



UNLOCKING CONNECTIVITY: A GUIDE TO WIRELESS SOLUTIONS

Our e-book, „Unlocking Connectivity: A Guide to Wireless Solutions,“ offers a comprehensive overview of the dynamic and rapidly evolving landscape of wireless connectivity. In today’s interconnected world, seamless communication is paramount, and our collection of articles serves as a roadmap to navigate this intricate terrain. We delve into the intricacies of simplifying the integration of wireless technologies, ensuring that businesses and consumers alike can effortlessly harness the power of connectivity.

From the exploration of Bluetooth® Low Energy (LE) Data Pumps to innovative motion-aware thin Bluetooth® LE beacon solutions for smart labels, we showcase the latest advancements driving efficiency and reliability in wireless communication. Moreover, we shed light on the transformative potential of NFC technology, exemplified by the PTX105R NFC Reader IC for IoT Applications, and elucidate the strategic advantages of choosing NFC for wireless charging applications.

This e-book serves as an invaluable resource for industry professionals seeking insights into the future of wireless connectivity. It equips readers with the knowledge and tools necessary to navigate the ever-changing landscape, driving innovation and propelling businesses forward in the era of connected devices.

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Navigating Complexity in the IoT Landscape with Renesas Wireless Connectivity



Smart home devices, appliances, ear buds, personal medical devices, smart energy meters, PoS terminals, asset, and fitness trackers, ... Whatever device you can think of that makes our lives more convenient, safer and more enjoyable, in today's world it's likely to be connected, often wirelessly.

Almost everywhere, connectivity is no longer an extra, it's expected. And expectations are growing – that wireless is ubiquitous, that devices interoperate

seamlessly, that set-up is simple, that performance is reliable and robust, and that security is there where it's needed.

The opportunities are huge – by 2028, the volume of the global Internet of Things (IoT) market could be worth 2,3 trillion USD. Yet as IoT expands into every aspect of life, so does complexity.

The challenge now is to reduce that complexity, including through wireless

technology solutions that make life easier for everyone: from device manufacturers and developers to the end user who wants products to work with no fuss straight from the box.

In this chapter, we outline why complexity is a growing issue and how it can be addressed. We also give an overview of the market leading Renesas portfolio which makes life easier for developers designing for wireless connectivity for IoT.

Navigating Complexity in the IoT Landscape with Renesas Wireless Connectivity CONTINUED

Connecting a world of devices – Growing complexity

For billions of IoT devices Bluetooth® / Bluetooth® Low Energy, Wi-Fi or NFC (Near Field Communication), will be the wireless technology of choice. Each technology provides specific benefits to support a vast array of use cases and performance requirements.

But the complexity of interconnecting billions of devices seamlessly and securely creates multiple challenges:

- Interoperability: designing for a market where multiple standards and protocols are in use.
- Performance: delivering, for example, high processing and data capacity with very low power.
- Scalability: maintaining large scale networks with optimal performance as billions of devices get connected.
- Energy efficiency: minimizing energy use and maximizing battery life for battery powered IoT devices communicating over wireless networks.
- Security: protecting privacy and preventing attacks and data breaches for all types of data and network.

In this complex space, semiconductor solutions clearly need to span a range of ecosystems, standards and protocols. However, diversity must be balanced with interoperability. Because without interoperability, end-users lose the promised convenience and ease of IoT connectivity. They end up struggling with incompatible devices or complicated onboarding, and network communication that is far from seamless and robust. New connectivity solutions need to assure interoperability with each other but also with the installed base which create further challenges. That's why standards and

protocols like Matter, Thread, ZigBee and Bluetooth® Low Energy are looking for ways to make interoperability easier.

Performance is equally vital. IoT use cases make tough demands on solutions. Battery operated smart home devices and wearables typically need to deliver ultra-low power at a highly competitive cost. Bluetooth® or NFC solutions for electric vehicle battery monitoring need to be automotive qualified to fulfil performance expectations. Gaming, streaming, smart home and connected health applications call for high processing capacity and better user experience.

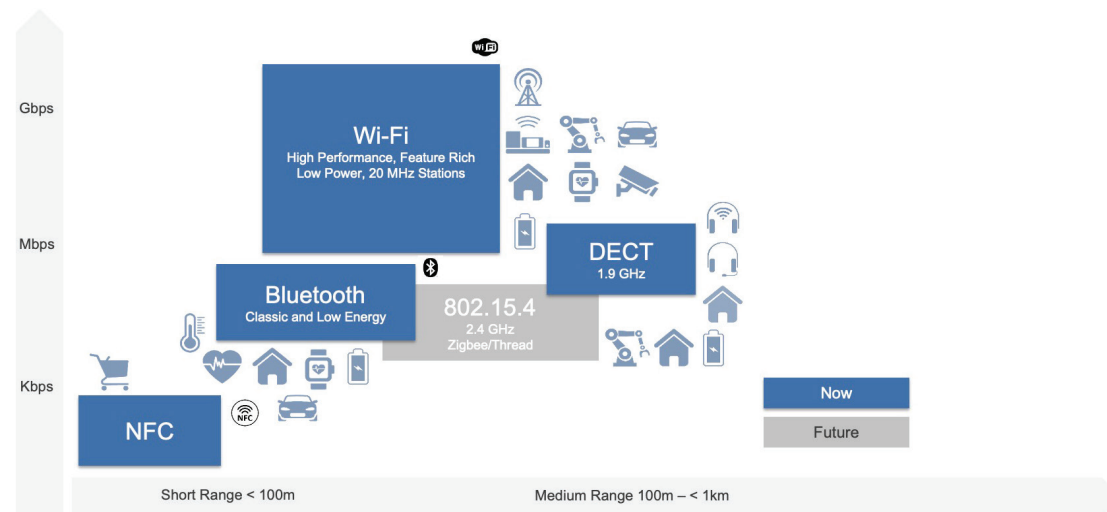


Figure 1. Wireless connectivity technologies and IoT applications

Navigating Complexity in the IoT Landscape with Renesas Wireless Connectivity CONTINUED

And end-to-end security is vital for in-hospital patient monitoring. The list of application requirements is long and growing.

Moreover, performance is the key to scalability and energy efficiency. In increasingly crowded IoT networks, solutions must deliver high performance in range, power usage and listen/receive sensitivity to maintain robust communication and long battery life.

Security is often seen as weakness in IoT. Weak authentication, unencrypted data, software vulnerability, insecure protocols and a lack of standardization can lead to data breaches, unauthorized access, and malign attacks. Wireless solutions (and the microcontrollers/microprocessor they attach to) need to offer the right level for each application. This can range from basic for many smart home devices, to end-to-end security in safety critical applications like smart metering and automotive.

Meeting the challenges: infinite possibilities, unmatched performance

Providing solutions to these challenges is part of the Renesas commitment to making life easier for device developers and manufacturers. We bring know-how as a world leader in microcontrollers (MCUs)

and (MPUs) combined with 27 years of experience in wireless solutions. And over the last decade, we have enriched our in-house wireless portfolio through acquisitions of specialist market leaders to create a comprehensive product offering.

This combined experience enables us to develop solutions with a clear understanding of embedded systems and how connectivity solutions 'attach' and interface to IoT applications. Our Bluetooth® Low Energy, Wi-Fi and NFC solutions are designed to work seamlessly with our entire range of MCUs and MPUs, as well as with third-party embedded controllers / processors. We also offer combined Bluetooth® Low Energy/Wi-Fi solutions (increasingly important in meeting the trend towards Bluetooth® onboarding and provisioning in Wi-Fi based IoT networks).

In addition, our 'Winning Combinations' bring together devices from across our embedded processing, power, analog, and connectivity portfolios. They provide complete engineering-vetted reference designs that accelerate product development and lower overall risk.

WIRELESS CONNECTIVITY IS AN INTEGRAL PART OF RENESAS' SOLUTIONS

Discover the latest executive blog on Renesas' website, unveiling the indispensable role of wireless connectivity within Renesas' innovative solutions. Experience firsthand the transformative power of seamless communication across diverse industries, facilitated by Renesas' cutting-edge wireless technology. With a steadfast commitment to innovation and excellence, Renesas ensures unparalleled reliability and efficiency in every wireless solution offered. Partnering with industry leaders and leveraging advanced semiconductor technology, Renesas stands as the beacon of progress in the wireless connectivity realm. Join us on this journey towards a connected future, where Renesas empowers businesses to thrive and excel in the digital age. Explore the blog now and unlock the potential of wireless connectivity with Renesas.



**EXPLORE
THE BLOG**

Navigating Complexity in the IoT Landscape with Renesas Wireless Connectivity CONTINUED

Performance, interoperability, and security

Performance is crucial to meeting IoT challenges. But not every application requires the same kind of performance. In high volume applications cost-effectiveness may be the key consideration; in others such in industrial settings, high speed processing or end-to-end security may be critical. For Renesas, the priority is high performance tailored to diverse needs. In both Bluetooth® and Wi-Fi In both Bluetooth® and WiFi we deliver the absolute lowest system power consumption. This creates new opportunities to bring wireless connectivity to battery operated applications like smart door locks and in NFC, best-in-class

total solutions for Point of Sale (PoS), access control and wireless charging applications

To address the industry-wide challenge of interoperability, Renesas is active in the Connectivity Standards Alliance (CSA) and the development of Matter. Matter is a single unified IP-based protocol that enables smart devices to connect with each other, regardless of brand, and across smart home ecosystems – a ground-breaking step towards making life easier for end-users.

Renesas is committed to Matter-compliance across all our current and future Bluetooth® and Wi-Fi products. Our Matter connectivity

products will also feature industry-leading security protocols, including the latest hardware encryption engine and authentication standards.

As Matter is an application layer solution it can be implemented over all key wireless technologies including Wi-Fi, Bluetooth® Low Energy, ZigBee and Thread. Plus, as data from devices can stay within the home network, Matter can help improve latency, security and response times, and ensure continuous operation even if internet connection to the cloud is interrupted.

