WQ
WIRELESS QUARTER

Issue 2, 2025

NEWS ALERT:
NORDIC SEMICONDUCTOR ACQUIRES MEMFAULT AND NEUTON.AI

View from the Top

Non-Terrestrial Networks are taking NB-IoT cellular IoT to every corner of the earth

BREAKING THE SOUND BARRIER:
AURACAST PROMISES INCLUSIVE AUDIO EXPERIENCE

A BURNING CHALLENGE:
WIRELESS NETWORKS TACKLE WILDFIRES

DEVELOPING WITH MATTER AND THE nRF54L SERIES

UNSTOPPABLE BLUETOOTH LE POWERS INNOVATION

INTRODUCING NORDIC'S ALL NEW nPM1304 PMIC

NORDIC SEMICONDUCTOR

Welcome

Vegard Wollan
Chief Executive Officer & President

Innovation and key acquisitions show leaders don't stand still

The first half of 2025 marks a pivotal moment for Nordic and the semiconductor industry. With the acquisitions of Memfault and Neuton.AI in June, Nordic is making bold strategic moves that redefine its role—from a traditional hardware supplier to a complete chip-to-Cloud solution provider and Edge AI leader.

Memfault, a long-time Nordic partner, brings a market-leading Cloud platform for monitoring, updating, and improving devices at scale in the field. Neuton.AI offers fully automated TinyML for edge devices, making Nordic's solutions smarter, faster, and more powerful. These integrations enable a new generation of connected products, and accelerate our transformation into a company offering a complete range of intelligent solutions – hardware SoCs, software, and chip-to-Cloud services.

With Memfault, we move beyond semiconductor boundaries. Combining world-class hardware and software with Cloud services and product lifecycle management, will drive the next wave of IoT innovation. This reflects a broader industry truth: The future lies not only in efficient hardware, but in intelligent, secure, and adaptable systems, addressing rapidly evolving security requirements and increasing software complexity.

Nordic remains committed to our long-term vision of truly global connectivity. This issue of *WQ* highlights how we're expanding that connectivity reach through cellular and satellite technologies. The new nRF9151, the market's most compact and lowest-power cellular IoT module, supports terrestrial and satellite networks—bringing reliable connectivity to previously unreachable sectors like remote agriculture, environmental sensing, metering, tracking, and logistics.

Nordic's leadership in low-power wireless technology, combined with its growing Edge AI and Cloud capabilities, positions us to deliver scalable, intelligent solutions—at the edge, in the Cloud, and everywhere else in between.

> "Nordic is strengthening its position as both a chip-to-Cloud solution provider and edge AI leader

We dedicate this edition of Wireless Quarter *to Steven Keeping – our long-time Editor, collaborator, and friend – in memory of his enduring contribution to Nordic.*

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The latest developments from Nordic Semiconductor

Corporate Acquisitions

Nordic makes bold "declaration of intent" with Memfault and Neuton.AI acquisitions

Nordic Semiconductor has announced two major acquisitions to strengthen its position as a complete chip-to-Cloud solution provider and edge AI leader. The company's acquisition of long-term partner, Memfault Inc., the market-leading Cloud platform provider for large-scale deployments of connected products, is a major step in Nordic's evolution from a traditional hardware supplier to a complete solution partner, providing hardware, software, tools, and chip-to-Cloud services.

With the Memfault acquisition Nordic now provides a comprehensive platform that simplifies development and accelerates time-to-market. Throughout the product lifecycle, continuous software upgrades strengthen the security, performance, power consumption, and functionality of products in the field. This allows customers to focus on innovation.

Done deal: François Baldassari, CEO of Memfault (left) and Vegard Wollan, CEO of Nordic Semiconductor

Memfault has established itself as the leading platform provider for device observability and management, and secure over-the-air (OTA) software updates to ensure the highest device reliability without field returns. Nordic will integrate Memfault's capabilities across its complete ultra-low power wireless product portfolio and into its existing nRF Cloud services platform, creating a significantly more powerful solution.

"This acquisition is a declaration of intent," said Vegard Wollan, CEO of Nordic Semiconductor. "Together, we enable thousands of customers to continuously interact with millions of devices in the field.

"We are setting a new standard in the global semiconductor landscape for integrating hardware, software, tools, and services. By combining Nordic's ultra-low power wireless connectivity solutions with Memfault's Cloud services, we are making it faster, simpler, and more secure to develop, maintain, and improve connected products through their entire lifecycle."

In addition, Nordic has acquired the intellectual property and core technology assets of Neuton.AI, a pioneer in fully automated TinyML solutions for edge devices. This ignites a new era of ML on the edge by combining Nordic's industry-leading nRF54 Series SoCs with Neuton's revolutionary neural network framework — bringing scalable, high-performance AI to even the most resource-constrained devices.

"This is a generational leap in embedded compute power and efficiency," said Wollan. "By uniting Nordic's low-power wireless leadership with Neuton.AI's cutting-edge TinyML platform, we empower developers to build a new class of always-on, AI-powered devices — faster, smaller, and more power-efficient than ever."

Through its neural network framework, which builds ultra-small models automatically without predefined architectures, Neuton.AI offers accurate, energy-efficient, and fast AI for edge applications, all while preserving precious device and system resources.

"We are proud to enable the powerful combination of Neuton's advanced ML technology with the performance of Nordic's ultra-low power nRF54 Series, redefining what's possible in ultra-efficient machine learning applications," said Oyvind Strom, EVP Short-Range at Nordic Semiconductor.

"Together, we're enabling developers to build smarter, ultra-low-power devices that deliver true machine learning at the edge, not only for the nRF54 Series, but across the wide portfolio of all Nordic's wireless connectivity SoCs.

"Embedded AI will now become more accessible and scalable than ever. Neuton's advanced ML technology enables effortless integration and trusted intelligence for next-generation edge AI devices."

Connected Health

Smart lenses adjust focus to enhance near and far vision

ViXion Inc., has released a smart eyewear solution that provides automatic, hands-free focus adjustment for both near and far vision, while maintaining the lightweight feel of regular glasses.

Designed to address various vision challenges including long and short sightedness, ViXion01S weighs 33 g (without outer lenses) and uses integrated sensors to measure the distance to viewing targets, enabling the device to modify lens shape to substitute for or enhance the eye's natural focusing function.

ViXion01S employs the Kaga FEI EJ2840 module based on Nordic's nRF52840 SoC to supervise the sensors and control all product functions, including lens control, sensor control, and button and buzzer operations. The nRF52840 SoC also provides the Bluetooth LE wireless connectivity enabling configuration and control of the ViXion01S eyewear from the ViXion Connect app.

The ViXion01S device uses a 3.7 V, 150 mAh Li-Po battery to provide approximately 15 hours of operation time and 3 hours of charging time. This is achieved thanks to the ultra-low power capabilities of the nRF52840, supported by the Nordic nPM1300 Power Management IC (PMIC). The nPM1300 PMIC simplifies system design by integrating essential power management functions required for embedded Bluetooth LE designs into one small package, enabling longer run times and efficient battery charging with fewer components.

"As a wearable, we needed to optimize the battery for all-day use while maintaining a compact and lightweight design, necessitating a low-power wireless module alongside an effective power management solution," says

Smart Agriculture

Seed monitoring platform drives efficiencies in smart agriculture

QuarterPoint LLC, formed as a partnership between Seedbox Solution and Trace Engineering, is providing a tailored version of its cellular IoT and Bluetooth LE monitoring products to power Seedbox Solution's Smartbox Platform. The Smartbox is an IoT-enabled version of the Seedbox — a large returnable container used by seed production firms and farmers across the United States.

The Smartbox Platform allows seed producers, dealers, and farmers to monitor the environment, location, container fill level, and overall quality of their seed inventory - down to the individual package level. By combining product data, inventory status and environmental metrics, this technology delivers unmatched supply chain visibility.

The upgraded Smartbox solution employs the next generation Nordic nRF9151 low power module's powerful 64 MHz Arm Cortex-M33 programmable application processor with generous 1 MB NVM and 256 KB RAM to collect and process the data from various integrated sensors — including temperature, pressure, humidity and acceleration. Using the nRF9151 module's multimode LTE-M/NB-IoT modem and GNSS, the device transmits the collected sensor data and device location to the Cloud, where it can be accessed via the associated app or web-based platform.

Smartbox also incorporates the Nordic nRF52840 SoC to provide the Bluetooth LE connectivity for local inventory tracking via a smartphone. Through the app, users can locate and navigate to specific Smartbox devices in a large warehouse or production facility.

In Brief

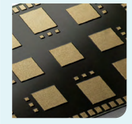
NORDIC SOLUTIONS HONORED AT EE AWARDS ASIA CEREMONY

Nordic Semiconductor has been awarded 'Best RF/Wireless IC of the Year' for its nRF54H20 advanced multiprotocol SoC, 'Best Power Semiconductor of the Year' for its nPM1300 Power Management IC (PMIC), and 'Best Technology Platform Award' for its nRF Cloud IoT Cloud services in the EE Awards Asia program. Nordic faced fierce competition in each category of the awards which forms an annual event that honors the most innovative and influential players in the electronics industry. Organized by the publisher of *EE Times Asia* and *EDN Asia*, the awards highlight those who have made significant contributions to the electronics field.

SMART BUILDING TECH LEADERS JOIN FORCES ON NR+

Nordic Semiconductor has joined a strategic interest group of smart building technology companies to ensure ultra-resilient and interoperable wireless connectivity in buildings using the DECT NR+ (NR+) technology standard. The interest group includes major smart building technology companies as well as wireless industry experts including Nordic and Wirepas. The NR+ interest group will work with hardware and software providers, smart building standards organizations, as well as promoting regulatory adoption to bring the NR+ standard to the forefront of the smart building sector.

nRF9151 VALIDATED FOR LTE-M NETWORK IN JAPAN



Nordic Semiconductor's nRF9151 low power module for advanced cellular IoT is now validated for use on NTT DOCOMO, Japan's largest cellular network. The telco giant's LTE-M network covers the majority of the country's population. Validation ensures developers nRF9151 module cellular IoT connectivity compatibility across the country on NTT DOCOMO's network. With the nRF9151 module having also received TELEC/MIC certification—mandatory product approval for radio and telecommunications equipment in Japan—developers are also guaranteed end product compliance for electromagnetic interference (EMI) and RF emissions.

Smart Metering

Nordic extends NR+ mesh networking for North American smart metering

Nordic Semiconductor has announced that its nRF9151 module, a low-power integrated LTE-M/NB-IoT and DECT NR+ ('NR+') modem solution with GNSS, now supports NR+ 915 MHz band operation. Support for the popular sub-GHz band complements the module's existing provision for 1.9 GHz global NR+ operation and opens up new North American smart grid and utility metering applications, among others.

Nordic demonstrated NR+ 915 MHz operation on the nRF9151 module at Distributech International 2025. The demonstration showcased the capabilities and value of the sub-GHz network in real-world scenarios.

"915 MHz support is a key enhancement for Nordic's NR+ offering," says Kristian Sæther, Product Director, Long Range with Nordic Semiconductor, and member of the Board of the DECT Forum. "Bringing this new capability to the nRF9151 module offers developers a compelling, seamless integration of hardware and software, delivering high-performance, energy-efficient and globally applicable sub-GHz 5G mesh networking to the smart grid and utility sector."

The support for 915 MHz operation combines Nordic's nRF9151 module—the lowest power cellular IoT and NR+ solution with industry-leading battery lifetime performance—with Wirepas' NR+ non-cellular 5G Mesh connectivity software.

Wirepas is a Tampere, Finland-based global leader in IoT connectivity and its software enables the deployment of private 5G networks without subscriptions or heavy infrastructure.

Its sub-GHz software, running on Nordic's nRF9151, is specifically designed for North American smart grids and utility meters.

Smart Lighting

Matter over Thread smart dimmer controls dimmable LED lighting

ION Industries has released a Matter over Thread compatible LED dimmer that enables users to control any dimmable LED lighting from 0.3 W up to a maximum of 200 W, via a Matter-compatible smart home ecosystem or compatible smartphone app.

The LED Matter Dimmer integrates Nordic Semiconductor's nRF52840 advanced multiprotocol SoC to enable ON/OFF power, dimming status, and minimum/maximum brightness control commands between the device and any Matter-certified smart home ecosystem, such as Apple Home and Amazon Alexa, using Matter over Thread wireless connectivity.

Matter is an open-source standard created by the Connectivity Standards Alliance (CSA) that brings interoperability between smart home devices and ecosystems to reduce complexity for the end user.

"The user-friendly open standard Matter makes it possible for a user to control the LED Matter Dimmer along with all their other smart home devices from a single application, providing more convenience and comfort," explains Erik Geijtenbeek, Sales Director at ION Industries.

The LED Matter Dimmer—said to be the world's first Matter-compatible smart dimmer employing a physical push-turn button—can remember the last used position of the lighting and provides a boost function to prevent unwanted high brightness when switching on the lamp. It also supports global sustainable development goals through its energy-saving capabilities.

By the Numbers

$155.1 million in revenue

Nordic Semiconductor has reported Q1 2025 revenue of $155.1 million, up from $150.2 million in Q4 2024. This also represents high year-on-year growth of 108 percent from Q1 2024, which was affected by significant inventory adjustments. The improvement reflects healthy underlying demand as well as the positive impact of orders from individual large customers. In general, Nordic has been well positioned to capitalize on the market recovery over the past year.

Connected Health

Smart wireless stethoscope with unmatched battery performance

Digital medicine company, Lapsi Health, has launched an FDA-approved smart stethoscope designed for wireless recording and analysis of auscultation sounds (internal body sounds) such as heartbeats. The Keikku has been created for use in both point-of-care and telemedicine applications.

Weighing just 100 g, this pocket-sized device is held against the patient's body to capture audio. Medical practitioners can then stream this sound directly to their headphones or speakers, adjust the volume by twisting the device, and begin recording with a double tap. The data is then transmitted via Bluetooth LE wireless connectivity—enabled by Nordic's nRF5340 SoC—for analysis through the Keikku smartphone application. Any abnormal results are both displayed in the app and indicated through a change in the device's LED color.

"The device is run entirely on the nRF5340 SoC," says Séamus Holohan, Chief Operating Officer at Lapsi Health. "The chip's robust processors and ample memory capacity are able to seamlessly manage the microphone system for audio detection, touch sensor, as well as the Inertial Measurement Unit [IMU]

for device control. Combined with the battery life achieved with the nPM1300 [Power Management IC], the Nordic devices are an integral part of our product."

