

# Sisteme Încorporate

## Cursul 13

### Wearable Computing

Facultatea de Automatică și Calculatoare  
Universitatea Politehnica București

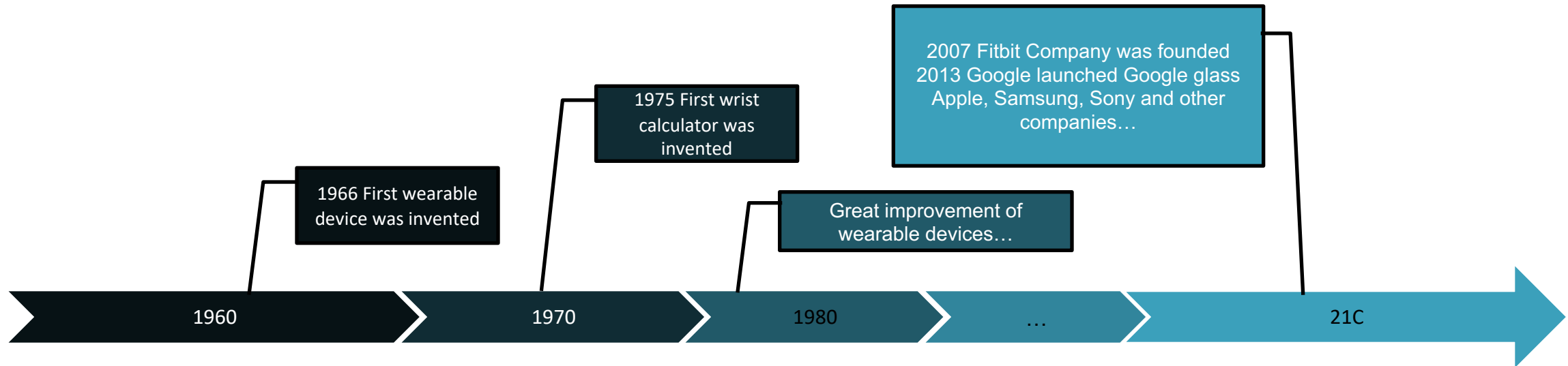
**THE ORIGINAL**



**GOOGLE GLASS**

A wearable device is a computer that is subsumed into the personal space of a user, controlled by the user, and has both operational and interactional constancy, i.e., is always on and always accessible.

# Wearable History



## Forms

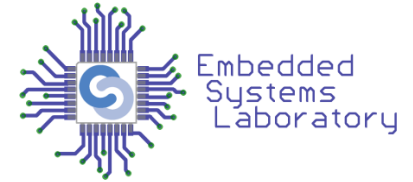
- Head-mounted (glass, helmet..)
- Body-dressed (coat, underwear, trousers..)
- Hand-worn (watch, bracelet, gloves..)
- Foot-worn (shoes, socks..)

## Functions

- Healthy living (sports wrist band, smart bracelet..)
- Information consulting (smart glass, smart watch..)
- Somatosensory Control (somatosensory controller..)

# Business case

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- In 2013, investors poured \$458 million into 49 wearable company deals ( *CB Insights* )
- \$139 Billion Industry in 2022
- Expected to triple in size by 2030
- Major tech companies like Apple, Google, Samsung and Intel investing heavily in wearables, with non-tech giants like Nike, Under Armour, Adidas, Fossil, Timex etc.

# What makes wearables special?

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- Used while the wearer is in motion
- Used while one or both hands are free or occupied with tasks
- Exist within the corporeal envelope of the user
  - Not merely attached to the body but becomes an integral part of the person's clothing
- Allows the user to maintain control
- (Should be) constantly available

# Some interesting issues

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Operating  
Systems

Data  
Transmission

Energy  
Consumption

Security &  
Confidentiality

Data  
Management

Application  
Development  
Platform

# Popularity Example

- Pebble
- Kickstarter Campaign
- Seeks : \$100K
- Raises : \$10+ Million



**KICKSTARTER**



# Factors in Wearable Tech Today

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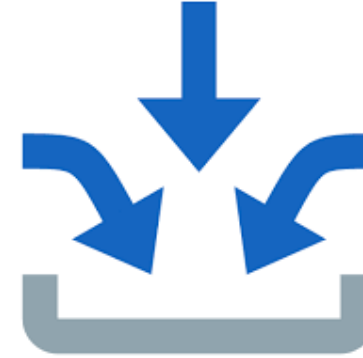
- Faster and Cheaper Hardware
- Cloud Storage
- Location Data
- Quantified Self Activity
- Gaming Industry
- Visual & Voice Technology
- User Experience



