Reverse Technology Report

Samsung Galaxy S6
Teardown & Physical Analyses of Key Components

September 2015 - Version 1 written by Romain FRAUX

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This reverse technology report has been conducted to provide a teardown and technology data for key components of the Samsung Galaxy S6 smartphone. The Galaxy S6 holds many integrated circuits which are listed and reviewed in the report (measurement, package type, pin count...). A supplier ranking by design wins and footprint consumption is also included and a special focus has been made on 11 “noteworthy” components among 4 selected topics: Advanced packaging, MEMS/Sensor, RF and imaging.
EXECUTIVE SUMMARY

Samsung GS6

- 2 components with advanced packaging features has been selected and cross-section has been made to highlight the packaging structure and understand the manufacturing process:
  - The Samsung Exynos Processor for its advanced Package-on-Package (PoP) structure
  - A Samsung power management IC featuring the smallest pitch Wafer-Level Package (WLP) on the board.
- 5 MEMS/Sensors components has been also physically analyzed:
  - The fingerprint sensor because it is the second generation of a fingerprint sensor in the Samsung Galaxy product line and it is much more reliable compared to the previous one.
  - The eCompass because it’s a completely new reference which has never been used in a smartphone before and it’s the smallest eCompass on the market.
  - The OIS gyroscope because it’s a relatively rare device and it’s the smallest gyroscope on the market.
  - And also the heart rate monitor sensor and the color, ambient light and proximity sensor.
- 1 RF device has been selected due to its integration: the 5G Wi-Fi & Bluetooth combo module which is a flip-chip BGA system-in-package.
- For the imaging thematic, the front and rear camera modules as well as the flash LED has been analyzed in order to show the choices made by Samsung in term of module size, image sensors and also lenses, auto-focus and OIS.
**EXECUTIVE SUMMARY**

- The Excel worksheet linked to the report lists all identified ICs and offers the possibility to make filters and to sort the data according to several features like the manufacturer name, package type, pin count, footprint, pitch...

<table>
<thead>
<tr>
<th>#</th>
<th>Photo Marking</th>
<th>Mfr.</th>
<th>Reference</th>
<th>Device type / Function</th>
<th>Package type / Pitch of pins</th>
<th>Package size (mm)</th>
<th>Board</th>
<th>Foot-Pitch (mm)</th>
<th>W (mm)</th>
<th>Package type</th>
<th>Package size (mm)</th>
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</thead>
<tbody>
<tr>
<td>27</td>
<td>[Image]</td>
<td>Samsung</td>
<td>[Image]</td>
<td>Baseband Processor 5G16GSP11 Flash Memory</td>
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<td>10</td>
<td>[Image]</td>
<td>Skyworks</td>
<td>[Image]</td>
<td>Front-End Power Amplifier Module for UMTS / LTE Bands 20, 21, 22, 23, 24, 26, and GSM EDGE 850/900 MHz</td>
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</table>
• The Reverse technology analysis is conducted in 3 phases:

Component Identification
- Teardown of the smartphone in order to have access to the electronic boards
- ICs marking identification, desoldering, measurement, pin/ball count
- ICs package decapsulation to identify unknown reference

Selection “Key” Components
- Selection of “notable” component among 4 topics: advanced packaging, MEMS/Sensor, RF, Imaging

Physical Analysis
- Package is analyzed and measured
- Molded packages are decapsulated and dies are extracted to get data on dimensions, marking
- Cross-section is made to have access to process structure
Teardown

- SGS6 Teardown
- Electronic Board
  - ICs Identification
  - PCB Characteristics
- Notable Packages
  - Samsung PoP-1154
  - Samsung WLCSP 0.35mm pitch
- Notable MEMS/Sensors
  - Fingerprint Sensor
  - eCompass
  - OIS Gyroscope
  - Heart Rate Monitor
  - Color, ALS & Proximity Sensor
- Notable RF Devices
  - Samsung WiFi Module
- Camera Modules & Flash LED
  - Rear Module
  - Front Module
  - Flash LED

Dimensions: 143.4 x 70.5 x 6.8 mm (5.65 x 2.78 x 0.27 in)
Weight: 138 g (4.87 oz)
**Electronic Board**

