# Key Elements for Initiating a Robotics-Oriented Platform

## Heterogeneous embedded platforms, Ubuntu OS & industrial cameras

- / Embedded Platforms
- / Ubuntu OS
- / Camera Interfaces
- / Product Selection Guide


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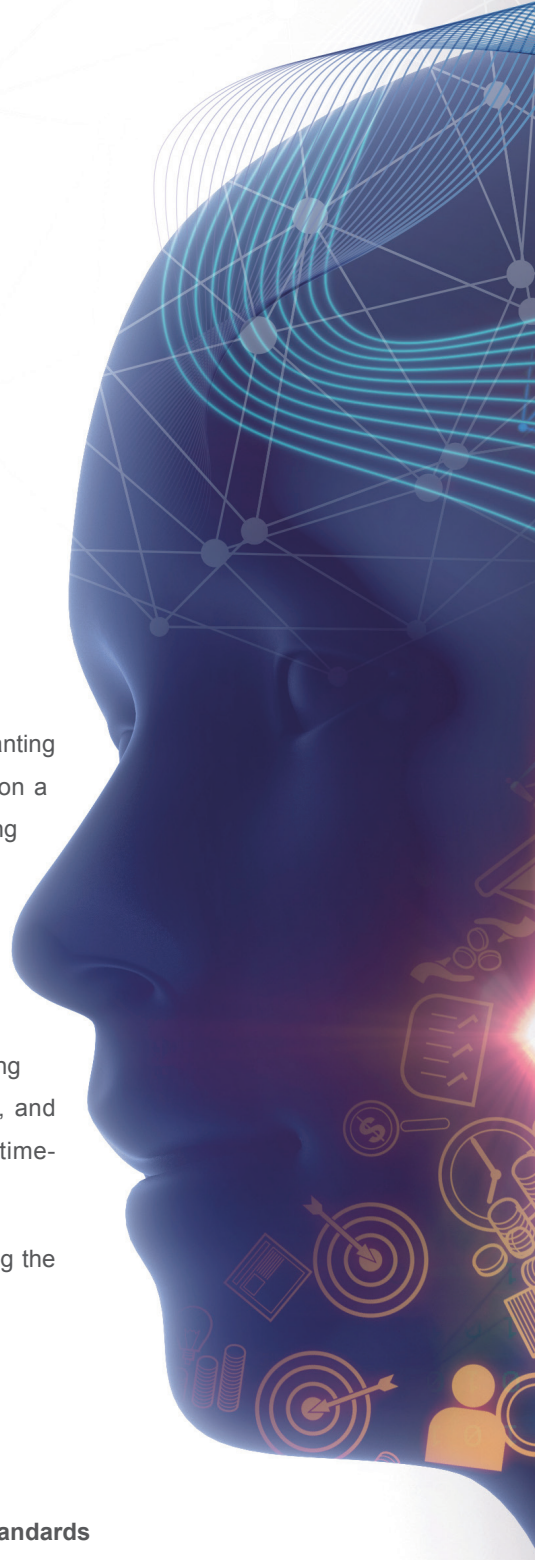
# Three Key Elements for Initiating Robotics-Oriented Platforms



What comes to your mind when you think about robots? A tinny mechanical voice chanting "Danger, Danger!" and waving its tube-like metal arms? Two anthropomorphic eyes on a display imitating human facial expressions? How about a steel exoskeleton with glowing red eyes from a famous tech-noir series?

Robots have developed with AI and become ubiquitous in commerce, entertainment and industrial automation. Illustratively, a study by Businesswire indicates that the market revenue for AGVs and AMRs is expected to reach US$13.2 billion by 2026 with a growth rate of around 35%[1]. Despite this, finding suitable hardware and computing platforms compatible with diverse signal receivers (e.g. cameras, vibration sensors, and motion controllers) and capable of initiating robotics-oriented applications can be time-consuming and confusing for developers.

Reducing the material sourcing efforts required of a product team necessitates exploring the three critical issues in the development of industrial robotics applications.