The low power operation of the nRF5340 SoC's network processor allows the device to function for up to 72 hours of continuous use on a single charge — equating to nearly a month of regular operation. This extended lifetime is further enabled by the Nordic nPM1300 PMIC, which improves charging efficiency, prolongs battery performance and reduces the need for additional components.

Cellular IoT

Nordic and Skylo bring ultra-low power satellite connectivity to massive IoT

Nordic Semiconductor and Skylo, the pioneer in Non-Terrestrial Network (NTN) communications, have launched a strategic partnership to certify Nordic's nRF9151 low-power cellular module on Skylo's satellite network service. Nordic and Skylo's partnership unlocks new massive IoT use cases, such as remote monitoring, asset tracking, and enhanced safety and security by enabling small, constrained IoT devices to connect seamlessly over satellite. It marks a clear path for device manufacturers to achieve global connectivity using 3GPP-compliant, off-the-shelf cellular solutions.

"This collaboration with Skylo opens the door to a new class of IoT solutions that can operate in remote or off-grid environments with standard ultra-low power cellular solutions like the nRF9151," said Oyvind Birkenes, EVP of Nordic' Long Range Business Unit.

"We see strong demand from the market for satellite connectivity on low power modules such as the award-winning nRF9151," added Tarun Gupta, co-founder and Chief Product Officer at Skylo. "This will enable device manufacturers to create innovative new products that stay connected far beyond the limits of terrestrial coverage."

With this partnership, industrial, consumer and healthcare markets can now benefit from ultra-low power satellite connectivity. Small, battery-operated devices can stay connected longer, leveraging Skylo's standards-based 3GPP satellite network.

In Brief

NORDIC AND DEUTSCHE TELEKOM ANNOUNCE LINK-UP

Nordic Semiconductor has collaborated with Deutsche Telekom to introduce an IoT solution aimed at enhancing global connectivity for embedded devices. The IEC (IoT Embedded Connect) solution, based on Nordic's nRF9151 module, will provide a fully integrated, scalable solution, designed to streamline IoT adoption for developers worldwide. The nRF9151 will be available through Deutsche Telekom, equipped with a pre-activated, integrated nuSIM. This setup ensures seamless connectivity across Deutsche Telekom's network and its roaming partners, addressing the critical need for reliable IoT connectivity.

ULTRASONIC WIRELESS CHARGING FOR STABLE POWER

Image: Korea Institute of Science and Technology (KIST)

Researchers have developed a biocompatible ultrasonic receiver that overcomes limitations of existing wireless power transmission methods. The team from Korea University and the Korea Institute of Science and Technology also demonstrated wireless charging of batteries by receiving ultrasonic waves. By designing an ultrasonic receiver that conforms to the curves of the human body while achieving stable power conversion, they were able to transmit 20 mW of power at a distance of 3 cm underwater and 7 mW at a depth of 3 cm from the skin — sufficient to continuously power implantable medical devices.

NORDIC SUPPORT ENHANCES IIJ SOFTSIM CAPABILITIES

Nordic's nRF9151 low power module now includes SoftSIM support for Japan's only SoftSIM provider, Internet Initiative Japan Inc. (IIJ). By using a SoftSIM instead of a traditional SIM, developers can reduce SIM and BoM costs, simplify design, and lower power consumption for cellular IoT end products based on the nRF9151 module. SoftSIM is ideal for space-constrained cellular IoT devices with low power consumption requirements, such as wearables. The SoftSIM offers access to globally certified cellular IoT technology, simplifying regulatory compliance for IoT devices globally and enhancing support for Japan-specific IoT applications and standards.

Power Management

nPM2100 PMIC extends life of primary cell-powered Bluetooth LE products

Nordic's new PMIC offers an efficient boost regulator and a range of energy-saving features to extend non-rechargeable battery operating time

Extracting as much energy as possible from primary batteries using dedicated PMICs to extend battery life eases material, supply chain, and disposal challenges

According to CORDIS, 28 billion primary (non-rechargeable) batteries are discarded worldwide each year and manufacturing a primary battery requires, on average, 50 times the energy it stores, making it an extremely inefficient energy source. Worse yet, inefficient power management wastes a substantial part of the stored energy, resulting in many batteries being thrown away before they are fully depleted.

"Not all IoT products can rely on rechargeable batteries or energy harvesting to operate. This means that primary batteries aren't going away any time soon," says Geir Kjosavik, Product Director – PMICs, at Nordic Semiconductor. "Designers need to access as much of the energy stored in those primary cells as possible, making products last longer between battery changes or allowing the use of smaller batteries for the same battery life."

To meet this challenge, Nordic has now introduced an addition to its nPM family of Power Management ICs (PMICs). The nPM2100 PMIC prolongs the operating time per battery for primary battery applications by managing energy resources using an ultra-efficient boost regulator and a wide range of energy-saving features. Application examples for the nPM2100 include wireless mice and keyboards, consumer asset tracking, remote controls, and body-worn medical devices.

Example batteries supported by the nPM2100 include one or two AA/AAA/LRxx batteries (in series), or one 3 V LiMnO2 cell. Single- or dual-cell silver oxide and zinc-air coin-cell batteries are also supported, plus any other primary battery that operates within the nPM2100's input voltage range.

Power management for SoCs and MCUs

Designed to provide highly efficient power regulation for any primary cell application, the nPM2100 comes with exceptional software support for Nordic's nRF52, nRF53 and nRF54 Series SoCs in the nRF Connect SDK. The PMIC offers maximum efficiency and compact size and is configurable through an I2C-compatible Two Wire Interface (TWI). This interface enables easy access to configure a range of advanced functions, including ship mode, and accurate battery fuel gauging. The PMIC also features two GPIOs that can be repurposed to direct control lines to time-critical control functions as an alternative to serial communication.

The nPM2100 features a boost regulator with an output range of 1.8 to 3.3 V, powered from an input range of 0.7 to 3.4 V. The regulator can deliver up to 150 mA maximum current. The regulator also powers a Load Switch/LDO supplying up to 50 mA across an output range of 0.8 to 3.0 V. The regulator features a quiescent current (IQ) of 150 nA and delivers up to 95 percent power conversion efficiency at 50 mA and 90.5 percent efficiency at 10 µA, making it one of the most efficient contemporary boost regulators on the market.

> "Nordic's PMIC offering plays a vital part in the company's continued focus on providing the lowest power IoT solutions possible for our customers

Low current ship- and hibernate-modes

The nPM2100 PMIC features a low current ship mode that enables products to be transported with the battery inserted. The ship mode supports a 35 nA sleep current with multiple wakeup options, including a patent-pending 'break-to-wake' function. This function allows a buttonless product to wake up from ship mode when an electrical connection is broken. The PMIC also features an ultra-low power wakeup timer that can run concurrently with ship mode to allow timed wakeups. The timer can be used for a deeper sleep setting than the power-off of a SoC or MCU can normally provide. The nPM2100's total current draw in hibernate mode is less than 175 nA.

The nPM2100 also supports precise algorithm-based fuel gauging, a feature not commonly found in PMICs for primary-cell batteries. The nPM2100 supports a voltage and temperature-based fuel gauge running on the host microprocessor that enables more accurate battery level measurements and enables users to access all the energy in the battery with confidence. The software-based fuel gauge places minimal additional load on the battery.

Bluetooth LE

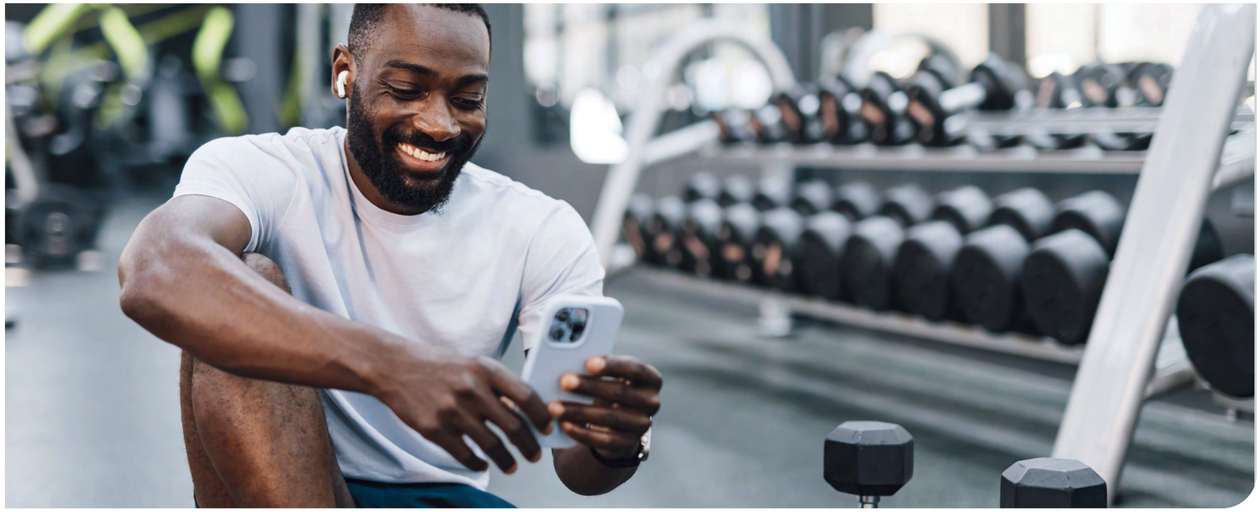
Increasing adoption of Bluetooth LE drives innovation across sectors

As the dominant short range wireless technology, Bluetooth continues to evolve and meet the shifting needs of the wireless device market

> Bluetooth will play a key role in creating a world that is healthier, more convenient, more productive, and more sustainable

With over five billion products shipping each year, Bluetooth technology is the most widely deployed wireless standard in the world. A key reason for its unmatched adoption and success is the continual evolution of the technology in critical areas, including higher data throughput, lower latency, greater positioning accuracy, and better co-existence. In 2024, Bluetooth evolved further and reached several key milestones, including increased real-world deployments of Auracast broadcast audio and the release of Bluetooth Channel Sounding — a new secure, fine-ranging feature.

Moving forward, all signs point to an ongoing upward trajectory. Projections from the *Bluetooth Market Update 2025*—a Bluetooth Special Interest Group (SIG) report—suggest Bluetooth will maintain its dominance in the short range wireless market throughout the decade and beyond. Driven by steady growth across many Bluetooth market segments, Bluetooth device shipments are projected to surpass 5.3 billion units in 2025 and reach 7.7 billion units by 2029.



Rapid growth for Bluetooth LE

Single-mode Bluetooth LE device shipments are experiencing rapid growth, fueled by new use cases across industries. Emerging applications like smart labels and electronic shelf labels (ESLs) are helping to drive adoption of single-mode Bluetooth LE, and the technology's low power consumption and flexibility continue to unlock new market opportunities.

Meanwhile, single-mode Bluetooth Classic—which proved a good solution for consumer applications—is seeing a decline, with shipments projected to decrease at a CAGR of -14 percent, reflecting a broader industry shift towards more flexible and energy-efficient Bluetooth LE implementations. Bluetooth Classic makes up less than 10 percent of total Bluetooth enabled device shipments.

The figures above are a powerful statement for innovations like Bluetooth LE Audio and Auracast broadcast audio. Through the introduction of these technologies, Bluetooth continues to raise the bar for audio performance and flexibility, supporting higher quality sound, lower power consumption, seamless connectivity across audio devices—particularly hearing aids and wireless headphones—and new listening experiences like shared audio in public venues.

Over 3.1 billion Bluetooth LE Audio enabled devices are expected to ship annually by 2029, while 1.5 million public venues are set to be transformed into Auracast locations, making inclusive listening experiences widely accessible within five years. Given the World Health Organization estimates 2.5 billion people will have some degree of hearing loss by 2050, and more than 700 million will require hearing rehabilitation, the forecast is significant.

Creating a better world

As well as contributing to a more accessible and inclusive society, the Bluetooth SIG expects Bluetooth will play a key role in creating a world that is healthier, more convenient, more productive, and more sustainable.

Bluetooth connectivity supports the seamless communication between medical devices and healthcare providers, optimizing telehealth operations while improving patient outcomes and access to care. In the connected health and fitness space, 477 million Bluetooth wearables, 70 million+ Bluetooth smart rings, and 60 million Bluetooth home health monitoring devices are expected to ship annually by 2029.

According to Andrew Zignani, Senior Research Director at ABI Research, "Taking advantage of Bluetooth LE's low-power consumption and streamlined connectivity to smartphones, a combination of reusable and disposable devices—such as continuous glucose monitors, blood pressure monitors, wearable ECGs, medical patches, insulin pens, inhalers, among many other emerging device types—are poised to grow rapidly over the next few years."

When it comes to industry, 30 percent of manual work is not performed correctly, wasting over $625 billion every year, claims *IoT For All*. In contrast, predictive-maintenance IoT technologies create a 70 percent reduction in equipment breakdowns, says Deloitte. Therefore, with 600 million Bluetooth enabled industrial devices predicted to ship annually by 2028, Bluetooth could play a pivotal role in industrial productivity, enabling industrial IoT solutions such as predictive maintenance and manufacturing automation. The Bluetooth SIG anticipates 45 percent of wireless condition monitoring sensors will include Bluetooth connectivity as soon as 2026.

On the sustainability front, the World Economic Forum claims 20 percent of global food production is lost or wasted, with much of it spoiling during storage and transport due to inadequate monitoring. The Bluetooth SIG believes Bluetooth can assist businesses optimize resources, reduce waste, and contribute to a greener economy — a sentiment supported by its prediction that 760 million Bluetooth asset tracking tags, 140 million Bluetooth smart labels, and 138 million Bluetooth ESLs will ship annually by 2029.

Need to Know

Nordic Semiconductor's new nRF54 Series SoCs are ideal for AI wearable applications that demand high processing power and excellent energy efficiency, as well as state-of-the-art security. The nRF54 Series SoCs enable Edge AI with low power consumption and extended battery life

Comment

Ole-Fredrik Morken
EVP — Supply Chain, Nordic Semiconductor

Multi-sourcing promotes customer confidence

Nordic's multi-sourcing provides the product customers need, when they need it, and at the right price

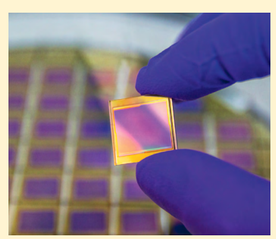
Multi-sourcing and supply chain resilience is critical in the semiconductor industry because of its highly globalized and capital intensive nature. The sector is extremely sensitive to disruption, and supply issues can have major downstream effects.