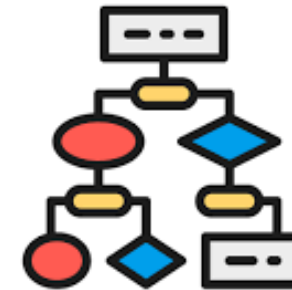
Devices



Applications



Inputs

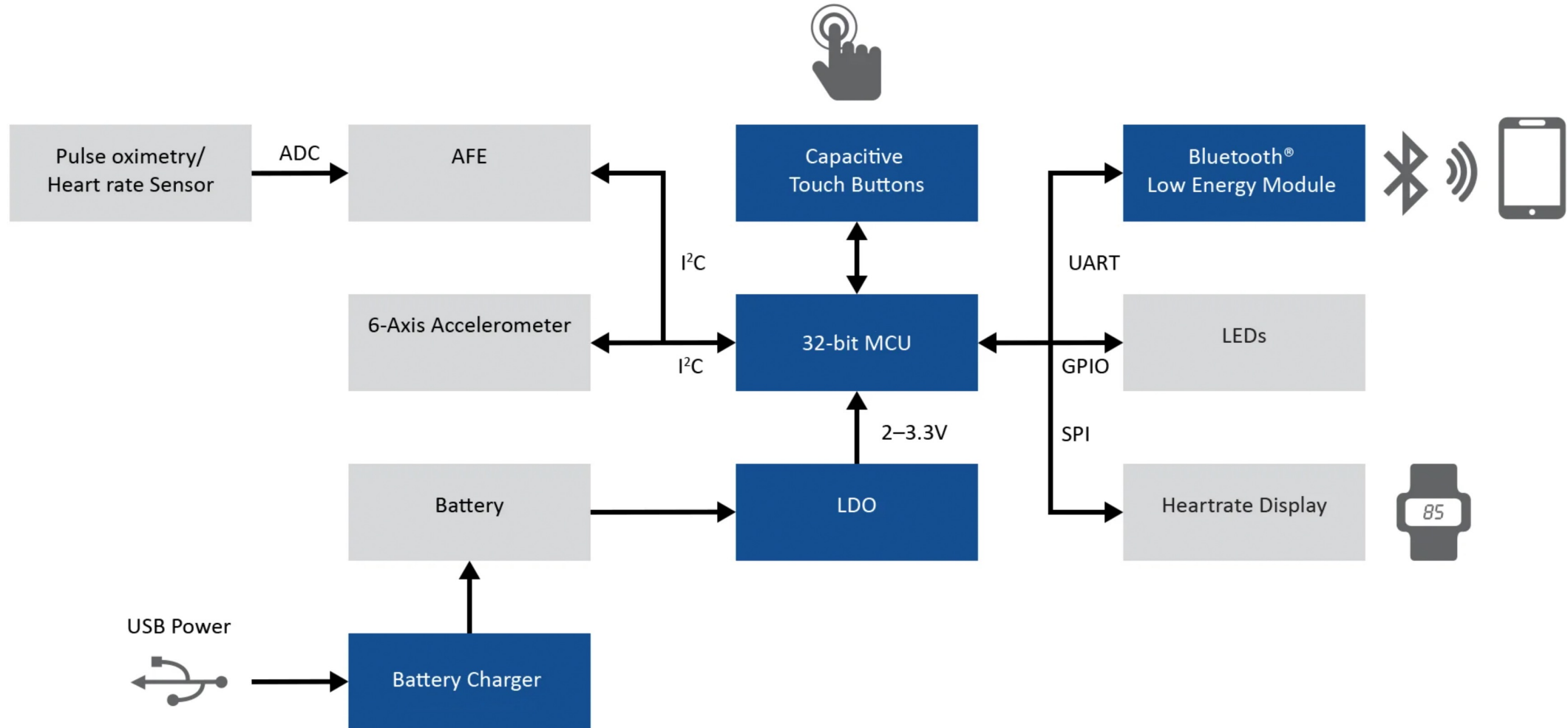


Algorithms

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# Hardware

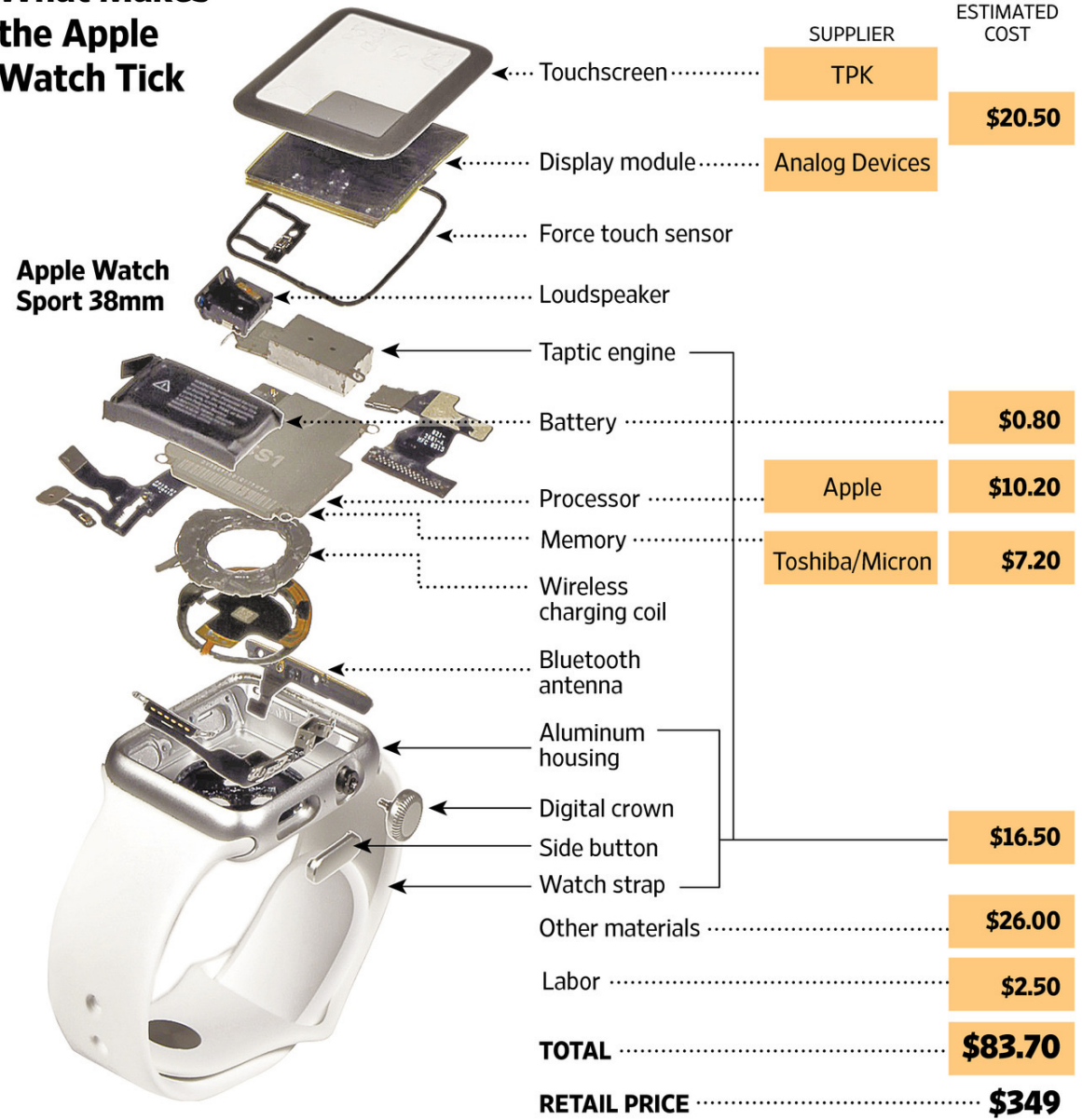
# What is (typically) inside a wearable?



# Apple Watch (Smartwatch)



## What Makes the Apple Watch Tick

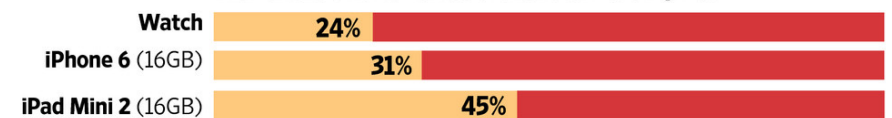


Note: Cost analysis excludes logistics, manufacturing, software and IP expenses.

