



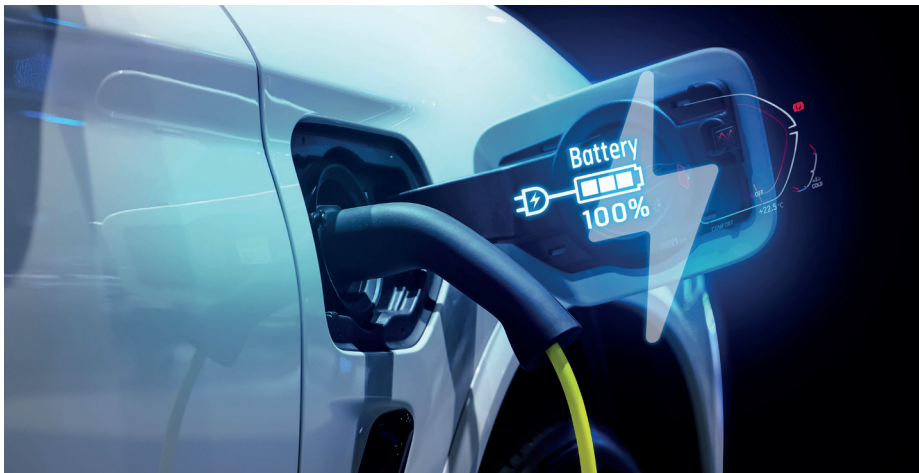
LATTICE SENSATM MULTI-OBJECT DETECTION FOR INTELLIGENT CHARGING STATIONS

Improve Charging Safety and Increase Station Throughput with Deterministic, Low Power Edge AI

Introduction

Electric vehicle charging stations are rapidly shifting into sensor-rich, safety-critical environments as adoption accelerates. High-energy conductive and wireless charging introduce new safety risks, especially in wireless pads where foreign objects can disrupt magnetic fields and create overheating hazards. At the same time, unpredictable user behavior and extended charger occupancy reduce throughput and operational efficiency. The Lattice sensAI solution stack addresses these challenges by enabling low power, near-sensor multi-object detection (MOD) on Lattice FPGAs, delivering deterministic real-time perception that strengthens safety, improves situational awareness, and enhances charger utilization across both conductive and wireless charging systems. See Figure 1.

Figure 1: Close-up of an Electric Vehicle Charging Port



MOD Creates a Unified Perception Layer

Modern charging stations rely on distributed sensing—cameras, radar, lidar, and ultrasonics—to monitor vehicles and pedestrians within charging bays. These systems classify objects, track movement, and provide real-time data to operators, but many still lack advanced perception capable of interpreting fast-changing environments. Studies also highlight operational inefficiencies caused by unpredictable driver behavior, extended parking at high states of charge, and suboptimal site placement.

MOD provides a unified perception layer that enables real-time identification and localization of vehicles, pedestrians, bicycles, and other relevant objects within a single frame. The Lattice sensAI 8.0 MOD models use anchor free, multiscale architectures optimized for far edge deployment under strict limits on power, memory, and latency. Running on Lattice FPGAs and validated through the MOD system on module (SOM) reference design with a MIPI camera and lightweight host, MOD enables efficient, deterministic, privacy-preserving inference directly at the station. This improves safety and utilization across both conductive and wireless charging environments.

KEY CHALLENGES

- Safety hazards in wireless charging zones caused by foreign objects disrupting magnetic fields
- Limited real-time situational awareness across cameras, radar, lidar, and ultrasonic sensors
- Unpredictable user behavior that reduces charger availability and throughput
- Poor station siting and utilization efficiency that lowers driver comfort and trip success rates
- Need for deterministic, low power edge intelligence under strict power, memory, and latency constraints

LATTICE SOLUTION

- Near-sensor multi-object detection that identifies vehicles, pedestrians, and foreign objects in real time
- Deterministic FPGA-based execution for safety-critical perception and consistent latency
- Ultra-low power edge AI that operates within tight station-side power and thermal budgets
- Unified perception across multiple sensor inputs without cloud dependency
- Privacy-preserving, on-device inference aligned with regulatory and compliance requirements



Key Challenges Facing Charging Station Operators

Charging stations are becoming increasingly complex in environments that must balance safety, situational awareness, and efficient utilization. As more vehicles circulate through these sites, and as both conductive and wireless charging systems operate at higher energy levels, operators face growing demands for real-time, low power perception to manage foreign object risks, unpredictable user behavior, and dynamic activity around charging bays.

