



Mission ~~im~~possible:
Shrinking electronics pack more and
more features into wearable devices

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Introduction

The idea of a wristwatch becoming popular as a convenient form factor for a wearable device can be traced back to World War I. Then soldiers needed a hands-free timepiece in combat conditions and so lugs were welded onto the sides of pocket watches to attach straps. The next milestone in this evolutionary story is the two-way Wrist Radio that appeared on the arm of a comic book detective called Dick Tracey in Jan 13th 1946. Amazingly, an inventor named Al Gross had just created such a device for real. Over the years, Dick Tracey's comic book watch had more features or gadgets added to it and naturally featured heavily in the film Dick Tracey. It actually resembles a smartwatch of today, which is perhaps not surprising as Tim Cook, Apple's CEO, described that, as a little boy, he hoped to see a real Dick Tracey Watch.

Dick Tracey was not the only user of a gadget watch. Because it is such a handy, always-with-you device, it is beloved of fiction writers to use it as a place to build in extra features to help the hero or heroine. James Bond's watches have had amazing gadgets incorporated by Q in the films since 1973, such as a circular saw, a powerful magnet, a laser, a grappling hook with cable, explosives and a pager although the pager feature is the nearest to make it into reality. Actually, the Bond spoof "Get Smart" TV series predated gadgets in watches by eight years with a wrist communicator watch in 1965! Almost every major science fiction series has had a wrist communicator or some form or another: Star Trek, Battlestar Galactica, Star Wars, Back to the Future, and not forgetting Buzz Lightyear in Toy Story! Some of these futuristic ideas have inspired engineers to change pure fiction into actual working features over the years.

Take a smartwatch of today back twenty years. It would be considered the work of pure science fiction: full mobile phone technology to connect to any other phone in the world, GPS, a powerful computer with full-color screen and numerous programs, a store of umpteen songs, a heart rate monitor, an ECG, blood oxygen sensor, etc. And that is just in some of the latest versions developed since the smartwatch launch around 2015 as smartphone features shrink down into the smartwatch.

What will the next five years bring in terms of new features? COVID has been a catalyst for accelerating the tracking's inclusion and health monitoring features, so expect many more health monitoring features as the location on the skin is ideal for biometrics such as a blood sugar sensor. Also, given the considerable increase in video calls due to the COVID lockdown and the increased bandwidth capability of 5G, video calls should be coming to your smartwatch soon, along with streamed video entertainment. These features are evolutionary predictions based on extrapolating current technology and shrinking smartphone technology. The real excitement for designers of smartwatches is the revolutionary features – the disruptive technology advances that form a quantum leap forwards. So, designers often see something in science fiction and it becomes a challenge to make it real; Star Trek's communicator inspired the Motorola flip phone. Smart glasses have been featured in several movies, with versions being made over the last decade. They have not really taken off but that is set to change with new technologies coming on stream that will make this the decade when smart glasses become a mainstream format. The world of electronic design is the most amazing place to work as it literally turns fiction into reality.

This article looks at the design trends and requirements of the so-called wearables that can be split into two groups. The first group is for devices that enhance the user experience with time, appointment reminders and other personal assistant features. The second group is for medical devices to track the user's health and activities such as heart rate, pulse, blood oxygen level, blood pressure, blood sugar, ECG, etc. These features are merging into devices in the first group as users become more health-conscious and want to know more and track their health to take responsibility for it.

