White Paper

Rugged Panel PCs Built for Seafood Cold Chain

Solving Harsh-Environment Challenges with IEI IP66 Stainless Steel Touch Panel PCs

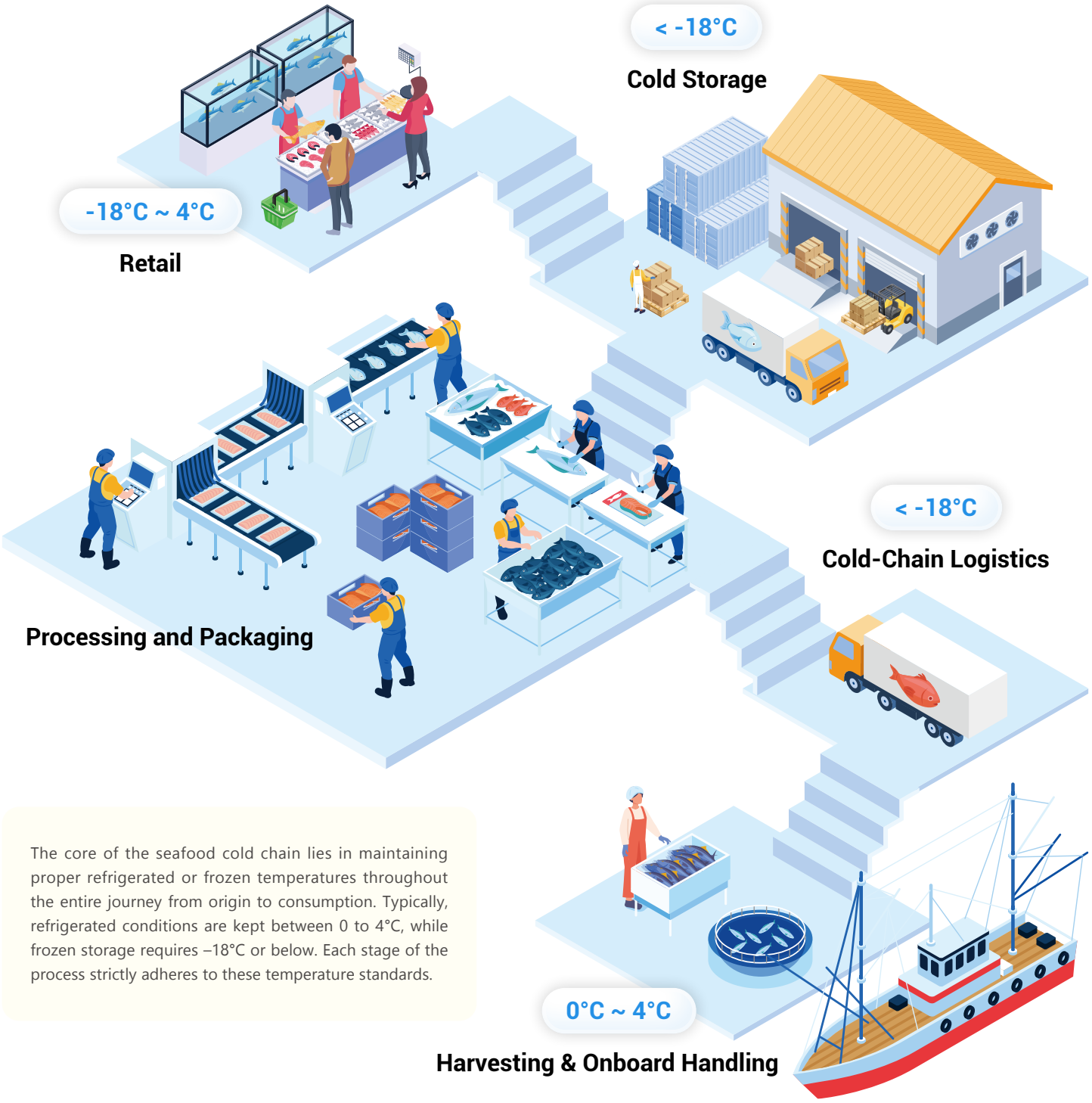
Introduction: Harsh Environments Demand Smarter Interfaces