1. **Categories of cameras suitable for robotics applications and their selection standards**
2. **Hardware platforms certified by Ubuntu offering guarantees to AIoT developers**
3. **Advantech's latest high-performance x86 platforms, AIoT device management software, and embedded design-in services**

[1] Source: https://www.businesswire.com/news/home/20210115005190/en/Global-Mobile-Robots-AGV-AMR-Market-Expected-to-Reach-14B-by-2026---The-New-Normal-in-Our-Day-to-Day-Operational-Activities---ResearchAndMarkets.com

# Designed for AI & Robotics Applications

### State-of-the-art in Heterogeneous Computing

CPU, GPU, xPU parallel computing with high-bandwidth architectures

### Time Deterministic & Low Latency

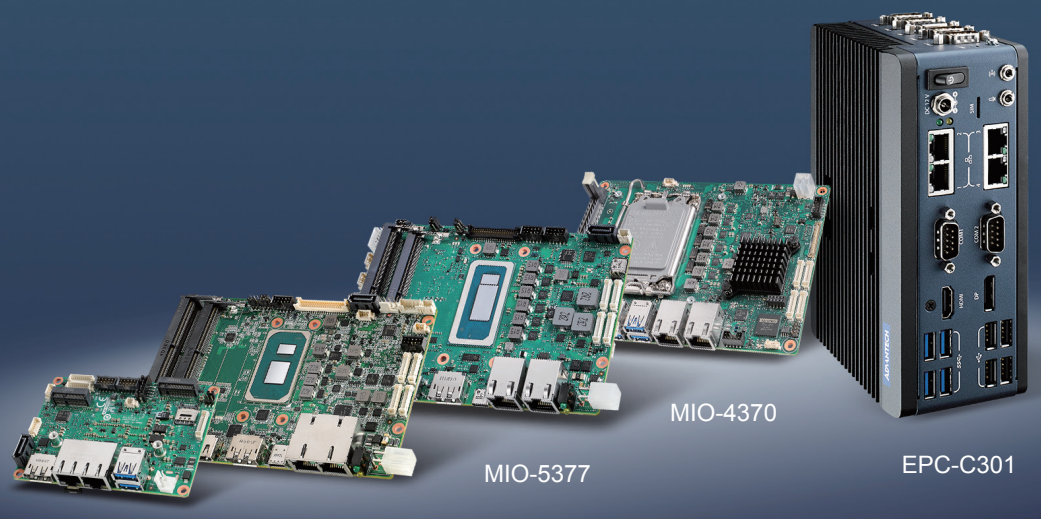
Wired TSN, I3C, CAN/-FD, FuSa & WiFi-6E & 5G with roaming ability

### Industrial-Grade Manufacturing Quality

Small footprint with rugged design & production

### Embedded Linux OS & Ubuntu Certificate

Certified Ubuntu AIoT devices & Yocto BSP for diverse scenarios



# Selecting a suitable camera interface

Choosing a camera that meets the needs of a specific robot requires an understanding of the four most prevalent camera interfaces — GigE, USB3.2, CameraLink, and CoaXPress.

GigE is the most common transfer interface used by industrial cameras. It is compliant with various specifications and supports plug-and-play capabilities. GigE may be advantageous because it supports long transfer distances (up to 100 meters). However, GigE is limited by lower bandwidth (at approximately 100MB/s) when compared to other transfer interfaces.

The second type is USB3.2. It supports up to 380MB/s, transfer rates (approximately 4 x the bandwidth of GigE), but has a shorter transfer distance of approximately (5 meters).

Alternatively, CameraLink provides a third option. It is superior to GigE and USB3.2 as it can reach up to 850MB/s with a standard transfer distance of 10 meters. However, CameraLink must be paired with an image capture card and camera.

The fourth type is CoaXPress, also known as the CXP12 interface. CXP12 can be used with diverse interfaces (Micro BNC or HD BNC), and offers the highest industrial interface transfer volume (1500 MB/s) with 40 meter transfer distances.

Camera resolution and frame rate correspond with selecting and pairing camera interfaces. Developers should consider that higher resolutions will result in better image quality and sharper detail, but will also increase the transfer times required during data flow. Different transfer interfaces have different frame rates according to their bandwidth. Consider the following example: imagine two 25MP resolution cameras; one with a CoaXPress interface and the other with a GigE interface. The camera with GigE enables four images to be transferred per second. Conversely, the camera with CoaXPress will transfer approximately 60 images per second.

