RF Front-End Module Comparison 2021 – Vol. 1 – 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.

SPR21588 - RF report by Stéphane ELISABETH
Laboratory analysis by Nicolas RADUFFE

March 2021 – Sample
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SAMPLE

Executive Summary – 2020 Volumes

RF Front-End Module Comparison 2020 – Vol. 1
Study on smartphones on Q3 2019

The report includes the study of at least twenty FEM and several components found in three smartphones: Apple iPhone 11 Pro, Samsung Galaxy Note10+ and OnePlus 7 Pro 5G. Also, it comes along with a database including information on 485 components in 17 smartphones.

RF Front-End Module Comparison 2020 – Vol. 2
Study on Huawei smartphones

The report includes the study of at least eighty FEM and several components found in ten smartphones: Mate and P series from 2015 to 2019. Also, it came along with a database including information on 483 components in 13 smartphones.

RF Front-End Module Comparison 2020 – Vol. 3
Wifi & Connectivity

The report includes the study of several FEMs and components found in 14 smartphones: From Apple to Xiaomi. Also, it came along with a database including information on 281 components in 44 smartphones.

RF Front-End Module Comparison 2020 – Vol. 4
Study on Chinese/Asian OEMs

The report includes the study of at least 50 FEM and several components found in five smartphones: Huawei P40 Pro, OnePlus 8 5G, Oppo Reno3 5G, Vivo X30 Pro, Xiaomi Mi 10 Pro 5G and ZTE Nubia Red magic 5G. Also, it comes along with a database including information on 516 components in 19 smartphones.
Apple Smartphone History and RF Front-End Major Players

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### Q1 2016 – Q4 2020

**Physical Comparison**

Apple used to release a single high and low end series of iPhone per year. This year we have seen the release of two of generations of iPhones at the same time, iPhone 11 and iPhone 12. This could become a trend going forward as Apple and other major players shift towards multiple releases per year and see lines of low end and high end devices.

For the supply chain, the company has added on SKywork and Avago and Qorvo since 2016. For the iPhone 11, Qorvo has a role in the supply chain mainly to manufacture the.

**Related Analyses**

Since the iPhone 11, Murata integrated the wireless units mainly with diversity module along with other components.

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RF Components Summary

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- 5G Sub-6 - Front-End Analysis
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- 5G mmWave - Front-End Analysis
- UWB/Wifi/BT/GPS - Front-End Analysis

Related Analyses
About System Plus

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## Package Views & Dimensions

- **Package Type:** XX LGA
- **Dimensions:** XX mm<sup>2</sup> x XX mm
  (XX x XX x XX mm)
- **Pin Pitch:** XX mm

### Physical Analysis
- Summary
- Baseband - Front-End Analysis
- 4G LTE - Front-End Analysis
- 5G Sub-6 - Front-End Analysis
- Antenna Adaptation - Front-End Analysis
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- UWB/WiFi/BT/GPS - Front-End Analysis

### Related Analyses
- About System Plus

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Component Overview

- The functions of the 6 dies inside the packaging have a following repartition.

- **SAW Filter:** XX
- **LNA:** XX

Package Opened View – Optical View
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Filter – Die Overview – Rx – Schematic

Package Opened View – Optical View

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RF Components Summary

**UWB FEM**
- XX Die/mm²
- LGA Packaging
- XX
- $XX/mm²
- $XX/Die

**Wifi FEM**
- XX Die/mm²
- LGA Packaging
- XX
- $XX/mm²
- $XX/Die

Related Analyses
- UWB #1
  - Antenna U3
- UWB #2
  - Antenna L3
- UWB #3
  - Antenna L1
- AP
  - Rx
  - Antenna L2
  - Rx
  - Antenna U2
- 5G
  - Rx
  - Antenna L1

Related Analyses
- AP
- RX
- Antenna L2
- Antenna U2
- 5G
- Antenna L1
- Antenna L3

Module in RF: Front-End and Connectivity

<table>
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<th>Module in RF Area proportion</th>
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Proportion of Module over RF Area

OnePlus 8 5G (Sub-6/mmWave)

Module area in RFFE (mm²)

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Components Summary – Module

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Package Type Evolution

Evolution of Module Packaging

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### Overview / Introduction

#### Company Profile & Supply Chain

- **Physical Analysis Summary**
  - Area Distribution per Supplier & Function
  - Qualcomm Content – 4G LTE vs. 5G NR
  - 5G Sub-6 vs. mmWave
  - Die Design Win in Number & Area
  - Die Distribution per Function
  - Filter Distribution
  - PA/LNA/Switch Distribution
  - Material Substrate Distribution

#### Physical Comparison

- **Area Distribution per Supplier & Function**
- **Qualcomm Content** – 4G LTE vs. 5G NR
- **5G Sub-6 vs. mmWave**
- **Die Design Win in Number & Area**
- **Die Distribution per Function**
- **Filter Distribution**
- **PA/LNA/Switch Distribution**
- **Material Substrate Distribution**

### Cost Comparison

#### Market Analysis

- **Physical Analysis**

#### Related Analyses

- **About System Plus**

### Table: Model, Manufacturer, Quantity, Component, Function, Band, Simplified Function

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### Graphs: 5G Component Area and 5G Component Cost

