# Table of Contents

## Overview / Introduction
- Executive Summary
- Reverse Costing Methodology
- Qorvo, Broadcom Limited, Skyworks Solution, STMicroelectronics, Murata Integrated Passive Solutions (Former IPDiA)
- Smartphones Teardown: Xiaomi Mi6, Samsung Galaxy S7, Samsung Galaxy S8, Apple iPhone X
- STMicroelectronics Technology
- IPDiA Technology
- IPD applications

## Company Profile
- Qorvo
- Broadcom Limited
- Skyworks Solution
- STMicroelectronics
- Murata Integrated Passive Solutions (Former IPDiA)
- Smartphones Teardown: Xiaomi Mi6, Samsung Galaxy S7, Samsung Galaxy S8, Apple iPhone X
- STMicroelectronics technology
- IPDiA Technology
- IPD applications

## Market Analysis
- RF Substrate
- Substrate by Application
- Glass Substrate Market for RF devices

## Physical Comparison
- Materials Comparison
- Passives density per applications
- Process Comparison
- Cost Comparison

## Physical Analysis
- Synthesis of the Physical Analysis
- RF IPD for Wi-Fi/Bluetooth Application
  - Qorvo’s IPD
  - Die Views & Dimensions
  - Die Top Structure
  - Die Electrical Structure
  - Die Cross-Section
  - Package Opening
  - Die Process
  - Skyworks’ IPD
  - STMicroelectronics’ IPD
  - RF IPD for LTE/HSPA/EDGE/GSM
  - Broadcom’s IPD
  - Murata’s IPD
  - Skyworks’ IPD

## Manufacturing Process Flow
- Global Overview
- RF IPD for Wifi/Bluetooth Application
  - Wafer Fabrication Unit
  - Front-End Process Flow
  - RF IPD for LTE/HSPA/EDGE/GSM
  - RF IPD for ISM/SDR

## Cost Analysis
- Yields Explanation & Hypotheses
- RF IPD for Wifi/Bluetooth Application
  - Qorvo’s IPD Die
  - Main Steps of Economical Analysis
  - Wafer Front-End Cost
  - Wafer Front-End Cost per process steps
  - Back-End O Cost: Bumping & Dicing
  - Back-End Final Test
  - Component Cost
  - Skyworks’ IPD
  - STMicroelectronics’ IPD
  - RF IPD for LTE/HSPA/EDGE/GSM
  - Broadcom’s IPD
  - Murata’s IPD
  - Skyworks’ IPD
  - RF IPD for ISM/SDR
  - STMicroelectronics’ IPD
  - IPDiA’s IPD
  - Skyworks’ IPD

## Estimated Price Analysis
- RF IPD for ISM/SDR
- STMicroelectronics’ IPD
- IPDiA’s IPD
- Skyworks’ IPD

## Company services

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Executive Summary

- This comparative technologies & cost study has been conducted to provide insight on technology & costing data for RF Integrated Passive Devices (IPD) working on different ranges of communication frequency. The report includes the study of seven IPDs found in flagships smartphones (Apple iPhone X, Samsung Galaxy S7 & S8, LeTv Le Max 2 Pro) or on the market. This report provides a deep analysis of RF IPD containing inductance, resistor, and capacitance. Its complete System Plus reports portfolio along with decoupling capacitors IPD.

- This comparative technology study was conducted to provide insight regarding technology and cost estimates for RF IPDs in various applications. This report studies nine devices in three applications (Wifi/Bluetooth/cellular communication (LTE/HSPA/GPRS/EDGE), industrial, and scientific/medical short-range devices (ISM/SRD), where five players (Qorvo, Skyworks, Murata, Broadcom, and STMicroelectronics) are active. Besides the ISM/SRD applications, the other devices are extracted from recent smartphones like the new Apple iPhone X.

- All devices are analyzed in detail, and electrical structures of each component are presented. Sizes and technologies are extracted to provide a large sampling of various IDMs’ technical and economical choices. We also provide an overview of passive integration techniques for inductors, resistors, and capacitors.

