Augmented RAIN RFID with Passive Sensors for Maintenance-Free and Ubiquitous Sensor Network Deployments

RAIN RFID Alliance Whitepaper

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1. RAIN RFID sensors enable IoT applications

RAIN RFID is a key technology that connects objects in the physical world with their virtual counterparts in the digital world -- referred to as Digital Twins -- preparing the ground for the Internet of Things (IoT).[1]

RFID often becomes a prerequisite for the IoT, since IoT refers to uniquely identifiable objects (things) and their virtual representations in an Internet-like structure[2]. Adding sensors to these objects allows each item to collect useful information such as moisture and temperature, creating smart IoT-enabled products capable of efficiently interacting with and managing their environment for users.

When off-the-shelf RAIN tags can be deployed to sense the real world, truly widespread sensing becomes a reality. Augmented RFID is about getting more value out of existing RAIN infrastructures. Passive RAIN sensors offer a highly integrated, cost-effective solution for battery-less, low-maintenance, eco-friendly sensor networks. Resulting Ubiquitous Sensor Networks (USNs)[3] enable Big Data-driven artificial intelligence applications for Smart Industries, Smart Healthcare and other IoT applications.

2. The challenge

Where IoT cannot really take shape because active sensor solutions are not cost-effective for widespread distribution, passive RAIN sensors can address these problems. Many use cases cannot tolerate the presence of a battery or its recycling and disposal constraints. Sensor-enabled tags can create and send metrics and other data in real time, expanding the capabilities of the connected devices by sensing different physical parameters: moisture, temperature, pressure, etc.

As a result, augmented RFID techniques will supplement existing RFID due to their strengths in wireless data transmission, battery-less tags and sensors, and cost-efficiency.

3. Use cases and benefits

The adoption of RFID technology is accelerating in many sectors. Battery-less RAIN sensors can create opportunities for companies taking advantage of RAIN technology. When combining RAIN with sensing, different use cases appear in already known market segments of the RFID world. This white paper provides insights into some of the possible applications across three different industry verticals: automotive, transportation and logistics, and agriculture.

3.1. Automotive industry

The automotive industry has been looking for new technologies to analyse and to streamline operations. Automotive OEMs and component manufacturers have recognized that end-to-end identification with RAIN is ideal to ensure smooth supply-chain operations thanks to up-to-date traceability information.

The possibility of combining accurate traceability data together with additional sensor information helps them to understand production processes better, notice production issues faster, and as a result, allows their operations to be more agile.

New, practical solutions to production problems are also enabled by RAIN sensors. Water leakage detection has been a well-known challenge in automotive manufacturing for many years. Electric and hybrid vehicles require improved solutions from OEMs for leakage detection, a challenge that passive RAIN sensors can address in a reliable and cost-efficient manner.

3.2. Transportation & logistics

Billions of RAIN transponders are used yearly to track logistical processes. Passive RAIN temperature sensors could add temperature on top of traceability, across all the acquisition points in the supply chain. Temperature sensing could leverage the already deployed reader infrastructure used today for item tracking. Automated temperature monitoring could help industry to better follow logistical processes as well as ensure a safe supply chain for critical items. Similarly, passive RAIN sensors could allow pressure, moisture, and tamper detection.

3.3. Agriculture

Moisture data is associated to a specific soil area or even a specific plant, allowing treating each of them independently to guarantee their best conditions for growth. Passive RAIN sensors supply information about moisture level around them providing warnings if soil moisture content is below or above a certain threshold, allowing an immediate response and avoiding irreparable damage of the plant.

Moisture detection can happen using Augmented RFID technology through the capacitive interface that the RAIN passive IC includes. The capacitive sensed value will change with the presence of different moisture levels.

These RAIN passive sensors tags based on Augmented RFID would consist of three elements: a UHF RFID antenna, an IC transponder, and a printed capacitive sensor.

3.4. Augmented RFID sensor technology

Augmented RFID sensors detect environmental events and changes and communicate the information wirelessly to an RFID reader. Read-outs can technically leverage any RFID

frequency standard, but some are more advantageous than others to address the problem at hand. True wireless sensor networks benefit from RAIN read ranges up to 30 feet, making it the preferred technology for such applications.