The increasing global demand for seafood products has made the efficiency and safety of the seafood supply chain more critical than ever. Seafood processing environments impose extreme demands on industrial equipment due to persistent exposure to salt-laden air, condensation, and daily high-pressure washdowns. These corrosive and moisture-intensive conditions accelerate the failure of conventional Human-Machine Interfaces (HMIs), leading to unplanned downtime, increased maintenance costs, and elevated food safety risks. Maintaining system reliability under such stressors is critical to ensuring operational continuity and compliance with HACCP (Hazard Analysis and Critical Control Points) standards.

This white paper presents a technical overview of how ruggedized industrial panel PCs—specifically the IEI SHIELD Series—address these challenges. Engineered with fully sealed IP66-compliant enclosures, -30°C operating capability, SUS304 stainless steel construction, and M12 waterproof connectors, the SHIELD Series ensures long-term durability and ingress protection in washdown zones and cold storage workspaces. Furthermore, by supporting seamless integration with SCADA systems, PLCs, and sensor networks, these panel PCs enable real-time monitoring, data logging, and process traceability—core requirements for digital transformation in regulated seafood processing environments.

Market Overview: Digitalizing the Seafood Cold Chain

The global seafood cold chain market is poised for significant growth, fueled by rising seafood consumption, tighter food safety regulations, and rapid advancements in refrigeration and logistics technologies. Industry estimates suggest that the seafood cold chain could reach USD 22-30 billion by 2025, forming a substantial portion of the broader cold chain market, which is projected to grow from USD 70.55 billion in 2025 to over USD 121 billion by 2030.



The core of the seafood cold chain lies in maintaining proper refrigerated or frozen temperatures throughout the entire journey from origin to consumption. Typically, refrigerated conditions are kept between 0 to 4°C, while frozen storage requires –18°C or below. Each stage of the process strictly adheres to these temperature standards.

Despite this momentum, the industry faces persistent challenges—especially in developing regions—where limited access to reliable cold storage leads to substantial food loss, economic hardship, and environmental strain. According to the UN FAO, up to 27% of landed fish is wasted between catch and consumption, largely due to cold chain failures. Maintaining consistent low temperatures is essential, as any compromise in product freshness is irreversible.

Inadequate refrigeration infrastructure, high energy demands, and the environmental impact of traditional refrigerants continue to hinder sustainable growth. These issues are particularly pronounced among small-scale fishers and low-income communities, where the lack of scalable cold chain solutions undermines both food security and livelihoods.

A 2023 report by the International Institute of Refrigeration and the Centre for Sustainable Cooling further highlights that 12% of global food production is lost each year due to temperature control failures—making cold chain resilience a critical priority across the seafood supply chain.

However, the industry must overcome operational challenges that impact profitability and compliance.

Top Operational Challenges in Seafood Processing Plants

Study from the Gro Centre in Iceland emphasized the role of inadequate sanitation design in fish processing plants, linking it to microbial contamination and mechanical wear.

These findings reinforce the real-world observations: seafood cold chain environments demand equipment with specialized protection, robust design, and proactive maintenance to avoid costly downtime and ensure compliance with food safety regulations.
In addition to environmental damage, seafood plants also face compounding issues at the operational levels:

- Constant exposure to salt mist, condensation, and daily high-pressure wash-downs quickly destroyed previous HMIs and barcode printers.
- Paper-based batch logging delayed corrective actions and complicated HACCP / ISO audits.
- EMI interference from motors and compressors causes Ethernet instability in freezer zones.
- Lack of real-time visibility into temperature compliance, production throughput, and inventory aging resulted in increased waste and missed optimization opportunities.

