

RF front-end module industry¹

What are the technical choices made by Apple?

OUTLINE:

- Market forecasts:
The RF² front-end and connectivity markets poised for double-digit growth is expected to reach US\$25.4 billion market by 2025.
Yole Développement (Yole) expects a 11% CAGR³ between 2019 and 2025.
The PA⁴ module market will grow from US\$5.4 billion in 2019 to US\$8.9 billion by 2025.
The FEM⁵ module market will grow from US\$2.6 billion in 2019 to US\$4.6 billion by 2025.
- Technology trends:
5G poses challenges to the RF front-end industry with the development of wideband Pas and filters.
To support 5G implementation, RF front-end companies decide large investments, especially in design and material engineering.
- Competitive landscape:
Apple lost market share, while all 4 major OEMs from China have significantly progressed. The five major companies, Murata, Skyworks, Broadcom, Qorvo and Qualcomm share almost 80% of the overall business.
A variety of other companies from China, South Korea, Japan and Europe complete the RF front-end competitive landscape.

*“In the iPhone series from 2016 to 2020, Apple’s strategy was to reduce the RF area size with a decrease of the board level at first until 2017.” asserts **Stéphane Elisabeth, PhD, Cost Analyst in RF and Advanced Packaging at [System Plus Consulting](#)**. “But since, the board is increasing along with a stabilization of the RF share mainly even with 5G integration. Between 2017 and 2020, Intel was the only modem and transceiver (RxTx) supplier for Apple.*

¹ Extracted from:

RF Front-End Module Comparison 2021 – Vol. I – Focus on Apple, System Plus Consulting
5G’s Impact on RF Front-End and Connectivity for Cellphones 2020, Yole Développement
[SAW Filter Comparison 2020](#), System Plus Consulting

² RF: Radio Frequency

³ CAGR: Compound Annual Growth Rate

⁴ PA: Power Amplifier

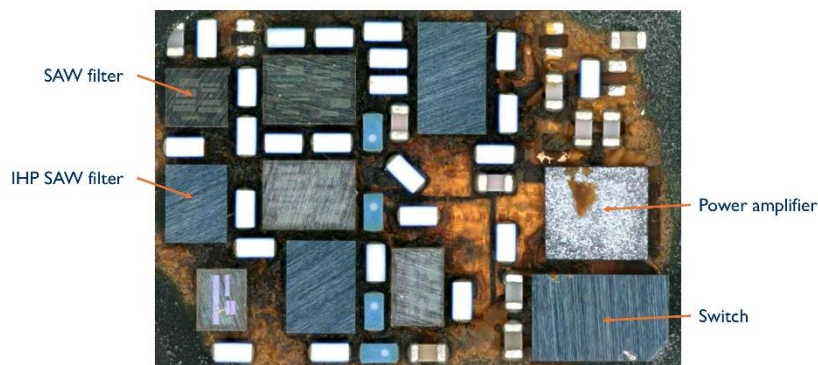
⁵ FEM: Front-End Module

Qualcomm who lost the market in 2017, is getting in the iPhone design in 2020 and is likely to be kept in 2021 because of the 5G. In 2022, in-house modem and RxTx could be expected from Apple.” In the iPhone 12 series just released in 2020, several innovations in communication have been implemented. The technical choices made by Apple have been deeply analyzed by the reverse engineering and costing company, System Plus Consulting in its latest comparison report: [RF Front-End Module Comparison 2021 – Vol. 1 – Focus on Apple](#).

These innovations include the NFC⁶ with an additional controller and NFC antenna at the rear of the phone for accessories identification, the GPS⁷ with the integration of the new band L5 (1175 MHz) with improved signal structure, higher transmitted power and wider bandwidth, and the 5G communication with the integration of several band compatibility like n260 and n261 in the mmWave frequency band.

RF front-end module - Apple iPhone Pro 12 max component opening

(Source: RF Front-End Module Comparison 2021 – Vol. 1 – Focus on Apple, System Plus Consulting)



System Plus Consulting and its partner, [Yole Développement \(Yole\)](#), both part of Yole Group of Companies, investigate disruptive RF technologies and related markets in depth. All year long, both companies point out emerging technologies and underline business opportunities.

Released today, the [RF Front-End Module Comparison 2021 – Vol. 1 – Focus on Apple](#) report provides insights into technology and cost data for RF front-end modules and a selection of components found in 18 smartphones from the Apple iPhone series since 2016. This includes a detailed technical and cost analysis of the main RF modules and components and a comprehensive overview of the related architectures available on the market.

“Apple’s dependency on specific component manufacturers is clearly underlined in this report, along with the different choices for integration of communication technology, even millimeter wavelength

⁶ NFC: Near Field Communication

⁷ GPS: Global Positioning Service

(mmWave) signal support in the latest generation. Our study also reveals how Apple maintains its leadership on the premium market”. comments **Stéphane Elisabeth from System Plus Consulting.**

In parallel, the market research and strategy consulting company Yole has released the 5G’s Impact on RF Front-End and Connectivity for Cellphones 2020 report, end of 2020. The 2020 edition gives detailed analysis of each RF technology’s strengths and weaknesses and delivers a detailed ecosystem snapshot. Including market trends and forecasts, market shares, ecosystem and US/China trade war analysis, Yole’s study also points out COVID-19’s impact on the RF front-end and connectivity business.