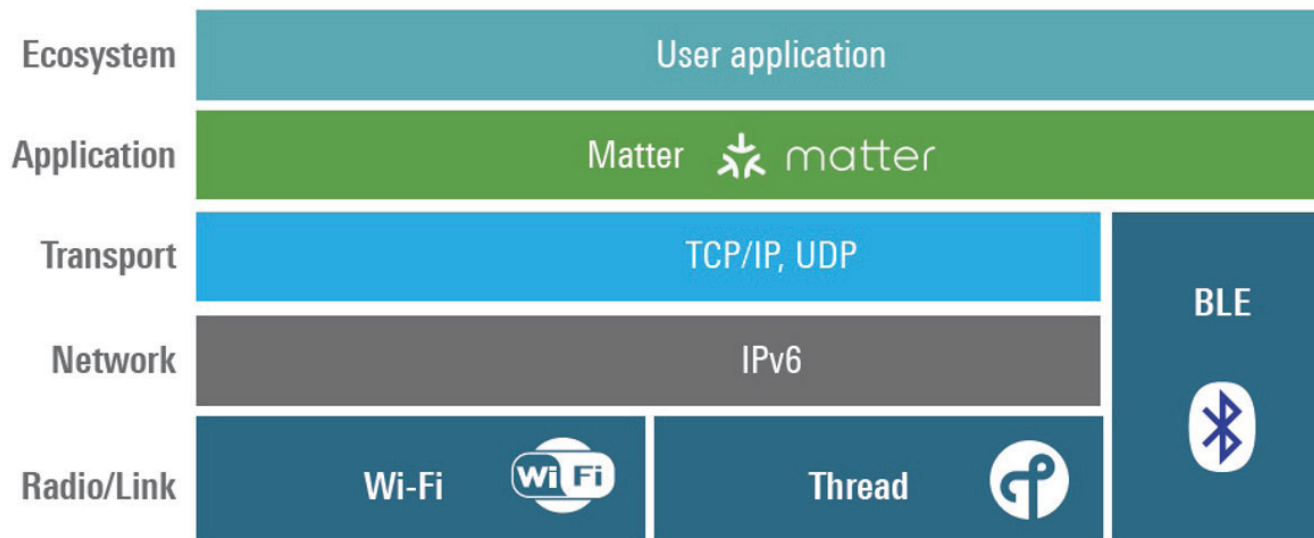


Figure 2. Matter architecture

Navigating Complexity in the IoT Landscape with Renesas Wireless Connectivity CONTINUED

Time to market

Meeting the challenges of IoT also means ensuring fast time to market. Here, Renesas' strength in MCUs/MPUs enables us to offer complete solutions that simplify integration of wireless connectivity and networking stacks. These solutions are backed by a mature ecosystem of software and hardware tools including the Renesas Quick-Connect IoT Platform for rapid evaluation, design and production ramp-up. They are also complemented by a growing library of complete reference designs (our Winning Combinations) and support from the Renesas Engineering Community.

Renesas: a portfolio for easier wireless connectivity Making Bluetooth® ubiquitous

Shipments of Bluetooth® products are expected to reach 7.6 billion by 2027, backed-up by a vibrant standards body, the Bluetooth® SIG, and an ambitious roadmap promising to enable many new applications. Recent announcements such as Auracast™, enabling audio transmission over Bluetooth® Low Energy to power novel applications such as audio broadcasting and sharing or the Periodic Advertisement with Response leading to Bluetooth-powered Electronic Shelf Labels (ESL) to improve retail operations and customer experiences are just some examples of how

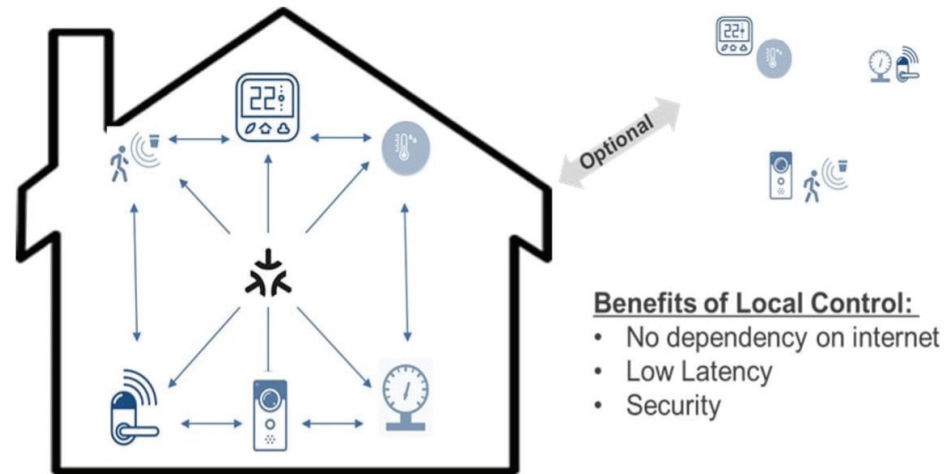


Figure 3. Matter in a smarthome

DA14592
Lowest Power Consumption Bluetooth®
Low Energy 5.2 Soc

RENESAS DA14592

Learn more

RENESAS

The advertisement features a smartphone displaying a location pin, a Wi-Fi symbol, and a Bluetooth symbol. The Renesas logo is prominently displayed at the bottom.

Navigating Complexity in the IoT Landscape with Renesas Wireless Connectivity CONTINUED

this low power technology is evolving to reach these numbers. Bluetooth® will also be part of the Matter standard, in particular for ease of onboarding and provisioning Bluetooth® devices.

As one of key Bluetooth® Low Energy market players, Renesas offers mature solutions, a software stack proven in over 600 million shipped devices, and comprehensive engineering support. Today, we are helping make Bluetooth® ubiquitous in all kinds of devices, many of them battery operated. Our low power high-performance solutions provide unrivalled versatility, spanning the widest range of price points and applications from feature rich SoCs for high-end products to low-cost simple ones suitable even for disposable products.

Plus, with the lowest power, smallest size and lowest cost solutions, the Renesas portfolio is ideally suited to Bluetooth® Low Energy. Our solutions adapt to numerous form factors, including extremely small sizes for applications such as styluses, ECG patches and medical devices. Developers can choose from a large variety of MCU configurations for applications from simple wireless sensors to complex IoT devices with graphic interfaces. And where cost and form factor are a consideration, Renesas offers highly

integrated solutions that reduce the system Bill of Material - depending on the SoC selected, a charger, a display driver or a complete power management unit with Lithium-Ion battery charger has been integrated into a single chip).

Wi-Fi: delivering outstanding performance

The rapid growth of IoT and increasingly demanding applications is spurring uptake of Wi-Fi 6/6E. Wi-Fi 6 provides higher performance, faster data rates (from gigabits per second to 1 Mbps) and lower latency, and extended communication range indoors. It can also support a large number of coexisting devices in a dense environment (even in the 2.4 GHz spectrum).

Additionally, Wi-Fi 6 incorporates numerous features to maximize IoT performance in environments from homes to large-scale enterprises and industrial applications. These include 'Target Wake Time' that improves spectral efficiency, reduces connectivity congestion and increases battery life, particularly in crowded networks with many sensors and always-connected battery powered devices. Wi-Fi 6 also enhances security with the new 'WPA3 certification (stronger encryption, protection against password guessing, ...), and devices can be connected via QR codes for simpler, safer end-user set-up.

Hot on the heels of Wi-Fi 6 is Wi-Fi 7. It will enable speeds up to four times faster, and deliver advances to reduce latency and network congestion, increase capacity, and boost stability and efficiency.

Renesas offers an extensive range of Wi-Fi 6/6E solutions. These enable feature-rich, high-throughput Wi-Fi 6/6E station devices (with integrated dual-mode Bluetooth® if required) through to industrial automation and access points. Right across the portfolio, developers can find the best characteristics for diverse requirements like high RF performance, robust security, ease of application development, and ultra-low power to extend battery life.

Indeed, Renesas' portfolio includes the industry's lowest power Wi-Fi SoC that delivers multi-year battery life while maintaining industry-leading range and security capabilities - performance that makes it a confirmed market leader. And right across our Wi-Fi portfolio, our fully integrated SoCs include the processor, SRAM, security, ROM, OTP, Wi-Fi (b/g/n) support, and provide industry-leading range (119.5 dBm) as well as end-to-end security features. Plus, our 'Wi-Fi Ready2go' solutions reduce development time and effort, from first idea through concept and development to production.

Navigating Complexity in the IoT Landscape with Renesas Wireless Connectivity CONTINUED

We are also constantly innovating to meet evolving market needs. For instance, our DA16200 Wi-Fi SoC is Matter compatible and offers dynamic power management, consuming virtually no power in sleep state. Moreover, the Renesas Longevity Program ensures that our Wi-Fi solutions receive continuous support including software updates, security patches, and technical assistance for an extended period.

NFC: total solutions with best-in-class performance

NFC is present in a vast array of applications from payments, authentication and user identification to building access control and smart home devices. And the NFC roadmap is set to bring advances such as increased power for wireless charging, greater range (for faster, easier contactless transactions) and enhanced device-to-device communication for PoS in NFC-enabled smartphones. These will take NFC into new areas such as healthcare and electric vehicles.

Renesas has been developing groundbreaking NFC technology and products since 2014. Our solutions target the most

demanding applications in NFC wireless charging, and PoS, and incorporate advanced features such as higher sensitivity and output powers. They enable sleek designs, reduce BOM and minimize costs, and simplify integration. For instance, developers can implement NFC for brand protection, authentication and payment with limited NFC experience required.

We simplify integration through higher reading distances and smaller antennae, with output power up to 2W and best-in-class receiver sensitivity, along with Direct Antenna Connection (DiRAC) for easy antenna matching and best interoperability. And in software, development is facilitated through optimized APIs and on-chip handling of time critical protocol operations that free up host MCU computation power and memory.

Plus, for the growing SmartPoS terminal market, the Renesas solution features a unique architecture that allows placement of the NFC antenna near or behind the display, making it the only NFC controller that enables EMVCo 3.0/3.1 in a mobile environment.