A key component of a RAIN system is the RAIN reader. This device is the bridge between the wireless RF world that controls the passive RAIN transponders and the IT infrastructure that transfers the data to the Enterprise Resource Planning (ERP) system or warehouse management system (WMS). It is particularly advantageous if the readers offer a variety of interfaces. In addition to wired interfaces such as Ethernet, wireless interfaces like Bluetooth, Wi-Fi or mobile communication are becoming increasingly common.

Augmented RFID transponders are energized by the reader, enabling simultaneous data transfer. For this purpose, the RAIN reader controls a corresponding RAIN antenna. This antenna must offer two main functions:

- Supply the sensor with an intermittent RF signal to energize the transponder
- Transmit or receive transponder data wirelessly

Readers are based on existing, worldwide standards for signal processing and data handling and are therefore universally applicable.

Also, because of the unique and serialized product information of RAIN transponders, RAIN readers can read additional data from different memory banks of the transponders or control data for transmission. Data exchange between reader and sensor tags in augmented RFID are based on global standards for RAIN readers.

This allows the rapid implementation of transponders with sensor functionality in different applications.

Augmented RFID sensors are ideal in situations where measurements are required to be made remotely and captured automatically. Depending on the sensor type, RAIN tags could sense variables such as presence detection, temperature, moisture, and more.

Host applications can collect and store sensor data for analysis or take immediate action based upon the sensor measurement.

Augmented RFID also enables entirely new passive sensor tag designs. Electrically decoupling the RF port from the sensing port allows tag designers to conceive inlays where the sensor part can be placed in proximity to the point of interest, exactly where the sensing needs to occur, while the antenna is placed elsewhere. This new type of design architecture has demonstrated that it can be used to simultaneously optimize read distance, sensing and ease of implementation. With a decoupled approach, changing conditions in the proximity of the sensing part no longer cause severe detuning in the unit.

Augmented RFID sensor technology provides low-cost sensing solutions using passive tags (no battery needed) and simpler sensor reading by implementing the data in boot-up to be part of the UII (XPC words) in the tag’s reply.

By leveraging available standard commands, no new commands on the reader side are needed.

Different types of sensing are possible, for example measuring capacitance in a RAIN sensor, enabling a wide number of applications, ranging from presence detection to liquid form moisture sensing, and many others. The user has tag-explicit control over the interaction between reader and environment.

Augmented RFID Sensor technology can enable other types of sensing without requiring any change to the reader (if it is compliant with ISO/IEC 18000-63 and EPC™ Gen2v2), antenna, or sensor design. Augmented RFID tags allow the same form factor and manufacturing processes as today's passive RFID tags.

4. Key takeaways

Integrated appropriately, passive RAIN sensors provide:

- Fully passive sensing
    - Maintenance free
    - Extended lifetime vs. active RFID solutions
    - Lower cost vs. active solutions
    - Accurate sensing
- Decoupled sensor and RF element
    - sensor part can be placed in proximity to point of interest
    - Read distance and sensing can be optimized independently
    - Fully EPC Gen2 compliant
- Easy deployment

5. Endnotes for further reading

[1] https://rainrfid.org/wp-content/uploads/2015/12/Kevin-Ashton.pdf

[2] https://www.researchgate.net/profile/Xiaolin-Jia-2/publication/254032690_RFID_technology_and_its_applications_in_Internet_of_Things_IoT/links/5b57cc16a6fdccf0b2f33dfb/RFID-technology-and-its-applications-in-Internet-of-Things-IoT.pdf

[3] https://www.itu.int/dms_pub/itu-t/oth/23/01/T23010000040001PDFE.pdf

6. Contributors

This white paper was created in association with the RAIN Alliance Smart Products Workgroup. While it was available to the whole group Smart Products for comment during its creation, the main contributors were:

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7. ABOUT RAIN RFID ALLIANCE

The RAIN RFID Alliance is an organization supporting the universal adoption of RAIN UHF RFID technology. A wireless technology that connects billions of everyday items to the internet, enabling businesses and consumers to identify, locate, authenticate, and engage each item. The technology is based on the EPC Gen2 UHF RFID specification, incorporated into the ISO/IEC 18000-63 standard.

Join the RAIN RFID Alliance to enable connectivity for your business and consumers: identify, locate, authenticate, and engage items in our everyday world. For more information, visit www.RAINRFID.org.

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