- **Safety Hazards in Wireless Charging Zones**
Foreign objects entering the charging area can disrupt high frequency magnetic fields, causing overheating, fire risk, or physiological effects.
- **Limited Real-time Situational Awareness**
Stations rely on cameras, radar, lidar, and ultrasonic sensors, but many lack the unified perception needed to track vehicles, pedestrians, bicycles, and other objects reliably.
- **Unpredictable User Behavior Reducing Charger Availability**
Vehicles frequently remain connected during long 80–100% state of charge (SOC) phases or after reaching full charge – limiting throughput and increasing congestion.
- **Poor Station Siting and Utilization Efficiency**
Inadequate placement or insufficient monitoring lowers driver comfort and reduces trip success rates across transportation networks.
- **Need for Deterministic, Low Power Edge Intelligence**
Real-time perception must run under strict power, memory, and latency constraints that traditional computing architectures struggle to meet.

The Lattice Solution

To address the safety, perception, and utilization challenges faced by modern charging stations, Lattice delivers a low power, near sensor MOD solution built on the Lattice sensAI 8.0 solution stack. By combining anchor free, multiscale detection models with deterministic FPGA acceleration, Lattice enables charging systems to run real-time object recognition, foreign object awareness, and surroundings monitoring directly at the edge, without relying on high power processors or cloud compute. This approach strengthens safety, improves operational awareness, and enhances station throughput while maintaining the efficiency, scalability, and privacy required in both conductive and wireless charging environments.

Key Capabilities

- **Ultra-low Power, Near Sensor Intelligence**
Lattice sensAI 8.0 MOD models run efficiently on Lattice FPGAs, enabling continuous, always-on perception at milliwatt-level power, ideal for charging stations that cannot accommodate high-power CPUs or GPUs.
- **Anchor Free, Multiscale Detection Architecture**
Supports accurate detection of multiple object classes (people, vehicles, bicycles, signage, etc.) within a single frame, even in crowded or dynamic charging station environments. The same architecture supports both broad 80-class detection and focused 8-class automotive perception, enabling flexible deployment across a wide range of embedded vision systems.

- **Deterministic, Real-time Performance**
FPGA-based execution ensures consistent latency and deterministic behavior, critical for safety-related scenarios such as foreign object detection, pedestrian movement, and vehicle alignment monitoring.
- **Privacy-preserving Edge Processing**
All inference runs locally on device; no video or sensitive data must be streamed to the cloud, helping operators meet privacy and compliance requirements.
- **Scalable Hardware Deployment**
Built on Lattice CertusPro™-NX FPGAs, a ready-to-use SOM reference design simplifies integration into both new and existing charging station architectures.
- **Robust Foreign Object and Surroundings Awareness**
MOD complements existing station sensors by adding unified, high accuracy object detection around pads, bays, and pedestrian areas, improving safety and situational awareness.
- **Easy Integration Into Station Side Processing Pipelines**
The MIPI camera-based reference design demonstrates how sensAI MOD can be added to local controllers or stationary nodes without major system redesigns.

Edge Intelligence for Smarter, More Efficient Charging Stations

Lattice is uniquely positioned to deliver intelligence for charging station environments because it provides the combination most charging system designers struggle to achieve: real-time perception, ultra-low power operation, and simple integration into existing hardware. Unlike traditional processors that require watts of power or external acceleration, Lattice FPGAs bring AI directly to the edge in a compact, efficient form factor. Lattice sensAI 8.0 adds an optimized software stack with ready-to-deploy MOD models and a proven reference design, enabling charging station OEMs to onboard intelligent monitoring without significant redesign or system overhead.

Benefits

- **Purpose-built for Embedded Environments**
Designed to fit directly into station controllers, sensor nodes, and pad-level hardware without thermal redesigns or added power budget.
- **Simplifies Adding AI to Existing Architectures**
The Lattice sensAI 8.0 provides a turnkey flow, model, compiler, and reference design, reducing development complexity for OEMs and integrators.
- **Reliable Operation for Safety-critical Workloads**
Deterministic FPGA timing ensures consistent behavior required for foreign object awareness and dynamic station monitoring.
- **Scalable Across Product Lines**
A single sensAI MOD pipeline can scale from low density camera nodes to higher capacity controllers (Lattice CertusPro-NX) without rearchitecting the system.
- **Future-proof Edge Platform**
Programmable hardware allows updates to detection classes, model versions, and workflows over time without replacing silicon.



Competitive Analysis

It is important to understand the range of technologies currently used for charging station monitoring and safety. These approaches span everything from traditional hardware-only sensors to cloud-based AI and closed proprietary systems, with each addressing only part of the overall challenge. While effective in specific scenarios, they often come with tradeoffs in accuracy, adaptability, latency, or interoperability that limit their effectiveness in real-world charging environments.

