performance to levels never seen before, with mounting pressure to deploy 5G handsets faster than any previous cellular standard. With this urgency to release 5G smartphones, potential Wi-Fi coexistence issues have largely been ignored, despite the fact that Wi-Fi and 5G cellular are complementary technologies and effective coexistence of the two technologies would greatly enhance the end user experience. In fact, Wi-Fi data usage can reach as high as 92% of total smartphone data usage according to various analytics reports.[1,2] Further, the 5 GHz Wi-Fi channel (802.11a/n/ac/ax) is being widely implemented in user equipment (UE) across the world, offering additional range beyond the traditional 2.4 GHz spectrum. Combined with the high speeds available in 5G, the efficient utilization of both Wi-Fi and 5G spectrums has the potential to offer substantially increased data rates with negligible latency. Therefore, it is important that Wi-Fi remain an integral part of smartphones and complement 5G in order to provide the optimal user experience.

Due to the proximity of cellular and Wi-Fi channels in 2.4 GHz and 5 GHz spectrums, utilization of both Wi-Fi and new radio (NR) spectrums can cause interference during operation. The 2.4 GHz Wi-Fi channel is adjacent to the n41, n40 and n7 spectrum, while the n79 band is adjacent to the 5 GHz Wi-Fi channel as shown in Figure 1.

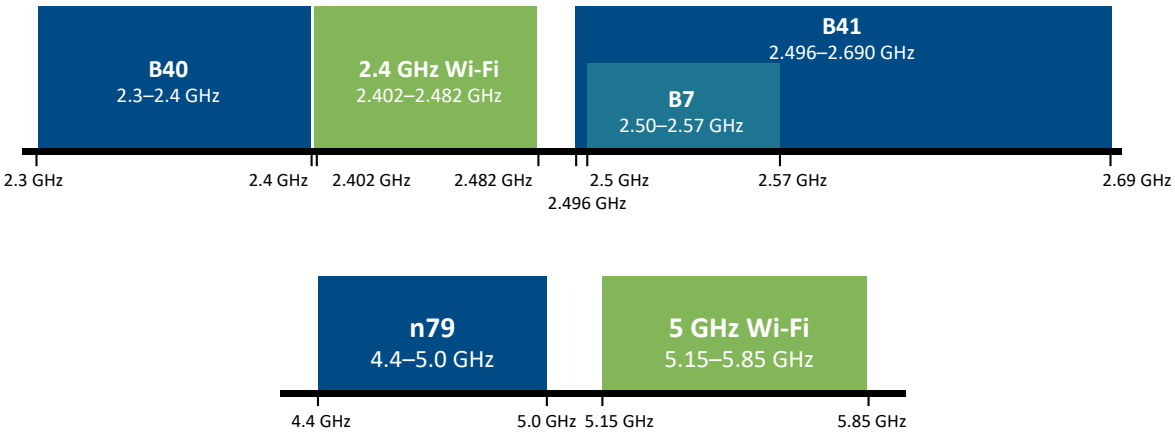

Figure 1. Cellular to 2.4 GHz and 5 GHz Wi-Fi Channels Adjacency

1. 2018 China Public WIFI Safety Report
2. Net Radar https://wifinowevents.com/news-and-blog/wi-fi-percentage-of-us-smartphone-traffic-at-74-says-netradar/

This poses serious interference threats due to transmit (Tx) leakage and Adjacent Channel Leakage Ratio (ACLR) in respective bands, which can greatly impact data rates if appropriate filtering is not used. In addition, there is the potential risk of hardware damage due to high power signals reaching receive (Rx) paths. Figure 2 shows a simple illustration of interferences in the n79 and Wi-Fi coexistence cases.

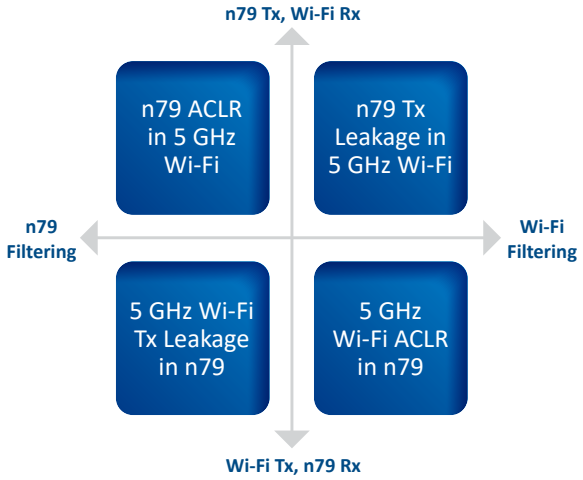

Figure 2. Interferences in n79 and 5 GHz Wi-Fi Coexistence Cases

To date, there have been no requirements from carriers or OEMs for n79 coexistence with 5 GHz Wi-Fi channels. Therefore, current RF front-end (RFFE) implementations do not take this into account. This can result in a significant desense in 5 GHz Wi-Fi channels if no additional measures are taken.

