

Health and Wellness in a Changing World

Renesas connectivity technology brings new potential to lifestyle monitoring and personal care products

We live in a data-rich world. Consumers are learning the value of personal data acquired from wearable and personal devices to improve their fitness, enhance their well-being, and support early and accurate diagnosis of health conditions. Manufacturers are responding to this changing demand by developing devices with more advanced health and wellness monitoring capabilities and smarter connections. These new wearable and personal products pose difficult challenges for designers to solve operating at ultra-low power to extend a small battery's run-time, the device also must provide slick performance in an attractive, compact form factor.

The hunger for more data from health, fitness and care products brings the manufacturer's approach to the provision of connectivity into particularly sharp relief: wearable and personal devices need extremely low-power, high-reliability Bluetooth®, Wi-Fi® and NFC chips to connect to a smartphone, internet access point or accessory.



Renesas Connectivity Solutions products provide a perfect fit for this new generation of health, fitness and care devices, offering Wi-Fi, Bluetooth and NFC chips and modules that are notable for their performance leadership, mature ecosystem and seamless integration.

This white paper provides a description of:

- The broad market trends which create demand for connectivity solutions
- The new and changing use cases for connectivity in personal and wearable devices
- The comprehensive Renesas solutions offering to manufacturers of health, fitness and care products, including a broad ecosystem of RF chips and modules, alongside microcontrollers, software and tools
- Stories of customers who have enjoyed success with Renesas Connectivity Solutions products

Your Life, Your Health and Fitness, Your Care: Why Technology is Becoming More Personal and Connected

Consumers are becoming used to having their lives tracked, measured and monitored by smart devices. Personal and home technology devices such as smartphones now know where we are, how we got there, and what kind of activity we are doing, at any time of day or night.

Now connectivity and intelligence are being built into a wider range of personal health, fitness and care devices, extending the benefits that consumers can derive from data shared with their smartphone and with cloud computing services.

This is driving fast growth in consumer demand for the most advanced health and wellness products for home or clinical use. Forecasts suggest that annual revenue in the global connected health device market is expected to reach \$31.6bn by 2030, increasing at a compound annual growth rate of 8.0% between 2024 and 2030 [1]. Commercial investment in products and technology is benefiting from the encouragement of governments: in the US, for instance, the Food and Drug Administration has launched a Digital Health Innovation Action Plan, and the China government is pushing digital healthcare technology through its Healthy China 2030 initiative.

New digital technology can help address the host of health and lifestyle problems prevalent in highly industrialized countries, from rising rates of obesity and diabetes - more than 1 billion people worldwide are now classified as obese [2], while it is estimated that one in 11 adults lives with diabetes [3] - to a recent fall in sleep quality, with a trend beginning in 2013 for more people to suffer from short sleep (defined as fewer than 6 hours a night) [4]. Products such as smart bands and smart rings have the potential to help consumers monitor their activity and sleep, and then make beneficial changes in lifestyle and habits to improve health or wellness.

This is giving rise to three broad trends that are driving demand for connectivity in personal and wearable devices.

1. Consumers in 24/7/365 measurement mode

Consumers have embraced the new capability to track their lives: via devices such as smartphones, smart watches and smart rings, people can track multiple lifestyle and health parameters continuously, in real time: not only lifestyle factors such as activity (eg step counting) and sleep, but also health-related factors such as cardiovascular state (heart rate, blood pressure, blood oxygen saturation) and body temperature.

Consumers are learning the new techniques of living a data-driven life: the information from smart devices is valuable, because it provides information that consumers can draw on to make health-enhancing changes to their lifestyle, and to adopt new healthy habits.

2. Technology to make technology easier to use

Consumers attach a high value to technology that is easy to use and quick to learn. Manufacturers can strengthen the appeal of their products by guiding the consumer through the set-up, use and maintenance of their devices – and this is often enabled by a Bluetooth connection between the device and a smartphone app, or an internet connection between the device itself and a cloud computing service.

So, connectivity, via Wi-Fi, Bluetooth or NFC, is a critical component of these new categories of smart devices.

