Apple iPhone 6s
Complementary Teardown Report with Additional Commentary
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Founded in 1992 to provide technical analysis capabilities to companies seeking to grow the potential of their IP and understand their competitors.

Headquartered in Ottawa, Canada with over 112 employees – offices in Canada, USA, Europe, Japan, Korea and Taiwan.

Provide solutions to over 200 global technology, semiconductor and electronics companies.

Five in-house laboratories with advanced tools and equipment for in-depth, world-class analysis.
Foundation of our products and services are built on

**Patent Knowledge**
- 60K patents read
- Our engineers read patents every day across a variety of technology areas
- Hire engineers out of their specific industry sector and teach them how to evaluate patents and speak to lawyers

**Technology Expertise**
- Wide spectrum of technology analysis expertise from semiconductor process and design techniques to electronics and software
- 80+ engineering projects going at any one time

**Market Understanding**
- Broad view of important industries – deep understanding of the key players, their products and revenue
- Proactively analyze 5 to 10 products a week
- Monitor current and future product trends to assess licensing potential
Two complementary business units

PATENT INTELLIGENCE SERVICES
Unrivalled Ability to Match Patents to Products
We provide insightful, customized solutions to help IP teams identify and fully leverage their best patents, protect their competitive position, prepare for litigation, and develop successful IP strategies.

COMPETITIVE TECHNICAL INTELLIGENCE
The Most Accurate Analysis of High Volume Consumer Devices
We provide timely, high-quality, and independent competitive technical analysis on which products are winning and why.
Apple iPhone 6s Smartphone

Specifications

- Manufacturer: Apple Inc.
- Product name: iPhone 6s
- Model number: A1688
- Size: 67.1 mm x 138.3 mm x 7.1 mm
- System: OS iOS 9
# Apple iPhone 6s Smartphone

## Specifications

<table>
<thead>
<tr>
<th>BASIC</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Product Name</strong></td>
<td>iPhone 6s, A1688</td>
</tr>
<tr>
<td><strong>Manufacturer</strong></td>
<td>Apple Inc.</td>
</tr>
<tr>
<td><strong>Minimum Size (mm)</strong></td>
<td>67.1 x 138.3 x 7.1</td>
</tr>
<tr>
<td><strong>Weight (g)</strong></td>
<td>143</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>BATTERY TIME</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Video Call (minutes)</strong></td>
<td>n/a</td>
</tr>
<tr>
<td><strong>Digital TV (minutes)</strong></td>
<td>n/a</td>
</tr>
<tr>
<td><strong>Other</strong></td>
<td>n/a</td>
</tr>
<tr>
<td><strong>Battery (size in mm)</strong></td>
<td>Li-ion polymer, 3.82 V, 1,715 mAh (38.17 x 95.03 x 2.87)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SYSTEM</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>OS</strong></td>
<td>iOS 9</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CPU / ROM / RAM</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CPU</strong></td>
<td>Apple A9, dual-core, 1.8 GHz, embedded M9 motion co-processor</td>
</tr>
<tr>
<td><strong>ROM</strong></td>
<td>16 GByte</td>
</tr>
<tr>
<td><strong>RAM</strong></td>
<td>2 GByte</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DISPLAY</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Main Display</strong></td>
<td>4.7-inch, 16,777,216 colors, 750 x 1334 dot, Retina HD, IPS LCD</td>
</tr>
<tr>
<td><strong>Sub Display</strong></td>
<td>n/a</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>COMMUNICATION</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>HSDPA/HSUPA (Mbps)</strong></td>
<td>3G: 42.2/5.76 LTE: 300/50</td>
</tr>
<tr>
<td><strong>Wireless LAN</strong></td>
<td>802.11 a/b/g/n/ac</td>
</tr>
<tr>
<td><strong>Bluetooth</strong></td>
<td>4.2</td>
</tr>
<tr>
<td><strong>GPS</strong></td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Infrared</strong></td>
<td>n/a</td>
</tr>
<tr>
<td><strong>RFID/NFC</strong></td>
<td>NFC</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CAMERA</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Main Camera</strong></td>
<td>12.0 MP CMOS with auto-focus, LED flash</td>
</tr>
<tr>
<td><strong>Sub Camera</strong></td>
<td>5.0 MP CMOS</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SENSOR</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Motion</strong></td>
<td>Accelerometer: Yes Digital Compass: Yes Gyroscope: Yes Barometer: Yes</td>
</tr>
<tr>
<td><strong>Ambient</strong></td>
<td>Light Sensor: Yes Proximity Sensor: Yes Temperature Sensor: n/a Humidity Sensor: n/a</td>
</tr>
<tr>
<td><strong>Security</strong></td>
<td>Fingerprint Sensor: Yes</td>
</tr>
<tr>
<td><strong>Healthcare</strong></td>
<td>Heart Rate Monitor: n/a</td>
</tr>
<tr>
<td><strong>Touch Panel</strong></td>
<td>Capacitive, multi touch, 3D</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>OTHER</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>HDMI</strong></td>
<td>n/a</td>
</tr>
<tr>
<td><strong>MicroSD (max. capacity)</strong></td>
<td>n/a</td>
</tr>
<tr>
<td><strong>Waterproof/Anti-shock</strong></td>
<td>n/a</td>
</tr>
</tbody>
</table>
Apple iPhone 6s Smartphone