The way ahead: infinite possibilities, unmatched performance

In the coming years, IoT will take convenience, safety, security, automation and enjoyment to even higher levels. The opportunities are exciting and challenging. That's why our focus is unceasingly on performance. Renesas is committed to delivering solutions that combine everything our customers need for the IoT of tomorrow. We are constantly strengthening our market-leading MCU and wireless connectivity portfolios, for increased intelligence and data processing in IoT end points. And we are expanding our ecosystem to integrate AI, for instance with our Reality AI technology for edge AI software development. In a world of infinite possibilities, unmatched performance will be key to unlocking the promise of IoT that's truly interoperable, easy to use, and always reliable – making life easier for everyone.

Exploring Bluetooth® Low Energy (LE) Data Pumps

Are you delving into the intricacies of Bluetooth® Low Energy (LE) data pump applications? Curious about how external microcontrollers seamlessly manage data flow through BLE-capable devices? Let's delve into these technical intricacies together. How do different interfaces engage with various levels of the Bluetooth® software stack? What influences design choices, ranging from speed and power consumption to cost and time to market? Join us as we dissect these complexities and identify optimal solutions for your application requirements.

And what about Renesas's DA14531 device? Intrigued by its potential for implementing data pump applications in specific use cases? Let's uncover its capabilities and evaluate its suitability for your project needs.

Data Pump Applications

Figure 1 depicts the fundamental architecture of a data pump, consisting of two primary components: the BLE-capable controller and the high-level application host. Depending on how the Bluetooth® LE stack is implemented within each subsystem, various configurations are feasible, as outlined later in this document.

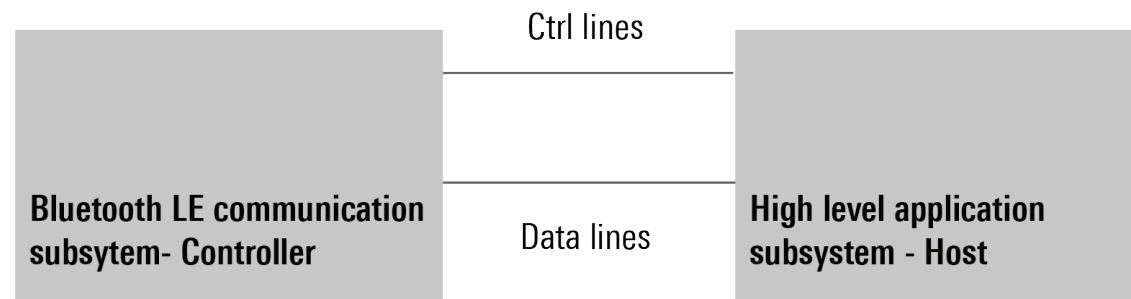


Figure 1. Generic Bluetooth® LE data pump architecture.

The controller and host subsystems exchange data and control lines to facilitate functions like flow control, sleep control, event indication, reset, and power gating. Data interface implementation typically adheres to standard serial protocols like UART, SPI, or I²C. Control-related features utilize additional GPIOs, with options to multiplex control requirements with data lines or utilize in-band control signaling. This architecture is commonplace in embedded systems, easing the transition from non-BLE to Bluetooth®-enabled systems.

While the HCI design option offers extensive control over the Bluetooth® LE controller, it entails a steep learning curve and necessitates significant memory and CPU

resources. Alternatively, simplified solutions have emerged to tackle these challenges, as discussed in the subsequent section.

Interface Options:

The UART interface commonly connects a Bluetooth® LE data pump controller and its host due to its full-duplex capability and simplicity, requiring only two lines. However, it lacks inherent support for a bus architecture and can be resource-intensive. Another option, SPI, offers higher data throughput and bus support but demands more signals and introduces complexity in handling full-duplex communication. I²C, with its two-wire interface and in-band addressing, offers simplicity but is strictly half-duplex and necessitates handshaking protocols.

Exploring Bluetooth® Low Energy (LE) Data Pumps CONTINUED

Power Management:

Battery-powered applications necessitate efficient power consumption. Both the host and controller should enter low-power states when idle. Sleep management is critical, with the capability to wake up for data exchange and buffer data during wake-up transitions.

Bandwidth:

The data pump must accommodate various throughput requirements, from occasional small data transfers to continuous streaming. A binary mode for raw data transfer at maximum speed is crucial for continuous streaming, while a protocol supporting notifications and minimal overhead suits sporadic data transfer.

Power Supply Considerations:

Designers must consider power supply compatibility when selecting a controller. Controllers should operate across a range of voltages typically found in microcontroller subsystems, accommodating various power sources like batteries, solar panels, or the grid.

Additional Requirements

Several other parameters influence the selection of a data pump controller. Below is a concise list:

Size: Embedded systems often face significant size constraints. The small size and minimal components of a modern Bluetooth® LE data

pump controller facilitate easy interfacing even in highly space-constrained designs.

Boot Latency: Boot time, the time required for the controller to become accessible to the external host after a reset, directly affects overall power consumption and responsiveness.

Transmit Output Power Control: This feature is necessary to fine-tune power consumption or implement near-field mode functionality.

Maximum Output Power: To enhance radio link throughput, especially during streaming.

Cost: Cost is a critical consideration. A lower overall cost of a data pump controller expands the group of existing non-connected applications that may decide to transition to the connected world.

Implementing Data Pumps over Bluetooth® LE

Before exploring the various flavors of Bluetooth® LE data pump architecture, let's review the Bluetooth® stack architecture (Figure 2). The Bluetooth® LE stack comprises several layers, with lower layers handling basic radio operations and connection management and higher layers focusing on data-driven operations and control.

Control is provided to the application layer through available APIs and data through profiles, services, or direct GATT API calls.

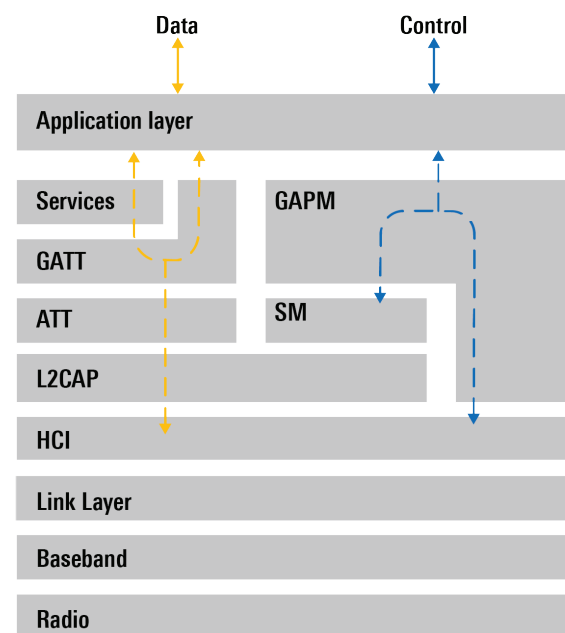


Figure 2: The Bluetooth® LE stack

Data Pump Variations

Figure 3 presents four potential ways to divide the Bluetooth® LE stack into a host-controller configuration. Each configuration involves a cut (Cx) splitting the Bluetooth® LE stack into a controller and a host. The data pump serializes messages passing through the cut to deliver them to the host, typically located in an external subsystem. Layers missing from the Bluetooth® LE stack must be implemented in the host device.

Exploring Bluetooth® Low Energy (LE) Data Pumps CONTINUED

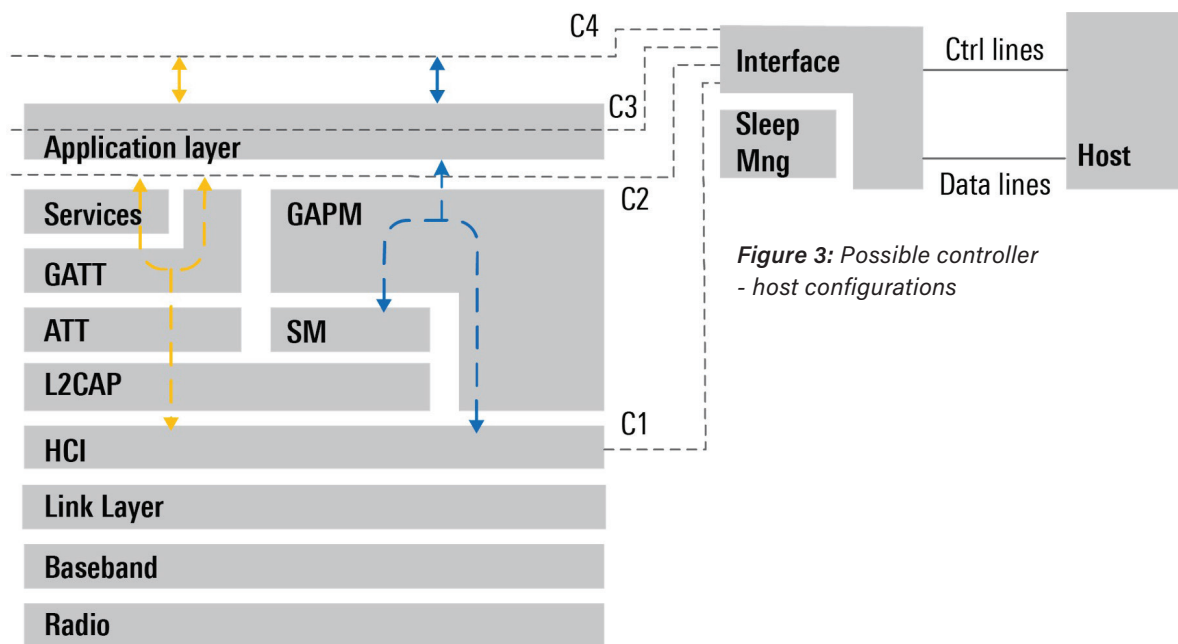


Figure 3: Possible controller - host configurations

HCI Host-Controller Architecture:

The Host-Controller Interface (HCI) configuration, a standard protocol within the Bluetooth® Special Interest Group (SIG), offers a standardized framework supported by numerous vendors. Renesas HCI exemplifies this by providing a standard UART implementation while also enabling the serialization of HCI messages over proprietary protocols like I²C or SPI. This architecture empowers the host with complete control over the controller's functionalities, allowing invocation and

management of any supported feature without limitations. However, drawbacks include the need for upper layers of the Bluetooth® LE stack or similar functionalities to be implemented in the host, leading to additional costs for a certified host stack and necessitating a certain level of Bluetooth® LE technology expertise. Additionally, power optimization is suboptimal, as the controller frequently wakes up to handle radio events and exchange information with the upper layers of the Bluetooth® LE stack, resulting in increased power consumption. Considerable

memory resources, typically around 50 Kbytes for code and 10 Kbytes for data, are also required for the Bluetooth® upper layers.

