Radiocrafts
Embedded Wireless Solutions

WIRELESS TECHNOLOGY

SELECTION GUIDE

FOR SOLAR TRACKING

SCALING WITH RELIABILITY IN SMART ENERGY

CONTENTS

INTRODUCTION

WHICH WIRELESS TECH

As wireless technology replaces hard-wired cabling in **solar panel tracking** worldwide, choosing the right wireless solution is critical to ensuring reliable performance under all operating conditions. This is because as projects grow in size, the reliability and scalability challenges grow as well.

This guide will examine the trade-offs and priorities a user must consider when comparing all four of the most commonly considered wireless technologies in solar tracking today : **RIIM**, **Zigbee**, **Wi-SUN**, and **LoRa**.

COMPARISON

RIIM VS ZIGBEE, WI-SUN & LORA

Specifications	RIIM	Zigbee	Wi-SUN	LoRa
Data Delivery Success Rate	99.99% +	90% +	95% +	85% +
Max Outdoor Network Range	40 x 40 km	5 x 5 km	30 x 30 km	48 x 48 km
Max Urban Network Range	19 x 19 km	0.45 x 0.45 km	15 x 15 km	11 x 11 km
Max Indoor Network Range	4 x 4 km	0.3 x 0.3 km	4 x 4 km	7 x 7 km
Max Data Rate	50 or 150 kbps	Up to 250 kbps	Up to 300 kbps	Up to 50 kbps
Mesh	✓	✓	✓	x / ✓
Automatic Channel Selection	✓	x	✓	x

WHY WIRELESS NOT WIRED

THE DRAWBACKS OF WIRED

Higher costs and complexity

Installing kilometers of copper and fiber optic cables is expensive, labor-intensive, and costly across large solar fields. The rising cost of copper, a scarce resource, further increases the cost of cabling.

Higher maintenance and damage risk

Cables are vulnerable to damage from weather, animals, and wear, that can be costly to repair. Risks like lightning strikes can disrupt entire systems.

Inflexibility

To expand or upgrade wired systems usually requires extensive rework, often involving significant, inconvenient and expensive, re-engineering and disruption.

THE ADVANTAGES OF WIRELESS

Lower installation and maintenance costs

Wireless has a lower total cost of ownership than wired. Wireless eliminates the need for expensive cabling and reduces maintenance costs because there are no cables to repair or replace.

Ease of installation

Wireless networks can be installed quickly and non-invasively, making them ideal for large solar fields.