Application Processors – Dual Sourced

- Apple has dual sourced its A9 Application Processor from Samsung (14 nm FinFET) and TSMC (16 nm FinFET). Chipworks will be doing deep structural analysis of the TSMC process.
- Chipworks is working to confirm if the process is TSMC 16FF or 16FF+. We will be able to differentiate between these two processes once we understand the standard cell architecture and BEOL integration, where major differences are expected. Stay tuned!
- Preliminary SEM and TEM images will be available to report pre-purchasers

<table>
<thead>
<tr>
<th>Chipworks Reports – TSMC 16 nm FinFET Process</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Basic Functional Analysis Report (FAR-1509-803)</strong> $7,500</td>
<td>~Late October</td>
</tr>
<tr>
<td>• Package photos/xrays</td>
<td></td>
</tr>
<tr>
<td>• Metal 1 or polysilicon die photo</td>
<td></td>
</tr>
<tr>
<td>• Die size measurements</td>
<td></td>
</tr>
<tr>
<td>• Digital, analog, and memory are annotated</td>
<td></td>
</tr>
<tr>
<td>• Node assessment</td>
<td></td>
</tr>
<tr>
<td>• IC cost estimate</td>
<td></td>
</tr>
<tr>
<td><strong>Advance CMOS Essentials Project (ACE-1509-801)</strong> $12,000</td>
<td>~Early December</td>
</tr>
<tr>
<td>• Concise analyst's summary of critical device metrics, TEM-EDS results, and salient features supported by the following image folders:</td>
<td></td>
</tr>
<tr>
<td>• SEM bevel: logic region and SRAM with SEM cross-section of the general device structure, metals, dielectrics, and detail of the FEOL structures</td>
<td></td>
</tr>
<tr>
<td>• TEM cross-sections: parallel and perpendicular to the transistor gates</td>
<td></td>
</tr>
<tr>
<td><strong>Structural Analysis Report (SAR-1504-802)</strong> $24,500</td>
<td>~Late November</td>
</tr>
<tr>
<td>• TSMC FinFET process</td>
<td></td>
</tr>
<tr>
<td>• Top-down layer-by-layer analysis of the back end processing</td>
<td></td>
</tr>
<tr>
<td>• Analysis of the front end processing including SEM and TEM imaging</td>
<td></td>
</tr>
<tr>
<td>• Memory cell analysis</td>
<td></td>
</tr>
<tr>
<td>• Layout – detailed SEM and optical plan-view images</td>
<td></td>
</tr>
</tbody>
</table>

Related Reports
- Samsung 14 nm FinFET suite of reports
- Intel 14 nm FinFET Cherry Trail suite of reports
- Intel 14 nm FinFET Broadwell suite of reports
Chipworks tracks the key metrics that allow your marketing team to know their market place:

- Package photos/xrays
- Metal 1 or polysilicon die photo
- Die size measurements
- Digital, analog, and memory are annotated
- Node assessment
- IC cost estimate

This is the first time we have ever found a dual sourced application processor. It will be a unique opportunity for us to compare implementation of the same chip from the two heavyweights in foundry services.

Not only will we be doing a functional block level comparison but we can dive down and look at the implementation of the standard cell libraries, showing cell layout and comparing routing efficiencies.
Apple iPhone 6s Smartphone

Application Processors – Sneak Peak, as promised!

APL1022 TSMC 16 nm FinFET

APL0898 Samsung 14 nm FinFET

NOTE: False color and image sharpening has been applied to the photos for the purposes of this article. High resolution images in Chipworks reports are not retouched.
Apple iPhone 6s Smartphone

Transistor Characterization Reports - compare reality to foundry targets and publications.

Chipworks recently completed transistor characterization of the Samsung 14 nm FinFET process (logic). Chipworks provides universal transistor curves that will allow you to easily compare between foundries.