There are many flavors of multi-sourcing ranging from 'copy-exact' (where an alternate fab replicates the original process and equipment configuration exactly), to 'similar function' (where the alternate fab produces functionally equivalent or similar chips but not necessarily using the same process, materials or tools). In Nordic's supply chain we employ a combination of these strategies between front-end (foundry) and back-end (assembly and test) to reduce risk, ensure supply continuity, and provide greater flexibility. It also allows us to ensure the best possible device performance and features for our range of solutions. Ultimately, multi-sourcing is just another pillar of Nordic's value offering—providing customers with the product they need, when they need it, and at an acceptable cost.

> Multi-sourcing is just another pillar of Nordic's value offering—providing customers with the product they need, when they need it, and at an acceptable cost

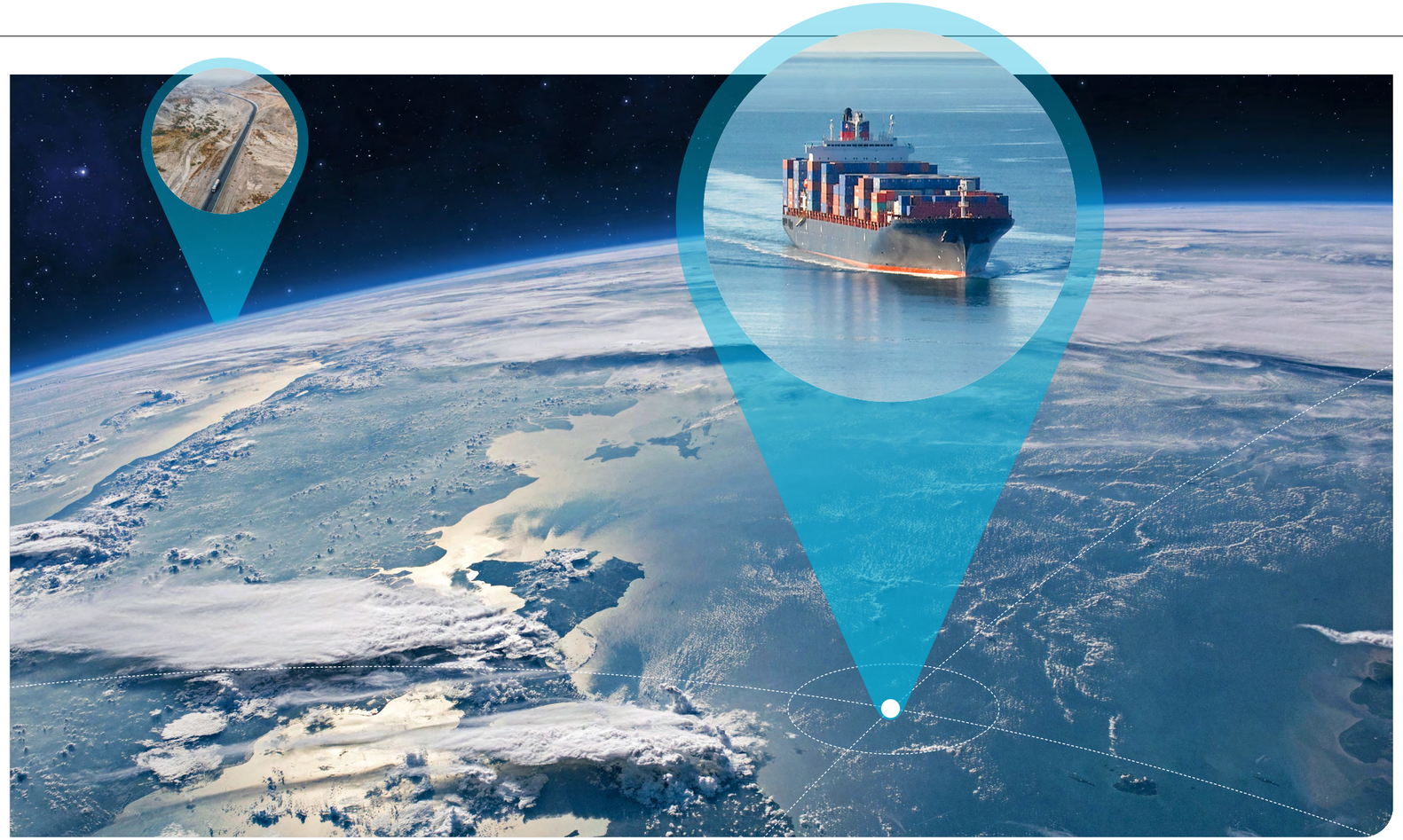
So for example, the company's nRF54L Series features a new hardware architecture fabricated using TSMC's 22ULL (22 nm) process technology. The nRF54H Series meanwhile is fabricated using GlobalFoundries' 22FDX (22 nm) process. Both of these leading wafer suppliers offer some very compelling features and strengths, on top of which they represent sourcing from two continents, with TSMC's leading 22ULL fab in Taiwan, and GlobalFoundries in Dresden, Germany. Establishing a top-of-the-range RF SoC on a new technology involves a steep learning curve and significant investment, and to go ahead and complete that with two foundries requires scale. While it's not unheard of among larger logic-based suppliers, it's quite unusual in Nordic's part of the market.

We have a product roadmap, with differentiated features between these two 22 nm technologies with a focus on building on the strengths of each, but also allowing us to bridge the function-gap should a need materialize. We believe this shows dedication to our belief in always trying to value add and drive the performance envelope. On top of this, the vendors of both technologies have announced future capability for sourcing same products from multiple fabs, again across continents, further helping future proof Nordic's supply chain.



View from the Top

Satellite IoT connectivity promises to lower the cost and extend the reach of wireless connectivity to the entire planet, enabling new global use cases and applications



In Short

4G/LTE technology covers roughly 90 percent of the world's population, but only about 15 percent of the earth's surface

IoT solutions that need to operate almost anywhere, monitor critical infrastructure, safeguard livestock, or track shipments of valuable goods need a global solution

Non-Terrestrial Network tech supports NB-IoT via satellites. The technology is serviced by a satellite constellation, backed by available cellular IoT infrastructure

Cellular connectivity is generally looked upon as a ubiquitous technology in today's world. 4G/LTE covers 90 percent of the world's population, and when you add in 3G and 2G as a back-up, most of us have generally come to expect a consistent cellular signal due to the network infrastructure that surrounds us. The reality can be a little different. If you live remotely from a city then it's probably worse, because geographically 4G/LTE only services around 15 percent of the Earth's surface. While that increases to between 30–35 percent when you factor in 2G and 3G, that's diminishing every year as operators phase out those networks worldwide.

This lack of cellular coverage is magnified for IoT solutions, that unlike people, may need to operate anywhere on the planet's surface. One example are the bulk carriers and cargo ships that sail the South Pacific Great Circle route between South America and New Zealand and Australia. This shipping route passes near Point Nemo, a point in the ocean almost 3,000 kilometers from any land mass, and so remote it is used as a graveyard for deorbiting satellites and space stations. The container ships that navigate this route carry amongst other things expensive mining and industrial equipment bound for South American mines, as well as luxury cars, electronics and other niche consumer goods. Tracking the end-to-end whereabouts and condition of such cargo can be essential in the event something goes wrong and it needs to be established which party is at fault, and who has to foot the bill.

There are critical tracking and monitoring applications in remote corners of our land mass too. Northern Canada, Australia, Patagonia and Central Asia are all home to large cattle farms far from cellular connectivity where tracking individual animals can be beneficial for livestock management, their welfare and to prevent theft. There are also up to 10 million kilometers of high voltage transmission lines and 7 million kilometers of oil and gas pipelines stretching in linear corridors across the planet, often in isolated or harsh environments, but where the need to monitor for leaks and faults is no less essential.

Cellular IoT devices such as Nordic Semiconductor's nRF91 Series, paired with a Bluetooth LE transceiver and sensors, are tailor made for asset tracking and monitoring solutions. They are reliable, secure, low power and economical enough to be employed at the individual parcel (or animal) level, or at regular intervals along a transmission line or pipeline, but there are limits. They provide connectivity across cities and countries and much of the populated globe, but not in the middle of the South Pacific Ocean or along a trans-Alaskan pipeline.

So how do manufacturers of IoT tracking solutions provide customers with uninterrupted global coverage when 70 percent of the planet has no cellular IoT coverage?

A NON-TERRESTRIAL SOLUTION

One solution is the 3rd Generation Partnership Project's (3GPP) Non-Terrestrial Network (NTN) technology. NTNs support NB-IoT via satellites rather than relying on cellular infrastructure. The technology is serviced by a satellite constellation, complemented by cellular IoT infrastructure where it is available. The result is access to global cellular networks that are accessed in a similar way to terrestrial LTE-M/NB-IoT networks.

3GPP NTN providers offer two equally important parts, the satellites replacing the cell towers, and the cellular core network. The core network allows NTN and terrestrial networks to seamlessly interact, enabling mobile IoT devices such as asset trackers to roam from a ground network to NTN, in the same way roaming occurs on today's terrestrial networks.

Just like IoT applications, all 3GPP NTNs are not the same. At the basic level, NTNs split into three main categories. The technology can be based on Geostationary Earth Orbit (GEO), Low Earth Orbit (LEO), or Medium Earth Orbit (MEO) satellites, although the latter is not widely used in the IoT.

A GEO satellite orbits the Earth at the same speed it rotates and can cover as much as one third of the globe. GEO satellites generally reflect the signals sent from an IoT device back to earth without any processing. The satellite is transparent to the IoT device and the communication is with a 'cell tower' on the ground. Data sent can reach a Cloud service while the NTN connection is active.

HIGHER THROUGHPUT WITH LEO

Low Earth Orbit (LEO) satellites, used by multiple emerging 3GPP NTN networks, are much closer to Earth at 600–800 km. This eases the challenges on the IoT device radio link budget and supports throughputs of 20-to-40 kbps, The high altitude (almost 36,000 km) and relatively low number of GEO satellites present challenges for the IoT device's radio link budget reducing throughput compared with terrestrial networks. The PHY bit rates are typically 1–2 kbps, using a standard power class 3 (23 dBm) module and a 0 dBm antenna.

Due to the relatively low effective data rate, but real time connection to the core network, NTN GEO has so far mainly been used for emergency communication. The main use case being direct-to-device (D2D) services for mobile devices and other use cases that need instant delivery.

With more services coming, this is now broadening to IoT use cases which also have very limited need of data but have important messaging where constant coverage and relatively low latency is a must-have—for example, an alarm that needs to be acted upon.

By the Numbers

15%
Percentage of earth's surface with access to 4G/LTE connectivity
Source: GSMA

95%
Percentage of earth's surface with access to NTN connectivity
Source: GSMA

175 million
NTN connections by 2030
Source: ABI Research

10 years
Potential battery lifespan for NTN IoT devices
Source: iiot-world.com

while using the same power class 3 module and antenna as that for GEO NTN. The higher effective data rates bring the extra advantage of reducing satellite connection time and therefore IoT device power consumption.

The downside of LEO NTN is that the satellites are orbiting the earth rapidly, taking only around 90 min for each orbit when at an altitude of 700 km. An individual LEO satellite is only in line-of-sight of the IoT device and the NTN core network for a few minutes per orbit.

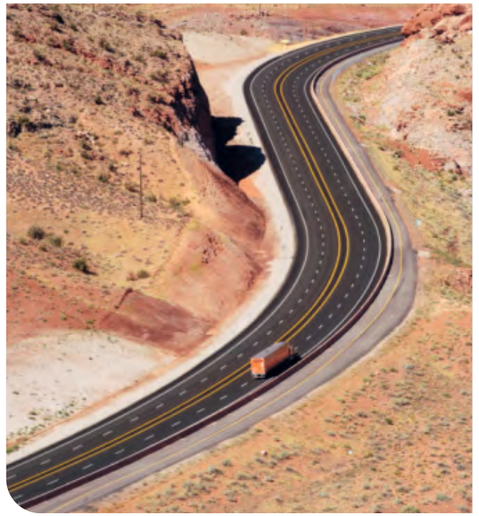
Robust coverage demands a constellation of tens or even hundreds of satellites, and a backhaul infrastructure relaying data through the LEO constellation to reach earth stations in real time. Until that infrastructure is in place, a 'store and forward' architecture is being used. This arrangement retains data in a particular satellite until it can be relayed to another satellite or earth station. The result is discontinuous coverage making LEO NTN networks more suitable for use cases where collected data doesn't require immediate attention from the Cloud.

As LEO constellations deploy more satellites, the time gaps in network availability as well as the end-to-end latency will go down, and users will get a continuous, global and low latency service for their IoT devices.

COVERING ALL BASES

NTN will provide exciting new opportunities for cellular IoT developers, but it is important they start by looking at the use cases of their product, and decide where, when, and if NTN will add value. For some end product solutions NTN will be the only connection, for others it will be the ultimate cellular coverage extension. Using terrestrial networks will still give the most efficient connection where

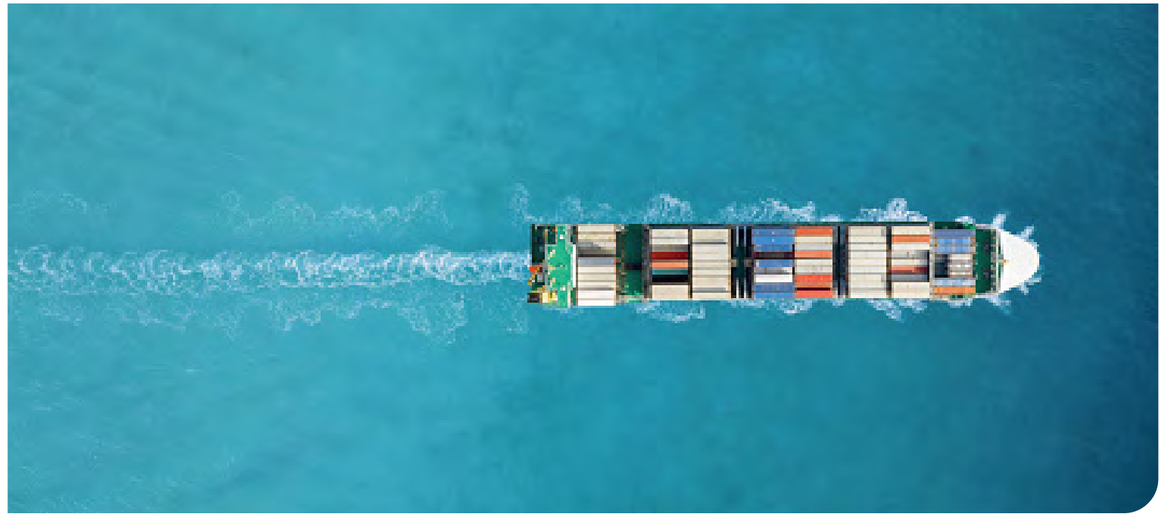
> NTN provides an invaluable alternative where efficient connection to a terrestrial network is unavailable



coverage is good, but NTN now provides an invaluable alternative where it doesn't. Most terrestrial network providers are already engaged with both GEO and LEO NTN networks to offer the broadest and best solution, and Nordic Semiconductor is ensuring developers have the technology platform to support any possible use case.