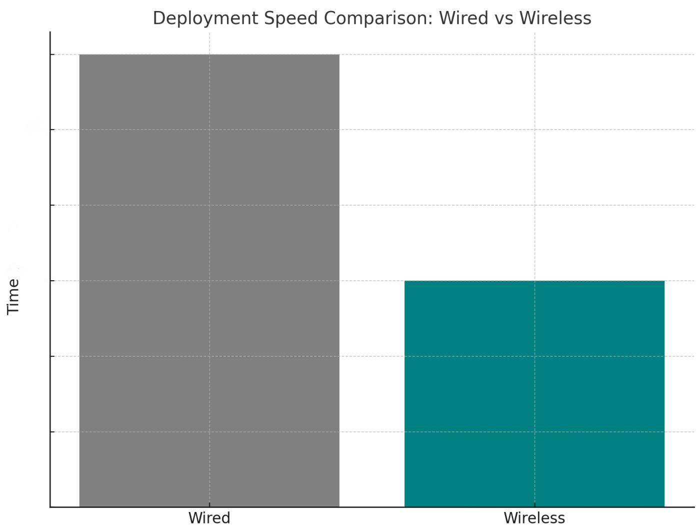
Scalable and adaptable

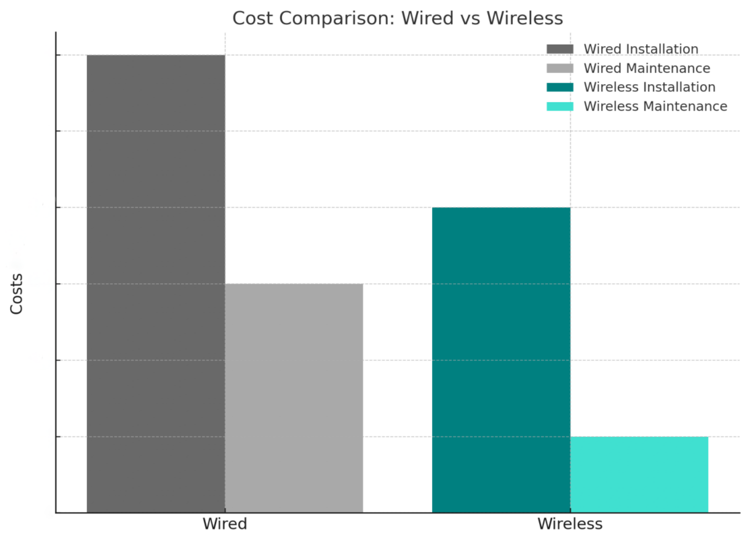
Wireless networks can also be more easily expanded or reconfigured to support future proofing over the decades.

All the drawbacks of wired are removed by switching to wireless technology.

WIRED vs WIRELESS

DEPLOYMENT & COST





WIRELESS CHALLENGES IN

SOLAR TRACKING

Solar panels are on the front line in the battle to reduce greenhouse gas emissions and global warming. They are driving the shift from polluting fossil fuels to clean, sustainable solar power. As the cost of solar panels declines, solar utility fields are increasing in number and size.

The wireless challenge lies in managing tens of thousands of solar trackers operating in close proximity, with dependable monitoring and control. This requires the sending and receiving of large amounts of data in a radio frequency environment facing congestion, interference, and adverse environmental conditions such as storms.

SOLAR TRACKING

WIRELESS CHALLENGES

The need for solar tracking

Solar panels face a fundamental challenge: they can only generate energy when exposed to sunlight. Maximizing energy production requires optimizing their ability to capture the maximum amount of solar energy during daylight hours. This is achieved through solar tracking. Here a dedicated tracker for each row of panels continuously adjusts their orientation to follow the sun's path. By keeping the panels perpendicular to the sun's rays, energy absorption is optimized.

In this way, **solar tracking can increase the energy output of solar panels by up to 40% compared to static arrays, making it a game-changer for large-scale utility fields.**

While solar tracking enhances performance, solar panels remain vulnerable to storm damage in high winds and hail storms. In such situations, remote commands are essential to activate a protective safe mode. Ensuring this safe mode is reliable and fast is critical, and increasingly a requirement from insurers.

The need for reliable wireless in solar

Although all wireless networks experience interference issues, the high density of panels in solar utility fields, that can number over 10,000 units, makes interference a particular challenge in wireless solar tracking.

Interference arises from various sources, including from within the network itself, neighboring networks, and external factors such as cellular radio traffic. Other interference factors include the distance between network nodes, the type of antenna used, and the frequency of data transmission. Managing this interference requires addressing multiple, complex engineering challenges.

Yet to achieve reliable solar tracking and dependable safe-mode functionality, a robust and wireless communication link is essential. Any performance issues could lead to substantially increased maintenance costs.

Finally, commissioning, or ensuring all nodes are correctly set up to join the right network, can be a significant challenge in large networks. This issue is not addressed by a single component, but instead requires a well-designed, whole system approach.

RIIM by Radiocrafts vs ZigBee vs Wi-SUN vs LoRa

RIIM VERSUS

ZIGBEE, WI-SUN, & LORA

An abundance of wireless technologies exists, both standards-based and proprietary, because no single wireless technology can meet the diverse needs of all applications.

Here we compare the four mostly commonly considered wireless protocols in solar tracking : **RIIM**, **Zigbee**, **Wi-SUN**, and **LoRa**.