Measurements include:
- AFP Image of the Measurement Area for NMOS Transistor 1
- Transfer Characteristics (VDS = 0.7 V)
- Extrapolated Linear VT (VDS = 0.05 V)
- Transconductance (gm) (VDS = 0.7 V)
- Subthreshold Swing (S) (VDS = 0.7 V)
- Transfer Characteristics Versus VDS
- DIBL (ΔVGS/ΔVDS)

<table>
<thead>
<tr>
<th>Related Transistor Reports</th>
<th>Report Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>TSMC 16 nm FinFET (logic)</td>
<td>Under consideration</td>
</tr>
<tr>
<td>Samsung 14 nm FinFET (logic)</td>
<td>TCR-1504-801</td>
</tr>
<tr>
<td>Intel 14 nm FinFET (SRAM)</td>
<td>TCR-1409-801</td>
</tr>
</tbody>
</table>

AFP image showing the probe locations for NMOS transistor CPU logic
In-Depth Technology Benchmarking

- Based on phone-level benchmarks, the otherwise identical iPhone 6s are not the same
  https://m.youtube.com/watch?v=0bAeJ5fJ1M0

- Apple’s Dual-Source of the A9 applications processor allows Chipworks a unique opportunity to directly benchmark two technologies in the exact same design
  - Process analysis and costing
  - Standard cell implementation and routing efficiency
  - Transistor characterization and capacitance modeling
  - Block-level power measurements

- Perf/Power/Area metric would indicate Samsung should have the lead in battery life based on area. However, our measurement of the 14LPE process on Exynos has shown a weak NMOS, can this be the cause of the power difference between TSMC and Samsung A9s?
Apple iPhone 6s Smartphone

Product Information
Teardown

display, touch panel, and FPC #3
center panel
Li-ion polymer battery
PCB #1
rear cover
FPC #1
FPC #2
Display Driver Win for Synaptics

Synaptics’ Q3 2014 acquisition of Renesas let them reap the rewards of the Renesas design win in the iPhone 6 and 6 plus, and Synaptics repeats this year with the design win for the iPhone 6s and 6s plus DDI.

Looking forward Synaptics may be able to leverage this design win to move Apple towards a touch screen controller and display driver integrated solution. Chipworks first catalogued this disruptive design in the ZTE Q7 S6 Lux.

According to Synaptics there are a number of key benefits to TDDI:

- **Best-in-Class Performance** – synchronizes touch sensing and display driving to virtually eliminate display noise and offer best-in-class capacitive touch performance.
- **Thinner Form Factors** – Integration of the touch sensor into the display results in thinner form factors.
- **Brighter Displays** – Fewer layers in the touchscreen results in a brighter display, or longer battery life for the same brightness.
- **Lower System Cost** – Reducing the number of components, eliminating lamination steps and increasing manufacturing yield lowers overall system cost for OEMs.

Touch Screen Controller

The touch screen controller was comprised of a two chip solution in the iPhone 6, this socket was held by Broadcom and Texas Instruments. In the iPhone 6S these two chips were combined into a single package with a third unknown chip. The next evolutionary step would be to move to an integrated touch and display driver solution.

NOTE: Chips are not scaled.
Fingerprint Sensor – 2nd Generation

The last three generations of the iPhone (5, 5s, 6) have contained the same fingerprint sensor. Apple is now releasing their 2nd generation fingerprint sensor. We were excited to find contacts going from the front to the back of the die. Could this be TSMC’s first demonstration of TSVs?

We have already launched two reports on this new fingerprint sensor and are considering deep circuit analysis.

### Related Fingerprint Sensor Reports

<table>
<thead>
<tr>
<th>Report Code</th>
<th>Report Title</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>FAR-1510-802</td>
<td>Apple iPhone 6S Fingerprint Sensor Basic Functional Analysis Report</td>
<td>Analysis Underway</td>
</tr>
<tr>
<td>PKG-1510-801</td>
<td>Apple iPhone 6S Fingerprint Sensor Package Report</td>
<td>Analysis Underway</td>
</tr>
<tr>
<td></td>
<td>Apple iPhone 6S Fingerprint Sensor Circuit Analysis Report</td>
<td>Under consideration Please contact us</td>
</tr>
</tbody>
</table>

TSVs?
Apple has been improving its user interface across its product lines by adding a force-based touch features to the Macbook, Apple Watch and iPhone 6S.

Chipworks recently completed systems analysis of the Apple Watch Force Touch sensor. This report examines market adoption and penetration for force-based touch, intellectual landscape, and the technology behind the Apple Watch Force Touch. It includes findings about the construction, connectivity, and operation.

We have just begun system analysis of the iPhone 6S 3D Touch. Contact us to find out more!

### Related Fingerprint Sensor Reports

<table>
<thead>
<tr>
<th>Report Title</th>
<th>Report Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apple iPhone 6S Force Touch Exploratory Report</td>
<td>EXR-1510-801 Analysis Underway</td>
</tr>
<tr>
<td>Apple Watch Force Touch Sensor Exploratory Report</td>
<td>EXR-1507-801</td>
</tr>
</tbody>
</table>
3D Touch – Apple’s adoption and what it may mean to the OEM World
An intellectual property perspective

On September 2, just a couple of days before Apple’s iPhone 6s announcement, Huawei announced its own Android-based smartphone, the Mate S, with a Force Touch-inspired pressure sensitive screen.