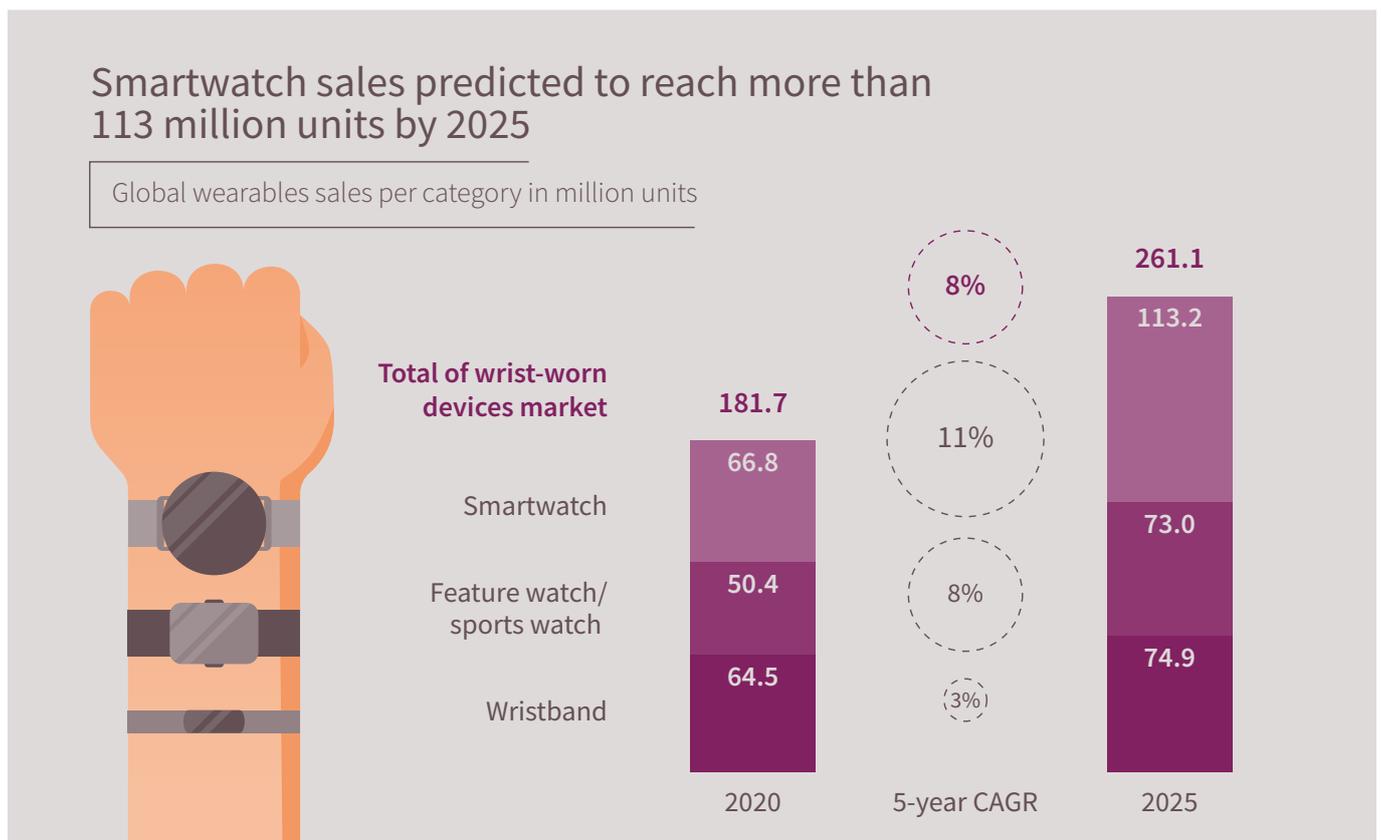
What was the key to the smartwatch suddenly becoming a success?

A better question is what was stopping it from becoming a success? It was simply that the battery life was not good enough to last a day of use. Having to recharge a watch during the day was just not a practical option for most people. The size of the watch case constrained the usual choice of a bigger battery: interestingly, traditional watches for women have had smaller cases, but that now seems to have faded away in favor of a large watch case with a big battery as practicality triumphs over fashion.

The most significant power drain is the color display. A partial solution was only to have it active when required by tapping the watch or flicking the wrist - not ideal as not that easy when doing other things such as driving and rather noticeable when in a meeting. It was only a couple of years ago that smartwatch sales really took off when better, less power-hungry screen technologies became available so that a single charge would last more than a day. So, the two key considerations when designing wearables are minimizing both energy consumption and the size of components so that you can pack more and more features within the standard-sized watchcase.

Growing market size

Now that the battery life problem has been solved, based on Strategy Analytics global unit shipment sales of wrist-worn devices are expected to continue to grow from 182 million units in 2020 to 261 million units by 2025 (CAGR of 8%). This is because more and more people find just how useful, productive, and fun it is to have a personal assistant and infotainment system on their wrists.