Nordic has developed a low power, integrated solution that will support both terrestrial and non-terrestrial connectivity, in the nRF9151 module. The nRF9151 supports NB-IoT, LTE-M, and DECT NR+, and will add support for NTN in a future release. The nRF9151 includes a dedicated 64 MHz Arm Cortex-M33 application processor with 1 MB Flash and 256 KB RAM, a multimode LTE-M/NB-IoT modem with GNSS, power management, and an RF front-end, all designed by Nordic. Application design is supported by Nordic's nRF Connect SDK and nRF Cloud Services.

At the same time the company has also been actively



partnering with multiple NTN providers including Iridium Communications, Skylo, Myriota, Omnispace and Gatehouse Satcom to offer its customers commercial options for their NTN deployments based on the nRF9151 module. As recently as May, Nordic announced participation in a successful 5G NB-IoT trial over a non-geostationary orbit satellite. The demonstration, conducted with Omnispace and satellite communications software firm Gatehouse Satcom, marks a key step toward bringing seamless, standards-based 5G IoT connectivity to remote and underserved areas.

"This demonstration marks a key step in making global, seamless 5G IoT connectivity a reality," said Ram Viswanathan, CEO at Omnispace. "Working with Gatehouse Satcom and Nordic Semiconductor, we are demonstrating what's possible for the future of global communications including powerful NGSO satellite solutions that seamlessly integrate with existing 5G terrestrial cellular networks."

THE FINAL FRONTIER

Even in the last 10 years, the IoT has evolved from a niche concept into a mainstream ecosystem that underpins almost everything we do at home, work and play. Connected devices have surged to more than 15 billion today, and will double again by 2030 according to the *Ericsson Mobility Report*. Edge computing and AI integration has allowed in some instances near real time decision-making, reducing latency and Cloud dependence. Cellular IoT has also evolved, enabling billions of high throughput, low latency applications where short range wireless connectivity is not an option. Today the IoT is critical infrastructure, reshaping industries, economies, and how humans interact with machines. Now it is extending beyond land, sky and sea into space, via new network paradigms such as NTN. The IoT hasn't reached its final frontier, it is just getting started.

Tech Check

The nRF9151 supports NB-IoT, LTE-M, and DECT NR+, and will add support for NTN in a future release. The nRF9151 includes a dedicated 64 MHz Arm Cortex-M33 application processor with 1 MB Flash and 256 KB RAM, a multimode LTE-M/NB-IoT modem with GNSS, power management, and an RF front-end, all designed by Nordic

State of Play

NTN opens IoT to world of new uses

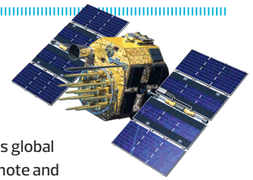
The predicted applications of NTN IoT by 2030 highlight its critical role in extending connectivity to areas beyond the reach of terrestrial networks. Agriculture and environmental monitoring are expected to lead adoption, reflecting the increasing need for precision farming, climate resilience, and remote ecosystem tracking. Asset tracking and logistics closely follow, driven by the globalisation of supply chains and the demand for real-time visibility of goods in transit. Maritime applications are another major area, as NTN enables coverage across vast ocean regions where no terrestrial alternative exists. Sectors like utilities, mining, and public safety also benefit from NTN's ability to provide always-on connectivity in hazardous or remote environments. While consumer applications remain a small share, growth is anticipated as NTN-integrated devices become more mainstream. Overall, NTN IoT will be a foundational technology in closing the global connectivity gap across both infrastructure and services.

Sector / Use case	Description	Est. Market Share
Agriculture & Environmental Monitoring	Soil, weather, crop, livestock monitoring	25–30%
Asset & Cargo Tracking / Logistics	Global shipping containers, vehicles, railcars, aviation cargo	20–25%
Maritime & Offshore	Vessel tracking, offshore oil/gas monitoring	15–20%
Utilities (Water, Gas, Energy)	Remote infrastructure monitoring, pipeline integrity, and off-grid smart metering	10–15%
Disaster Recovery & Public Safety	Emergency response, wildfire and flood detection	5–10%
Mining & Industrial Monitoring	Connectivity for remote mining operations, quarry sensors, and autonomous equipment	5–10%
Consumer & Wearables	NTN-enabled GPS trackers, smartwatches, and outdoor wearables	<5%

Sources: GSMA, ABI Research and Markets&Markets

Nordic Inside:

A brief history of 3GPP NTN



The Third Generation Partnership Project (3GPP) began formal work on Non-Terrestrial Networks (NTN) in response to the growing demand for ubiquitous global connectivity — particularly for remote and underserved regions beyond the reach of traditional terrestrial cellular networks. While satellite communications had existed for decades, they operated independently of mobile network standards until 3GPP introduced NTN into its global cellular framework. NTN work formally began with 3GPP Release 15, which laid the groundwork for integrating satellite links into the broader 5G architecture. However, it was Release 17, completed in 2022, that marked a pivotal milestone. For the first time, 3GPP standardized support for NB-IoT and LTE-M over satellite. This enabled direct-to-device (D2D) communication using standard chipsets, allowing IoT devices to connect via Low Earth Orbit (LEO), Medium Earth Orbit (MEO), or Geostationary Orbit (GEO) satellites without relying on terrestrial towers.

Release 17's specifications enabled a wide range of applications, from remote agriculture and maritime tracking to disaster recovery and environmental monitoring. These use cases benefited from the long battery life, low data rate, and global reach of satellite-enabled IoT. Building on this foundation, 3GPP Release 18 expands NTN support to include 5G NR (New Radio) NTN, offering higher throughput and mobility features. This opens up new possibilities for voice, video, and broadband services via satellite to smartphones and mobile terminals.

NTN is now a critical part of 3GPP's vision for 5G Advanced and 6G, integrating seamlessly with terrestrial networks to provide truly global, resilient, and standardized mobile connectivity. This convergence is driving innovation and helping bridge the global digital divide.

Breaking the Sound Barrier

When announced LE Audio promised better sound and longer battery life. The introduction of Auracast has gone further and delivered an inclusive, barrier-free audio experience for everyone

In Short

A key requirement of LE Audio was that it support broadcast audio. Auracast was born, enabling a source device to broadcast audio streams to unlimited Bluetooth LE audio receivers

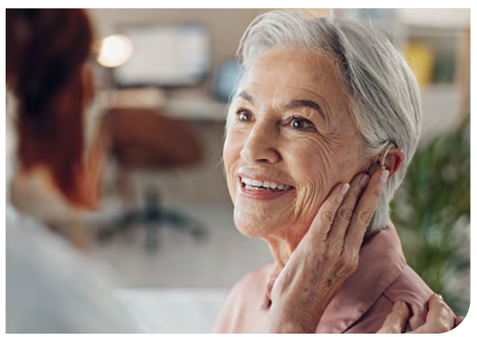
For people with hearing or even vision loss, Auracast can provide a more inclusive listening experience, and one they can control

Auracast can help reduce the effect of language barriers in certain contexts by improving how audio is shared and accessed in public spaces

When the Bluetooth SIG released the LE Audio specification back in 2020 that it said would not only deliver higher quality sound but also extended battery life from speakers and headphones, the industry was all ears.

Developers immediately understood the significance because their customers were already fully invested in wireless audio. Since 2016, Bluetooth headphones had been outselling wired ones, and the industry was shipping around a billion Bluetooth audio streaming devices annually. Now LE Audio would allow them to design the next generation of wireless audio solutions with significantly longer battery life, and at the same time noticeably improve sound quality. Alternatively, products could use smaller batteries, be miniaturized further, and still achieve the same playback time as they had before. That was potentially useful for any product, but hugely important for discrete audio tech, such as hearing aids.

By simultaneously addressing three of the biggest consumer concerns with wireless audio products—battery life, sound quality, and device size—and decreasing latency while enabling new use cases by supporting multiple (bi-directional) audio channels, LE Audio promised to propel wireless audio into the retail stratosphere.



Five years on, and developers are working hard to bring commercial LE Audio solutions to market, but there could yet be an even more seismic legacy of LE Audio thanks to the introduction of Auracast Broadcast Audio in 2022.

ENTER AURACAST

From the outset of the LE Audio specification development, a key requirement was the ability to support broadcast audio. From this Auracast was born, enabling an audio source device such as a smartphone, laptop, TV, or sound system to broadcast one or several audio streams to an unlimited number of Bluetooth audio receivers.

Initially Auracast was driven by the need to cater for people with hearing loss and improve on existing inductive loop technology, where sound is transmitted wirelessly to hearing aids through a magnetic field created by a looped wire. This loop carries an audio signal, and hearing aids with a telecoil (T-coil) within the loop can pick up this signal and convert it into sound. But there are limitations.

For the user it can be susceptible to electromagnetic interference, which can affect the quality of the audio signal. Additionally, it may not be as effective in noisy environments or multi-theater settings where spillover from other loops can occur. For the host venue, installation can be expensive and challenging, and maintenance may be required. Where inductive loop technology either doesn't exist or doesn't work as it should, hearing aid users report muffled sound and a generally diminished experience.

PROMOTING INCLUSIVITY

Auracast eliminates these problems completely, and without the installation complexity. An Auracast transmitter installed at a venue can send one or more audio streams to an unlimited number of Auracast receivers (hearing aids for example) in the room, and via an Auracast assistant (usually an app on the user's smartphone), the user can easily adjust the settings and deliver the best audio experience for them.

For example, in a cinema or theater setting in the auditorium the standard audio mix is played through the loudspeaker system. Meanwhile Auracast can transmit several additional mixes, such as a speech-only or speech-enhanced track, to make following the dialogue easier, or an audio description track, where the action is described to make the performance accessible to blind and partially sighted people.

The technology has proven so successful that permanent Auracast installations are already located from the Sydney Opera House in Australia, to the University of the Arts in London, U.K., and the Marriott Theatre in Chicago, Illinois. Trials and assessments of the technology are also ongoing in a host of internationally-renowned venues including the Lincoln Center in New York, the Smithsonian and Kennedy Center in Washington, DC, St Paul's Cathedral in London, and the Royal Danish Theatre in Copenhagen.

For people with hearing loss the benefits are profound. No more straining to hear, a more inclusive listening experience they can control, improved communication, and ultimately a more connected world. "Hearing and understanding speech in various environments can be a daily struggle for people with any degree of hearing loss," Barbara Kelley, Executive Director of the Hearing Loss Association of America, said. "Having choices in technology to meet the varying needs of people with hearing loss is critical. The advent of technologies like Auracast broadcast audio has the potential to give people who wear hearing aids and cochlear implants an important new option for hearing access in their everyday lives."

ACROSS THE LANGUAGE DIVIDE

As development of the LE Audio specification and Auracast progressed, more companies joined the process. It may have taken a couple of years for the technology to reach commercialization, but Auracast is now being rolled out in a wide range of solutions that benefit not just people with hearing loss, but everyone (see *Nordic Inside* page 19).

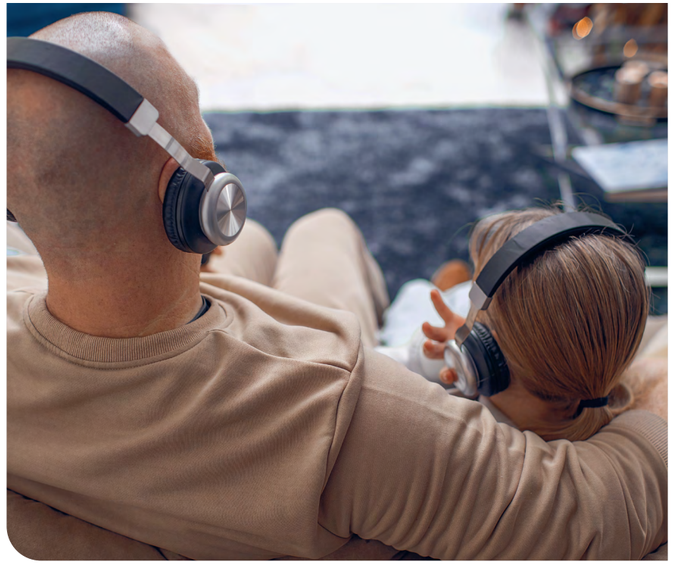
"Today, the broadcast feature in Bluetooth LE Audio is seen by many as its most important feature, bringing shared audio to everyone – not just hearing aid users," wrote Nick Hunn, in *Introducing Bluetooth LE Audio*. "As developers start to understand its benefits and roll out new audio experiences that use its features, it is fair to say that it could be the biggest step change in consumer audio since the introduction of stereo in the late 1950s."