COMPARISON

RIIM VS ZIGBEE, WI-SUN & LORA

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ZIGBEE

2.4 GHZ

Zigbee is a consumer-focused, low-power wireless protocol that operates on the 2.4 GHz frequency band, the same as Bluetooth and Wi-Fi. This is the highest operating frequency of the four protocols compared here, with the other three all operating at sub-GHz.

In consumer focused wireless applications such as home automation, entertainment, and personal fitness, 2.4 GHz has proven a huge success.

While not as widely deployed as Bluetooth or Wi-Fi, Zigbee is gaining significant traction in smart home applications like lighting, security, and energy management.

As a rule of thumb, higher frequencies support higher data rates, but at the trade-off of range and building penetration. Higher frequencies are also more vulnerable to weather interference and physical obstructions. This means Zigbee's 2.4 GHz operating frequency can struggle in large solar fields.

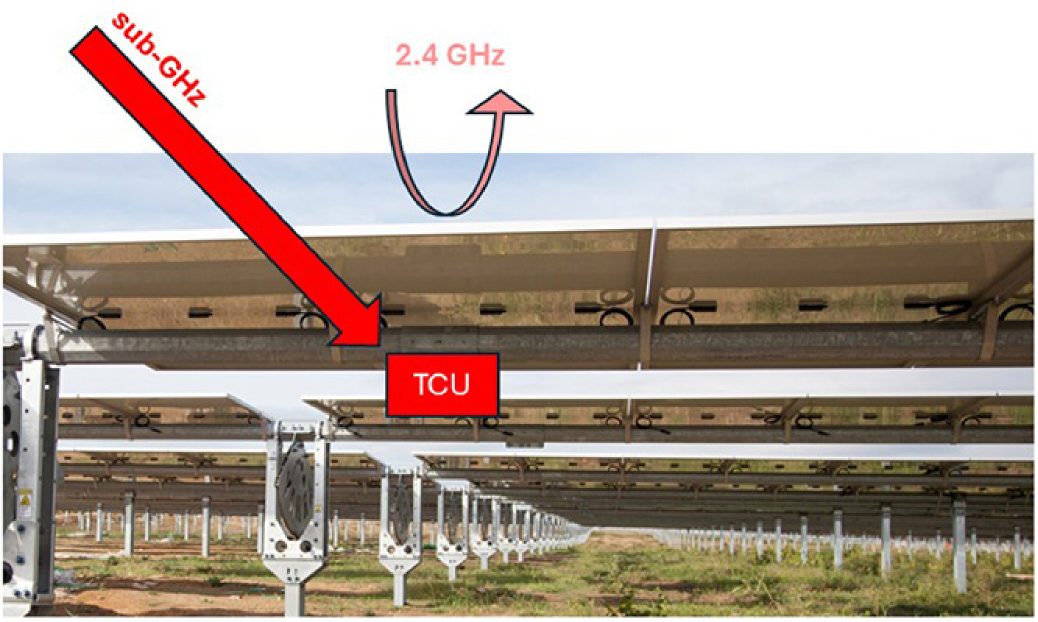
While Zigbee theoretically supports data rates up to 250 kbps, its real-world performance is usually limited to 20–100 kbps due to its low-power design. Although slightly faster than LoRa, Zigbee lags behind RIIM and Wi-SUN, which deliver significantly greater throughput.

Zigbee's range is typically limited to 10–20 meters indoors and 100 x 100 meters outdoors, which is approximately ten times less than sub-GHz frequencies can achieve.

Additionally, Zigbee was not designed for large industrial installations that can experience a 10-20% packet loss rate. Nor does Zigbee support frequency hopping which is required for reliability. As a result, Zigbee is less reliable than RIIM or Wi-SUN, but comparable to LoRa.

IN SUMMARY

While Zigbee is very effective for consumer applications, its limited range, lower reliability, and less efficient scalability make it a less viable choice for large industrial applications like solar tracking.



