RF Front-End Module Comparison 2020 – Vol.1

Apple iPhone 11 Pro, Samsung Galaxy Note 10 Plus, OnePlus 7 Pro

SP20504 - RF report by Stéphane ELISABETH
Lab. Analysis by Nicolas RADUFE & Guillaume CHEVALIER

January 2020 – Sample
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Executive Summary

This first volume has been conducted to provide insight on technology data for RF FEM and Components in Smartphones. 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.

With teardowns of a large variety of smartphones, the main RF Modules and components have been extracted and physically analyzed, from the output of the transceiver to the antenna. Packaging, sizes and technologies have been studied to provide a large panel of OEM technical and economical choices and an overview of the market.

The report includes a description of each component and statistical analyses for most of front-end modules. It also tries to explain the OEMs choices and the supplier tendencies. Finally, cost estimation of the module and filter impact are given.

Note:

Antenna tuner has been integrated in this report.
Discrete filters and duplexer has been integrated in this report.
Wifi and Bluetooth Module analyses are not included in this report.
An Excel Database came along with this report to allow further comparison.
Samsung Smartphone History & RF Major Players

Samsung utilizes a fully integrated IDM model. They perform design, manufacturing, assembly and wafer testing.

2017  2018  2019  2019

Galaxy S8  Galaxy S9  Galaxy S10  Galaxy Note 10

Avago Technologies  muRata  Qorvo  Avago Technologies  Skyworks  Avago Technologies  Qorvo  Qualcomm

EU Version

USA Version

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For the Galaxy Note 10 Plus, the main board takes only XX% of the space available on the front frame.
Footprint PCB Area: 
\~ X,XXX mm^2

Total PCB Area: 
\~ X,XXX mm^2

The main board is made with two pieces of PCB in stacked configuration.

By using this technology, Samsung managed to implement a X,XXX mm² board in a footprint XX% smaller.
Software Consulting

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- Samsung
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**RF Board area:**

---

![RF Board Area](image)

---

### RF Components (Marking)

<table>
<thead>
<tr>
<th>RF Components (Marking)</th>
<th>Manufacturer</th>
<th>Type</th>
<th>Band</th>
<th>Area (mm²)</th>
<th>Quantity</th>
<th>RF Board Proportion</th>
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<tbody>
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<td>AFEM-9100</td>
<td>Broadcom</td>
<td>HB/MB PAMiD</td>
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<td>XX</td>
<td>X</td>
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<tr>
<td>SKY77365</td>
<td>Skyworks</td>
<td>PAM</td>
<td></td>
<td>XX</td>
<td>X</td>
<td>XX</td>
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<tr>
<td>TWFA</td>
<td>Murata</td>
<td>LB PAMiD</td>
<td>X;X;X;X</td>
<td>XX</td>
<td>X</td>
<td>XX</td>
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<tr>
<td>361</td>
<td>Murata</td>
<td>LB Diversity</td>
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<td>XX</td>
<td>X</td>
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<tr>
<td>409</td>
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<td>MB/HB Diversity</td>
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<td>Switch</td>
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**Total** XX %
# Components Summary – Filter Technology

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<th>Smartphone OEMs</th>
<th>Filter Technology Type #1 (Number)</th>
<th>Filter Total Cost</th>
<th>Filter Technology #3 (Number)</th>
<th>Filter Total Cost</th>
<th>Ratio Filter/Component Cost (%)</th>
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<td>Apple</td>
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<td>OnePlus</td>
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</tbody>
</table>
Band Repartition per Phones

LTE Band Distribution

- iPhone 11 Pro
- Note 10 Plus
- 7 Pro 5G

Average

- XX
Components Summary

- List of devices
  - Main Suppliers & Functions
  - OEMs Main Suppliers

Component Distribution per Supplier

- Qorvo
- Skyworks
- Broadcom
- Murata
- QCOM
- IFX
- HiSilicon
- Sony
- On Semi
- STM
- Toshiba
- NXP
- WISOL
- Unidentified

Component Distribution per Function

- LB PAMiD: 6%
- HB/MB PAMiD: 6%
- UHB PAMiD: 6%
- Multiplexer: 8%
- Switch: 6%
- FEM: 2%
- PAM: 6%
- ET: 4%
- RFIC: 4%
- LNA: 4%
- Filter: 15%
- Diversity Switch: 13%
- Antenna Tuner: 25%
- Switch/LNA: 2%
- Filter: 15%
- Diversity Switch: 13%
- Antenna Tuner: 25%
- Switch/LNA: 2%
Smartphone Comparison – Devices in Module Distribution – 2019 vs. 2020

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  Apple, Samsung

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2019 Integrated devices Area distribution per Smartphone

2020 Integrated devices Area distribution per Smartphone

Average Area (mm²)