- **SG6 Teardown**
- **Electronic Board**
  - ICs Identification
  - PCB Characteristics
- **Notable Packages**
  - Samsung PoP-1154
  - Samsung WL CSP 0.35mm pitch
- **Notable MEMS/Sensors**
  - Fingerprint Sensor
  - eCompass
  - OIS Gyroscope
  - Heart Rate Monitor
  - Color, ALS & Proximity Sensor
- **Notable RF Devices**
  - Samsung WiFi Module
- **Camera Modules & Flash LED**
  - Rear Module
  - Front Module
  - Flash LED

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### TOP SIDE – ICs IDENTIFICATION

<table>
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<tr>
<th>Nb</th>
<th>Mfr.</th>
<th>Ref. / Pkg. / Die Marking</th>
<th>Function</th>
<th>Package Type</th>
<th>Pin Nb</th>
<th>Package Size (mm)</th>
<th>IC Analyzed</th>
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Note: More details are available in the Excel report.

: Analyzed devices

**xxxxx:** Sensors

**xxxxx:** Unknown mfr. devices
Electronic Board

- SGS6 Teardown
- Electronic Board
  - ICs Identification
  - PCB Characteristics
- Notable Packages
  - Samsung PoP-1154
  - Samsung WLCSP 0.35mm pitch
- Notable MEMS/Sensors
  - Fingerprint Sensor
  - eCompass
  - OIS Gyroscope
  - Heart Rate Monitor
  - Color, ALS & Proximity Sensor
- Notable RF Devices
  - Samsung WiFi Module
- Camera Modules & Flash LED
  - Rear Module
  - Front Module
  - Flash LED

**IC n° 16:**
Die size: 0.73x0.33mm
Marking: AN30 2005

**IC n° 23:**
Die size: 0.8x0.6mm
Marking: SIC2137A S2
Electronic Board

- SGS6 Teardown
- Electronic Board
  - ICs Identification
  - PCB Characteristics
- Notable Packages
  - Samsung PoP-1154
  - Samsung WLCSP 0.35mm pitch
- Notable MEMS/Sensors
  - Fingerprint Sensor
  - eCompass
  - OIS Gyroscope
  - Heart Rate Monitor
  - Color, ALS & Proximity Sensor
- Notable RF Devices
  - Samsung WiFi Module
- Camera Modules & Flash LED
  - Rear Module
  - Front Module
  - Flash LED

IC PACKAGE REPARTITION
(based on 51 ICs)

- WLP
  - 33%
Electronic Board

- SGS6 Teardown
- Electronic Board
  - ICs Identification
  - PCB Characteristics
- Notable Packages
  - Samsung PoP-1154
  - Samsung WLCSP 0.35mm pitch
- Notable MEMS/Sensors
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  - Front Module
  - Flash LED

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Design Win</th>
</tr>
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<tbody>
<tr>
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</table>

| Total | 51 |

IC DESIGN WIN BY MFR. (TOTAL OF 51 ICS)

Samsung 22%
Electronic Board

- SGS6 Teardown
- Electronic Board
  - ICs Identification
  - PCB Characteristics
- Notable Packages
  - Samsung PoP-1154
  - Samsung WLCSP 0.35mm pitch
- Notable MEMS/Sensors
  - Fingerprint Sensor
  - eCompass
  - OIS Gyroscope
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- Notable RF Devices
  - Samsung WiFi Module
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  - Rear Module
  - Front Module
  - Flash LED

### IC MANUFACTURER PACKAGE FOOTPRINT

<table>
<thead>
<tr>
<th>Mfr.</th>
<th>IC Package Footprint (mm²)</th>
<th>%</th>
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</thead>
<tbody>
<tr>
<td>Samsung</td>
<td>487.60</td>
<td>58.7%</td>
</tr>
</tbody>
</table>

Total 837.4 100%

IC FOOTPRINT BY MFR.