GTL Host-Controller Architecture:

The Generic Transport Layer (GTL) architecture integrates a complete Bluetooth® stack directly into the controller, distinguishing it from the HCI approach. GTL serves as a dedicated protocol facilitating the exchange of all application-related messages over a serial link, with interface options including UART, I²C, or SPI. Unlike HCI, GTL is inherently more power-efficient, as the external host only handles application-related information. Renesas introduces its DGTL (Dual GTL) data pump architecture, offering two distinct possibilities: a pure GTL approach and a hybrid partitioning model. In the hybrid model, part of the application code resides within the controller, providing flexibility to optimize power consumption and reduce host software complexity. This flexibility allows designers to strategically allocate services between the host and controller, optimizing wake-up frequencies and data exchange overhead. Despite its advantages in power efficiency and throughput, DGTL tightly couples the host implementation to the controller vendor, necessitating a high level of Bluetooth® expertise.

Exploring Bluetooth® Low Energy (LE) Data Pumps CONTINUED

Application-Defined Protocols:

At the highest level of customization, we find the implementation of a complete Bluetooth® LE application directly within the controller. This approach enables fine-tuning of functionalities, allowing the controller to manage all Bluetooth-related operations internally. Through a bespoke protocol, specific data, commands, and events are selectively exposed to the external host. This level of customization offers unparalleled control over the Bluetooth® LE functionalities but requires a deep understanding of the Bluetooth® protocol and the controller's architecture.

DSPS Host-Controller Architecture:

Within this realm of custom protocols, one notable application is the Dialog Serial Port Service (DSPS), operating as a virtual UART cable emulator. Engineered for simplicity and efficiency, DSPS lacks direct control over Bluetooth® link parameters. Instead, connection settings are hardcoded within the controller, simplifying the connection process but limiting flexibility. Despite this limitation, DSPS optimizes data throughput through internal mechanisms like ring buffers and flow control. By minimizing host intervention, DSPS serves as an efficient data pump for transferring large data chunks with minimal overhead.

CodeLess AT Commands Data Pump:

Another intriguing approach resembling DSPS is the CodeLess AT Commands data pump.

Leveraging the familiarity of AT commands, this solution provides a straightforward interface for Bluetooth® LE communication. Users interact with the controller using simple, human-readable commands issued over standard communication interfaces like UART, SPI, or I²C. This abstraction shields users from the complexities of the underlying Bluetooth® LE protocol, facilitating rapid development and experimentation. However, the CodeLess AT Commands implementation sacrifices some optimization in data throughput and may not support the full spectrum of Bluetooth® LE functionalities. Despite these limitations, its ease of use makes it an attractive option for accelerating development and familiarizing users with Bluetooth® LE concepts.

The DA14531 in Data Pump Applications

The DA14531 is both cost and power-optimized, aiming to serve simple, disposable, and data pump applications. It can serve any of the data pump architectures presented in this document, functioning as an HCI, GTL, DSPS, or CodeLess AT controller.

As explained above, among the key requirements for a data pump application are data throughput, interface options between the host and controller, low power consumption, flexibility in power supply, small size, and low boot latency. The DA14531 has been designed from the beginning to address the basic requirements of a data pump controller.

Compliant with the Bluetooth® 5.1 specification, it provides all three types of serial interfaces (UART, SPI, and I²C), allowing any serial communication available in the host subsystem. The DA14531's power consumption has been optimized, thanks to configurable transmit power and a radio receiver current below 2.2 mA for a buck configuration powered from 3.3V.

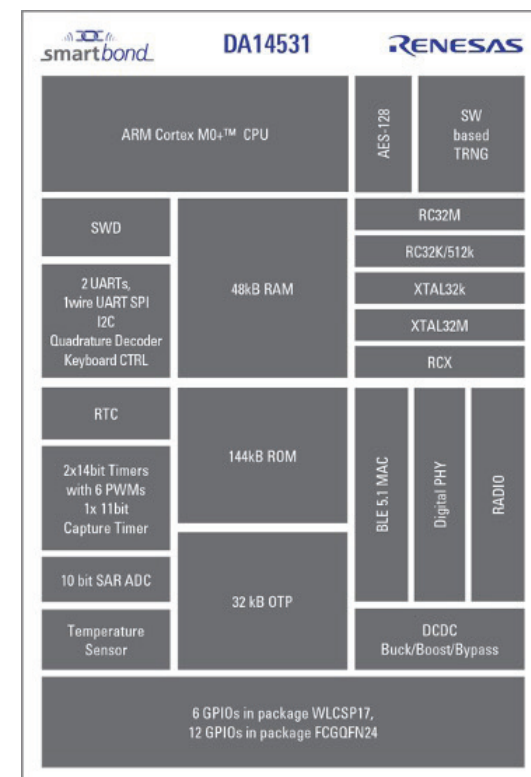


Figure 4: Block diagram of DA14531.

Exploring Bluetooth® Low Energy (LE) Data Pumps CONTINUED

The power management circuitry comprises 2 rails, VBAT_HIGH and VBAT_LOW. Between these rails, a DC/DC converter, an LDO, and an internal switch are situated. This setup enables the DA14531 to operate from whichever voltage is available in the host subsystem. For example, if a voltage below 1.8 V is available, it can be provided at VBAT_LOW and boosted to VBAT_HIGH using the internal DC/DC converter. Voltages between 1.8 and 3.3 V can be supplied to VBAT_HIGH. In this scenario, various options are feasible. The voltage can be bucked to VBAT_LOW with the internal DC/DC converter to optimize power consumption. For cost-effective solutions, both rails can be externally shorted to save the cost of the DC-DC inductor. Alternatively, the internal LDO or switch can be used instead of the buck DC/DC configuration to extend VBAT_HIGH operation below 1.8 V to drain the battery.

The DA14531 is available in a choice of packages. The FCGQFN24 version measures 2.2 mm x 3.0 mm and provides 12 available GPIOs, while the WLCSP17-package version is just 1.694 mm x 2.032 mm, yet still has 6 available GPIOs, minimizing the area required to enable Bluetooth® LE connectivity.

The device cold boots to fully operational in less than 30 ms if code is read from external Flash memory. If code is stored in the internal OTP memory, boot time falls to just 1.5 ms.

Since most white goods lack Bluetooth® LE standard services, a DSPS-like data pump is an excellent starting point to bring connectivity to these devices. With no interoperability requirements, developing a proprietary command-response protocol on top of the wireless serial interface provided by DSPS enables appliances to exchange information and commands without spending time making Bluetooth® LE-related decisions.

Smart White Goods

Most mid- and high-end white goods appliances already include a microcontroller unit to enable high-end features such as elaborate controls and advanced user interfaces. However, they often lack connectivity, primarily due to cost and complexity. Integrating connectivity into such devices opens up a range of possibilities, enabling consumers to interact with appliances through their smartphones. This could include exchanging valuable usage statistics (such as operating time and power consumption) and service or error codes logs for remote diagnosis. Additionally, appliances could be configured or personalized via the powerful interface provided by smartphones. In such cases, Bluetooth® LE security becomes crucial. Renesas offers tools (SDKs, reference designs) to facilitate the development of such applications.

BLUETOOTH® LOW ENERGY SUCCESS STORIES

Embark on a journey of inspiration with Renesas' Customer Success Stories in Bluetooth® Low Energy technology. Delve into real-world examples showcasing the transformative power of Renesas' solutions in diverse applications. From smart agriculture to healthcare and beyond, witness how Renesas enables seamless connectivity, innovation, and success for our valued customers. These stories are a testament to Renesas' unwavering commitment to driving excellence and empowering businesses to thrive in an interconnected world. Explore our Customer Success Stories today and unlock the potential of Bluetooth® Low Energy technology with Renesas.



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Exploring Bluetooth® Low Energy (LE) Data Pumps CONTINUED

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Battery-Operated Tools

Connectivity offers similar benefits to all kinds of small devices. However, for battery-operated devices like cordless drills, more control over the Bluetooth® link is required. To conserve power, the device should not advertise its existence all the time and may need to disconnect if there is no user action. Such functionality can be easily implemented using the CodeLess AT Commands approach. The CodeLess AT Commands application provides sufficient control and information to understand the state of the Bluetooth® LE link.

Selecting the Right Architecture

Where defined Bluetooth® LE services relate to the specific use case, the GTL architecture may be the best approach. This enables services to be exposed to other interoperable applications or allows the target device to access services provided by a smartphone.

Thermometers, glucose meters, blood pressure meters, weight scales, etc., could benefit from standard Bluetooth® LE services. The GTL architecture offers the flexibility of a Bluetooth® stack through a serial port, albeit with increased development costs for a Bluetooth® application in the host. A typical code footprint for a simple application is 5-10 Kbits.

Conclusion

In the realm of Bluetooth® Low Energy data pump applications, we've embarked on a journey through the intricacies of external microcontrollers seamlessly navigating data flow within BLE-capable devices. Together, we've navigated the technical intricacies, exploring the diverse landscape of interface options, power management strategies, and controller considerations.