WI-SUN

SUB GHz

Wi-SUN is an established standards-based, sub-GHz mesh wireless networking protocol designed for large-scale industrial Internet of Things (IoT) applications. Unlike the other wireless technologies discussed here, Wi-SUN is specifically optimized for dynamic environments with moving devices.

As a result, Wi-SUN uses unsynchronized channel hopping that is optimized for devices in motion. In static environments, this dynamic optimization means Wi-SUN cannot rely on time synchronization to coordinate transmissions and avoid interference like RIIM.

As a result, Wi-SUN trades some static reliability for dynamic flexibility. Whereas RIIM prioritizes static reliability through the use of time synchronized transmissions.

In real-world scenarios, this means Wi-SUN achieves a typical data delivery success rate of around 95%.

While completely adequate for many industrial applications, this is significantly lower than RIIM's near-perfect 99.99% reliability that solar tracking demands.

RIIM is also optimized for low latency and ultra-reliable broadcasting which is essential for safe position mode in solar tracking. This feature is not available with Wi-SUN.

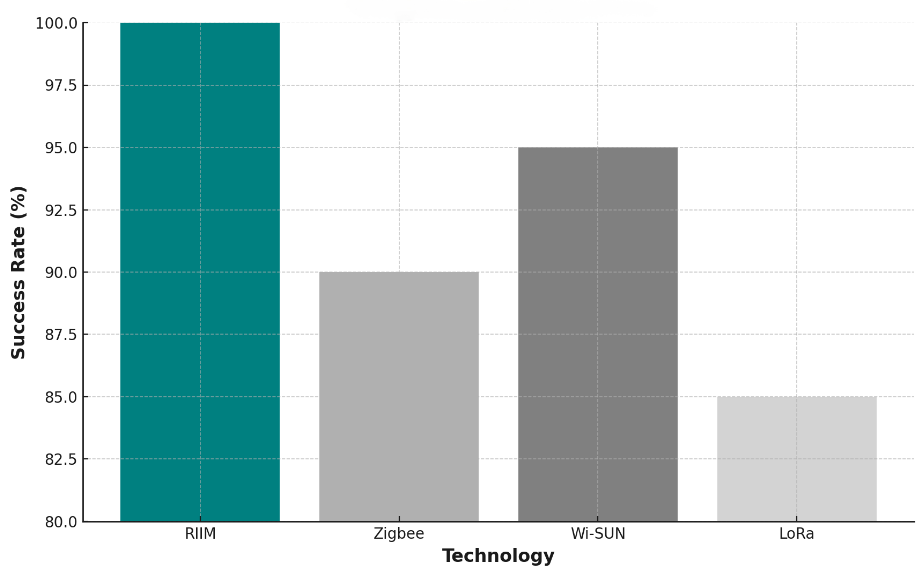
Finally, as a standards-based protocol, Wi-SUN, like both Zigbee and LoRa, cannot easily be tweaked or tailored to meet the specific requirements of demanding applications.

IN SUMMARY

While Wi-SUN provides flexibility for dynamic industrial environments, its lower reliability and lack of customization options make it less ideal than RIIM for static industrial applications like solar tracking.

COMPARISON

DATA DELIVERY SUCCESS RATE



LORA

SUB GHz

LoRa is a low-power, wide area protocol well-suited for applications with low data rate requirements and infrequent communication. Examples include remote agricultural and environmental (e.g. wild fire) sensing.

LoRa also has the longest range of all wireless technologies considered here. However, LoRa faces limitations in large-scale industrial applications that demand continuous monitoring and control, and so a higher data throughput than LoRa can support.

LoRa lacks time synchronization, making it more susceptible to packet collisions and interference. As a result, its real-world data delivery success rates decline as the number of connected devices grows, reducing reliability in larger networks.

To cover a large installation, multiple LoRa networks with fewer devices per network are required. This significantly increases cost and complexity due to the need for a larger number of additional gateways.

LoRa also has a severely limited downlink speed limiting its ability to acknowledge packet delivery. This results in latency, bottlenecks, and extended Over-the-Air (OTA) firmware update times. In large installations, these delays increase with network size.