Source and photo: IHS Technology

THE WALL STREET JOURNAL.

### Materials and labor as a share of retail price



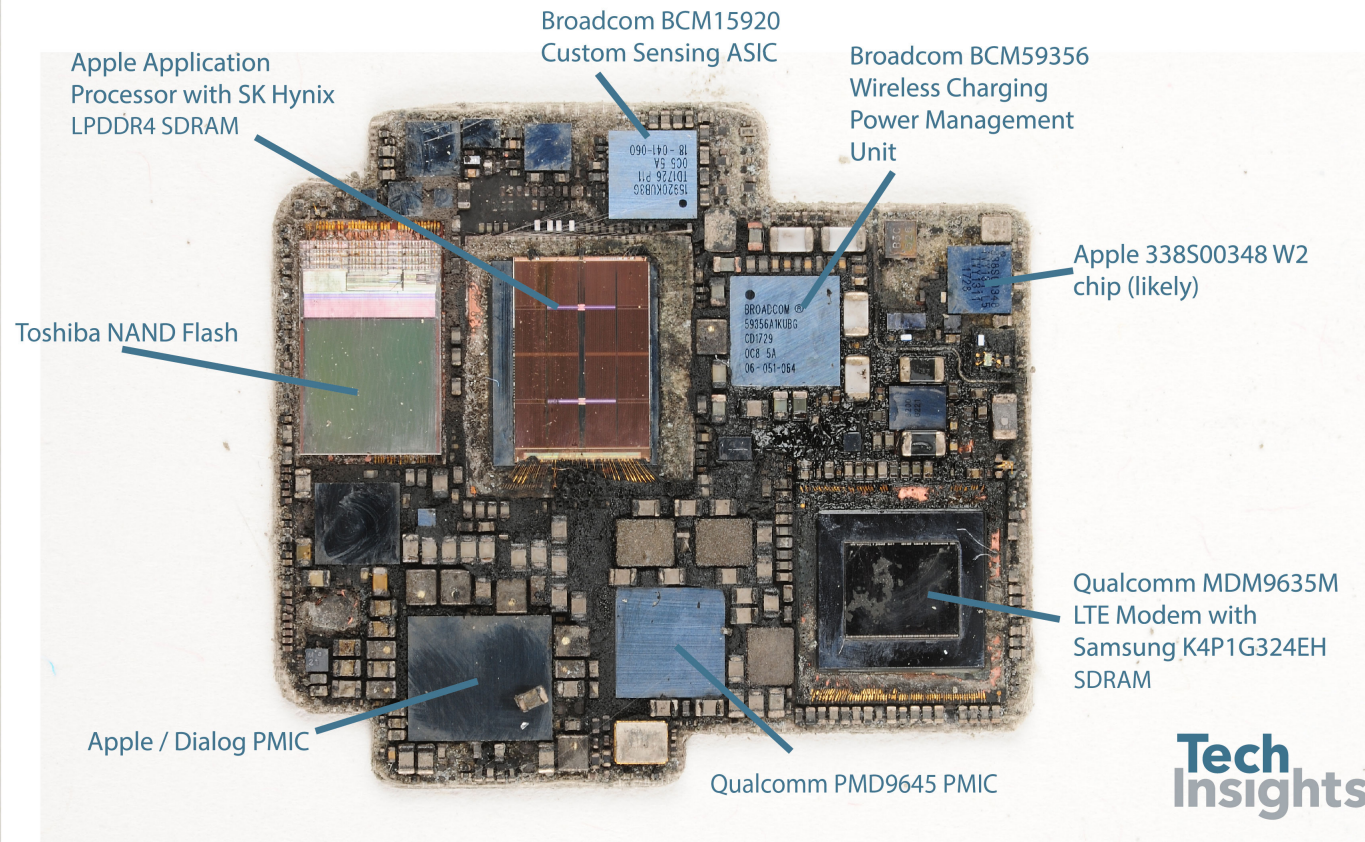
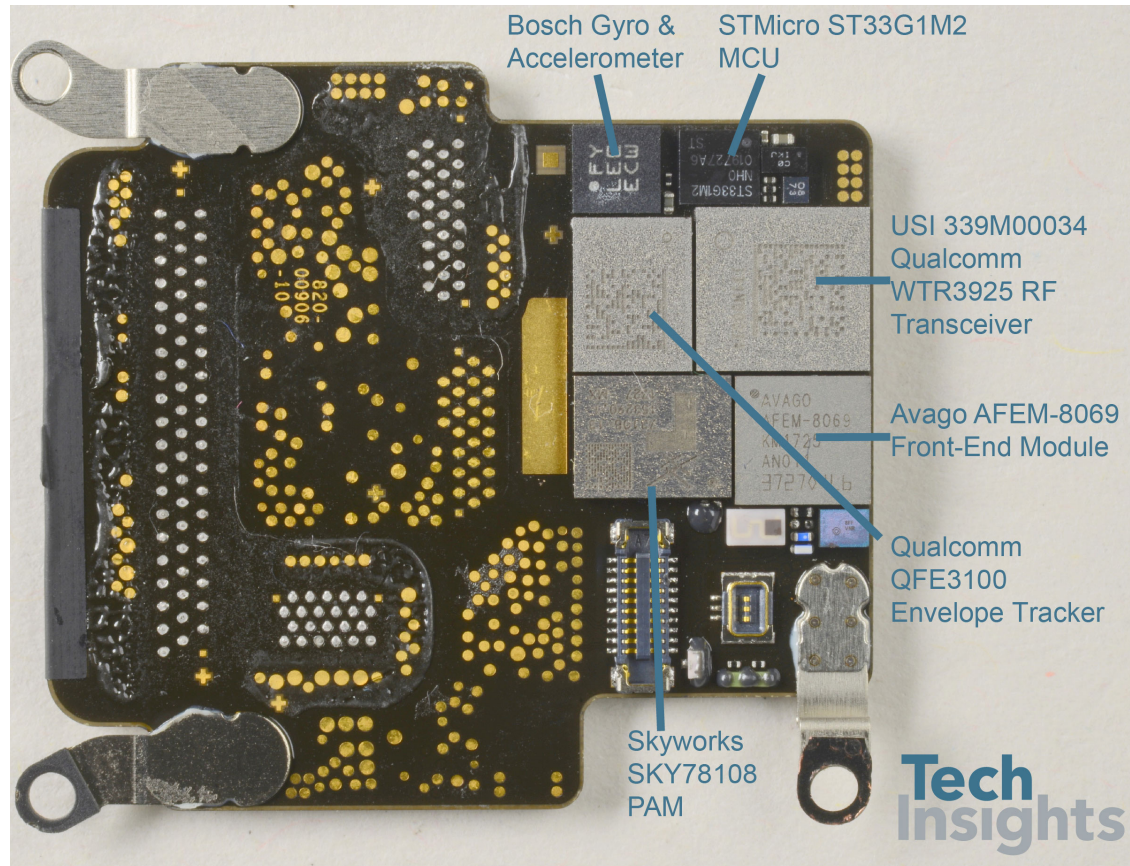
# Apple Watch

