5G Impact on Mobile RF Front End

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Abstract

5G will totally redefine how the radio frequency (RF) front-end interacts in-between the network and the modem. Indeed, new radio frequency bands, sub-6 GHz, and mm-wave (as defined in 3GPP release 15) pose big challenges for the industry. However, with these challenges comes opportunity to disrupt the market's leadership.

On the sub-6 GHz side, the current front-end leaders (Broadcom, Qorvo, Skyworks, and Murata) have already begun adapting to these changes. Broadcom prepared for the arrival of 5G ultra-high band by integrating mid and high bands together. And with its FBAR BAW filter technology, Broadcom also owns the main critical building block for the high and ultra-high frequency bands. Skyworks is positioned on the 5G ultra-high band market with its newly announced Sky5TM platform. Moreover, the company has already earned some design wins in the high-end segment with its SkyOneR LiTE platform, in addition to the low-end segment with its leading position among Chinese OEMs (Huawei, Oppo, Vivo, Xiaomi). Qorvo has a similar approach, with a broad product portfolio covering the high-end and low-end segments with its RF FusionTM and RF FlexTM platforms, respectively. Another Qorvo strength is its internal test and packaging capability, which enable quick reaction time and continuous improvement. Notably, Qorvo was the first player to unveil a front-end module for ultra-high band coverage. Murata mostly covers the low band, but is very well positioned for the growing, diversity module market. Qualcomm is the new entrant that brings with it an end-to-end solution from modem to antenna. Also, strategic investment in TDK Epcos' filtering technology has become profitable. The first revenue was generated in the RF front-end segment during 2018. We can expect further revenue to come in the near future. A first mobile phone (i.e. Sony's XZ2) already adopted Qualcomm's complete solution.

Along with sub-6 GHz, the mm-wave front-end module will completely disrupt the front-end industry, representing a completely different technology mindset that could create a new path to high data-rate access. While Qualcomm is one of the new entrants clearly positioned for mmwave technology, all of the top platform providers (i.e. Intel, Samsung, HiSilicon, and Mediatek) are exploring this new business opportunity. However, the sub-6 GHz radio band will always be required for radio coverage and link integrity, but complexity could drop in the sub-6 GHz regime with mm-wave technology's arrival, especially in dense urban areas when the mm-wave network is deployed.

The mobile handset RF front-end market, along with the WiFi connectivity sector, is expected to reach $35.2B in 2023 at a CAGR of 14%. LTE evolution clearly is the first growth wave (as we stated in our 2017 report), but most of the market opportunities in the mid-term will come from 5G non-stand-alone (NSA) radio, which became prevalent in late December 2017 (as defined in 3GPP during release 15). The need for dual connectivity (i.e. the 5G new radio (NR) band attachment to the LTE) implies evolution on RF frontend architecture and additional components. Not all components will exhibit equal market growth. Filters, which represent the RF front-end industry's biggest market segment, will almost triple from 2017 - 2023. This growth will come mainly from the significant penetration rate of high-quality BAW filters, which will be required for the ultra-high frequency range defined by 5G NR. Another example is co-existence filters for diversity antenna-sharing with Wi-Fi, since band rejection will be critical. The LNA market will also exhibit a significant market growth with the implementation of the diversity module, along with integration in power amplifier modules for handsets. The switch market will enjoy the same growth due to the addition of a new RF path with 4x4 MIMO implementation, which will lead to more diversity switch needs. The antenna tuner market is also expected to record significant growth with 4X4 MIMO technology's penetration. It is worth noting that 4x4 MIMO will be mandatory for 5G. Power amplifier (PA) will be the sole market to remain almost flat over this period. High-end LTE PA market growth, especially in high and ultra-high band, will compensate for the 2G/3G market's shrinkage due to service shutdown.

LTE evolution has led to complex architecture in today's mobile phones. Meanwhile, RF's board area and available antenna space have been reduced, leading to a densification trend with more handset OEMs adopting power amplifier modules and implementing new technics, i.e. antenna-sharing between LTE and WiFi. In the low frequency band, the inclusion of the 600 MHz band (for which T-Mobile recently acquired licenses) will pose new challenges for low-band antenna design and antenna tuners.