> *A 2019 study from the U.S. National Library of Medicine confirmed elevated equipment failure risks due to outdated machinery, poor ventilation, and salt-rich conditions in seafood processing.*

Application Scenarios of IP66 Stainless Steel Panel PCs in Seafood Cold Chain

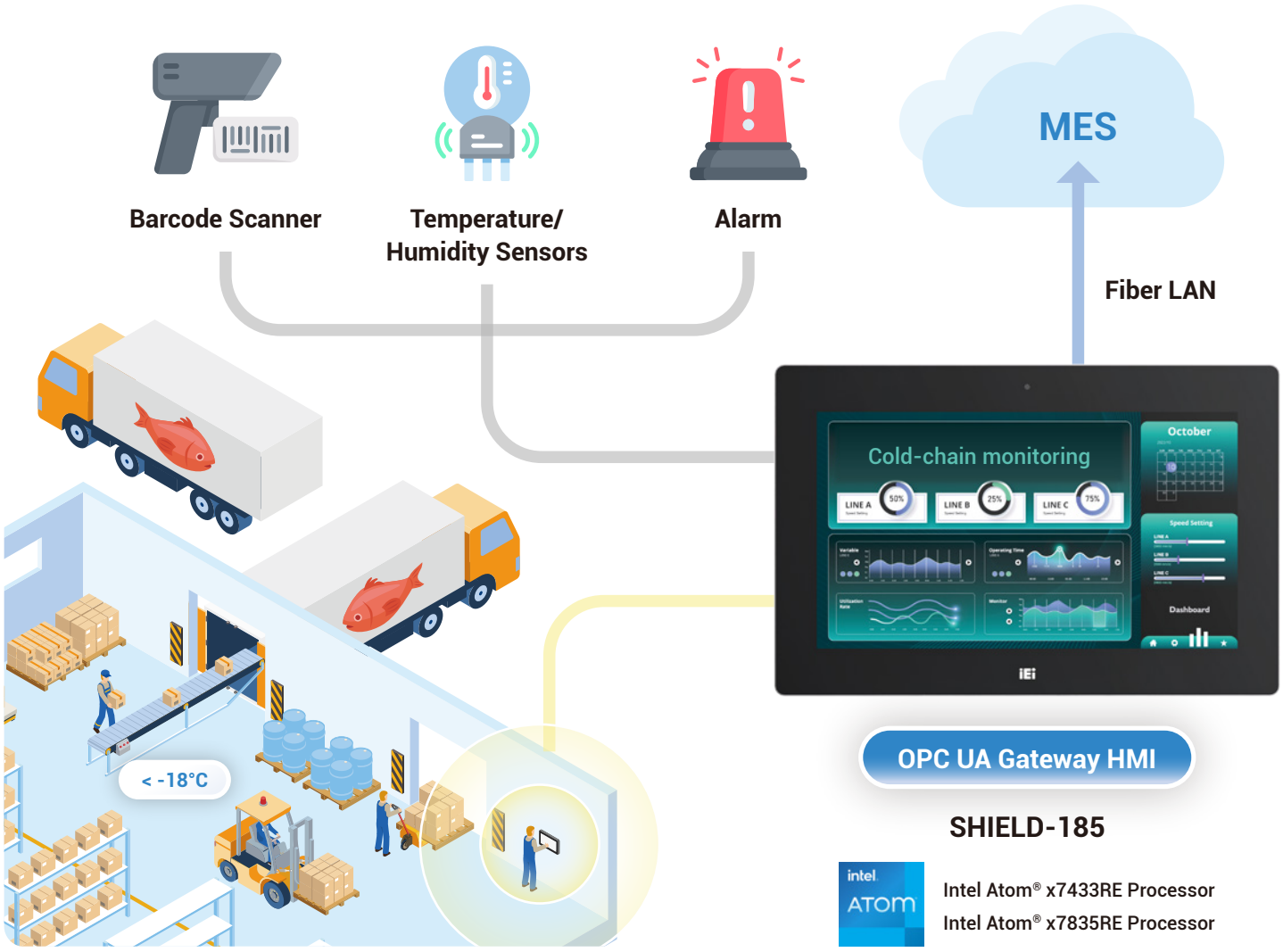
IP66 stainless steel panel PCs have a wide range of applications in the seafood cold chain, primarily due to their robust, waterproof, dustproof, easy-to-clean, and corrosion-resistant properties. These characteristics make them an ideal choice for the following stages:

- **Processing Plants:** In seafood processing plants, equipment requires frequent cleaning and disinfection to meet strict hygiene standards. IP66 stainless steel panel PCs can withstand high-pressure water jets and corrosive cleaning agents, making them suitable for production line monitoring, quality control, recipe management, and automation control.
- **Cold and Frozen Storage Warehouses:** In low-temperature and high-humidity cold and frozen storage warehouses, ordinary computers are prone to malfunction. The wide operating temperature range and moisture-proof design of stainless steel panel PCs ensure stable operation in extreme temperatures, and they can be used for inventory tracking, temperature monitoring, and inbound/outbound management.

System Architecture

Seafood Traceability at the Edge

This edge-computing system architecture enhances seafood cold chain operations by providing ruggedized panel PC integration for real-time monitoring, traceability, and environmental resilience. With IP66-rated stainless steel devices and OPC UA gateway connectivity, it enables efficient automation, hygiene compliance, and end-to-end visibility—reducing risks, improving uptime, and supporting HACCP and regulatory requirements in harsh seafood environments.



Key Advantages of Edge-Based Seafood Traceability Architecture

Harsh Environment Adaptability:

The IP66 rating ensures complete dust protection and resistance to powerful water jets, while the stainless steel enclosure provides excellent corrosion resistance, making them perform exceptionally well in wet, dusty, low-temperature, high-salinity, or chemicalexposed seafood cold chain environments.

Hygiene and Cleanliness:

The smooth stainless steel surface and fanless design prevent dust and bacteria accumulation, facilitating frequent cleaning and disinfection. This meets the stringent hygiene requirements of the food industry and reduces the risk of cross-contamination.

Improved Efficiency and Automation:

Through real-time data collection, monitoring, and management, panel PCs help optimize cold chain processes, reduce manual errors, and enhance operational efficiency and automation.

Data Traceability and Quality Control:

Enabling end-to-end data traceability from catch to consumption helps quickly identify problem sources, ensure product quality and food safety, and meet increasingly strict regulatory requirements.

Reduced Maintenance Costs:

The robust design and high protection rating reduce equipment failure rates and maintenance needs, lowering long-term operating costs.

Reliability and Stability:

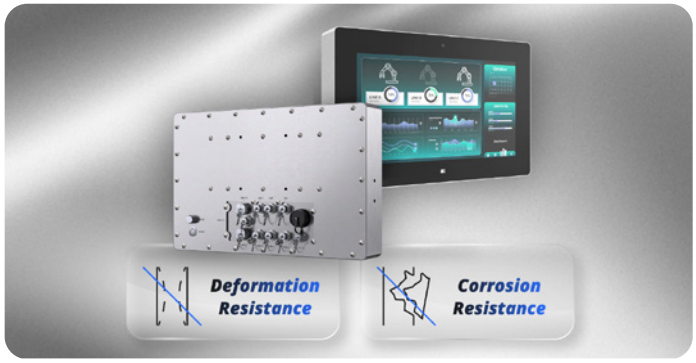
The fanless design and industrial-grade components ensure high stability during 24/7 continuous operation, minimizing downtime and ensuring the continuity of the cold chain.

Purpose-Engineered for Extreme Environments

Built to meet the demands of harsh seafood processing conditions, SHIELD series combines advanced hardware design with seamless data integration and operator-friendly features.