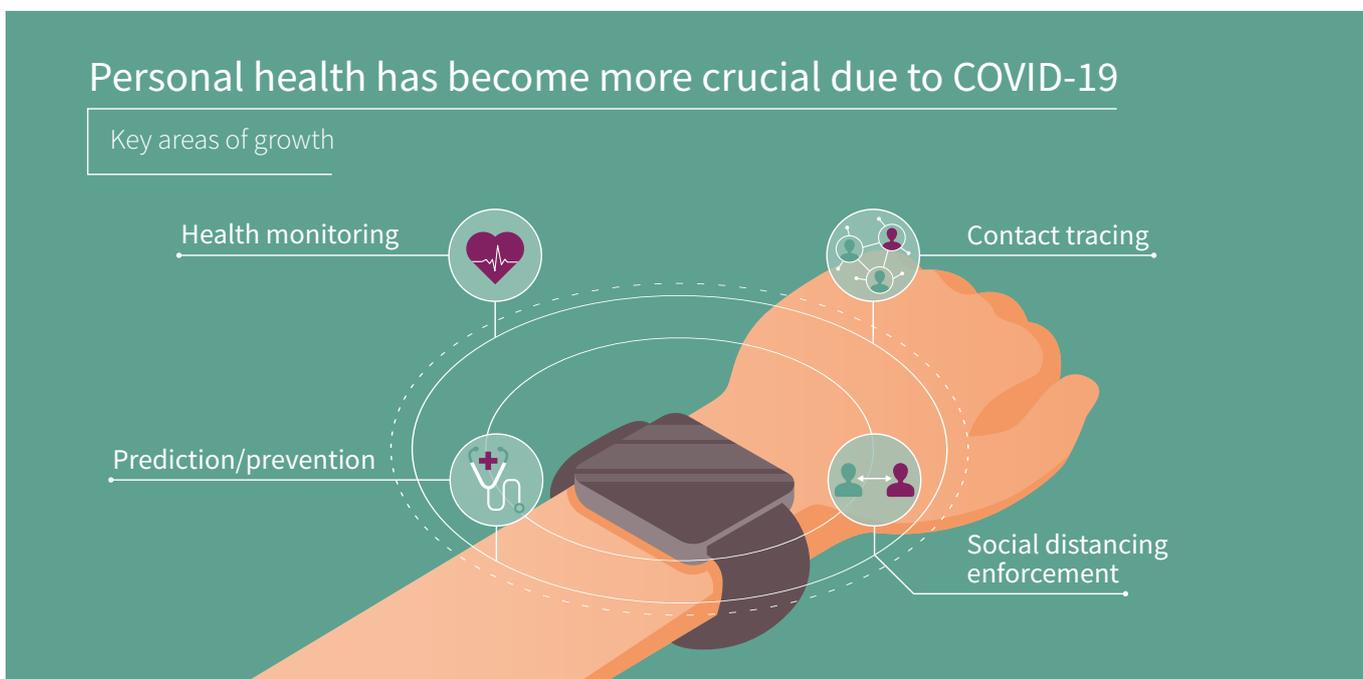


Until 2024, OMDIA reports that the segments consumer medical, diagnostic, patient monitoring and therapy, will reach a revenue of \$3,22bn (CAGR(2020-2024) of 6%) which will also boost the health wearable market. The trend here is for medical devices to be adapted into health devices for consumers. For example, a multi-lead Electrocardiogram (ECG) machine that required a trained operator to be attached has now been transformed into something that fits within a watch form factor, albeit with a very narrow use case of detecting atrial fibrillation. And, amazingly, this can fit into the smartwatch format along with all its other features.

But why do users want these health features?

Firstly, people live longer and realize that they need to look after their bodies and that monitoring can really help keep a check and motivate themselves. The little reminder to stand up every hour makes a difference against the effects of a sedentary lifestyle. Some health insurers even incentivize their customers to use these devices to help keep them healthy. According to Insider Intelligence research, more than 80% of US consumers are willing to wear fitness technology, with a quarter of US adults already doing so and even more are predicted to do so every year. Secondly, COVID has brought home the importance of health checking, especially for early warning signs. For example, a blood oxygen sensor to detect low blood oxygen levels that have been linked to COVID-19. Also, social distancing and contact tracing are likely to be a standard part of life for a while and so these features will quickly migrate into smartwatches assisted by employers wanted to ensure that their staff are safe.