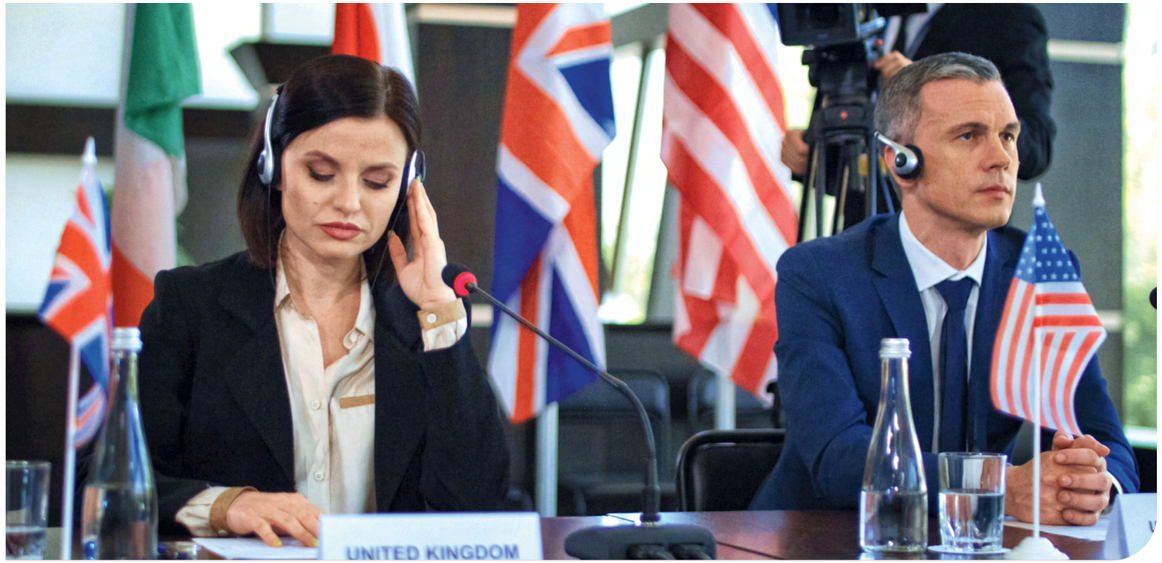
One example is Auracast's ability to breach the language divide in our increasingly interconnected world. Anyone who has travelled in a country where they don't speak the native tongue will readily appreciate the importance of being understood, particularly in the event of an emergency.

Auracast doesn't directly overcome language barriers like a human translator or AI translator, but it does help reduce the effect of language barriers in certain contexts by improving how audio is shared and accessed.

For example, cinemas could offer different language

> "The broadcast feature in Bluetooth LE Audio ... could be the biggest step change in consumer audio since the introduction of stereo in the late 1950s





tracks for films eliminating the need for subtitles; museums and art galleries can provide multi-language guide services direct to a visitor's own earbuds or headphones; and international schools with multinational, multilingual and multicultural student populations can offer simultaneous audio streams in multiple languages, allowing students to tune into their preferred language, using their own devices.

Developers are already pioneering solutions that combine AI simultaneous interpretation with Auracast with a response time as fast as that of a human interpreter. This opens the way for innovative applications where people can speak in their preferred language while it's translated in real time into the language preferred by their listeners.

Meanwhile in the home, an increasing number of television programs are available with multiple language tracks, and Auracast enables different users to watch the same programming in a different language at the same time. Practically this requires all viewers to use earbuds or headphones to avoid simultaneously hearing one language through the TV speakers, and another through their own headphones, but technically it's precisely what LE Audio and Auracast were designed to do.

DEVELOPING WITH AURACAST

From a developer perspective, implementing LE Audio and Auracast comes with a number of hardware and software considerations when selecting a wireless SoC for the job. To enable LE Audio the Bluetooth 5.2 Core Specification introduced Isochronous Channels as the transport mechanism for transmitting audio in a synchronized, low latency manner. For Auracast, Broadcast Isochronous Streams (BIS) enabled audio to broadcast to multiple receivers simultaneously without establishing a connection. Then the subsequent introduction of the Low Complexity Communication Codec (LC3) ensured it was possible to achieve high quality audio transmission with low bitrates and minimal energy consumption.

To meet the requirements of LE Audio and Auracast, Bluetooth LE SoCs must at a minimum be qualified against Bluetooth 5.2.

SoCs must also include sufficient processing power and memory for computationally intensive LC3 encoding and decoding and the ability to manage multiple concurrent streams—for example in stereo or multi-language broadcasts—as well as secure encryption and decryption.

On the software side, alongside a qualified Bluetooth LE Stack with ISO support, qualified LE Audio profiles and services for Auracast are required for a complete and interoperable solution.

MEETING DEVELOPER DEMANDS

Through its contribution to Bluetooth SIG working groups, Nordic Semiconductor has been an active participant in the development and standardization of LE Audio and Auracast, and its nRF5340 SoC was built to handle all their requirements.

The nRF5340 SoC supports Bluetooth 5.4 including LE Isochronous Channels, and provides enhanced ATT throughput to increase the speed and efficiency of data transmission crucial in LE Audio and Auracast applications. Its dual core architecture provides a dedicated Arm Cortex-M33 application processor and a second M33 network processor. The application processor is optimized for performance and provides ample overhead to look after the computational demands of advanced audio codecs and manage the audio application logic. The LE Controller runs in the network processor which is optimized for low power consumption and also supervises wireless connectivity.

To ease the development process, the nRF5340 Audio Development Kit (DK) contains everything a user needs to get started with LE Audio and Auracast, while the nRF Connect SDK offers a fully-featured software solution including the Bluetooth LE stack, LE Audio Profiles, the LC3 Codec and a range of sample applications including an Auracast/Broadcaster, and an LE Audio USB dongle.

While the nRF5340 SoC can get developers up and running on LE Audio today, Nordic's next generation nRF54H Series will not only support today's LE Audio and Auracast applications but also tomorrow's, where the processing power to support TinyML and Artificial Intelligence (AI) may be required for increasingly sophisticated audio solutions.

AI, particularly natural language processing (NLP), has already significantly transformed the audio industry for use cases such as digital voice assistants, but that's just the beginning.

Advances in acoustic sensors will bring augmented audio reality experiences to constrained small form factor devices, while AI will support language processing for voice and video call translation. Context-aware functionality could improve sound in crowded environments by adapting the audio stream to the conditions, or by using predictive speech techniques to mitigate potential distortions or anomalies.

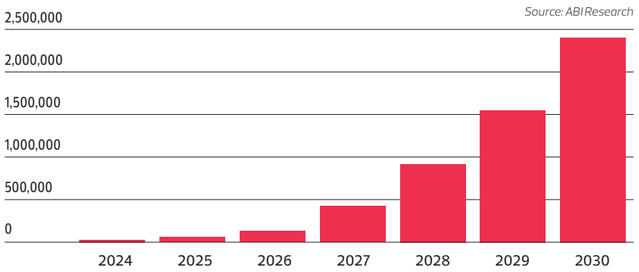
As the technology develops, SoCs that can support not only LE Audio and Auracast but also TinyML and AI will further tear down the barriers created by hearing loss and a lack of language comprehension, and deliver a better and more inclusive tomorrow for us all.

State of Play

Hear today, and tomorrow

By 2028, annual shipments of LE Audio-enabled devices are expected to reach three billion. This growing ecosystem will incentivize millions of venues to deploy Auracast broadcast audio technology over the next few years due to wider availability and awareness of Auracast, alongside a critical mass of Auracast-compatible receiver devices being adopted by end users.

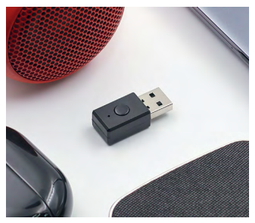
Total Auracast Broadcast Audio Deployments, World Markets



Nordic Inside:

Last year GN Group launched a world first LE Audio and Auracast broadcast audio TV streamer, enabling people suffering from hearing loss to stream hi-fidelity audio between their television and their hearing aids, with all the benefits of Auracast. Working seamlessly with the company's ReSound Nexia hearing aids or other LE Audio compatible solutions, the TV-Streamer+ integrates a Nordic LE Audio- and Auracast-capable wireless SoC to deliver low power, low latency, and long range wireless connectivity with improved audio quality.

Swiss embedded electronics designer, Arendi, has released an LE Audio and Auracast broadcast audio TV streamer, providing high quality streamed audio from a TV, stereo, PC, or similar device to an end user's Bluetooth LE- or Auracast-enabled headphones, speakers, or hearing aids. The Arendi Auracast TV Streamer employs Nordic Semiconductor's dual core nRF5340 SoC and nRF21540 RF front-end module (FEM) to deliver low power, long range, reliable wireless connectivity with improved audio quality.



Shenzhen Feasycom has released a USB-based Bluetooth transmitter that enables older televisions, PCs, or any sound source to stream hi-fidelity LE Audio to any compatible end device. The FSC-BP401 Bluetooth Audio Transmitter integrates Nordic Semiconductor's LE Audio- and Auracast-capable nRF5340 high-end multiprotocol SoC to provide high quality, low latency LE Audio connectivity between the transmitter and receiving devices, such as hearing aids, headphones, or wireless speakers.

A Burning Challenge

As harmful wildfires intensify all around the world, wireless networks offer hope from early detection through to better response and recovery efforts

In Short

Hotter and drier weather conditions are contributing to more extreme and widespread fire seasons

IoT solutions that use sensors, wireless connectivity, and AI promise not only quicker detection of fires, but improvements right across the wildfire management lifecycle

Devices using location services and cellular IoT can help fire crews pinpoint the precise location of a fire

Fueled by severe drought conditions and powerful winds, the Palisades and Eaton fires erupted in Los Angeles, Southern California on January 7, 2025. Both fires burned for 24 days before being fully contained, destroying 37,000 acres and razing more than 16,000 structures in the process, *ABC News Network* reported. The tens of billions of dollars in damage will take years to clean up, but the real impact of this disaster on affected communities is almost impossible to measure. Worryingly, this is far from an isolated global occurrence. As recently as 2019, there were 6,872 annual wildfire incidents in California alone, according to the Center for Disaster Philanthropy. The same organization reported that between September 2019 and March 2020 in Australia, the 'Black Summer' bushfires—as wildfires are known in the country—saw around 186,000 square kilometers burned, 35,000 homes lost and more than one billion animals perishing.

Numerous studies have established that hotter, drier weather conditions—potentially fueled by the forces of climate change—are contributing to more extreme and widespread fire seasons. This is because longer drought periods and higher temperatures increase vegetation flammability. United Nations (UN) experts predict extreme wildfires will only become more intense and frequent, with wildfire events increasing by 50 percent by the end of the century. While natural effects have long been a common cause of wildfires, human activity—such as unattended campfires, equipment malfunctions, discarded cigarettes, and arson—is increasingly to blame.

Understandably, authorities, researchers and scientists are looking for a better way to limit the damage wildfires cause to property, animals and human life. Not to mention the compound effect on the climate itself through the release of additional carbon. Research by the journal *Science* shows there has been a 60 percent increase in carbon emissions from forest fires globally between 2001 and 2023.

IoT TO THE RESCUE

Thankfully there is some light at the end of the canopy. When it comes to mitigating the risks and impacts of wildfires, timing is everything. It's common wisdom in emergency management circles that quelling a wildfire within the so-called smoldering phase, or within the first hour, offers the best chance of containment.

To this end, technology—specifically IoT solutions that draw together sensors, wireless connectivity, and artificial intelligence (AI)—promises not only quicker detection of fires, but improvements right across the wildfire management lifecycle from prevention through to response and recovery.

Increased deployments of IoT-enabled sensors and detectors can play a vital role in wildfire management by providing early warning of a wildfire outbreak. For instance, infrared (IR) sensors placed on trees in forests susceptible to wildfires can provide authorities with accurate early warning signs of a fire, by detecting the gases emitted during the smoldering phase.

Systems that can also integrate these sensors with long-range connectivity and powerful location services—such as the latest addition to Nordic's nRF91 Series of cellular IoT devices, the nRF9151 module, with support for LTE-M/NB-IoT, DECT NR+, Non-Terrestrial Networks or NTN and integrated GNSS—can aid fire crews even further by also pinpointing the precise location of the fire.

As well as detecting gases like carbon dioxide and oxygen, sensors could also be deployed to detect environmental indicators such as humidity and temperature. This is where IoT edge devices with embedded machine learning (ML) capabilities bring significant value.

By collecting sensor data on air quality and other variables such as humidity, temperature, and wind conditions, and by also analyzing that data using ML capabilities, IoT edge-computing devices can send valuable insights to emergency management teams. For example, this might include early warnings when the risk of fire escalates above a predetermined threshold, along with predictions on the chances of fire breaking out, and how quickly and where an outbreak is likely to spread.

Using the nRF9151, it is possible to develop AI and ML-powered applications, including environmental monitoring applications, on battery-powered, compact devices. The nRF9151 is well matched for 'Edge AI'—where AI and ML is performed locally rather than sending data up to the Cloud—because it combines the optimal balance of computational power and power efficiency.

The value of Nordic-powered wildfire management solutions extends beyond detection. A critical challenge for authorities during wildfires is the need to rapidly identify residents in danger and evacuate them – a task complicated by the spread of the fire itself, which can render some areas inaccessible.

Using IoT deployments, fire services can better pinpoint the location and trajectory of burning blazes and broadcast emergency alerts and evacuation instructions via text message to individuals within a certain radius. Safety for firefighters can also be enhanced.

Moreover, temperature sensors deployed in forests are not only helping with prevention but are now sparking new research findings and insights about the overall behavior of wildfires that can be observed when these forests undergo controlled 'hazard reduction' burns. These insights illuminate how natural fires move and shift and how they are impacted by factors such as wind and ground vegetation – invaluable inputs for formulating strategies for preventing and responding to wildfires. And data produced by sensors after a fire passes also helps conservation agencies monitor forest recovery, animal migration, and disease spread, supporting more focused restoration efforts.

Tech Check

With Nordic's end-to-end cellular IoT support incorporating nRF Cloud Services, developers using the nRF9151 (and other nRF91 Series modules) can further extend battery life by using the location services and trading-off location accuracy against power consumption

REMOTE RESPONSE

Nascent deployments of IoT into forests have illuminated several of the key challenges and considerations for solutions teams. Due to the vastness and natural remoteness of many forests, sensors need to be placed in hard-to-reach areas for extended periods.

This makes solutions that support extended battery life critical. Nordic's nRF9151 module takes energy conservation to the next level by supporting several power saving techniques that can be used to minimize radio transmission time while ensuring a reliable network connection. These techniques include extended Discontinuous Reception (eDRX), which lets the IoT device remain attached and registered to the network but spend longer periods in a sleep mode, and Power Saving Mode (PSM), which puts the cellular IoT device into a deep sleep state, only waking up at preset times or whenever triggered by, for example, an alarm. With Nordic's end-to-end cellular IoT support incorporating nRF Cloud Services, developers using the nRF9151 (and other nRF91 Series modules) can further extend battery life by using the Location Services and trading off location accuracy against power consumption.

Connectivity is another key challenge. Where cellular connectivity is available, it's an effective and robust solution. The leading low power wide area network (LPWAN) technology, cellular IoT enables connected devices to communicate over distances of several miles while using modest amounts of energy.