## Check Points for Camera Selection

| Resolution | Speed | Interface | Others |
|---|---|---|---|
| The details of the measured object | The number of images that can be captured per second | Camera connect to PC | Lighting (White, Red, Blue ..) |
| The size of the test object? Defect/target size? | FPS (frame per second) | Resolution & FPS | Lens (Resolution, Focal Length, FOV, Working Distance) |
| Higher resolution, better image quality | Inspection Time | Stability & Reliability | Cable (Normal、High Flex..) |
| Higher resolution, higher data rate | Resolution, Exposure Time, Interface | GigE, USB 3.1, Camera Link, CoaXPress | |

Other factors that affect image quality include:

1. The availability of light impacts image quality. Cameras must increase exposure time in low light conditions. This will impact transfer speed, increase noise distortion, and result in lower frame rates. Similarly, the wavelength and angle of different light sources can also affect image quality.
2. Camera resolution must be paired with appropriate lens' resolutions to ensure image quality.
3. The lens' focal length influences ideal image capture range.
4. Different cable grades can affect image quality and transfer stability.

For example, automated optical inspection devices (AOI) require cameras capable of capturing tiny defects at high speeds. This necessitates using high-resolution, high-frame rate cameras with 12 megapixel CoaXPress interfaces and anti-winding cables for optimal performance. Cameras used in robotic arms often encounter slow movement speeds where images are taken from a stationary state. This means that GigE interface cameras with anti-winding cables are good option. The size of the objects intended to be photographed may also influence the choice of camera and interface.

3D imaging technologies are also adopted widely in intelligent automation. There are three commonly-applied types:

1. **Structured light.** This principle refers to the projection of a unique light pattern onto an object. Cameras are then used to image capture the code of this unique light pattern. This code is compared to the original image before trigonometric calculations are used to find 3D coordinates which is suitable for 3D automated optical inspection (AOI) applications.
2. **Active/passive 3D vision.** This principle exploits parallax differences using two or more cameras that capture an object. After image capture, trigonometric calculations determine the distance from the detected object which is suitable for robotic arms that pick up and place objects.
3. **Time of flight.** This principle measures distance using the light's time of flight and is suitable in large work areas (larger than 10 meters). It offers slightly poorer depth and accuracy when compared to the two methods listed above, and is therefore more suitable for logistics and AMRs. Likewise, its resistance to infrared interference and IP67-rated camera shells make it suitable for outdoor/harsh-environment applications.

## Common Interfaces Comparison

| | GigE Vision | 5 GigE Vision | 10 GigE Vision | USB3 Vision | CoaXPress CXP-12 | Camera Link |
|---|---|---|---|---|---|---|
| **Bandwidth Max in MB/S** | 100MB/s | 600MB/s | 1200MB/s | 380MB/s | 1500MB/s (One channel) | 850MB/s |
| **Cable Length** | 100m | 100m | 55m(Cat6) 100m(Cat6A) | 5m | 40m | 10m |
| **Speed in 25MP Camera (IMX530/540)** | 4fps | 24fps | 48fps | 15fps | 4fps (in 4 channel) | 34fps |
| **Multi Camera** |  |  |  |  |  |  |
| **CPU Loading** |  |  |  |  |  |  |
| **Cost** | $ | $ | $ | $ | $$ | $$$ |

# What is the Ubuntu certificate and why does it matter?

AIoT edge devices, like autonomous  mobile robots (AMR), consist of multiple single board computers connected with different signal receivers (e.g. cameras, Wi-Fi cards, and motion controllers). Consequently, updating their OS regularly is crucial in ensuring device functionality.

The stock OS shipped with hardware from factories may endure unexpected vulnerabilities and defects; and require repair. Using an open and objective software security test indicator, such as Common Vulnerabilities Exposures (CVE), enables users to address vulnerabilities via downloads verified by professional OS companies. Canonical, the publisher of Ubuntu, has a designated team responsible for publishing/repairing vulnerabilities on CVE. Users can also utilize Ubuntu Security Notices (USN), a testing tool that quickly identifies patched vulnerabilities. USN also checks which versions have patches, and whether security is needed for machines currently in use.

Ubuntu also uses the Canonical Driver Test Suite (CDTS) to deliver a set of tests to OEMs, ODMs, and IHVs for use in prototyping hardware and drivers. This suite includes over a hundred test items that ensure that hardware can run Ubuntu out-of-the-box. In addition, Ubuntu regularly releases security patches that are re-verified on certified machines to confirm that bugs have been fixed. The Long Term Support (LTS) program secures a maintenance cycle of up to 10 years. These commitments apply to ROS/ROS 2 platforms as well.