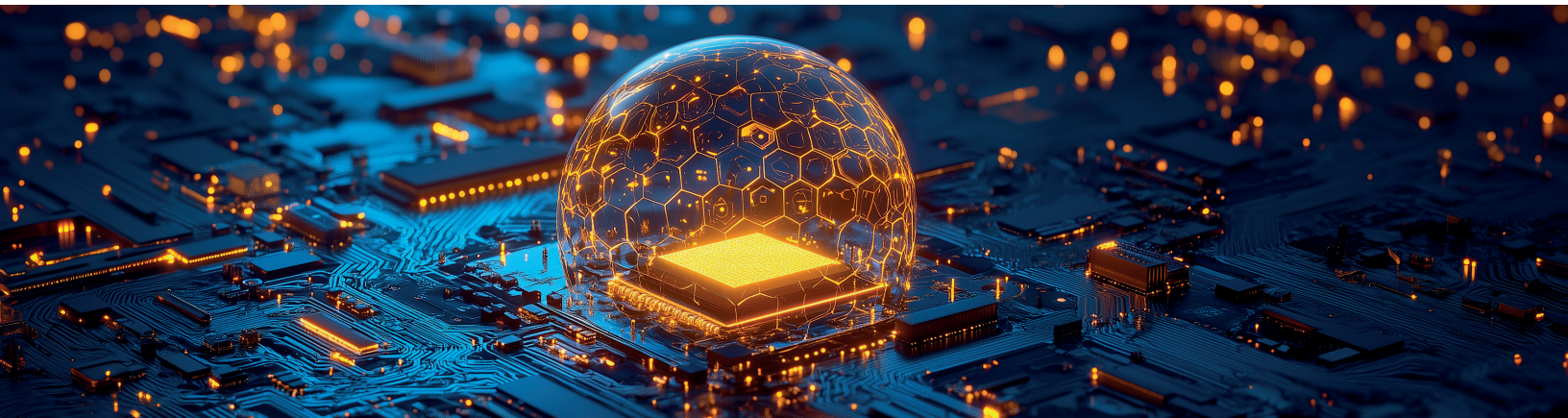
Alternative Charging Station Technologies

- **Pure Sensor Based Systems (IR, Ultrasonic, Magnetic, and Capacitive)**
Detect objects through heat signatures, sound reflections, magnetic disturbance, or capacitance changes. These systems frequently miss nonmetallic or soft objects, struggle with irregular shapes, and adapt poorly to diverse materials.
- **Cloud Only AI Processing**
Sends raw video or sensor data to remote servers for inference. This creates high latency, requires stable connectivity, increases bandwidth use, and raises privacy concerns.
- **Legacy Embedded Systems (Non-FPGA and Fixed DSP Chips)**
Depend on rigid, predefined detection logic with limited ability to update or add new object classes. They often consume more power and scale poorly for modern AI workloads.
- **Single Modality Vision (Basic Cameras without ML)**
Provides image capture without intelligent inference, forcing reliance on human monitoring or slow downstream analysis.
- **Nonstandard Proprietary Systems**
Closed, vendor locked architectures not aligned with ISO/SAE/IEC standards, making integration into EV charging ecosystems difficult or costly.

In comparison to these fragmented and limited approaches, the Lattice sensAI 8.0 multi-object detection delivers a unified, AI driven perception pipeline that can identify a wide range of objects, vehicles, people, bicycles, tools, debris, signage, and more, regardless of material type, shape, or thermal characteristics. Running directly on low power Lattice FPGAs, MOD provides deterministic real-time inference, full scene situational awareness, and privacy preserving edge processing without relying on cloud connectivity. With anchor free, multiscale models optimized for far edge operation and a ready to deploy SOM reference design, Lattice offers a scalable, standards aligned, and futureproof alternative that eliminates the sensing gaps and integration barriers found in traditional charging station solutions.

Conclusion

Lattice sensAI 8.0 MOD provides a practical, edge-optimized approach to real-time multi-object detection, combining anchor free, multiscale architectures with FPGA-based execution designed for far edge environments. It supports both broad 80-class detection and focused on 8-class automotive perception, enabling flexible deployment across a wide range of embedded vision systems. With real-time performance demonstrated on the compact Lattice CertusPro-NX SOM and a toolchain that delivers deployment accurate quantization and deterministic behavior, Lattice sensAI 8.0 MOD offers a reliable, efficient, and scalable foundation for integrating high quality object detection into modern edge devices.



Ready to Learn More?

To learn more about Lattice low power FPGA-based solutions for industrial, automotive, communications, computing, and consumer applications, visit www.latticesemi.com or contact us at sales@latticesemi.com.

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