Qualcomm’s First 5G mmWave Chipset: SDX50M and QTM052

A study from modem to antenna of the very first compact-form 5G millimeter-wave chipset for handset applications.

With the integration of the first mmWave chipset in a handset, Qualcomm has started the 5G revolution early. We have seen a first glimpse of how compatible the system could be to very high frequency connectivity. This year, we have seen the introduction of real 5G connectivity, led by Samsung. Starting with the Sub-6GHz application, Samsung launched its flagship at the beginning of this year in South Korea. The second step was to release the mmWave version in America in partnership with Qualcomm, which supplies the complete chipset for this version.

The complete solution has been especially designed for smartphone applications, starting with Samsung but soon to spread to other designs from companies such as Motorola and Xiaomi. The module in the Samsung Galaxy S10 5G USA, comes with four systems spread throughout the smartphone. The first System-in-Package (SiP) is the baseband processor, which uses standard Ball Grid Array (BGA) SiP packaging, coupled with Flip-Chip and Wire Bonding integration. The other systems are the antenna module, which are spread around the corner of the smartphone in order to provide spherical coverage. The modules are placed in the smartphone in order to provide full coverage without any hand-blocking constraints.

Two generations of antenna modules are integrated in the flagship. The first generation comes with a dipole antenna coupled with a patch antenna. The first generation comes with a dipole antenna coupled with a patch antenna. The patch antenna is designed in order to provide a wide-band radiating system. Among the innovations in the antenna design, Qualcomm seems to integrate an Aperture Coupling Patch, Dual Polarized Antenna, and Dual-Band Antenna. In the second generation, the component has been shrunk by almost 30% in order to fit in the smartphone’s z-height.

This report includes a full investigation of the system, featuring a detailed study of the SiPs, including die analyses, processes and board cross-sections. It contains a complete cost analysis and a selling price estimation of the system. Finally, it features a technical comparison with the structure of the Sub-6GHz chipset and the Qualcomm’s WiGig chipset dedicated to handsets.

COMPLETE TEARDOWN WITH

- Detailed photos and cross-sections
- Precise measurements
- Material analysis
- Manufacturing process flow
- Supply chain evaluation
- Manufacturing cost analysis
- Estimated sales price
- Comparison with WiGig chipset for handset application
**TABLE OF CONTENTS**

Introduction

Company Profile and 5G Technology

Samsung Galaxy S10 5G USA Teardown

Market Analysis

Physical Analysis

- Physical analysis - Methodology
- Module analysis
  - Module view: dimensions, marking, integration and block diagram
- Main board analysis
  - Board overview and cross-section
- Baseband processor SiP analysis
  - Package view and dimensions
  - Package opening and bill of material
  - Package cross-section: PCB, dimensions
  - Package process analysis
- Antenna SiP analysis: Gen. 1 and Gen. 2
  - Package view and dimensions
  - Package X-Ray: overall view, PCB routing, antenna structure, cross-sections
  - Package opening and bill of material
  - Package cross-section: PCB, dimensions
  - Package process analysis
- Die analysis: Baseband processor, transceiver, PMIC
  - Die view and dimensions
  - Die delayering and main block IDs
  - Die cross-section and process
- Physical analysis comparison
  - Sub-6 vs. mmWave
  - WiGig System vs. 5G system for handsets

Manufacturing Process Flow

- Die fabrication unit: Baseband processor, transceiver, PMIC
- SiP packaging fabrication unit

Estimated Price Analysis

- Overview of the cost analysis
- Supply chain description
- Yield hypotheses
- Die cost analyses: Baseband processor, transceiver, PMIC
  - Front-end cost
  - Wafer and die costs
- Baseband and antenna SiP package cost analysis
  - Baseband and antenna SiP front-end cost
  - Baseband and antenna SiP ost by process step
- Final test cost
- Final assembly
- Component cost

Estimated Price Analysis

**AUTHORS**

Dr. Stéphane Elisabeth has joined System Plus Consulting’s team in 2016. He has a deep knowledge of Materials charaterizations and Electronics systems. He holds an Engineering Degree in Electronics and Numerical Technology, and a PhD in Materials for Microelectronics.

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 ST Microelectronics in Crolles.