Ubuntu OS contains various AI software development kits (SDK) and a comprehensive software development ecosystem. This functionality is bolstered by close partnerships cloud services — including Azure, AWS, and Oracle. Users can utilize these services directly to train their AI models.

Canonical also verifies Advantech's latest hardware platforms regularly. Doing so ensures customers receive a direct, boot-up experience that save engineers resources when verifying compatibility between operating systems and hardware. Likewise, selecting Ubuntu certified machines for development applications offers assurances in upgrade and maintenance, post-sales update services, and cloud resource integration.

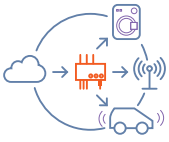
## Benefits for Acquiring Ubuntu Certificate

10 Year shield trio


Safety & reliability

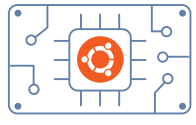

Extended security maintenance

10 years support


IoT gateways on ubuntu


IoT constant updates


Ultra-reliable updates


Embedded Linux

Source: Canonical

# Embedded Single Board Computer (ESBC) for Robotic Applications

Recent research regarding the development trends of industrial and mobile robotics devices indicates that hardware computing platforms are moving in the following directions:

1. **From traditional serial computing towards heterogeneous computing and parallel computing:** Data sources such as images, video streams, voices, and the sensor fusion mechanism have been included for realizing the era of AIoT. Traditional CPUs provided a general-purpose computing performance that is suitable for serial computing. However, to process the abovementioned data sources with deep learning and AI inference using algorithms such as DNN, CNN, and RNN, parallel computing proved to be more advantageous. Thanks to the latest technology, developers now can leverage SoC built-in NPU and VPU or extended GPU, FPGA, and xPU via a high-bandwidth interface to achieve workload consolidation.

2. **Time deterministic computing and low-latency network connections have become essential:** The use of low-latency network connections improves computing performance by ensuring that more actions or data can be processed within a single time unit. AIoT equipment interacts closely with its environment. The use of low-latency network technologies — such as TSN (Time Sensitive Networking), Wi-Fi 6/6E, and 5G — enables devices to perform real-time computing in their environments and respond accordingly. This greatly expands the service range of robotic equipment.

3. **Increased demand for industrial-grade design and manufacturing:** The operation environment for robots has shifted from indoor (e.g. factory floors and large-scale warehousing logistics) to outdoor scenarios (e.g. grocery deliveries or community safety inspections.) Maintaining reliability necessitates outdoor-oriented robots capable of operating in rugged environments. Such solutions require water-/shock-resistant designs with wide-range temperature tolerances. Advantech's embedded single board computers (ESBC) are adapted to wide operating temperature ranges (-40 ~ 85 °C) and are treated with conformal coating during the manufacturing process. These products all passed IPC-A-610 Class 3 standards manufacturing criteria for improved durability and stability.

4. **Ubuntu OS and Ubuntu certified AIoT devices have gone mainstream:** A 2020 HackerEarth Developer Survey[2] indicates that 66% of experienced developers and 69% of students prefer Ubuntu over comparable Linux distributions. Indeed, Ubuntu OS is very popular with AIoT device developers due to its ease of use, excellent security, and robust ecosystem support. Advantech has invested resources in Ubuntu OS certification for embedded single board computers (ESBC) before shipping them from the factory. This saves customers' time when testing software/hardware compatibility during the early periods of a project.

   Through Ubuntu certification program, AIoT devices with Ubuntu certification receive a tri-weekly verification service on the released patch. This provides peace of mind of knowing that your AIoT devices remain secure and updated.

The Advantech ESBC team offers a full range of high-performance Ubuntu certified embedded platforms that fulfill the needs of intelligent robotics applications and the trends discussed in this report. Our highly-integrated solutions are designed to reduce their users' time-to-market while providing the reliability needed to enhance AI development.