It seems Force Touch technology applications are going to get crowded rather quickly. We decided to investigate who is patenting in the area. In other words, who would be interested in and prepared for potential licensing and litigation? We also wanted to find patents possibly applicable to Apple’s existing and future Force Touch products.

There are already some reports on BlackBerry (then RIM) patenting in the area (US9092057) at the time of their Storm smartphone release in 2008. This report, however, missed the point, since the patents discussed relate more to haptic feedback than to the force touch applied in Apple products.

A quick keyword search shows us the filing companies.

One glaring omission seems to be Huawei. This is odd, as one would expect they will become one of the preferred targets in any potential war. Expect Huawei to go after patent acquisitions.
Apple iPhone 6s Smartphone

3D Touch – Apple’s adoption and what it may mean to the OEM World
An intellectual property perspective

What are patented topics?

It is obvious that Force Touch, touch sensors, threshold value, and actuators dominate the filings.

Which patents are potentially applicable against Apple (and other) products?

Analyzing patenting companies and patents themselves, two companies appear in the forefront: BlackBerry and Qualcomm. We managed to uncover a couple of examples that we feel are applicable to Apple products.
Get more insight, more quickly with fewer experts

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- Analyze and understand large patent portfolios
- See changes in portfolios due to M&As
- Map competitor portfolios to your own
- Find relevant patents of value, faster
- Get an instant perspective for better IP decision making

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LEARN MORE
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PCB Dimensions and Markings

<table>
<thead>
<tr>
<th></th>
<th>PCB #1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturer</td>
<td>OPC</td>
</tr>
<tr>
<td>Dimension</td>
<td>57.25 mm x 96.54 mm x 0.84 mm</td>
</tr>
<tr>
<td>Layer</td>
<td>10</td>
</tr>
<tr>
<td>Connector (pin)</td>
<td>0</td>
</tr>
<tr>
<td>Connector (socket)</td>
<td>13</td>
</tr>
<tr>
<td>Connector (ACF)</td>
<td>0</td>
</tr>
</tbody>
</table>
PCB #1 Display Side – Cellular

- Power amplifier (Avago)
- AFEM-8030 3G/4D mid band PAD Module (B1/25(2)/3/4)
- Power amplifier (Skyworks)
- SKY77812-19 Low band 3G/4G PAD Module (B8/13/17(12)/20/26(5)/28AB/29)
- Power amplifier (Qorvo)
- TQF6405 PAD Module (High Band)
- Envelope tracker (Qualcomm)
- QFE1100
Power Amplifier

Chipworks has extensive circuit analysis available on leading edge power amplifier manufacturers. The number of components in these modules is astounding, in the Avago ACPM-8010 (below) Chipworks has catalogued 23 die!

This is a hotly contested space and it is not uncommon to find several manufacturers winning in the same phone.

<table>
<thead>
<tr>
<th>Related Power Amplifier Circuit Analysis Reports</th>
<th>Report Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>AVAGO ACPM-8010 Power Amplifier Circuit Analysis Reports</td>
<td>CAR-1507-201</td>
</tr>
<tr>
<td>Qualcomm QFE2320 RF Power Amplifier with Antenna Switch Circuit Analysis</td>
<td>CAR-1406-802</td>
</tr>
<tr>
<td>Qualcomm QFE2340 RF Power Amplifier with Tx-Rx Switch Circuit Analysis</td>
<td>CAR-1406-803</td>
</tr>
<tr>
<td>Avago ACPM-7600 Power Amplifier Circuit Analysis Reports</td>
<td>CAR-1311-902</td>
</tr>
<tr>
<td>Skyworks SKY85303 Power Amplifier Circuit Analysis Report</td>
<td>CAR-1307-901</td>
</tr>
<tr>
<td>Skyworks SKY85707 Power Amplifier Circuit Analysis Reports</td>
<td>CAR-1307-902</td>
</tr>
</tbody>
</table>
PCB #1 Display Side – Key Components

Accelerometer and Gyroscope Reports

<table>
<thead>
<tr>
<th>Report Description</th>
<th>Report Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bosch BMI160 Circuit Analysis Report</td>
<td>CAR-1510-901</td>
</tr>
<tr>
<td>Invensense MPU-6500/6515 ASIC Full Analog Circuit Analysis Report</td>
<td>CAR-1405-901</td>
</tr>
<tr>
<td>Bosch Triaxial Gyroscope ASIC from BMI055/BMG160 Circuit Analysis Report</td>
<td>CAR-1402-901</td>
</tr>
<tr>
<td>Maxim Integrated MAX21000 3-Axis Digital Output Gyroscope ASIC Circuit Analysis Report</td>
<td>CAR-1308-901</td>
</tr>
</tbody>
</table>
Apple iPhone 6s Smartphone