SUS304 Stainless Steel Enclosure for Corrosion Resistance

Constructed with SUS304 stainless steel, the enclosure offers high resistance to corrosion, making it ideal for seafood processing environments where salt exposure is constant.

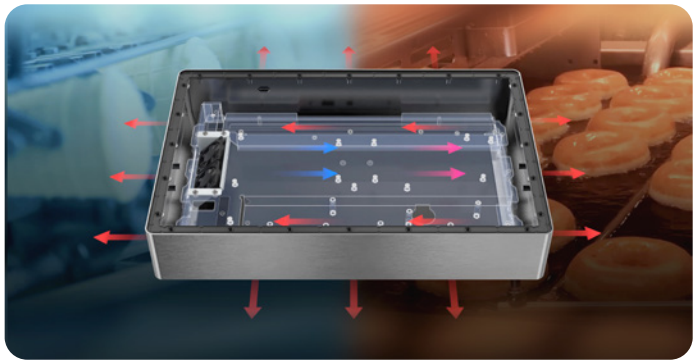


Fully IP66-rated Enclosure

M12 waterproof connectors effectively prevent water jets and dust ingress. The moisture-resistant front panel design also minimizes internal condensation, reducing the risk of short circuits and component corrosion.

Built for -30°C Cold Chain Demands

The thermal design is tested for durability in low temperatures (-30°C), high temperatures (50°C), and high-humidity chambers to ensure stable operation and reliability of the equipment under extreme environmental conditions.

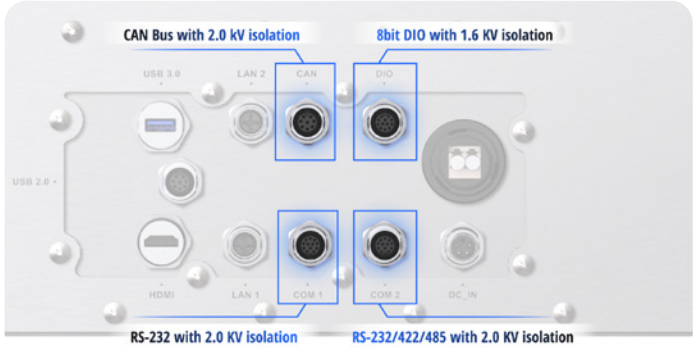


Data Integration

- Native OPC UA gateway pushes sensor, barcode, and weight data to cloud in under 1 second
- Remote dashboard mirrors freezer KPIs in production office

Industrial Connectivity

Rugged M12 I/O and SFP fiber ports mitigate EMI and ensure signal integrity

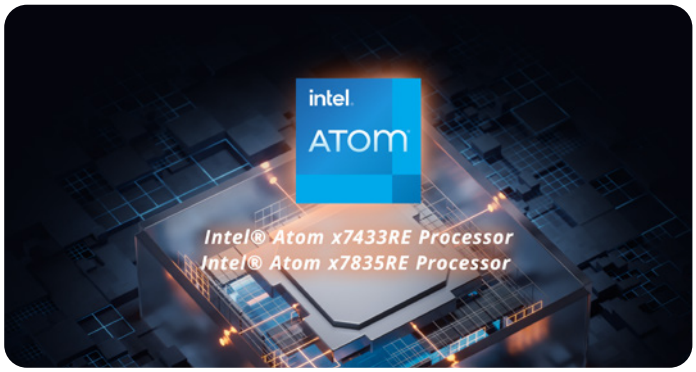


Reliable Operator Interaction

- Capacitive glove-friendly touchscreen
- Tethered barcode scanner eliminates data duplication and paper records

Industrial Connectivity

Rugged M12 I/O and SFP fiber ports mitigate EMI and ensure signal integrity



A Better Solution

Numerous data sources and case studies demonstrate that implementing Panel PCs in cold-chain operations, especially in the seafood sector, significantly improves traceability, abnormality response time, equipment effectiveness, and reduces waste. Key benefits include:

Traceability in Seconds

Batch-trace retrieval cut from 15 min to < 60 s, satisfying third-party auditors on first request.