Now equipped with a deeper understanding of the Bluetooth® LE stack architecture and the various data pump configurations, you're empowered to make informed decisions tailored to your specific application needs. Whether you're considering the robust control offered by the HCI architecture or the streamlined simplicity of the DSPS and CodeLess AT approaches, our exploration has laid the groundwork for strategic implementation.

With Renesas's DA14531 device standing as a beacon of cost-optimized, power-efficient versatility, you have a powerful ally in realizing your data pump aspirations. Its flexibility to serve as an HCI, GTL, DSPS, or CodeLess AT controller, coupled with its compact footprint and rapid boot time, positions it as a cornerstone for driving innovation in your projects.

As you navigate the realm of data pump architectures, remember that every decision is an opportunity for advancement. Whether it's enabling connectivity in smart white goods, enhancing battery-operated tools, or delving into standardized Bluetooth® LE services, the possibilities are vast, and the solutions are within reach.

Motion aware thin Bluetooth® LE beacon solution for smart labels

A beacon is a tiny Bluetooth® radio battery powered transmitter. Its functionality resembles a lighthouse that can be seen by everyone within a certain range. Instead of a light, these small hardware devices constantly transmit Bluetooth® Low Energy packets. These can be scanned and visually represented by any modern smartphones with a built-in Bluetooth® transceiver using an appropriate and interactive application.

Beacons provide an inexpensive broadcasting solution capable of autonomous operation over very long periods of time. Furthermore, when used inside a building, for example, no additional technology is needed as everything can be integrated into the same eco-system of the wireless network. And with some extra functionality, the simple idea of broadcasting messages can be extended to enable beacons to be used in other application areas.

In this paper we will show how beacons can support extended functionality by employing a range of peripherals to allow them to process and display data while maintaining autonomous operation.

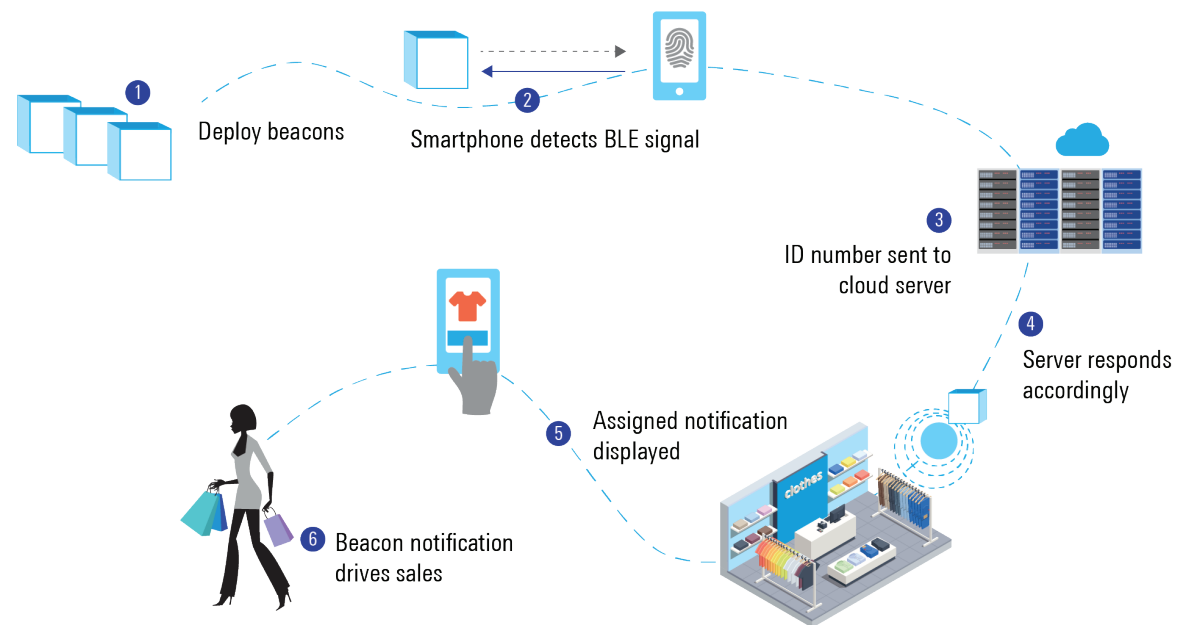


Figure 1: Bluetooth® LE eco-system example

A typical Bluetooth® LE eco-system is presented in Figure 1. This example shows a proximity marketing use case where the deployed beacons broadcast an ID number through Bluetooth® LE channels approximately 10 times/second. A Bluetooth® -enabled device (e.g. a smart phone) placed close to the beacon receives this ID number.

When an app recognizes this ID number, it links it to an action which can be as simple as displaying a marketing offer on the smart phone, or performing a more complicated task such as downloading an app.

Additional Bluetooth® LE beacon use cases include, but are not limited to:

Motion aware thin Bluetooth® LE beacon solution for smart labels CONTINUED

Indoor navigation: GPS signals are very weak, if present at all, indoors. A network of BLE beacons can be used for accurate positioning in areas like large shopping malls, museums, airports, etc.

Smart labelling: Especially popular in large retail stores where traditional labels can be replaced with beacons to enable smart labelling schemes that help minimize the time and personnel needed to update product prices, introduce new offers, etc.

Healthcare: BLE beacons can offer great improvements by reducing patient waiting times, notifying doctors about a patient's medical history including medicines, medical equipment tracking (asset tracking), injection devices, patches and more

Without additional hardware, namely a motion sensor or visual aids, these use cases cannot be supported with a traditional Bluetooth® LE beacon. An extended functionality version is required. In this paper, we present an extended functionality Bluetooth® LE beacon solution including its most important peripherals: a low-profile thin battery, motion sensors and a user interface component (LCD, buttons). These peripherals will be further detailed in the next sections.

Another aspect, also outlined in this paper, is the use of flexible PCB technology for the Bluetooth® LE beacon manufacturing.

This is a key requirement for several niche applications such as smart labelling, pharma product applications and wearable, medical applications.

Flexible PCB technology

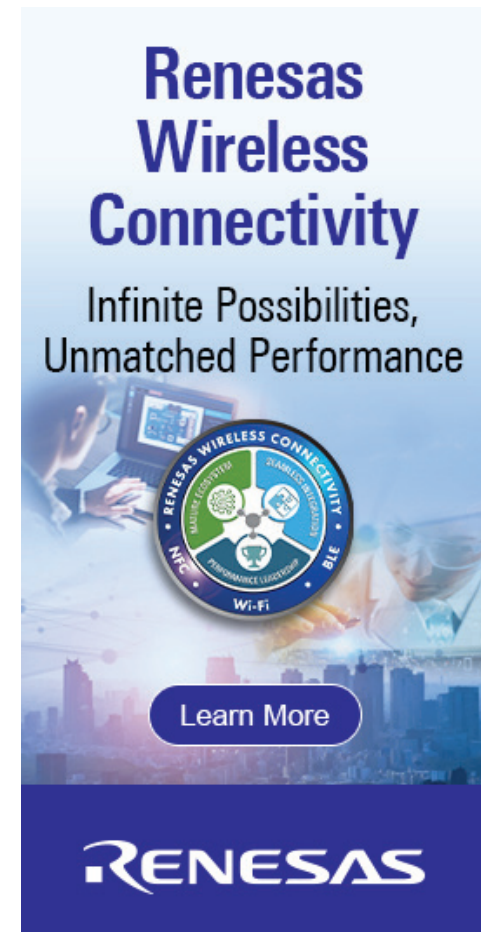
Flexible circuitry adaption delivers the following advantages:

Dynamic Flexing: Flexible circuits have excellent bending or movement capabilities. This feature helps maintain connection through devices that extend, contract or telescope during application. This is a very useful advantage of the flex PCB technology in wearable and medical applications where the available space is very limited.

Reliability: Flexible circuitry has an excellent record of performance and reliability in the highly demanding area of medical applications. Its fundamental advantage is the elimination of the connection points, simplifying assembly and reducing the risk of interconnect faults such as poor solder joints, to provide increased reliability and durability.

Space and weight: Recent and growing demand for smaller and lighter devices makes flexible circuits an ideal choice in applications when space and weight are critical. Flexible circuits are ultra-thin and can be easily bent to adapt to almost any surface. These flexible circuits are also lighter compared to standard rigid PCB boards.

Cost: As flexible circuits can minimize the amount of connections required, they can be manufactured efficiently in high volumes. This helps to reduce the assembly cost. Avoiding the use of soldered wires, rigid printed circuits, and connectors offers further possibilities to reduce the total cost.



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The graphic features a central circular logo with 'RENEAS WIRELESS CONNECTIVITY' around the perimeter. Inside the circle are icons for 'MAINTAIN CONNECTION', 'STABLE RELIABILITY', 'PERFORMANCE THROUGHOUT', and 'BLE'. Below the circle is a 'Wi-Fi' icon. The background shows a person using a laptop and a person wearing glasses, with a city skyline at the bottom.

Motion aware thin Bluetooth® LE beacon solution for smart labels CONTINUED

Bluetooth® LE Beacon system overview

An extended functionality beacon BLE system typically consists of the following main components:

Bluetooth® LE SoC unit: A Bluetooth® connectivity System on Chip (SoC) with a built-in Microcontroller unit (usually an ARM processor) for the necessary computing tasks. The main processor selection is driven by the type and the complexity of the device. Modern MCUs integrate most of the functions in a single chip. The Bluetooth® LE SoC has an attached antenna, which broadcasts at a specific wavelength and frequency.

Battery: A Bluetooth® LE SoC should be able to operate for long periods of time, this is achieved by using an appropriate battery source. Coin cell battery have proven to be the most cost, size and duration effective solution. Rechargeable batteries are generally not recommended, due to the increased cost of supporting the charging operation using dedicated circuitry.

Motion Sensors: A motion sensor with, for example, an accelerometer could be used, to increase battery life and hence the autonomy of the system by introducing system sleep mode capability when no movement is detected. This optional feature is, of course, dependent on the beacon use case.