PCB #1 Battery Side – Cellular

LTE/WCDMA/CDMA/GSM RF transceiver and GPS (Qualcomm) WTR3925

SAW filter (Epcos) 8ME 3BL
antenna switch (Qorvo) RF5150

duplexer bank (Murata) Yd G54
RF FEM (Murata) 240 M1

gsm/edge PA module USI (Skyworks) SKY77357

duplexer bank (Murata) Ne G98
unknown (Avago) SFi529 157714

Qualcomm RF Front End Circuit Analysis

- RF Transceiver WTR3925 (in Galaxy S6 Verizon)
- LTE Modem MDM9635M (in Galaxy S6 Verizon)
- Power Management PMD9635 (in Galaxy S6 Verizon)
- Envelope Tracker QFE1100

We have deep circuit analysis on the following devices:

1. **QFE2320**: Multi-mode Multi-band Power Amplifier with Integrated Antenna Switch
2. **QFE2340**: High Band Multi-mode Multi-band Power Amplifier with Integrated Transmitter/Receiver mode switch
3. **WTR-xxxx Transceivers**:
   - WTR3925
   - WTR1625L
   - WTR1605L
4. **QFE1100**: Envelope Tracker
Qualcomm RF Front End Circuit Analysis

The Qualcomm WTR1605 RF Transceiver chip has been a fabulous winner for Qualcomm. It has been used in at least three different families of Qualcomm components. These components have in turn been found in a total of 89 different products from 24 different manufacturers (some are highlighted in the image on the right).

This type of component/product information is tracked in Chipworks’ Design Win Tracker (DWT).

DWT is an annual, customizable subscription-based service with an exclusive focus on the integrated circuit (IC) design wins and losses in the highest volume phones and tablets.

Design Win Tracker addresses the number one problem faced by decision makers in the semiconductor industry: getting accurate, timely, and reliable information on the nature of design wins and losses.
Apple iPhone 6s Smartphone

PCB #1 Battery Side – Key Components

- WiFi Module (Universal Scientific Industrial) 339S00043
- NFC controller (NXP) 66V10
- audio codec (Cirrus Logic) 338S00105
- power management (Texas Instruments) TPS65730
- power management (Dialog) 338S00120-A1 (assumption)
- flash memory (SK Hynix) H23QDG8UD1ACS
- class D audio amplifier (Cirrus Logic) 338S1285
- power management (Qualcomm) PMD9635
- likely interface IC (NXP) 1610A3
- battery charger (Texas Instruments) SN2400AB0
- unknown 56ALHHI 6BB27
- class D audio amplifier (Cirrus Logic) 338S1285

Barometer (Bosch Sensortec) likely BMP280

Barometer Circuit Analysis Report Code

Bosch BMP280 CAR-1405-902
Apple iPhone 6s Smartphone

PCB #1 – Connectors

- **FPC #1**
  - H: 0.49

- **Li-ion polymer battery (mnf. unknown)**
  - L: 7.11
  - W: 3.86
  - H: 0.79

- **FPC #1 (mnf. unknown)**
  - pin pitch: 0.35
  - pin #40
  - L: 9.96
  - W: 1.90
  - H: 0.83

- **Antenna**
  - H: 0.51

- **PCB #1 - PCB #1**
  - H: 0.50
  - PCB #1 - PCB #1
  - H: 0.48

LED flash, volume, and power button (mnf. unknown)
- pin pitch: 0.35
- pin #12
- L: 4.52
- W: 1.98
- H: 0.61

5 MP camera, light, and proximity sensor microphone (mnf. unknown)
- pin pitch: 0.35
- pin #36
- L: 9.13
- W: 1.86
- H: 0.71

display (mnf. unknown)
- pin pitch: 0.35
- pin #44
- L: 10.04
- W: 1.67
- H: 0.62

13 MP CMOS camera (mnf. unknown)
- pin pitch: 0.35
- pin #34
- L: 8.10
- W: 1.92
- H: 0.68

3D touch panel (mnf. unknown)
- pin pitch: 0.35
- pin #22
- L: 6.87
- W: 1.78
- H: 0.82
FPC #1 – Key Components

- Lightning connector (mnf. unknown)
- Headphone port (mnf. unknown)
- Microphone (Knowles) 5280 KSM2
- Microphone (Knowles) 5280 KSM2
FPC #1 – Connectors

lightning connector (mnf. unknown)
- pin pitch: 0.635
- pin # 8
- L: 8.84
- W: 15.87
- H: 3.27

PCB #1 (mnf. unknown)
- pin pitch: 0.35
- pin # 40
- L: 8.79
- W: 1.20
- H: 0.72

Measurement Unit: millimeters (mm)
FPC #2 – Key Components

- microphone (Knowles) 5280 KSM2
- power button (mnf. unknown)
- LED flash
- volume button (mnf. unknown)
- ring/silent switch (mnf. unknown)
FPC #2 – Connectors