[2] Source: https://recruit-c7ff.kxcdn.com/recruit/wp-content/uploads/2020/05/he-developer-survey-2020.pdf

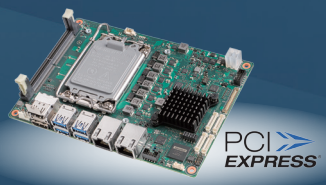
# Advantech Domain-Focused Embedded SBC Platforms




## MIO-2364

*Pico-ITX 32EU*
*Compact Sized and Low Power Design*

- Next Gen. Intel® Atom up to 8 E-Cores, TDP=6~15W
- Intel® UHD GFx Gen12 up to 32EUs for AI Inference
- 2.5GbE opt. PoE/PD module for camera input
- M.2 E-key & B/M-key for WiFi/BT, 5G/LTE and storage




## MIO-4370

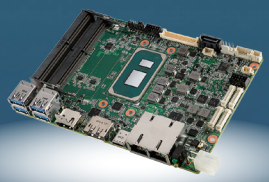
*4"SBC 32EU*
*Scalable & Flexible AI Computing Platform*

- 12th Gen. Intel® Core i9/i7/i5/i3 Celeron, TDP=35W
- Scalable AI from built-in Xe GFx to M.2 PCIe x4 Gen.5
- 3 M.2 includes dual M.2 2280 for NVMe storage & AI expansions
- Dual 2.5GbE w/ TSN for real-time, 6 USB, 2 UART, CAN

## MIO-2375

*Pico-ITX 96EU*
*Light-Weight AI Platform*

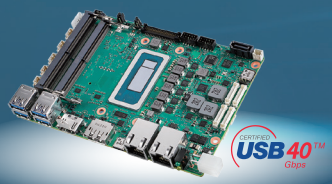
- 11th Gen. Intel® Core i7/i5/i3/Celeron, TDP=15W
- Onboard dual channel LPDDR4x maximum AI capacity
- Sufficient sensor interfaces via 2 GbE, 4 USB, 2 RS-232/422/485
- standard 0~60°C and extended -40~85°C variants



## MIO-5375

*3.5”SBC 96EU*
*Maximum Built-in AI with Rich Expansions*

- 11th Gen. Intel® Core i7/i5/i3/Celeron, TDP=15/28W
- Rich I/O ports include 2 GbE, Type-C, 6 USB, 4 UARTs, CAN, 4 Displays
- 3 M.2 expansion via E-key, B-key, M-key PCIex4 Gen.4
- DC-in 12~24V, standard 0~60°C and extended -40~85°C variants




## MIO-5377

*3.5”SBC 96EU*
*Hybrid-core design with 8x Camera & 9x Sensor I/O*

- 12th Gen. Intel® Core Hybrid i7/i5/i3/ Celeron, TDP=15/28W
- Rich I/O ports include 2 GbE, USB4, Type-C, 4 UARTs, 3 I2C, 2 CAN
- 4 individual displays include LVDS, HDMI2.0, DP1.4, USB4, Type-C up to 8K
- 3 M.2 via E/B/M-key for WiFi/BT, 5G/ LTE, NVMe, DC-in 12~24V

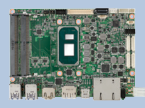


## EPC-C301

*Fanless BOX PC*
*Compact Embedded System with Rich I/O Ports*

- 8th Gen. Intel® Core i7/i5 Quad Core, TDP=15W
- Rich I/O ports include 4 GbE, 8 USB, 4 UART, 2 CAN isolation
- 4 expansions: M.2 E-key, B-key, M-key, miniPCIe for wireless & AI
- Extended operating temperature: -20~60°C

# ESBC Product Selection

| |  Preliminary<br>MIO-2364 |  <br>MIO-2375 |  <br>MIO-5375 |
|---|---|---|---|
| **Form Factor** | Pico-ITX | Pico-ITX | 3.5" SBC |
| **Processor** | Next Gen. Intel Atom | 11th Gen. Intel Core/Celeron | 11th Gen. Intel Core/Celeron |
| **Cores/ Threads** | 8C/8T | 4C/8T | 4C/8T |
| **Memory** | DDR5 1-CH 32GB | Onboard LPDDR4x 32GB | DDR4 2-CH 64GB |
| **Display** | LVDS, HDMI1.4 | eDP1.4/MIPI-DSI, DP1.4 | LVDS/eDP, HDMI2.0, DP1.4, Type-C |
| **Expansion** | M.2 E-Key & B/M-Key | M.2 E-Key & B/M-Key | 3x M.2 E/B/M-Key |
| **Power Input** | DC-in 12V, ATX/AT Mode | DC-in 12V, ATX/AT Mode | DC-in 12~24V, ATX/AT Mode |
| **I/O Ports** | GbE, 4 USB, 2 UART, GPIO, SATA, Audio, SMBus, TPM | 2 GbE, 4 USB, 2 UART, GPIO, SATA, Audio, I2C, TPM | 2 GbE, 6 USB, Type-C, CANBus, 4 UART, GPIO, SATA, Audio, I2C, TPM |
| **Thermal** | Fanless Heatsink | Active Cooler | Fanless Heatsink for TDP=15W<br>Active Cooler for TDP=28W |
| **Operating Temperature** | 0~60°C | 0~60°C & -40~85°C | 0~60°C & -40~85°C |
| **Dimensions** | 100 x 72mm | 100 x 72mm | 146 x 102mm |
| **Software** | Windows, Ubuntu, Yocto | Windows, Ubuntu, Yocto | Windows, Ubuntu |