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<https://www.ifixit.com/News/53688/three-former-apple-engineers-helped-us-tear-down-apple-watch-series-7>

# Apple Watch – main board



<https://www.techinsights.com/blog/apple-watch-series-3-teardown>

# Jawbone (Activity Monitor)



**MotionX<sup>®</sup>**  
Powered

## RECHARGEABLE BATTERY

Up to 10 days of use on a single charge.

## VIBRATION MOTOR

Powers your silent alarm clock & reminds you to move.

## PRECISION MOTION SENSOR

Accurately tracks your movement and sleep activity.

## 3.5MM PLUG

Syncs your band with the app on your phone.

## SWEAT-PROOF & WATER-RESISTANT\*

Wear the band while showering or working out.

\* Water-resistant up to 1m.

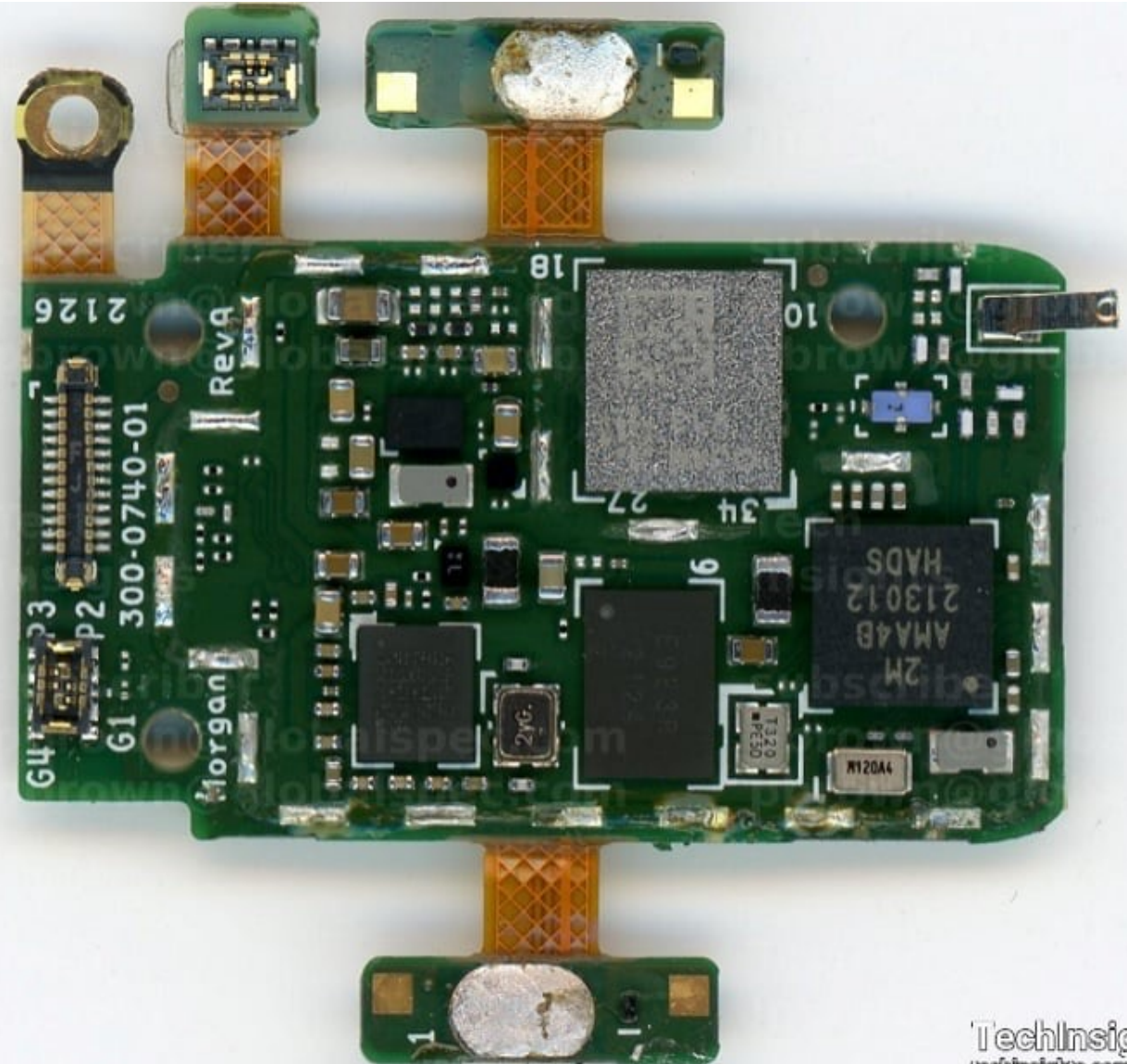


# Fitbit Charge 5 (Fitness Tracker)



# Fitbit Charge 5 – main board

- 1.02 inch OLED touchscreen
- ARM M-4 microprocessor
- Heart rate monitor and sensor
- TI AFE for heart rate monitor and bio-sensor
- TI's load switch, LDO regulator, haptic driver & 600 mA step-down converter
- Zinitix's DC-DC controller
- ST Microelectronics' 300 mA LDO regulator, three-axis MEMS accelerometer



# Oura (Smart Ring)



# Oura (Smart Ring)

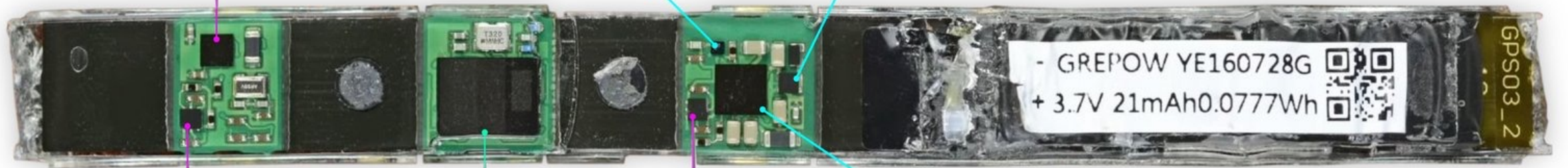
Unknown  
Rohm (?)  
Accelerometer/Gyroscope



Unknown  
Unknown  
Operational Amplifier (?)