As an example, Skyworks' SKY58255 module shown in Figure 3 is an ultra-high band Tx/Rx module supporting bands n77 to n79.

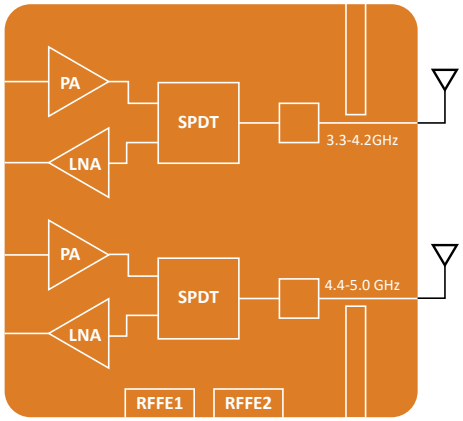

Figure 3. Ultra High Band SKY58255 n77, n78 and n79 Tx/Rx Module

This module is currently being designed into multiple phones in China and other markets. Since n79 with 5 GHz Wi-Fi is not considered a design target, this module is optimized for best-in-class insertion loss and noise figure which may result in less than ideal Wi-Fi coexistence performance as shown in Table 1.

Rejection / Freq. (MHz)	5150	5350	5550	5750	5850
5 GHz Wi-Fi Rejection from LPAMiF	-2	-3.2	-5.3	-8.2	-9.9
Expected Desense in 5 GHz Wi-Fi	36.4	30.5	18.8	13.7	11.6

Table 1: Current n79 LPAMID/DRX rejection without use of external high rejection filtering

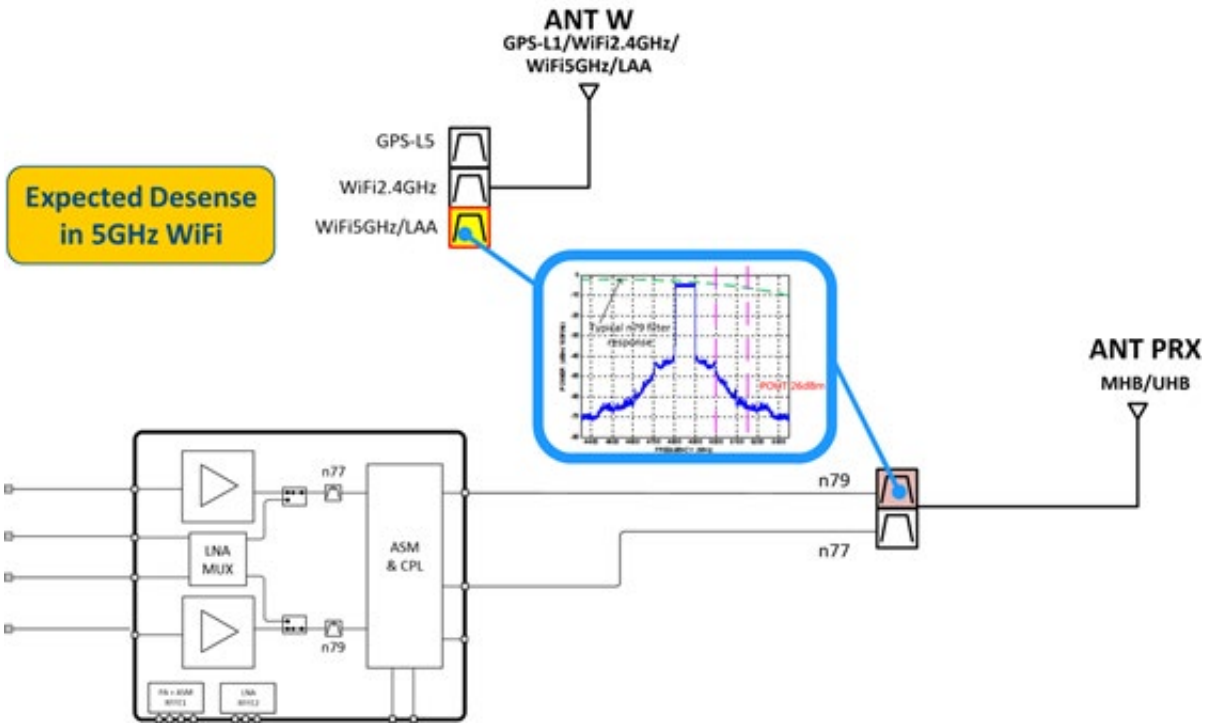

Figure 4. Skyworks' Antennaplexers for Improved Coexistence

The use of external high rejection filters and antennaplexers as shown in Figure 4 can help remedy this issue. With rejection up to 25-35 dB, utilizing one of Skyworks' antennaplexers can greatly improve the desense and enable the end user device to achieve the coexistence needed for proper utilization of both spectrums. Table 2 demonstrates the enhancement.

