Apple Watch 4’s PPG and ECG Health Sensors

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## Feedbacks

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Executive Summary

This full reverse costing study has been conducted to provide insight on technology data, manufacturing cost and selling price of the Apple’s Health Sensors found in the Watch 4.

The medical wearable market is fore-casted to become worth an impressive $32B by 2024. We see a convergence of needs, where healthcare costs must fall, IT telecommunication is being deployed and patients want to be involved in monitoring their health. This convergence accelerates the demand for medical-grade wearables. The Apple Watch series 4 targets these needs as the first mass-produced consumer accessory receiving FDA approval for its ElectroCardioGram (ECG).

The two main health sensors in the Apple Watch series 4 are an enhanced PhotoPlethysmoGram (PPG) and, for the first time in an Apple watch, an ECG.

The PPG is the core of the continuous heart beat sensor. A new, more compact, design reduces the surface area by 30%, while the number of components decreases from 14 to six. This enhances heartbeat measures. OSRAM supplies the watch’s green LEDs, and you can discover other component suppliers in the report.

The ECG electrically measures very small currents using three electrodes. Two wrist electrodes are integrated on the back side of the watch. The third electrode is in the digital crown. The signals are captured and amplified by Analog Devices circuits.

This report constitutes a thorough analysis of the Apple Watch 4’s health sensors and the back optical window. The electronic components are standard and can be readily found in the market.

However, their integration and the optical window are unique to Apple. Apple has fully redesigned its watch to integrate more efficient health sensors. The report studies exactly how the sensors are integrated.

This report also analyzes the complete health sensor system, including a full analysis of the infrared LED from Epistar, green LEDs from OSRAM and the photodiodes from OSRAM for the PPG. For the ECG sensor, the integrated circuits and the three electrodes are also studied in the report. Moreover, the back window’s specific lenses, optical system and electrodes are analyzed.

Additionally, the report includes a physical and technical comparison with the PPG components from the first three watches that again examines system integration.
Apple Watch Series 4 Cellular Teardown

Physical Analysis
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Physical Comparison

Manufacturing Process Flow

Cost Analysis

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Apple Watch Series 4 – Global View
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ECG Electrodes Wrist

ECG Flex is glued on the wireless charge coil.
EEG Window Cross-Section
XXX Die Dimensions

Die Area: xxmm²
(xx x xxmm)

Nb of PGDW per 8-inch wafer: XXX

Pad number: 6
- Connected: 6

PGDW: Potential Good Dies per Wafer
IR LED die Dimensions

LED Die – Optical view

LED Die cross-section – Optical view
Green LED die Details
Epistar XXX - IR LED Wafer Process Flow Epitaxy

- Epitaxy alGaAs

- GaAs substrate

- GaAs substrate

- GaAs substrate

"drawing not to scale"
Analog Devices XXX - Front-End Cost
Health Sensor - ECG and PPG

Cost Analysis
- Cost Analysis Summary
- Yields Explanation & Hypotheses
- ECG – Sensor Die Cost
- PPG – IR LED Cost
- PPG – Green LED Cost
- PPG – Photodiode Cost
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