User interface: Depending on the use case, various Man Machine Interface options can be considered for usage in beacons:

A low power display such as e-paper technology that has the advantage of continuously showing a single image after being completely powered off, very useful for retail store labelling applications,

Mechanical buttons that could be used as a part of the ON/OFF mechanism, extending the battery life even further.

Figure 2 depicts a top-level block diagram for an extended functionality Bluetooth® LE beacon device that consists of:

- Bluetooth® LE SoC powered by a microprocessor unit ARM Cortex class M0 for data transmission
- High-capacity SPI flash memory
- Accelerometer/Gyro sensor
- 32MHz crystal

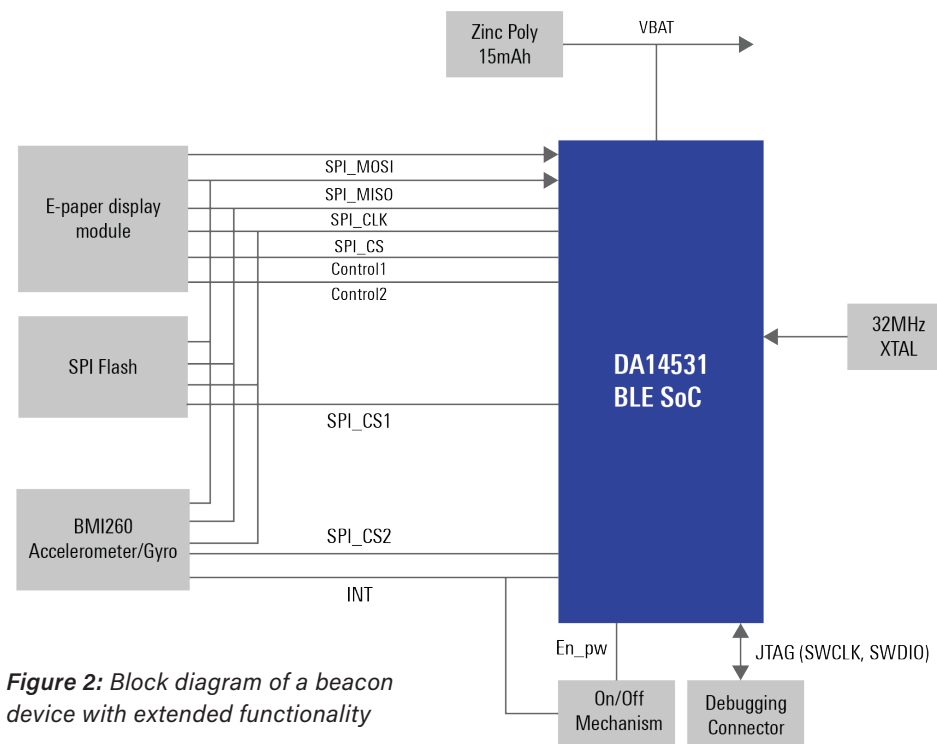


Figure 2: Block diagram of a beacon device with extended functionality

Motion aware thin Bluetooth® LE beacon solution for smart labels CONTINUED

- On/Off power switch
- A low-resolution e-paper color display that can be also connected to the beacon system taking into consideration the limited display drive capabilities of the Bluetooth® LE SoC

Another key aspect of the Bluetooth® LE beacon is that it should exhibit a very low power consumption from all its active components to support a long battery duration.

DA14531 BLE SoC

The DA14531 BLE SoC stands out as the quintessential choice for beacon solutions due to its unparalleled combination of compact size, low power consumption, and robust performance. Renowned as one of the world's smallest Bluetooth® 5.1 System-on-Chip solutions, the DA14531 boasts record-breaking low hibernation and active power consumption levels, ensuring extended operating and shelf life even when powered by the tiniest disposable batteries. Its diminutive 2.0 x 1.7 mm package belies its formidable capabilities,

as it houses a potent 32-bit ARM Cortex M0+ processor along with integrated memories and a comprehensive suite of analog and digital peripherals. This remarkable blend of features not only facilitates efficient utilization of space within compact beacon designs but also guarantees reliable and long-lasting performance, making the DA14531 the perfect fit for beacon solutions across various industries.

In the dynamic realm of Bluetooth® LE beacons, the integration of motion sensors and user interface components heralds a significant leap in functionality and versatility. Capitalizing on the benefits of flexible PCB technology, manufacturers can tailor beacons to suit a diverse array of applications, ranging from smart labeling to healthcare.

As the demand for intelligent, autonomous devices continues to burgeon, Bluetooth® LE beacons equipped with extended functionality are poised to play a pivotal role in reshaping the landscape of connectivity and interaction across diverse industries.

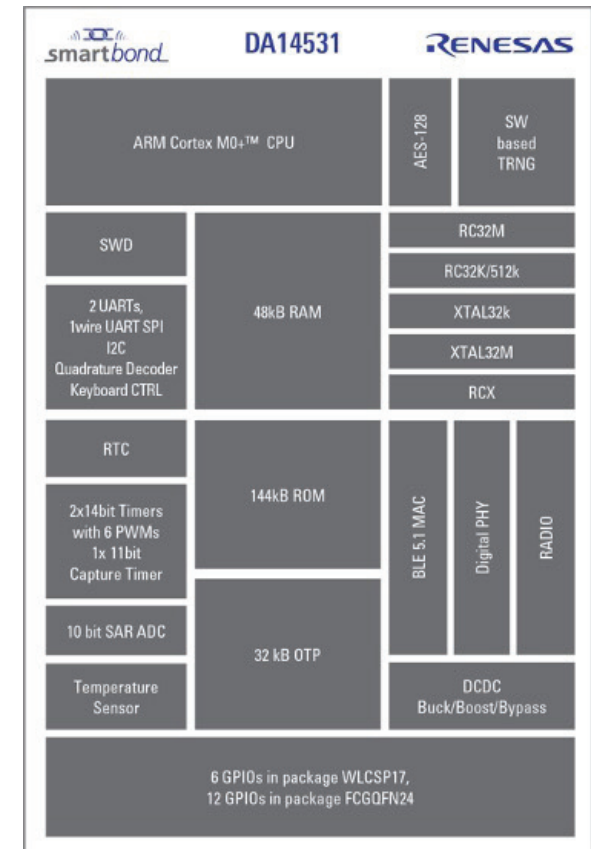


Figure 3: DA14531 block diagram

PTX105R NFC Reader IC for IoT Applications

In this time of smart homes, cities, and industries, NFC technology is broadly accepted as an enabler of convenience and simplicity by providing a secure, low-power data exchange between devices. Consumers have enthusiastically adopted the technology for applications such as access control, home automation, authentication, and contactless payment because of its convenience.

So what are the challenges in implementing NFC in IoT applications and limitations of the conventional architecture of NFC readers? Let's dive into the core features of Renesas' PTX105R NFC Reader IC and explore its use in different IoT applications across industries.

Challenges in NFC-enabled IoT Applications

The use of NFC technology in IoT applications offers many benefits, including simplicity, security, and energy efficiency. However, it also comes with some challenges that need to be addressed:

Interoperability: For IoT applications, NFC antennas come in various sizes and designs, each optimized for specific use cases. Antenna variations in geometries, dimensions, and characteristics impact the

PTX105R NFC Reader

- Best-in-class receiver sensitivity of -80dBc
- Optimized for IoT application



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effective communication range and signal shape, making it challenging for NFC-enabled devices to consistently communicate with one another.

Integration complexity: Integrating NFC functionality into IoT devices requires adding special software and hardware components into the existing system. Adding an NFC IC, antenna, and sometimes additional peripherals physically on the device's PCB demands careful design, layout, and considerations for signal interference. Integration of firmware and software also needs to be done carefully to provide an intuitive and reliable end user experience.

Power Requirement: Since many of the IoT devices are battery powered, having a power efficient solution not only for the NFC component but also for the complete system becomes extremely important.

Additionally, standard compatibility, cost, and time to market are all important aspects of IoT applications.

Limitations of conventional NFC controller architecture

As shown in Figure 1, conventional NFC Reader architecture typically employs a push-pull output stage which generates square-wave at the Transmitter output pins.

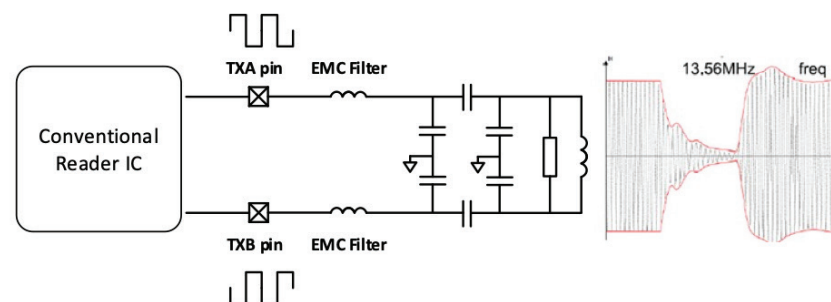


Figure 1:
Conventional
architecture
of NFC controllers

PTX105R NFC Reader IC for IoT Applications CONTINUED

While being rather easy to implement on the silicon, this kind of structure also has some fundamental limitations.

EMC filter

Having a square-wave at the output of the transmitter requires the EMC filter to remove the additional frequency components before the signal can be applied to the antenna. One of the shortcomings of EMC filters is the additional resonant frequency introduced to the system. This additional resonant frequency makes the matching much more complicated and the system becomes much sensitive to detuning.

The inductors in the EMC filter are directly in the signal path, which introduces additional losses since they are not ideal. Variation introduced by the EMC filter components also needs to be considered in the system design.

Supply and Output power

Another issue of the conventional push-pull stage is current spikes on the supply. Since the output stage is basically switching between low and high (voltage level defined by the supply) and needs low impedance so that sufficient current can be provided to the antenna, the transition between these two states often creates spike currents in the 27.12MHz frequency range. Without careful handling, these spikes can be coupled into the system supply and disturb other electrical components.

Limited by the matching impedance (including EMC filter) and the transmitter output current, higher output power is achieved in conventional architecture by having higher a supply voltage of the output stage. This typically requires an additional power management unit such as a DC-DC booster, on chip or off chip, which makes the system more complicated and introduces additional losses.

