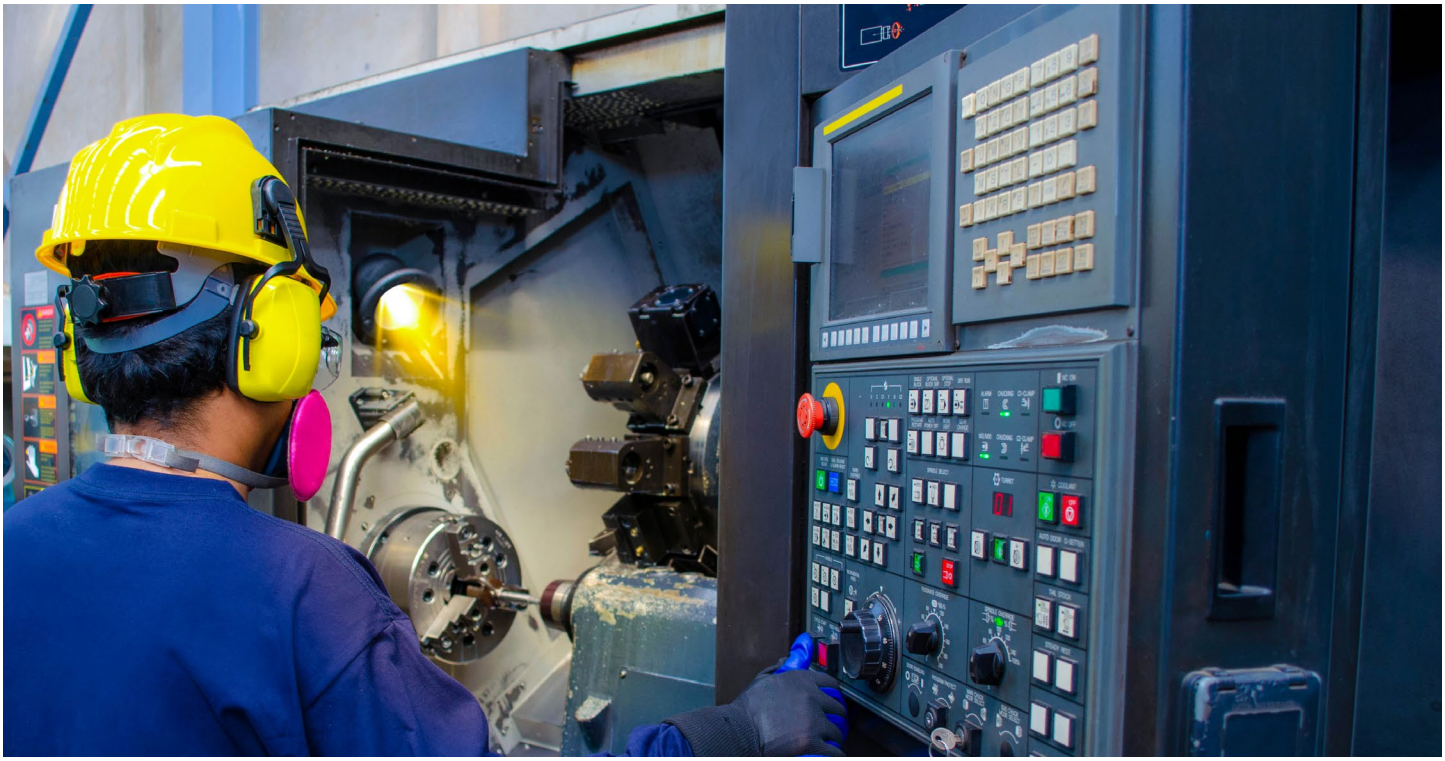
PCs & Industrial Computers: What's the Difference and How Do You Choose?



Introduction

Industrial computers have different use cases and operating environments than commercially available, desktop consumer PCs. Consumer PCs are often used in an office-type environment, with relatively stable conditions. Industrial computers are deployed across a wide spectrum of environments, from factory floors to wind turbines, to naval ships and rail transports, to satellites. As a result, industrial computers have more rigorous requirements than standard PCs.