Unlike RIIM and Wi-SUN, LoRa does not support mesh networking, which limits its scalability and reliability in complex deployments. Without mesh capabilities, LoRa networks require additional gateways, further increasing costs and complexity in large installations.

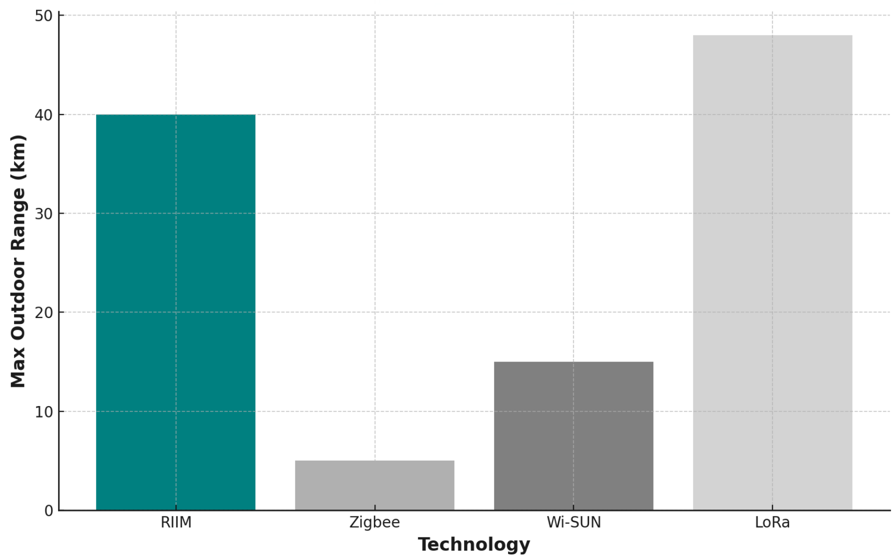
LoRa lacks the time synchronization of RIIM, leading to more frequent packet collisions and greater vulnerability to interference.

IN SUMMARY

While LoRa is well-suited for low-power, long-range infrequent data transmission applications, its limitations in data rate, reliability, updates, and scaling, make it less suited for complex solar tracking applications.

COMPARISON

MAX OUTDOOR NETWORK RANGE



RIIM FOR SOLAR TRACKING

FLEXIBILITY, RELIABILITY, & SCALABILITY

RIIM leverages years of Radiocrafts' industry experience in serving the solar sector.

Unlike standards-based wireless technologies that can't easily be modified, RIIM is a proprietary technology that allows it to be optimized in a multitude of ways to specifically meet the unique application requirements of each solar tracking application.

Solar installations have varying priorities: some may require quick network joining times, others low latency, others the ability to connect as many devices as possible on a single network. RIIM's network settings can be fine-tuned to prioritize these specific needs. Additionally, Radiocrafts offers custom feature design services to meet any unique customer requirements that may arise.

Extended range: no solar field too large

RIIM is designed to cover utility-scale solar fields spanning up to 40 x 40 km with just a single gateway, eliminating the need for costly and more complex multi-gateway setups.

With RIIM, even the largest solar fields can be managed efficiently and cost-effectively by deploying several RIIM networks alongside each other. These are engineered to operate at the same time without interfering with one another.

As a result, RIIM can cover solar utility installations of any geographical size with a minimal number of gateways and complexity.

Safety and damage prevention

RIIM enhances the safety and durability of solar tracking systems by enabling panels to automatically and reliably move into a safe mode position during high winds and storms. This protective functionality helps shield panels from storm damage that can be caused by high speed winds and hail storms, reducing repair costs and minimizing downtime.

RIIM's low-latency network also ensures repositioning commands are transmitted and executed swiftly during sudden weather events. This rapid action protects solar assets, extends the lifespan of panels, and maintains the long-term performance of solar tracking installations.