What are the technical choices made by the RF front end module manufacturers and OEMs⁸? What are the cost differences between the modules? What are the different manufacturing process steps? How can the smartphone maker’s choices and supplier tendencies be explained?

System Plus Consulting and Yole present today their vision of the latest innovations in the RF front-end module industry.

RF front-end module - Apple iPhone Pro 12 max filter opening

(Source: RF Front-End Module Comparison 2021 – Vol. 1 – Focus on Apple, System Plus Consulting)



© 2021 | www.systemplus.fr - www.reverse-costing.com

As analyzed by System Plus Consulting’s team in the new RF Front-End Module Comparison 2021 – Vol. 1 – Focus on Apple report, 5G Sub-6 and mmWave integration in the 12th generation of iPhone lead to an increase of the module area. Compare to other players like OnePlus, the RF area is almost 40 % larger. Among the player who benefit from the 5G, System Plus Consulting lists Broadcom, Murata, Qorvo and Qualcomm.

On the packaging side, disruptive solution like DSBGA⁹ became to be the standard packaging for FEM. But in 2020, module supplier goes further with DSMBGA¹⁰ following Murata’s path.

⁸ OEM: Original Equipment Manufacturers

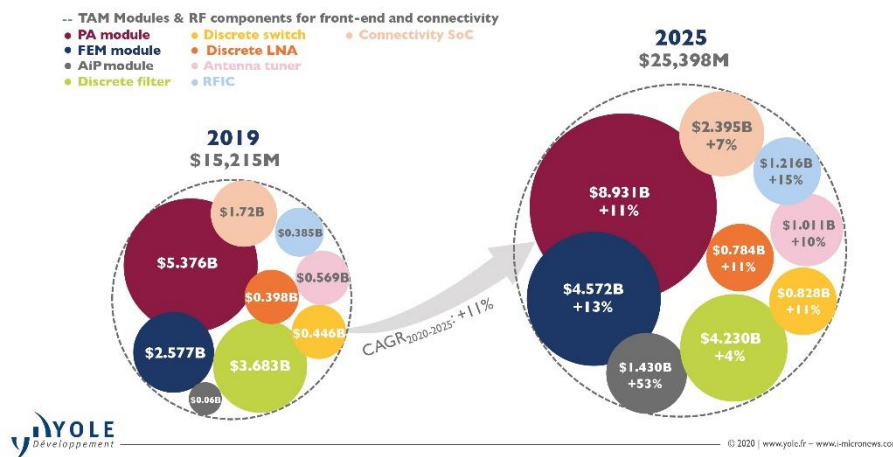
⁹ DSBGA: Dual Side Ball Grid Array

¹⁰ DSMBGA: Dual Side Molding BGA

Since 2016, Murata remains the main supplier followed by Qorvo, Skyworks, and Broadcom. More than 90 % of the components are integrated devices. Apple rely on highly integrated US supplier like Qorvo, Broadcom or Skyworks but each for a unique position in the design. Moreover, using Qorvo’s Antenna tuners, Apple is able to offers a smartphone with a low number of Antenna.

2020-2025 RF front-end and connectivity market forecast - Per type of component

(Source: 5G’s Impact on RF Front-End and Connectivity for Cellphones 2020 report, Yole Développement, 2020)



As part of the RF front end module industry, the SAW¹¹ filters are playing a key role. This has been examined in the [SAW Filter Comparison 2020 report](#) from System Plus Consulting. IHP¹² SAW filter appears in 2018 with the iPhone Xs Max. Since it’s only used in Murata’s components in small production.

But, with the last generation i.e iPhone 12 Series, the BAW¹³ filter had a huge increase in the dedicated area (x6). Indeed, with the rise of 5G and WiFi6 almost all market leaders are looking for BAW solutions.

Stéphane Elisabeth from System Plus Consulting and **Cédric Malaquin, Technology & Market Analyst, RF devices & technologies at Yole** had the opportunity to deliver their expertise in a dedicated article for [Microwave Journal](#) on [i-Micronews](#).

Also, IPD¹⁴ device has double its area. This is mainly due to the 5G and UWB¹⁵ implementation. Indeed, 5G is commercially available in many countries around the world. IPD solution seems to be preferred to discrete filter in the new design.

According to **Cédric Malaquin** in the [5G’s Impact on RF Front-End and Connectivity for Cellphones 2020](#) report: “Decades of experience in the design and manufacturing of all major RF components explain the leading positions of Murata, Skyworks, Broadcom, Qorvo and Qualcomm. All major mobile device manufacturers rely on the expertise of one or more of these five as a first choice,

¹¹ SAW: Surface Acoustic Wave
¹² IHP: Incredible High Performance
¹³ BAW: Bulk Acoustic Wave
¹⁴ IPD: Integrated Passive Device
¹⁵ UWB: Ultra-Wideband

as these companies provide state-of-the-art RF components. However, a variety of other companies from China, South Korea, Japan and Europe complete the RF front-end offering”.