When a device is smart and connected, it is:

- **Easier to commission** – a simple tap can seamlessly pair an NFC-enabled device with the user's smartphone. Once the connection is established, the appropriate configuration is then automatically pushed to the device via the cloud-connected smartphone app.
- **Easier to maintain** – smart devices can track usage over time, providing the user automatically with alerts when a consumable needs to be replaced. A device's connection also allows for automatic downloading of firmware upgrades over-the-air, or of improved configuration settings adjusted to match the usage of the device. Usage and performance data also enable preventive maintenance, alerting the user to the need to service or repair a device before it fails.
- **Easier to fit compatible accessories** – smart devices that require accessories or consumables can use an NFC connection to identify specific units and monitor their usage. Paired with a smartphone via a Bluetooth link, the device can send the user an alert when a replacement accessory is required.

3. A single platform connected to everything

The information from a single personal device such as a smartphone can provide a partial view of a person's health or lifestyle, such as their activity levels. Combining data from multiple systems, including devices such as a smart ring and a continuous glucose monitoring patch, can enrich the information available to produce a comprehensive, rounded picture of the user's state of health.

This is what a cloud platform can do today, aggregating data from a range of connected monitoring devices. This is leading to new practices in patient monitoring and treatment:

- Practitioners can monitor at-risk patients remotely 24/7, enabling timely interventions when a patient is showing indications of elevated risk of conditions such as heart attack or stroke. Remote monitoring also enables real-time adjustment of therapeutic interventions for patients suffering from conditions such as diabetes, without requiring a visit to a hospital or clinic.
- Remote monitoring is also valuable for family members and carers, for instance to receive an alert when a device detects that an elderly person has fallen at home.
- Medical services can correlate data from multiple devices to track the evolution of a patient's health condition and identify symptoms of disease at an early stage.
- Consumers can track trends in indicators such as blood pressure, heart rate, and sleep quality, to assess whether lifestyle changes are necessary to enhance their well-being or long-term health outlook.

All three trends – 24/7 monitoring, smart tech for convenience, and aggregation of multiple data sources – are leading to increased demand for Bluetooth, NFC and Wi-Fi networking solutions to link battery-powered health, fitness and care devices to each other, to smartphone apps, and to the cloud.

This calls for a new generation of RF chips and modules which provide high performance and ultra-low power consumption, alongside software and tools which support artificial intelligence (AI) data processing at the edge on advanced microcontrollers and microprocessors.

The Uses of Pervasive Connectivity in Personal Devices

The next generation of smart health, fitness and care products is set to benefit consumers at every stage of life. But how are tomorrow's device users going to take advantage?

The Social Media Generation

Young people taking their first steps into adult life treat the online world as an organic extension of the real world. Technology natives, they use every device to the max for convenience and time saving.

A young adult will be comfortable tapping a terminal with their NFC-enabled smart ring to pay for goods or travel tickets. They will expect their hair dryer to be a smart hair dryer: their favourite social media influencer knows the best accessories to use with it. They hate wasting time, so they just want the hair dryer to connect automatically with their phone to go straight to the app for ordering their recommended accessory.

In these devices, space is at a premium: the smaller the NFC or Bluetooth Low Energy circuit can be made, the more space is available for the designer to optimise the appearance of the device, or to fit in extra value-added features.

Young people also do not want to be bothered to set reminders to change the brush head on their toothbrush: they want a smart toothbrush to automatically log usage, and alert them when the brush needs replacing – an intelligent toothbrush can even advise them on which type of brush head to choose to best match their brushing habits.

The Fit and Active Thirtysomething

Approaching middle age, many thirtysomethings work hard to be healthy and fit – and they want to make sure that they stay that way.

Personal tracking devices provide them with the data they need to manage their healthy lifestyle – not only a smartphone for step counting and activity tracking, but a smart ring for sleep monitoring, and 24/7 measurement of vital signs such as heart rate, blood pressure, blood oxygen saturation, rate of respiration and skin temperature.