PCB #1
(mnf. unknown)
pin pitch: 0.35
pin # 12
L: 3.40
W: 1.24
H: 0.48

Measurement Unit: millimeters (mm)
Apple iPhone 6s Smartphone

FPC #1 – Connectors

lightning connector (mhf. unknown)
- pin pitch: 0.635
- pin # 8
- L: 8.84
- W: 15.87
- H: 3.27

PCB #1 (mhf. unknown)
- pin pitch: 0.35
- pin # 40
- L: 8.79
- W: 1.20
- H: 0.72

Measurement Unit: millimeters (mm)
FPC #3 – Key Components

- microphone (GoerTek) 529 GWM1
- proximity sensor (mnf. unknown)
- 5 MP CMOS camera (mnf. unknown)
- light sensor (mnf. unknown)
Time of Flight Sensor – A better solution to proximity detection

STMicroelectronics VL6180 Time of Flight Sensor

- Chipworks’ first recorded design win of the VL6180 occurred in the BlackBerry Passport. We have since found the VL6180 in 5 different LGE smartphones.
- The primary application of the VL6180 is the replacement of existing proximity detection technology. Proximity sensors are used in nearly all smartphones to detect the user’s head during a phone call. Unfortunately, the amplitude of the reflected light varies according to the distance but also with the reflectance level of the target, which can be as low as 3 percent for dark black hair. This can lead to ambiguous results - quite frustrating to some users.
  - The VL6180 allows absolute distance to be measured independent of target reflectance. Instead of estimating the distance by measuring the amount of light reflected back from the object, the VL6180C precisely measures the time the light takes to travel to the nearest object and reflect back to the sensor.
  - Was used in the LG G3 as the laser autofocus for the rear facing camera
  - The integration of the SPAD, IR emitter and Ambient Light Sensor is an impressive engineering feat. We expect to find many more design wins for this disruptive technology!
  - Fabbed in STMicroelectronics BCD9 Process.
FPC #3 – Connectors

PCB #1 (mnf. unknown)
pin pitch: 0.35
pin # 36
L: 8.04
W: 1.42
H: 0.54

Measurement Unit: millimeters (mm)
Apple iPhone 6s Smartphone

PCB #1, FPC#1, FPC #2, and FPC #3 – Connectors Plugged
Others – Fingerprint Sensor
Apple iPhone 6s Smartphone

Others

- Speaker
- Vibrator (Taptic Engine)

Images of different components, including speakers and a vibration motor.
# Main Display Dimensions

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Display Module Size</td>
<td>61.17 x 110.46 x n/a (stack-on-glass)</td>
</tr>
<tr>
<td>Display Marking (location)</td>
<td>C3F5353E4HQQ873L7-A3MEQ298Q2K54 (bottom metal plate)</td>
</tr>
<tr>
<td>Display Panel Manufacturer</td>
<td>JDI</td>
</tr>
<tr>
<td>Display Diagonal Size (inch)</td>
<td>4.7</td>
</tr>
<tr>
<td>Display Mode (alignment)</td>
<td>IPS (stripe alignment)</td>
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<tr>
<td>Pixel Count (dot)</td>
<td>750 x 1334, Retina HD</td>
</tr>
<tr>
<td>Resolution (pixel per inch)</td>
<td>326</td>
</tr>
<tr>
<td>Peripheral Margin (from reverse side)</td>
<td></td>
</tr>
<tr>
<td>Left</td>
<td>1.31</td>
</tr>
<tr>
<td>Top</td>
<td>1.34</td>
</tr>
<tr>
<td>Right</td>
<td>1.33</td>
</tr>
<tr>
<td>Bottom – up</td>
<td>0.08</td>
</tr>
<tr>
<td>Bottom – low</td>
<td>5.00</td>
</tr>
<tr>
<td>Seal marking: Y/N (length in mm)</td>
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<tr>
<td>Display Component Thickness</td>
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<td>1a: LCD Top Polarizer</td>
<td>n/a (stack-on-touch-panel)</td>
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<tr>
<td>1b: LCD Panel</td>
<td>n/a (stack-on-touch-panel)</td>
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<tr>
<td>1c: LCD Lower Polarizer and Reflector</td>
<td>0.08</td>
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<tr>
<td>2: Diffuser</td>
<td>n/a</td>
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<tr>
<td>3: Brightness Enhancement Film</td>
<td>0.05</td>
</tr>
<tr>
<td>4: Brightness Enhancement Film</td>
<td>0.05</td>
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<tr>
<td>5: Diffuser</td>
<td>0.03</td>
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<tr>
<td>6: Light Guide</td>
<td>0.30</td>
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<tr>
<td>7: Reflector</td>
<td>0.07</td>
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<tr>
<td>Display Component Total Thickness (clearance)</td>
<td>n/a (stack-on-glass)</td>
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<tr>
<td>Display Back Light LED Count (size)</td>
<td>12 (2.86 x 0.80 x 0.48)</td>
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<tr>
<td>Display Cable Width/Pin Pitch/Pin Count</td>
<td>10.49 (socket)/0.35 x 44</td>
</tr>
</tbody>
</table>