The Differences Between Commercial PCs and Industrial Computers

One of the primary differences between industrial and consumer computers is the central processing unit (CPU). In general, industrial CPUs are engineered for reliability, efficiency, and their ability to work in harsh environments, often at the expense of raw performance. They are designed to meet the demands of continuous operation, low power consumption, and long-term availability. Conversely, commercial CPUs prioritize high performance, versatility, and feature sets that cater to a broad range of applications in controlled environments. In practical terms, there are some major structural and, for lack of a better word, philosophical differences between industrial and consumer CPUs.

Though there are many different types of processors used in industrial computers – from manufacturers to architectures – two of the most common are Intel Atom® processors and Intel® Core™ processors. Ultimately, the selection of either an Atom or Core processor boils down to the application.

Industrial CPUs

Priorities

- Edge computing
- Wide operating-temperature range
- Ruggedness and reliability

Environmental

- Low power consumption and energy efficiency, especially in fanless or battery-operated systems.
- Advanced thermal management to reduce heat generation and ensure reliable operation in environments where cooling solutions are limited.
- Built for high reliability and continuous operation, often 24/7.
- Capable of operating in a wide range of environmental conditions, including extreme temperatures, humidity, and exposure to dust and vibration.

Maintenance & Management

- Lower clock speeds and fewer cores compared to high-end consumer CPUs, prioritizing efficiency and stability over peak performance.
- Designed to handle real-time processing and control tasks.
- Use industrial-grade components with extended lifespans and are tested for reliability under harsh conditions.
- Longer availability and support cycles to ensure consistent supply and maintenance over many years.
- Designed to operate on a wider range of power inputs, including DC power, and often feature redundant power supplies for increased reliability.
- Designed for ease of maintenance in the field with features like modular components and easy access panels.
- Often include remote management capabilities for monitoring and control in industrial environments.

Commercial CPUs

Priorities

- General purpose computing
- Gaming
- Media player

Environmental

- Typically designed for office or home environments with controlled conditions.
- Standard enclosures made of plastic or light metal.
- Designed for typical daily use with periodic shutdowns.
- Often rely on active cooling (fans), which can be a point of failure in dusty or harsh environments.

Maintenance & Management

- Consumer-grade components with shorter lifespans.
- Faster product cycles with more frequent updates and changes in parts availability.
- Operate on standard AC power supp

Intel Atom®

Atom processors have been optimized for energy efficiency over raw performance and are suitable for lightweight applications such as basic computing, simple edge devices, and embedded systems. Further, Atom processors generate minimal heat, often enabling fanless designs and simpler, more compact packaging suitable for use in small form-factor devices. The Atom line of processors is less expensive and designed specifically for low-power, less performance-intensive tasks.

Intel® Core™

The Intel Core line of processors is on the other end of the spectrum. Although there are many different versions of Intel Core processors, there are some generalities that apply to the product line, especially in contrast to the Atom line. Broadly, Intel Core processors are designed for high-performance computing tasks and have higher clock speeds and more cores than Atom processors. Core processors are suitable for demanding applications such as gaming, multimedia editing, machine vision, AI, motion control, and real-time decision-making tasks, but they also have higher levels of power consumption and, by extension, require more robust cooling solutions.

Atom processors are optimized for low power consumption, cost efficiency, and simpler tasks, making them ideal for embedded systems and applications where energy efficiency is critical. Core processors offer higher performance, and better features, and are suitable for demanding computing tasks but come with higher power consumption and costs. Again, the determining factor in processor selection is the application.

I/O in Industrial Computing

I/O is the critical link that enables devices to communicate with each other, allowing data to be passed between controllers, sensor systems, and rugged industrial computers. A trend driving Industry 4.0 has been to retrofit older machines and manufacturing processes with advanced electronics for remote monitoring and control. Industrial computer systems need to manage a variety of data inputs that collect and send information for real-time decision-making. Modern industrial computers, therefore, need to support a variety of legacy and new I/O ports for more robust computing operations.