This vital sensor data becomes valuable once it is transferred to an app where it can be analysed. A smart ring's Bluetooth Low Energy connection needs to provide for reliable data exchange with a smartphone, but the design is challenging: the smart ring's battery is minuscule, yet the user demands adequate run-time between charges, so the Bluetooth chip or module must offer extremely low power consumption. And space is so limited in a smart ring that the Bluetooth chip's form factor is also of critical importance: every square millimetre that can be saved in the chip's board footprint is valuable.

An important new source of power savings in smart sensor devices is artificial intelligence (AI) performed locally on the device with an AI-capable microcontroller. Local processing of this sensitive data not only protects the user's privacy: it can also enable a huge reduction in the amount of data that needs to be transferred from a smart ring to a data processing service in the cloud. Active transmission and reception of data consume large amounts of power in a Bluetooth or Wi-Fi radio system: by reducing the number and volume of data uploads, AI at the edge can reduce power consumption.

This technique for reducing power consumption is also applicable to other forms of personal monitoring. At night, our thirtysomething wears a smart mouthguard for monitoring sleep. Connected via a Bluetooth Low Energy link to a smartphone app, the mouthguard enables analysis of sleep data and monitoring of improvements in sleep behaviour over time.

To enable a mouthguard, which is in constant contact with the user's saliva, to be hermetically sealed, it includes an NFC connection to provide for wireless charging alongside the Bluetooth Low Energy radio for data exchange. As in the smart ring, the requirement for the mouthguard's Bluetooth and NFC components is for ultra-small size alongside low power consumption.

Supporting the User's Life at Home

Connected health and care products have a valuable role to play in keeping users safe, and in monitoring their health for the early onset of illness. A continuous glucose monitor (CGM), for instance, enables real-time monitoring of insulin levels in diabetic patients. Monitoring data are transferred from the CGM to the user's smartphone via a Bluetooth Low Energy link. As with other personal health devices, so with the CGM the requirement of the Bluetooth chip is for a combination of extremely low power consumption, to prolong battery run-time, with a small package size.

The acuity of people's hearing declines with age: the latest NFC technology can enable hearing aids to be charged wirelessly. The NFC link also allows for data exchange with its charging cradle, for instance for power negotiation during charging, or to update the charging cradle's firmware. In a space-constrained device such as a hearing aid, NFC chips must combine small size with high RF performance: an NFC circuit that requires few or no external components and that operates via a small antenna offers the greatest value in a hearing aid.

Connectivity adds value to home devices that are for personal care as much as for health and wellness. For instance, a connected fragrance diffuser can perform auto-configuration of a range of fragrance pods and connect wirelessly to air quality sensors to trigger operation automatically.

Home care devices need to be capable of being placed in any room, no matter how distant from the main internet access point. The Wi-Fi chip which connects, for instance, a fragrance diffuser to the cloud needs to provide high sensitivity and RF output power to ensure its signals reach the farthest corner of the home, while minimizing the board footprint to enable the OEM to create sleek and unobtrusive product designs.

A Portfolio of Wireless Technologies for the Key Application Requirements in Health, Fitness and Care Products

Across the use cases for smart health, fitness, and care products, wireless connections are required to perform different functions. With a broad portfolio of Bluetooth Low Energy, Wi-Fi and NFC chips and modules, Renesas Connectivity Solutions provides all the functionality required.

Bluetooth Low Energy

The universal wireless technology for connecting to the smartphone, Bluetooth Low Energy links provide for data exchange at rates up to 2Mb/s, sufficient for many functions in smart devices such as transferring live sensor data, updating location information, and uploading firmware updates over-the-air. Bluetooth Low Energy can do this while providing ample range for coverage within a typical room in a home, office or

other building. And this connectivity capability is combined with very low energy consumption, allowing use even in devices that have the smallest of batteries, such as a hearing aid or continuous glucose monitor.

Renesas products are continually updated to maintain compliance with the latest versions of the Bluetooth specifications. New versions of the Bluetooth technology regularly add new capabilities which are supported in Renesas Connectivity Solutions products. These include support for indoor positioning and navigation, functions which underpin tracking in connected healthcare applications.