- This report includes a description of each component, its major characteristics (substrate type: GaAs, silicon, glass), passivation layers, passive integration, etc.) and a comparison of all devices analyzed. Also included is a manufacturing cost estimate for the IPDs.
Smartphones Teardown – Apple iPhone X

Company Profile & Supply Chain
- Qorvo
- Broadcom
- Skyworks
- STMicroelectronics
- Murata Passive Integrated Solution
- Technologies

Physical Analysis

Manufacturing Process Flow

Cost Analysis

Selling Price Analysis

About System Plus
Package Opening

- Package opening reveal

Balun with wire bonding

Package Opening – Top View
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Integrated Passives Devices Applications

Overview / Introduction

Company Profile & Supply Chain
- Qorvo
- Broadcom
- Skyworks
- STMicroelectronics
- Murata Passive Integrated Solution
- Technologies

Physical Analysis

Manufacturing Process Flow

Cost Analysis

Selling Price Analysis

About System Plus
Glass Material Market for RF devices

**Overview / Introduction**

**Company Profile & Supply Chain**
- Qorvo
- Broadcom
- Skyworks
- STMicroelectronics
- Murata Passive Integrated Solution
- Technologies

**Physical Analysis**

**Manufacturing Process Flow**

**Cost Analysis**

**Selling Price Analysis**

**About System Plus**
## Materials Comparison

<table>
<thead>
<tr>
<th></th>
<th>Substrate</th>
<th>Lines</th>
<th>MIM Capacitor</th>
<th>Resistors</th>
<th>Deep Trench Capacitor</th>
</tr>
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<tbody>
<tr>
<td><strong>WiFi/Bluetooth</strong></td>
<td><img src="image1" alt="Qorvo" /></td>
<td><img src="image2" alt="STMicroelectronics" /></td>
<td><img src="image3" alt="Skyworks" /></td>
<td><img src="image4" alt="Broadcom" /></td>
<td><img src="image5" alt="IPDiA" /></td>
</tr>
<tr>
<td><strong>LTE/HSPA/EDGE/GSM</strong></td>
<td><img src="image6" alt="murata" /></td>
<td><img src="image2" alt="Skyworks" /></td>
<td><img src="image4" alt="Broadcom" /></td>
<td><img src="image2" alt="STMicroelectronics" /></td>
<td><img src="image5" alt="IPDiA" /></td>
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<tr>
<td><strong>ISM/SRD</strong></td>
<td><img src="image2" alt="STMicroelectronics" /></td>
<td><img src="image5" alt="IPDiA" /></td>
<td><img src="image5" alt="IPDiA" /></td>
<td><img src="image5" alt="IPDiA" /></td>
<td><img src="image5" alt="IPDiA" /></td>
</tr>
</tbody>
</table>

### Physical Analysis
- Synthesis
- Qorvo’s WiFi IPD
- Skyworks’s WiFi IPD
- STMicroelectronics’ Bluetooth IPD
- Broadcom’s LTE IPD
- IPDiA’s IMS IPD

### Manufacturing Process Flow

### Cost Analysis

### Selling Price Analysis

### About System Plus
Synthesis of the Physical analysis

- **Overview / Introduction**
- **Company Profile & Supply Chain**
- **Physical Analysis**
  - Synthesis
    - Qorvo’s WiFi IPD
    - Skyworks’s WiFi IPD
    - STMicroelectronics’ Bluetooth IPD
    - Broadcom’s LTE IPD
    - IPDiA’s IMS IPD
- **Manufacturing Process Flow**
- **Cost Analysis**
- **Selling Price Analysis**
- **About System Plus**
STMicroelectronics’ IPD – Package/Die View & Dimensions

- Package:
- Dimensions:
- Pin Pitch:

- Package Marking:
- Die Marking:

Package Top View

Package Bottom View

Package Side View
STMicroelectronics’ IPD – Die Structure – Top view
STMicroelectronics’ Bluetooth IPD – Die Structure – Electrical Structure
STMicroelectronics’ Bluetooth IPD – Die Structure – Top view

- Die overview – Optical View

- Series Capacitance

- [Image of Die Structure]
STMicroelectronics’ Bluetooth IPD – Die Structure – Top view