Health monitoring features, which are being developed at the moment, include cardiac condition and blood glucose along with blood pressure monitoring without the need for an arm cuff. The latter is already in development using the Infineon XENSIV™ Radar sensor along with software and algorithms from a US startup called Blumio.

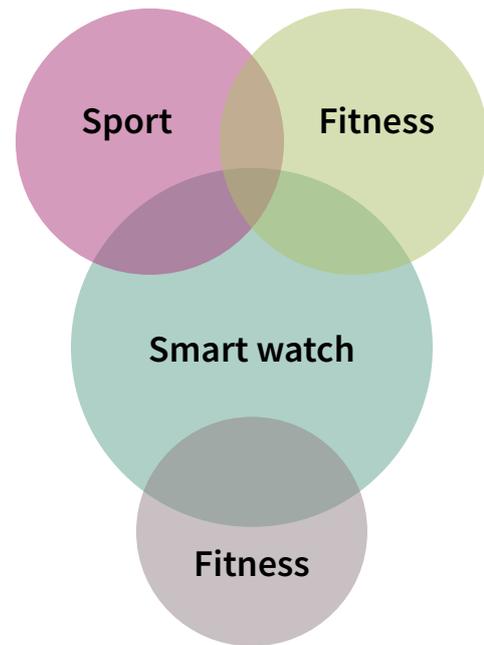


So, incorporating more sensors to monitor for potential health issues into smartwatches is clearly going to continue. The challenge is that they have to fit inside the established form factor and all the other components and not impact the battery lifetime. The answers can be found in Infineon's comprehensive range of products that address all the major functionalities of wearables – both smartwatches and medical/healthcare wrist-worn devices. They are easy to integrate with precise and robust measurements, tiny sizes and low power needs.

The Venn diagram of wearables and their features

Wearables can be split into four groups depending on their main usage scenario and the use-cases they feature:

1. Sports watches that are designed to be robust and usually water-resistant as they are used by leisure or professional athletes to monitor their sporting activity such as running, swimming, etc., to provide health information often along with sleep patterns. As a result of this focus, they usually don't have many of smartwatch features, although they might have GPS to track a running route on a map shown on display.
2. Fitness wristbands are a pared-down version of a sports watch with limited functionality and a primary display. Inexpensive and straightforward, there is only a limited range of basic monitoring such as step counting, sleep monitoring, access control, body temperature monitoring, etc.
3. Medical wrist-worn devices measure and analyze the wearer's physical activity and body functions who has a medical condition or is elderly and infirm. An alarm to call for help is usually incorporated. Here, the focus is on the accuracy of medical monitoring, so most smartwatches' features are not required. Again, the wrist and watch format work perfectly for this application. If categorized as a medical device, then there are much stricter regulations for such devices, so they are often described as health monitors.



The smartwatch is the supergroup that can have all the features of the other three for health, fitness and medical monitoring. In addition, there are other features for convenience such as NFC contactless payment, access control and ticketing, features for entertainment such as Bluetooth audio streaming to earbuds, and communication via text and phone call. Driven by the premium brands of Apple, Samsung Huawei, and others, the huge demand for smartwatches means that there are opportunities for competitors to create their own products that differentiate on design, features or price to win market share, especially as most of the parts for the features of current smartwatches are readily available to them.

There are two subsets of note that are becoming increasingly important:

1. Tracker watches for children. There are worrying statistics about child safety, such as the current global spike in child trafficking, with one in seven runaway children likely to be victims of child sex trafficking and abduction into gangs, with India reporting 44000 children forcibly involved in gangs every year. Even everyday events such as a trip to a large shopping center or a festival can result in the harrowing experience of losing track of where a child is. The key to these designs is a long battery life between charges of days or even a couple of weeks. This can be achieved by paring down features and having regular real-time location updates rather than continuous tracking. Add in an SOS button to alert a parent's phone and two-way communications to reassure and find the child, and both parents and child can feel much safer.
2. Monitor watches for the elderly. In today's busy world, there is less time to regularly check up on an elderly person, which has been made much worse by COVID. A wristwatch is a familiar format for a person to use and wear – mobile phones can be easily misplaced or not to hand when an emergency occurs. A simple SOS button is easy to use (no fiddly keypad with small buttons that are hard to see and operate). It activates a two-way connection to a monitoring center or family member to send the appropriate help. Add some sensors, and it can detect a fall, a change in body temperature, or a change in pulse to call for help automatically. Add GPS and the wearer's location is always known, which is vital in the case of people that go wandering off lost and disoriented. Lastly, ensure that the design has a very long battery life as wearers are likely to forget to recharge it regularly. A clear, low battery warning helps to remind them along with, perhaps, a next stage of an automatic alert to the monitoring station that a recharge is needed.