NFC

NFC is most familiar to consumers as a technology enabling contactless payment and ticketing via a smartphone, smart watch or smart ring at short range, typically up to 10cm.

In smart health, fitness and care products, NFC connectivity provides other valuable functions. When an accessory equipped with an NFC tag is tapped to a device that has an NFC reader embedded in it, the main device can automatically identify the accessory – for instance a brush head fitted to a smart toothbrush, or a fragrance capsule for a fragrance diffuser. The device can then automatically adjust its configuration to optimise for the chosen accessory. The device can also track usage of a uniquely identified accessory and alert the user when it needs to be replaced – a valuable benefit, for instance, for the toothbrush user who keeps multiple brush heads in use concurrently. Such value-added services can encourage the user to choose only branded accessories.

NFC technology also supports energy harvesting and wireless charging of the battery in small devices such as smart rings, hearing aids and mouthguards. NFC wireless charging technology from Renesas enables charging via a very small antenna, with high tolerance of misalignment between the device's antenna and the chargers.

And an NFC tag in a device such as a smart fragrance diffuser can support data exchange with a smartphone to enable automatic onboarding to a home Wi-Fi or Matter network, saving the user the laborious task of configuring network connections and a device ID.

Wi-Fi

Wi-Fi technology is the way most wireless devices connect to the internet. For a laptop computer or smartphone, the benefit of Wi-Fi is its high data transfer rate. In smart health, fitness and care products, Wi-Fi technology is as valuable for its long range – typically 30m or more inside a building. This provides for reliable data transfer from any room in the home, even at a long distance from an access point.

Wi-Fi connections are valuable in home and personal care devices. For instance, a Matter-compatible fragrance diffuser connected to a home's internet access portal can connect via the Wi-Fi network to Matter-enabled air quality sensors, triggering it to release fragrance when the sensor detects unpleasant odours indoors.

Renesas: An Integrated Ecosystem for Control and Connectivity

Communications technologies, whether Wi-Fi, Bluetooth, or NFC, provide the connections that make possible the operation of smart personal and wearable devices.

Many manufacturers of smart devices today look to Renesas to provide the semiconductors, software, tools and development environment on which their products are based. Their choice of Renesas is built on three foundations:

- Mature ecosystem
- Performance leadership
- Seamless integration

A Mature Ecosystem that Combines Control with Connectivity

When manufacturers engage with Renesas Connectivity Solutions, they are working with the world's largest manufacturer of microcontrollers, shipping 3.5 billion units per year. Alongside its microcontrollers, Renesas also offers a broad portfolio of Wi-Fi, Bluetooth and NFC products.

These connectivity solutions are partner products to the microcontrollers: for instance, Renesas wireless devices are readily supported in the e2 studio integrated development environment, which is familiar to users of Renesas microcontrollers. In fact, users of Renesas Connectivity Solutions products and microcontrollers have complete access to the industry's most comprehensive set of design tools and resources, including:

- Flexible Software Package (FSP) of middleware, drivers and operating systems
- Reality AI Tools[®] solution for development of edge AI applications on connected smart devices such as gateways and endpoints. These systems can be highly resource constrained in terms of power, memory and processing capability: the Reality AI Tools system helps designers to optimize AI performance within these constraints.
- Ready-to-use protocol stacks for Wi-Fi, Bluetooth and NFC connections
- Rich libraries of software code and hundreds of code examples
- Debugging and simulation tools
- Security software, certifications and provisioning capabilities

Renesas has announced its intent to acquire Altium, a premier supplier of electronic design systems. Altium's sophisticated cloud platform capabilities combined with the Renesas' extensive portfolio of embedded solutions promises to deliver users an integrated and open electronics system design and lifecycle management platform.

The combination can also enable integration with third-party vendors to execute all electronic design steps seamlessly on the cloud.

By partnering with the leading provider of embedded controller products, manufacturers of smart health, fitness and care devices gain access to a uniquely rich set of developer and software resources.