# ESBC Product Selection

| |  MIO-5377 |  MIO-4370 |  EPC-C301 |
|---|---|---|---|
| **Form Factor** | 3.5" SBC | 4" SBC | Embedded Fanless PC |
| **Processor** | 12th Gen. Intel Core/Celeron | 12th Gen. Intel Core/Celeron | 8th Gen. Intel Core i7/i5 |
| **Cores/ Threads** | 4P+8E/16 | 8P+8E/24T | 4C/8T |
| **Memory** | DDR5 2-CH 64GB | DDR5 1-CH 32GB | DDR4 2-CH 32GB |
| **Display** | LVDS, HDMI2.0, DP1.4, Type-C, USB4 | eDP1.4, 2x HDMI1.2 | HDMI1.4, DP1.2 |
| **Expansion** | 3x M.2 E/B/M-Key | M.2 E-Key, 2x M-Key | 3x M.2 E/B/M-Key, mPCIe |
| **Power Input** | DC-in 12~24V, ATX/AT Mode | DC-in 12V, ATX/AT Mode | DC-in 12V, ATX Mode |
| **I/O Ports** | 2 GbE, USB4, 6 USB, Type-C, CANBus, 4 UART, GPIO, SATA, Audio, I2C, TPM | 2 GbE, 6 USB, CANBus, 2 UART, GPIO, Audio, I2C, TPM | 4 GbE, 8 USB, 2 CANBus, 4 UART, GPIO, Audio |
| **Thermal** | Fanless Heatsink for TDP=15W<br>Active Cooler for TDP=28W | Active Cooler | Fanless Design |
| **Operating Temperature** | 0~60°C & -40~85°C | 0~60°C | -20~60°C w/0.7m/s Air Flow |
| **Dimensions** | 146 x 102mm | 165 x 115mm | 170 x 118 x 70 mm |
| **Software** | Windows, Ubuntu | Windows, Ubuntu | Windows, Ubuntu, Yocto |

# Embedded Peripheral Solutions

## AIW-163BR

- **Form Factor**
  M.2 2230 A-E key
- **Wireless Standard**
  802.11ax + BT5.2
- **Chipset**
  RTL 8852BE
- **Signal Protocol**
  WiFi: PCIe BT: USB
- **Antenna**
  2 x MHF4 connectors
- **Operating Voltage**
  DC 3.3V
- **Temperature Range**
  0~70 °C (32~158°F)
- **Dimensions**
  22 x 30 x 2.2 mm
  0.86x1.18x0.086 in
- **Security**
  WPA/WPA2/WPA3
- **MIMO**
  2T2R MIMO
- **Data Rate**
  802.11ax: 1.2Gbps
- **OS support**
  Windows / Linux

## AIW-210XU-001

- **Form Factor**
  M.2 2242 B-key
- **GPS Type**
  Hardware Standalone
- **Signal Protocol**
  USB
- **Chipset**
  NEO-M9N
- **Operating Temperature**
  -40°C ~ 85°C
  (-40°F ~ 185°F)
- **RF Receiver Type**
  GPS module, multi-GNSS (GPS/BeiDou/Galileo/ GLONASS/QZSS/SBAS)
- **GPS Acquisition**
  Cold Start: 24s /
  Hot Start: 2s
- **GPS Accuracy**
  Aided Start: 2s
- **GPS Sensitivity**
  Tracking & Navigation: -167 dBm
  Reacquisition: -160 dBm
  Cold Start: -148 dBm