+20% Equipment Efficiency

Line interruptions uncovered by live SPC (Statistical Process Control) trends; overall equipment efficiency improved ~20 % within two months.

50% Less Waste

Automated expiry alerts slashed seafood spoilage and boosted high-value product yield.

Zero Downtime

Proven ruggedness with no unplanned shutdowns after 1 year in freezer environments—ideal for 24/7 seafood processing.

Conclusion

Panel PCs provide a proven, scalable solution for the harsh realities of seafood processing environments. By replacing vulnerable HMIs with rugged, intelligent systems, plants gain improved traceability, compliance readiness, reduced downtime, and better operational visibility.

Ready to upgrade your processing line?
Contact us today to explore the right Panel PC solution for your facility, or download our Rugged Panel PC Selection Guide to get started.

Product Selection Guide

intel.

Intel® Atom® processor

Model	SHIELD-156	SHIELD-185	SHIELD-215
LCD Display	15.6"	18.5"	21.5"
Resolution	1920 (W) x 1080 (H)	1920 (W) x 1080 (H)	1920 (W) x 1080 (H)
Brightness	450 cd/m²	500 cd/m²	500 cd/m²
Contrast Ratio	800:1	1000:1	1000:1
LCD Color	16.2M	16.7M	16.7M
Pixel Pitch (mm)	0.179 (H) x 0.179 (V)	0.213 (H) x 0.213 (V)	0.248 (H) x 0.248 (V)
Viewing Angle (H-V)	178°/178°	178°/178°	178°/178°
Backlight MTBF	50,000 hours	50,000 hours	50,000 hours
Touchscreen	Multi-point projected capacitive type (anti-UV / anti-glare coating,support gloves) Surface hardness: ≥7H		
Touch Controller	Projected capacitive type: ILI2520		
CPU (SoC)	Intel Atom® x7433RE Processor 6M Cache, up to 3.40 GHz / TDP 9w Intel Atom® x7835RE Processor 6M Cache, up to 3.40 GHz / TDP 12w		
Memory	1 x SO-DIMM DDR5-4800 up to 16GB (Pre-installed 8GB) (ECC supported)		
Ethernet	2 x 2.5GbE LAN via Intel I226-IT		
Storage	1 x M-Key 2280 (PCIe Gen3 x2) for M.2 SSD 1 x 128GB Emmc (optional)*		
Expansion slot	1 x M.2 M-Key 2242/2280 (PCIe Gen3 x1 + SATA) 1 x M.2 B-Key 3052/3080 (PCIe Gen3 x1 + USB 3.0 x1) 1 x NANO-SIM 1 x M.2 E-key 2230 (PCIe Gen3 x1 + USB 2.0 x1) for optional WIFI/BT module		
Camera	1 x Camera (Wide-viewing angle)		
External I/O Interface	M12 Waterproof Connector for 2 x RJ-45 2.5GbE LAN M12 Waterproof Connector for 1 x RS-232(with 2.0 kV isolation) M12 Waterproof Connector for 1 x RS-232/422/485(with 2.0 kV isolation) M12 Waterproof Connector for 1 x CANBUS(with 2.0 kV isolation) M12 Waterproof Connector for 1 x 8bit DIO (Isolator) (with 1.6 KV isolation) with SMbus M12 Waterproof Connector for 1 x USB2.0 M20 Waterproof Connector for 1 x USB3.0 M20 Waterproof Connector for 1 x HDMI 1.4b Waterproof Connector for Power switch M12 Waterproof Connector for DC Input Power		
Construction Material	304 Stainless Steel Chassis		
Mounting	VESA Mount 100 x 100 / Pole Mount / YOKE Mount		
IP Rating	Fully IP66		
Power Input	DC 10~28V		
Operating Temperature (with airflow)	-30°C~55°C@50%RH		
Storage Temperature	-40°C~70°C		
Humidity	10 to 90%RH @ 40°C, non-condensing		
Safety and EMC	CE/FCC		
OS	Windows 10/11 IoT Enterprise 64-bit Linux		