Performance Leadership to Meet Demanding Requirements for Power and Throughput

In smart health and care products, power consumption is a critical parameter of concern, to extend the run-time of a device's battery, and to simplify thermal management: efficient systems generate less waste heat. At the same time, always-on health and care products require robust, strong connections. The superior

performance of Renesas Connectivity Solutions products ensures manufacturers can gain a competitive design advantage in both power and performance.

Ultra-low power operation – Renesas deploys VirtualZero™ Wi-Fi technology which provides the longest battery run-time for power-constrained Wi-Fi-connected devices. A broad range of Bluetooth Low Energy chips and modules takes advantage of proprietary Renesas silicon fabrication and circuit design innovations to achieve extremely low power consumption. Extended battery run-times are possible with the use of Renesas Connectivity Solutions products: 30 days of operation in battery-operated insulin injectors, for instance, which have a tiny 1.5V silver oxide battery; and up to 21 days' operation in a continuous glucose monitor, also running on a silver oxide battery.

Small form factors – thanks to advanced packaging technology and circuit design, Renesas Connectivity Solutions products are available in ultra-small packages which can be accommodated in the smallest products, such as smart rings. Superior design features in Renesas Bluetooth Low Energy modules means that they require just six external components, compared to more than 15 for competing modules. The reduction in component count substantially reduces the system's board footprint.

Renesas NFC products are similarly space-saving: for wireless charging, the PTX30W integrates the entire listener circuit in a 1.78mm x 1.78mm package. The use of wireless charging eliminates the need for a mechanical connection (pogo pins), and the system operates through a PCB antenna of flexible configuration, occupying a board footprint of typically 50mm² or less.

Connecting at the edge – Renesas enables intelligence at the end node thanks to the AI capabilities in its microcontrollers and microprocessors, which pair seamlessly with Renesas Connectivity Solutions products. Supported by the Reality AI Tools solution, new smart device designs support pre-processing of data at the edge so that less data needs to be transmitted, saving power.

Local AI data processing also protects the privacy of the user's personal health data and eliminates the risks involved in third-party ownership of personal data. It also enables analysis of critical information in real time, without the latency inherent in cloud server processing. This can provide life-saving speed of response, for instance when a device's local AI detects that a vulnerable person has fallen at home, posing a high risk of injury.

Where the user's life or safety depend on a medical device such as a continuous glucose monitor or insulin injector, AI at the edge can detect operational anomalies that indicate a risk that the device is likely to fail, enabling the user to replace it with a sound replacement.

Feature set optimization – the broad range of products in the Renesas Connectivity Solutions portfolio meets varied requirements. Renesas Connectivity Solutions has a long heritage in the Wi-Fi, Bluetooth and NFC markets thanks to its track record of strategic investment in best-in-class producers.

Over a range from tens of millimeters up to longer than a kilometre, the Renesas Connectivity Solutions portfolio provides for all connectivity needs.

Technology innovation and superior R&D – Renesas products benefit from the company's advanced silicon process technologies, in-house fabrication capabilities, and long-term investment in research and development into improving circuit and system designs. Examples include DiRAC® technology for NFC wireless charging at twice the speed of competing products, and ultra-low power VirtualZero™ technology for always-on Wi-Fi networking.

Seamless Integration of Connectivity and Control Products into High-Performance Device Designs

Across its broad portfolio of products covering multiple wireless networking technologies, Renesas Connectivity Solutions ensures that customers' connectivity designs co-operate seamlessly. For instance, NFC and Bluetooth products can be designed to work together to support simple touch-to-pair functionality. And Renesas is a member of the Connectivity Standards Alliance, which created the specifications of the Matter protocol for seamless interoperability of personal and home devices. Renesas is integrating support for the Matter protocol into its portfolio of Wi-Fi solutions.

Integration of Renesas connectivity products is eased by the availability of expert technical assistance from a worldwide team of applications engineers, backed by a rich set of development tools, resources and documentation.

And once an OEM has designed in a Renesas Wi-Fi, Bluetooth or NFC chip, they can be confident of its availability for the life of the product: the Renesas Longevity Program guarantees long-term availability of products and secures customers' investment in product designs and IP. Products in the program are backed by a stable and robust supply chain.