Technologies such as LTE-M/NB-IoT are ideal, as they are optimized for solutions involving battery-powered sensors that must run for long periods and need only send small data volumes – the precise scenario for most wildfire deployments.

Outside of cellular IoT, other options could involve complementary connectivity solutions like satellite IoT. For example, using satellite networks, the nRF9151 module can report information when there is no cellular connectivity – perfect for IoT applications in the most rural and remote parts of the planet, such as vast forest areas.

This is made possible by Nordic's nRF9151's 3GPP NTN connectivity capabilities. 3GPP NTN using the nRF9151 promises to revolutionize the IoT by allowing small and cost sensitive IoT devices to achieve standardized connectivity anywhere across the globe.

With remote areas of the planet lacking terrestrial cellular connectivity, a significant commercial opportunity exists to build actual low-power devices with satellite connectivity using the nRF9151 module.

In addition to wildfires, IoT solutions involving sensors, wireless connectivity, and data analytics might improve preparedness and response outcomes for a range of natural disasters including hurricanes, earthquakes, floods and monsoons. Technology will continue to lead the way for communities and environments fighting for a safer future.

> With remote areas lacking terrestrial cellular connectivity, an opportunity exists to build low-power devices with satellite connectivity

Nordic Inside:

5G NB-IoT satellite trial proves remote monitoring potential

Nordic Semiconductor is helping to unlock new global use cases in remote areas such as forests by proving reliable low power IoT connectivity over non-geostationary orbit (NGSO) satellite. Nordic has participated in a successful 5G NB-IoT trial over a NGSO satellite operated by Omnispace, the company redefining mobile connectivity for the 21st century. The demonstration, conducted with Omnispace and market-leading provider of satellite communications software Gatehouse Satcom, marks a key step toward bringing seamless, standards-based 5G IoT connectivity to remote and underserved areas.

Central to the trial was Nordic's nRF9151 module – the smallest cellular IoT module in the market, optimized for satellite communication and designed to meet the 3GPP NTN specifications. The integration of the nRF9151 will support a wide range of low-power 5G devices to reliably transmit and receive data over Omnispace's S-band NGSO satellite.

"This breakthrough enables low-power IoT devices to connect via non-stationary satellites in remote or infrastructure-limited areas, supporting use cases such as remote monitoring," says Kristian Sæther, Product Director, Long-Range at Nordic Semiconductor.

"This demonstration marks a key step in making global, seamless 5G IoT connectivity a reality," said Ram Viswanathan, CEO at Omnispace.

"Working with Gatehouse Satcom and Nordic Semiconductor, we are demonstrating what's possible for the future of global communications including powerful NGSO satellite solutions that seamlessly integrate with existing 5G terrestrial cellular networks."

This achievement expands the potential for low-power satellite IoT across various industries including environmental monitoring where global, resilient connectivity is critical.

Sport & Fitness

Carv 2

This AI-powered ski trainer from Motion Metrics provides personalized real time coaching, enabling skiers of all standards to improve their technique on the run

The global sports technology market was valued at $18.85 million in 2024, and is projected to grow at a CAGR of 21.9 percent from 2025 to 2030. According to Grand View Research this growth can be attributed to the increasing need for technology-based sports services, the growing use of data analytics, and the integration of AI to monitor athletes' health, fitness and safety

Carv 2's Nordic-powered IMU creates a high-resolution biometric model of ski boot movement to capture the finer details of the skier's technique. This is made possible by Motion Metrics' 'Large Motion Model AI' technology, built on a database of over 500 million turns. Carv 2 can also automatically detect the snow surface, allowing the skier to get coaching tailored to the snow type as well as their ability

In a typical 2-minute downhill run, a skier's legs endure g-forces of 3G or more, similar to what astronauts experience during rocket launch. So for a 75 kg skier, during high speed turns, compression zones, or quick direction changes, their legs and core must support 225 kg of force. In extreme moments such as a tight high-speed corner with a vertical drop it can briefly exceed 4G. That's why elite skiers don't skip leg day at the gym and have workouts that would destroy mere mortals

In addition to the nRF52832 SoC, Carv 2 also employs Nordic's nPM1100 PMIC designed to ensure reliable power delivery and stable operation, whilst maximizing battery life. The Carv device offers up to five full days of skiing between charges, using a 300 mAh Li-ion battery. This extended battery life is achieved through a combination of the ultra-low power consumption of the nRF52832 SoC, and Nordic's highly efficient nPM1100 PMIC

The tiny Carv 2 device clips directly to the user's ski boot and captures high resolution motion data using a 6-axis IMU, comprising a 3-axis accelerometer and 3-axis gyroscope. The data is relayed to an app on the user's smartphone using Bluetooth LE wireless connectivity provided by Nordic's nRF52832 SoC. The app then detects the user's skiing technique, and provides real time, personalized coaching through their headphones. Alternatively the skier can disable audio tips and view feedback in the app once their run is complete

Skiing is a pastime you can learn at any age. Take for example George Jedenoff, who didn't learn to ski until he was in his forties. Nothing unusual about that except he was still skiing 60 years later, only finally hanging up his skis at the ripe old age of 103, when the altitude started to get too much for him. Now 107, Jedenoff hasn't stopped exercising completely, he still works out for 45 minutes before breakfast each morning to keep himself limber

Even regular skiers might assume the only way to ski is with two poles, however people have been skiing for more than 6,000 years and it's only in the last 100 that the use of two poles has become the norm. For millennia, a single pole was the way a skier propelled across snow as one hand was needed to be free to shoot an arrow or a gun. The one-pole tradition was so strong it carried over into early racing and recreational skiing. All that changed with the arrival of downhill skiing and steep uphill climbing, and the need for greater upper body balance and support

Tech Check

The nPM1100 is a dedicated PMIC with a highly efficient dual-mode configurable buck regulator and integrated battery charger. The highly efficient step-down buck regulator can deliver up to 150 mA of current at a selectable output voltage. It features soft startup and automatic transition between hysteretic and PWM modes. The battery charger is designed to charge Li-ion and LiP batteries and includes battery thermal protection and automatic selection of three charging modes: automatic trickle, constant current and constant voltage

Temperature Monitoring

Refrigeration monitoring solution tracks inventory and temperature levels

CoolR's VistaZ enables supermarkets to remotely monitor the condition and stock levels of commercial fridges and freezers

> It is estimated that over 30 percent of retail visits by [restockers] are wasted. By equipping team members with actionable insights, we help reduce these inefficiencies

Bacteria thrives in what is commonly referred to as the 'danger zone'—between five and sixty degrees Celsius—where it can multiply rapidly, increasing the risk of spoilage and foodborne illness. To prevent this, most refrigerated foods need to be kept below this range. Likewise, frozen food must be reliably stored at temperatures at or below -18 degrees Celsius to maintain freshness and preserve shelf life.

According to the European FluoroCarbons Technical Committee, over 13 percent of all food is lost due to refrigeration issues. To both protect consumers and reduce food waste, it's key to ensure that these foods are stored correctly throughout the supply chain, as even minor deviations from the recommended temperature ranges can detrimentally affect food quality and safety.

"There are over 120 million existing commercial refrigerators, freezers, and ambient shelves in use," says Durlabh Jain, CEO and CTO at CoolR, an AI and IoT solutions company. "While this represents a significant opportunity to reduce food waste, it also highlights the potential for energy loss caused by improper temperature settings and doors being left open."

To help address this issue, CoolR has released the VistaZ – a commercial temperature monitoring solution designed to track temperature levels in commercial coolers, shelves and freezers. It features an Inertial Measurement Unit (IMU) to monitor door activity and position, as well as a camera to check stock availability. The device can be attached to the glass door of a refrigeration unit using a simple peel-and-stick application method.

CoolR's Nordic Semiconductor nRF52840 SoC-powered VistaZ temperature monitoring solution for commecial coolers, shelves and freezers, can transform them into smart devices, increasing retail sales, and at the same time eliminating unnecessary retail visits by restockers

Analysis for actionable insights

"VistaZ can transform traditional commercial fridges into smart devices without needing to replace them," explains Jain. "It offers on-shelf availability insights for efficient restocking, reducing the frequency of supplier visits. Moreover, the built-in temperature sensor helps businesses proactively address potential product spoilage caused by cooling issues."

Using the IoT to help monitor storage conditions enables quick intervention, helping to reduce food waste and minimize potential consumer safety risks.

The VistaZ employs Nordic's nRF52840 SoC to provide Bluetooth LE connectivity to commission and configure the device's camera to the refrigerator or freezer during installation. In addition, the SoC oversees the VistaZ's cellular IoT, Wi-Fi modules and integrated sensors.

Need to Know

The VistaZ solution monitors temperature levels, door position and stock levels to provide actionable insights that can help minimize restocking trips and reduce the risk of product spoilage. Powered by the Nordic nRF52840 SoC, the device is able to leverage this ample memory capacity and low power consumption, allowing the VistaZ to operate for extended periods using only ambient energy harvesting

"When creating our application code, we used the Nordic nRF Connect SDK," Jain continues. "We found it invaluable throughout the software development process."

Once the data has been captured, it is transmitted to a Cloud-based platform via cellular connectivity for further analysis. From there, CoolR's AI-powered solution 'StoreAware' can deliver near real-time insights—such as recommended orders and actions—to retailers, CPG sales teams, and even marketing departments.

Generous memory capacity

By tracking inventory levels, the solution also helps reduce unnecessary restocking trips – reducing operational inefficiencies and waste, as well as improving on-shelf availability of products.

"It is estimated that over 30 percent of retail visits by [restockers] are wasted. By equipping team members with actionable insights, we help reduce these inefficiencies," says Jain. "[Additionally], our solutions improve on-shelf availability, ensuring consumers can easily find their desired products and avoid unnecessary trips to the store."

At the heart of the device is the Nordic SoC's 64 MHz, Arm Cortex M4 processor with floating point unit (FPU), to deliver the necessary computational performance. This is complemented by the SoC's generous 1MB Flash memory and 256 kB RAM.

"This product is already being implemented in real-world applications, including at Unilever Ice Cream," says Jain. "The company has experienced double-digit sales growth wherever they have deployed our solution to address on-shelf availability challenges. Unilever highlighted in a *New York Times* article that by leveraging the VistaZ's camera, the company achieved a more than 13 percent uplift in same-store sales."

Ambient power harvesting

Extended operational lifetime is also key – reducing the risk of interruptions to monitoring. This ensures important updates, such as changes to stock levels or fluctuations in temperature, are consistently recorded and transmitted.

"The device is powered by a rechargeable battery combined with ambient energy harvesting, ensuring the unit can operate for years without the need for external battery charging or replacement," says Jain. "This approach not only reduces battery waste, but also eliminates the need for frequent maintenance visits to recharge or replace batteries."

Jens Albertsen
Chief Technology Officer and Co-Owner, Secuyou

Smart locks provide security and convenience

Matter allows smart home devices to operate seamlessly together, driving consumer adoption

While the smart lock sector has seen significant growth in recent years, there still remains potential for accelerated implementation. Despite the clear benefits these technologies offer, consumer adoption has lagged.

One of the primary barriers to broader uptake was the lack of a unified home automation standard – not just for manufacturers, but also for consumers. As convenience is the primary driver for most users, uncertainty around product compatibility—along with lingering concerns regarding setup complexity, ongoing maintenance, and security—can hinder implementation.

The emergence of the Matter protocol has been a game-changer not only for the smart lock sector, but for smart home industry as a whole. By aligning the major players in the home automation space, Matter addresses interoperability challenges, enabling devices from different brands to operate together seamlessly. With Matter now established as the unified connectivity standard, effective marketing has become essential to both increase awareness and build consumer trust. By simplifying interoperability and enhancing the user experience, Matter empowers consumers to confidently begin their journey into home automation.

> Matter enables devices from different brands to operate together seamlessly

Unifying the smart home

At Secuyou, we have long anticipated the need for a unifying standard, having followed the battle among various wireless technologies such as Zigbee, Thread, and Z-wave – a situation reminiscent of the VHS versus Betamax era.

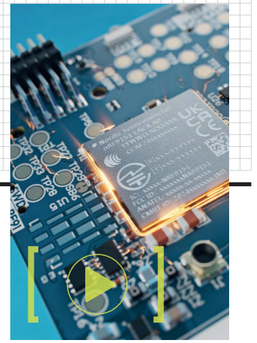
Widely regarded as the natural next step for the smart home automation industry, Matter has had positive impacts in a variety of areas – from simplifying development tools, to creating a unified, consumer-friendly ecosystem.

However, unification needs to extend beyond just connectivity. Security standards—particularly for technology protecting vulnerable entry points to the home, like windows and patio doors—need to be aligned across the industry in order to ensure consumers are reliably protected. This will require a collaborative effort from device manufacturers, software developers and other key stakeholders.

In addition, despite these technological advancements, the smart lock market has yet to fully realize its full potential in replacing traditional analog locks. Features such as automatic locking functionality, for example, remain underutilized – despite the obvious security benefits. Here, insurance providers have a valuable opportunity to help drive adoption of certified smart lock solutions through discounted premiums for consumers who employ certified smart lock solutions, both encouraging uptake and supporting broader risk reduction.

[Tech Zone]

An in-depth look at Nordic's wireless solutions



Cellular IoT

Nordic Thingy:91 X streamlines prototyping of cellular IoT and Wi-Fi locationing

Nordic Semiconductor has launched its latest IoT prototyping platform, the Nordic Thingy:91 X, for LTE-M, NB-IoT, Wi-Fi SSID locationing, DECT NR+, and GNSS applications. The Thingy:91 X simplifies IoT prototyping for developers via its suite of features that streamline the development of cellular IoT applications and shorten time-to-market. Thingy:91 X is a battery-operated device that leverages Nordic's new, award-winning nRF9151 module. The nRF9151 is the most compact cellular IoT module for battery-powered and global locationing applications. It supports LTE-M, NB-IoT, GNSS, and DECT NR+ technology.

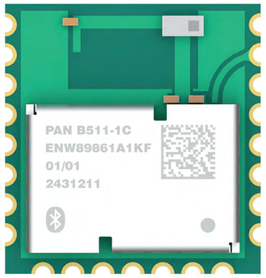
Thingy:91 X comes equipped with multiple sensors to monitor environmental conditions and track movement. It also features user-programmable buttons and LEDs, and multiple antennas. A 1350 mAh rechargeable LiPo battery supervised by Nordic's award-winning nPM1300 power management IC (PMIC) ensures exceptional battery life and precise fuel gauging. Onomondo and Wireless Logic preloaded SIM cards enable immediate cellular IoT connectivity. Upon initial setup, the IoT prototyping platform seamlessly connects to the web interface that's connected to nRF Cloud—Nordic's platform for Cloud services optimized for the company's wireless solutions—precisely identifying the Thingy:91 X's location.