Unknown  
Unknown  
Battery Fuel Gauge IC (?)

Unknown  
Unknown  
Wireless Charging IC (?)



Unknown  
Unknown  
IR LED Driver (?)

CY8C6336BZI (?)  
Infineon  
PSoC 6 MCU with BLE  
Connectivity

Unknown  
Unknown  
IR LED Driver (?)

BQ25155 (?)  
Texas Instruments  
Battery Management IC

# Apple AirPods (Smart Headphones)



# Apple AirPods (Smart Headphones)

- **Apple 343S00289** (likely Apple's new H1 chip)
- **Dialog Semiconductor** (Formerly Adesto) [AT25SL128](#) 128 Mb serial flash memory
- **Apple 338S00420** (likely a low-power stereo audio codec)
- **Bosch Sensortec** [BMA280](#) 3-axis accelerometer (likely)

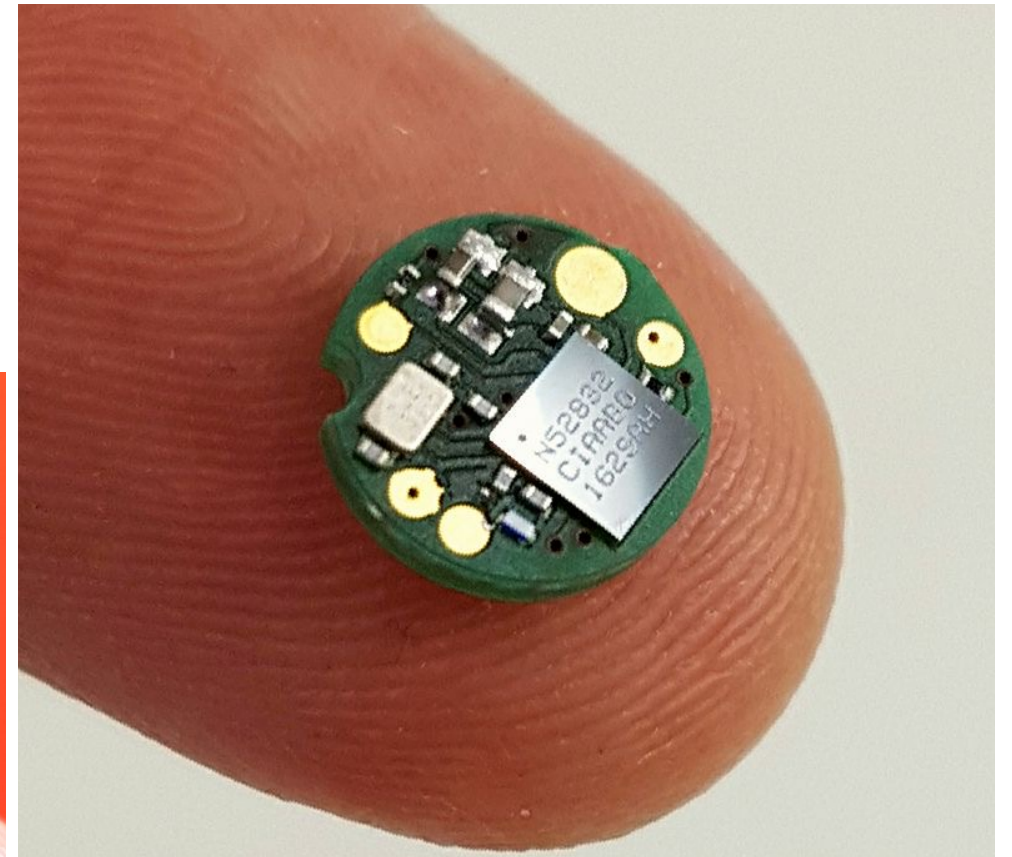
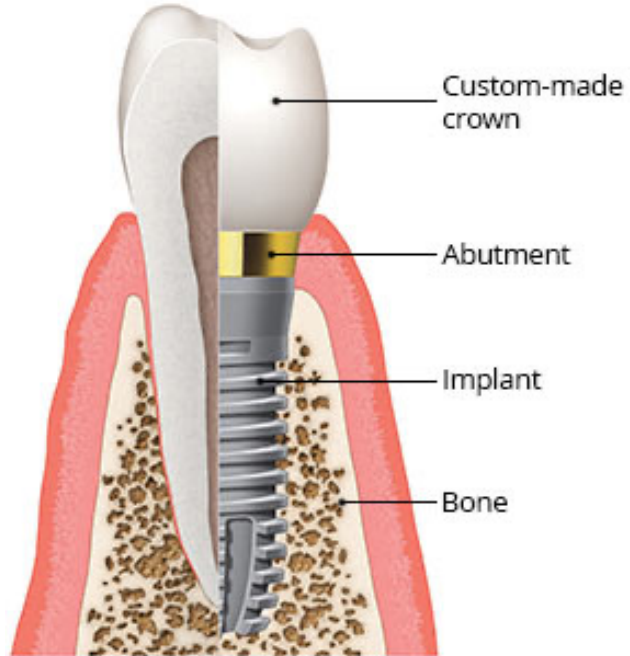