RIIM FOR SOLAR TRACKING

FLEXIBILITY, RELIABILITY, & SCALABILITY

Open and closed loop control

RIIM supports both open-loop and closed-loop solar tracking systems, giving operators the flexibility to choose the most effective method for maintaining optimal panel orientation.

Open-loop systems rely on pre-set solar trajectories, which RIIM's reliable network can efficiently support to ensure accurate and consistent panel positioning.

Closed-loop systems use real-time data from solar sensors to dynamically adjust panel angles based on live sunlight conditions, further optimizing energy capture in changing environments.

SIMPLICITY & FLEXIBILITY

With the capacity to support up to 1,000 devices across a 40 x 40-km area using just a single gateway, RIIM not only simplifies large-scale deployments but also provides the flexibility for seamless future expansions without the need for significant and costly re-engineering.

WHY CHOOSE RIIM

SCALABILITY, RANGE & ROBUST LONG-TERM RELIABILITY

Radiocrafts' Industrial IP Mesh (**RIIM**) is a proprietary wireless technology optimized for large industrial applications that demand robust, reliable long-range communication.

RIIM operates on the license-free, global sub-GHz frequency band reserved for Industrial, Scientific, and Medical (ISM) applications. Its specific operating frequency varies by region: E.g. 868 MHz in Europe, and 915 MHz in the US.

RIIM enabled devices can communicate over distances of 1.5 km outdoors and 150 m indoors or in densely-built urban environments.

Because a RIIM data packet can hop up to 27 times from device to device within a network, this effectively extends the network range to 40 km x 40 km outdoors, 19 x 19 km for urban, and 4 x 4 km indoors.

RIIM's extensive range and coverage, combined with its capacity to connect up to 1,000 devices from a single gateway, make it highly scalable and flexible in router placement.

Such flexibility can significantly help reduce installation costs, as often only one gateway is required to support a large-scale solar field. For even larger areas, an additional gateway can be added. This simplicity enhances RIIM's reliability and ensures network issues can be resolved quickly.

Pre-certified modules are good to go

RIIM is supplied as an FCC and CE pre-certified RF module-based solution, designed for seamless integration into solar tracking applications.

Symmetric upload download speeds

RIIM provides equally fast upload and download performance, significantly reducing network congestion during periods of high activity. This ensures that users can efficiently and reliably send commands, and update device firmware, even when the network is fully deployed and operating at capacity.

For example, RIIM can typically complete firmware Over-the-Air (OTA) updates for an entire wireless solar field in under three minutes, which is exceptionally fast compared to other sub-GHz mesh technologies.

Hardwired wireless reliability

While sub-GHz operation is also offered by technologies such as Wi-SUN and LoRa, RIIM sets itself apart with a 99.99% data transmission success rate in real-world environments.

This level of reliability rivals that of a hardwired cable and surpasses Wi-SUN, LoRa, and Zigbee.

Time-Synchronized Channel Hopping

RIIM's reliability arises from its use of Time-Synchronized Channel Hopping (TSCH).

TSCH is a standards-based (IEEE 802.15.4-2015) frequency hopping methodology that is natively integrated into RIIM's physical (PHY) hardware and managed communication (MAC) software layers.