All year long, Yole Group of Companies, including System Plus Consulting and Yole Développement publishes numerous reports and monitors. In addition, experts realize various key presentations and organize key conferences.

Throughout the year, discover the numerous RF front-end-related reports. Make sure to be aware of the latest news coming from the industry and get an overview of our activities, including interviews with leading companies and more on i-Micronews. Stay tuned!

Press contacts

Sandrine Leroy, Director, Public Relations, leroy@yole.fr

Marion Barrier, Assistant, Public Relations, marion.barrier@yole.fr

Le Quartz, 75 Cours Emile Zola – 69100 Villeurbanne – Lyon – France – +33472830189

www.yole.fr - www.i-micronews.com – [LinkedIn](#) – [Twitter](#)

About our analysts

Stéphane Elisabeth, PhD is Senior Technology and Cost Analyst at System Plus Consulting, part of Yole Développement (Yole). Stéphane regularly works on numerous reverse engineering and costing reports while also managing custom projects in the RF electronics and advanced packaging fields. His mission at System Plus Consulting is to provide an in-depth understanding of the technologies selected by the leading semiconductor companies as well as the ecosystem around a device. In this context, Stéphane is leading a strategic watch to identify the latest innovative devices and collaborates closely with System Plus Consulting's laboratory to analyze devices or components. His aim is to reveal the link between functionality and the technical choice made by the device maker. Based on the identification of each process step and process flow, our analysts can then provide an accurate evaluation of the manufacturing cost. His significant industrial and technical knowledge allows him also to update internal simulation tools developed by System Plus Consulting's experts. In addition, Stéphane supports the development of RF electronics activities through key customer projects, including presentation of their results. Prior to this collaboration with System Plus Consulting, Stéphane worked on projects in partnership with THALES for the development of innovative hybrid RF circuits. He also regularly publishes articles and interviews within key RF electronics and packaging magazines. Stéphane holds an engineering degree in electronics and numerical technology (Université de Nantes, France) as well as a PhD. in Materials for Microelectronics (Université de Nantes, France).

Nicolas Radufe is in charge of physical analysis at System Plus Consulting. He has a deep knowledge in chemical and physical analyses. He previously worked in microelectronics R&D for CEA/LETI in Grenoble and for STMicroelectronics in Crolles.

As a Technology & Market Analyst, specialized in RF devices & technologies within the Power & Wireless division at Yole Développement (Yole), **Cédric Malaquin** is involved in the development of technology & market reports as well as the production of custom consulting projects. Prior his mission at Yole, Cédric first served Soitec as a process integration engineer during 9 years, then as an electrical characterization engineer during 6 years. He deeply contributed to FDSOI and RFSOI products characterization. He has also authored or co-authored three patents and five international publications in the semiconductor field. Cédric graduated from Polytech Lille in France with an engineering degree in microelectronics and material sciences.

Antoine Bonnabel works as a Technology & Market Analyst for the Power & Wireless team of Yole Développement (Yole). He carries out technical, marketing and strategic analyses focused on RF devices, related technologies and markets. Prior to Yole, Antoine was R&D Program Manager for DelfMEMS (FR), a company specializing in RF switches and supervised Intellectual Property and Business Intelligence activities of this company. In addition, he also has co-authored several market reports and is co-inventor of three patents in RF MEMS design. Antoine holds a M.Sc. in Microelectronics from Grenoble Institute of Technologies (France) and a M.Sc. in Management from Grenoble Graduate School of Business (France).

About the reports

RF Front-End Module Comparison 2021 – Vol. I – Focus on Apple

Technical and cost overview of the evolution of the radio frequency front-end module technologies integrated in the Apple iPhone series from 2016 - 2020. – Performed by System Plus Consulting

5G's Impact on RF Front-End and Connectivity for Cellphones 2020

An intensifying US-China competition for RF technology supremacy. – Performed by Yole Développement

SAW Filter Comparison 2020

Deep dive analysis and cost review of key SAW filter technologies from Murata, Skyworks, Qorvo, Qualcomm, Wisol, Taiyo Yuden, Kyocera, Tai-SAW, SAWNICS and Shoulder. – Performed by System Plus Consulting

Related reports

- [RF Front-End Module Comparison 2020 – Volume 4](#)

- [Broadcom AFEM-8200 PAMiD in the Apple iPhone 12 Series](#)

About Yole Développement

Founded in 1998, Yole Développement (Yole) has grown to become a group of companies providing marketing, technology and strategy consulting, media and corporate finance services, reverse engineering and reverse costing services and well as IP and patent analysis. With a strong focus on emerging applications using silicon and/or micro manufacturing, the Yole group of companies has expanded to include more than 80 collaborators worldwide... [More](#)

About System Plus Consulting

System Plus Consulting specializes in the cost analysis of electronics, from semiconductor devices to electronic systems. Created more than 20 years ago, System Plus Consulting has developed a complete range of services, costing tools and reports to deliver in-depth production cost studies and estimate the objective selling price of a product... [More](#)

**For more information and images, please visit our website [i-Micronews](#)
###**