# Apple AirPods (Smart Headphones)

- 93mWh battery
- T 8 36 (likely STMicroelectronics inertial sensor)



# Microsal (Smart Dental Implant)





# Software

# watchOS

- Released 2015 exclusively for Apple Watch
- Limited open-source components
- WatchKIT API for developer use
- UNIX-like, slimmed down version of iOS
- Mostly closed ecosystem



[apple.com/watchos/watchos-9](https://apple.com/watchos/watchos-9)

- Open-source OS
- Developed by Intel, Vodafone, Orange, Samsung
- Not exclusively for wearables
- Native HTML5 app support
  - HTML, CSS and JS
- Tizen for wearable OS
  - Light version developed by Samsung
- Low footprint
- Optimized battery life



- Launched 2014, multiple HW platforms
  - 32-bit ARM, x86
- Open-source, closed source components
- Modified Linux kernel
- Multiple partners
  - LG, Asus, Samsung, Sony, Motorola



- Open-source RTOS
- Runs on a variety of HW platforms
  - From 8-bit AVR to 32-bit ARM
- UNIX-like, POSIX compliant
- Modified versions for trackers & watches
  - Fitbit, Xiaomi
- Growing user base and following



# Concerns

- Wearables might lead to an improved, better life
- Putting your body online might not always benefit you
- Give whole level characteristics to the service provider not each user level specific information
- Ensure visibility for what the user is sharing
- Human agency and responsibility need to be in the loop

- Wearable Device can be hacked and attacked wirelessly. Patients may die.
- Spoofing and altering are dangerous phenomena which can actually derail the whole purpose. May create panic.
- Side channel attack through power trace analysis is possible.



# Energy

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- Main reason applications on wearables are limited
- A lot of R&D effort spent at all levels (HW+SW) to solve this issue
- Main trends
  - Processors become more and more efficient – smaller nm technologies for ICs
  - Software becomes more and more optimized – double-edged sword
  - New energy sources become attractive – wearable might end up powered by you

- Too much personalization or assistance will repel users
- Users will be overwhelmed by the huge amount of data and can easily be panicked by misinterpreting any vital health data
- May curb creativity and reduce recall rate

# What comes next?

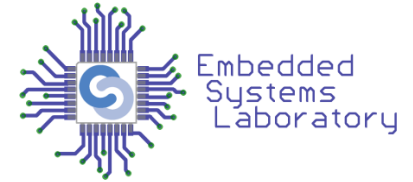
# Deeper Integration?

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- Move towards seamless integration with other systems
- Market becomes more consolidated and standardized
- Advanced sensing – neural link, health assessment
- Metaverse?

# Edible Computers?

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- "I expect to see edible computers pills, which will act like little medical monitors, downloading information about your state of health to a computer you wear."
  - Nicholas Negroponte, MIT Media Lab, 1999
- Technology already small enough to become implantable, only limitation is battery life