Waveshape

Since the square wave output of the transmitter first needs to be filtered by the EMC filter and then applied to the antenna, conventional architectures have no direct control over the antenna signal shape. When different power levels or signal shapes are needed on the antenna, a push-pull stage only has two parameters to adjust: voltage level (defined by the power supply), or the pulse width. Either way the output power of the transmitter is adjusted, hoping to be 'translated' correctly by the EMC filter and achieve the desired waveshape on the antenna.

This lack of control on the antenna signal together with the extra vulnerability of detuning caused by dual resonating circuits composed by EMC filter and antenna, often leads to over-/undershoot and other signal shaping issues, resulting in poor interoperability and bad customer experiences.

Watch the video on Renesas website to learn more about the PTX105R NFC Reader Evaluation Kit



All-new architecture features sine-wave output

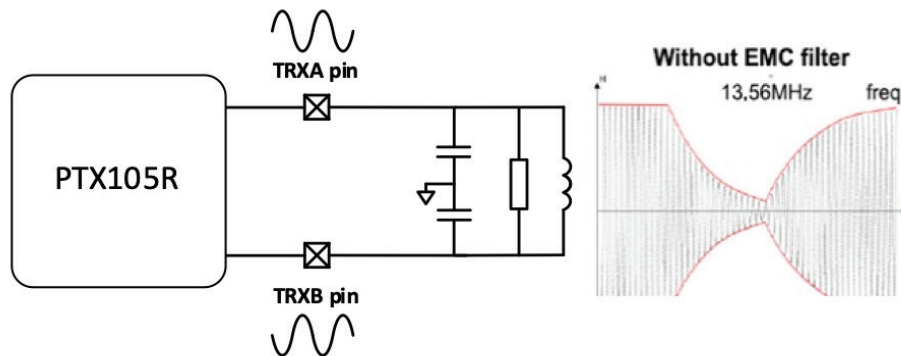
Tailored to the specific needs of the IoT market, the PTX105R NFC Reader IC aims at providing effective solutions for these challenges by offering an all-new, patented architecture featuring a sine-wave output based on a Switch Capacitor Power Amplifier (SCPA) driver.

SCPA Architecture

As shown in Figure 2, PTX105R generates a sine-wave signal on the transmitter output which can be directly applied to the antenna (Direct Antenna Connection, DiRAC). By eliminating the EMC filter, the antenna matching becomes a lot simpler. Issues related to the inductors such as additional power loss or current limiting factor can also be avoided.

PTX105R NFC Reader IC for IoT Applications CONTINUED

Figure 2: SCPA architecture implemented in PTX105R



Significantly reducing the matching components does not only reduce BOM cost and PCB area, it also helps to achieve consistent RF performance with minimal variation since the variations introduced by these components are omitted.

Having direct sine-wave output also allows much finer wave shaping on the antenna signal, reducing over-shoots and under-shoots. The same mechanism is also used for output power regulation, providing relatively stable power over the complete operating volume and avoiding saturation even when the counter device is very close to the reader antenna.

All these features lead to a much more stable RF performance and better interoperability across diverse antenna form factors.

Receiver Sensitivity

Different than the conventional receiver which typical includes voltage division, the sine-wave architecture provides a direct connection between the antenna and the PTX105R receiver input stage, allowing usage of the full signal dynamic range. With receiver sensitivity as high as -80dB, applications in noisy environment, such as below low-cost display, can be enabled.

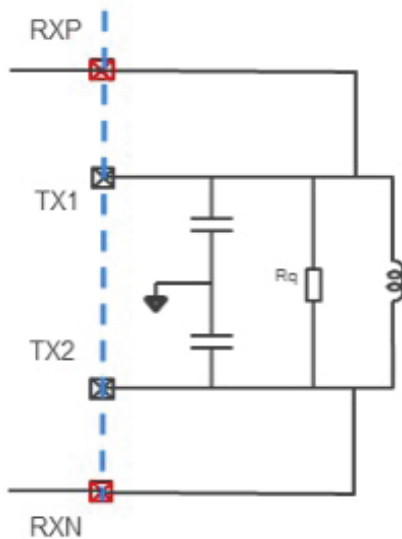


Figure 3: PTX105R DiRAC Antenna matching

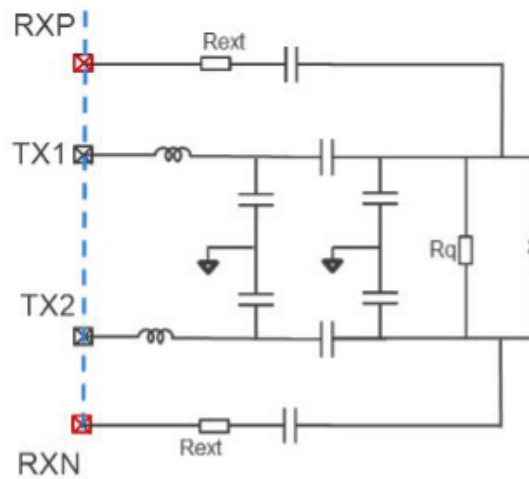


Figure 4: Conventional Antenna matching

PTX105R NFC Reader IC for IoT Applications CONTINUED

Split-Stack Software

PTX105R offers a Split-Stack software solution where time-critical operations are running on the on-chip MCU. This on-chip handling of the low-level protocol tremendously reduces the package exchange on the Host Interface and frees up the resource of the Host Controller. In this way the usage of a cost-effective MCU becomes possible, which is especially attractive for IoT applications.

Recap

Conventional NFC controllers have found themselves trapped by a silicon architecture that makes it difficult to provide one solution seamlessly interacting with diverse counter devices.

By introducing an all-new sine-wave architecture in the PTX105R NFC Reader IC, Renesas is providing an innovative solution which offers higher RF performance and

optimal interoperability, while enabling the usage of a smaller antenna in challenging operating environments. With its simplified antenna matching and easy software integration, PTX105R is the perfect fit for the fast-expanding IoT market.

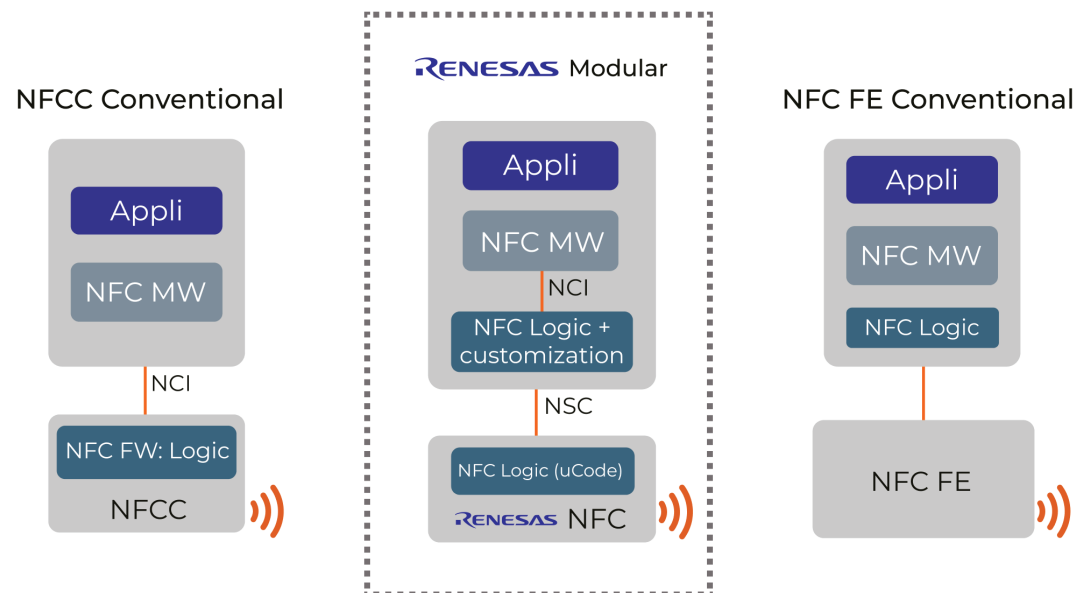


Figure 5: Split-Stack SW architecture vs conventional

Why choose NFC for wireless charging

Understanding the advantages of NFC technology for wireless charging of wearable devices

The growth in demand for wearable devices shows no sign of stopping: already in 2019, more than 722 million wearable devices were in use globally. At the start of 2020, more than one in five adult Americans said that they were regularly wearing a smart watch or wearable fitness tracker. The spread of wearable technology is bringing into sharp focus the drawbacks of conventional contacting charging interfaces, including standard systems such as USB Type-C, proprietary barrel connectors, and compact devices such as high-density circular connectors.

Mating a contacting connection is a mechanical operation: this means that the connector is prone to physical damage either through repeated mating/unmating cycles, or failure caused by contamination after contact with the user's body.

Beyond the risk to a wearable device's mechanical integrity, the need to accommodate a contacting connector

interface imposes constraints on the design of a product's enclosure. This is partly because the receptacle occupies space on the surface of the enclosure – space that is limited in many types of wearable device, such as earbuds or smart rings. The position of the receptacle relative to the rest of the system also hampers the designer: the siting of the receptacle dictates the routing of power and/or signal lines to and from the main circuit components, reducing the designer's flexibility to optimize the size and shape of the PCB.

These drawbacks have sparked interest in various methods for wireless charging. The advantages of wireless charging are the opposite of the drawbacks of battery charging via a contacting connector:

- A wireless charging interface requires no physical mating or unmating, so has a practically unlimited lifetime.
- A wireless charging system allows the creation of a fully sealed enclosure which is completely resistant to the ingress of contaminating grease, oil, dust or liquid

- Free of the need to accommodate a contacting receptacle, the product designer has greater freedom to reduce the surface area of the enclosure of very small products such as earbuds.

For wearable products with a small battery, such as earbuds, smart rings, and activity-tracking wristbands, NFC wireless technology is emerging as designers' preferred choice. As this article shows, the performance of NFC in space-constrained designs, the additional features that NFC offers such as bi-directional communication, and the interoperability of NFC-compliant components all help to explain the growing adoption of NFC wireless charging.