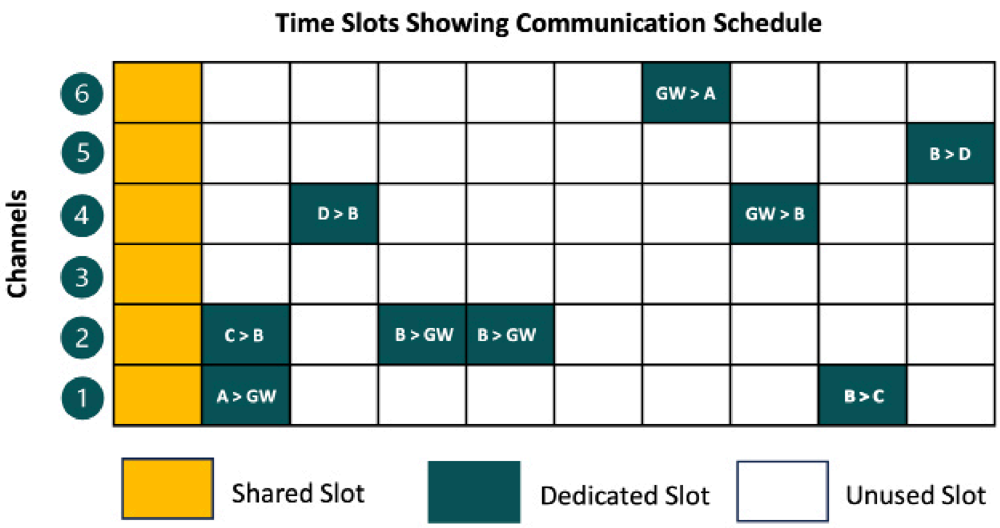
TSCH ensures consistent and robust network performance by transmitting data across multiple pre-set radio channels within precisely synchronized time slots.

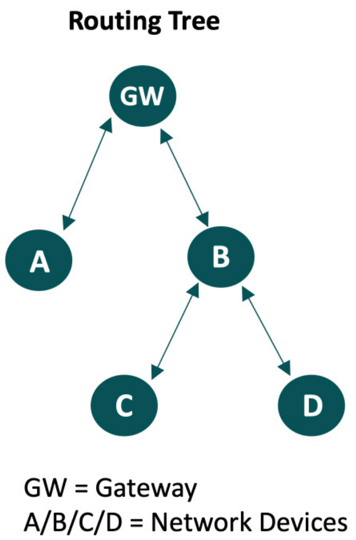
In this way, RIIM devices always know exactly which channel and time slot to use for data transmission, eliminating uncertainty.

If a data packet is lost between devices, it is automatically re-sent on a different channel in the next available time slot, increasing the reliability of the network significantly. This approach is particularly critical in the crowded Sub-GHz ISM band, where countless devices compete for bandwidth. By leveraging TSCH, RIIM maintains reliable communication in even the most congested RF environments.

HOW IT WORKS

TSCH





Interference immunity

In addition to TSCH, RIIM employs a pioneering technique called Polite Spectrum Access, which combines what's termed Adaptive Frequency Agility (AFA) and Listen Before Talk (LBT) methods to significantly reduce interference and data packet collisions.

This further ensures exceptional resilience to radio frequency noise, even in environments crowded with other wireless devices.

In practice, the RIIM protocol scans all available channels for interference before each transmission. If interference is detected, RIIM excludes those channels from its TSCH frequency hopping list to transmit on only the best and least noisy channels.

In Europe, RIIM's Polite Spectrum Access strategy allows it to transmit approximately 37 times more data than other sub-GHz wireless technologies, while fully complying with strict EU regulations mandating how often a device can send data.

Mesh networking

RIIM features a self-forming, self-healing, and self-optimizing mesh network architecture.

The mesh network design allows devices to communicate directly, or relay data through intermediate nodes, ensuring reliable performance even if some nodes go offline or encounter interference.

RIIM's mesh network also makes the rollout of solar tracking networks virtually plug-and-play simple. The entire commissioning and onboarding process is fully automatic, eliminating the many complexities typically associated with setting up large networks.