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<th>2020</th>
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<tr>
<td>IPD</td>
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</table>
Smartphone Comparison – Material Distribution

Material Distribution per smartphone (mm²)

- Silicon
- SOI
- GaAs
- LT/LN
- Glass
- Total

IPhone 11 Pro
Note 10+
7 Pro 5G

<table>
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<th>Min (mm²)</th>
<th>Average Area (mm²)</th>
<th>Max (mm²)</th>
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<tr>
<td>Glass</td>
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RF Board Area: XXX mm²

• XX% of increase in the RF Front-End Area compared to iPhone Xs.

iPhone 11
## RFFE report 2019 vs. 2020 – Apple iPhone Series

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<th>Type</th>
<th>Band</th>
<th>Area (mm²)</th>
<th>Quantity</th>
<th>RF Board Proportion</th>
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<tr>
<td>Broadcom</td>
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</table>

**Area Distribution by Supplier**

**Area Distribution by Function**

**2019 vs. 2020 Area Distribution in Modules**

**2019 vs. 2020 Distribution in Modules**

**2019 vs. 2020 Filters in Modules**

**Material Distribution**

**2019 vs. 2020 Silicon Consumption**

**Supported band & Filter Distribution**

**Apple, Samsung**
Smartphone Comparison – Cost Distribution per function

Cost Distribution per function

- 7 Pro 5G
- Galaxy Note 10+
- iPhone 11 Pro

RF Board Cost ($)
RF Components Summary

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Model</th>
<th>Type</th>
<th>Smartphone</th>
<th>OEMs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broadcom</td>
<td>HB/MB PAMiD</td>
<td>Apple</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Triplexer</td>
<td>Apple</td>
<td></td>
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</tr>
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<td>Triplexer</td>
<td>Apple</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>HB/MB PAMiD</td>
<td>OnePlus</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>HB/MB PAMiD</td>
<td>Samsung</td>
<td></td>
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</tr>
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</table>

Broadcom Analysis
- Skyworks Analysis
- Murata Analysis
- Qorvo Analysis
- Qualcomm Analysis
- Infineon Analysis
- NXP Analysis

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SKY78223 – Package Opening

SKY78223 – Package Opening View – Optical View
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- Flip-Chip Die
- PCB Substrate
- Bare Die
- Wire bonding
- SMD components

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Cost Comparison
Market Analysis

Physical Analysis
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- Skyworks Analysis
- Murata Analysis
- Qorvo Analysis
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Package Opening – Optical View

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SKY78223 – Package Cross-Section

Package Cross-Section Plan – Optical View
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## SKY78223 – Package Summary

<table>
<thead>
<tr>
<th>Package Area (mm²)</th>
<th>Number of Dies</th>
<th>Flip-Chip/Wire Bonded (%)</th>
<th>Number of SMD</th>
<th>SMD Components/Package (%)</th>
<th>Internal Blank Space (%)</th>
<th>Filter/Package (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>XX x XX (XX)</td>
<td>XX</td>
<td>XX</td>
<td>XX</td>
<td>X</td>
<td>XX</td>
<td>X %</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Package Area (mm²)</th>
<th>Substrate Type</th>
<th>Number of layer</th>
<th>Package Thickness (µm)</th>
<th>PCB/Package Thickness (%)</th>
<th>Copper Line Thickness (Mid Value µm)</th>
<th>Line/Space (µm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>XX x XX (XX)</td>
<td>PCB</td>
<td>XX</td>
<td>XX</td>
<td>XX</td>
<td>XX</td>
<td>XX/XX</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Package Area (mm²)</th>
<th>Dielectric Layers Thickness (Mid Value µm)</th>
<th>Micro-Via Dimensions (Diameter x Depth µm)</th>
<th>Shielding Composition</th>
<th>Shielding Thickness (µm)</th>
<th>Solder Mask Layer Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>XX x XX (XX)</td>
<td>XX</td>
<td>XX x XX</td>
<td>XX/Cu</td>
<td>XX</td>
<td>XX</td>
</tr>
</tbody>
</table>
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**REVERSE COSTING ANALYSES - SYSTEM PLUS CONSULTING**

**RF & PACKAGING**
- Qualcomm’s First 5G mmWave Chipset: SDX50M and QTM052
- Qorvo QM76018 RFFEM in the Apple iPhone Xr
- Murata Incredible High Performance (IHP) SAW Filter
- Broadcom AFEM-8092 System-in-Package in the Apple iPhone Xs/Xr Series

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**ADVANCED PACKAGING**
- 5G’s Impact on RF Front-End Module and Connectivity for Cell phones 2019
- Advanced RF System-in-Package for Cellphones 2019

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Business Models Fields of Expertise

- Custom Analyses
  (>130 analyses per year)
- Reports
  (>60 reports per year)
- Costing Tools
- Trainings

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