Finally, Winning Combinations reduce the customer's design effort by offering ready-made vetted circuit designs that combine compatible products in a pre-tested architecture, to give OEMs a head-start in implementing designs for smart health, fitness and care devices.

Connectivity in Health, Fitness, and Care Products — Use Case Examples

Connected Health

Continuous glucose monitor

The glucose monitor, which is used by diabetic patients, has undergone a technical transformation which has led to a renewed emphasis on the low-power operation of a Bluetooth Low Energy link to a smartphone or dedicated medical reader. Renesas Bluetooth products suitable for a glucose monitor are equally applicable to other types of medical monitoring devices worn on or just under the skin.

Traditionally, patients have used a blood glucose monitor (BGM), which requires them to draw blood up to ten times a day. This type of monitor is supplied by a primary or rechargeable battery.

The **DA1469x family of Bluetooth systems-on-chip** (SoCs) provides the ideal solution for this device, because its high level of integration keeps the system's component count and size to a minimum. The SoC contains a 96MHz Arm® Cortex®-M33F CPU core to run application functions such as processing signals from the glucose sensor, alongside a 96MHz Cortex-M0+ core operating as a sensor node controller and configurable media access controller for the on-board Bluetooth Low Energy v5.2 radio. The device's rich set of integrated features includes an LCD controller and a USB charging controller with software fuel gauge.

The latest form of glucose monitor is the continuous glucose monitor (CGM), a patch worn on the skin: replaced every 14-21 days, the patch runs on a disposable silver oxide battery of the type typically used in watches. The patch communicates over a Bluetooth link with a paired medical reader. A buck-boost converter integrated in the DA1453x SoC eliminates the need for an external DC-DC battery power

converter, reducing component count and bill-of-materials cost. The buck-boost operation extends battery run-time, as it allows for continued operation far into a 1.5V battery's discharge cycle, when its output voltage has fallen below its nominal value.

Using the DA1453x, a complete Bluetooth Low Energy system can be realized with the addition of just six external passive components, and a crystal timing device. It is supplied in a 2.0mm x 1.7mm or 3.0mm x 2.2mm package.

The medical reader paired with the patch will benefit from the use of a **DA1470x family Bluetooth Low Energy SoC**. These highly integrated devices enable a streamlined design implementation with a low component count and small board footprint.

Based on a 160MHz Arm Cortex-M33F CPU, these SoCs include a 2D graphics processor, Voice Activity Detector (VAD) and Power Management Unit (PMU). Equipped with an ultra-low-power radio transceiver, the DA1470x SoCs support the Bluetooth v5.2 specifications.



Hearing aids

Hearing aids with rechargeable batteries benefit strongly from the implementation of wireless charging. The use of rechargeable batteries increases the value to the user, because it simplifies operation and eliminates the need to stock and replace primary batteries at home, or to take the hearing aids to a service centre for battery replacement.

A mechanical connection – typically a pogo pin – between the hearing aid and its charger is prone to failure caused by contamination: dirt, dust and wax from the user's ear readily build up on the pogo pin over long periods of continuous wearing.

The use of wireless charging enables the hearing aid manufacturer to create a completely sealed unit with no opening for the ingress of dirt or fluids.

Renesas offers a complete integrated system for wireless charging on the listener (hearing aid) side: housed in a 1.78mm x 1.78mm WLCSP package, **the PTX30W** includes an NFC tag, active rectifier, limiter, battery charger circuit, and dedicated core. The PTX30W's core implements the wireless charging protocol on-chip, allowing the design of stand-alone listener systems with no host microcontroller.

Powerful and efficient, the PTX30W harvests up to 1W from the charger, and provides a channel for data exchange, useful for uploading information to the charger, for instance about the battery's state of charge, or for over-the-air firmware updating.

While eliminating the need for external discrete components, the PTX30W offers superior RF performance to enable the use of a small antenna with flexible placement of the poller's (charger's) and listener's antennas.

Insulin pen/Injector

Manufacturers of smart injectors, which require a Bluetooth Low Energy connection to the user's smartphone and to a medical reader, grapple with a challenging set of design requirements.