USB

USB 2.0 has some speed, power, and bandwidth limitations over 3.2, but it is still a very relevant technology, especially for simple hardware applications, and is significantly less expensive than 3.0. USB 2.0 is backwards compatible with all previous versions of USB. The primary features include:

- Speed – 480 Mbit/s
- Power Requirements - USB 2.0 allows a power draw of up to 500 mA
- Cost – Less expensive at ~ 70% of the price of USB 3.2 devices
- Physical Characteristics and Bandwidth – 4 wires total that can only handle one-way communication, either in or out at any given time.

USB Versions		Data Rate bits/sec	Common USB Connector
USB 2.0	Basic Speed (USB 1.0)	1.5Mbps	Type-A, Type-B
	Full Speed (USB 1.1)	12Mbps	Type-A, Type-B, Mini-A, Mini-B
	High Speed (USB 2.0)	480Mbps	Type-A, Type-B, Mini-A, Mini-B, Micro-A, Micro-B, Micro-AB, Type-C
USB 3.2	USB 3.2 Gen1 (USB 3.0)	5Gbps	Type-A SuperSpeed, Type-B SuperSpeed, Micro-A SuperSpeed, Micro-B SuperSpeed, Micro-AB SuperSpeed, Type-C
	USB 3.2 Gen2 (USB 3.1)	10Gbps	
	USB 3.2 Gen2x2 (USB 3.2)	20Gbps	Type-C

USB Versions and Common Connections

USB 3.2 offers significant upgrades in capabilities over USB 2.0, but with the upgrades comes a higher price tag. USB 3.2 is completely backward compatible, but when utilized in a 2.0 connection, data speeds and power utilization are limited to 2.0 levels. 2.0 connections are also accepted by 3.2 ports, but again only utilize 2.0 functionality, except for 3.2 type-B connectors which utilize a new design, which will not fit into 2.0 type-B jacks.

- Speed – 5.0 Gbit/s to 20 Gbit/s
- Power Requirements - Provides up to 900 mA, but is dynamic – providing more power when needed and conserving power when the device is connected but idling.
- Cost –More expensive than USB 2.0.
- Physical Characteristics and Bandwidth – 8 wires total that create 2 unidirectional paths that allow simultaneous in and out communication.

Optically Isolated Inputs

Optical isolation is a technique that protects electronic devices and circuits from ground loops, power surges, and electromagnetic interference. Optical isolation involves the use of optical isolators to transmit signals between two circuits while keeping them electrically isolated from each other. The basic principle of the practice is the conversion of electrical signals into optical signals, which are then transmitted through an optical medium such as an optical fiber or an air gap. The optical signal is received by a photodetector on the receiving side, which converts it back into an electrical signal. The major benefit of optical isolation is its ability to provide complete electrical isolation between two circuits. This means that any electrical noise, ground potential differences, or power spikes present in one circuit will not be transferred to the other circuit. It prevents the passage of unwanted electrical currents, voltages, or transients between the isolated circuits.

Many applications benefit from optical isolation; the most prominent use case is medical devices. Any power quality problems – such as voltage distortion, current harmonics, electrostatic discharge, power surges, or electromagnetic interference – can affect the calibration and sensitivity of diagnostic devices used by doctors and healthcare professionals. Erroneous test results can end in misdiagnosis and potentially harmful treatment plans for patients. Optical isolation limits the power quality problems by separating the power input circuitry from the device input/diagnostic circuitry.

Solid-State Relay Outputs

Solid-state relays (SSRs) use semiconductor devices or transistors to perform the switching function. SSRs are popular in PCB applications because of their fast-switching speed, high reliability, and lack of mechanical parts, which makes them ideal for applications with high electrical noise or vibration. SSRs use a low-power electrical signal to create an optical semiconductor signal that transmits and energizes the output signal. When activated, the input optical signal acts as the switching mechanism that allows a high-voltage signal to pass through the SSR's output. There are several methods to achieve this, but the common theme is the lack of moving parts, thus making them solid-state.

SSRs are quite versatile and generally have more features and functionality than electromechanical relays, but there is a tradeoff. SSRs are more expensive than electromechanical relays and can have increased heat dissipation levels.