Rejection / Freq. (MHz)	5150	5350	5550	5750	5850
Wi-Fi 5 rejection from LPAMiF n79 Tx	-2.1	-3.2	-5.3	-8.2	-9.9
Rejection with High Rejection AntennaPlexer	-22	-22.2	-23.5	-30.8	-25.8
Combined Rejection	-24.1	-25.4	-28.8	-39	-35.7
Expected Desense in Wi-Fi 5 with Combined Rejection	14.6	8.9	1.3	0.1	0.2

Table 2: Improved Desense Performance with Skyworks' Antennaplexers

While there are some techniques available to help improve coexistence performance, the use of hardware filtering for coexistence can offer multiple advantages including higher throughput, which translates directly into faster data rates. The hardware filtering is also platform-agnostic – offering OEMs the flexibility to use the transceiver platform of their choice. In addition, it removes any restriction on Wi-Fi and the end user benefits from hotspot or external-AP modes. Most importantly, hardware filtering is future-proof, so any additional band combinations would not affect the filtering, particularly as 5G continues to evolve and new bands are allocated.

An example of hardware filtering can be found in Skyworks' n77 to n79 antennaplexer, which offers rejection of greater than 25 dB with low insertion loss and enables coexistence between Wi-Fi and n79 frequencies shown in Figure 5.

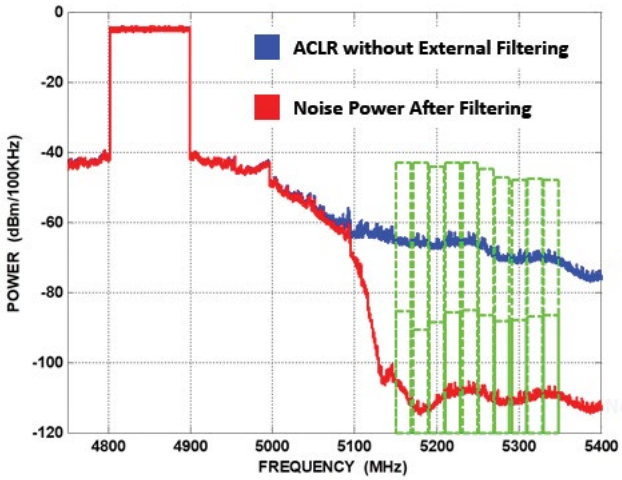

Figure 5. Plot Demonstrating High Rejection Filtering with n77/79 AntennaPlexer (Not to Scale)

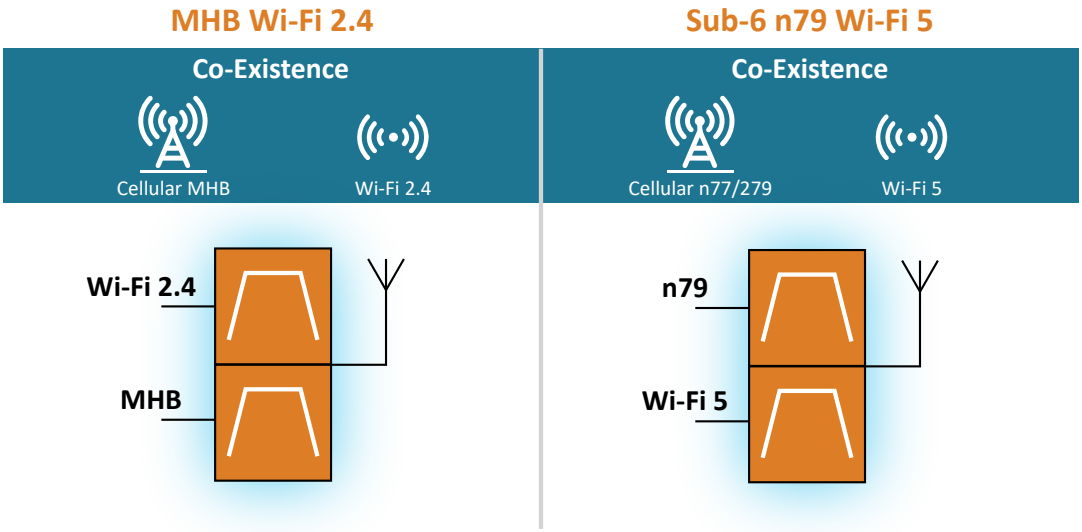

Figure 6. AntennaPlexers for 2.4 GHz Wi-Fi and 5 GHz Wi-Fi

A similar concept can be extended to the mid-high band 2.4 GHz Wi-Fi filtering to enable n7 and n41 to 2.4 GHz Wi-Fi and n40 to 2.4 GHz Wi-Fi n7- coexistence as shown in Figure 6. External implementation of the filter also allows flexibility in some SKUs where certain bands may not be required.

In addition, potential application scenarios exist in NR/LAN interworking and NR/WLAN dual connectivity, which have been discussed in 3GPP as a working item. Having a hardware-based solution will enable UE to take advantage of this advanced capability.

As data rates increase and the user experience becomes more critical with the evolution to 5G, Skyworks is committed to offering the most advanced wireless engines that help us achieve our mission of *Connecting Everyone and Everything, All the Time*.

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