Injectors operate from a very small silver oxide primary battery, which has high internal impedance. This leads to high peak currents at start-up. The small battery also needs to retain its charge over a potentially long shelf life. The tiny plunger cap at the top of the injector has to accommodate all the electronics.

The highly integrated **DA14531 Bluetooth Low Energy SoC** is an ideal solution for this set of requirements. The benefits of small size and reduced component count which are valuable for a continuous glucose monitor (see above) apply equally to injectors. In addition, the DA14531 includes:

- Built-in peak current limiting to protect the system at start-up
- Ultra-low current of 270nA in hibernation mode at 25°C, for long shelf life
- On-chip quadrature encoder, providing a data interface to a rotary encoder IC for detection of the first dose event and dose setting

The DA1459x series Bluetooth Low Energy SoCs are another attractive option, as they provide new scope to reduce power consumption in injectors and other types of battery-powered medical device.

In their low-power mode, the DA1459x devices draw transmit current of just 2.3mA at 0dBm, and radio receive current of 1.2mA. Hibernation current is only 90nA, which extends the shelf life of end products shipped with a connected battery. For products that require extensive application processing, the DA1459x boasts an ultra-low active current of 34µA/MHz.

Connected Fitness

Smart ring

A smart ring provides a rich set of sensor data processing and connectivity functions in a tiny form factor. Smart rings may include NFC capability for contactless payment and wireless charging, while a Bluetooth Low Energy connection provides an interface to the user's smartphone for uploading health and lifestyle monitoring data.

Renesas DA14592 or DA1469x Bluetooth Low Energy SoCs (see Continuous Glucose Monitor above) provide a wide range of integrated functions, to reduce component count and save space.

The DA14592 provides ample data processing capability thanks to its dual-core architecture and on-chip 15-bit sigma-delta ADC. An Arm Cortex-M33 core backed by generous memory provision manages application functions, while a Cortex-M0+ core handles radio communication. The SoC operates at ultra-

low power to extend the run-time of a smart ring's tiny rechargeable battery: active-mode current is 34 μ A/MHz, and the SoC draws just 90nA in hibernation mode. The device is supplied in a 3.3mm x 2.5mm WLCSP package.

For NFC connectivity and wireless charging, the **PTX30W** (see hearing aids) is a complete single-chip solution for the listener (smart ring) side.

For the smart ring's charging case, the **PTX130W poller IC** provides for the maximum power transfer and fast charging thanks to its DiRAC[®] direct antenna connection technology. This technology also makes the PTX130W simpler to implement in a charging case design than competing products by removing the need for EMC filters: this simplifies antenna matching and enables more flexible placement of the charger's antenna relative to the smart rings.

This means that a smart ring manufacturer can design a single charger for a range of smart rings of different sizes, simplifying manufacturing and reducing the cost of production and inventory.

Smart mouthguard

Smart mouthguards produced by [Prevent Biometrics](#) are becoming an essential part of the toolkit of professional and academy sports teams for monitoring the impact on the head of players of contact sports such as rugby and American football.

For consumers, mouthguards are also available for monitoring the user's sleep, and the condition Bruxism (nocturnal teeth grinding).

Like a hearing aid, the mouthguard benefits from NFC technology's ability to combine wireless charging and data transfer in a single circuit. The use of wireless charging allows for the design of a hermetically sealed enclosure which is impervious to saliva.

[Renesas flagship NFC Wireless technology solutions](#) supports the mouthguard and charging case for fast charging at up to 1W, and flexible alignment of the antennas.

Connected Care

Smart toothbrush

A smart toothbrush uses a combination of NFC and Bluetooth Low Energy technologies to provide for wireless charging, device usage monitoring, and the one-touch purchase and identification of replacement brush heads.

Wireless charging is supported by a complete system solution from Renesas: the **PTX30W listener SoC** in the toothbrush body and the **PTX130W poller IC** in the charger stand.

NFC also provides for communication between replaceable brush heads and the toothbrush body: a tag in each brush head logs and stores the duration of use and transmits the data to an NFC reader in the toothbrush body. The body then sends the data over a Bluetooth Low Energy link to an app on the user's smartphone, where the user can see an alert when the brush head needs replacement and perform one-click ordering of replacement heads.