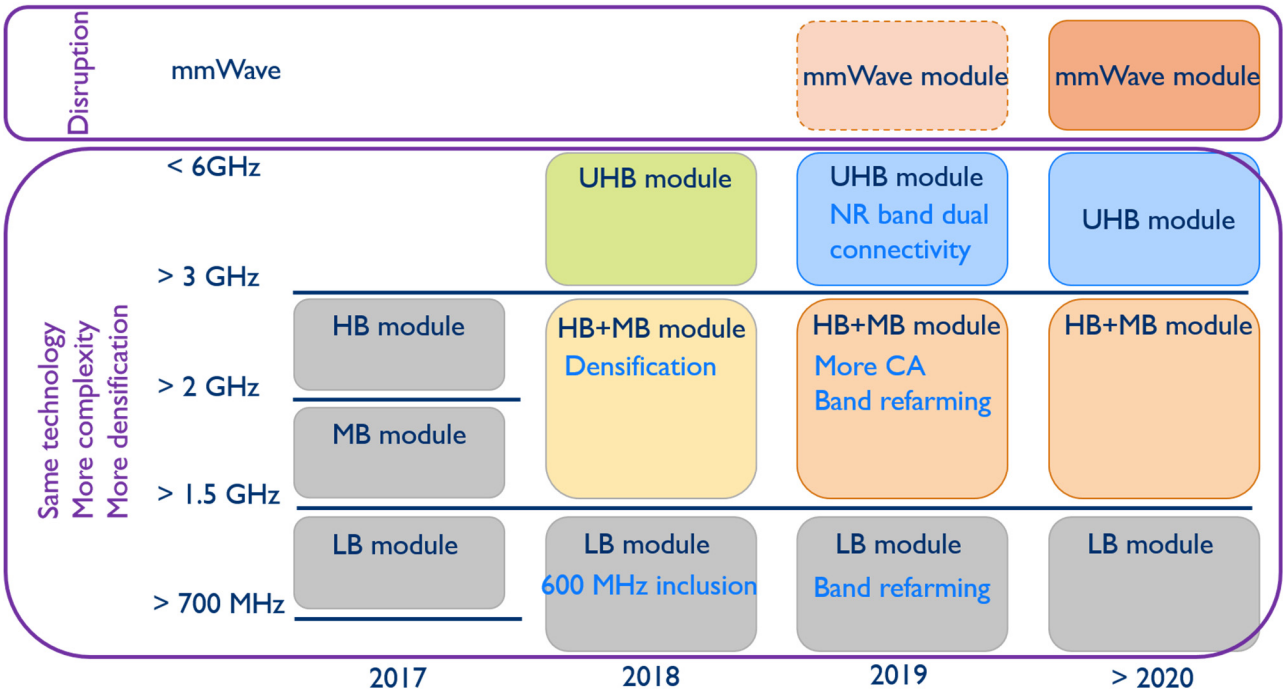

Fig. 1. RF Front-end evolution in mobile handset with the upcoming 5G network.

5G will add even more complexity, with new radio bands released in ultra-high frequencies (N77, N78, N79). Band re-farming (early bands are N41, N71, N28, N66, with more to come) with dual connectivity will also contribute to increasing constraint for the front-end as shown in Figure 1. More densification in front-end modules will be required to enable new band integration. Another new 5G requirement will be 4x4 MIMO implementation, which will turn from a "nice to have" luxury on LTE high-end mobile phones to a "must-have" for every 5G handset. This will add a significant amount of RF streams in the handset, and combined with carrier aggregation requirements will lead to more complex specifications for antenna tuners and multiplexers.

Last but not least is the implementation of the mm-wave module into the handset - a topic that poses many challenges, ranging from antenna array integration (taking into account radiating efficiency and handblockage effects) to power amplifier efficiency, since antenna gain cannot be too high given the low number of antenna array elements allowable in the handset format. While still at the R&D level, great progress has been made on these mm-wave front-end silicon-based platforms, demonstrating record power efficiency and noise level improvement. Bulk CMOS is preferred by Qualcomm, with TSMC's 28nm platform. Other possible platforms include SiGe and RFSOI, for example with GLOBALFOUNDRIES' capability.

Conclusions

It is clear that the with this new mm-wave connectivity for cell phones, we are entering an exciting new era of technology competition and breakthrough performance. This will seriously impact RF front-end's bill of materials.

References

[1] Yole Report: 5G impact on RF Front-End Modules & Connectivity for Cellphones 2018

Acronyms

BAW: Bulk acoustic wave
CAGR: Compound annual growth rate
FBAR: film bulk acoustic resonator
HBT: Heterojunction Bipolar Transistor
OEM: Original equipment manufacturer
LTE: Long term evolution
MIMO: Multiple input multiple output
PA: Power amplifier
SOI: Semiconductor on insulator