The Thingy:91 X incorporates Nordic's nRF7002 Wi-Fi companion IC enabling Wi-Fi service set identifier (SSID) locationing to complement other locationing technologies. The IoT prototyping platform's capability to support multiple locationing technologies including cellular (single cell (SCELL) and multi-cell (MCELL), Wi-Fi, and GNSS, coupled with nRF Cloud Location Services, enables the developer to perfectly balance location accuracy and power consumption. This makes the Thingy:91 X ideal for asset tracking applications.

Modules

Panasonic modules promise high performance for advanced IoT applications

Germany-based Panasonic Industry Europe GmbH has announced a Bluetooth LE module based on Nordic Semiconductor's next generation of wireless SoCs, the nRF54L Series. The PAN B511-1C module is designed to support smart lighting, industrial sensor, healthcare, and energy management applications, and is ideally suited for smart home IoT applications based on the Matter protocol in particular. The pre-certified PAN B511-1C module comes in a compact 10.35 by 9.8 by 1.9 mm form factor and features Nordic's next level nRF54L15 SoC. The module includes a comprehensive set of peripherals and provides access to all 32 GPIOs of the nRF54L15, enabling one of the best pin-to-size ratios for Bluetooth modules currently on the market, according to the company. With its unique castellated holes and LGA packaging the module allows for a two-layer PCB design, optical outgoing inspection, and robust functionality through all 32 GPIOs. The PAN B511-1C module is available in three distinct specification variants to cater to diverse application requirements. For example, the modules are available with an additional integrated slow clock crystal to maximize power efficiency during sleep mode and extend battery life, and additional 4 MB Flash memory to support more advanced IoT solutions, including Matter applications.



Smart Home

Module enables Matter over Thread

China-based company Wisdom has launched a Bluetooth LE and Matter over Thread compatible module, designed for use in space-constrained, low-power smart home and lighting applications. The 12 by 15 by 2 mm W-MT-36 module is powered by Nordic Semiconductor's nRF52840 multiprotocol SoC. The SoC is a Thread certified component and is suitable for developing products for the Matter connected home ecosystem. The Wisdom module supports Bluetooth LE and Matter over Thread technologies. For Matter applications the module uses the nRF52840 SoC's Thread connectivity for transport and Bluetooth LE connectivity for commissioning new devices to a network. The combination of wireless technologies enables applications such as smart home controllers and bridges, ON/OFF switching for smart lighting, and various IoT smart sensors.

Smart Home

Reference application for Aliro and Matter

Nordic Semiconductor and Qorvo have announced availability of a reference application targeting access control systems utilizing Connectivity Standards Alliance's (CSA) Aliro and Matter. The solution is based on Nordic's nRF54L Series multiprotocol SoC and Qorvo's QM35825 ultra-wideband (UWB) SoC. The reference application will enable developers to easily and quickly get started on Aliro and Matter access control – making the smart lock design process accessible for any manufacturer. Aliro is a CSA communication protocol under development which aims to standardize using a smartphone or wearable in place of a key. The reference application will help developers come up with applications based on Nordic's Bluetooth LE, Thread, and Wi-Fi solutions, and Qorvo's UWB technology, that will be compliant with the Aliro v1.0 specifications and certification program when they are released by the CSA.

Smart City

'Two-in-one' smart street lighting controller solution to improve modern cities

Telemetry and SCADA solution manufacturer, LACROIX Environment, has released a 'two-in-one' smart street lighting solution. The PS-Pak unit is a smart street lighting control device that can be used to setup any type of lantern driver or to supply power to an external management node. The product is installed in the street lamp pole and wired to the lantern driver. The PS-Pak supports the latest DALI2 protocol, an industry -standard technology for bi-directional, digital communication between lighting-control devices.

The PS-Pak integrates the Insight SiP ISP1507-AX module based on Nordic Semiconductor's nRF52832 SoC. The SoC's Bluetooth LE wireless connectivity enables simple and complex configurations of the PS-Pak from the associated My DL-Pak iOS/Android app, without the need to access the interior of a potentially high-voltage lighting unit – thus reducing the time and risk associated with routine operations. The wireless connectivity enables over-the-air software updates and lighting configuration. One PS-Pak can configure, individually, up to six lantern drivers of the same light pole. The PS-Pak is compatible with LACROIX's and other lantern drivers from the market.

"We are delighted to support Lacroix Environment in their mission to make modern cities safer and more energy efficient," says Nick Wood, Sales and Marketing Director for Insight SIP. "We believe there will be an increasing need for this kind of application to meet carbon emission targets whilst not compromising on personal safety."

The PS-Pak targets existing and new installations for local management or the anticipated evolution to remote management.

nPM1304 PMIC

The new nPM1304 is a highly integrated, flexible, and easy-to-use Power Management IC (PMIC) ideal for space-constrained battery-operated applications

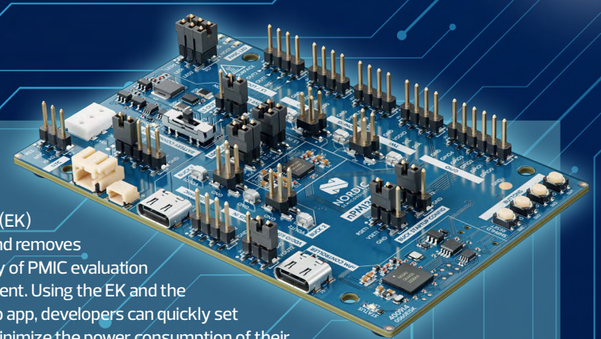
The nPM1304 PMIC is based on Nordic's nPM1300 PMIC but is optimized for use with smaller batteries. It works seamlessly with Nordic's Bluetooth LE SoC and reduces an end product's Bill of Materials (BoM) by combining circuitry into a single chip that previously required five or more discrete components

The nPM1304 PMIC simplifies system design by integrating essential functions required for embedded Bluetooth Low Energy designs into one small package, enabling longer run times and efficient battery charging with fewer components

The PMIC's battery charge current is programmable in 0.5 mA steps from 4 mA up to 100 mA, and the termination voltage can be set as high as 4.65 V allowing the battery to store more energy

Nordic's PMIC solutions are ideally suited for consumer, healthcare, and industrial markets, powering applications including smart rings, health monitors, asset trackers and body sensors

The nPM1304 features two power rails regulated by separate DC-to-DC buck converters configurable between 1.0 and 3.3 V and up to 200 mA maximum current. The other two power rails operate as load switches—switching currents of up to 100 mA from external sources—but can also perform as LDOs

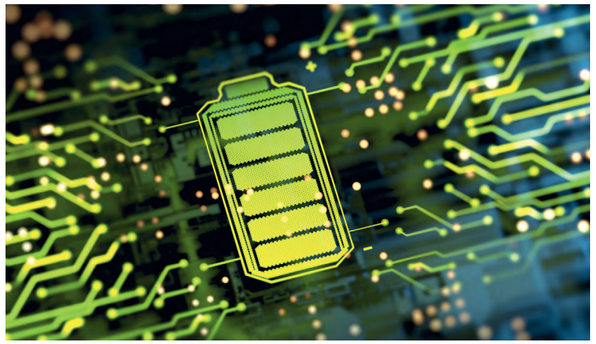


The nPM1304 Evaluation Kit (EK) streamlines and removes the complexity of PMIC evaluation and development. Using the EK and the nPM Power Up app, developers can quickly set things up to minimize the power consumption of their application, without the need to write any software

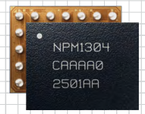
The nPM1304 includes key system management features including a hard system reset to power cycle a hung device, timed wake-up to enable a hibernate mode, and a watchdog timer that can, for example, instruct the PMIC to stop battery charging if the software has crashed, or reset the host processor and, on timing out, power cycle the whole system

Precise Fuel Gauging

The nPM1304 PMIC features a highly accurate fuel gauge. The fuel gauge algorithm is fully integrated into the nRF Connect SDK, and runs on the host controller. There's minimal hardware overhead, and the software is included with the PMIC—so there's no extra cost



The key to the fuel gauge's accuracy is the algorithm on the host processor which is used to power it. An embedded processor such as the Arm Cortex-M33 used on Nordic's nRF54L Series SoCs, has ample power to run the algorithm without any impact on the rest of the application code. The host processor uses information such as the current flowing into and out of the PMIC, the output from a voltage divider monitoring the battery terminal voltage, and a thermistor providing information on battery temperature. With this current, voltage and temperature information, the host processor uses the Nordic-developed algorithm to accurately determine the battery's state of charge.



Tech Spec

Battery Compatibility
LiFePO4, Li-ion, LiPo

Features
2 buck regulators, battery charger, 2 low dropout regulators (LDOs), 2 load switches

Development tools
nPM1304 EK, nPM fuel gauge board, nPM Power Up app

Package options
5.5 mm QFN32, 3.1 x 2.4 mm WLCSP

Compliance
CE, JEITA, RoHS

Developing low power Matter-over-Thread accessories with nRF54L Series

Selecting advanced SoCs, mature development tools, and innovative power management chips allows developers to build Matter over Thread applications with extended battery life

Matter is an open-source connectivity standard for the smart home developed by the Connectivity Standards Alliance (CSA). It works by building on top of established smart home wireless connectivity technologies—Wi-Fi, Thread, Ethernet, and Bluetooth LE for commissioning—and is Internet Protocol-(IP) based.

While the Matter device's baseline power consumption depends on the choice of networking technology, this article focuses only on the Matter over Thread network solution. Matter over Thread is the preferred solution for battery-powered devices that require optimized power consumption. While the networking technology determines a base power consumption, the developer can use techniques to reduce the duration and frequency of the device's activities to force it into an ultra-low power sleep state for most of the time.

However, there is a trade-off - limiting the device's activity time typically lowers responsiveness and throughput. That means the developer must consider both responsiveness and power consumption to find the optimal configuration for the specific use case. In the case of Matter, the stack can be configured by the engineer to meet that optimal configuration.

> The developer must consider both responsiveness and power consumption to find the optimal configuration for the specific Matter over Thread use case

Matter over Thread devices

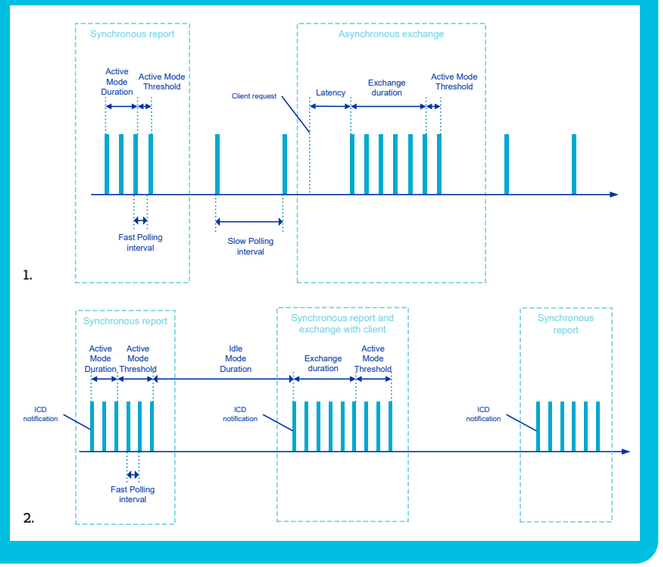
The Matter specification v1.4.1 defines occasionally unreachable devices in the network that are not always online as 'Intermittently Connected Devices' (ICDs).

Their behavior significantly affects power consumption, depending on whether they are configured with Short Idle Time (SIT) or Long Idle Time (LIT) settings (see *What are ICD configurations?* below for details). SIT devices need to be responsive and thus sleep for just a couple of seconds. LIT devices are configured to sleep more than 15 seconds, often tens of minutes, but are still able to wake up if they have something to report. Usually SITs are actuators and LITs are sensors.

SIT and LIT are application-layer configurations, while lower-layer behaviors also play a role—specifically, whether a device operates as a Sleepy End Device (SED) or a Synchronized Sleepy End Device (SSED), which manage how and when the device's radio is active. A SED uses periodic data polls to ask for data from the parent after spending periods asleep. The parent sends data if it has something in the data buffer. A SSED listens in synchronized time slots for incoming data. The parent knows when the SSED is going to ask for data.

What are ICD configurations?

An Intermittently Connected Device (ICD) can have one of two configurations: Short Idle Time (SIT) or Long Idle Time (LIT). The configuration used has a significant impact on the device behavior and power consumption. For example, SITs typically sleep for less than 15 seconds so are generally responsive. These would be used in typical actuator applications such as a door lock. In this case it makes sense the controller initiates the communication via a Thread Border Router. Figure 1 shows an example communication pattern for an ICD SIT. LITs sleep for more than 15 seconds and even up to hours. Maximum configuration is 18 hours. The devices are not responsive, and the Matter controller can only reach it after a server-driven communication via the Thread Border Router. A typical use case might be a sensor such a CO alarm. Figure 2 shows an example communication pattern for an ICD LIT. Unlike a SIT, a LIT device must also support additional ICD features: Check-In Protocol (CIP), which is used to notify the client device that the LIT is available for Communication; and User Active Mode Trigger (UAT), which allows the user to enforce Active mode to, for example, introduce configuration changes.



Matter over Thread is designed to be used with battery-powered devices. While the networking technology determines a base power consumption, the developer can choose hardware and design techniques to optimize an application's power consumption

SEDs can cause energy drain due to frequent polling, even when no data is transmitted. On the other hand, the concept is so simple and reliable so there are very few things that can go wrong. It can be difficult to predict the power consumption of SEDs, yet it is important to do so as they are widely supported by all Thread certified devices. SSEDs activate their radio only during scheduled communication windows, reducing unnecessary radio usage, but require highly acurate timing. Otherwise, the listening time by the child is extended and that costs battery power. Power consumption relies on the parent's timing accuracy which is difficult to predict in the field.