**RELATED REPORTS**

Qualcomm 60GHz WiGig/WiFi 802.11ad Chipset World’s First Smartphone Edition

Early glimpse of very compact form millimeter-wave chipset commercially available for handset applications.

July 2018 - EUR 3,490*

RF Front-End Module Technical Comparison 2019

Extensive overview of 100 RF Front-End modules and components found in eight leading flagship smartphones from Apple, Samsung, Huawei, Xiaomi, and Oppo.

July 2018 - EUR 3,490*

Broadcom AFEM-8092 System-in-Package in the Apple iPhone Xs/Xr Series

Second generation of mid/high band Front-End module with advanced and innovative packaging.

February 2019 - EUR 3,990*
Our analysis is performed with our costing tools 3D Packaging CoSim+ and IC Price+.
System Plus Consulting offers powerful costing tools to evaluate the production cost and selling price from single chip to complex structures.

### 3D Packaging CoSim+
Cost simulation tool to evaluate the cost of any Packaging process: Wafer-level packaging, TSV, 3D integration...

### IC Price+
The tool performs the necessary cost simulation of any Integrated Circuit: ASICs, microcontrollers, memories, DSP, smartpower...

### WHAT IS A REVERSE COSTING®?
Reverse Costing® is the process of disassembling a device (or a system) in order to identify its technology and calculate its manufacturing cost, using in-house models and tools.

### CONTACTS

**Headquarters**
22, bd Benoni Goullin
Nantes Biotech
44200 Nantes
France
+33 2 40 18 09 16
sales@systemplus.fr

**Europe Sales Office**
Lizzie LEVENEZ
Frankfurt am Main
Germany
+49 151 23 54 41 82
llevenez@systemplus.fr

**America Sales Office**
Steven LAFERRIERE
Western USA & Canada
+1 310-600-8267
lafriere@yole.fr

**Asia Sales Office**
Takashi ONOZAWA
Japan & Rest of Asia
+81 80 4371 4887
onozawa@yole.fr

Chris YOUMAN
Eastern USA & Canada
+1 919-607-9839
chris.youman@yole.fr

Mavis WANG
Greater China
+886 979 336 809
wang@yole.fr

Peter OK
Korea
+82 10 4089 0233
peter.ok@yole.fr

System Plus Consulting is specialized in the cost analysis of electronics from semiconductor devices to electronic systems.
A complete range of services and costing tools to provide in-depth production cost studies and to estimate the objective selling price of a product is available.

Our services:
- **STRUCTURE & PROCESS ANALYSES**
- **TEARDOWNS**
- **CUSTOM ANALYSES**
- **COSTING SERVICES**
- **COSTING TOOLS**
- **TRAININGS**

www.systemplus.fr
sales@systemplus.fr
Please process my order for “Qualcomm’s First 5G mmWave Chipset: SDX50M and QTM052” Reverse Costing® – Structure, Process & Cost Report
Ref: SP19482

☐ Full Structure, Process & Cost Report : EUR 3,990*
☐ Annual Subscription offers possible from 3 reports, including this report as the first of the year. Contact us for more information.

SHIP TO
Name (Mr/Ms/Dr/Pr): .............................................................
Job Title: .............................................................................
Company: .............................................................................
Address: .............................................................................
City: ....................................................................................
State: ...................................................................................
Postcode/Zip: ........................................................................
Country: ..............................................................................
VAT ID Number for EU members: ...........................................
Tel: ......................................................................................
Email: ..................................................................................
Date: ....................................................................................
Signature: ............................................................................

BILLING CONTACT
First Name : ...........................................................................
Last Name: ............................................................................
Email: ..................................................................................
Phone: ..................................................................................