Measurement unit: millimeter (mm)
Main Display Detail – Pixel

- Back light: ON
  Front light: OFF

- Back light: OFF
  Front light: ON

- Back light: ON
  Front light: ON
Main Display Detail – Peripheral
12 MP CMOS Camera

camera module size: 8.45 mm x 8.31 mm x 5.61 mm
camera module marking: AW52 3842
83E1 18AE
sensor diagonal size: 6.01 mm
sensor manufacturer: unknown
sensor board thickness: 0.88 mm
### iSight and FaceTime Camera Overview and Reports

<table>
<thead>
<tr>
<th></th>
<th>iPhone 6s iSight Camera</th>
<th>iPhone 6s FaceTime Camera</th>
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</thead>
<tbody>
<tr>
<td>Resolution (MP)</td>
<td>12</td>
<td>5</td>
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<tr>
<td>Pixel size (µm)</td>
<td>1.22</td>
<td>1.12 (2.24 µm color filter pitch)</td>
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<tr>
<td>Aperture</td>
<td>f/2.2</td>
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<tr>
<td>Configuration</td>
<td>Stacked back-illuminated CMOS image sensor</td>
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<td>Imaging chip supplier</td>
<td>Sony</td>
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<tr>
<td>Autofocus</td>
<td>On-chip phase-detection autofocus (PDAF)</td>
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<tr>
<td>Report Code</td>
<td>DEF-1509-803</td>
<td>DEF-1509-804</td>
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</table>

1. iSight Die Photo, Color Filters Removed
2. iSight Stacked CIS Cross-Section
3. iSight CIS Array Corner
4. iSight Phase Pixels
5. FaceTime CIS Array Corner
6. FaceTime Pixels
CHIPSELECT IMAGE SENSORS

Regular, Succinct Analysis of High-Volume Imaging Applications

For leaders who want to separate road maps from reality and understand what’s really cooking under the hood of state-of-the-art imaging devices, ChipSelect Image Sensors is the ideal solution.

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- Consumer (smartphones, tablets, and digital cameras)
- Professional (digital and video cameras)
- Automotive and security
- Specialty devices (gaming and industrial)
- Emerging growth areas

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Unlimited, 24/7 online access to package photos, die photos, and poly die photos

Image Sensor Design Wins Tracking spreadsheet (monthly)

Unlimited, 24/7 online access to Chipworks’ Device Essentials Image Set and Summary deliverables

Recent Analysis Summary from Chipworks Senior Technology Analysts (tri-annually)

Annual onsite seminar delivered by Chipworks’ Image Sensor Sector Analyst – an important opportunity to ask an unlimited number of questions

Noteworthy Patents Summary (tri-annually)
Quartz – PCB #1 Battery Side

(F1) FORK-XTAL (Epson)
A533L
1.60 x 1.11 x 0.55

(F2) AT-XTAL (Epson)
2400P
E551K
1.62 x 1.09 x 0.52

(F2) AT-XTAL (KDS)
TH19.2
D527
2.07 x 1.65 x 0.57

Measurement unit: millimeters (mm)
Silicon Audio (Microphone)

- microphone (Knowles) 5280 KSM2
- microphone (Knowles) 5280 KSM2
- microphone (Knowles) 5280 KSM2
- microphone (GoerTek) 529 GWM1
**Knowles Microphone Design Win**

Our teardown of the iPhone 6S was big news for Knowles showing a total of 3 out of 4 microphone design wins with their 5280 KSM2.

**Commentary**

Looking forward, we are hoping to find microphone design wins from newcomer Vesper MEMS. They are producing the first piezoelectric MEMS microphone, it’s also waterproof and dust proof.

Read more about this disruptive design in an article from tom’s Hardware

---

**Related Microphone Reports**

<table>
<thead>
<tr>
<th>Knowles Microphone ASIC die mark 19380 from MacBook Circuit Analysis (Analysis underway)</th>
<th>CAR-1510-903</th>
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<tbody>
<tr>
<td>Infineon E2150C MEMS Microphone from AAC Technologies SDM0102B-263-M02 Basic Device Overview Report</td>
<td>CWR-1410-901</td>
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<tr>
<td>AAC Technologies SDM0102B Omnidirectional MEMS Microphone Circuit Analysis Reports</td>
<td>CAR-1408-902</td>
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<tr>
<td>Knowles S1129 XCO18 Microphone ASIC Circuit Analysis Reports</td>
<td>CAR-1403-901</td>
</tr>
<tr>
<td>AAC Technologies M1729D Microphone ASIC (from iPhone 5) Full Analog Circuit Analysis Reports</td>
<td>CAR-1301-902</td>
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</tbody>
</table>
Ambient Sensor