Things to consider when designing a smartwatch



There is a well-known saying in computer science - 'Garbage In, Garbage Out' meaning that flawed input data will result in faulty output. It is particularly relevant to smartwatch designs for health monitoring functions that can only be as good as the accuracy of the data gathered by its sensors. User expectations for these features are high. They want them to be accurate enough to provide early warnings of issues so that they can see their doctor and catch them early, which continual monitoring can do rather than only when having a check-up. The blood oxygen monitoring feature was developed in response to monitoring for signs of COVID, for example.

Having selected the best sensors to gather the data, the next issue is how it is processed into useful information. Some can be done within the watch, such as pulse rate but, as these features become more sophisticated, additional processing needs to be done on service provider servers via the cloud. As this is personal data, this data's security is paramount when being transmitted to the cloud and for the processed results coming back. Infineon offers IoT embedded security chips that ensure the integrity of these transmissions. Naturally, the data processing providers must also have in place robust measures to protect the privacy of the user's data.

As mentioned before, achieving a long operational life between recharges is critical. Any way to power down unwanted features can help prolong this time, such as

the example mentioned earlier of turning off the display. Movement sensors in the watch can detect when it is off the wrist because the user is swimming, showering or napping and so power some functions down. Also, turning off GPS if the user is clearly not moving much. Building in the intelligence to automatically use sensor data to save power can significantly improve operational life.

Another way to address this issue is to harvest energy to top up the battery. Automatic or self-winding watches are an early example of this that harvests the energy of wrist movements and stores it by winding up the mainspring. Similarly, some watch designs have solar panels to harvest sunlight to top up batteries. The current power requirements for Smart Watches are too great for these types of energy scavenging. Maybe one day, harvesting energy from the surroundings or even the human body (as it constantly radiates heat) could be used as there are plenty of possibilities, especially for wearables explicitly designed for low power requirements. Wireless charging at the moment requires close proximity for the inductive transfer of energy. However, if the distance between the smartwatch and charging device is increased without too much loss of energy, it could be possible to have a charging device on a desk that sends power to a smartwatch. This could even be at the same time it is being worn from a device built-in under a keyboard.

Health monitoring will increasingly feature in smartwatches

The Venn diagram shown earlier shows the overlap between smartwatches and medical monitoring devices. Medical monitoring provides early warning or predictions of possible health issues but, until recently, these devices were usually complex and needed trained operators that restricted their use to hospitals or doctors' offices. In some cases, they are small boxes that patients were connected to and carried around for a few days. Shrinking these into wearable form factors increases their usability as they can be used as patients go about their everyday lives and detect anomalies over a long period of monitoring. Shrink even more into a smartwatch and you have 24/7 unobtrusive monitoring that can even call for help in an emergency such as a fall or heart attack. This is particularly important for the growing demographic of the elderly, who are often

quite capable of a normal life but will be subject to early warning signs that they don't notice, but the smartwatch does. For example, ECGs can provide an early warning of a possible stroke or blood sugar level monitoring makes sure that people with diabetes take insulin or sugar exactly when needed.