IC PACKAGE FOOTPRINT BY MFR. (EXCLUDED SAMSUNG)
- **Package total thickness (without balls):**
  - Memory package thickness:
    - Memory dies thickness:
    - PCB thickness:
  - Processor package thickness:
    - Die thickness:
    - PCB thickness:

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**Packages**

- SGS6 Teardown
- Electronic Board
  - ICs Identification
  - PCB Characteristics
- Notable Packages
  - Samsung PoP-1154
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**PoP Package Cross-Section — Optical View**
Packages

- SGS6 Teardown
- Electronic Board
  - ICs Identification
  - PCB Characteristics
- Notable Packages
  - Samsung PoP-1154
  - Samsung WLCSP 0.35mm pitch
- Notable MEMS/Sensors
  - Fingerprint Sensor
  - eCompass
  - OIS Gyroscope
  - Heart Rate Monitor
  - Color, ALS & Proximity Sensor
- Notable RF Devices
  - Samsung WiFi Module
- Camera Modules & Flash LED
  - Rear Module
  - Front Module
  - Flash LED

**Cross-section Overview**

**Package Cross-Section – SEM View**
MEMS/Sensors

- SGS6 Teardown
- Electronic Board
  - ICs Identification
  - PCB Characteristics
- Notable Packages
  - Samsung PoP-1154
  - Samsung WLCSP 0.35mm pitch
- Notable MEMS/Sensors
  - Fingerprint Sensor
  - eCompass
  - OIS Gyroscope
  - Heart Rate Monitor
  - Color, ALS & Proximity Sensor
- Notable RF Devices
  - Samsung WiFi Module
- Camera Modules & Flash LED
  - Rear Module
  - Front Module
  - Flash LED

### Table: Sensor Design Win by MFR.

<table>
<thead>
<tr>
<th>Mfr.</th>
<th>Design Win</th>
<th>Function</th>
<th>Packages Area (mm²)</th>
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<tbody>
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</table>

Total: 11

358.5 mm²
• We have selected 5 components for physical analysis.

- 2-Axis Gyroscope for OIS
- 3-Axis eCompass
- Fingerprint Sensor
- Color, ALS & Proximity Sensor
- Pulse Oximetry and Heart-Rate Monitor Sensor
MEMS/Sensors

- SGS6 Teardown
- Electronic Board
  - ICs Identification
  - PCB Characteristics
- Notable Packages
  - Samsung PoP-1154
  - Samsung WLCSP 0.35mm pitch
- Notable MEMS/Sensors
  - Fingerprint Sensor
  - eCompass
  - OIS Gyroscope
  - Heart Rate Monitor
  - Color, ALS & Proximity Sensor
- Notable RF Devices
  - Samsung WiFi Module
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  - Front Module
  - Flash LED

FINGERPRINT SENSOR – CROSS-SECTION

- Aluminum base
- Bottom PCB
- Fingerprint Sensor Cross-section - plane #1
- Fingerprint Sensor Cross-section - plane #2
- Soldier Ball
- AI Ring

Cross-section plane #1 & #2

FINGERPRINT SENSOR – CROSS-SECTION

#1

#2
MEMS/Sensors

- SGS6 Teardown
- Electronic Board
  - ICs Identification
  - PCB Characteristics
- Notable Packages
  - Samsung PoP-1154
  - Samsung WLCSP 0.35mm pitch
- Notable MEMS/Sensors
  - Finger print Sensor
  - eCompass
  - OIS Gyroscope
  - Heart Rate Monitor
  - Color, ALS & Proximity Sensor
- Notable RF Devices
  - Samsung WiFi Module
- Camera Modules & Flash LED
  - Rear Module
  - Front Module
  - Flash LED

COLOR, ALS & PROXIMITY SENSOR – PACKAGE OPENING

Sensor Die Overview
Camera Modules

- Samsung Galaxy S6 Teardown
- Electronic Board
  - ICs Identification
  - PCB Characteristics
- Notable Packages
  - Samsung PoP-1154
  - Samsung WLCSP 0.35mm pitch
- Notable MEMS/Sensors
  - Fingerprint Sensor
  - eCompass
  - OIS Gyroscope
  - Heart Rate Monitor
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  - Samsung WiFi Module
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  - Front Module
  - Flash LED
Samsung Galaxy S6 Teardown

Electronic Board
- ICs Identification
- PCB Characteristics

Notable Packages
- Samsung PoP-1154
- Samsung WLCSP 0.35mm pitch

Notable MEMS/Sensors
- Fingerprint Sensor
- eCompass
- OIS Gyroscope
- Heart Rate Monitor
- Color, ALS & Proximity Sensor

Notable RF Devices
- Samsung WiFi Module

Camera Modules & Flash LED
- Rear Module
- Front Module
- Flash LED

Camera Module Cross-Section – Optical View

Flex PCB
4 layers