References

1. Industrial Technology Research Institute. Taiwan cold chain logistics industry trend analysis report: Application cases from the Smart Cold Chain Platform[R]. Hsinchu: Industrial Technology Research Institute, 2025.
2. Borjeson L, Oosterveer P. Improved traceability in seafood supply chains is achievable by process & technology integration[J]. Trends in Food Science & Technology, 2021, 111: 739–747. DOI: 10.1016/j.tifs.2021.02.046.
3. Taiwan Cold Chain Association. Smart preservation technology prepares for new challenges in low-temperature logistics: ITRI launches AI-powered cold chain platform[EB/OL]. 2023-10-25 [2025-08-02]. Available: Taiwan Cold Chain Association. (2023, October 25). Smart preservation technology prepares for new challenges in low-temperature logistics: ITRI launches AI-powered cold chain platform. Taiwan Cold Chain Association.
4. Department of Industrial Technology, Ministry of Economic Affairs. Smart 3D warehousing and AI cold chain solutions by ITRI enhance logistics and temperature control[EB/OL]. 2023 [2025-08-02]. Available: Department of Industrial Technology, Ministry of Economic Affairs. (2023). Smart 3D warehousing and AI cold chain solutions by ITRI enhance logistics and temperature control. Ministry of Economic Affairs, Taiwan.
5. AI Hub. AI empowers smart cold chain: Reducing food waste and enhancing logistics transparency[EB/OL]. (2022-09-23) [2025-08-02]. Available: AI Hub. (2022, September 23). AI empowers smart cold chain: Reducing food waste and enhancing logistics transparency.
6. Pindi M. Revolutionizing cold chain logistics: Leveraging IoT and AI for enhanced food safety and waste reduction[J]. World Journal of Advanced Research and Reviews, 2025, 26(2): 1412–1424. DOI: 10.30574/wjarr.2025.26.2.1627.
7. Hu K Y. A study on risk assessment of cold chain operations[D]. Hsinchu: Department of Industrial Engineering and Management, National Chiao Tung University, 2014.
   Available: https://ir.lib.nycu.edu.tw/bitstream/11536/132363/1/10239863-201401-021001-139-160.pdf

About IEI Integration Corp.

IEI Integration Corp. is a global leader in industrial computing and AIoT systems with over 28 years of experience. We deliver rugged panel PCs, embedded computers, and edge AI platforms for smart manufacturing, digital healthcare, and network communications. IEI solutions are trusted by system integrators and enterprises worldwide to power intelligent infrastructure in the most demanding environments.

威強電工業電腦 IEI Integration Corp.

Headquarters

威强電工業電腦
IEI Integration Corp.

- No. 29, Zhongxing Rd., Xizhi Dist.,, New Taipei City 221, Taiwan
- TEL: +886-2-86916798
  +886-2-26902098
- FAX: +886-2-66160028
- sales@ieiworld.com
- www.ieiworld.com/tw

America

IEI Technology USA Corp.

- 138 University Parkway, Pomona, CA 91768
- TEL: +1-909-595-2819
- FAX: +1-909-595-2816
- sales@usa.ieiworld.com
- usa.ieiworld.com

China

威强电工业电脑
IEI Integration (Shanghai) Corp.

- 515, Shen Fu Rd., Xin Zhuang Industrial Develop Zone, Shanghai, 201108, China
- TEL: +86-21-3116-7799
- FAX: +86-21-3462-7797
- sales@ieiworld.com.cn
- www.ieiworld.com.cn