Die overview – Optical View

Coupled Inductance
STMicroelectronics’ Bluetooth IPD – Die Cross Section

Cross-Section Plan

Die Cross-Section – Optical View
STMicroelectronics’ Bluetooth IPD – Die Cross Section – Capacitance
Qorvo’s IPD – MEMS Process Flow
Qorvo’s IPD – Die Process Flow 1/4
# STMicroelectronics’ IPD – Wafer Front-End Cost

## Overview / Introduction

- **Company Profile & Supply Chain**
- **Physical Analysis**
- **Manufacturing Process Flow**

## Cost Analysis

- Supply Chain
- Yields
- Front-End Cost
- Back-End Cost
- Component Cost

## Selling Price Analysis

## About System Plus

### Table: Front-End Cost Breakdown

<table>
<thead>
<tr>
<th>Yields</th>
<th>Low Yield</th>
<th>Medium Yield</th>
<th>High Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>Substrate Cost</td>
<td>Cost</td>
<td>Breakdown</td>
<td>Cost</td>
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<tr>
<td>Clean Room Cost</td>
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<tr>
<td>Equipment Cost</td>
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<tr>
<td>Consumable Cost</td>
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<tr>
<td>Labor Cost</td>
<td></td>
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<tr>
<td>Yield losses</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Diagram: Front-End Cost Breakdown

- Substrate Cost
- Clean Room Cost
- Equipment Cost
- Consumable Cost
- Labor Cost
- Yield losses Cost
STMicroelectronics’ IPD – Component Cost

**Component Cost Breakdown (Medium Yield)**

- Front-End Cost
- BE: Test Cost
- BE: Packaging Cost
- BE: Yield losses

**Wafer Cost**

- Nb of potential dies per wafer
- Nb of good dies per wafer

**Low Yield**

<table>
<thead>
<tr>
<th>Cost</th>
<th>Breakdown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Front-End Cost</td>
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</tr>
<tr>
<td>Packaging Cost</td>
<td></td>
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<tr>
<td>Final Test Cost</td>
<td></td>
</tr>
</tbody>
</table>

**Medium Yield**

<table>
<thead>
<tr>
<th>Cost</th>
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</thead>
<tbody>
<tr>
<td>Front-End Cost</td>
<td></td>
</tr>
<tr>
<td>Packaging Cost</td>
<td></td>
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<tr>
<td>Final Test Cost</td>
<td></td>
</tr>
</tbody>
</table>

**High Yield**

<table>
<thead>
<tr>
<th>Cost</th>
<th>Breakdown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Front-End Cost</td>
<td></td>
</tr>
<tr>
<td>Packaging Cost</td>
<td></td>
</tr>
<tr>
<td>Final Test Cost</td>
<td></td>
</tr>
</tbody>
</table>

By adding the probe test cost, the **wafer cost** ranges from \[\ldots\].

The number of **good dies per wafer** is estimated to range from \[\ldots\] according to yield variations, which results in a **component cost** ranging from \[\ldots\].

- The **die** represents \[\ldots\]
- The **package assembly** represents \[\ldots\]
- **Final test and yield losses** account for \[\ldots\]
## STMicroelectronics’ IPD – Estimated Manufacturer Price

<table>
<thead>
<tr>
<th></th>
<th>Low Yield</th>
<th></th>
<th>Medium Yield</th>
<th></th>
<th>High Yield</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cost</td>
<td>Breakdown</td>
<td>Cost</td>
<td>Breakdown</td>
<td>Cost</td>
<td>Breakdown</td>
</tr>
<tr>
<td><strong>Component cost</strong></td>
<td></td>
<td>STMicro Gross Profit</td>
<td>Component price</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

We estimate that STMicroelectronics realizes a better gross margin on the IPD balun due to a good market position. We estimate this gross margin to 50%, which results in a final component price ranging

This corresponds to the selling price for large volume to OEMs.
Related Reports

**REVERSE COSTING ANALYSES - SYSTEM PLUS CONSULTING**

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RF
- Glass Substrate Manufacturing in the Semiconductor Field
- Advanced RF System-in-Package for Cell Phones 2017
RF Integrated Passive Devices: Reverse Costing Overview

Technology and cost review of nine RF IPD found on the market from different suppliers: Broadcom, IPDiA, Murata, Qorvo, Skyworks and STMicroelectronics

With integrated passive devices (IPD) accounting for almost 70% of the PCB area in smartphones, integration is a challenge that several integrated device manufacturers (IDM) and outsourced semiconductor assembly & test (OSAT) companies have accepted in the last few years. Players active in the RF applications market include IDM companies like Qorvo, Skyworks, Murata, Broadcom, and STMicroelectronics, as well as OSATs such as STATS ChipPAC, ASE, Amkor, and TSMC.