Form C Relay Outputs

Form C (or changeover/CO) relays have a set of normally open contacts and a set of normally closed contacts. When the relay is not energized, the normally closed contacts are closed, and the normally open contacts are open. When the relay is energized, the opposite occurs—the normally closed contacts open, and the normally open contacts close. Form C relays are often used to switch between two circuits or control different operations simultaneously, such as in automation systems or multipurpose control applications.

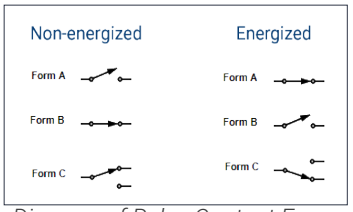


Diagram of Relay Contact Forms

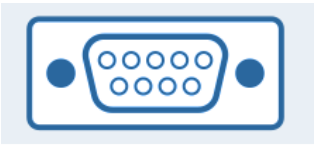
Ethernet

Over the last decade or so, industrial Ethernet has become the largest and fastest-growing industrial networking segment, outpacing serial communications. There are two main reasons for this: Ethernet connections have higher speeds than serial fieldbus and wireless connections, and Ethernet cables can be effectively extended to much longer distances than either serial connections or wireless connections. Common industrial Ethernet protocols include PROFINET, EtherNet/IP, and EtherCAT.


Ethernet Port

Serial Ports

Serial ports, in an industrial computer context, are used for a variety of purposes, primarily focused on communication and control. Many older and legacy industrial machines and equipment use serial ports like RS-232, RS-422, and RS-485 for communication. Serial ports on industrial computers allow these legacy machines to interface with modern control systems and software. In addition to serving as the main component in communication, serial ports are often employed as a redundant, fail-safe communication method, ensuring continuous operation should the primary communication methods fail.

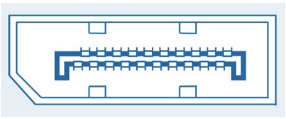

DB-9 Serial Connector

Display

There are a wide variety of display interfaces, with each having different benefits.

DisplayPort

DisplayPort is a digital display interface used to connect a video source to a display device. DisplayPort 1.4 and above supports four displays per cable, making it a great choice for multiple monitor displays for digital signage or kiosk applications. Both DisplayPort and HDMI can be adapted to several different video interfaces using passive or active adapters, although DisplayPort is more easily adapted to analog interfaces like VGA or DVI.


DisplayPort Connector

DP++

A standard DisplayPort (DP) can only support DP signals and will require an active adapter to convert to HDMI or DVI signals. Dual-Mode DisplayPort (DP++), however, offers flexibility since it supports DP signals and will convert HDMI and DVI signals. DP++ ports are identical to normal DisplayPorts, but generally have the logo printed on the device near the connector.


DP++ Logo

HDMI

HDMI Connector

High Definition Multimedia Interface (HDMI) is an audio/video interface that is most common on televisions or displays; it is the most frequently used interface for transferring both high-definition audio and video over a single cable. Each HDMI port only supports a single display.

VGA

VGA Connector

Video Graphics Array (VGA) is the oldest display connector that is still in common use. VGA is an analog interface that was originally designed for use with old CRT displays. While VGA is insufficient to run high-resolution displays, it is ubiquitous and widely supported by older devices and can be a reliable choice for legacy equipment. Much like serial ports, VGA can be employed as a redundant, fail-safe display connection, ensuring continuous operation should the primary display connections fail.

Industrial Embedded Computing Challenges & NUC Alternatives

A major constraint faced by industrial computers is one of space and size. Further, as industrial computing tasks are becoming more and more complex, incorporating things like machine learning and AI, the already demanding footprint constraints are joined with higher performance requirements.

The NUC (Next Unit of Computing) is a line of small form factor personal computers that were initially designed and sold by Intel.[1] Introduced in 2012, NUCs are compact and versatile computers, featuring powerful processors.