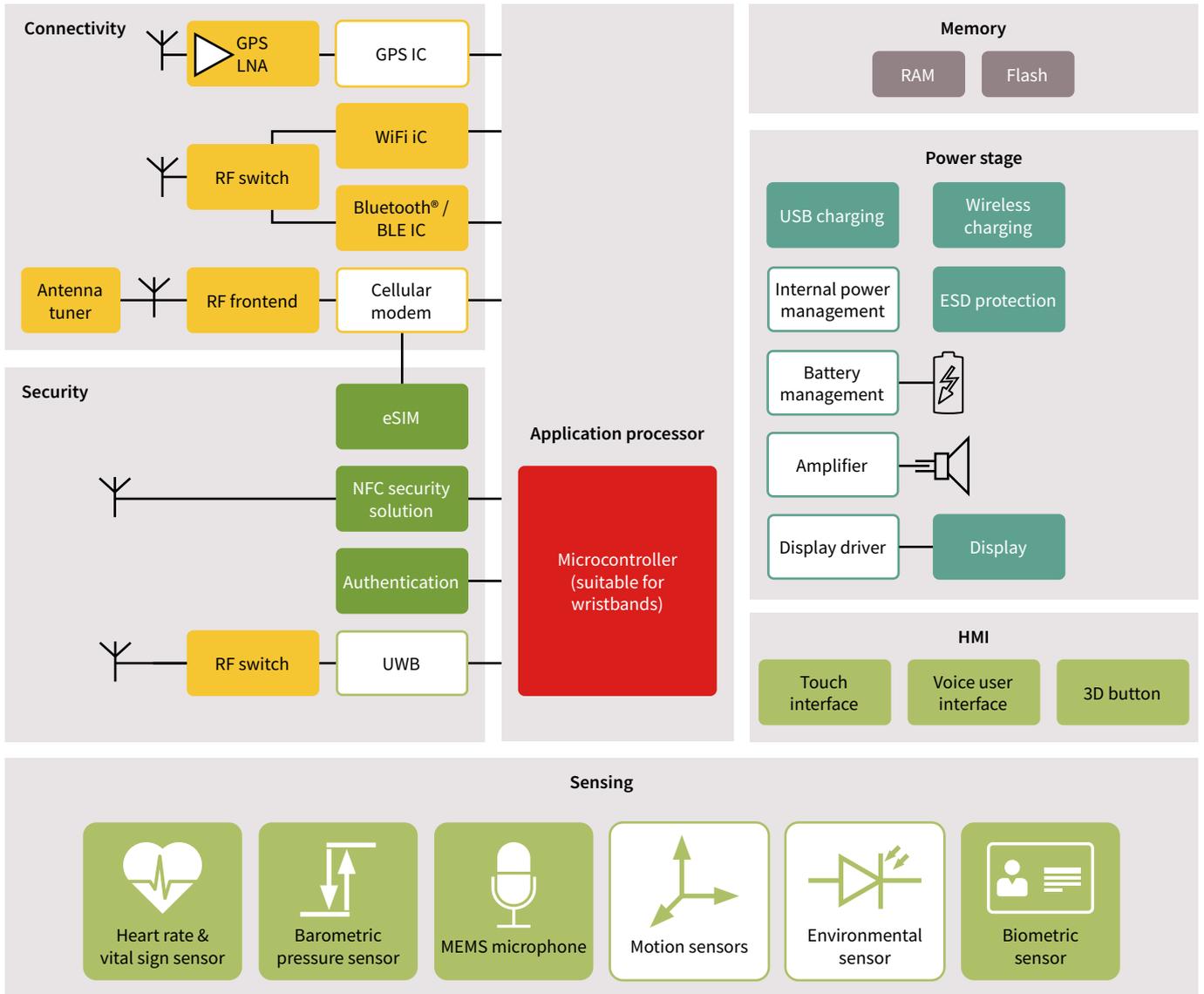
As more and more medical monitoring solutions are incorporated into smartwatches, the better the health of the wearer can be maintained so consumers will want more and more medical monitoring features. Old age is inevitable; what you want is to be healthy for as long as possible in your old age.

Infineon is a one-stop-shop for virtually every feature of a wearable design

Key enabling products from Infineon

- > [XENSIV™ 3D image sensor REAL3™](#)
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Example: smartwatch – block diagram



A wearable designer has to decide what features are required for the device from Infineon’s extensive list of power ICs and sensors that are already optimized for use in wearables with precision measurements, ultra-low power requirements and small size.

The list is growing as more features become available because Infineon continually pushes the envelope with new features for wearables. This makes Infineon the perfect partner for wearable designers who want to be at the forefront of product design with easy-to-integrate solutions to stay ahead of the competition with a fast time-to-market for new products. Infineon provides components and extensive support and system knowledge to assist customers in creating their latest designs. There is also an Infineon ecosystem of trusted software companies specializing in applications to run on the smartwatches for further product innovation and differentiation.

For further information on Infineon’s product range and world-class support, [please visit the application page](#).

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