## SQR-SD5N

- **DDR**
  DDR5
- **DIMM Type**
  SODIMM
- **Pin Number**
  262pin
- **Frequence(MHz)**
  4800
- **Capacity**
  8/16/32GB
- **Voltage**
  1.1V
- **Operating Temperature**
  0 ~ 85 °C
- **DeviceOn/ SQ Manager**
  Developing

## SQF-S8B 650

- **Connect Type**
  NGFF B&M Key
- **Flash Type**
  3D TLC
- **Capacity**
  64GB ~ 2TB
- **Transfer Mode**
  SATA III (Up to 6Gb/s)
- **Max. Power Consumption**
  Read: 1.5 W, Write:1.75 W
- **Sustained R/W Performance (*)**
  up to 550/ 520 MB/sec
- **Operating Temperature**
  Commercial Temperature:
  0 to +70 °C
  Minus Temperature:
  -20 to +85 °C
  Extended Temperature:
  -40 to +85 °C
- **Shock Resistance**
  1,500 G, peak / 0.5 ms
- **Vibration Resistance**
  20 G, peak / 80 ~ 2000 Hz
- **Dimensions (mm)**
  80.0 x 22.0 x 3.8

(*) These values are for reference only; they may change according to the flash memory used.

# Embedded Board Solutions

| |  AIMB-218Z |  EPC-U3233 |  SOM-6883 |  EPC-R7200/7300 |
|---|---|---|---|---|
| **Form Factor** | Mini-ITX Motherboard | Embedded System | COMe Compact | Embedded System |
| **Processor** | Intel Atom x6413E | Intel® Core™ i7-8665UE | Intel® 11th Gen Core™ I Processors | NVIDIA Jetson Family |
| **Cores/ Threads** | 4C/4T | 4C/8T | 4C/8T | Up to 8 CPU cores & 1024 CUDA cores |
| **Memory** | 2 Channel 260-pin DDR4 SODIMM up to 3200 MHz<br>2 SODIMM slots, Max. 32GB (16GB per DIMM) | 1 x DDR4-2400 SO-DIMM (260-Pin)<br>32GB Max | 2 Channel 288-pin DDR4 SODIMM up to 3200 MT/s, Max. 32GB | Up to 16GB |
| **Display** | DP, HDMI, LVDS(eDP) | 2 HDMI | VGA, LVDS, eDP(Optional), HDMI/DP | HDMI |
| **Expansion** | 1 PCIe x1 | M.2 M-Key 2280<br>M.2 E-Key 2230<br>M.2 B-Key 3042 | 5 PCIex1<br>(Up to 6 by option) | M.2 KeyB, KeyE and UIO40-Express |
| **Power Input** | DC-in 12V | DC-in 12V | Vin: 8.5V ~ 20V<br>VSB: 4.75V ~ 5.25 V | DC-in 9-24V |
| **I/O Ports** | x2 GbE<br>x3 USB 3.2 Gen 1<br>x5 USB 2.0<br>x1 RS-232<br>x5 RS-232/422/485 | x2 GbE<br>x2 USB 3.2 Gen1<br>x2 USB 2.0<br>x4 COM<br>x2 GPIO | x1 GbE<br>x4 USB 3.2 Gen2<br>x8 USB 2.0<br>x2 2-wire UART<br>x2 SATA 3.0<br>x8 GPIO<br>x1 I2C<br>x1 TPM (Optional) | x2 GbE<br>x2 USB 3.2 Gen 1<br>x2 RS-232<br>x1 CAN<br>* more I/O configurations can be extended by UIO40-Express |
| **Thermal** | Fanless | Fanless | Heat-spreader and Smei-heatsink with Fan, QFCS | Fanless |
| **Operating Temperature** | -20°C ~ 70°C | 0°C ~ 50°C | -40°C ~ 85 °C<br>(Depends on CPU) | -20°C ~ 70°C |
| **Dimensions** | 170 mm x 170 mm | 180 x 116.7 x 66mm | 95 x 95 mm | 152 x 138 x 42 mm |
| **Software** | SUSI API<br>WISE-DeviceOn<br>Windows<br>Linux Ubuntu | SUSI API<br>WISE-DeviceOn<br>Windows<br>Linux Ubuntu | WISE-DeviceOn<br>Windows | Linux Ubuntu<br>WISE-DeviceOn |