NFC wireless charging: proven technology for short-range communications and power transfer

NFC operates over a radio link using a base frequency of 13.56MHz, with a typical range of up to 10cm between a reader and card. For payment terminals, range is typically up to 6cm. The standard specifications are produced by the [NFC Forum](#), a broad

Why choose NFC for wireless charging CONTINUED

industry consortium, and include multiple versions optimised for products including mobiles, tablets, wearable devices, cars and door locks, along with battery-free use cases such as tags embedded in clothing, packaging and other consumer products.

The most common use case for NFC today is as a secure, low-latency communications technology for functions such as contactless payments, access control, identification, authentication, or device pairing. In this mode, NFC communication is initiated by a reader that broadcasts a modulated signal. When a tag is in range of the signal, it receives the signal and applies load modulation to it. This load modulation is in turn decoded by the reader.

Another operating mode supported by the NFC Forum standard is the wireless charging mode, which is used for the transfer of up to 1W of power. The communication function enabled by NFC is used to manage the power transfer between the power source or 'poller,' and the power receiver, or 'listener.' NFC in wireless charging mode will charge small devices with a battery capacity of up to 500mAh, such as hearing aids, smart rings, true wireless stereo earbuds, medical devices and smart glasses.

In an NFC wireless charging system, the poller supplies power to the antenna, but also provides reader functionality to support

data exchange with the listener. In the same way, the listener is optimized for harvesting power transferred to its antenna, but also includes tag functionality to allow for data exchange. Because of the communications capability of NFC wireless charging, the system that charges a wearable device's battery can also, for instance:

- Share information about the battery's state of charge or fault status
- Upload data securely to the wearable device or the poller
- Perform device authentication as a security step before the poller's configuration is modified
- Upload firmware updates to, or download firmware updates from, the poller

To harvest power efficiently via its antenna, the listener implements the following functional blocks:

- A rectifier
- NFC tag to receive the poller's NFC signals
- Battery charger
- System power management
- Controller for NFC protocol handling

These functions may be implemented in the listener device with discrete components. One of the main advantages of NFC wireless charging over other wireless technologies, however, is its small size. This advantage has recently been strengthened by the introduction of the PTX30W from Pantronics: this is a single chip in a 1.78mm x 1.78mm WL-CSP package which integrates a rectifier, tag, battery charger, power management unit, and controller core for protocol handling (see Figure 1). Use of the PTX30W in place of a circuit based on discrete components reduces the typical wireless charging system footprint by around 75%.



Figure 1: The PTX30W is a fully integrated listener system-on-chip in a small WL-CSP package

Why choose NFC for wireless charging CONTINUED

MUSE WEARABLES AIMS TO DISRUPT FITNESS TRACKER STATUS QUO WITH 'RING ONE' LAUNCH

Explore the captivating success story of Ring One by Muse Wearables, a stylish smart ring offering advanced health tracking and convenient on-the-go payments. Discover how Renesas' technology seamlessly integrates into Ring One, enhancing its functionality and reliability. From monitoring health metrics to facilitating secure transactions, Ring One showcases the innovative potential of wearable technology. Join us in celebrating this remarkable achievement, where Renesas continues to push the boundaries of connectivity to enrich users' lives.



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Comparison with Qi wireless charging

The most familiar alternative to NFC technology for wireless charging today is Qi, the standard specified by the Wireless Power Consortium. In fact, Qi charging serves a different market from NFC: Qi provides a higher power capability of between 5W and 15W, making it suitable for charging the large batteries in devices such as smartphones. But this higher power capability and the frequency at which Qi operates call for a much larger antenna than NFC requires. In addition, effective power transfer over a Qi connection requires very precise alignment of the transmitter's and receiver's antennas. By contrast, NFC pollers and listeners can maintain efficient power transfer even with some antenna misalignment. The high tolerance of antenna misalignment in systems based on the PTX30W is ideal in applications such as smart glasses, in which the relation of poller and listener to each other depends on the order in which the glasses' arms are folded.

The large antenna size and alignment sensitivity of a Qi system mean that Qi is unsuitable for use in the small and wearable devices to which NFC wireless charging technology is well suited.

A further advantage of implementing NFC wireless charging is that a poller/reader device can provide dual-mode functionality via a single NFC antenna. For instance, a wearable device could be configured to support contactless payments in card emulation mode, and to receive power in wireless charging mode – all via a single antenna (though not concurrently).

This enables space and bill-of-materials cost savings compared with systems that use separate antennas for data exchange and for power transfer, or which perform charging via a contacting connector.

Whatever the architecture of the NFC charging system, the device manufacturer benefits from the global adoption of the NFC standard in many types of end product. This has had the advantage of spawning a vibrant market of off-the-shelf NFC components from many semiconductor manufacturers, including Pantronics, and ensuring seamless interoperability between readers and tags, or pollers and listeners, from different manufacturers. In addition, the healthy outlook for the NFC market and the broad industry support that it enjoys will give confidence to device manufacturers that their decision to build NFC wireless charging into new project designs will be matched by NFC component manufacturers' long-term commitment to the market.

Why choose NFC for wireless charging CONTINUED

Easier compliance with RF regulations

In fact, the NFC chip market is expected to grow in value from \$8.7bn in 2021 to \$17.8bn in 2028, a compound annual growth rate of 10.8%. This fast rate of growth is spurring competition between rival component suppliers. In NFC wireless charging, an important factor affecting the device manufacturer's choice is the challenge of achieving compliance with regulatory standards, such as FCC and CE, that govern the behaviour of radio devices.

A Panthronics innovation is the sine wave architecture implemented in silicon in poller devices such as the PTX130W (as well as Panthronics' reader ICs for payment terminals and other communications applications). The sine wave architecture disposes of the lossy EMC filter circuitry required in conventional NFC controllers, which have a square-wave output signal (see Figures 2a, 2b). With the elimination of the EMC filter, the PTX130W's sine wave output produces reduced 3rd harmonic emissions. This greatly simplifies the achievement of compliance with the requirements of the FCC and CE specifications.

Optimistic outlook for NFC wireless charging

Technology developments such as the PTX130W and the PTX30W are making NFC even more attractive as a technology for wirelessly charging small and wearable devices. For batteries smaller than 500mAh, NFC now provides a proven way to provide convenient, secure and fast charging, while enabling device manufacturers to enjoy the many benefits of eliminating a contacting connector from their design.

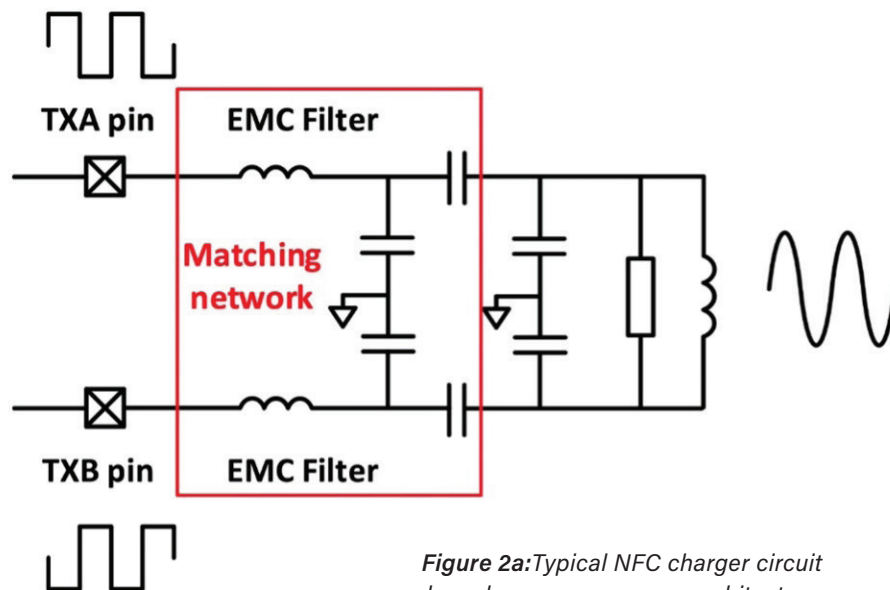


Figure 2a: Typical NFC charger circuit based on a square wave architecture

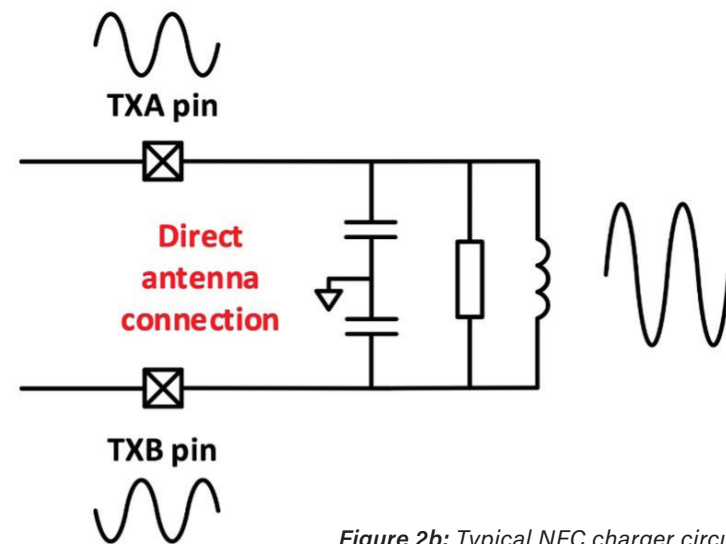


Figure 2b: Typical NFC charger circuit based on the Panthronics sine wave architecture



○

At Renesas we continuously strive to drive innovation with a comprehensive portfolio of microcontrollers, analog and power devices. Our mission is to develop a safer, healthier, greener, and smarter world by providing intelligence to our four focus growth segments: Automotive, Industrial, Infrastructure, and IoT that are all vital to our daily lives, meaning our products and solutions are embedded everywhere.

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