Developing with the nRF Connect SDK

Nordic's nRF Connect SDK is the company's primary development tool for developing low power Matter devices. It includes various Matter samples such as Matter door lock (using SITs, and Thread SEDs), Matter light switch (SIT, Thread SED), CO alarm (LIT, Thread SED), and Matter window covering (SIT, Thread SSED). All these samples are energy optimized.

The developer can use the samples to start building applications but can equally configure their own LIT, SIT, SED, and SSED applications from within the SDK. There is also information in the SDK documentation on the best way to reduce power consumption of a given application. The data on power consumption can be used to estimate battery life for a given application. (Nordic has produced a whitepaper (tinyurl.com/3938yrsz) that offers over 40 pages of information on how to lower the power consumption of Matter applications using the company's PPK II.)

Building with the nRF54L15 and nPM PMICs

Nordic's nRF54L15 SoC is an ideal hardware solution for low power Matter applications. (It is also possible to build Matter applications using the nRF5340 and nRF52840.) The SoC is an advanced multiprotocol SoC that supports Thread, Bluetooth LE, and other 2.4 GHz wireless protocols. The nRF54L15 offers greater overall performance and much lower power consumption than the widely adopted nRF52 Series under comparable workloads. For example, in like-for-like applications, power consumption of the nRF54L15 is 30 to 40 percent of the nRF52 Series while offering about double the processing power.

The performance increase primarily comes from an Arm Cortex-M33 processor running at double the clock speed of the older chips, and fabricating the nRF54L15 at the 22 nm process node. To optimize power consumption when building Matter applications, the nRF54L15 can be teamed with one of Nordic's nPM Series power management chips (PMICs)

PMICs regulate and manage the output from DC or battery power sources. They can also look after battery charging if the Matter device has a rechargeable battery. More advanced features include system management. An example is the nPM1300 which includes fuel gauging. (*See WQ Issue 3, 2023 pg 36.*)

nPM2100 is for use with primary cells. This is very useful for ultra-low power primary battery applications such as Matter wireless devices powered by AA or AAA batteries and ensures the maximum energy is extracted from the cells.

Minimizing power consumption

Matter over Thread is designed for ultra-low power smart home applications. But to maximize performance while minimizing power consumption requires the selection of the ideal hardware and development tools. Performance can also be enhanced by considering the power supply side with innovative PMICs. Nordic's nRF54L Series, nRF Connect SDK, nPM Series PMICs, and Matter over Thread expertise provide answers to these challenges.

A Nordic webinar Developing low-power Matter devices with nRF54L Series is available from: https://tinyurl.com/55s8mub3

Tech Check

Nordic's nRF54L15 is an ideal hardware solution for ultra-low power Matter applications. The nRF54L15 offers greater overall performance and much lower power consumption than the billion selling nRF52 Series. In like-for-like applications, power consumption of the nRF54L15 is 30 to 40 percent of the nRF52 Series while offering about double the processing power

Nordic Product Guide

This handy summary describes all of Nordic's IoT solutions

Full product details at: www.nordicsemi.com/Products

RF SoCs and SiPs

		nRF 91 SERIES	nRF 70 SERIES	nRF 54 H SERIES	nRF 54 L SERIES	nRF SERIES 53	nRF 52 SERIES
		nRF91 Series	nRF70 Series	nRF54H Series	nRF54L Series	nRF53 Series	nRF52 Series
IC TYPE		Wireless SiP	Wi-Fi Companion IC	Wireless SoC	Wireless SoC	Wireless SoC	Wireless SoC
ICs		nRF9160, nRF9131	nRF7002, nRF7001, nRF7000	nRF54H20	nRF54L15, nRF54L10, nRF54L05	nRF5340	nRF52840, nRF52833, nRF52832, nRF52820, nRF52811, nRF52810, nRF52805
WIRELESS	LTE-M, NB-IoT, NON-TERRESTRIAL NETWORKS (NTN), DECT NR+, GNSS	Yes					
	DUAL-BAND Wi-Fi 6		Yes (with host)	Yes (with nRF70 Series)	Yes (with nRF70 Series)	Yes (with nRF70 Series)	Yes (with nRF70 Series)
	Wi-Fi LOCATIONING	Yes (with nRF70 Series)	Yes (with host)	Yes (with nRF70 Series)	Yes (with nRF70 Series)	Yes (with nRF70 Series)	Yes (with nRF70 Series)
	BLUETOOTH LOW ENERGY 6.0			Yes	Yes	Yes	Yes
	BLUETOOTH CHANNEL SOUNDING			Yes	Yes		
	BLUETOOTH LE AUDIO			Yes		Yes	
	BLUETOOTH MESH, ZIGBEE, THREAD, MATTER, AMAZON SIDEWALK, NFC			Yes	Yes	Yes	Yes
	ESB AND 2.4 GHz PROPRIETARY PROTOCOLS			Yes up to 4 Mbps	Yes up to 4 Mbps	Yes up to 2 Mbps	Yes up to 2 Mbps
MCU FUNCTIONALITY	PROCESSOR	64 MHz Arm Cortex-M33		2x Arm Cortex-M33, up to 320 MHz	128 MHz Arm Cortex-M33	2x Arm Cortex-M33, up to 128 MHz	64 MHz Arm Cortex-M4
	RISC-V COPROCESSOR			320 MHz FLPR, 16 MHz PPR	128 MHz FLPR		
	NVM	1 MB		2 MB	Up 1.5 MB	1 MB + 256 KB	Up to 1 MB
	RAM	256 KB		1 MB	Up to 256 KB	512 KB + 64 KB	Up to 256 KB
	STANDARD PERIPHERALS AND INTERFACES	Yes	High-speed SPI/QSPI	Yes	Yes	Yes	Yes
	HIGHLIGHTED DIGITAL INTERFACES			480 Mbps USB, CAN-FD		12 Mbps USB	12 Mbps USB
SECURITY	ISOLATION	TrustZone		Secure Domain and TrustZone	TrustZone	TrustZone	TrustZone
	CRYPTOGRAPHIC ACCELERATOR	Yes		Yes with side-channel leakage protection	Yes with side-channel leakage protection	Yes	Yes
	TAMPER DETECTORS			Yes	Yes		
GPIOs		32		64	Up to 32	48	Up to 48
PACKAGE TYPES		LGA	QFN, WLCSP	WLCSP	QFN, WLCSP	aQFN, WLCSP	aQFN, QFN, WLCSP
MINIMUM PACKAGE SIZE		11x7x1 mm	3.8x3.4 mm	4.7x4.3 mm	2.4x2.2 mm	3.5x3.6 mm	2.5x2.5 mm
COMPATIBLE PMICs		nPM1300, nPM6001	nPM6001	nPM1300, nPM1100, nPM6001	nPM1300, nPM1100, nPM6001	nPM1300, nPM1100, nPM6001	nPM1300, nPM1100, nPM6001
nRF Cloud SERVICES		Yes	Yes				

PMICs

nPM FAMILY

		nPM6001	nPM2100	nPM1304	nPM1300	nPM1100
TYPE	PMIC	●	●	●	●	●
FEATURES	BUCK REGULATOR	4		2	2	1
	BOOST REGULATOR		1			
	BATTERY CHARGER			●	●	●
	LDO		1	2	2	2
	LOAD SWITCH		1	2	2	
CHARGER/BATTERY	TERMINATION VOLTAGE			3.5 to 4.65 V	3.5 to 4.45 V	4.1 to 4.2 V or 4.25 to 4.35 V
	MAX CHARGING CURRENT			100 mA	800 mA	400 mA
	POWER PATH MANAGEMENT					●
	THERMAL PROTECTION					●
	BATTERY COMPATIBILITY		LiMnO₂, AA/AAA 1S or 2S, Silver Oxide	LiFePO₄, Li-ion, LiPo	LiFePO₄, Li-ion, LiPo	Li-ion, LiPo
	INPUT VOLTAGE	3 to 5.5 V	0.7 to 3.4 V	4 to 5.5 V	4 to 5.5 V	4.1 to 6.7 V
	USB COMPLIANCE			Type-C	Type-C	
POWER RAILS	REGULATED OUTPUT VOLTAGE	0.5 to 3.3 V	1.8 to 3.3 V	1 to 3.3 V	1 to 3.3 V	1.8 to 3 V
	MAX CURRENT PER DC/DC	550 mA, 200 mA, 150 mA, 150 mA	150 mA	200 mA, 200 mA	200 mA, 200 mA	150 mA
SYSTEM MANAGEMENT	SYSTEM MONITORING		Battery-voltage and -temp (derived from die temp)	System-, input bus- and battery-voltage; battery-current and -temp; die temp	System-, input bus- and battery-voltage; battery-current and -temp; die temp	
	FUEL GAUGE		●	●	●	
	HARD SYSTEM RESET		●	●	●	
	TIMED WAKE-UP (HIBERNATE)		●	●	●	
	WATCHDOG TIMER	●	●	●	●	
	SHIP MODE	●	●	●	●	●
	BROWN-OUT DETECTOR	●	●	●	●	●
	LED DRIVERS, GPIOs	0, 3	0, 2	3, 5	3, 5	2, 0
	CONTROL INTERFACE	TWI	TWI	TWI	TWI	Pin-configurable
REGULATORY COMPLIANCE		CE, RoHS	CE, RoHS	CE, JEITA, RoHS	CE, JEITA, RoHS	CE, JEITA, RoHS
OPERATING TEMPERATURE		-40 to 85°C	-40 to 85°C	-40 to 85°C	-40 to 85°C	-40 to 85°C
EVALUATION KITS		nPM6001 EK	nPM2100 EK	nPM1304 EK	nPM1300 EK	nPM1100 EK
PACKAGE OPTIONS		2.2x3.6 mm WLCSP	4x4 mm QFN16, 1.9x1.9 mm WLCSP	5.5 mm QFN32, 3.1x2.4 mm WLCSP	5x5 mm QFN32, 3.1x2.4 mm WLCSP	4x4 mm QFN24, 2.1x2.1 mm WLCSP

Range Extender

nRF21540

nRF 21 SERIES

Description

The nRF21540 is a RF front-end module (FEM) offering enhanced link robustness with an integrated power amplifier (PA) and low noise amplifier (LNA) for use with Nordic's nRF52, nRF53 and nRF54 Series SoCs. The nRF21540 is a complementary device operating as a 'plug-and-play' range extender with the addition of just a few external components. The nRF21540 connects to an SoC's antenna output. It includes two additional antenna ports for antenna diversity support. The TX output power, TX gain control and antenna switching can be controlled via SPI, GPIO pins or a combination of both.

The nRF21540's 13 dB RX gain and low noise figure of 2.7 dB, coupled with up to +21 dBm TX output power, ensure a superior link budget boosting the range of supported SoCs by between 6.3 and 10x. In demanding RF environments, or where the application is operating close to the range limit, it can be more energy efficient to use the nRF21540 than continuously resend packets.

The RF FEM suits all applications that require increased range and/or robust coverage, including smart home, asset tracking, audio as well as industrial applications.

Operation

The nRF21540 is supplied in a 4 by 4 mm QFN16 package and supports Bluetooth LE, Bluetooth mesh, Matter, Thread, Zigbee and 2.4 GHz protocols. The RF FEM's TX output power is dynamically adjustable and can be set to comply across all geographical regions. The RF FEM provides an extended operating temperature range qualified from -40 °C to 105 °C, making it an ideal choice for professional lighting or industrial applications when used in conjunction with an nRF52820, nRF52833 or nRF5340 SoC.

Development

The nRF21540 Development Bundle (DB) consists of the nRF21540 DK and the nRF21540 Evaluation Kit (EK). The nRF21540 DK is the perfect tool to develop products that require the range extension capabilities and/or link budget improvements provided by the nRF21540 RF FEM. The nRF21540 DK includes both the nRF21540 RF FEM and the nRF52840 SoC. The nRF Connect SDK is the software development kit for the nRF21540 RF FEM, and it has board support for the nRF21540 DK and nRF21540 EK.

Tech Spec

Output power
Adjustable in small increments up to +21 dBm

Receive gain and noise figure ratings
13 dB receive gain. 2.7 dB noise figure

Input supply
1.7 to 3.6 V

Package
4 by 4 mm QFN16

Development bundle
nRF21540 DK and nRF21540 EK. The EK is a shield for use with nRF52 and nRF53 Series DKs

Applications
Asset tracking, smart home, industrial, toys, audio

Cloud Services

nRF Cloud Services

Description: nRF Cloud Services are optimized for Nordic's low power IoT Devices. nRF Cloud Services consist of nRF Cloud Location Services, and Device Management and Security Services. Both Device-to-Cloud or Cloud-to-Cloud use cases are supported. CoAP and MQTT protocols are both supported.

Services: nRF Cloud Location Services include Assisted GPS, Predictive GPS, Wi-Fi, single-cell and multi-cell, and supply accurate and power-efficient location data for IoT devices employing nRF91 Series products. The Wi-Fi feature requir es a Wi-Fi scanning IC, such as one of the nRF70 Series Companion ICs. Each location feature has accuracy and power efficiency benefits, so switching between different location services during operation can be useful.

nRF Cloud Device Management enables an IoT data-as-a-service model. It acts as the single entry-point for all device data, scaling across different devices and applications. Device management includes a firmware-over-the-air (FOTA) update function, whereby modem and/or application wfirmware can be updated. Device management keeps IoT products in the field operating at their best to ensure the data continues to flow. The data collect feature allows devices to send both operational and application data to nRF Cloud, utilizing a unified interface that ensures the lowest power and simplest implementation.

nRF Cloud Security Services provide a secure and unique identity for devices that can be used for authentication. Nordic's nRF91 Series SiPs have a cryptographically provable unique identity to verify origin during end-product manufacturing. Secure provisioning then enables an IoT device to be configured remotely with the required credentials and custom configurations. This eliminates the need for customer credential management or the need to generate keys on the factory floor – simplifying and lowering the cost of manufacture. Remote secure provisioning enables the manufacture of generic products that can be deployed and provisioned anywhere. And nRF Cloud Security Services ensure devices stay secure after deployment with the capability to rotate keys, rollout new certifications or clean credentials and configurations.

Tech Spec

Location services
A-GPS, P-GPS, Wi-Fi, Single-Cell, Multi-Cell

Additional features
Device-to-Cloud and Cloud-to-Cloud use cases.
CoAP, MQTT and REST API support

Supported products
nRF9131, nRF9151, nRF9160, nRF9161 modules,
nRF7000, nRF7001, nRF7002 Companion ICs

Applications
Industrial, smart appliances, asset tracking, RTLS