# Worldwide

3 Manufacturing Sites

14 Service Cente


## Contact Information

www.advantech.com/contact/inquiryrequestform

# Presence

ers

4 Logistics Center

28 Countries


Regional Service center  Branch Office

## Regional Service and Customization Centers

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **China** | Kunshan<br>86-512-5777-5666 | **Taiwan** | Taipei<br>886-2-2792-7818 | **Netherlands** | Eindhoven<br>31-40-267-7000 | **Poland** | Warsaw<br>00800-2426-8080 | **USA** | Milpitas, CA<br>1-408-519-3898 |

# Worldwide Offices

## *Asia Pacific*

***Taiwan***

| | |
|---|---|
| Toll Free | 0800-777-111 |
| Taipei & IoT Campus | 886-2-2792-7818 |
| Taichung | 886-4-2372-5058 |
| Kaohsiung | 886-7-392-3600 |

***China***

| | |
|---|---|
| Toll Free | 800-810-0345 |
| Beijing | 86-10-6298-4346 |
| Shanghai | 86-21-3632-1616 |
| Shenzhen | 86-755-8212-4222 |
| Chengdu | 86-28-8545-0198 |
| Hong Kong | 852-2720-5118 |

## *Asia Pacific*

***Japan***

| | |
|---|---|
| Toll Free | 0800-500-1055 |
| Tokyo | 81-3-6802-1021 |
| Osaka | 81-6-6267-1887 |
| Nagoya | 81-0800-500-1055 |
| Nogata | 81-949-22-2890 |

***Korea***

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|---|---|
| Toll Free | 080-363-9494/5 |
| Seoul | 82-2-3660-9255 |

***Singapore***

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|---|---|
| Singapore | 65-6442-1000 |

***Malaysia***

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|---|---|
| Kuala Lumpur | 60-3-7725-4188 |
| Penang | 60-4-537-9188 |

***Thailand***

| | |
|---|---|
| Bangkok | 66-02-2488306-9 |

***Vietnam***

| | |
|---|---|
| Hanoi | 84-24-3399-1155 |
| Hochiminh | 84-28-3836-5856 |

***Indonesia***

| | |
|---|---|
| Jakarta | 62-21-751-1939 |

***Australia***

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|---|---|
| Toll Free | 1300-308-531 |
| Melbourne | 61-3-9797-0100 |

***India***

| | |
|---|---|
| Bangalore | 91-94-4839-7300 |
| Pune | 91-94-2260-2349 |

## *Europe*

***Netherlands***

| | |
|---|---|
| Eindhoven | 31-40-267-7000 |
| Breda | 31-76-523-3100 |

***Germany***

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|---|---|
| Toll Free | 00800-2426-8080/81 |
| Munich | 49-89-12599-0 |
| Düsseldorf | 49-2103-97-855-0 |

***France***

| | |
|---|---|
| Paris | 33-1-4119-4666 |

***Italy***

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|---|---|
| Milan | 39-02-9544-961 |

***UK***

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|---|---|
| Newcastle | 44-0-191-262-4844 |
| London | 44-0-870-493-1433 |

***Spain***

| | |
|---|---|
| Madrid | 34-91-668-86-76 |

***Sweden***

| | |
|---|---|
| Stockholm | 46-0-864-60-500 |

***Poland***

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|---|---|
| Warsaw | 48-22-31-51-100 |

***Russia***

| | |
|---|---|
| Moscow | 8-800-555-01-50 |
| St. Petersburg | 8-812-332-57-27 |
| | 8-921-575-13-59 |

***Czech Republic***

| | |
|---|---|
| Ústí nad Orlicí | 420-465-524-421 |

***Ireland***

| | |
|---|---|
| Galway | 353-91-792444 |

## *Americas*

***North America***

| | |
|---|---|
| Toll Free | 1-888-576-9668 |
| Cincinnati | 1-513-742-8895 |
| Milpitas | 1-408-519-3898 |
| Irvine | 1-949-420-2500 |
| Ottawa | 1-815-433-5100 |
| Chicago | 1-888-576-9668 |

***Brazil***

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|---|---|
| Toll Free | 0800-770-5355 |
| São Paulo | 55-11-5592-5367 |

***Mexico***

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|---|---|
| Toll Free | 1-800-467-2415 |
| Mexico City | 52-55-6275-2777 |

## *Middle East and Africa*

| | |
|---|---|
| Israel | 072-2410527 |
| Turkey | 90-212-222-0422 |
| Turkey-Bursa | 90-224-413-3134 |

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