#### Sub-6 GHz (FR1) and mmWave (FR2) Phones

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Filter Distribution

Filter Distribution per technology

Filter substrate Area

Filter die type distribution

18 Smartphones; From 2016 to 2020; 521 Components; 1,925 Dies

Filter die substrate distribution

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### Physical Analysis Summary
- **Area Distribution per Supplier & Function**
- **Qualcomm Content – 4G LTE vs. 5G NR**
- **5G Sub-6 vs. mmWave**
- **Die Design Win in Number & Area**
- **Die Distribution per Function**
- **Filter Distribution**
- **PA/LNA/Switch Distribution**
- **Material Substrate Distribution**

### Physical Comparison

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### Cost Comparison

- **Market Analysis**
- **Physical Analysis**
- **Related Analyses**
- **About System Plus**

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**Overview / Introduction**

**Company Profile & Supply Chain**

**Physical Analysis Summary**

**Physical Comparison**

- Area Distribution per Supplier & Function
- Qualcomm Content – 4G LTE vs. 5G NR
- 5G Sub-6 vs. mmWave
- Die Design Win in Number & Area
- Die Distribution per Function
- Filter Distribution
- PA/LNA/Switch Distribution
- Material Substrate Distribution

**Material Distribution per Smartphone**

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**Material Distribution per Smartphone without RxTx**

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**Average:**
- Total Die Substrate Area (mm²): XX mm²
**Overview / Introduction**

- **Company Profile & Supply Chain**
- **Physical Analysis Summary**
- **Physical Comparison**
- **Cost Comparison**
  - Chipset Cost per Supplier
  - Qualcomm Content – 4G LTE vs. 5G NR
  - Cost Distribution per Supplier & Function
- **Market Analysis**
- **Physical Analysis**
- **Related Analyses**
- **About System Plus**

**Chipset Cost per Supplier**

- **RF Module Cost per Smartphone**

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<th>iPhone X (CDMA)</th>
<th>iPhone XS Max</th>
<th>iPhone XR</th>
<th>iPhone 11</th>
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Qualcomm Content – 4G LTE (CDMA) vs. 5G NR FR1 & FR2

Cost Distribution per supplier

- Breakdown of component costs by supplier for different iPhone models.

Qualcomm's Design wins since 2016

- Evolution of Qualcomm's design wins across various iPhone models since 2016.

Chipset Cost of smartphones featuring Qualcomm’s Components

- Comparison of chipset costs for different iPhone models featuring Qualcomm components.

Qualcomm RF Components

- Breakdown of RF components used in different iPhone models by supplier.

BROADCOM
MURATA
NXP
QORVO
QUALCOMM
SKYWORKS
SONY
USI

Number of Components per Smartphones

- Comparison of number of components per smartphon model.
RELATED ANALYSES
Related Analyses

RELATED REPORTS

By System Plus Consulting:
- Broadcom AFEM-8200 PAMiD in the Apple iPhone 12 Series
- Apple iPhone 12 series mmWave 5G Chipset and Antenna
- RF Front-End Module Comparison 2020 – Volume 3

By Yole Développement:
- 5G’s Impact on RF Front-End and Connectivity for Cellphones 2020
- System-in-Package Technology and Market Trends 2020

RELATED TEARDOWN TRACKS

By System Plus Consulting:
- Consumer Track – Phone

SAMPLE
Our Core Activity: The Reverse Costing®

A Structure, Process and Cost Analysis

Reverse Costing® consists in disassembling a device or a system, in order to identify its technology and determine its manufacturing processes and cost, using in-house models and tools.
Fields Of Expertise

Electronic System
- Automotive
  - ADAS
  - Infotainment
  - Telematics
  - Electrification
  - Safety
- Consumer
  - Smartphone
  - Smart Home
  - Wearable
- Telecom
  - Router/Set-Top Box
  - Base Station
- Industrial
- Medical

Semiconductor Device
- Advanced Packaging
  - WLP (Fan in, Fan out)
  - SIP
  - Embedded
  - 3D Packaging
- Imaging
  - Infrared
  - Visible
- Integrated Circuit
  - ASIC
  - SOC
  - MPU/GPU/MCU/DSP
  - MEMS & Sensors
    - Inertial Sensor
    - Environmental Sensor
    - Fingerprint Sensor
    - Oscillator
    - Microphone
    - Inkjet
    - RF MEMS
    - Light / Optics
- Memory
  - NAND
  - DRAM
  - Emerging
- Power Electronics
  - Discrete
  - Module
  - Compound (GaN, SiC)
  - Power RF
- RF
  - Radar
  - Filter
  - Module (FEM, WiFi, BT)
  - Power Amplifier
- Solid State Lighting
  - LED
  - Laser / VCSEL
  - Photonics
Business Model

- **Monitor**
  - 1 per year quarterly updated

- **Teardown Track**
  - 205+ teardowns per year

- **Custom Analysis**
  - 150 custom analyses per year

- **Costing Tools**
  - 5 process-based and 3 parametric costing tools

- **Report**
  - 60+ per year

- **Cost Methods Training**
  - On demand

**Related Analyses**

- **Physical Analysis Summary**
- **Company Profile & Supply Chain**
- **Physical Comparison**
- **Market Analysis**
- **Physical Analysis**

**About System Plus**

- **Company Services**
  - Reports
  - Costing Tools
  - Monitor

- **Contacts**

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Worldwide presence

100+ collaborators in 8 different countries

Headquarters
- Nantes – System Plus Consulting
- Lyon – Yole Développement
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