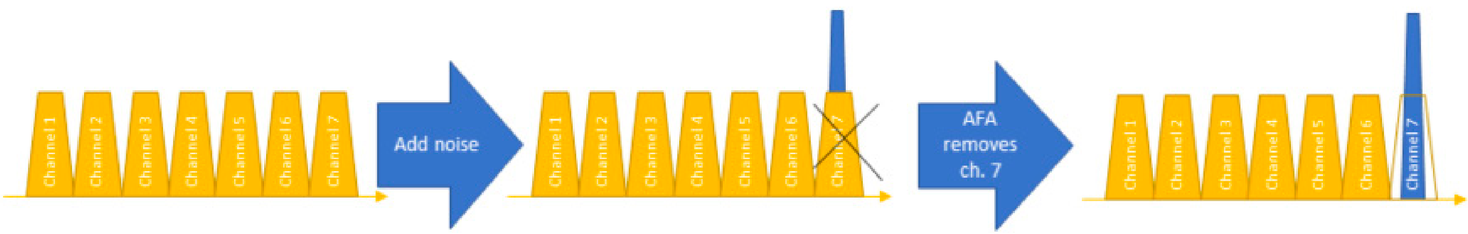
RIIM uses factory-shipped devices that automatically configure themselves with minimal effort, requiring little more than a simple 2D barcode scan to join the network.

OUTDOOR RANGE

RIIM is designed to cover large utility-scale solar fields spanning up to 40 x 40 km in size from just a single gateway.

HOW IT WORKS

POLITE SPECTRUM ACCESS



WHAT OUR CUSTOMERS SAY

“The Radiocrafts RIIM module has allowed us to create and implement a mesh-based, cloud-connected datalogger for use in ultra-difficult real-world RF environments.”**– Logan Stephens, Design Manager of InFact**

“Our partnership with Radiocrafts has been instrumental in the success of our products. The RIIM module proved to be a high-quality product allowing us to create a highly robust and long-range mesh network fitting for our application. In addition, we are elated with the Radiocrafts support team who provided quick and efficient support every step of the way from the proof-of-concept phase all the way to production.” **– Tore Johnsen, CEO of Aiwell AS**

“Working with Radiocrafts on integrating their new RIIM product line with our electric sub-meter energy management at the board level was a refreshing experience in today’s world. We truly value our relationship with Radiocrafts, their expertise, and are looking forward to a mutually beneficial relationship.”

– Ryan Fetgatter, CEO of EZ Meter

QUICK FACTS

ABOUT RADIOCRAFTS

IN SOLAR TRACKING

Radiocrafts RIIM wireless technology is optimized to perform reliably in massive networks with up to tens of thousands of solar trackers. In addition, the RIIM network enables solar panels to rapidly switch to a safe position for protection against severe weather conditions such as high-speed winds and hailstorms.

SUMMARY

WHY SUB-GHz MESH

Solar tracking is a uniquely demanding challenge for wireless technology.

Large solar fields require continuous tracking of tens of thousands of panels. They also need the ability to switch instantly to a protective safe mode during adverse weather to prevent damage to delicate equipment.

With the wrong choice of wireless technology, solar tracking applications will struggle with reliability and coverage issues. Challenges that only worsen as projects scale in size, driving up maintenance complexity, downtime, and cost.

Solar tracking applications are designed to last for decades, requiring the durability to withstand the test of time. This includes robust interference immunity that ensures seamless operation, even as the local wireless environment evolves unpredictably over the years.

The ideal wireless technology would be fit-and-forget reliable, future-proofed, and easy to install, maintain, and adapt. This minimizes the total cost of ownership and ensures the project avoids serious operational issues, both now and in the future.

RIIM sets a benchmark for wireless solar tracking, offering reliability, range, scalability, and a future-proofed design built to last for decades.

TAKE THE NEXT STEP

WITH RIIM WIRELESS TECHNOLOGY

ARE YOU READY TO TAKE YOUR SOLAR TRACKING PROJECT TO THE NEXT LEVEL?

RIIM™ by Radiocrafts

GET STARTED TODAY

ORDER YOUR RIIM DEVELOPMENT KIT

Experience RIIM's capabilities firsthand with our user-friendly development kit, designed for real-world testing in solar tracking applications. The kit enables out-of-the-box wireless network setup, allowing you to quickly assess network performance and explore the full potential of RIIM in your application.

BOOK A FREE DEMO CONSULTATION

Schedule a free Teams consultation or book an on-site demo with a Radiocrafts expert. Discover how RIIM can optimize your solar tracking project and get practical, real-world advice and insights.

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