PAYMENT
By credit card:
Number: |__|__|__|__|  |__|__|__|__|  |__|__|__|__|
|__|__|__|__|  
Expiration date: |__|__|/|__|__|  
Card Verification Value: |__|__|__|

By bank transfer:
HSBC - CAE- Le Terminal -2 rue du Charron - 44800 St Herblain France
BIC code: CCFRFRPP
• In EUR
  Bank code : 30056 - Branch code : 00955 - Account : 09550003234
  IBAN: FR76 3005 6009 5509 5500 0323 439
• In USD
  Bank code : 30056 - Branch code : 00955 - Account : 09550003247
  IBAN: FR76 3005 6009 5509 5500 0324 797

*For price in dollars please use the day’s exchange rate
*All reports are delivered electronically in pdf format
*For French customer, add 20 % for VAT
*Our prices are subject to change. Please check our new releases and price changes on www.systemplus.fr. The present document is valid 6 months after its publishing date: September 2019

ANNUAL SUBSCRIPTIONS
Each year System Plus Consulting releases a comprehensive collection of new reverse engineering and costing analyses in various domains. You can choose to buy over 12 months a set of 3, 4, 5, 7, 10 or 15 Reverse Costing® reports.
Up to 47% discount!

More than 60 reports released each year on the following topics (considered for 2018):
• Power: GaN - IGBT - MOSFET - Si Diode - SiC
• Imaging: Camera - Spectrometer
• LED and Laser: UV LED – VCSEL - White/blue LED
• Packaging: 3D Packaging - Embeded - SIP - WLP
• Integrated Circuits: IPD – Memories – PMIC – SoC
• RF: FEM - Duplexer
• Systems: Automotive - Consumer - Energy - Telecom
1. INTRODUCTION
The present terms and conditions apply to the offers, sales and deliveries of services managed by System Plus Consulting except in the case of a particular written agreement. Buyer must note that placing an order means an agreement without any restriction with these terms and conditions.

2. PRICES
Prices of the purchased services are those which are in force on the date the order is placed. Prices are in Euros and worked out without taxes. Consequently, the taxes and possible added costs agreed when the order is placed will be charged on these initial prices. System Plus Consulting may change its prices whenever the company thinks it necessary. However, the company commits itself in invoicing at the prices in force on the date the order is placed.

3. REBATES and DISCOUNTS
The quoted prices already include the rebates and discounts that System Plus Consulting could have granted according to the number of orders placed by the Buyer, or other specific conditions. No discount is granted in case of early payment.

4. TERMS OF PAYMENT
System Plus Consulting delivered services are to be paid within 30 days end of month by bank transfer except in the case of a particular written agreement. If the payment does not reach System Plus Consulting on the deadline, the Buyer has to pay System Plus Consulting a penalty for late payment the amount of which is three times the legal interest rate. The legal interest rate is the current one on the delivery date. This penalty is worked out on the unpaid invoice amount, starting from the invoice deadline. This penalty is sent without previous notice. When payment terms are over 30 days end of month, the Buyer has to pay a deposit which amount is 10% of the total invoice amount when placing his order.

5. OWNERSHIP
System Plus Consulting remains sole owner of the delivered services until total payment of the invoice.

6. DELIVERIES
The delivery schedule on the purchase order is given for information only and cannot be strictly guaranteed. Consequently any reasonable delay in the delivery of services will not allow the buyer to claim for damages or to cancel the order.

7. ENTRUSTED GOODS SHIPMENT
The transport costs and risks are fully born by the Buyer. Should the customer wish to ensure the goods against lost or damage on the base of their real value, he must imperatively point it out to System Plus Consulting when the shipment takes place. Without any specific requirement, insurance terms for the return of goods will be the carrier current ones (reimbursement based on good weight instead of the real value).

8. FORCE MAJEURE
System Plus Consulting responsibility will not be involved in non execution or late delivery of one of its duties described in the current terms and conditions if these are the result of a force majeure case. Therefore, the force majeure includes all external event unpredictable and irresistible as defined by the article 1148 of the French Code Civil?

9. CONFIDENTIALITY
As a rule, all information handed by customers to System Plus Consulting are considered as strictly confidential. A non-disclosure agreement can be signed on demand.

10. RESPONSIBILITY LIMITATION
The Buyer is responsible for the use and interpretations he makes of the reports delivered by System Plus Consulting. Consequently, System Plus Consulting responsibility can in no case be called into question for any direct or indirect damage, financial or otherwise, that may result from the use of the results of our analysis or results obtained using one of our costing tools.

11. APPLICABLE LAW
Any dispute that may arise about the interpretation or execution of the current terms and conditions shall be resolved applying the French law. It the dispute cannot be settled out-of-court, the competent Court will be the Tribunal de Commerce de Nantes.