proximity sensor (mnf. unknown)
2.78 mm x 2.38 mm x 1.28 mm

light sensor (mnf. unknown)
1.85 mm x 1.30 mm x 0.50 mm
Antenna

WLAN/BT/GPS

cellular

WLAN/Bluetooth/GPS

Antennas built-in, details unknown
Apple iPhone 6s Smartphone

Antenna

NFC
PCB EMI
### Touch Panel

<table>
<thead>
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<th>Surface glass, display, and touch panel thickness</th>
<th>2.04</th>
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<td>Adhesion</td>
<td>Air gap</td>
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<tr>
<td>Touch panel material</td>
<td>Unknown</td>
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</table>

**PCB #1**
- (mfr. unknown)
- Pin Pitch: 0.35
- Pin #: 44
- L: 9.50
- W: 1.28
- H: 0.43

**PCB #1**
- (mfr. unknown)
- Pin Pitch: 0.35
- Pin #: 22
- L: 5.68
- W: 1.09
- H: 0.59

**3D touch panel controller**
- (Analog Devices)
- 343S00014
- 1522
- 3172076.1

**EMI shield film**

**Fingerprint sensor**
- (mfr. unknown)
- Pin Pitch: 0.35
- Pin #: 10
- L: 3.19
- W: 1.10
- H: 0.53

Measurement unit: millimeters (mm)
Power Source – Battery
Power Source – Charger/Holder
## Technical Note

<table>
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<tr>
<th>Unique/positive</th>
<th>3D touch</th>
<th>X/Y-axis touch sensing by in-cell touch panel. Z-axis touch sensing by intendent sensing sheet.</th>
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<tr>
<td>Negative</td>
<td>–</td>
<td>–</td>
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<tr>
<td>Other</td>
<td>–</td>
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</table>

3D touch panel controller (Analog Devices)
343S00014
1522
3172076.1

- in-cell sensor for X/Y-axis
- external sensor Z-axis
# Key Component List

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>FUNCTION</th>
<th>MARKING</th>
<th>PACKAGE SIZE (mm)</th>
<th>MNF</th>
<th>REMARK</th>
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</thead>
<tbody>
<tr>
<td>CELLULAR</td>
<td>WCDMA TRANSCEIVER</td>
<td>WTR3925 TCG411000 AW521 203VV08</td>
<td>3.93 X 3.88 X 0.53</td>
<td>QUALCOMM</td>
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<td>WCDMA TRANSCEIVER</td>
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<td>GSM TRANSCEIVER</td>
<td>WCDMA TRANSCEIVER</td>
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<td>QUALCOMM</td>
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<tr>
<td>POWER AMPLIFIER</td>
<td>AVAGO</td>
<td>AVAGO AFEM-8030 KM1528 MB065 OOMBO</td>
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<td>TriQuint</td>
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<td>POWER AMPLIFIER</td>
<td>(LOGO)</td>
<td>(LOGO) 77812-19 1307380.1 1530 MX</td>
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</table>
### Key Component List

<table>
<thead>
<tr>
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<th>FUNCTION</th>
<th>MARKING</th>
<th>PACKAGE SIZE (mm)</th>
<th>MNF</th>
<th>REMARK</th>
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<td>WLAN</td>
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<tr>
<td>CONTROLLER</td>
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<tr>
<td>APPLICATION PROCESSOR</td>
<td>A9</td>
<td>A9 APL0898 339S00113 ON 155 1525 D9SND N91BFM111Z 1531</td>
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<td>APPLE</td>
<td>DRAM POP</td>
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<tr>
<td>BATTERY MANAGEMENT</td>
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</table>
## Key Component List

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<th>FUNCTION</th>
<th>MARKING</th>
<th>PACKAGE SIZE (mm)</th>
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<th>REMARK</th>
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<td>DISPLAY CONTROLLER</td>
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*Apple iPhone 6s Smartphone*

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*chipworks*
## Key Component List

<table>
<thead>
<tr>
<th>CATEGORY</th>
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<th>MARKING</th>
<th>PACKAGE SIZE (mm)</th>
<th>MNF</th>
<th>REMARK</th>
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<tbody>
<tr>
<td>AUDIO</td>
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<td>GYROSCOPE</td>
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<td></td>
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<tr>
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<td>DRAM</td>
<td>A9 APL0898 339S00113 ON 155 1525 D9SND N91BFM111Z 1531</td>
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<td>MICRON</td>
<td>APP POP</td>
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<td>FLASH MEMORY</td>
<td>SK hynix H23QDG8UD1ACS BC A1 526A M18VR986QB</td>
<td>14.76 x 11.86 x 0.86</td>
<td>SK HYNIX</td>
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