With 5G communication technology incoming, this is the perfect time to explore several IPD technologies and compare the different companies’ integration choices and cost efficiencies.

This report provides a deep analysis of RF IPD containing inductance, resistor, and capacitance. It completes System Plus Consulting reports portfolio along with decoupling capacitors IPD.

This comparative technology study was conducted to provide insight regarding technology and cost estimates for RF IPDs in various applications. This report studies nine devices in three applications (Wifi / Bluetooth / cellular communication (LTE / HSPA / GPRS / EDGE), industrial, and scientific / medical short-range devices (ISM / SRD), where five players (Qorvo, Skyworks, Murata, Broadcom, and STMicroelectronics) are active. Besides the ISM/SRD applications, the other devices are extracted from recent smartphones like the new Apple iPhone X.

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### Overview / Introduction

Company Profile (Skyworks Solutions, Murata, iPDIA, Qorvo, Broadcom, STMicroelectronics)

Smartphone Teardown (Xiaomi Mi6, Samsung Galaxy S8, Samsung Galaxy S7, Apple iPhone X)

### Market Analysis

#### Physical Analysis
- **RF IPD for Wifi/Bluetooth Applications**
  - Qorvo, STMicroelectronics, and Skyworks IPD
  - Die view and dimensions
  - Die structure: Inductance, capacitance, resistance, electrical schematic
  - Die cross-section: Metal layers, capacitance, resistance, passivation
- **IPD technologies comparison**

#### Manufacturing Process Flow
- RF IPD die fabrication unit
- RF IPD package process flow

#### Cost Analysis
- **Cost analysis overview**
- **Supply chain description**
- **Yield hypotheses**
- RF IPD die cost analysis
  - RF IPD die front-end cost
  - RF IPD die cost by process step
- **Final test cost**
- **Component cost**

### Estimated Price Analysis

**Authors:**

- **Stéphane Elisabeth**
  Stéphane has a deep knowledge of materials characterizations and electronics systems. He holds an Engineering Degree in Electronics and Numerical Technology, and a PhD in Materials for Microelectronics.

- **Véronique Le Troade (Lab)**
  Véronique is in charge of structure analysis of semiconductors. She has deep knowledge of chemical and physical technical analyses. She previously worked for 20 years at Atmel’s Nantes Laboratory.

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<thead>
<tr>
<th>Process-Based Costing Tools</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Integrated Circuits</td>
<td>IC Price+</td>
</tr>
<tr>
<td>MEMS</td>
<td>MEMS Price+</td>
</tr>
<tr>
<td>Power Devices &amp; Modules</td>
<td>Power Price+</td>
</tr>
<tr>
<td>LEDs</td>
<td>LED CoSim+</td>
</tr>
<tr>
<td>Advancad Packaging</td>
<td>3D-Package CoSim+</td>
</tr>
<tr>
<td>Electronic Boards Substrates</td>
<td>SYScost+</td>
</tr>
<tr>
<td>Electronic Systems</td>
<td>PCB Price+</td>
</tr>
<tr>
<td>Displays</td>
<td>Display Price+</td>
</tr>
</tbody>
</table>

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<tr>
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<th>Silicon Capacitor Technology and Cost Review</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical analyses and cost estimation of radio-frequency Systems-in-Packages from Skyworks Solutions, Murata, TDK-Epcos, Qorvo and Broadcom / Avago.</td>
<td>Review of RF front-end modules and components found in five flagship smartphones: Apple iPhone 7 Plus, Samsung Galaxy S7, Huawei P9, LG G5, and Xiaomi Mi5.</td>
<td>Discover the differences between silicon capacitor technologies from TSMC, Skyworks, Murata / IPDiA and Vishay and their related costs.</td>
</tr>
</tbody>
</table>

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