While the NUC line of computers is versatile, there are certain characteristics that may make them less suitable for industrial computing environments:

- Lifecycle Support – Industrial applications typically require hardware with long lifecycle support to ensure compatibility and reliability over extended periods. Consumer-oriented NUC computers, on the other hand, do not offer the extended support and guaranteed availability that industrial-grade hardware requires. This is evidenced by Intel licensing the product line to Asus and ending support and production of NUC computers.
- I/O and Compatibility – Industrial computing often requires highly specialized hardware configurations, including additional I/O ports, expansion slots, and customized interfaces. NUC computers, like most consumer-grade devices, lack the diversity of I/O connections required in industrial settings.
- Ruggedness – Industrial computing requires devices that can withstand harsh environments, which include extreme temperatures, high dust, moisture, and vibration. Standard NUC computers are not designed with these environments in mind and may not be reliable when used in these conditions. In fact, the standard NUC computers are actively cooled by a fan, which is one of the most common points of failure in computers.

Flexio Fanless Industrial Embedded Computers provide a NUC-alternative computing system that is affordable, fanless, and American-made with guaranteed long-term availability. Flexio Fanless Industrial Embedded Computers, fueled by Intel Atom and Core processors, combine industrial processing with configurable and application-specific I/O.

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1. *In July of 2023, Intel announced that the company would no longer design products in the NUC line. Instead, Intel "agreed on a term sheet for a non-exclusive license for ASUS to manufacture, sell, and support 10th to 13th Gen NUC systems." https://www.asus.com/us/content/nuc-overview/*

Sealevel Flexio Fanless Industrial Embedded Computers

The Flexio was developed specifically to address the characteristics the challenges that users face when attempting to integrate NUCs, and similar computers, in industrial applications. The end product allows for seamless integration of a single computer with robust I/O across a wide variety of industrial and rugged applications.

- Lifecycle Support – As with all Sealevel products, Flexio computers come include a long-term availability guarantee. Generally, availability and support for industrial products ranges from three to five years. Sealevel provides direct access to applications engineers with first-hand experience with the Flexio for the life of your application. Sealevel is committed to manufacturing the Flexio, or if needed a form-fit-function replacement, as long as it is needed by customers to avoid costly migration or recertification efforts.
- I/O and Compatibility – The base models of the Flexio computers support 4K display via DisplayPort and HDMI ports (Core) and DP++ port (Atom) and include audio Mic In/Line Out connections. Standard I/O on each model includes serial, USB, and Gigabit Ethernet ports, allowing the Flexio to effectively communicate with sensors, PLCs, and other peripherals. Flexio computers offer fully integrated expansion I/O for a variety of USB to serial, USB to digital, and USB to analog-based control systems, allowing the Flexio to interface with new and legacy devices of all shapes and sizes.
- Ruggedness – Flexio Fanless Industrial Embedded Computers feature a solid-state design for an extended lifespan, long-term reliability, and quiet, fanless operation. All Flexio computers are passively cooled, utilizing an extruded aluminum enclosure to enable natural convection cycles – shifting heat from internal components to the surrounding air. The entire system has no moving parts, allowing it to operate reliably in high-dust environments like factories, warehouses, and other industrial environments. With a rugged enclosure, carefully designed tolerances through analytics, and statistical performance modeling, Flexio computers have fully optimized thermal properties, resulting in a wide 0° to 60°C operating temperature range.

Meeting the Demands of Industrial Embedded Computing

Industrial computing systems are designed and engineered to meet the rigorous demands of harsh environments and continuous operation, distinguishing them from their consumer counterparts. The choice of CPU, whether an energy-efficient Intel Atom or a high-performance Intel Core, is critical and depends heavily on the specific application needs. Additionally, the versatile I/O interfaces allow for seamless integration with both legacy and modern equipment, ensuring reliable communication and control. The Flexio Fanless Industrial Embedded Computers offer a robust solution, tailored to address the limitations of consumer-grade systems like NUCs. With their rugged design, extended lifecycle support, and customizable I/O, Flexio systems exemplify the level of durability and reliability required in industrial settings, making them an ideal choice for demanding applications.

About the Author

Drew Thompson is a marketing specialist for Sealevel Systems. A writer/editor by training, he spends his days creating and delivering content relevant to our technical community and business partners.