A compact, highly integrated Bluetooth SoC such as a device from the **DA145xx and DA146xx series** provides a space-saving, low-power way to connect the smart toothbrush body to a smartphone.

A **PTX105R reader** embedded in the toothbrush body reads the NFC tag in a replacement head, providing for identification of branded accessories and download of usage data. The PTX105R reader offers superior sensitivity, accurate digital wave shaping, and a smaller bill-of-materials than conventional square-wave

NFC controllers, to give optimal interoperability, simplified FCC certification, and easier compliance with NFC Forum specifications.

Smart hair dryer

Like the smart toothbrush above, a smart hair dryer supports usage monitoring, authentication of branded accessories, and automatic configuration.

Via a wireless connection provided by a **DA14531 Bluetooth Low Energy SoC** (see Continuous Glucose Monitor above), the hair dryer connects to an app on the user's smartphone.

This provides for over-the-air firmware updates, usage monitoring, and remote maintenance and access to usage statistics, helping the hair dryer's manufacturer to maintain the product's optimal performance and to take user behaviour into account in the development of new models.

A **PTX105R NFC** reader (see smart toothbrush above) identifies the NFC tag in accessories. The embedded microcontroller in the DA14531 automatically adjusts airflow and temperature to match the accessory fitted to the dryer.

Via a Bluetooth connection to the user's smartphone, the hair dryer can launch its app and enable the user to go directly to an online store for compatible accessories.

Success Stories: Renesas Connectivity Solutions Products in Action

Wearables Manufacturer Marries Renesas NFC Technology with Advanced Smart Ring

Muse Wearables, of Bangalore in India, is a pioneering manufacturer of wearable devices, including a smart watch and a smart ring #Ring One. The Ring One's tiny form factor presents a challenge for the design of the battery power system. Muse wanted to implement wireless charging, to enable the creation of a completely sealed mechanical design. But the question was, how to fit an antenna for wireless power charging alongside an antenna for data exchange to the user's smartphone?



Ring One - Muse Wearables

The answer was in Renesas' NFC products, the PTX30W, a listener SoC in the Ring One, and the PTX130W poller in the Ring One's charging case. Based on innovative DiRAC® direct antenna technology, the PTX30W and PTX130W provide outstanding RF performance through a compact antenna which is capable of carrying both power and data signals. Eliminating the inefficient and bulky EMC filter components required by competing NFC products, the Renesas solution saves space while enabling power harvesting up to 1W for fast charging.

Renesas for NFC Wireless Charging and Data Exchange in Smart Mouthguard

Prevent Biometrics, of Minnesota in the US, has developed the Prevent smart mouthguard for head impact monitoring in contact sports such as rugby and American Football. Equipped with an array of inertial motion sensors, the Prevent mouthguard detects when the force of a head impact in a match or in training exceeds a pre-determined threshold, and immediately alerts medical staff on the sidelines. This enables players to be withdrawn for detailed assessment immediately, greatly improving the safety of participation in high-impact sport.

The mouthguard needs to be completely sealed, with no metal connector parts, because of its exposure to the wearer's saliva. This requires wireless charging of the device's small rechargeable battery. Each mouthguard's shape and size are matched to the wearer's jaw, so the antenna position is slightly different from one mouthguard to the next.

This meant that Prevent Biometrics required a wireless charging solution which would cope with some misalignment between a variably sized mouthguard and a standard charging case design.

The solution was the NFC wireless charging solution from Renesas [NFC WLC technology](#): the listener in the mouthguard and the poller solutions in the charging case have excellent RF coupling thanks to the innovative DiRAC® direct antenna technology, regardless of the alignment of the two antennas. The Renesas solution gave Prevent Biometrics a great deal of design flexibility to optimize the shape of the mouthguard for the variety of players' physiognomies while still achieving fast charging at a rate of up to 1W, to ensure that the mouthguards are charged and available for use quickly after the end of a training session or match.

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